Sea Wall Biodiversity Handbook

by Tim Gardiner, Rob Pilcher and Max Wade

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Images are the authors unless labelled.

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Authorship

Production of this handbook was commissioned by the Environment Agency and its publication was achieved through a partnership between the Environment Agency and RPS consultants.

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Contents

Whilst this handbook has been written primarily to inform those involved in managing vegetated sea walls, notably the Environment Agency, other operating authorities, landowners, land managers, land use advisors and contractors, it is also intended to have wider appeal to anyone with an interest in sea walls and coastal ecology. As such, whilst the text is consistent with Environment Agency decision-making guidance, care has been taken to ensure the language used is as jargon free and as easy to read as possible by anyone with an interest in sea wall vegetation management.

Photographs are used to illustrate pertinent points, e.g. to show what good sea wall management may look like, as well as of certain species where this is thought to be helpful. The latter has been deliberately restricted as the handbook is not intended to be seen as a field guide to the habitats or species that can occur on sea walls. Photographs have been provided by the Environment Agency and RPS unless otherwise stated. All artwork was prepared by Jonathan Graham unless otherwise stated. The source of the information is cited throughout and a comprehensive reference list provided to enable further reading.

Chapter 1: Introduction

Introduction

Sea walls are well known as vital engineered structures for the defence of our flat coastal areas such as along the Severn Estuary, around the Solent, the Pevensey Levels in Sussex, the North Kent Marshes and a significant part of the Essex coast. What is less well known is the importance of these structures for wildlife. Made up of a range of habitats, sea walls lie at the interface of the shoreline, be it of an estuary or the open sea with a marine influence and, on the landward side, usually grazing marshes and other agricultural habitats. They have strong linear characteristics, including their continuous nature and long length: 2,141 km in England (Figure 1.1; Table 1.1) with the county having the greatest length being Essex (450 km). This combination, not surprisingly, serves to support a wide range of flora and fauna, some of which are unique to sea walls and move along them and into the habitats on either side, using them as refuges at high tide or particular times of year, and as vital corridors between other habitats.

Table 1.1: Length of sea wall flood defence (raised earth embankment) throughout England sorted by former Environment Agency region (see Figure 1.1).

Former Region	Sea wall length (km)	% of national length
Anglian	1,202	56
Midlands	43	2
North-east	102	5
North-west	198	9
South-east	421	20
South-west	175	8
Total	2,141	100

This Sea Wall Biodiversity Handbook draws together the growing body of knowledge about the wildlife, value and management of vegetated sea walls found around our coasts and estuaries in England. This is used to present a synthesis of good practice guidance on how to manage the constituent habitats in a way that achieves the critical flood risk management requirements relating to the condition of sea walls whilst at the same time optimising their nature conservation value.

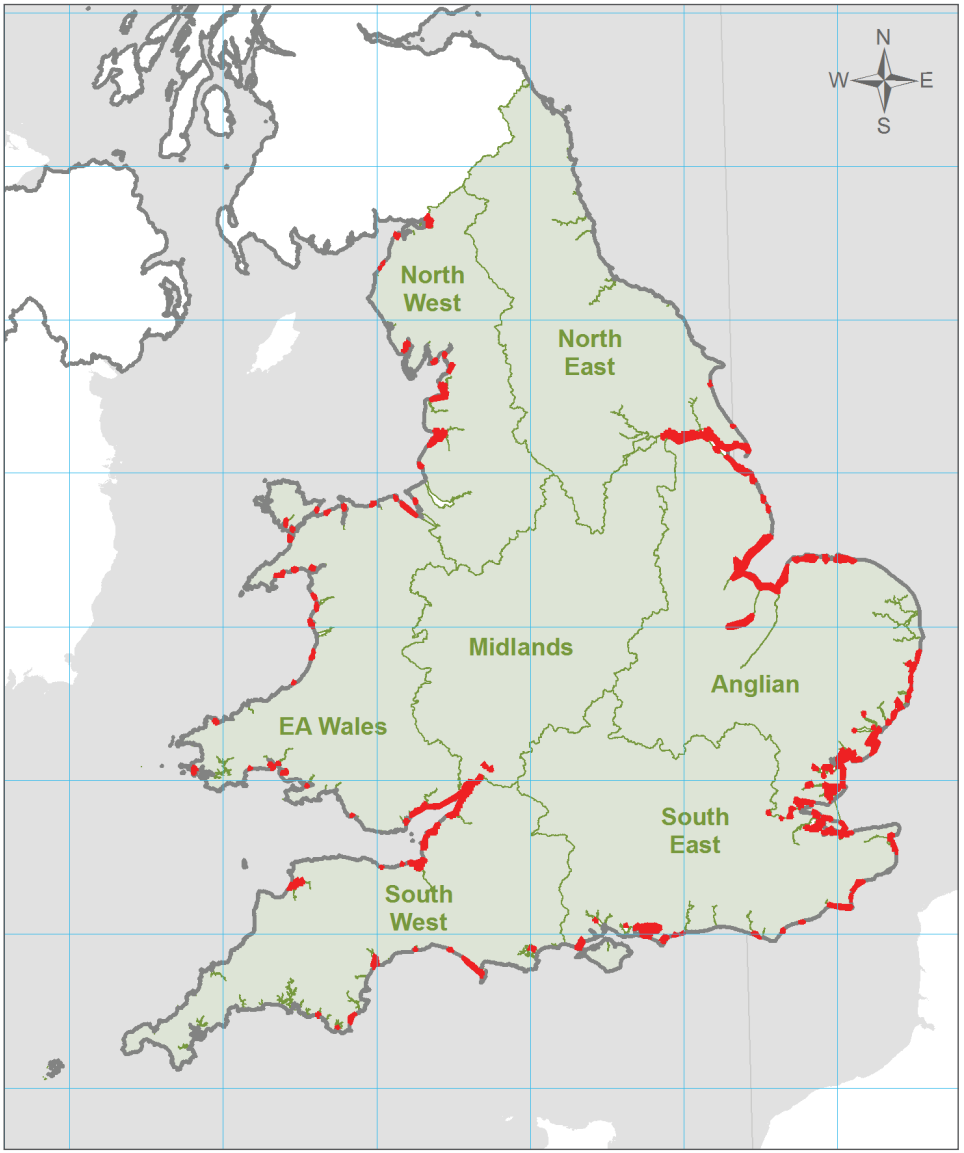


Figure 1.1. Distribution of sea walls in England

What is a sea wall?

So, what do we mean by a sea wall? For the purposes of this Handbook, a sea wall is taken to mean any vegetated flood defence embankment or retaining wall present along the open coast or adjacent to tidal waters (such as an estuary) which is at least in part covered by vegetation. Such sea walls may be entirely earthen, though many will be constructed from a variety of materials, and may or may not have a seaward face that is protected against erosion in some way.

△ Landscape (Steven Falk)

Need for this handbook

Significant changes have occurred to the way many vegetated sea walls around the coasts and estuaries of England are managed, not least through increasing efforts to meet common standards with respect to flood risk management. The main changes relate to increased removal of woody vegetation, changes in the frequency of mowing and a reduction in grazing of sea walls. The reduction in grazing generally reflects wider issues that have affected livestock farming due to market and political forces. The growth of woody vegetation can undermine the structural integrity of sea walls and promote the activity of burrowing mammals such as Badgers *Meles meles*. Woody vegetation and tall, unmown grassland make it hard for engineers to inspect the condition of sea walls as a defence against tidal flooding, which is after all their main function, in the event of overtopping, water will pour over the crest and down the landward face ripping grass tussocks and trees out of the earth damaging the sea wall, e.g. by leaving holes in the surface.

At the same time, there has been growing evidence of the nature conservation value of sea walls for a range of flora and fauna, especially for plants, invertebrates and reptiles, including several protected or otherwise notable species. For example, the grassland found on vegetated sea walls is typically unimproved in nature and therefore can contain nationally important plant and animal communities. However, much of the research undertaken on the ecology of sea walls is contained within disparate reports, not always easily available. This means that the value of sea walls is not widely recognised and that as such their management for nature conservation is generally poorly understood.

In addition to providing significant swathes of habitats in areas where the extent of natural habitats has generally declined, vegetated sea walls also provide vital linear corridors linking other areas of habitat. Many stretches also lie within or on the boundaries of sites designated for their nature conservation

interest, including international designations such as Ramsar sites, Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), national designations, notably Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs) and local designations such as Local Wildlife Sites (LWSs) and Local Nature Reserves (LNRs).

Coupled with this has been a growing increase in public interest about environmental matters and engagement in decision making. As such, anyone seen as having a role in either maintaining a vegetated sea wall, or in changing its condition, is likely to be open to scrutiny and possible criticism. This is especially true for those public bodies which have a legal duty to undertake their activities in a way which furthers nature conservation. This specifically includes flood risk management.

Aims of this handbook

The main aim of this handbook is to bring together information on the ecology of sea walls, with guidance on vegetation management techniques available in a suite of best practice guides on specific habitats or taxonomic groups supported by relevant case studies. By drawing this information into one place, it will provide a sound evidence base on which both flood risk managers and ecologists can more easily justify the sometimes difficult management decisions needed when managing sea wall vegetation. In keeping with handbooks covering other habitats, we have sought to provide an accessible and practical guide, which through the use of selected case studies, seeks to promote vegetation management techniques on sea walls which further nature conservation.

This evidence base has been derived through the collation of available literature. A significant proportion of this information has come from the more extensive studies carried out on the ecology of East Anglian sea walls, notably those of Essex. This collation of information does not cover the establishment of vegetation on new sea walls.

The focus has been on how to maintain and improve the biodiversity of existing sea walls in a manner which seeks to balance and integrate the conservation of habitats and species with vegetation management required for flood risk management. Biodiversity needs can usually be reconciled with flood risk management (as well as other interests) through careful planning and clear communication. Best

practice techniques are generally of low or no additional cost. Most of the techniques are after all either merely an extension of traditional vegetation management practices or are applied in a slightly different way.

Case studies

Case studies have been used throughout the handbook to help illustrate particular points or provide detailed information on the species sea walls support and ways to manage them.

Given the extensive length of sea walls around Essex, Suffolk and Norfolk, the case studies have a strong East Anglian focus. There are also case studies from other areas such as the Tees and Humber Estuaries in the north-east, Wyre and Dee Estuaries in the north-west, Torridge Estuary in the south-west, Solent and Pagham Harbour on the south coast and Medway Estuary in the south-east.

A complete list of the case studies is provided below for ease of reference:

- Barn Owl and Kestrel, Donna Nook, north Lincolnshire (Chapter 3)
- Great Green Bush-cricket on the sea walls of East Anglia (Chapter 3)
- Mammals on the Parkgate sea wall at high tide, Wirral Peninsula (Chapter 3)
- Wall butterflies at Bawdsey, Suffolk (Chapter 3)
- Rock Sea-lavender on the Wyre Estuary sea walls, Lancashire (Chapter 3)
- Mowing sea walls for Fisher's Estuarine Moth, Hamford Water, Essex (Chapter 4)
- Bee walls on the Hoo Peninsula, Kent (Chapter 4)
- Adaptive management, Pagham Harbour, Sussex (Chapter 4)
- Dingy Skipper butterflies on the Greenabella sea wall, Tees Estuary (Chapter 4)
- Creating suitable egg-laying sites for Grass Snakes (Chapter 5)
- Hadleigh Marsh borrow dyke and sea wall Local Wildlife Site, Essex (Chapter 5)
- Home Marsh Farm butterfly transects, Taw and Torridge Estuary, Devon (Chapter 5 and Chapter 9)
- Cutting trials at Brightlingsea and Orford sea walls, East Anglia (Chapter 5), The effect of mowing on reptiles, Brightlingsea, Essex (Chapter 5)
- The Natterjack Toad, Norfolk and Suffolk (Chapter 6)
- Oystercatcher eggs trampled on cattle grazed sea wall, Langenhoe, Essex (Chapter 6)
- Grazing on sea walls in Kent and Essex (Chapter 6)
- Impact of sward height on grasshoppers and bush-crickets (Orthoptera) of grazed sea walls in Essex (Chapter 6)
- Breeding birds on the Snodland sea wall, Medway Estuary, Kent (Chapter 7)
- Bumblebee usage of sea wall scrub as a foraging resource at Brightlingsea, Essex (Chapter 7)
- Compensatory planting of trees to offset scrub clearance on Essex sea walls (Chapter 7)

- Glow-worms at Creeksea, Essex (Chapter 7)
- Ground Penetrating Radar survey of Badger sett at Bradwell-on-Sea, Essex (Chapter 7)
- Response of Shrubby Sea-blite to cutting at Goldhanger, Essex (Chapter 7)
- Scrub management on Suffolk and Essex sea walls (Chapter 7)
- Surfacing of a public footpath on Wallasea Island, Essex (Chapter 8)
- Ploughing of sea wall folding (berm), Alresford, Essex (Chapter 8)
- Folding recovery after disturbance, Wallasea Island, Essex (Chapter 8)
- Breeding bird study on Essex sea walls (Chapter 9)
- Factors affecting scarce plant species on the sea walls of North Kent (Chapter 9)
- Larvae of the Sloe Carpet moth at Old Hall Marshes, Essex (Chapter 9)
- Bonners Barn reptile survey, the Strood near Peldon, Essex (Chapter 9)

Chapter 2: Scope

Introduction

For the purposes of this handbook, the generic term sea wall is used to cover any engineered flood defence earth embankment or retaining wall (other than sand dune defences) which fronts the open sea or tidal waters and is at least in part covered in vegetation. The handbook does not cover hard engineered raised structures with little or no natural vegetation for which a process guide already exists (Including Ecological Enhancements in the Planning, Design and Construction of Hard Coastal Structures, Naylor *et al*. 2011). For the design of wildlife features into hard coastal defences we refer the reader to this comprehensive document.

The handbook is relevant to all sea walls found along the coast or around the estuaries of England, the majority of which provide a standard of flood risk protection for what are predominantly rural areas. There is a strong east coast of England focus due to the long lengths of sea walls in this part of the country. Where possible, any differences in terms of the wildlife present or vegetation management techniques between east and west coast sea walls or north and south coast sea walls are identified, notably through case studies. These case studies are mostly written by those involved, to whom we are very grateful for their expertise and time.

The handbook concentrates on the day to day management of the vegetation on sea walls and does not specifically address issues that arise when capital works are proposed, such as the translocation of protected species or the creation of vegetation cover on newly constructed sea walls, guidance for which is available elsewhere, for example Baker *et al*. (2011), Britt *et al*. (2003), Crofts & Edgar *et al*. (2010), Day *et al*. (2003), Jefferson (1999) and Kirby 1992).

The habitats covered by the handbook are those found between the engineered toe on the seaward (strandline) face of a sea wall and the top of the near bank of any borrowdyke or field boundary on the landward side. It does not therefore cover any fronting saltmarsh which has its own handbook, the Saltmarsh Management Manual (Adnitt *et al*. 2007), freely available to download from http://publications.environment-agency.gov.uk/PDF/SCHO0307BMKH-E-E.pdf. It also does not directly cover the borrowdyke, the vegetation types of which are dealt with in the Drainage Channel Biodiversity Manual (Buisson *et al*. 2008), also freely available to download from http://publications.naturalengland.org.uk/publication/50004.

The sea wall complex

A typical sea wall (Figure 2.1) can be divided into four zones, namely:

- Seaward (outer) face;
- Crest;
- Landward (inner) face; and
- Folding (berm) comprising the generally flat, grassy area between the landward toe of the sea wall and the borrowdyke or field boundary on the landward side.

These terms are used consistently throughout this handbook to define these zones, which are defined as follows.

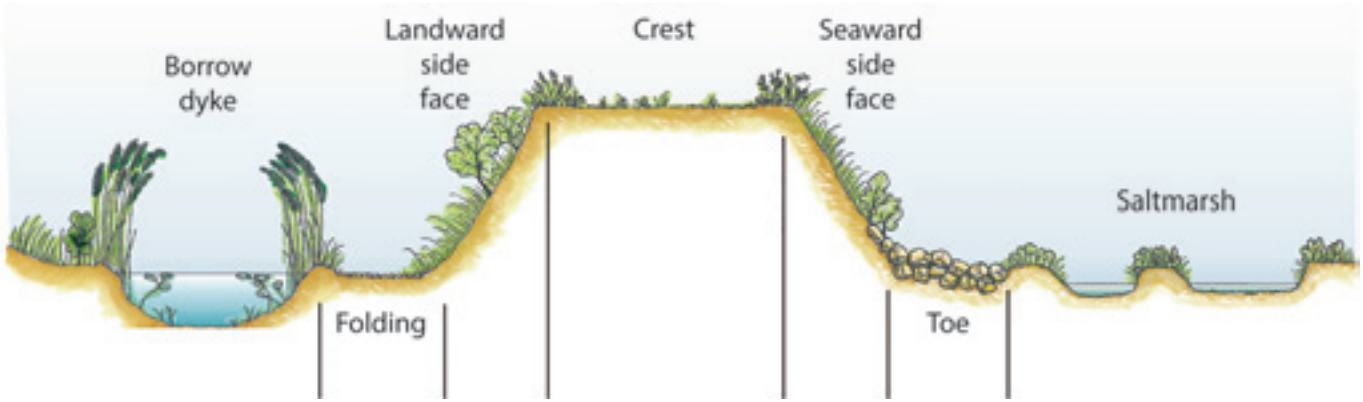


Figure 2.1: Cross-section of a typical sea wall

The seaward face

The seaward (or outer) face of a sea wall generally inclines at an angle of about 30° to the horizontal, though it can be steeper, as well as in places having a more gentle slope. It is usually exposed to salt spray and inundation on at least some high tides and often to within 1m of the crest on the highest spring tides.

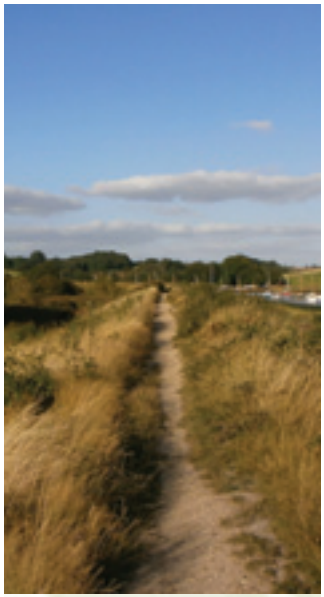
The seaward face is usually armoured with ragstone boulders or small square concrete blocks. Armouring is needed to protect the face of the sea wall against wave action, usually concrete blocks or open stone asphalt are used (for example 'Essex' blocks approx. 0.3 x 0.3 m) in walls of older design, or with solid concrete in walls of newer design. Armouring is surfacing (material additional to the earth embankment such as interlocking blocks or rip-rap (rock or other material used to armour shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour)) applied to the structure to protect it from the erosive power of flowing water or waves. The practice of armouring is generally used in areas prone to erosion in order to add extra resilience to the defence structure, absorbing the wave energy and if suitable, holding beach material. Larger blocks (known as 'Canewdon' blocks approx. 1 x 2.5 m) are sometimes used, particularly along the Essex coast. A variety of other kinds of outer surfacing are however to be found, e.g. bitumen or concrete skimming over or amongst ragstone boulders. Some walls have different facings at different levels. For example, many seaward faces with ragstone boulders or concrete-blockwork at the toe have a non-armoured earth surface in the upper 1m (the swash-bank).

△ Essex Blocks

▽ Canewdon Blocks

Vegetation on the seaward face can vary from the sparsest scattering of salt-tolerant ruderals in joints on concrete armoured sea walls and lichens on the hard surfaces, to dense grassy swards on earth-faced sea walls in places such as creek-heads where the flood risk management function is less critical. On older walls faced with small concrete blocks it is common for a dense root mat of creeping grasses, mainly Sea Couch *Elytrigia atherica* and Common Couch *Elytrigia repens*, to form over the blocks to depths as great as 30 cm.

Wave action and the deposition of flotsam may maintain low levels of disturbance in the swards that establish on the seaward faces of sea walls and a distinctive strandline community can develop. The vegetation is generally unmown, though may be subject to grazing or occasional herbicide treatment.



△ Sea wall crest

The crest

The crest of a sea wall is generally about 2-4m wide, and usually has a public footpath running along it which can be heavily used where close to towns or seldom used on more remote sections of sea wall though a certain amount of winter use by ornithologists occurs everywhere there is public access. A few walls also have cycle-paths along the crest.

The character of the vegetation on the crest is a reflection of factors including trampling which maintains different levels of disturbance along the edges of the paths, rutted areas created by occasional use by cycles and maintenance vehicles where saline conditions may become a dominant controlling factor as the crest is exposed to salt spray, and dog fouling which leads to localised eutrophic conditions.

The landward face

The landward (or inner) face of a vegetated sea wall is generally earth with a grassy sward which usually inclines at an angle of about 30º to the horizontal, though it can be steeper as well as having a more gentle slope in places. It is the least saline part of the wall, though there may still be some exposure to salt-spray. In the past the landward faces of many sea walls would have been grazed, but as this has become much rarer, most are now mown instead. The maximum permitted angle where mowing work can be undertaken depends on the machinery available. Where the work is being completed by standard agricultural specification tractors, slopes of up to 5% can be cut. However, machines purpose built for mowing slopes can handle slopes of up to 40%. Before mowing commences each section of defence needs to be assessed by an engineer or other competent person and where mowing is feasible, a safe system of work formulated.

△ Landward face

The folding

The folding (or berm) of vegetated sea walls is the relatively level area between the toe of the landward face and landward boundary of the sea wall. The latter is often marked by a borrowdyke or field boundary, though can also be a road or property. The folding generally supports a grassy sward, though there may be stands of scrub, especially along the landward boundary. There may also be a non-surfaced track used by farm or maintenance vehicles, which can be heavily rutted in places. These, and other wet places may be subject to saline influences due to the accumulation of salt-spray, occasional over-topping or seepage of saltwater through (or under) the sea wall. Some tracks have semi-hard surfaces of one kind or another.

△ Folding

▽ Bee Orchids

Most foldings are mown at least once a year, usually in late July or August to prevent scrub encroachment and to maintain a grass sward. The folding or berm is in some instances critical to the stability and long-term resilience of sea walls as it is the footing on which the wall sits. For example, the landward slope can be unstable and susceptible to slippage into the borrowdyke where a folding is absent due to the lack of support it provides. Some sea walls have two foldings, for example, the large flood defences on Canvey Island in Essex, where there is an upper berm (intermediate) halfway up the landward slope as well as a lower berm which acts as a conventional folding. The upper berm is critical to the structural integrity of the flood defence in these instances, whereas, the lower one is less so. All usage of the term folding in this handbook is to the lower berm unless specific mention is made to the upper berm.

The lower folding is often the least important zone of the sea wall from a flood risk management perspective, particularly as many are quite wide (approximately 30 m), exceeding the necessary width required to act as a foundation for the defence. Whereas, the crest and landward face are critically important should there be an overtopping event the folding is generally not critical to the structural integrity of a sea wall, but rather provides an easy means of access for machinery along a sea wall. Consequently, the folding often offers the most significant opportunities to manage a sea wall in a more wildlife friendly way.

Structure of this handbook

For ease of reading, this handbook has been divided into chapters covering different aspects of sea wall vegetation management.

Chapter 3 summarises the evidence that vegetated sea walls can be of ecological interest, with an emphasis on the protected or otherwise notable species of plants, invertebrates, amphibians, reptiles, breeding and wintering birds and mammals that sea walls around the coasts and estuaries of England have been found to support.

Chapter 4 delves into the often complex task of deciding the best way forward in relation to sea wall vegetation management in the face of pressing and sometimes apparently conflicting demands. It outlines the main drivers for management, including maintenance of flood risk standards and the need to comply with legislation and statutory duties. It considers the importance of carefully planning and then adopting integrated vegetation management programmes, and shows the clear benefits of ensuring those who have an interest in how sea walls are managed having the opportunity to constructively engage in the decision making process. The chapter also considers sources of information and the need to take an evidence based approach to setting clear, achievable objectives. The chapter concludes with a framework setting out some simple principles in relation to sea wall vegetation management for integrating the requirements of flood risk management and nature conservation with other objectives such as public access and safety.

Chapters 5, 6 and 7 cover managing sea wall vegetation through the principle techniques of mowing, grazing and scrub control. For completeness, this is followed by a roundup of other management techniques available (Chapter 8). Using relevant case studies and published evidence, each of these management chapters profiles how the wildlife communities found on sea walls respond to each technique. They outline the responses of plants, invertebrates, amphibians, reptiles, nesting birds and mammals. These chapters also provide details of best management practices to achieve the required growth characteristics of the grassland. A summary of key principles is provided at the end of each chapter in the form of bullet points for ease of usage by those who do not wish or do not have the time to read the entire chapter.

Chapter 5 on mowing, the first of these management chapters, provides practical advice on the mowing techniques required to maintain a grassland sward on sea walls from a flood risk management perspective. Best practice is presented for offsetting the impacts of mowing on wildlife, such as leaving part of the folding uncut during summer mowing and adopting a rotational management programme whereby different sections of a sea wall are mown at different times. Consideration is also given to specific regimes such as hay cutting undertaken on a limited number of sea walls which has the added benefit of removing cuttings.

Although somewhat less well studied, Chapter 6 covers what is known about the effects of grazing on the wildlife communities of sea walls. By reference to case studies in Kent, Essex and Suffolk it explores species richness of sea walls in response to grazing. Due to the limited direct evidence, the ecological implications of grazing on vegetated sea walls are gleaned from more general studies where necessary. The options available for grazing are considered and general mention made to the preference for sheep grazing over cattle grazing from a flood risk management perspective (because cattle can lead to damage to sea walls by excessive poaching).

Chapter 7 provides a synthesis of the available information on managing scrub on sea walls. The focus is on reducing or removing scrub to enable the proper inspection of sea wall condition and to help maintain their structural integrity. A range of techniques is described, including manual and mechanical cutting, flailing of scrub margins, browsing and stump management, along with a review of their advantages and limitations in relation to sea walls. Detail is provided on the response of wildlife to scrub management, giving particular attention to species of conservation importance such as Shrubby Sea-blite *Suaeda vera*. Brief consideration is also given to the benefits of compensatory planting to offset impacts where scrub is removed.

Chapter 8 covers a range of other techniques for managing sea wall vegetation. Particular attention is given to herbicides and the targeted removal of undesirable species, as well as the circumstances in which such techniques may be used. This chapter also covers the issue of what to do with excess cut vegetation.

Chapter 9 considers the importance of conducting ecological surveys and monitoring the effects of vegetation management. Some of the more common survey and monitoring techniques that can be employed to record key indicator species of flora and fauna are described, together with how these may best be applied to sea walls. As with the other chapters of this handbook, this is supported by case studies discussing the results of specific surveys and monitoring programmes related to the management of sea wall vegetation. This chapter also covers aspects such as the benefits of monitoring, targeting key species and the need for the results to be passed on to the county recorder, Local Record Centres (LRCs) and local or national recording scheme where one exists.

Further reading

By its very nature, this handbook only provides brief details on each of the management techniques available. For more detailed information, readers are recommended to refer to the following (see References section for full details):

The Drainage Channel Biodiversity Manual: Integrating Wildlife and Flood Risk Management (Buisson *et al*. 2008)

The lowland grassland management handbook (Crofts & Jefferson, 1999).

Habitat management for invertebrates: a practical handbook (Kirby, 1992).

The scrub management handbook (Day *et al*., 2003).

Amphibian habitat management handbook (Baker *et al*., 2011).

Reptile habitat management handbook (Edgar *et al*., 2010).

The herbicide handbook (Britt *et al*., 2003).

The saltmarsh management manual (Adnitt *et al*. 2007)

Chapter 3: Wildlife interest

Introduction

Sea walls offer a mosaic of habitats which can support a diverse range of wildlife. For example, in a desk based study of wildlife records related to the sea walls of north Norfolk and the Suffolk estuaries (Pilcher & Graham 2011), 31 key species were found to be associated with sea wall habitats. These comprised nine plants, ten invertebrates, two amphibians, two reptiles, one mammal, three breeding birds and four foraging birds. These species all receive some degree of legal protection and/or had a nature conservation status. This included species protected under the Wildlife and Countryside Act 1981 (as amended), European Protected Species, citation species for Ramsar sites, species listed as being of importance under the Natural Environment and Rural Communities (NERC) Act 2006, UK and local Biodiversity Action Plan (BAP) species and species considered nationally rare.

Vegetated sea walls form very long corridors of predominantly grassland habitat in many of the coastal counties of England. In some places, such as the the Greater Thames Estuary, the approximately 805 km of vegetated sea walls represent one of the last expanses of grassland habitat in south-east England, known to support a wide range of uncommon plants and animals. Whilst this may be self evident on sea walls in predominantly rural areas, it equally applies to sea walls in more developed areas. The sea wall beside the old ICI works at Fleetwood on the Wyre Estuary, Lancashire, for example supports an interesting flora, including some limestone specialists such as Bee Orchid *Ophrys apifera*, Northern Marsh Orchid *Dactylorhiza purpurella* and Yellow-wort *Blackstonia perfoliata*. Sea walls can interact strongly with adjacent ditches, lagoons, saltmarsh, pasture and previously developed habitats, thereby increasing the capacity of the landscape to support biodiversity, especially where the ecological requirements of a species require several habitats (Falk personal communication).

Despite their ecological value, there appear relatively few scientific studies of the wildlife found on sea walls. Those studies which have been conducted and have revealed notable populations of plants, invertebrates, amphibians, reptiles, birds and mammals are used in the following review. However, there is a lot of unpublished and informally published data (particularly biological records collected by the UK's impressive network of amateur recorders) which is vital for understanding sea walls (Falk personal communication).

Higher plants

Vegetated sea walls generally support unimproved neutral grassland. In the absence of frequent mowing, and with relatively little grazing, such sea walls are often characterised by tall swards of coarse grasses, such as False Oat-grass *Arrhenatherum elatius*, Sea Couch and Cock's-foot *Dactylis glomerata*. Dry neutral grassland was for example found to be common on the sea walls of the Severn Estuary in Somerset, North Somerset and Bristol where they were also associated with Red Fescue *Festuca rubra* (Dargie 1999). Although growing on artificial structures, such grassland communities represent unimproved grassland (i.e. they have not been ploughed, subject to fertiliser applications or treated with herbicides). Such unimproved grasslands are now generally uncommon and those found on sea walls can provide an important wildlife resource, especially in urban areas or intensively farmed landscapes. In addition, they often form a continuous linear corridor of habitat that allows species to disperse both along and between otherwise isolated sites (Gibson 2000).

Whilst many sea walls are characterised by species-poor swards of tall grasses, in places they can support a more distinctive flora. For example the sea walls of the Humber Estuary support species at the northern edge of their British range such as Stone Parsley *Sison amomum* (an acid–neutral grassland indicator) and Narrow-leaved Bird's-foot-trefoil *Lotus glaber* (East Riding of Yorkshire Council 2010). Similarly, the rare Sand Lucerne *Medicago sativa* subspecies *varia* with its different coloured flowers on the same plant has persisted on the sea wall of Paulsgrove Lake, Havant, for at least ten years.

▽ Footpath on sea wall crest

Different plant communities can develop in the different habitat zones of a sea wall. The edges of borrowdykes, trackways, small depressions, percolation pools on the folding, and small "salty" runnels at the bottom of the landward side slope of sea walls can support species more typical of saltmarshes, especially where subject to saline intrusion, salt spray or historical flooding during an over-topping event. These include Spear-leaved Orache *Atriplex prostrata*, Grass-leaved Orache *Atriplex littoralis*, Sea Aster *Aster tripolium*, Annual Sea-blite *Suaeda maritima*, Lesser Sea-spurrey *Spergularia marina*, Sea-milkwort *Lysimachia maritima*, Saltmarsh Rush *Juncus gerardii* and glassworts covering *Salicornia* and *Sarcocornia* species which are well recognised as a very difficult genus to separate (e.g. Dalby 1989, Ingrouille 1989 and Rose 1989). Purple Glasswort *Salicornia ramosissima* is one of the more widespread species of glasswort and often most conspicuous in brackish hollows behind sea walls, such as those at Hayling and Keyhaven and Pennington Marshes in Hampshire (Hampshire & Isle of Wight Wildlife Trust 2010).

The Nationally Scarce perennial grass Bulbous Foxtail *Alopecurus bulbosus* is restricted to coastal grasslands around the Severn Estuary and along the south coast of England. It is usually found in damp brackish turf, winter-wet hollows along the edges of borrowdykes and trampled cattle droves at the base of sea walls. It can tolerate quite high levels of salinity but is a species of brackish grasslands as opposed to being a saltmarsh plant. From work on a former flooded marsh in Suffolk, this species has been shown to have two quite short growth periods, in the autumn to start new leaves, and for about 100 days between mid-April and July to flower and seed (Trist 1981). The rest of the time it is dormant and an inconspicuous species that is at risk from habitat change.

△ Saline ruts on folding

The Somerset Rare Plants Group has been monitoring the population of Pennyroyal *Mentha pulegium* at Pawlett Hams, Bridgwater, for over 15 years (Somerset Rare Plants Group 2007). This species, which is associated with seasonally wet habitats, is not native here; but was apparently accidentally introduced by the Environment Agency in a seed mix used on a new sea wall. Many thousands of plants have been found, mainly along the edge of a drainage ditch with a few plants scattered in the grassland and on the sea wall. Despite having been lost from many sites across Britain, this short-lived perennial plant is doing well here and appears to be spreading.

An Essex sea wall survey (Eco Surveys 1990) underlined the value of the sea wall folding for vascular plants of conservation concern, including Nationally Scarce BAP species such as Sea Barley *Hordeum marinum*, Slender Hare's-ear *Bupleurum tenuissimum* and Sea Clover *Trifolium squamosum*.

Sea Barley is a small, free-flowering and strictly annual grass that is easily overlooked. Reproduction is entirely from seed, with seedlings developing in spring and autumn, though the latter may not survive the winter. This species seems to prefer brackish ground that is wet in winter, or in the spray zone, but dry and bare in summer. As a result, it principally occurs on the trampled margins of dried-up pools and ditches in coastal grazing marshes, on tracks, on sea walls, and notably in the upper transitional zone of saltmarshes. Narrow bands of this species can mark tide-lines on estuaries, including the seaward toe of sea walls, as well as winter flood-lines around pools. Sea Barley is found with Dittander *Lepidium latifolium* in the drier areas of the Sea Couch dominated vegetation characteristic of the drift line along the Severn Estuary (Dargie 1998).

Whilst found along the south and east coasts of Britain around the Severn Estuary and locally elsewhere in lowland areas such as beside salt-treated roads, Sea Barley appears to have decreased its distribution in recent years. This is probably the result of the conversion of coastal grazing marsh to arable farmland, infilling of pools and ditches, strengthening and upgrading of sea walls and cessation or reduction in those management activities which result in the creation of open ground. Sea Barley requires a short, open and disturbed environment to survive and is therefore susceptible to successional changes, tending to be overpowered by perennial grasses (notably Sea Couch). Locally, the cessation of traditional coastal grazing is one of the principal factors in its decline.

Slender Hare's-ear is a late-flowering (generally July to September), rather inconspicuous small annual which is primarily a colonist of dry, thinly vegetated or disturbed coastal sites in southern England. This includes grazing marshes, margins of brackish ditches, coastal banks, sea walls and less frequently the upper zone of saltmarsh. It typically occurs in short turf with plenty of bare ground, and can be locally abundant in disturbed areas, for example areas subject to poaching by livestock and along the sides of trackways and footpaths where the ground is open enough for seeds to germinate. The seed of Slender Hare's-ear germinates in autumn and spring, and the fact that plants normally grow in open situations suggests that bare ground is important for germination and successful seedling establishment.

▽ Sea Barley

Many Slender Hare's-ear populations are now closely associated with sea walls as shown by the national distribution of the species (Biological Records Centre 2012) and are therefore at risk from inappropriate management regimes. This species has disappeared from almost all its inland stations as well as some coastal sites, particularly towards the northern edge of its range. Open ground and hence frequent disturbance required for Slender Hare's-ear to survive has traditionally been provided by cattle or sheep grazing. In its absence, this species is quickly out-competed by taller vigorous species, typically by Sea Couch (JNCC 2012). To maintain, or enhance, the presence of this species, sympathetic management involving light mowing and occasional disturbance has been identified as necessary to control the Sea Couch sward (Mountford *et al*. 2006).

On sea walls, **Sea Clover** is similarly often restricted to disturbed ground of the access tracks and footpaths. Without this regular disturbance it struggles to compete against the coarser, aggressive grasses found on other parts of sea walls, such as False Oat-grass and Sea Couch. Regular vehicular disturbance on the folding and trampling by walkers on the crest of sea walls may be important in maintaining the diversity of plant species.

The landward slope of sea walls typically supports a similar tall grassland sward to the folding but with a greater number of tall herbs including Hemlock *Conium maculatum*, Alexanders *Smyrnium olusatrum*, Prickly Sow-thistle *Sonchus asper*, Black Horehound *Ballota nigra*, Cow Parsley *Anthriscus sylvestris*, Black Mustard *Brassica nigra*, Curled Dock *Rumex crispus*, Bristly Oxtongue *Picris echioides*, Common Ragwort

Senecio jacobaea, Great Lettuce *Lactuca virosa* and more interesting plants such as Grass Vetchling *Lathyrus nissolia*. Sea Clover is a native annual of open and often disturbed grasslands in mostly central and southern England, particularly grassy banks, roadside verges, coastal grasslands and sea walls such as those around the Greater Thames Estuary (English Nature 1997).

Sea walls can also be important for plants representative of unimproved grassland such as Rough Clover *Trifolium scarbrum* which is found locally around the coast, including on sea walls, such as the inner slope of a sea wall at Langstone in Hampshire in 2011. Other notable species that can locally be found within the grasslands that occur on sea walls include Dittander, Hog's Fennel *Peucedanum officinale*, Borrer's Saltmarsh-grass *Puccinellia fasciculata* and Least Lettuce *Lactuca saligna*.

△ Dittander

Dittander is a tall (up to 1.5 m), patch-forming, tough and robust rhizomatous perennial herb, native on the coast of East Anglia, Kent and the Severn Estuary where it occurs in habitats such as marshy grassland and the upper fringes of estuarine saltmarshes. It is less frequently found on sea walls where it persists in the tall grassland due to its size and persistent rhizomes. This species principally spreads by rhizomatous growth as seeds ripen only in warm years. Dittander would appear to be maintaining its numbers in the south-east of England and increasing inland where it can become naturalised in ruderal habitats such as disturbed road verges associated with salt run-off.

Hog's Fennel is a robust perennial principally confined to coastal grassland, though it can be found in the upper saltmarsh, mainly restricted to two stretches of coast: the north Kent coast from Faversham Creek to Reculver and north-east Essex which is estimated to hold 60% of the total British population, having risen from around 30% in the 1970s. A full account of the ecology of Hog's Fennel is presented by Randall & Thornton (1996). Most plants are found on sea walls and brackish grazing marsh (Biological Records Centre 2012) with the overwhelming majority of plants growing within 15 m of brackish or salt water and entirely on heavy London Clay soils with a pH between 5.5 and 8.0. Flowering is usually between July and September, with high summer temperatures apparently required for seeds to ripen fully. Even when seeds do ripen, germination is often rather patchy, being best where the sward is open and contains bare ground. Germination success has been found to vary with ground cover conditions with no seedling establishment in an uncut grass sward (Blyth, 1987). As a result, it is thought this species largely relies on spreading through rhizomatous growth. Hog's Fennel is listed in the Red Data Book (RDB) as Lower Risk, Near Threatened, though some doubt has been cast upon whether it is truly a native species. This is due to its distribution possibly reflecting planting in response to the former use of its roots as a stimulant resin (Tutin 1980) and as fodder for pigs. However, Britain may equally be a natural outlier of the otherwise predominantly continental distribution of this species.

Hog's Fennel is the sole larval food plant for two nationally rare moths, a micromoth *Agonopterix putridella* and the vulnerable Fisher's Estuarine Moth *Gortyna borelii lunata*.

Whilst its persistent rhizomes and size mean Hog's Fennel can survive in the tall, uncut grassland of sea walls, it is likely to benefit from some mowing either bi-annually or annually. Such occasional reduction in top growth may result in development of a vigorous root system, but the effects of long term mowing do not appear to have been studied. Harvey & Meredith (1981) suggested mowing the closely related Milk Parsley *Peucedanum palustre* on road verges in May allowed plants to reach flowering in August and then set viable seed. Mowing in June or July resulted in rapid regrowth and late-August or early-September flowering. However, in such circumstances viable seed was rarely produced. Unsympathetic mowing has therefore been identified as one of the threats to the conservation of this species.

Borrer's Saltmarsh-grass is a short-lived perennial grass that flowers in July and August and spreads only by seed. It is predominantly found around the grazing marshes and sea walls of southern England, notably in Kent and Essex and along the Solent, as well as on a few sites on the Severn Estuary and in north Norfolk such as Thornham, Brancaster and Cley-next-the-Sea. As an early coloniser of muddy ground, disturbance through de-silting of ditches, cattle-poaching and passage of vehicles often govern where it occurs. In the absence of disturbance, this species is quickly out-competed by taller, more vigorous plant species, typically by Sea Couch (JNCC 2012). Local populations may therefore disappear for several years but become re-established from buried seed when the ground is disturbed and bare patches become present again.

▽ Hog's Fennel

Least Lettuce is an autumn or spring-germinating annual listed in the Red Data Book and protected under Schedule 8 of the Wildlife and Countryside Act 1981 (as amended). It grows on sparsely vegetated, disturbed sandy shingle and old sea walls. It has suffered a severe decline in its distribution as a result of sea wall refurbishment, notably following the 1953 coastal flood of south and east England. It is now largely confined in the wild to two sites: a sea wall at Fobbing on the north side of the Thames Estuary in Essex where it benefits from cattle grazing and Rye Harbour in Sussex. At one time, the sea wall at Fobbing supported 99% of the total national population of Least Lettuce (English Nature 1997). It can however re-appear at former sites following disturbance, for example being re-found on the Isle of Grain in north Kent in 1999.

In a review of ecological data related to the sea walls, Pilcher & Graham (2011) found that over 90% of the sea walls of north Norfolk and the Suffolk estuaries had public access along the crest and as such were subject to trampling to a greater or lesser extent. The sea walls of north Norfolk for example formed part of the Peddars Way and Norfolk Coast path while those along the west bank of the Alde-Ore Estuary formed part of the Suffolk Coast and Heaths path.

Regular trampling accompanied by occasional mowing to keep the footpaths passable can result in the crests of sea walls supporting a short (less than 10 cm) grassland sward dominated by species such as White Clover *Trifolium repens* and fine-leaved grasses such as Perennial Rye-grass *Lolium perenne*, Red Fescue and Creeping Bent *Agrostis stolonifera.* Locally, these swards can become more herb-rich including species such as Tufted Vetch *Vicia cracca*, Daisy *Bellis perennis*, Common Cat's-ear *Hypochaeris radicata*, Smooth Tare *Vicia tetrasperma*, Common Knapweed *Centaurea nigra*, Hoary Ragwort *Senecio erucifolius*, Red Clover *Trifolium pratense*, Ribwort Plantain *Plantago lanceolata*, Common Bird's-foot-trefoil *Lotus corniculatus*, Lesser Trefoil *Trifolium dubium*, Black Medick *Medicago lupulina* and Spotted Medick *Medicago arabica*.

The vegetation of a sea wall on the Exe Estuary in Devon locally supports herb rich, semi-improved neutral grassland (Andrew McCarthy Associates 2006). Grass species present included Crested Dog's-tail *Cynosurus cristatus*, which likes fairly well-drained soils and does not tolerate water-logging very well, Common Bent *Agrostis capillaris*, Smaller Cat's-tail *Phleum bertolonii a*nd Perennial Rye-grass. Herbs included Common Cat's-ear, Common Bird's-foot-trefoil, Common Vetch *Vicia sativa*, Smooth Hawk's-beard *Crepis capillaris*, Selfheal *Prunella vulgaris*, Creeping Cinquefoil *Potentilla reptans*, Ribwort Plantain, Lesser Trefoil, Yarrow *Achillea millefolium* and Water-dropwort species *Oenanthe* species.

Similarly herb rich grasslands can locally develop on sea walls where these are subject to either sheep or cattle grazing, provided this is neither too light nor too heavy. Perennial Rye-grass mesotrophic grassland was also found to be the commonest form of cover on grazed sea walls on the Severn Estuary in Somerset, North Somerset, Bristol and Gloucestershire (Dargie 1998). Elsewhere, more local species can occur on disturbed areas of sea walls. Knotted Hedge-parsley *Torilis nodosa*, for example, is locally frequent in Suffolk on the Alde Estuary sea wall above Aldeburgh and along the sea wall on the right bank of the Deben Estuary, north of Waldringfield (Pilcher & Graham 2011).

The botanical interest of the Wells sea wall in Norfolk which runs for a mile due north from the Quay alongside Beach Road, has long been recognised, but in 2011 was enhanced by the early spring drought leading to a profusion of deep-rooted flowering plants at the expense of grasses and smaller herbs (Moore 2011). Particularly apparent was the parasitic Common Broomrape *Orobanche minor,* which evidently avoided water stress by relying on the root systems of its hosts, which can include Common Bird's-foot-trefoil, clovers and members of the daisy family.

Older walls that have sandy as opposed to compacted clay crest substrates can support leached, mildly acidic grassland with species such as Sheep's Sorrel *Rumex acetosella*, Sweet Vernal-grass *Anthoxanthum odoratum*, Heath Groundsel *Senecio sylvaticus* and Common Mouse-ear *Cerastium fontanum*.

Whilst the crest of sea walls is often affected by vehicular usage or trampling from pedestrians resulting in some bare ground, the vegetation of the seaward slope tends to be more indicative of saline influence. This is typified by the sward of many seaward slopes of sea walls being dominated by Sea Couch with occasional herbs such as Sea Beet *Beta vulgaris* subspecies *maritima*. Sea Beet is tolerant of mowing and historically it was used as a cut and come vegetable that can be harvested and will then sprout (come) again. Such a community dominated the seaward slope of the older sea walls in the middle reaches of the Alde Estuary in Suffolk for example (Guthrie & Cottle 2002).

A habitat survey of approximately 150 m of a 1.5 – 2.0 m high earth sea wall on the River Tamar in Devon found that in addition to Sea Beet, the seaward face of the sea wall supported Old Man's Beard *Clematis vitalba* and Scentless Mayweed *Tripleurospermum inodorum*, with Sea Campion *Silene uniflora* nearer the toe (Street 2011). The seaward slope of the sea wall on the Humber Estuary at Easington similarly indicated a saline influence through the presence of not only Sea Couch, but also Greater Sea-spurrey *Spergularia media*, Grass-leaved Orache, Sea Plantain *Plantago maritima*, Buck's-horn Plantain *Plantago coronopus* and Sea-purslane *Atriplex portulacoides* at the toe (ADAS Consulting 1998).

Although the drift line along the toe of the seaward slope of sea walls is frequently dominated by Sea Couch (often extending from the seaward slope above), saltmarsh plant species can be common in places. Notable species characteristic of this fringe zone include Reflexed Saltmarsh-grass *Puccinellia distans*, Golden-samphire *Inula crithmoides*, Rock Sea-lavenders *Limonium binervosum* aggregate, Sea Purslane and Shrubby Sea-blite.

Reflexed Saltmarsh-grass tends to favour compacted, poorly-drained, heavy soils in saline areas along the coast (Preston *et al*. 2002) and has been reported growing at the foot of the new sea wall at Paull Holme Strays on the south side of the Humber (Brown & Garbutt 2004).

Golden-samphire is a relatively tall, robust and long-lived perennial plant that grows in two distinct types of coastal habitat: sea-cliffs, such as those in Kent and west of Purbeck on the south coast of England, it grows on ledges, in crevices and in open turf on calcareous or base-rich soils, and elsewhere in southern England in the uppermost zone of saltmarsh, on shingle ridges and along the drift line at the seaward toe of sea walls which adjoin areas of saltmarsh or shingle (Biological Records Centre 2012). In south-east England, it is mainly restricted to the Solent, west Sussex, the Thames Estuary and Essex, with the Orwell Estuary in Suffolk being the northern limit of this species on the east coast of England.

Rock Sea-lavender species endemic to Britain (i.e. found growing wild nowhere else in the world) all belong to the *Limonium binervosum* aggregate. The taxonomy of this group was revised in 1986 and nine species (some of which are split into subspecies) are now recognised, of which eight are believed to be endemic to Britain.

As the name implies, all Rock Sea-lavenders grow almost exclusively on rocks, along the seaward toe of sea walls and on sea cliffs, although a few have also been recorded from other habitats. All known colonies of the endemic species are confined to a few scattered localities along the west coasts of England and Wales between Dorset and Cumbria, with different species predominating on different stretches of coast. Whilst there is limited evidence that any *Limonium* species or subspecies have declined significantly, conservation action is proposed in a number of local BAPs because of their endemic status, relatively small numbers and because local populations may be at risk from activities such as flood risk management and recreation through trampling. Of the endemic species and sub-species, nine are classified as vulnerable and the other six as near threatened in the British Red Data Book (Wiggington 1999). Whilst they all receive general protection under the Wildlife and Countryside Act 1981 (as amended), none receives the additional protection by being listed on Schedule 8. The Act Section 13 identifies measures for the protection of wild plants prohibiting the unauthorised intentional uprooting of any wild plant species and forbidding any picking, uprooting or destruction of plants listed on Schedule 8. It also prohibits the sale, or possession for the purpose of sale of any plants on Schedule 8.

Case Study

Rock Sea-lavender on the Wyre Estuary sea walls, Lancashire

The UK BAP species Rock Sea-lavender *Limonium britanicum* subspecies *celticum* is confined to coastal sites in north Wales, Cheshire, Lancashire and Cumbria. It is Nationally Rare (i.e. known from 15 or fewer 10-km squares) as it is recorded in only three 10-km squares. Four subspecies have been distinguished, all of which are listed in the British Red Data Book as Near Threatened (Wiggington 1999). *Limonium britanicum* subspecies *celticum*, first collected in the county at Staynall on the east side of the Wyre Estuary in 1843 (Smith & Greenwood 2009), was subsequently identified at scattered localities around both the Wyre and Lune estuaries on drier areas of intertidal mud and the upper parts of saltmarshes. More recently in Lancashire, it has only been recorded from the stone pitched revetments of the seaward slopes of the sea wall and stabilised muddy shingle at the toe of the wall along the eastern side of the Wyre Estuary. Here, there are two colonies within 1 km of each other, one at Arm Hill (Barnaby Sands) and the other at Knott End on Sea, comprising a total of 1,300 plants (Halcrow 2011). A former colony some 5 km further upstream had only a single surviving plant in 1999.

The species is the subject of a Species Action Plan in the Lancashire BAP (Jepson 2001). Potential threats include inappropriate maintenance of sea walls, development, pollution and competition from other vegetation. The old Victorian stone faced sea walls around the Wyre Estuary on which the plant grows were also noted as subject to erosion and/or a rise in sea level. As a result, the

effects on the Rock Sea-lavender population need to be carefully monitored. Surveys of suitable habitats for this species were carried out along both shores of the Wyre Estuary SSSI in 2003 (Harwood 2003). Populations were found adjacent to the saltmarsh south of Hackensall Brows (230 clumps), the western flank of Arm Hill (40 clumps on the shingle and 600 clumps on the sea wall), and on the causeway running between the ridge off the south-western corner of the Preesall Wastewater Treatment Works and the start of the ridge leading to Arm Hill (40 rosettes). With limited data available from more recent studies it is difficult to assess what, if any, effects the threats identified have actually had on the colonies of *Limonium britanicum* subspecies *celticum* around the Wyre Estuary (Halcrow 2011). It was however noted in the Natural England Wyre Estuary SSSI condition monitoring assessment in November 2010 (Natural England 2012) that the outer sea wall of Arm Hill supported a particularly species rich calcareous grassland community and that the Rock Sea-lavender colony was still thriving at this location with plants present along the extent of the sea wall.

Sea-purslane is a low, clump-forming shrub of saltmarshes, commonly fringing intertidal pools and creeks, or as a fringe in the upper saltmarsh, including along the toe of sea walls, especially where these adjoin areas of saltmarsh or where transition zones are restricted to a zone near the foot of sea walls. Although a member of the goosefoot family, it is a perennial and in ungrazed areas can develop into extensive, dense stands with bare or almost bare ground beneath. This species is likely to be outcompeted by vigorous stands of Sea Couch and may therefore benefit from a mowing regime which reduces the vigour of Sea Couch and creates a shorter and more open sward. Although not monitored, casual observations during a trial to assess the response of Shrubby Sea-blite to flail mowing (cutting) in Essex suggested that damage to other notable species such as Sea-purslane on the front face of the sea wall was mostly avoided with this species re-growing quite vigorously after cutting (Gardiner 2011b).

Sea-purslane is the principle food plant of the larvae of certain species of insects including the moths Sea-purslane Case-bearer *Coleophora salinella* and Saltern Groundling *Scrobipalpa instabilella*, which are both locally common along the sea walls of Suffolk for example.

Shrubby Sea-blite is a robust, evergreen shrub reaching almost 1 m in height, more typically found in the Mediterranean. In the UK, it is a Nationally Scarce species restricted to coastal localities in southern and eastern England (Gardiner 2011b) where it tends to grow on the drier, upper zones of saltmarshes, sand-dunes and shingle banks and regularly occurs on the seaward toe of the sea wall where it can form a distinct linear community. This species has probably always been scarce and its distribution appears to have changed little in recent times, with relatively few cases of the species having been lost from sites. Its northern limit on the east coast does however appear to have moved several times (Gibbons 1975, Boorman 2003). Large stands are mainly restricted to the counties of Norfolk, Suffolk and Essex, and the south coasts of Dorset and Kent.

Bryophytes

△ Shrubby Sea-blite

There are a variety of habitat niches found on sea walls that are exploited by mosses and liverworts (bryophytes). Heim's Pottia *Hennediella heimii*, an attractive moss with chocolate-coloured capsules, occurs in a wide range of coastal habitats including behind sea walls, on grazed turf, the banks of dykes and on footpaths (Purley & Hodgetts 2005). Concrete structures are colonised by various species with the most salt tolerant, such as Seaside Grimmia *Schistidium maritimum* and Frizzled Pincushion *Ulota phyllantha*, on the seaward side probably on the lower sections of the wall, with other common *calcicolous* species (any plant that thrives in calcareous soil) such as Wall Screw-moss *Tortula muralis* and Grey-cushioned Grimmia *Grimmia pulvinata* much higher up. Blackthorn *Prunus spinosa* is usually poor for epiphytes but Blackthorn scrub on shingle at Dungeness supports Pendulous Wing-moss *Antitrichia curtipendula*. Such relatively unusual species may also grow on other shrub species on sea walls. Elder *Sambucus nigra* shrubs which can occur on sea walls are pre-eminent for epiphytic bryophytes in many lowland habitats (Purley and Hodgetts 2005).

More investigation is required of the mosses and liverworts of sea walls as relatively little attention has been paid to them.

Fungi

Although there are few studies of the fungi to be found on sea walls, they may have value for characteristic grassland species such as waxcaps. Waxcaps are bright and shiny members of the genus *Hygrocybe* which are seen in the autumn. Waxcaps are generally found in unimproved grassland, which has never been ploughed or had inorganic fertilisers applied, and are a good indicator of this habitat. So far the limited surveying of fungi on sea walls makes it hard to ascertain how important they are for waxcaps, but one species, *Hygrocybe conica* var. *conica,* a member of Witch's Hat, has been recorded on a sea wall on the Dengie Peninsula in Essex (Boniface 2004). Research suggests that one to three species of waxcap indicate that grassland is of limited importance for them. This suggests that the Dengie sea wall is not especially valuable for waxcaps in either a regional or national context.

Other more common species of fungi such as the Giant Puffball *Calvatia gigantea*, Shaggy Parasol *Chlorophyllum rhacodes* and the Yellow Fieldcap *Bolbitius titubans* have been recorded on sea walls in the south-east of England. Further surveying is needed to assess the value of sea walls for fungi throughout the UK.

Puccinia bupleuri is a rust of Slender Hare's-ear which is only recorded from a handful of sites in Britain.

Invertebrates

The mosaic of habitats and microhabitats provided by sea walls supports a wide range of insects and other invertebrate species, a number of which are Red Data Book and UK BAP species. Invertebrates are also increasingly recognised as providing vital ecological services such as pollination. Invertebrates often make interesting demands on sea walls and the habitats that surround them as a result of the varying demands of early and adult stages, plus the complex and often mobile behaviour of adults (Falk personal communication). As such, the resources offered by sea walls may provide a critical yet incomplete set of requirements for some species, or all the requirements for others. Sea walls may provide flowers for flies breeding in ditches and for bumblebees, prey for dragonflies breeding in ditches, or nesting habitat for solitary bees foraging on saltmarsh or flowery ditch margins. The shelter and insolation provided by sea walls can also make adjacent habitats more favourable for some species, especially thermophilic insects (insects an organism that thrive under warm conditions) that struggle in exposed conditions.

This section focuses on a range of insects and other invertebrates which demonstrate the complexity of their ecology which can vary both from group to group and within a group, and from species to species. This in turn provides challenges when trying to decide on the management that is most appropriate for sea walls.

Whilst there is considerable information about some groups of invertebrates, e.g. bumblebees and grasshoppers and bush-crickets (Orthoptera), our knowledge of other taxa such as beetles (Coleoptera) and bugs (Hemiptera) is more limited. For example, there may be more types of fly on sea walls than any other group of invertebrates. Easily accessible published information on these groups may be scarce but unpublished data do exist.

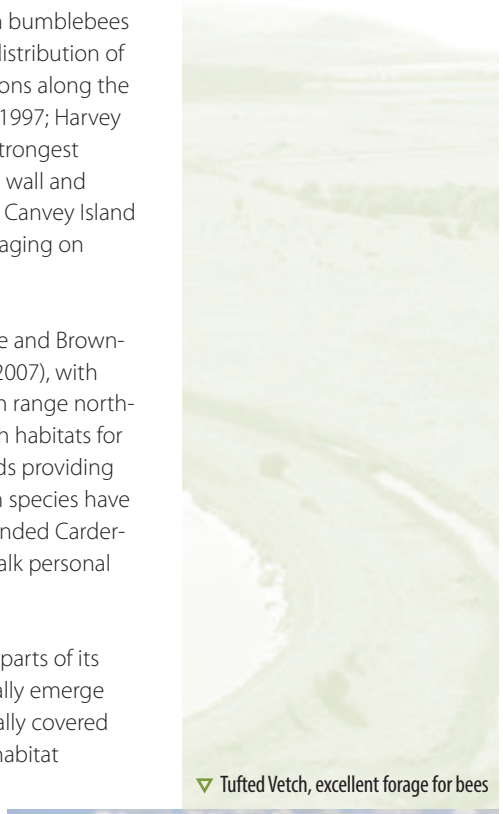
Bumblebees (Hymenoptera: Aculeata – Bombus)

Sea walls support some of the richest modern bumblebee assemblages, with 14 social species capable of regularly exploiting this habitat and up to 11 of these co-existing along sea walls within the Thames Estuary. This includes five UK BAP species: Shrill Carder-bee *Bombus sylvarum,* Brown-banded Carder-bee *Bombus humilis,* Moss Carder-bee *Bombus muscorum*, Large Garden Bumblebee *Bombus ruderatus* and Red-tailed Carder-bee *Bombus ruderarius*. A surprising amount of regional variation exists, with sea banks of Hampshire west of the Solent lacking these latter UK BAP species but having a good presence of Heath Bumblebee *Bombus jonellus* and Tree Bumblebee *Bombus hypnorum* (possibly due to the New Forest's influence). The sea banks of east Sussex have Moss Carder-bee and Large Garden Bumblebee but lack the Shrill Carder-bee and a strangely complementary distribution of Brown-banded Carder-bee and Moss Carder-bee occurs around the coast of East Anglia.

Shrill Carder-bee needs extensive flower-rich areas and suitable nesting sites of long tussocky grass to survive (Benton 2000). As a late nesting and foraging species (often into late October), suitable habitats are often found on unmown sea walls, which may also be important corridors along which bumblebees can disperse. The loss of flower-rich habitats since the 1940s led to a steep decline in the distribution of the Shrill Carder-bee (Edwards & Williams 2004) until it was largely restricted to a few locations along the Thames Estuary east of London (south Essex and north Kent) by the 1990s (Plant & Harvey 1997; Harvey 2000). It now relies more heavily than ever on sea walls and adjacent habitats and has its strongest populations in such settings along the Thames Gateway, showing a particular liking for sea wall and brownfield mosaics (as does the Brown-banded Carder-bee). Such situations occur around Canvey Island and West Thurrock in south Essex. On sea walls there is a particularly heavily reliance for foraging on clovers, Red Bartsia *Odontites vernus*, Creeping Thistle *Cirsium arvense* and Bristly Oxtongue.

More recently, there has been a northward expansion in the range of both Shrill Carder-bee and Brown-Banded Carder-bee in Essex away from the east Thames corridor (Benton & Dobson 2006, 2007), with both species being present on the north-east Essex coast at Mersea Island in 2010, a shift in range north-eastwards of approximately 30 km. As sea walls often formed the last remaining flower-rich habitats for this species in south Essex, this range expansion has been dependent on sea wall grasslands providing some forage and nesting habitat on a yearly basis (Benton personal communication). Both species have also shown an increase in the coastal grazing marsh of south-west Kent, and the Brown-banded Carder-bee is increasing inland within the Midlands, suggesting climatic change may be at play (Falk personal communication).

Moss Carder-bee, once fairly widespread, is now primarily a coastal species in the English parts of its range where it is largely restricted to coastal grazing marsh. Queen Moss Carder-bees usually emerge between March and May to search for a nest site. The nest is built at ground level and usually covered by moss, dry grass or leaf litter collected by the bees. With approximately 1 km^2 of forage habitat estimated as possibly being needed to support each bumblebee nest (Edwards 2001), this species may be restricted to extensive areas of flower-rich grassland in the heart of coastal grazing marsh where it forages on clover and other legumes while complementing these resources with thistles *Cirsium* species and *Carduus* species, Brambles *Rubus fruticosus* aggregate and bird's-foot-trefoils on sea walls (Falk personal communication). Like other carder-bees, the Moss Carder-bee is probably reliant on a relatively restricted range of flowers found on sea walls, including a number of tall herb species such as Black Horehound and Spear Thistle *Cirsium vulgare* that can persist in the tall swards of False Oat-grass and Sea Couch (Essex Field Club 2012). Trefoils such as the Narrow-leaved Bird's-foot-trefoil, clovers such as Sea Clover, and asters are also likely to be particularly favoured where they occur (Buglife 2012).



▽ Tufted Vetch, excellent forage for bees

As a colony can persist until August or September there is a need for a continuous succession of flowers from spring through to autumn to ensure there is a continual food supply and this includes species such as Spear Thistle for new summer queens and males (Falk personal communication). The Moss Carder-bee, like other bumblebees, therefore benefits from management of a sward that maintains optimum levels of flowering plants (JNCC 2012) such as an abundance of key forage resources (bird's-foot-trefoils, clovers, thistles and vetches). However, annual mowing of sea walls in late July and August to prevent scrub encroachment and maintain a grass sward could potentially eliminate most bumblebee forage plants and nests as well as potentially causing significant bee mortality (Benton 2000). It must be remembered that the Moss Carder-bee probably cannot use sea walls in isolation from other habitats such as grazing marsh and may be less reliant on them than the Shrill and Brown-banded Carder-bees (Falk personal communication). Flower-rich foldings/berms next to clover-rich pastures may be an important combination of habitats.

Gardiner & Benton (2011) showed there was clear evidence that sea walls occupied by this species had a much higher percentage of their length with a folding (as opposed to no folding), with many of the occupied sea walls having a folding present for their entire length. The Essex Sea Wall Survey (Eco Surveys 1990) underlined the value of the folding for vascular plants likely to be used as forage sources by bumblebees. Key forage species for the Moss Carder-bee were predominantly recorded on the folding, with only a few observations of them from the landward/seaward slopes of sea walls (Benton 2000).

▽ Moss Carder-bee (Ted Benton)

There is also evidence that microclimate may be important in determining the suitability of sea wall habitats for foraging by bumblebees, as well as for other species of invertebrates. Gardiner & Benton (2011) found the stretches of landward folding predominantly utilised by Moss Carder-bee as foraging habitat along sea walls in Essex were on the north or west sides. It was suggested that a folding on the northern side of an Essex sea wall will receive a degree of protection from the prevailing south-westerly winds, whereas, a folding to the west of a sea wall will be shielded from easterly on shore winds but exposed to south-westerly winds which can have a significant cooling effect. The authors found few instances of Moss Carder-bee occurring on landward foldings on the eastward side of sea walls. Such areas can receive early morning sunlight raising ground temperatures and creating a very warm and dry microclimate which may be unsuitable for Moss Carder-bee (Benton 2000).

Large Garden Bumblebee and Red-tailed Carder-bee, two further UK BAP bumblebees, will forage on sea walls in south-east England (Falk personal communication). Both have late emerging queens which like to forage on White Dead-nettle *Lamium album*, Ground-ivy *Glechoma hederacea*, comfreys *Symphytum* species and early clover. Workers like an abundance of legumes such as clovers and bird's-foot-trefoils plus plants from the Dead-nettle family (Lamiaceae) such as woundworts *Stachys* species, but will visit various other species too. Again, Spear Thistle can be important for queens.

Sea walls as corridors for scarce bumblebees

Sea walls can therefore form important corridors that bumblebees may utilise when there are extensive habitats such as coastal grazing marsh on the landward side. What is not yet clear is whether sea walls can support populations of bees when inland adjacent habitats are unfavourable (e.g. arable farmland). There are unpublished data however which suggest that sea walls tend to retain only the commoner bumblebee species and lose UK BAP species once adjacent grazing marsh habitats have been lost (Falk personal communication). This is well displayed in the Thames Gateway and Sussex areas. Arable farmland may be used by BAP bumblebees if flower-rich margins are present around fields, these can be used by all the UK BAP species especially if there is flowering White Dead-nettle for queens and plentiful clover. Fields of Oil-seed Rape *Brassica napus* may even be used by scarce bumblebees when they are next to sea walls.

Table 3.1. Noteworthy bees recorded in close proximity of sea walls

Scientific name	Common Name	Comments
Bombus ruderarius	Red-tailed Carder-bee	Occurs in small numbers on grazing marshes and sea walls where there is an abundance of forage plants (Benton 2008, Falk personal communication). Edwards (1999) noted its presence (with Moss Carder-bee) on a sympathetically managed (intermittently mown) stretch of sea wall in a Kent Wildlife Trust reserve at Graveney and there is also a good population at Wallasea Island in south Essex (Falk personal communication).
Lasioglossum sexnotatum	Solitary Bee	Adults observed to take nectar from Tufted Vetch and Hogweed *Heracleum sphondylium* (both of which commonly occur on sea walls).
Dasypoda hirtipes	Hairy Legged Mining Bee	Occurs in southern Britain, and whilst still reasonably widespread and locally common on southern coastal dunes, it has declined significantly inland (Falk 1991). Nests in bare or sparsely vegetated sandy or other friable soils and females collect pollen exclusively from plants of the daisy family especially yellow flowered species such as Bristly Oxtongue and ragworts *Senecio* species which occur on sea walls.
Colletes halophilus	Sea-aster Mining Bee	Listed as an endemic species of the southern part of the North Sea coasts and added to the UK BAP in 2007. In Britain, most records are from the south-east and East Anglia. Britain holds internationally important populations of this species (Harvey 2001) with the most important ones occurring in the Thames Estuary and Essex coast. Females forage mainly on flowers of Sea Aster.

What is clear is that sea walls can harbour important populations of scarce bumblebees, even if they only utilise the unmown areas as foraging habitat (see Chapter 5).

Concern has been expressed by some naturalists that sea wall mowing regimes have not been favourable to the conservation of rare insects on the coast such as bumblebees, especially where entire sea walls were mown to a short sward height (< 10 cm) in midsummer (July and August). This was seen as likely to remove much of the available bumblebee forage resources in one event (Benton 2000). Rare and endangered bumblebee species such as the Shrill Carder-bee are likely to continue to decline unless suitable flower-rich foraging habitats, including sea walls, are sympathetically managed (Dicks *et al*. 2010).

Other noteworthy bees often associated with sea walls are show in Table 3.1.

Scarcer mining bees like Trimmer's Mining Bee *Andrena trimmerana*, *Andrena proxima* and *Andrena alfkenella*, *Lasioglossum pauperatum*, and the spectacular Long-horned Bee *Eucera longicornis* can also be associated with sea walls (Falk personal communication). Ground-nesting bees and wasps can support an interesting array of parasites, 'cuckoos' and inquilines, including oil beetles and bee flies. Unlike bumblebees, they often require short turf or sparse vegetation on sunny, south-facing slopes, for nesting. They can be influenced by the ground-conditions of the sea walls e.g. whether clay-rich, silt-rich or with a sandy component and are often helped by mild disturbance such as walking or low-level vehicle usage. They also show more of a reliance on flowers such as umbellifers (notably Alexanders, Hogweed, Fennel *Foeniculum vulgare*, Wild Carrot *Daucus carota* and Upright Hedge-parsley *Torilis japonica*), crucifers and smaller legumes, than bumblebees.

Butterflies and moths (Lepidoptera)

The popularity of butterflies and moths means they are often one of the better recorded groups of invertebrates. As a result, the tall grassland communities frequently found on sea walls have been shown to support a variety of butterfly and moth species. The populations of many of the butterfly species generally found in such grassland habitats are in steep decline across Europe (Van Swaay *et al*. 2010) and in some areas, sea walls can now form one of the most important remaining habitats for butterflies such as the Wall *Lasiommata megera*.

Case study

Wall butterflies at Bawdsey, Suffolk

△ Wall butterfly (Karen Brown)

The Wall has undergone a 65% decrease in the UK since 1976 compared with a 72% decline over the last 20 years in Europe. Whilst the reasons for this decline remain somewhat unclear, it has been attributed to a loss of species-rich unimproved grassland as a result of conversion to arable, agricultural intensification and abandonment (Thomas & Lewington 1991). In East Anglia, it is now a declining resident in Suffolk with an increasingly coastal distribution (Butterfly Conservation Suffolk Branch 2012). This includes sea walls at Bawdsey, Suffolk. In Norfolk it now largely only occurs within a narrow band around the coast (NBIS 2009). In Essex, the Wall may now be almost entirely dependent on sea walls where adults can feed on plants such as Daisy, Common Fleabane *Pulicaria dysenterica*, hawkweeds *Hieracium* species, Common Cat's-ear, Common Knapweed, Common Ragwort, thistles and Yarrow (UK Butterflies 2012). It is noted for example that the sea wall of Holehaven Creek on Canvey Island provides shelter for the Wall butterfly.

Wall butterflies principally fly in May and early June, with a second brood seen in late July and August, possibly extending into October in warm summers (Norfolk Butterflies 2012). The timing of the first flight period has advanced by almost three weeks in recent years (Botham *et al*. 2008). The male Wall is territorial and will often inhabit a particular area, such as a path along a sea wall. As this butterfly is often found in relatively small, self-contained colonies, they can be more vulnerable to habitat change and loss than some other species of butterfly. As some individuals may wander further afield allowing the species to quickly colonise suitable nearby sites, the critical consideration is often more therefore whether there is suitable breeding habitat nearby, which adults will be able to find (Thomas *et al*. 2011).

The Wall breeds in short, open grassland where the turf is broken or stony (Butterfly Conservation 2012). Such habitat can occur on sea walls, particularly along the crest, whilst the slopes and folding can support the primary food plants (which include a range of grasses) of the larval stages. The primary and secondary larval food plants for the Wall listed on the UK Butterflies website (http://www.ukbutterflies.co.uk/foodplants.php) are shown in Table 3.2.

Table 3.2. Primary and secondary larval food plants of the Wall butterfly

Plant species	Scientific name
Bents (various)	*Agrostis species*
Tor-grass	*Brachypodium pinnatum*
False Brome	*Brachypodium sylvaticum*
Cock's-foot	*Dactylis glomerata*
Wavy Hair-grass	*Deschampsia flexuosa*
Yorkshire Fog	*Holcus lanatus*

Due to concerns over Environment Agency management of a stretch of sea wall with Wall butterflies at Bawdsey in Suffolk, a mowing trial has been devised in liaison with Butterfly Conservation (Suffolk Branch) to determine the impact. The landward slope of an 800 m length of sea wall is to be cut on rotation from 2013 onwards, so that every summer grassland will remain uncut as habitat for the Wall. Optimum windows of opportunity have been identified related to the life cycle of the species (shown as green in Figure 3.1). During winter from mid-November to March, grass cutting is thought to pose little risk to the hibernating caterpillars as long as the grass height is kept high. Other periods suitable for cutting include mid-late May at the start of the flight period before eggs are laid, and late March/April (caterpillars present so avoid if possible) or late October/early November (if third brood then it's possible that small caterpillars will be present so avoid if possible). The entire summer and early autumn period (June-October) must be avoided (shown red in Figure 3.1) as it is the main activity period for the species. Therefore, this trial shows how mowing regimes can be adapted taking into account the requirements of individual species such as the Wall. It is intended to monitor adult butterflies and larvae during the Bawdsey trial to see how successful it is in conserving this declining butterfly.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grass Cutting	Grass cut possible, 150mm sward height		(1)	Avoid pupation period	(2)	Main activity period, egg-laying, caterpillar growth and feeding and population - two broods. Avoid work in this period					(3)	Grass cut possible, 150mm sward height

Notes: (1) Late March, early April, mature caterpillars present, increased activity on new grass growth, avoid if possible
(2) Mid - late May, grass cut possible at start of flight period before egg laying - late May. Walkover survey prior to work advised
(3) Late Oct, early Nov, if third brood - potential for small and vulnerable caterpillars to be present, try to avoid this period

Figure 3.1. Optimum time to undertake sea wall works where Wall butterfly populations exist with regard to their life cycle

In some counties, such as Essex, the distribution of the locally uncommon Marbled White *Melanargia galathea* has historically been concentrated on sea wall grassland (Butterfly Conservation 2000), and there have been recent records from Paglesham (Roach Estuary), Lee-over-Sands (Colne Estuary) (Gardiner 2012c) and Benfleet SSSI. Adults of this distinctive medium-sized black and white butterfly are on the wing in summer from June to early August. Strong colonies can be found in warm, species-rich calcareous grasslands, but other habitats including sea walls are also frequented. The adults can often be found feeding on the flowers of species such as Common Knapweed, whereas caterpillars feed on a variety of fine-leaved grasses, notably Red Fescue.

The herbs growing on sea walls can also provide an important nectar source for the adults of other species of butterflies which are not specialists of sea walls. These include strong flying species such as the Small Tortoiseshell *Aglais urticae*, Painted Lady *Vanessa cardui*, Red Admiral *Vanessa atalanta*, Peacock *Inachis io* and Comma *Polygonia c-album* which are attracted to nectar-rich flowers on sea walls from adjoining habitats. All were recorded for example along sea walls at Snape Marshes nature reserve on the Alde-Ore Estuary (Wright 2009) and Painted Lady and Marbled White were recorded on sea walls at RSPB Old Hall Marshes.

Whilst most butterflies recorded from sea walls are grassland species, where scrub and trees persist; there may be localised butterflies such as the Purple Hairstreak *Favonius quercus*. This species flies in the summer between the end of June and early September and is very rarely seen as it spends much of its time perched on leaves at the top of oak trees, including smalls stands, hedgerows or even single oaks in more open landscapes such as those growing along the edge of borrowdykes on the folding of sea walls.

▽ Marbled White

The larvae of several species of moth such as Dusky Brocade *Apamea remissa*, Large Nutmeg *Apamea anceps* and Shoulder-striped Wainscot *Mythimna comma*, are known to feed on grasses which grow on sea walls such as Cock's-foot, whilst the larvae of many other species feed on herbaceous plants of sea walls. The abundance of potential larval food plants found growing on sea walls for some of these species, together with the close proximity of moth records to walls, suggests a large number of moth species inhabit sea walls on a regular basis. This is supported by many records collected by enthusiasts being localised within 100 m of a sea wall. A review of moth records held by the Suffolk Moth Group (2012) for example suggests that species such as the Wormwood Case-bearer *Coleophora artemisiella*, Sea-purslane Case-bearer, Nettled Sweep *Epichnopterix retiella*, Saltern Groundling and Rosy Wave *Scopula emutaria* can all be associated with sea walls.

The Wormwood Case-bearer is locally common on sea walls and edges of saltmarshes along the east coast of England such as on the Deben and Blyth estuaries in Suffolk (Suffolk Moth Group 2012). In their larval stage, they create small tunnels by feeding within the leaf structure of the host plant. The tracks left in the leaves are often a characteristic feature of identification as most leaf-mining species inhabit only one, or relatively few closely related plant species (Ellis 2011), in this case Sea Wormwood *Seriphidium maritimum*, a relatively short plant which is largely confined to the landward, drier edges of saltmarshes and sea walls (Clapham *et al*. 1962), especially those subject to sea wash or sea spray (UK Moths 2012). The Wormwood Case-bearer is single brooded with adults flying and laying eggs in July and August. The larvae start to mine the leaves and later feed on flowers and seeds. In September, the larvae leave the food plant and attach themselves low down on a stem to over winter in a case (British Leaf Miners 2012).

The Sea-purslane Case-bearer is a scarce resident species of moth found on sea walls and the edges of saltmarshes in northern England and from Dorset to the Humber. Adults fly in July and August and primarily lay their eggs on plant species such as Sea-purslane, Grass-leaved Orache and Spear-leaved Orache. Larvae are active from September to October and primarily feed on seeds in a movable case, though will also feed on leaves after the case is formed (British Leaf Miners 2012). Once fully fed, they hibernate over the winter to pupate the following June or July (Emmet *et al*. 1996). It would appear that this species is not mentioned in many of the more eminent publications on Coleophoridae from the mid-twentieth century suggesting that perhaps in the past it may have been confused with other species. This highlights the need for caution when reviewing historical data.

The Nettled Sweep is a Nationally Scarce species only found in or near the saltmarshes of south-east England between Hampshire and Suffolk. As larval stage food plants include Common Saltmarsh-grass *Puccinellia maritima* and other coastal grasses it has been swept from grassy sea walls on the Stour Estuary in Suffolk and is probably over-looked (Suffolk Moth Group 2012). As a single brooded species of moth, the adult males fly in the daytime between May and July, especially on calm sunny days. In contrast, the females are wingless and grub-like (UK Moths 2012).

The **Saltern Groundling** is a locally common resident restricted to coastal saltmarshes, mudflats and sea walls where it can sometimes be found in large numbers with 100 recorded in the Blakeney/Cley-next-the-Sea area of the north Norfolk coast in 2007 (Norfolk Moth Group 2012). Care is needed with the identification of this species as it can be confused with other members of the family group. Adults emerge in May and June and are on the wing until July or early August. This single brooded species of moth has several food plants, though Sea-purslane seems to be the most frequently used (UK Moths 2012). Other host plant associations mentioned in the literature, such as Sea Aster, Grass-leaved Orache, Sea Plantain and Shrubby Sea-blite probably originate from erroneous identifications (British Leaf Miners 2012).

The Nationally Scarce Rosy Wave moth principally occurs on the edges of coastal saltmarshes, vegetated shingle and sea walls where the larva can usually be found feeding on Sea Beet (Suffolk Moth Group 2012).

Fisher's Estuarine Moth, one of Britain's rarest species of moth, is listed on Schedule 5 of the Wildlife and Countryside Act, 1981 (as amended) and the only moth resident in the UK to be listed in the Habitats Directive. It is restricted to unimproved grassland on sea walls and low-lying coastal marshes in north-east Essex. Within this area, there appear a number of semi-isolated sub-populations, with the Hamford Water sea walls providing one of the main strongholds (Ringwood *et al*. 2004; Gardiner & Ringwood 2010). The optimum habitat comprises an abundance of long, coarse grasses, such as couch, Cock's-foot and False Oat-grass for egg laying. Oviposition observations have shown 75% were made on either Sea Couch or Common Couch (Parsons *et al*. 2002). The ova are generally deposited on grass located within 30 cm of Hog's Fennel, the sole food plant of the larvae. The composition of the habitat is therefore important, with the density of Hog's Fennel not too high so that it limits the presence of grasses (at least 25% ground coverage of suitable grass species are required to fulfil the moth's egg laying requirements), or too low, as this will reduce the success of freshly hatched larvae migrating to a Hog's Fennel plant in late spring. Hog's Fennel plants must also be in at least their third growth year, before they are sufficiently large to fulfil the moth's larval feeding requirements. Young larvae initially feed in the stems of Hog's Fennel, later boring into the roots. The number of larvae and affected plants declines over the summer, and it is likely that no plant ultimately supports more than a single larva. After pupation, the adult moths emerge to fly in September and October.

▽ Fisher's Estuarine Moth (Micky Andrews)

Ground beetles (Coleoptera: Carabidae)

The poached and summer dry clay tops of walls are an important habitat for some species of ground beetle which are able to take cover under the low growing plant rosettes associated with this type of trampled vegetation. Noteworthy species of ground beetle that could potentially make use of sea walls are shown in Table 3.3.

Table 3.3. Noteworthy ground beetles associated with sea walls

Scientific name	Comments
Dolichosoma lineare	Found in southern and south-eastern England, as far north as Lincolnshire in saltmarshes, tidal creeks and coastal grassland (Essex Field Club 2012). This species is threatened by the loss of saltmarsh (e.g. to coastal erosion and sea level rise), as well as the overgrazing of otherwise suitable habitats.
Elaphropus (Tachys) parvulus	A predatory ground beetle scattered widely over southern England and south Wales. It occurs in early successional habitats both inland and at coastal sites, notably alongside paths (Hyman & Parsons 1992).
Masoreus wetterhalli	A rare xerophilus southern ground beetle known to occur from Cornwall to Norfolk in a range of coastal habitats such as sand dunes, coastal cliffs, coastal shingle and sea walls.
Anisodactylus poeciloides	A rare (listed as RDB3 by Hyman & Parsons 1992) UK BAP species originally thought to be a strict saltmarsh species but now found in a variety of coastal habitats including margins of borrowdykes that have gently sloping edges adjacent to dense grass (Essex Field Club 2012).

Four of the UK's eight native oil beetle species are thought to be extinct. The remaining species have suffered large declines over the last 100 years and as a consequence are priority species included in the UK BAP. The habitats they utilise include wildflower-rich grasslands with a succession of nectar sources throughout the spring and summer. Oil beetles are nest parasites of solitary mining bees and dig burrows into bare ground for egg-laying. Therefore, a combination of bare ground (with close mown grass) and taller uncut grassland is required for completion of the life cycle. Disturbance to the ground is essential for oil beetles and this often occurs through the poaching of soil associated with livestock grazing. Surveys of the Essex coast have found oil beetles to be frequent along sea walls on the Dengie Peninsula and on Wallasea Island. The Black Oil Beetle *Meloe proscarabaeus* has been recorded in some numbers on the Wallasea Island sea walls in a survey in March 2012 by Buglife and the RSPB. As a consequence a short section (1.5 km) of sea wall has been brought into a rotational mowing regime (e.g. a third of the landward slope cut every year). For information please see Buglife's Oil Beetle Species Management Sheet (Buglife 2012) from which this information has been taken.

Grasshoppers, bush-crickets, groundhoppers (Orthoptera) and allied insects (e.g. earwigs (Dermaptera) and cockroaches (Dictyoptera)

Coastal areas around England can be rich in grasshoppers, bush-crickets, groundhoppers and allied insects (Dermaptera and Dictyoptera) with 18 species being recorded on a regular basis on the Essex coast of eastern England, for example (Gardiner & Ringwood 2010).

The complex mosaic of microhabitats provided by the sea wall has the considerable potential to satisfy the habitat preferences of a range of orthopteran species and up to 13 species can be found on suitably managed sea walls in south-eastern England and East Anglia (Benton 2012) (see Table 3.4). The Field Grasshopper *Chorthippus brunneus* and Meadow Grasshopper *Chorthippus parallelus* tended to be confined to the shorter sward and bare ground along the rutted track of a folding of a sea wall at Brightlingsea, with Lesser Marsh Grasshopper *Chorthippus albomarginatus* more frequent in longer grass on the landward and seaward slopes (Table 3.4). Coneheads *Conocephalus* species (no attempt made to distinguish species in quadrat counts) and Roesel's Bush-cricket *Metrioptera roeselii*, too, were frequently present in the longer grass strips of the uncut folding and landward slope. The Short-winged Conehead *Conocephalus dorsalis* is likely to be the commonest *Conocephalus* species present among marginal vegetation especially stands of Sea Club-rush *Bolboschoenus maritimus* along the banks of the borrowdykes (Benton 2012). Despite not being recorded in the Brightlingsea quadrat survey, Common and Slender Groundhoppers *Tetrix undulata* and *Tetrix subulata* respectively can be found on heavily disturbed parts of the folding in association with bare ground partially colonised by algae and mosses. Where the folding and associated dyke have been left unmanaged, the combination of rank, tussocky grasses and woody plants such as Hawthorn *Crataegus monogyna*, Blackthorn and Brambles may harbour populations of the scarce Great Green Bush-cricket *Tettigonia viridissima* (Benton 2012) and commoner species such as Dark Bush-cricket *Pholidoptera griseoaptera,* Oak Bush-cricket *Meconema thalassinum* and Speckled Bush-cricket *Leptophyes punctatissima* (all four species recorded on Brightlingsea sea wall mostly by beating scrub).

▽ Black Oil Beetle (Steven Falk)

Table 3.4. Total number of species of Orthoptera recorded from five sections of a sea wall near Brightlingsea from standardised quadrat sampling in summer 2011

Orthoptera species	Folding (uncut)	Folding (track)	Landward slope	Crest	Seaward slope	Total (%)
Conehead species	52	0	35	0	7	94 (13)
Dark Bush-cricket	6	0	0	0	0	6 (1)
Field Grasshopper	1	31	12	9	10	63 (9)
Meadow Grasshopper	15	32	15	0	3	65 (9)
Lesser Marsh Grasshopper	5	4	35	6	41	91 (12)
Roesel's Bush-cricket	236	1	170	1	7	415 (57)
Total	315	68	267	16	68	734 (100)

What the quadrat counting on the sea wall at Brightlingsea showed is that the usage of sea wall grassland by Orthoptera varies between species (Table 3.4). For example, grasshoppers requiring bare earth for basking and egg-laying were more commonly found on the rutted track on the folding (Field and Meadow Grasshoppers), whereas, bush-crickets (Roesel's Bush-cricket and coneheads) needing the shelter and cover provided by tall, uncut grassland were more frequently found in uncut grassland on the folding and landward slope. The landward slope was east facing at Brightlingsea so would have received more early morning sunlight than the west facing seaward slope, therefore this may explain the higher number of individuals on the landward face (Table 3.4). By far the most important part of the sea wall in terms of overall numbers of adults and species was the uncut folding next to the borrowdyke (which had six species in the quadrat survey, as well as Oak, Speckled and Great Green Bush-crickets recorded outside of the standardised sampling by beating and hearing the stridulation (song)). Due to not being cut for many years, large populations of Orthoptera (particularly Roesel's Bush-cricket) have managed to build up in this undisturbed grassland, a total of nine species of Orthoptera (and Common Earwig *Forficula auricularia* from the allied insects) being notable in an Essex context.

▽ Great Green Bush-cricket (Ted Benton)

Grasshopper surveys of the unimproved grasslands on the sea walls of Essex in 2011 using a standard open 2 x 2 m quadrat found numbers were highest (> 3 adults per m^2) on a sea wall at Old Hall Marshes (Gardiner 2012a,b). The rotational management of this sea wall, interspersed with grazing, created

conditions suitable for large populations of grasshoppers, particularly of the Lesser Marsh Grasshopper. The south-facing slope with its potentially warmer microclimate, especially where the sward was fairly sparse and there were patches of bare earth, was found to be particularly favoured (Gardiner & Charlton 2012). However, on the folding of a sea wall in north-east Essex at Lee-over-Sands near Clacton-on-Sea, high grasshopper numbers in late June were associated with patches of uncut Meadow Barley *Hordeum secalinum* and the Nationally Scarce Sea Clover. A similarly large number of grasshoppers were found in swards with Sea Clover and vehicle ruts on the folding of a sea wall in the north of the county at Little Oakley near Harwich, Essex.

Cattle grazing and associated poaching of the soil by hooves can create the exposed soil and sparse grassland required by grasshoppers. At Langenhoe near Colchester for example, grasshoppers were found in lightly grazed swards with the Nationally Scarce Sea Barley and the localised Spiny Restharrow *Ononis spinosa*. However, heavy grazing by cattle on sea walls can create extremely short grassland swards (< 10 cm in height) with little heterogeneity (e.g. short and tall vegetation in close proximity) in structure and consequently reduced grasshopper interest.

Several Nationally Scarce species have been recorded on sea walls, including Lesne's Earwig *Forficula lesnei* and Grey Bush-cricket *Platycleis albopunctata*. A small-scale survey of Lesne's Earwig along the Stour Estuary on the border of Essex and Suffolk was undertaken in August 2012 (Gardiner 2012d; Gardiner 2013). In four hours of standardised beating, four Lesne's Earwig males were recorded, compared to 131 Common Earwigs. Mature trees fringing a sea wall flood defence and along a railway embankment were utilised by Lesne's Earwig in this study. It appears that Lesne's Earwig is found in much smaller numbers than the Common Earwig and sustained beating effort is required to locate it (e.g. in four hours beating only four Lesne's were observed). Mature Ash *Fraxinus excelsior* and Pedunculate Oak *Quercus robur* fringing sea wall flood defences was an important habitat which had been left untouched during recent Environment Agency clearance of woody growth from raised embankments to improve their structural integrity and allow inspection of the flood banks by engineers.

▽ Field Grasshopper

A lone male Grey Bush-cricket was heard stridulating (or singing) from the uncut seaward slope of a sea wall at Lee-over-Sands in north-east Essex in 2011. No further observations have been made of this insect on the sea wall so its use of the grassland has not yet been ascertained (e.g. not an established population).

Roesel's Bush-cricket is particularly noted for its large populations on the Essex coast (Wake 1997). Although the insect has been spreading inland since the 1940s, sea walls remain an important habitat for this species, particularly as they can still hold large 'donor' populations for its continued expansion in range. The Humber sea walls for example, support a distinctive fauna, including some species at the northern edge of their British range such as Roesel's

Bush-cricket. This, together with other species more typically found further south, such as the Essex Skipper *Thymelicus lineola*, a butterfly (East Riding of Yorkshire Council 2010), suggests sea walls may provide important corridors and habitats to help facilitate the northward migration of wildlife in response to climate change.

There are two other species of Orthoptera, Short-winged Conehead and Great Green Bush-cricket, which in Essex, are almost entirely restricted to the coast, mainly utilising sea wall grassland and scrub. Therefore, the total of 15 species of Orthoptera and allied insects recorded on the Essex sea walls in recent years compares very favourably with the total of 18 species recorded on the Essex coast.

Case study

Great Green Bush-cricket on the sea walls of East Anglia

The Great Green Bush-cricket is a scarce coastal insect predominantly found in scrub and tall grassland on sea walls. In 2011, the number of stridulating (singing) adult males was recorded from late June to early September on the folding of several 1 km long sections of sea wall in Norfolk, Suffolk and Essex (Gardiner 2012b). The results showed that the largest populations of this insect probably occurred on sea walls on the Alde Estuary in Suffolk and Burgh Castle in Norfolk (Figure 3.2). Most populations in Essex were small by comparison, except for the sea wall at Tollesbury Wick Marshes on the Blackwater Estuary. At Heybridge Basin near Maldon, a site where Great Green Bush-cricket had been recorded in the past, no singing males were heard despite the favourable hot and sunny weather.

▽ Roesel's Bush-cricket (Micky Andrews)

Across the entire survey, most Great Green Bush-crickets were recorded on the folding next to the edge of the borrow dyke. There was only one case where this species was found to be more abundant on the landward slope or crest of a sea wall than the folding; this was on the sea wall at Snape Maltings on the Alde Estuary. In a 3.1 km extension to the 1 km transect which covered most of the sea walls at Tollesbury Wick, of the remarkable total of 320 singing male Great Green Bush-crickets recorded, 300 were on the folding and 20 on the landward slope and crest. This may be because annual summer mowing regimes

have often focused on the crest and landward slope due to the critical function these have in the structural integrity of sea walls. As a result, the less frequently mown, or even unmown, band of grassland that has developed on the folding, especially along the edge next to the borrow dyke, may offer a more favourable habitat for the Great Green Bush-cricket and act as a refuge for them and other species of insect.

Figure 3.2. Great Green Bush-cricket occurrence at known sea wall locations (number of stridulating males per 1 km) in Norfolk, Suffolk and Essex.

True bugs (Hemiptera)

Our knowledge of the true bugs found on sea walls is limited and further surveys are required. However, the Sea Wormwood Leafhopper *Chlorita viridula*, a UK BAP priority species, feeds on Sea Wormwood a plant that grows on the upper levels of saltmarshes and sea walls. This leafhopper has been recorded at over 25 localities, but all of them lie within a restricted geographical area: around the Thames Estuary (both the Kent and Essex sides) and the north Kent coast. It appears to be genuinely confined to this area, even though apparently suitable stands of the host plant occur widely around the south and east coast of England (Auchenorrhyncha Recording Scheme for Britain and Ireland 2012).

Spiders (Araneae)

The structural diversity of sea wall habitats is of considerable importance to spiders not least because of the influence this has on microclimate and ability to construct webs. Spiders can therefore be valuable indicators of the success or otherwise of vegetation management regimes (Spider and Harvestman Recording Scheme 2012). The sea wall grassland habitats from the top of the high tide line through the landward slopes of the sea walls towards the borrowdykes on the Alde-Ore estuaries in Suffolk for example are known to hold several nationally important populations of a range of RDB / UK BAP Priority species spiders, including Yellow-striped Bear-spider *Arctosa fulvolineata*, Duffey's Bell-head Spider *Baryphyma duffeyi* and Heath Grasper *Haplodrassus dalmatensis* (SWT Trading Ltd 2012).

The 61 records nationally of the large UK BAP Priority species Yellow-striped Bear-spider suggest this species is confined to a few saltmarshes on the south and south-east coast of England. In Suffolk, for example, it has historically been recorded on the Stour and Orwell estuaries in the south of the county (it is listed on the Ramsar citation for these two estuaries) and the Blyth Estuary. More recently, it has also been recorded on the lower reaches of the Alde Estuary (Spider and Harvestman Recording Scheme 2012). Despite being a relatively large wolf spider and Cooke (1961) reporting considerable numbers in places along the saltmarshes of Essex, it was not re-discovered here despite extensive searches until finally being found at Colne Point in 2004 under debris on tidal mud in two areas adjacent to a track (Essex Field Club 2012).

Due to its apparently highly specialised habitat requirements, the Yellow-striped Bear-spider appears restricted to very small areas within apparently suitable habitat. The available literature suggests that this species is typically found under stones in the uppermost zones of saltmarshes and under lumps of mud and wet, tightly matted debris along the seaward toe of sea walls. There is evidence suggesting the Yellow-striped Bear-spider may benefit from the invasion of saltmarshes and adjacent sea walls

by Sea Couch. Pétillon (2009) for example reported studies showing higher densities of this spider in areas invaded by Sea Couch and suggested this could be explained by differences in habitat structure between invaded and natural habitats with the former offering a more complex litter structure favouring invertebrates such as the Yellow-striped Bear-spider.

Whilst further research is required to establish exactly what features are needed for its survival (JNCC 2012), as it is thought to generally occur low down on the seaward face of sea walls in crevices and under rocks and other debris, it is expected to be out of the main mowing zone. It may however still potentially be vulnerable to being covered with mud or severely disturbed during a higher than normal tide event. The available evidence suggests there has been a 90% decline in this species between 1951-1986 and 1987-2000 (JNCC 2010a). These two survey periods represent the first major modern survey of spiders following the publication of British Spiders (Locket & Millidge 1951) and the second major survey of spiders resulting from publication of the provisional national atlas.

Snails (Mollusca)

Narrow-mouthed Whorl Snail *Vertigo angustior* was once one of the rarest snails in the UK with colonies reported in Scotland, Cumbria, Norfolk and Suffolk. It is a minute (less than 2 mm long) species of land snail that inhabits short grassland areas that are kept moist by the presence of moss, leaf litter, small tussocks or low herbs (Cameron *et al*. 2003). Such habitat is found in calcareous fens, wet meadows, coastal grasslands, damp hollows or slacks in sand dunes, sea walls, saltmarsh where there are freshwater seepages, and among flood debris affected by periodic desiccation or regular flooding (Kerney 1999). Wherever it occurs, this species is often restricted to a narrow zone only a few metres wide because of its specific microhabitat requirements.

A research project funded by the Countryside Council for Wales into the ecology of this species (and that of the related Geyer`s Whorl Snail *Vertigo geyeri*) was completed in 2001 (Cameron 2003). The Narrow-mouthed Whorl Snail probably feeds on micro-fungi growing on decaying plant material in the litter layer. Adults laid proportionally large eggs in relation to their body mass in the damp field layer, with juveniles being present from early summer onwards, probably reaching a peak in numbers in October. Spring and summer weather conditions were found to cause the percentage of juveniles in the total population to vary from between eighteen to fifty eight percent. Little more is known of the life cycle other than this snail probably has a relatively short lifespan.

In relation to the sea walls of East Anglia, until recently Narrow-mouthed Whorl Snail was only really known from one site on the south side of Martlesham Creek on the Deben Estuary (Killeen 1997). Following a survey for this species of the Blyth Estuary complex (Killeen & Moorkens 2004), the results of

a wider survey carried out from 2007-2008 for the Environment Agency (Abrehart 2008) revealed the distribution of Narrow-mouthed Whorl Snail across the Suffolk estuaries to be as follows:

- Blyth: found on sea wall grasslands along both banks of most of this estuary from the harbour mouth at Southwold to 7 km upstream, north through Buss Creek and through suitable habitat to Dunwich 4 km to the south.
- Alde/Ore: found throughout this system, including at Shingle Street north along the sea walls for over 1 km, along Butley Creek, in ungrazed grasslands near Chillesford at the top end of Butley Creek (there is also much suitable habitat on the southern bank) and from Snape to Hazelwood Marshes in sea wall grasslands.
- Deben: found from Bromeswell Green in the north to Bawdsey at the river mouth, suitable habitat is to be found along the entire length of this estuary (e.g. Martlesham Creek according to the Ramsar citation), though at lower densities towards Bawdsey.

Based on this more recent data, the sea walls of the Suffolk estuaries support nationally important communities of Narrow-mouthed Whorl Snail (Abrehart 2008). Here, the species generally occupies couch, fescues and other fine-leaved grasslands associated with the upper seaward slope of sea walls just above the high water mark. Specifically in Suffolk, the species has been found in the transition zone between grassland and saltmarsh where sedges *Carex* species are dominant (Suffolk Biodiversity Partnership 2003).

According to the Joint Nature Conservancy Committee (JNCC), sea walls were the occupied habitat in 35 of the 54 1-km squares known to be occupied by Narrow-mouthed Whorl Snail in the UK (JNCC 2007). Although there were 19 populations in 43 1-km squares in England, this was based on the East Anglian estuaries comprising 12 separate populations (i.e. 63% of the populations in England). It was recognised that some, if not all, of the populations on the East Anglian estuaries could belong to a single population.

The small number of sites known to support this species in the UK was the focus of much research to ensure measures were in place to conserve this Habitats Directive Annex II and British Red Data Book Endangered species. A survey for this species on the Solway coast of Scotland for example (Killeen & Colville 2000) found it occurred at a mean density equivalent to 344 individuals per m^2. Such numbers made this the most common snail species in the sample area, representing 31 percent of the overall mollusc fauna. Whilst this population dominance over other snail species has been found to be a typical feature elsewhere, difficulties in sampling efficiency, naturally large population fluctuations between years, and behavioural responses to climatic conditions collectively mean most estimates of numbers of this species need to be treated with caution. Instead, provided there is sufficient survey data, it is really only practical to consider populations either as containing an abundance of individuals or that the sampling indicates a relatively small population is present.

Whilst the reasons for the rarity of this snail, other than it being relatively difficultly to identify, remain unclear, it seems that the main factors involved are sensitivity to changes in hydrological conditions and vegetation management (JNCC 2012). Whilst the Narrow-mouthed Whorl Snail appears to require microhabitats with high humidity, it does not tolerate deep or prolonged inundation. The relatively narrow (often no more than a metre wide) linear habitat range of this species on sea walls means it is therefore vulnerable to sea level rise. Equally, drought causes the snails to retreat within the soil and they are generally absent from habitats which have dry substrates for long periods.

In terms of vegetation management, although Narrow-mouthed Whorl Snail occurs where there is livestock, over-grazing is detrimental. Similar reasoning can be applied to areas which are mown, though this species does not necessarily favour a complete lack of management. In Scotland for example, where populations appear rather small, declines in the numbers recorded at Whiteport were attributed to natural succession and coastal erosion (JNCC 2007). A study of the Almorness population at Solway in 1999 also found that the highest densities occurred in more open habitats (Killleen & Colville 2000). Shading by scrub altered both the composition and diversity of the field layer in a way that did not provide the specific habitat requirements of the Narrow-mouthed Whorl Snail, or at worst, create unsuitable areas of bare ground. At one site in Suffolk, shading by Reed Canary-grass *Phalaris arundinacea* and tall herbs may also have contributed to a local decline in the species (Abrehart 2008; Suffolk Biodiversity Partnership 2003).

The Narrow-mouthed Whorl Snail is in serious decline throughout much of its European range, though on the continent it most frequently is found in calcareous fenland (JNCC 2012). Discoveries of new populations have also extended the known range of this species in north-east Scotland and Northern Ireland and there is a strong likelihood that more sites will be found to support this species, probably along the coast of southern England (JNCC 2007). Consequently, in contrast to the rest of Europe there is no evidence to suggest a significant decline to the population size in the UK and it is reasonable to assume that the UK population is probably relatively stable. Whilst there is therefore less concern now that it is known to be more common than once thought, ensuring populations are maintained at all known sites, or at least on a 1-km square level, is still important.

Amphibians and reptiles

Sea walls can also have notable populations of amphibians and reptiles. These include two species of amphibians (Common Toad *Bufo bufo* and Natterjack Toad *Epidalea* (formerly *Bufo*) *calamita*) and four species of reptiles (Common or Viviparous Lizard *Zootoca vivipara*, Grass Snake *Natrix natrix,* Adder *Vipera berus* and Slow-worm *Anguis fragilis*). The Common Lizard, Grass Snake, Slow-worm, and Adder are protected from killing and injuring under Schedule 5 (Section 9) of the Wildlife and Countryside Act 1981 (as amended).

The Common Toad is widely distributed throughout much of lowland Britain (Arnold 1995) including in rough grassland such as that found on sea walls. Due to significant declines in numbers in southern and eastern counties (Carrier & Beebee 2003), the Common Toad was added to the list of priority species in the 2007 revision of the UK BAP. The reasons for the decline have not been firmly identified other than generally related to factors arising from human disturbance and alteration of habitat (Halliday 1993).

Although commonly thought of as associated with water, outside the breeding season Common Toads spend most of their time in terrestrial habitats. Indeed, this species is the most terrestrial of the widespread amphibians (Strijbosch 1980) and more tolerant of dry conditions than other species of amphibian except the Natterjack Toad. Whilst Common Toads tend to breed in larger, more open waterbodies, drainage ditches are also used and tadpoles have been recorded in brackish water (Hagström 1981). After breeding, adults move back into terrestrial habitat and can sometimes move several kilometres from their breeding sites (Janin *et al*. 2009). On damp nights in June or July, juvenile Common Toads disperse in nearby habitats to spend their entire juvenile life, which can last two or three years, on land before returning to the water as breeding adults.

▽ Common Toad

The terrestrial habitat requirements of the Common Toad are relatively simple in that they need cover to provide damp resting places which will prevent desiccation during the driest parts of the year and support the invertebrate prey on which they feed. They tend to rest in the same hiding place each day and forage at night. Like all amphibians in Britain, the Common Toad also requires a suitable place in which to hibernate. This is usually under piles of damp leaves, rotting logs, crevices or in underground tunnels (Baker *et al*. 2011). Such hibernation sites can be some distance from breeding sites and sea walls may therefore provide important corridors between suitable hibernation, foraging and breeding habitats.

From a Common Toad conservation perspective, mowing of sea walls should ideally be carried out during winter when amphibians are inactive. Where vegetation has to be cut at other times of year, a high cut (minimum 15 cm) is recommended. This is because during the daytime amphibians tend to hide away in leaf litter or amongst the lower stems of herbaceous vegetation where moisture is retained.

Natterjack Toad, in contrast to the widespread Common Toad, is almost only found in sand dunes and lowland heath. Over the last century it has been lost from over 75% of its former haunts, notably the heathlands of southern and eastern England (Baker *et al*. 2011). It now has a highly restricted distribution with the main populations in mainland Britain limited to the coastal areas of East Anglia and Lincolnshire, north Wales and the north-west coast between Liverpool and the Solway Estuary. Smaller and more isolated populations are present in Staffordshire, Oxfordshire, Bedfordshire, Kent, Surrey, Hampshire and Dorset (Natural England 2007b). A re-introduction programme has been running for some years (Denton *et al*. 1995) and has included a site on the Suffolk coastline (Griffiths *et al*. 2010).

As with other amphibian species, Natterjack Toads require both terrestrial and aquatic habitat at different times of the year. The key breeding habitat requirements are shallow (usually with water only 5-10 cm deep), often ephemeral pools with gradually shelving margins that are not shaded (Baker *et al*. 2011). Juvenile Natterjack Toads (toadlets) usually leave the water from mid-May to July to seek out moist conditions in open, sandy habitat nearby. The terrestrial habitat requirements usually need to be present within a few hundred metres of the breeding pools as Natterjack Toads appear unlikely to cross extensive areas of unsuitable habitat (Natural England 2011a).

It usually takes around three to four years for young Natterjack Toads to reach maturity. Both juvenile and adult Natterjack Toads actively feed at night on small invertebrates, especially beetles and ants (Formicidae family) (Banks *et al*. 1993). During the day, they shelter in burrows dug into suitable substrate, usually sand, or beneath objects such as large stones, pieces of wood or other debris. They also shelter in crevices in sea walls where these are present, notably on the north Norfolk coast and at a protected site on the Suffolk coast where it was reintroduced as part of a species recovery programme (Denton & Beebee 1994).

On most sites supporting Natterjack Toads, grazing is used as a key method for maintaining the required short sward. Cattle are usually the most useful herbivore because they tend to break the turf to create bare ground more so than sheep. It is virtually impossible to overgraze a site for Natterjack Toad conservation (Baker *et al*. 2011). As Natterjack Toads tend to remain underground during the day outside the breeding season, regular, low cut mowing can achieve the same habitat requirement. Where Natterjack Toads are present they tend to be the conservation priority.

The Common Lizard can be found in a wide range of well-drained habitats across Britain, including most types of tall grassland (Edgar *et al*. 2010). Short, mown grassland is unsuitable because it is structurally deficient and lacks sufficient invertebrate prey. Uniform stands of vegetation, including sea walls with completely closed rank grassland are also likely to be avoided. Habitat mosaics, including grassland with patchy scrub on the folding of sea walls, together with the crevices in both seaward and landward slopes, can provide suitable hunting grounds for this species, as well as cover against predators and the weather. The more open character of the crest of sea walls, together with any blockwork or revetments, can be used for basking. As such, despite being somewhat elusive and under recorded, it is thought the Common Lizard may be quite frequent on sea walls.

Due to their need for warmth during the active season (in Britain this is generally March to October), Common Lizards will preferentially use more open areas on south-facing slopes for basking, though appear to tolerate a wider range of successional habitat stages than other species of reptiles. During the subsequent inactive season, they enter a period of hibernation or extended torpor with greatly reduced metabolic activity. Hibernation usually takes place underground in places that are frost-free, humid (but not wet) and safe from flooding and predators (Bauwens 1981). Typical sites include burrows dug by other species, cracks and crevices, piles of rubble and under logs or other debris. Hibernation sites almost always have a south-facing aspect, and are normally in full or partial sun (Edgar *et al*. 2010).

As it is generally unable to cross large expanses of unsuitable terrain, the Common Lizard is particularly susceptible to the effects of habitat fragmentation. The ability to disperse to areas of suitable habitat therefore largely depends on this being connected to existing areas of habitat. Sea walls can offer potential corridors linking otherwise isolated areas of habitat. Other threats to existing populations include both a lack of habitat management resulting in increased shading and degradation of key microhabitat features (such as sea walls which have not been mown for some years) as well as unsympathetic vegetation management (such as too frequent mowing or uniform mowing along long lengths of sea walls).

Research by Webb *et al*. (2010) for example demonstrated that some widespread species, including reptiles, may decline as a result of generalised management prescriptions not providing the habitat requirements needed throughout their life cycle. The grasslands found on sea walls should therefore be managed to maintain a mosaic of habitats with a diverse structure and prevent succession to scrub, with different areas grazed or mown on at least a three year rotation. This can be achieved by adopting a strategic approach to vegetation management with defined areas or stretches scheduled for management. Many smaller areas are preferable to a few larger ones to maintain habitat diversity at a local scale. The maximum unit size suggested is 2 ha (Edgar *et al*. 2010).

Where sea walls need to be mown, this should ideally be carried out in a way that prevents Common Lizards becoming stranded in isolated stands of vegetation. The best time of year to mow grassland from a Common Lizard conservation perspective is when they are inactive. Such mowing needs to avoid creating large areas of short vegetation around hibernation sites so that some cover is available following emergence in spring. On sites where mowing needs to be carried out when reptiles are active, it is recommended that surveys are carried out to identify any key areas of habitat on a sea wall that it may be possible to leave uncut. Where practical, different areas should be cut at intervals staggered over several weeks, so that there is always some vegetation cover available. The cut should also be taken as high as possible (minimum 10-15 cm) to help avoid injuring any individuals hiding in the grass (Kent Reptile and Amphibian Group 1997; Gardiner 2012a).

In Britain, Grass Snakes can be found in a wide variety of habitats in southern and central England, especially those associated with wetlands. However, Grass Snakes are more mobile than most other species of reptiles and may also be found in farmland, woodland, heathland, rough grassland and some coastal habitats, including on sea walls. Because it ranges so widely, unlike many other species, the Grass Snake is seldom reliant on a single habitat to meet the needs of its entire life cycle, but rather a mosaic which provides open, sunny areas and dense cover.

In common with other species of reptiles, Grass Snakes usually emerge from hibernation in March as soon as daily temperatures become warm enough. Preferred sites for hibernation include rubble piles, mammal burrows and thickly-vegetated banks. Sea walls can therefore provide suitable features to support hibernating Grass Snakes.

A study on free-living Grass Snakes at a site in southern England (Reading & Davies 1996) found they primarily feed on juvenile and adult amphibians, especially slower moving toads. Other prey included ground nesting birds and small mammals in areas of rough grassland. It is not surprising therefore that Grass Snakes recorded in the open water and reed swamp of borrowdykes have been seen to forage on the berm and slope of the adjacent sea wall. Grass Snakes will often make for cover with surprising speed when they disturbed. Whilst they can escape by swimming across borrowdykes, areas of rough grassland may also provide important refuges.

During the day, Grass Snakes require access to areas of bare ground or low vegetation where sunlight can provide them with the warmth they need. This is especially the case first thing in the morning when Grass Snakes may bask in sheltered areas, especially south-facing slopes (Edgar *et al*. 2010) and more open areas on the crest of a sea wall.

Grass Snakes also need access to decomposing material in which to lay their eggs. Preferred sites include compost piles, manure heaps and piles of rotting logs or leaves (Suffolk Wildlife Trust 2011). Whilst such features are seldom present on sea walls, they will use piles of grass clippings and seaweed heaps (Edgar *et al*. 2010). Hatching usually occurs in late August and September, though if the summer has been particularly cool this may continue into October, after which Grass Snakes move into areas which offer suitable protection from frost, flooding and predation in which to hibernate (Froglife 1995). This can include artificial refugia created on the folding of sea walls away from disturbed areas and where landowner approval has been forthcoming.

From a Grass Snake conservation perspective, the mowing of sea walls should aim to create areas of long, rough grass interspersed with areas of short grass for basking. This can be achieved through a programme of rotational mowing. Uniform mowing over long lengths of sea wall will make them less attractive to Grass Snakes by removing vegetation structure and creating large areas of short grass which lack the habitat needed for cover and foraging. A lack of management can also lead to areas of high potential becoming less suitable for Grass Snakes. Wherever possible, mowing should be avoided when Grass Snakes are sluggish such as when they first emerge, early in the mornings before they have had opportunity to bask or just prior to hibernation. As Grass Snakes appear sensitive to disturbance, the Suffolk Wildlife Trust (2011) recommends areas of rough or long grass should be walked prior to mowing to encourage any Grass Snakes present to move away.

Adders prefers light, often sandy soils, and are almost never found in habitats based solely on heavy clays. As seldom found far from coastal dunes or heathlands they have a markedly localised distribution in Britain. They can also be found on sea walls where these provide the necessary open, undisturbed, dry, sunny conditions adjacent to areas of dense ground cover. The Essex sea walls in particular have long been known to support important populations of this species. A search of the long grasses along the sea wall at Hullbridge on the Crouch Estuary for example in April 1961 recorded five male Adders and an immature specimen (Malenoir 1961). More recent surveys have shown a sea wall at Peldon on the Blackwater Estuary to contain what is probably one of the largest populations of Adders in the county (Cranfield personal communication). Adders are also considered a common occurrence along the sea walls of Pagham Harbour in Sussex (Holloway & Holloway 2012).

▽ Adders (Kim Thirlby)

Adders can be found on sea walls throughout the year. In summer, they may be encountered basking in sheltered, sunny areas of short vegetation on some sea walls. For example, a sluggish Adder was photographed basking in the spring sunshine in the lee of the sea wall in Maydays Marsh on Mersea Island. The often high level of disturbance from walkers, especially those with dogs,

may help explain why few are observed. In winter, scrub (especially Brambles) on the south-facing slopes of sea walls can be important hibernation sites as it provides the necessary protection from predators such as raptors.

Birds

The habitats found on sea walls can provide nesting sites (March – August inclusive) and hunting habitat for raptors.

Nesting birds

Where scrub is present on sea walls it may be used by a variety of more common passerines for territorial perches and foraging, as well as occasional breeding by species such as Goldfinch *Carduelis carduelis*, Chaffinch *Fringilla coelebs*, Greenfinch *Carduelis chloris,* Whitethroat *Sylvia communis* and Dunnock *Prunella modularis*. In contrast, despite most vegetated sea walls being accessible to the public, notably via the footpaths that run along their crests, the grasslands they support can provide suitable breeding habitat for ground nesting birds, though the taller and ranker vegetation found on many sea walls generally offers fewer nesting opportunities than those which support short grassland.

Two ground nesting BAP species of bird commonly found nesting on sea walls are the Skylark *Alauda arvensis* and the Meadow Pipit *Anthus pratensis*.

The Skylark has been awarded unfavourable conservation status across Europe due to significant population declines (European Commission 2007) and is a species of high conservation concern in Britain. In a study of Skylark habitat associations, Chamberlain & Gregory (1999) showed that whilst semi-natural grassland often held the highest overall mean nesting densities, this species preferred not to breed in excessively tall or dense vegetation. Whilst sward heights ranging from bare ground up to 25 cm were shown to best meet the nesting and feeding requirements of Skylarks (Crofts & Jefferson 1999), the optimum vegetation height range for nesting in southern England has been shown to be 20–60 cm (Wilson *et al*. 1997), but less than 30 cm in height over at least 90% of the area (Kirby *et al*. 2000).

This suggests that as vegetation increases in height during the growing season it becomes less suitable for nesting. The Skylark has also been shown to generally avoid nesting in fields with hedgerows or boundary trees as well as areas of intensive grazing (Wakeham-Dawson *et al*. 1998).

Buckingham *et al*. (2010) report on experiments to estimate how varying cutting heights, and different cutting times affected breeding success of Skylarks in silage fields. Raised cutting heights were thought to offer two benefits: reduced incidence of mower blade strikes on nests or fledglings and accelerated re-nesting, as minimum sward heights for nesting would be reached more quickly. However, as Skylarks often nest in shallow depressions, few nests were found to be struck by cutting machinery. Whilst raising cutting heights was therefore shown to have a negligible direct impact, one of the main causes of nest failure during silage cropping was found to be nest abandonment at both the egg and chick stages during mowing operations, particularly if this resulted in a nest becoming covered in cut grass. As abandonment rates fell rapidly as chicks grew older, it was suggested delaying cutting by a few days could substantially reduce the risk.

As the Skylark breeding season usually extends from April to July, delaying mowing until August will also be beneficial. However, mowing also has the potential to benefit this species by creating suitable nesting habitat for longer during the breeding season, provided at least seven weeks is allowed between mowing operations to enable Skylarks to successfully nest and fledge their young (Flade *et al*. 2003).

Another important consideration is food availability. In addition to seeds, during the breeding season and especially chick rearing the di*et al*so includes sward-dwelling invertebrates such as beetles, flies (Diptera), butterfly and moth larvae, sawflies and spiders (Kirby *et al*. 2000). Skylarks will also feed on leaves and other parts of broad-leaved plants, especially in winter, and the widespread loss of winter stubble is thought to be another reason for the decline in numbers (Donald *et al*. 2001). Food availability may therefore be an important consideration in the use made of sea walls which still offer stands of vegetation in winter, especially as at this time numbers are swelled with birds from northern Europe giving rise to an internationally important over-wintering population in Britain.

▽ Skylark nesting habitat

Researchers have sought to explain patterns of grassland usage as foraging habitat by birds such as the Skylark in terms of two main factors: food abundance and the accessibility of that food. In general terms, as sward height increases, food abundance, particularly of seeds and sward-dwelling invertebrates tends to increase (Vickery *et al*. 2001), whereas accessibility to that food decreases (Butler & Gillings 2004). In response, as vegetation becomes taller, Skylarks may preferentially forage along path edges and in bare areas. Sea wall crests may also therefore offer a potentially valuable feeding resource at this time.

Whilst sward structure has been shown to have a strong influence on the ability of birds such as the Skylark to forage in grasslands, the effects of food abundance (in relation to structure) on foraging behaviour are generally poorly understood. What is clear is that collectively the abundance and accessibility

of key food items can be strongly influenced by mowing. For example, seed abundance tends to be low where frequent mowing prevents plants from flowering or setting viable seed. As Skylarks seem to favour extensively managed areas, which are increasingly scarce in the modern lowland farmland landscape, the grassland swards found on many sea walls may become ever more important for this species.

In contrast to the Skylark, the Meadow Pipit is one of the few species of birds which routinely nests in stands of tall grass (Crofts & Jefferson 1999). Whilst they seem to prefer areas comprising a mosaic of short, long and tussocky grassland, the loss of patches of tall, rough grassland has contributed to the virtual disappearance of sward-nesting species such as the Meadow Pipit from large swathes of lowland Britain (Buckingham *et al*. 2010). As a result, the areas of taller grassland that remain are seen as being of high conservation importance for this species (JNCC 2012).

Mowing of tall grassland during the breeding season of the Meadow Pipit (usually mid-March to June) may therefore place nests at risk, especially as instead of flushing on the approach of possible danger, this species tends to remain crouched, often only breaking cover at the last moment (Cramp & Perrins 1994). As the Wildlife and Countryside Act 1981 (as amended) prohibits the destruction of bird nests, the presence of nests on sea walls has potentially serious implications for vegetation management. However, although sea walls support nesting birds (the Dengie SSSI citation for example indicating both Skylark and Meadow Pipit nest in the rough grassland of the sea wall folding), surveys in advance of vegetation management have shown there may be relatively few nests. A survey in 2007 of a sea wall at Walton-on-the-Naze in Essex for example revealed two pairs of nesting Meadow Pipits, one along the edge of the borrow dyke (outside the areas to be mown) and one which needed to be avoided at the base of the landward slope where it met the folding. Additional care was required here as it is well known that there can be increased predation of ground-nest sites where these have been left as islands of unmown vegetation in an area of mown vegetation (Ejsmond 2008).

Under suitable management, the grassland communities on sea walls can also provide important foraging areas for bird species like the Meadow Pipit (Buckingham *et al*. 2010). In a study on the influence of grassland sward structure and food resources on bird usage in lowland England, Atkinson *et al*. (2005) showed a strong negative relationship in summer foraging between insectivorous species like Meadow Pipit and increasing sward height. This suggested they preferred to forage in more open, shorter grasslands where prey was easier to find. This is supported by evidence of Meadow Pipits congregating on freshly cut hay to forage (Vickery *et al*. 2001). Freshly mown grassland on sea walls may therefore provide similarly attractive foraging areas. However, whilst the creation of short swards through regular mowing may increase accessibility to prey, this is likely to be offset by overall reductions in both their abundance and diversity (Buckingham *et al*. 2010).

Whittingham & Devereux (2008) investigated the effect of not mowing, mowing early, mowing late and early and late mowing on the distribution of wintering birds in agricultural fields. Wintering Meadow Pipits were shown to prefer unmown plots with longer grass. It was suggested this could possibly be explained by increased food abundance (e.g. above-ground invertebrates) in the longer swards. This is consistent with the findings of Perkins *et al*. (2000) which showed that taller swards were preferentially selected in winter by birds such as Meadow Pipit. However, it was suggested that the presence of bare ground also seemed important. There is also evidence that this species has a strong relationship with the availability of seeds in winter (Atkinson *et al*. 2005). As the seeds of broad-leaved species were an important food source in winter, the coarse-grass dominated swards found on many sea walls may be of importance as foraging habitat for Meadow Pipit at this time.

Less common species of birds may also nest on sea walls. The Rock Pipit *Anthus petrosus* for example has recently been reported breeding and foraging amongst the boulders found at the toe of the seaward slope of some sea walls such as that at Melton on the Deben Estuary (Wildlife Around Melton 2012). There is also evidence that other bird species use sea walls for loafing and feeding. Seed eaters, particularly species of finch, for example, have been recorded foraging on walls on the heads of thistles (*Cirsium* and *Carduus* species) and Teasel *Dipsacus fullonum*.

Hunting habitat for raptors

A number of raptors hunt along sea walls, notably Barn Owl *Tyto alba,* Short-eared Owl *Asio flammeus,* Hen Harrier *Circus cyaneus*, Kestrel *Falco tinnunculus* which are widely reported, as well as Montague's Harrier *Circus pygargus*, Buzzard *Buteo buteo*, Sparrowhawk *Accipiter nisus* and Hobby *Falco subbuteo*.

The Barn Owl is a bird of farmland and open country. It primarily preys upon small mammals, notably the Field Vole *Microtus agrestis* (Buckley & Goldsmith 1975). This common rodent often occurs in the highest densities in rough grassland, notably tussocky grass with a thick litter layer (RSPB 2012). The Barn Owl population in Britain has undergone a dramatic decline, largely as a result of the widespread loss of rough grassland for hunting and widespread use of rat poison. Remaining areas of tall grassland, particularly long, linear tracks such as those commonly encountered on the infrequently mown sea walls such as those of north Norfolk and around the Suffolk estuaries can therefore offer important foraging habitat for Barn Owls.

The Short-eared Owl is a regular winter visitor to coastal sites around Britain where they hunt over open tracts of countryside, including heaths and grazing marshes close to the coast, saltings and along sea walls (Piotrowski 2003). Based on the observations of 40 ornithologists, Glue (1977) found the main hunting technique was by quartering flights some 0.5 to 2 m above the ground. Although

the Field Vole accounted for about 50% of the diet, a wide variety of small mammals and small to medium sized birds were also taken. Whilst generally hunting alone, Short-eared Owls often roost communally on the ground amongst long grass (Piotrowski 2003), including on more remote sea walls bordering saltmarshes covered in rough grass (Glue 1977). The location of such roosts is often betrayed by the presence of pellets amongst the vegetation, though these may be hard to find.

In winter, Hen Harriers can be found over lowland farmland, heathland, fenland, river valleys and coastal marshes. Those found in eastern and south-east England at this time are mostly migrants from mainland Europe (RSPB 2012). The Hen Harrier usually hunts during the hours of daylight at low level, using the terrain (such as sea walls) to mask its approach on potential prey which includes passerines and several species of wading bird (Madders 2003). Voles and mice make up the majority of mammals taken (Lack 1986). Hen Harriers invariably roost amongst rank ground vegetation, in a variety of open habitats, with 28% of roost sites on the ground (Clarke & Watson 1990). This may include vegetated sea walls in more remote and quiet areas.

Case study

Barn Owl and Kestrel, Donna Nook, north Lincolnshire

On the Wash and Humber Estuary, where successive land restoration projects have been undertaken, grassy sea walls, old and new, bisect the landscape. In these areas, a long-standing project has been undertaken by Colin Shawyer (Wildlife Conservation Partnership), which has established the value of these habitats to small mammals and hence Barn Owls and Kestrel. Historically this reclaimed landscape offered no nesting opportunities to these birds. In 1990, the project set about designing and installing pole-mounted two-chambered nestboxes. By 2010, these areas held some of the highest Barn Owl breeding densities in Britain which were almost entirely dependent on the prey-rich sea walls and ditch banks for successful foraging (Shawyer personal communication). Kestrels were also frequent hunters along the sea wall.

Linked to this success is the reduction in intensive mowing and in some cases, grazing regimes, on sea walls and river banks. This helped to re-establish a tussock structure and to provide a deep litter layer and a rank grassy sward, critical habitat components for the Field Vole, the major prey for Barn Owls and Kestrels.

Grassland management for small mammals does not involve complex management regimes. It requires the provision of a largely perennial grassland sward which is capable of developing dense tussocks, and a litter layer under which Field Voles can make hidden runways, create food

stores and nest. A tall rank sward is not critical but provides a more immediate indicator that the grassland is likely to comprise the necessary components for high Field Vole abundance. Occasional mowing to the landward bank/folding and the outer edges of the crest (every second or third year in September/October) with cutting blades set at 6-7.5 cm is usually necessary to prevent the invasion of scrub. The cutting of the seaward face and access track on the crest should be managed to suit the particular conditions, e.g. close mowing where vehicular and pedestrian movement is required. Mosaics of grassland habitat can, in any case, be beneficial.

Today in England and Wales there is a growing matrix of habitat networks established for the benefit of Barn Owls including sea walls, some of which have been designated as Species Recovery Areas (SRAs) and Barn Owl Recovery Networks (BORNs). These identify specific areas and habitat networks where concerted conservation efforts have taken place and as a result, deserve particular consideration with respect to sympathetic vegetation management. These networks have largely been responsible for a resounding conservation success with Barn Owl numbers recovering from about 4,000 pairs in the late 1980s and the 1990s to an estimated 8,000-9,000 today.

Linked to this success, pole-mounted nestboxes were installed on newly constructed sea walls at Donna Nook, north Lincolnshire.

Overwintering birds

Some sea walls are noted as high tide roosts especially where sea walls or the saltmarsh fringing the tidal face of sea walls could be used as a high tide roost over winter (November-March) for migrant bird species or where mudflats against a sea wall are utilised by wading birds and wildfowl as feeding areas at low tide. Often these roosts will be in or near internationally designated sites such as SPAs or Ramsar sites, or those of national interest such as SSSIs or NNRs for their overwintering bird populations. There has been some research on behavioural responses of coastal birds to noise disturbance and escape distances (EDs) vary between species (Laursen *et al*. 2005). The escape distance was defined as the shortest distance at which birds flush from a person or another disturbing stimulus. These escape distances have been used to determine buffer zones between disturbing activities (which mowing or scrub clearance could be classed as) and waterbirds. Table 3.5 shows the mean EDs (and minimum and maximum EDs) for a range of coastal birds. Escape distances vary greatly between species and can be influenced by a whole range of factors such as wind force and region (Laursen *et al*. 2005). Disturbance also depends on the noise level of the machinery used to cut sea walls (Cutts *et al*. 2009). For instance research suggests that birds will habituate to regular ambient noise levels (e.g. below 70db(A)) and may be more susceptible to disturbance at higher noise levels

(above 70db(A), particularly if it is more irregular in nature (e.g. stop and start). Operatives walking around during sea wall management may also lead to more disturbance than if they are largely restricted to the cab of a mowing machine for example.

Table 3.5. Escape distances (mean, minimum and maximum) for selected species of waterbirds in autumn and spring during a study in the Danish Wadden Sea (data from Laursen *et al*. 2005)

Bird species	Mean ED (m)	Minimum ED (m)	Maximum ED (m)
Wildfowl			
Brent Goose *Branta bernicla*	319	130	1000
Shelduck *Tadorna tadorna*	225	55	700
Mallard *Anas platyrhynchos*	236	60	400
Teal *Anas crecca*	197	80	450
Pintail *Anas acuta*	294	100	500
Wigeon *Anas penelope*	269	150	1000
Waders			
Oystercatcher *Haematopus ostralegus*	119	20	400
Lapwing *Vanellus vanellus*	142	45	450
Curlew *Numenius arquata*	298	58	650
Bar-tailed Godwit *Limosa lapponica*	156	40	450
Redshank *Tringa totanus*	137	40	450

Research from the Stour and Orwell Estuaries SPA in eastern England showed that there were differences in the level of bird disturbance overwinter depending on the estuary (Ravenscroft *et al*. 2007). The greatest disturbance to birds was caused by walkers with dogs and boats. Relatively infrequent disturbance events such as shooting, aircraft noise and bait digging also caused disturbance. Disturbance was site specific and varied depending on the number of activities, the state of the tide (disturbance was greatest at high tide), width of mudflat and shore characteristics (Ravenscroft *et al*. 2007). What was clear from the study was that birds could habituate to benign disturbance from horses and vehicles and that the impact of disturbance was reduced at low tide and near larger areas of mudflats.

If mowing or other management is to be undertaken near a known high tide roost or mudflat valuable as a feeding resource at low tide (BTO, Natural England, RSPB or local birders could advise on locations of overwintering birds) then consideration will need to be given to the timing of the works, in liaison with Natural England if the area is within a statutorily designated site. In general, given the escape distances displayed in Table 3.5, it is sensible to adopt an approach of not working within 250 m of a known winter high tide roost or mudflat between November-March if a high level of noise is expected (Cutts *et al*. 2009). This buffer zone should ensure that birds are not subjected to undue disturbance, particularly if large numbers of people will be walking around on the sea wall. Where vegetation management has to occur close to a high tide roost for example, then low tide working is advised. However, in less sensitive locations (e.g. no roosts) it may be acceptable to mow or clear scrub on a sea wall over winter, accepting that adherence to the freezing weather guidelines developed by Natural England/JNCC in liaison with wildfowling groups is observed. For example, works should stop after 7 days of freezing weather (below zero temperatures) (a voluntary wildfowling ban) and may only restart after 3 days of warmer temperatures. For more information on these guidelines see The British Association for Shooting and Conservation (BASC) website (http://basc.org.uk/) where a voluntary ban (i.e. 7 days of freezing weather) on wildfowling (the trigger for sea wall works to stop near sensitive bird sites) would be officially announced.

Mammals

Mammals as a group are notoriously under-recorded in the field (Mammal Society 2012). As such, there is usually insufficient knowledge about their distribution and abundance to be able to identify those sea walls which support important or vulnerable populations. That said, the mosaic of habitats present on vegetated sea walls, especially raised embankments which predominantly protect farmland, usually offer excellent mammal habitat. To put this into context, in Essex alone, over 300 ha (equivalent to 3 km^3) of grassland was left uncut on the foldings of sea walls in 2011. This represented not only a significant extent of habitat suitable for small mammals, but just as importantly a valuable corridor linking other areas of suitable mammal habitat. With twenty species of mammals shown to be associated with the sea walls of Essex, they are increasingly being recognised as one of the most important mammal habitats in the county (Gardiner personal communication).

▽ Small mammal habitat

The tall, unmown grasslands frequently found on the folding and landward slopes of sea walls provide particularly suitable cover and food for common small mammals such as Field Vole, Common Shrew *Sorex araneus* and Wood Mouse *Apodemus sylvaticus*.

The Field Vole, or Short-tailed Vole, tends to live in ungrazed grassland where it eats seeds, roots and leaves. Although active by day and night, they spend considerable time in runs and burrows and are therefore less likely to be seen than some other small mammals. Periodic crashes in Field Vole numbers are well documented, though recovery seems to quickly follow, not least because Field Voles can have three to six litters a year, of up to seven young each.

The Common Shrew is a small insectivorous mammal found hunting through undergrowth for their prey, which includes earthworms, spiders and chrysalises. Common Shrews can be found in most habitats, including well-vegetated sea walls. They are occasionally encountered for example on the sea walls of Pagham Harbour in Sussex (Holloway & Holloway 2012). The Wood Mouse is also a common small mammal around Pagham Harbour where it frequents not only more traditional habitats such as the edge of woodland and copses, but also the more open vegetation of the sea walls which have some scrub cover. The diet of this species includes fruits (or berries), notably those of Hawthorn, as well as seeds and small invertebrates. They nest under bushes, which on sea walls can include Gorse *Ulex europaeus* and Blackthorn.

Further up the food chain, small mammals form an extremely important part of the diet of many predators. A Weasel *Mustela nivalis* for example was seen carrying a dead Common Shrew in its mouth on the sea wall folding at Old Hall Marshes in 2011 (Gardiner personal communication) and in some years, after a good breeding season, can be numerous hunting along the West Wall at Pagham Harbour (Holloway & Holloway 2012). The frequency with which birds of prey are also seen hunting uncut grassland and scrub next to shorter mown swards on sea walls also suggests small mammals are probably present in good numbers. Analysis of Barn Owl pellets on the Dengie Peninsula in Essex for example suggested the Harvest Mouse *Micromys minutus* was commonly found in the vicinity of the sea walls in the area (John Dobson personal communication). Equally, the shorter grass sward, with an improved structure, resulting from the introduction of grazing to sea walls at Orfordness on the Alde-Ore Estuary in Suffolk was found to contribute to its value as habitat for small mammals such as mice, shrews and voles, and in turn the area provides valuable hunting territories for raptors such as the Barn Owl, Short-eared Owl and Hen Harrier (National Trust 2000).

Case study

Mammals on the Parkgate sea wall at high tide, Wirral peninsula

Due to the nature of the tides in the Dee Estuary the sea now only comes up to the sea wall at Parkgate on the Wirral peninsula on the very highest tides. At this time, and when conditions are right, the entire fronting marshland becomes submerged forcing large numbers of small mammals from their hiding places to seek higher ground on the sea wall. Species commonly seen include Field Vole swimming towards the sea wall then climbing up to hide in grassy tussocks or even sitting on top of the wall in full view. Water Shrews *Neomys fodiens* are also numerous. Other species observed at these times include Common Shrew, Pygmy Shrew *Sorex minutus*, Wood Mouse and House Mouse *Mus musculus*. The spectacle offers a unique opportunity to view in close proximity a number of small mammal species which are seldom seen in the wild otherwise to the extent that these events are publicised by organisations such as the RSPB (Britt 2008).

Whilst the Parkgate sea wall can therefore be seen as offering a valuable high tide refuge, something that may be replicated elsewhere, small mammals can be vulnerable to predation when exposed by the high tides. At Parkgate, they may be taken by Grey Heron *Ardea cinerea* and Little Egret *Egretta garzetta*, as well as by birds of prey such as Short-eared Owl and Kestrel. However, the risk is not only from avian predators as Weasels have also been seen hunting for voles in the grassy tussocks along the Parkgate sea wall.

Brown Hare *Lepus europaeus* is another species which benefits from uncut sea wall grasslands. The national population of this species underwent a marked decline in the latter half of the 20th century, but is believed to have stabilised in the last 10 years. It still occurs widely across much of rural Britain, especially the open farmland landscapes of Eastern England (Natural England 2007a).

Unlike Rabbits *Oryctolagus cuniculus,* Brown Hares do not reside in underground burrows. Instead, they spend most of their time lying in or near a surface depression known as a 'form', from which they move out to feed between dawn and dusk (Cowan 2004). The tall grassland found on many sea walls which protect open farmland may therefore provide suitable habitat within which Brown Hares can create a 'form', as well as to forage and find cover if disturbed. In intensive agricultural landscapes the rough grassland present on sea walls may become particularly

important, even if only temporarily or seasonally. Frylestam (1992) for example, demonstrated that narrow, linear strips of land comprising a range of grasses and herbs can offer valuable feeding refuges for Brown Hares to help ensure continuity of food supply in habitats otherwise dominated by arable crops. Tapper & Barnes (1986) suggested that the home ranges of Brown Hares may expand to include such habitat areas, notably with day-time refuges lying outside night-time foraging ranges and several authors have concluded that the needs of this species are likely to be most easily met in habitats that are relatively diverse (e.g. Vaughan *et al*. 2003).

Approximate estimates of annual mortality amongst adult Brown Hares range from 48-65% across Europe (e.g. Kovacs 1983). Annual mortality in grassland habitats in the UK has been shown to be at the upper end of this range at 65% (University of Bristol 2003). McLaren *et al*. (1997) suggested that increasing fragmentation of good quality habitat might be important in the poor performance of this species in grassland landscapes. Maintaining suitable corridors such as those offered by many sea walls may therefore be important to Brown Hare populations in coastal areas.

Whilst the optimum habitat requirements have not yet been fully defined for this BAP species, boundary strips and areas of grassland in predominantly arable areas are important (Tapper 1999). The quality of available cover is also likely to be important, particularly in protecting leverets from predation. Breeding generally takes place between February and September. The substantial increase in grass grown for silage which is repeatedly cut from May onwards is thought to have led to a substantial reduction in leveret survival, especially with the instinct of young Brown Hares to remain motionless likely to prove fatal. Although, Brown Hares are often flushed from sea walls during early summer, sea walls appear to seldom be used for breeding. Nevertheless, to help ensure young Brown Hares are not harmed, it is recommended that areas of long grass should be walked prior to mowing to encourage any Brown Hares present to move elsewhere.

Whilst sea walls do not normally provide suitable roosting sites for bats they can provide foraging habitat for some species, notably Serotine *Eptesicus serotinus* and Noctule *Nyctalus noctula*.

The Serotine bat has a southerly distribution in Britain and tends to forage over lakes, along rivers and in open habitats (Vaughan *et al*. 1997). Three main feeding strategies have been identified: short flights, ground feeding (gleaning), and aerial hawking, with the latter often predominant (Catto *et al*. 1996). The national bat habitat survey (Walsh & Harris 1996) showed Serotines utilised the coast for foraging where there was suitable habitat to support their insect prey. The diet mainly consists of Coleoptera, including both crepuscular and diurnal species (Battersby & Tracking Mammals Partnership 2005). Lepidoptera and Diptera have also been shown to make up part of the Serotine diet (Vaughan 1997). The greatest diversity of prey items were consumed in June (Catto *et al*. 1995), something that could have some bearing on the timing of sea wall mowing.

The Noctule (a UK BAP species) is one of the first British bats to emerge in the evening with foraging activity often peaking for one hour at dusk and half an hour at dawn. It is one of the larger British bat species and primarily feeds by aerial hawking of moths, beetles and other large insects. The diet consists mainly of Diptera, with both crepuscular and diurnal species being taken (Vaughan 1997). Noctules forage exclusively in open habitats (Kronwitter 1988). They have been reported feeding over coastal marshes, though this may be related to the presence of water-filled borrowdykes, especially those that are well-sheltered and connected to other habitats.

Chapter 4: Making management decisions

Introduction

The vegetation management techniques applicable to sea walls are detailed later in this handbook. The purpose of this chapter is therefore to outline the main considerations to take into account when deciding on the most appropriate vegetation management techniques to apply to sea walls.

Four guiding principles can be seen as underpinning delivery of an informed, integrated and holistic approach to sea wall vegetation management:

- Compatible with delivering consistent standards for sustainable flood risk asset management;
- Compliance with legislation and policy covering flood risk management and nature conservation, including in relation to species protection;
- Managing the requirements of land owners and other users of sea walls, through a proactive approach to customer engagement which responds to, and manages, expectations; and
- All sea walls have the potential to be valuable for biodiversity to a lesser or greater extent and should therefore be managed to achieve nature conservation priorities, preferably through some form of rotational management.

Compatibility with maintenance standards

Maintenance standards (i.e. acceptable condition) determine the vegetation management regimes required to maintain flood risk assets such as sea walls. These are detailed in the Flood and Coastal Risk Management (FCRM) Asset Management Maintenance Standards Version 3 (Environment Agency 2012) and help determine the regular (routine) maintenance activities necessary to maintain assets in an acceptable condition.

The Environment Agency has devised five maintenance standards, three of which are particularly relevant to sea wall vegetation management:

- Good (target condition 2) with only minor defects that will not reduce the performance of the asset;
- Fair (target condition 3) with some defects that could reduce performance of the asset; and
- Poor (target condition 4) with defects that significantly reduce the performance of the asset.

There are two other maintenance standards (target conditions 1 and 5) but these are not used in assessing sea walls as the former is 'Very Good' (e.g. a newly built wall with only cosmetic defects) and the latter (Very Poor) is for serious failures and should not be an aim to achieve. Each standard defines the maintenance activities that are undertaken in most circumstances. In relation to sea walls, these include:

- Grass cutting by hand (GH) covering all methods of grass control by hand held or hand guided equipment, including by scythe, strimmer, pedestrian mower, spraying, etc;
- Grass cutting by mechanical means (GM) covering all methods of grass control using ride on or ride in machinery; and
- Tree work (TW) covering pollarding, felling, coppicing, branch lopping, stump removal and clearance of scrub.

Maintenance standards also determine the number of times per year (frequency) that each particular maintenance task should be undertaken (e.g. twice a year or once every twenty years).

The Environment Agency has devised four mowing options (MS1-4) which can be applied to the management of vegetation on sea walls (Enviroment Agency 2012). These mowing options are displayed in Chapter 5 (Figure 5.1). However, where wildlife considerations dictate, there can be deviation from these mowing options as long as the reasons for this are clearly justified and documented.

Compliance with legislation and policy

Landowners have the primary responsibility for safeguarding their land and property against tidal flooding. Whilst there is no general duty on the Government to protect land or property against flooding, operating authorities have permissive powers to carry out works and maintain flood defences in the public interest.

This section outlines the main components of nature conservation legislation and policy framework in operation in 2015 relevant to vegetation management of sea walls. It is not a comprehensive review, neither is it a definitive description of the law. Rather, it focuses on those pieces of legislation and powers, duties and policies relevant to decision making.

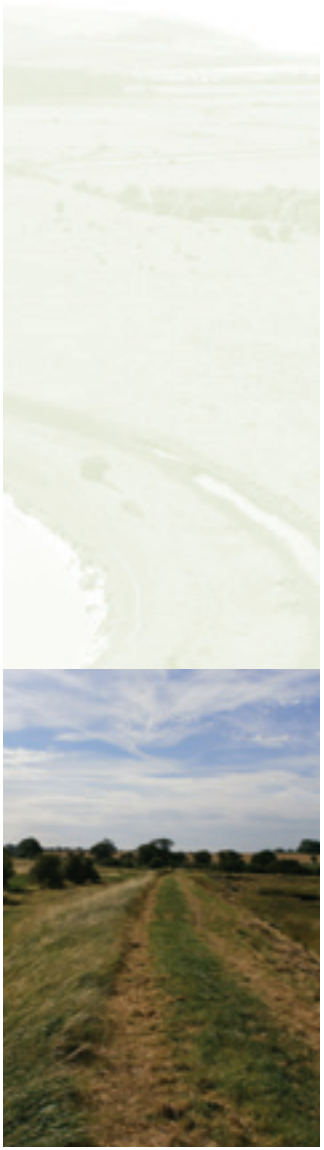
International legislation

Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive) 1992

The principal aim of this Directive is the protection of natural habitats. Whilst it also protects any species that occur within those habitats (e.g. Shrubby Sea-blite and Sea-purslane), a range of species are listed on Annexes as requiring special protection.

Annex 4 species are of Community interest in need of strict protection. They are protected from killing, capture, disturbance or the destruction of their habitat. An example of an Annex 4 species that can occur on sea walls is the Natterjack Toad, which is known to use the sandy sea walls of north-west Norfolk.

Annex 2 species are of European Community interest (i.e. endangered, vulnerable, rare or endemic in the European Community) whose conservation requires the designation of SACs. These species would therefore be the primary interest features of an SAC. Two examples of Annex 2 species that can occur on sea walls are the Narrow-mouthed Whorl Snail and Fisher's Estuarine Moth. Hog's Fennel is a notified feature within Hamford Water SSSI. A public consultation commenced in July 2012 on designating those areas where Hog's Fennel grows within this SSSI as an SAC for Fisher's Estuarine Moth, this is described in the case study below.



Case study

Mowing sea walls for Fisher's Estuarine Moth, Hamford Water, Essex

Fisher's Estuarine Moth is found within grassland habitats, including those on sea walls, where Hog's Fennel, its sole larval food plant, grows. Fisher's Estuarine Moth is legally protected under Schedule 2 of the Conservation of Habitats and Species Regulations 2010. As a European protected species, the deliberate capturing, disturbing, injuring or killing of Fisher's Estuarine Moth is prohibited, as is damage or destruction of their breeding sites or resting places.

The Hamford Water area of the north Essex coast is the main stronghold for the moth in the UK (Ringwood & Woodrow 2012). Much of the habitat where the moth is found occurs along stretches of sea wall maintained by the Environment Agency. It is necessary for these stretches of wall to be managed under a mowing regime that enables them to be properly inspected and maintained to the condition standard required for the flood risk management function of the sea walls, but which is also sympathetic to the requirements of Fisher's Estuarine Moth.

The Environment Agency has been managing the main sites with Hog's Fennel on the sea wall according to a mowing regime agreed in 2006. In July/August 2011, all areas where Hog's Fennel had been mapped the previous year were surveyed for larval feeding signs of Fisher's Estuarine Moth. The results showed that numerous areas along the sea wall with Hog's Fennel supporting Fisher's Estuarine Moth were not included within areas subject to the agreed mowing regime.

Following a meeting in June 2012 between the Environment Agency, Natural England and Tendring District Council, the area covered by the mowing regime aimed at conserving Hog's Fennel was extended to take account of all stretches of the Hamford Water sea wall with Hog's Fennel. The entire stretch of wall covered by this regime until at least 2026 is now approximately 23 km.

Initial research into the conservation management of Fisher's Estuarine Moth found that annual cutting of sea walls at the end of August was detrimental to the abundance of the species (Ringwood 2004a), probably because mowing at this time of year left the grass too short for the ovipositing female moths to lay their eggs on. It is recommended that where sites must be mown in August this is performed on rotation, leaving much of the site uncut each year (Ringwood 2004b). This moth prefers to lay its eggs on long, coarse grass species such as False Oat-grass, Cock's-foot, and Couch spp. (Ringwood *et al*. 2002b), which occur in close proximity to the larval foodplant, Hog's Fennel (Ringwood *et al*. 2002a). The response of Fisher's Estuarine Moth to a rotational sea wall mowing regime was monitored in Hamford Water in north-east Essex. The protocol for mowing was agreed with Natural England due to the listing of the moth in Schedule 5 of the Wildlife and Countryside Act (1981) and the soon to be established SAC which is purely designated for the presence of this species. There was an increase in larval occurrence on the sections mown between 10-25th August on a three-year rotation, and a decrease on the unmown strip next to the borrowdyke (Figure 4.1).

Before the mowing regime was established in 2005, larval feeding signs were concentrated on Hog's Fennel along the borrowdyke edge. Consequently, it appeared that the revised rotational management resulted in Fisher's Estuarine Moth utilising the sea wall more uniformly, rather than being largely confined to areas that were not mown, such as the borrowdyke edge. In 2007, the percentage of Hog's Fennel plants with signs of larval feeding was considerably higher than in 2005, indicating that the rotational management was beneficial to the abundance of the moth on the sea wall. Scrub encroachment where sections of sea wall are uncut appears to be a significant problem for the moth because Blackthorn can quickly smother the larval foodplant, Hog's Fennel (Ringwood 2008). A targeted programme of scrub clearance may be necessary to maintain stands of Hog's Fennel under rotational mowing regimes.

The optimum management for Fisher's Estuarine Moth is to conduct the minimum amount of cutting necessary to maintain a rank grassland habitat and prevent scrub encroachment. The moth lays its eggs on long grass during its flight season in September/October. Consequently when cutting in the

agreed August window (1-25 August), no more than a third of a site should be cut in any one year to ensure the moth has sufficient grasses to fulfil its egg laying requirements. The only exception to this rule is where the site has a considerable invasion of encroaching scrub that must be controlled. In such cases, up to 50% of the site can be cut each year until the scrub is under control.

It is recognised that the Environment Agency now require walls to be cut on a regular basis to enable them to be inspected and maintained. A cutting rotation has been agreed between the Environment Agency and Natural England that enables this to be achieved whilst ensuring that the management requirements of the moth are met. It was decided that, due to the widespread distribution of the moth along the sea wall and folding around Hamford Water, the cutting rotation should be applied to the entire stretch of wall where areas of Hog's Fennel are found, rather than to individual plots only.

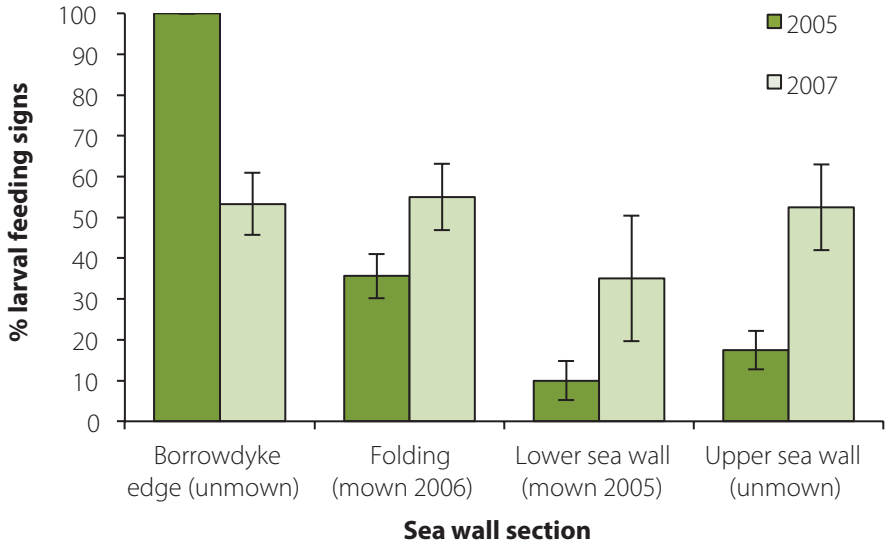


Figure 4.1. Mean percentage occurrence of larval feeding signs of Fisher's Estuarine Moth on Hog's Fennel for four landward sections of a sea wall mown on a three-year rotation established in 2005 (standard error bars shown) (data: Ringwood 2008)

The four principles governing the mowing of the Hamford sea walls supporting Hog's Fennel are listed in Table 4.1.

Table 4.1. The four principles governing the mowing of the stretches of the Hamford sea walls supporting Fisher's Estuarine Moth

Key considerations	
Timing	All mowing along the stretches of sea wall identified as supporting Hog's Fennel must be conducted between the 1st and 25th August. This is when Fisher's Estuarine Moth is underground either feeding as a larva or pupating within the rootstock of Hog's Fennel and as such will not be directly damaged by mowing.
Geographical coverage	Due to the widespread distribution of Fisher's Estuarine Moth along the sea wall and folding around Hamford Water, the mowing regime will be applied to the entire stretch of wall where Hog's Fennel has been identified, rather than to individual stretches or plots.
Extent of mowing	The agreed regime requires the minimum amount of mowing necessary to maintain a rank grassland habitat and prevent scrub encroachment. Generally, no more than a third of a stretch of sea wall should be mown in any one year. This is to ensure sufficient long grass is available for egg-laying by Fisher's Estuarine Moth during the adult flight season in September/October.
Frequency	For inspection and maintenance purposes the Environment Agency required the landward face of the sea wall to be cut every two years and the seaward face to be cut every four years. An access strip along the folding also needed to be cut every two years. It was agreed that this would be achieved by splitting the folding into two halves: borrowdyke side and sea wall side. Consequently, the four year rotational mowing plan was as follows: **Year 1:** Cut seaward face of sea wall, borrowdyke half of folding for access and crest of sea wall (where required) **Year 2:** Cut landward face of sea wall **Year 3:** Cut sea wall half of folding for access **Year 4:** Cut landward face of sea wall.

The EC Directive on the Conservation of Wild Birds (The Birds Directive) 1979

The EC Directive on the Conservation of Wild Birds (79/409/EEC) (the Birds Directive) is the primary piece of European legislation dealing with the protection of wild birds within the European Union. It bans activities that directly threaten birds, such as the deliberate killing or capture of birds, the destruction of their nests and taking of their eggs, and associated activities such as trading in live or dead birds (with some exceptions listed in Annex III of the Directive). It provides for the designation of SPAs for populations of rare or vulnerable species listed on Annex I of the Directive as well as for all regularly occurring migratory species. Annex 1 birds of prey which may hunt along sea walls include wintering Short-eared Owl.

The main provisions of the Birds Directive relevant to the conservation of foraging raptors found in Europe relate to habitat protection, general species protection and sale of live and dead birds. Within the European Union, the Directive implements the ornithological aspects of the Bonn Convention on the Conservation of Migratory Species of Wild Animals and the Convention on the Conservation of European Wildlife and Natural Habitats (the Berne Convention).

The Bonn Convention on the Conservation of Migratory Species of Wild Animals 1979

This Convention is concerned with the protection of populations of migrating species (and related habitats) from the threat of degradation / destruction. There are two main categories of species listed on Appendix 1 and 2. Those on Appendix 1 are considered endangered and may not be killed, taken from the wild etc. Habitats that are used by these species are to be protected (and restored if possible), obstacles preventing migration should be removed / minimised, and any factors contributing to further endangerment of the species should be prevented / removed. Those listed on Appendix 2 are considered vulnerable and could easily become endangered without appropriate protection.

Council of Europe Convention on the Conservation of European Wildlife and Natural Habitats (Berne Convention) 1979

The aim of the Berne Convention is to protect important populations of listed wild species and their habitats. Those listed under Appendix 2 of the Berne Convention are considered species requiring special protection (`appropriate and necessary legislative and administrative measures`). This includes from all forms of deliberate capture and keeping and deliberate killing; the deliberate damage to or destruction of breeding or resting sites; the deliberate disturbance of wild fauna, particularly during the period of breeding, rearing and hibernation, insofar as disturbance would be significant in relation to the objectives of this Convention; the deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty; and the possession of, and internal trade, in these animals, alive or dead, including stuffed animals. An example of a species listed on Appendix 2 which may occur on sea walls is the Natterjack Toad.

Species listed under Appendix 3 of the Berne Convention require special protection through 'appropriate and necessary legislative and administrative measures' in their natural range which includes Britain. It focuses on those species not listed in Appendix 2 but which still require protection from exploitation (including mass killing, trading etc.). Species listed on Appendix 3 which may occur on sea walls include Common Toad, Grass Snake and Common Lizard.

The Convention on Wetlands of International Importance, especially as Waterfowl Habitat 1971

The Convention on Wetlands (Ramsar, Iran, 1971), generally called the Ramsar Convention, is an intergovernmental treaty embodying the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the wise or sustainable use of all of the wetlands in their territories. The way in which this is achieved is mainly through the designation of Ramsar sites. A range of species, including plants, invertebrates and birds are listed as interest features on the Ramsar site citations. Examples of species listed on Ramsar site citations which include vegetated sea walls are shown in Table 4.2.

Table 4.2. Examples of species listed on Ramsar site citations likely to occur on vegetated sea walls

Common name	Scientific name	Example Ramsar citations
Slender Hare's-ear	*Bupleurum tenuissimum*	Benfleet and Southend Marshes
		Colne Estuary (Mid Essex Coast)
		Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)
		Deben Estuary
		Foulness (Mid Essex Coast Phase 5)
		Humber Estuary
		Severn Estuary
		The Swale
Sea Barley	*Hordeum marinum*	Benfleet and Southend Marshes
		Blackwater Estuary (Mid-Essex Coast Phase 4)
		Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)
		Dengie (Mid-Essex Coast Phase 1)
		Foulness (Mid Essex Coast Phase 5)
		Medway Estuary and Marshes

		Severn Estuary
		The Swale
Shrubby Sea-blite	*Suaeda vera*	Colne Estuary (Mid Essex Coast)
		Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)
		Deben Estuary
		Dengie (Mid-Essex Coast Phase 1)
		Foulness (Mid Essex Coast Phase 5)
		North Norfolk Coast
		Poole Harbour
Dittander	*Lepidium latifolium*	Alde-Ore Estuary
		Blackwater Estuary (Mid-Essex Coast Phase 4)
		Deben Estuary
		Severn Estuary
Borrer's Saltmarsh-grass	*Puccinellia fasciculata*	Blackwater Estuary (Mid-Essex Coast Phase 4)
		Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)
		Deben Estuary
		Medway Estuary and Marshes
		Thames Estuary and Marshes
Narrow-mouthed Whorl Snail	*Vertigo angustior*	Deben Estuary
		Minsmere-Walberswick
Yellow-striped Bear-spider	*Arctosa fulvolineata*	Minsmere-Walberswick
		Stour and Orwell Estuaries
		Solent and Southampton Water
Whelk-shell Jumper	*Euophrys browningi*	Alde-Ore Estuary
		Dengie (Mid-Essex Coast Phase 1)
A weevil	*Cosmobaris scolopacea*	Blackwater Estuary (Mid-Essex Coast Phase 4)
		Dengie (Mid-Essex Coast Phase 1)
		Medway Estuary and Marshes

National legislation

Land Drainage Act, 1994

Section 61 of the Land Drainage Act, 1994 places a duty on operating authorities when formulating or considering any proposals relating to their functions, to exercise their powers to further the conservation and enhancement of natural beauty and the conservation of flora and fauna.

The Land Drainage Act, 1994 also places a duty on operating authorities to consult Natural England before carrying out any works, operations or activities which appear likely to destroy or damage flora, fauna or other features for which an area of land has been notified as a SSSI.

Natural Environment and Rural Communities Act, 2006

Section 40 of the Natural Environment and Rural Communities (NERC) Act 2006 places a duty on public bodies to consider biodiversity in the full range of their activities. It is a legal requirement that:

> ***"Every public body must, in exercising its functions, have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity."***

The duty affects all public authorities in England and Wales, which include public bodies and government and statutory undertakers. The latter includes bodies carrying out functions of a public character under a statutory power. The Environment Agency and other public bodies with a responsibility for flood risk management therefore have a statutory duty under the NERC Act 2006 to maintain, restore and where possible enhance the natural environment when carrying out sea wall vegetation management.

A range of both plant and animal species are listed in Section 41 of the NERC Act 2006 as being of principal importance for the conservation of biodiversity in England. The Act places a duty on public bodies to consider the presence of these species when performing any of their functions with a view to conserving biodiversity. The inclusion of a species or habitat in Section 41 means they are of principal importance for the conservation of biodiversity . The NERC Act 2006 placed a duty on public bodies to have regard to the conservation of biodiversity during their normal decision-making.

The Conservation of Habitats and Species Regulations 2010

The Conservation of Habitats and Species Regulations 2010 replaced The Conservation (Natural Habitats, &c.) Regulations, 1994. They makes it an offence to deliberately kill, capture, or disturb any species listed in Schedule 2 (animals) or to damage or destroy the breeding site or resting place of such an animal,

or to pick, collect, cut, uproot or destroy any part of a species listed in Schedule 4 (wild plants). Inclusion on either Schedule makes that species a "European Protected Species". It also makes it an offence to keep, transport, sell or exchange, or offer for sale or exchange, any live or dead part of a European Protected Species, or any part of, or anything derived from, such a species. An example of a species listed on Schedule 2 and therefore a "European Protected Species" which may occur on sea walls is the Natterjack Toad.

Wildlife and Countryside Act, 1981 (as amended)

The Wildlife and Countryside Act, 1981 (as amended by the Countryside and Rights of Way (CROW) Act 2000) is the principal piece of legislation protecting wildlife and the natural environment in the UK. It is split into various sections covering plants, animals, birds and miscellaneous others with each section relating to various lists of species (schedules) covered by the provisions of that section.

All wild birds are covered by Section 1 of the Act, protecting them from killing, injuring or taking along with the taking, damaging or destroying of any nest of a wild bird whilst it is being built or in use or eggs once present. It also prohibits possession of wild birds (either dead or alive) or their eggs. There are additional penalties for offences relating to birds listed on Schedule 1 of the Act and it is, in addition, an offence to disturb these birds whilst building a nest, near a nest containing eggs or unfledged young or their dependent young.

Section 9 Part 1 of the Act prohibits the intentional killing, injuring or taking of those wild animals listed on Schedule 5. Places used by animals covered under Part 4(a) of this Section for shelter and protection are protected against intentional damage, destruction and obstruction. In addition to this, animals protected under Part 4(b) of the Section must not be intentionally disturbed whilst occupying those places. Therefore, where there will be a significant change in habitat, a reasonable effort must be taken to remove reptiles off site to avoid committing an offence. The Natterjack Toad is an example of a species listed on Schedule 5 which receives full protection under Section 9. Grass Snake and Common Lizard receive partial protection under Part 1 and Part 5, while Common Toad is protected under Part 5 only.

The Brown Hare is not listed under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is thus not afforded any special protection under this legislation because it is a game animal that can be managed by farmers and landowners. Whilst it receives little legal protection, the Hare Preservation Act 1892 forbade the sale of this species during the notional main breeding season of 1 March to 31 July inclusive. This legislation was intended to protect numbers in response to a dramatic decline in the Brown Hare population (Stroud *et al*. 1999). However, the Agriculture Act 1947 enables notices to be served to control pest species, including Brown Hare, to protect crops, pasture, foodstuffs, trees, banks, hedges or works on any land. The species also now receives some legal protection under the Wild Mammals Protection Act 1996, which prohibits cruel treatment of all wild mammals.

All wild plants are protected under Section 13 of the Wildlife and Countryside Act 1981 (as amended). Part 1(a) prohibits the intentional picking, uprooting or destruction of plants listed on Schedule 8. Part 1(b) of the Act prohibits the unauthorised intentional uprooting of any wild plant species not included in Schedule 8.

A range of species are also listed as interest features on the citations of SSSIs, notified under the Wildlife and Countryside Act 1981, as amended. These include Shrubby Sea-blite, Narrow-mouthed Whorl Snail, Natterjack Toad and Short-eared Owl.

Biodiversity Action Planning

UK BAP

The UK BAP is a UK Government initiative intended to help protect "biological resources". This includes species and their habitats. A major review of the UK BAP took place in 2007, resulting in many additional species becoming BAP species. Species-specific BAPs are being created and implemented for these at both a national and local, most often county, level. Some species-specific BAPs are not yet complete. The majority of species listed are considered to be "Priority" species. Those UK BAP species included in the list produced under Section 41 of the NERC Act 2006 are now also considered of principal importance for the conservation of biodiversity in the UK. The revised UK BAP contains a number of species that are listed as 'Research Only', in recognition of the inadequately understood decline of formerly common species. The Small Heath *Coenonympha pamphilus* butterfly is an example of a species in this category that can be found on sea walls.

▽ Small Heath (Karen Brown)

Primarily because Brown Hare populations have been in decline across much of Europe for the past forty years, the Brown Hare has been included in the UK BAP. The species is not threatened; indeed it is more abundant than a number of truly native mammal species not included in the BAP (Tapper 2000). However, it can be regarded as an important indicator species for the general quality of lowland agricultural habitats and in helping ensure that common species remain common.

Local BAPs

The UK BAP placed an obligation on public bodies to consider the implementation of the aims of the various national action plans at local BAP level. The NERC Act 2006 places a duty on public bodies to consider the presence of a species listed on either of these BAPs during decision-making.

Local BAPs translate national plans into local action, whilst at the same time reflecting issues of local importance. They often provide a structure intended to play an important role in the conservation of nature conservation at a local level which will:

- Identify actions to reverse the decline in local biodiversity
- Provide the opportunity to co-ordinate action
- Ensure the best use of scarce resources
- Help organisations recognise their potential roles
- Monitor the effectiveness of actions
- Enable the celebration of success

However, many are working documents that will be updated in light of changing circumstances and new evidence.

Nature conservation status in the UK

Numerous lists of rare or scarce status species have been produced at international, national, regional and local levels. There is considerable overlap between the statuses given to some species which appear on several lists. The JNCC collates many of the current nature conservation status lists and makes them available via the National Biodiversity Network (NBN) Gateway.

Species rarity and the degree to which invertebrates and plants are endangered and therefore of conservation concern are generally assessed by analysing the number of national 10-km grid squares in which they occur. This is slightly altered for the most endangered species, which are recorded in national RDBs as well as several county RDBs. Here, the listing as RDB1 (Endangered), RDB2 (Vulnerable) and RDB3 (Rare) is more strictly an assessment of how threatened or endangered the species is in Britain, rather than how many squares it is absent from. Nevertheless, all RDB species are found in very few locations. The definitions of the three categories are as follows (adapted from Shirt 1987):

- **RDB1** species are considered to be in danger of extinction and whose survival is therefore unlikely if the causal factors continue operating. These include species known from only a single locality since 1970; species restricted to habitats that are especially vulnerable, species that have shown a

rapid and continuous decline in the last twenty years and are now estimated to exist in five or fewer localities and species believed extinct but which would need protection if re-discovered.

- **RDB2** species are believed likely to move into the RDB1 category in the near future if the causal factors continue operating. These include species declining throughout their range, species in vulnerable habitats and species whose populations are low. An example is the Grayling *Hipparchia semele* butterfly where the 10-year population trend suggests a decline of 30-49%.
- **RDB3** species are those with small populations that are not at present endangered (RDB1) or vulnerable (RDB2) but which are nevertheless considered rare and hence at risk. These include species that are estimated to occur in 15 or fewer localities.

In addition to these categories, there is a fourth, more general category, RDBK species suspected to fall within the RDB categories but which are at present insufficiently known to enable placement. Two other scarcity categories are generally recognised: "Nationally Scarce" and "Local", particularly for plants. The concept of "Nationally Scarce" species was introduced in Ball (1986). This status, based on the number of 10-km squares of the Great Britain grid system in which a species occurs, is sometimes divided into two bands for some species. Band "Na" comprises species occurring in 16 to 30 10-km squares of the National Grid System whilst band "Nb" comprises species found in 31 to 100 10-km squares. The concept of "Local" is less well defined, but comprises species of distinctly limited or restricted distribution, with such limitations being brought about by climate, dependency on a scarce habitat type, host (in the case of parasitic species) or similar ecological factor.

Whilst the RDB criteria were generally superseded by International Union for Conservation of Nature (IUCN) categories in 1994, they are still applicable to species that have not subsequently been reviewed, such as many species of moths. Indeed, the lack of information on many species of moths means it has not been possible to determine their status. The IUCN categories are based on the most comprehensive information on the distribution and status of species and provide a far more valid assessment of extinction risk than earlier versions. They are particularly applicable to species with good quantitative data such as butterflies. The results confirm that butterflies are a highly threatened group of insects in Great Britain (Fox *et al*. 2010).

The conservation status of birds occurring in Britain is regularly assessed, with populations being placed on one of three lists: Red, Amber or Green (Eaton *et al*. 2009). Red List species are those which are Globally Threatened, whose population or range has declined rapidly in recent years, or that have declined historically and have not shown a substantial recent recovery. Amber List species are those which have an unfavourable conservation status in Europe, whose population or range has declined moderately in recent years or those whose population has declined historically but with a substantial recent recovery. It also includes rare breeders and those for which the UK holds internationally important or localised populations. Species on the Green List fulfil none of the above criteria and are of least conservation concern.

The conservation status of birds in Europe has been reassessed by Burfield and van Bommel (2004). The more recent exercise classified 524 species into four categories, based on applying international 'Red List' criteria at a regional (continental) level, details of which are summarised below. The first three categories represent Species of European Conservation Concern (SPEC).

- SPEC 1 species are those which are of global conservation concern.
- SPEC 2 species are those which have an unfavourable conservation status in Europe (if the population is threatened, declining, depleted from historical levels or is found only in a few locations) and are concentrated in Europe (i.e. more than 50% of the global population occurs in Europe).
- SPEC 3 species are those which have an unfavourable conservation status in Europe (see above), but which are not concentrated in Europe.

Species which do not fulfil these criteria are regarded as non-SPEC species and of least conservation concern.

Managing expectations through customer engagement

Engaging with those who have an interest in the management of the vegetation growing on sea walls (i.e. internal and external customers of the Environment Agency) should be integral to the decision making process. This is necessary to meet the ever increasing expectations of customers for timely information, opportunities to be involved, transparency in decision making and how their input has been acted upon, and a high level of project performance.

Meaningful engagement provides many benefits including increased confidence amongst customers not only about the decision making process but also ultimately about the delivery of a project that is sensitive to the local situation. It can also help avoid misunderstandings and unforeseen impacts.

The first task is often to identify who the main customers are. Whilst this might seem straightforward, it is not always clear who may have an interest in a particular length of sea wall or who might be concerned about the management of sea wall vegetation. This is especially the case where some interests may apply to only a short length of sea wall or a particular season. On sea walls, in addition to land owners and land managers, depending on the circumstances this may also include nature conservation organisations such as Natural England, Wildlife Trusts, the RSPB, the National Trust, natural history societies and wildlife recording groups, as well as other organisations such as Parish Councils, estuary partnerships and rambling groups.

The timing of engagement also needs to be considered. Whilst there is often a demand for engagement at the outset of decision making, this needs to be tempered by having sufficient information to enable an informed debate. However, leaving engagement to a consultation exercise near the end of the process is also likely to result in missed opportunities and increased concerns. All engagement should therefore be timed to ensure sufficient information is available for constructive dialogue and to enable follow up on the discussions in order to reach a way forward that is agreed across as many interests as possible.

Thirdly is the need to decide what to communicate. Good communication meets the needs of the recipient. It should clearly explain the objectives of what is trying to be achieved through sea wall vegetation management and provide an appropriate level of detail that is neither too simple nor too complex.

Lastly, there is a need to decide how to engage. Whilst customer engagement can be undertaken by site notices, letters or e-mail, telephone conversations and face-to-face meetings should feature as an essential mechanism for communication with key customers and to address any challenges wherever practical.

The key components to successful communication include:

- Early engagement to establish good working relationships and common understanding from the outset;
- Clear lines of communication with contact points and both formal and informal engagement;
- Engagement at both a strategic and local scale;
- Submission of detailed method statements with clear milestones and timelines;
- Provide timely updates on progress written in plain English which are accurate, define any constraints in a meaningful way, offer practical solutions and generate understanding and ownership in the final recommendations; and
- A positive and proactive approach.

There are many challenges to successfully engaging with stakeholders, but they are small in comparison to the risks of failing to engage with them in a sensible, timely and strategic manner.
The following rules of engagement based on practical experience offer a recommended approach:

- Take engagement seriously and keep it focused on the priority issues;
- Concentrate on customers who are directly affected or empowered to take decisions or can influence actions;
- Ensure customers know how their involvement will add value and influence the implementation of projects;
- Be responsive to customers having limited time and choose the right format for engagement, tailored as appropriate to each organisation or individual;
- Show willingness to listen, provide positive and constructive comments and strive to ensure a common understanding;

- Promote inclusiveness and partnership working;
- Respect confidentiality;
- Make sure customers have realistic expectations on the outcomes of the engagement and any roles or responsibilities they accept; and
- Follow up on actions and provide feedback and updates.

It is important not only to be aware of potential areas of disagreement, but also to treat such issues with due care and sensitivity, maintain a level of professional neutrality, and help facilitate consensus.

Case study

Adaptive management, Pagham Harbour, Sussex

At Pagham Harbour in Sussex, a management group comprising representatives of the Environment Agency, District Councils, West Sussex County Council, Natural England and key customers such as local landowners and parish councils, has been established to develop and implement an Adaptive Management Plan.

This plan provides the framework for flexible decision-making though engagement with local residents and interests. In this way, decision making at Pagham Harbour is inclusive, transparent and responsive to changing circumstances. Adaptive management is a structured, iterative process of decision making in the face of uncertainty, and aims to reduce the level of uncertainty over time through monitoring. Because adaptive management is based on learning, it can improve management decision making in the long-term. The challenge however in using adaptive management lies in balancing short-term decisions based on current knowledge against gaining knowledge to improve management in the future (Allan & Stankey 2009).

There are a number of scientific and social processes which are vital components of adaptive management, including:

- Management linked to appropriate temporal and spatial scales;
- Management retains a focus on statistical power and controls;
- Use of computer models to build synthesis and consensus;
- Use of embodied ecological consensus to evaluate strategic alternatives; and
- Communication of alternatives to political arenas for negotiation of a selection.

In relation to the management of the sea wall, this has included improving the surface and gradient of the approach ramp up to the sea wall to accommodate motorised wheelchairs.

Managing sea walls for nature conservation

Before deciding how the vegetation growing on a particular stretch of sea wall can best be managed, including whether to leave it unmanaged, it is necessary to assess the flood risk management objectives in the context of the nature conservation value of the habitats and species present, as well as any other constraints.

There is no currently accepted method for assessing the nature conservation value of a sea wall, though a few localised attempts based on plant species composition have been suggested (e.g. in north Kent and Essex). It is likely that such approaches will out of necessity be regionally specific, and also need to take account of evidence that sea walls provide breeding, resting or foraging habitat for protected or otherwise notable species of fauna.

The wildlife interest of many sea walls is not accurately known due to the lack of records for many areas. However, many natural history societies will have records collected by dedicated amateur observers and these can be a useful way of determining how valuable a stretch of sea wall is for biodiversity. One such system which has been devised in Essex, which could be applicable elsewhere, particularly in the south-east, involves assessing each sea wall against the following criteria (Table 4.3). One point is awarded for each criterion satisfied up to a maximum of ten points which would be the highest value sea wall for biodiversity.

Table 4.3. Sea wall rating system which could be used as a tool for assessing the biodiversity value (each wall can score a maximum of 10 points i.e. all criteria are met)

	Criteria	Explanation for achieving one point
	Physical characteristics	
1	Inland coastal grazing marsh/ grassland	Is there a significant area of grazing marsh or unimproved grassland (>1 ha in area) managed for conservation inland of the sea wall? If yes, 1 point.
2	Designated sites	Is the sea wall within a legally designated conservation site (e.g. SSSI, SPA or Ramsar site)? If yes, 1 point.
3	Width of folding	1 point if the folding is greater than 7m wide, no point if it is less than that width or not present at all.
	Wildlife	
	Vertebrates	
4	Reptiles	There are three or more reptile species recorded on the sea wall or suspected (due to high quality habitat) to be present. If yes, 1 point.
5	Nesting birds	The wall has potentially suitable bird nesting habitat (e.g. tall, unmown grassland or scrub). If yes, 1 point.
	Invertebrates	
6	Bumblebees	At least one scarce bumblebee species (e.g. RDB or BAP) has been recorded (e.g. Shrill or Moss Carder-bees), 1 point.
7	Grasshoppers and bush-crickets	At least six or more species of Orthoptera have been recorded. 1 point.
	Flora	
8	Upper saltmarsh plants	Plants of upper saltmarsh on tidal face present (e.g. Golden-samphire and Shrubby Sea-blite). 1 point.
9	Ruderal plants	Tall growing scarce plant species such as Dittander and Hog's Fennel present. 1 point.
10	Annual plant species	Scarce annual plant species of disturbed ground (e.g. Sea Barley and Slender Hare's-ear) present. 1 point.

When applied to 79 stretches of Essex sea walls, it was possible to grade 53 of them (67%) with the available knowledge on species and characteristics. There was insufficient data on the other 26 sea walls to allow a reasonably accurate and objective grading to be made. The results of the grading show two different classes in the biodiversity value of Essex sea walls. Many sea walls (23 out of 53 or 43%) achieved a high point score of eight or more (Figure 4.2). These sea walls clearly have a very good or exceptional value for biodiversity which is encouraging, and mowing and grazing regimes at these sites are clearly important in maintaining their high value. Another class of sea walls was also apparent, those with 4-6 points which have a moderate biodiversity value. Alteration of mowing and grazing regimes at these sites

could lead to a long-term increase in the biodiversity value of the sea walls, and could be targeted at those species groups which are not present. For example, mowing could be targeted to attract scarce bumblebees if they are absent.

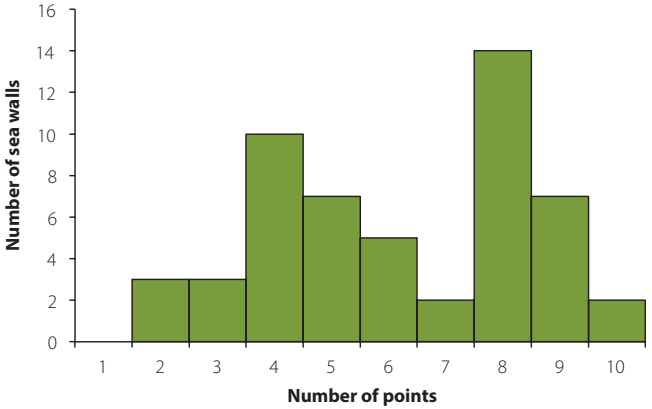


Figure 4.2. The number of sea walls with their point score determined using the grading system devised in Table 4.3. The maximum of 10 points indicates the best sea wall from a biodiversity perspective

Obviously, this way of rating sea walls is tailored well to south-eastern England (e.g. Essex and Kent), and it may be more difficult to satisfy some of the wildlife criteria (e.g. six or more Orthoptera species) further north in the UK as the number of invertebrate species in particular declines. Here it might be better to lower the number of species required, and the type of species (e.g. Shrubby Sea-blite is not often found in the north and west of the UK so a different type of shrub such as Sea Buckthorn *Hippophae rhamnoides* or Tamarisk *Tamarix gallica* might be more appropriate as a selection feature).

In general terms, sea walls of high nature conservation value which usually contain rare species have habitat continuity and are structurally complex (with regard to vegetation) both within and between habitats. Sea walls of low conservation value will generally support few protected or otherwise notable species of wildlife, be structurally simple and relatively homogeneous (e.g. uniformly short grassland). In practice, most sea walls will usually fall somewhere between these two extremes, with some lengths or zones of a single sea wall being of higher or lower nature conservation value than others.

The key to managing sea wall vegetation for nature conservation is to firstly know where the wildlife interest exists or may potentially exist. Whilst this can be gained from specific, targeted surveys and monitoring programmes, despite their value, there appear to be relatively few such studies of the wildlife found on most sea walls.

Assessments of the nature conservation value of sea walls often therefore have to rely on desk studies of ad-hoc records collected by the wildlife recording community. Validated and verified records can be held in a variety of places, including Local Record Centres, county recorders, local and national recording schemes, wildlife organisations such as the RSPB and the National Biodiversity Network (NBN) Trust through the NBN Gateway.

Like all datasets, those containing wildlife records have both strengths and weaknesses. Notably, data has seldom been collected solely for a sea wall, but rather a wider area which may include a sea wall. Because it is often held at a variety of resolutions (e.g. on a 1-km or 10-km square basis), localising records to individual sea walls (or sections of sea wall) can prove difficult. There may be inconsistencies in the number of records for different taxonomic groups, with considerably more records for 'popular' wildlife groups such as birds and butterflies in contrast to species of lower plants, invertebrates, reptiles and mammals.

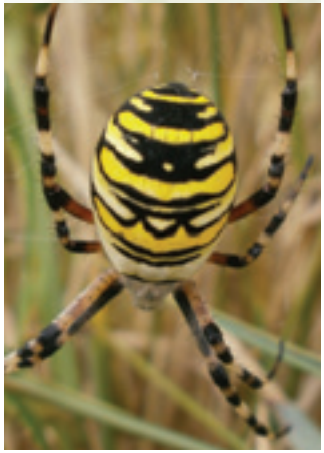
Some geographic areas also tend to be better covered than others, with the amount of available data often reflecting survey effort, ease of access and the presence of a local recorder as much as where species actually occur. For example, the Havant Nature Notes of Ralph Hollins (formerly of the Hampshire Wildlife Trust) who lives at Havant on the Hampshire coast published on-line at http://homepage.ntlworld.com/ralph.hollins/index.html and http://ralph-hollins.net/ include:

- Langstone South Moors sea wall had a good cluster of 20+ plants of Slender Hare's-ear on the sea wall in August 2007. It was noted that the low ground inside the sea wall was in the past a reliable place to find the plant but that area had become thickly overgrown with species such as Sea Couch grass. A search of the sea wall in August 2010 found two plants, not yet in flower, showing that the species is not yet extinct there. Other species recorded on this sea wall include Rock Samphire *Crithmum maritimum* seen flowering on the sea wall in June 2011 and Wasp Spider *Argiope bruennichi*, with four noted on the sea wall in August 2007.
- Hayling Island sea wall was noted as first supporting the invasive Bastard Cabbage *Rapistrum rugosum* in August 2007 at approximately SU 710005 where a water channel has an exit into Langstone Harbour under the sea wall. This species was found to have spread to the full length of the short stretch of sea wall which protects the Saltmarsh Lane area of west Hayling by June 2011. Other species recorded on this sea wall include Slender Hare's-ear in September 2012.
- Thorney sea wall supports flowering Slender Hare's-ear and at least six juveniles of the Pointed Snail *Cochlicella acuta* clinging to grass stems were noted on the Thorney Island sea wall at the west end of the Great Deeps in July 2010. Although the colony of this tiny snail of dry land (usually near the sea) had been recorded on the inside of the sea wall for over ten years, especially in warm weather when they climb plant stems and wooden posts to escape being 'fried' on bare ground, only half a dozen empty shells and no live specimens (despite a good look) were found in July 2011. Other species recorded on this area include flowering Hop Trefoil *Trifolium campestre* on the North Thorney sea wall in May 2011 and flowering Sea Plantain along the north-west sea wall of Thorney Island in July 2007.

Holders of biological data seldom receive all available records for a myriad of reasons, not least of which is that the flow of data between wildlife recorders, local groups, county recorders, LRCs, national recording schemes and the NBN Gateway is often complex. Whilst LRCs tend to have data exchange relationships with local groups and county recorders, there appear generally few formally agreed mechanisms by which data are exchanged with national recording schemes. Whilst the Biological Records Centre acts as the host for many national recording schemes and holds over 15 million records of more than 12,000 species, in general, they have few direct dealings with individual LRCs. As a result, much is left to the local network of voluntary recorders and local groups to decide how best to share their data. Thus, unless individuals are prepared to submit records to both their LRC (if one exists) and national recording scheme or society there is a high risk that not all data will be available at both local and national levels.

Caution is therefore needed when interpreting data collated through a desk study. Notably, it is important to understand that the presence of an historical record from a sea wall does not necessarily mean that a species is currently present. Similarly, the absence of a record from a particular wall may merely reflect that it has not been surveyed. One such desk study of available ecological data was completed in relation to the vegetated sea walls maintained by the Environment Agency along the north Norfolk coast and around the south Suffolk estuaries (Pilcher & Graham 2011). Whilst this was subject to a number of research constraints, notably that records in a number of private collections could not be accessed and several taxa (including mites, ticks, aphids, fleas and Bryozoa a phylum of aquatic invertebrates, commonly known as moss animals, typically about 0.5 millimetres in size) were not included either due to a general lack of data, or particular difficulty in accessing information within the timescale available, it did collate a wealth of information that had never been readily accessible before.

▽ Wasp Spider



The assessment (based on a combination of site surveys and desk based studies) of what species are present, or may potentially be present, is critical to making the right management choices in maintaining and enhancing the nature conservation value of sea walls. As such, opportunities to gain information about the wildlife found on sea walls should be pursued whenever possible. Notwithstanding, the absence of detailed wildlife data should not be seen as preventing the management of sea wall vegetation in a way that benefits biodiversity, as this can be often be achieved by merely following five simple principles:

- The biodiversity priorities for a given section of sea wall should be based on what information is available. This can include the habitats present, habitat structure, the relationship between features, any data on populations of protected or otherwise notable species, including possible population size and needs throughout their life cycle, as well as how the sea wall has been managed in the past.
- The management of individual sections of sea wall should be considered in the context of other sea walls in the area. Whilst the maximum potential for sea walls to support wildlife is often provided by those which support a range of habitats and successional stages from bare ground to scrub, this needs to be balanced against the need to provide suitable habitat for key species such as Hog's Fennel,

Narrow-mouthed Whorl Snail and bumblebees, where these are known to be, or could be, present.

- Where possible only part of a sea wall should be managed at a time, preferably through some form of rotational management programme. With the management of sea wall vegetation increasingly undertaken through the use of machinery, it can appear more efficient and cost-effective to manage long lengths of sea wall in a single operation. However, without due care, and in particular attention to habitats at different scales, such an approach can damage or even destroy important wildlife habitats and in turn the species they support.
- Management for biodiversity is not to be constrained by generic guidance. For example, whilst the Environment Agency has developed four standard maintenance options (numbered MS1-MS4) for mowing sea walls (Environment Agency 2012) (see Chapter 5 and Figure 5.1), local circumstances can result in variations. In Essex for example, a revision to the MS1 sea wall cutting regime in place since 2011 has resulted in an unmown section of folding where this is more than 4m wide even when there are no specific protected species issues such as Fisher's Estuarine Moth. The mown section is normally next to the landward toe of the sea wall and the unmown section nearest the borrowdyke or landward boundary. The unmown section can be expected to support a range of invertebrates, particularly grasshoppers and bush-crickets, butterflies and bumblebees, as well as reptiles and ground nesting birds.
- Lastly, it needs to be recognised that the sea wall vegetation management decision making process from the initial assessment to the identification of appropriate management techniques, will often be complicated by the range of other objectives that need to be considered, including flood risk management, land owner interests and the wider public services provided by sea walls. There will also often need to be a compromise between achieving aspirations, however worthwhile, and practicalities such as available resources.

Case study

Dingy Skipper butterflies on the Greenabella sea wall, Tees Estuary

The embanked sea wall alongside the Huntsman Tioxide chemical works at Hartlepool on the western side of Sea Sands in the Tees Estuary is known as the Greenabella sea wall. This sea wall, which extends from OS grid reference NZ 5165 2563 to NZ 5207 2693 and is approximately 1.6 km in length, was initially built during the late 19th/early 20th century as a 'twin bank'. Remedial works carried out in the mid 1990s resulted in the space between the inner and the outer banks being filled and capped with clinker and slag (Environment Agency 2010). The sea wall is maintained by the Environment Agency and in 2010 had a condition assessment rating of 2 (JBA Consulting 2010).

In August 2008, the Environment Agency commissioned a Phase 1 Habitat Survey of the Greatham North flood cell which included the Greenabella sea wall (Royal Haskoning 2008). This found that the landward side of the sea wall was primarily covered by scrub species including Bracken *Pteridium aquilinum*, Bramble and Hawthorn. In the winter, this scrub and the mosaic of habitats on the adjacent Greenbella Marsh attracts flocks of small birds such as Twite *Carduelis flavirostris*, Goldfinch and Linnet *Carduelis cannabina*. The winter flock of Twite can reach over 100 (Teesmouth Bird Club 2010).

Further south, in the absence of scrub the landward side of the sea wall was characterised by coastal grasses including fescues *Vulpia* species and bents *Agrostis* species. A high diversity of plant species was found to be present on the made surface of crushed clinker and slag on the crest of the sea wall, including Carline Thistle *Carlina vulgaris*, Smooth Hawk's-beard, Red Clover and trefoil species.

The sea wall is of note for its butterflies with 17 Dingy Skipper *Erynnis tages* recorded there in 2009 (Butterfly Conservation North East England Branch 2009). Information supplied by the Industry Nature Conservation Association (INCA) in 2009 indicates that the Greenabella sea wall may be a stronghold for this species in the Tees Valley. The species occurs in grassland with an open, low sward, containing patches of bare ground on which it likes to bask. Within this, the larval food plant, Common Bird's-foot-trefoil, often grows abundantly. The Dingy Skipper is locally distributed throughout Britain and Ireland, but has declined seriously (Wainwright 2005). It is on this basis that the butterfly is now recognised as a conservation priority, being a UK and Tees Valley BAP species. It is a sedentary species and is unlikely to colonise new areas of habitat unless these are close to existing populations. One of the main threats to this species is loss of suitable habitat due to the encroachment of tall herbaceous vegetation and scrub. The adult butterflies typically live in small discrete colonies of less than 50 individuals.

Huntsman has a long-term commitment to help support the wildlife that flourishes on Greenabella Marsh and working with the INCA a Biodiversity Action Plan (BAP) was developed which identifies species and habitats that are of conservation importance on the site. This plan links in closely with the Tees Valley BAP and it details appropriate management to maintain habitats in favourable condition. This management includes maintaining a mosaic of habitats which retain patches of scrub but also enhance the grassland habitat for Nationally Scarce butterflies such as the Dingy Skipper (Butterfly Conservation North East England Branch 2010).

Sea wall management plans

Linear habitats and conservation

The concept of managing linear habitats to maximise their value for wildlife is not a new one. Many counties have a network of important roadside nature reserves, often mown with the primary aim of conserving their distinctive unimproved grassland flora. For example, a network of Special Roadside Nature Reserves was set up in the 1970s by Essex County Council (ECC) with the aim of conserving many of the rare and uncommon flowers which grow on them. Each reserve is marked up on the ground with posts at either end to remind mowing operatives that the cutting regime is different to the normal one. So far, there are 103 roadside nature reserves in Essex covering approximately 44 km managed in partnership between ECC, Essex Wildlife Trust and the Museums Service. Other coastal counties have similar lengths of roadside verge nature reserve (Kent 89 km and Lincolnshire 80 km).

An estimated 230 km of linear habitat in Essex is present along byways (much of it green lane). The flora of much of it is degraded by legal and illegal vehicular access, and trampling from walkers and horse riders. However, guidelines have been produced to improve the management of these green lanes to maximise biodiversity potential (Gardiner 2008) which suggests how Traffic Regulation Orders (TROs) could be used to restrict motorised vehicular usage and conserve the unimproved grassland flora. Unfortunately, only approximately 12% or 23 km of byway (determined by length) have TROs mainly restricting motorised usage. Even those green lane byways which have TROs suffer from scrub encroachment due to a lack of usage and mowing management (Gardiner & Vaughan 2009). Conversely, flailing of the grassy verges of byways in mid July has contributed to the severe decline of Crested Cow-wheat *Melampyrum cristatum*, a rare plant now largely confined to Essex in the UK (Adams 2008; 2009).

Sea walls offer the same potential as roadside verges and green lanes and form an important network of nature reserve habitats for a whole range of species around the coast of the UK. Unlike most roadside nature reserves and green lanes, many sea walls are covered by SSSI and Ramsar designations (e.g. only 5% (or 12.5 km) of byways in Essex are covered by a SSSI designation), which require the conservation of their grassland plant communities, insect assemblages and nesting birds for example. Sea walls are present in NNRs, other nature reserves (e.g. RSPB and Wildlife Trust reserves) and National Trust properties which have sea walls managed as one of the habitats on site. Therefore, there is an important ecological driver for the better management of sea wall habitats. The Water Framework Directive (WFD) is concerned with the ecological status of rivers, but also coastal waterbodies (the latter are known as transitional waterbodies such as the Blackwater and Colne). The WFD seeks to prevent the deterioration of aquatic waterbodies and where possible lead to their enhancement. Sea walls fall under this European directive because they are riparian habitats for estuaries and have macrophytes

(such as Golden-samphire and Sea-purslane) of the intertidal zone on the tidal (seaward) face. Therefore, the management of the tidal face of sea wall habitats will have implications with respect to the WFD.

So far, in Essex, approximately 100 km of sea walls (c. 22% of the 450 km of sea walls in Essex) are mown differently to the normal regime. The entire sea wall network (23 km) of Hamford Water in north-east Essex is mown according to a rotational cutting regime to benefit Fisher's Estuarine Moth and its larval foodplant Hog's Fennel for example. This management regime will bring other benefits for a whole range of species such as Slender Hare's-ear and Moss Carder-bee, whilst also allowing inspection of the structural integrity and maintenance of the flood defences.

Although not marked up on the ground, short management plans exist for most of the Essex sea wall nature reserves, with basic detail on the species present, map of the sea wall length to be cut and a table containing the features present on the wall and the timing of mowing to conserve these features. The format of these management plans was adapted from the Essex Local Wildlife Sites project and should be easy to interpret by those actually mowing the sea walls. The creation of a network of Sea Wall Nature Reserves in Essex and beyond will aid the enhancement of the biodiversity value of tidal flood defences.

Case study

Bee walls on the Hoo Peninsula

On the Hoo Peninsula in north Kent, a partnership between the Environment Agency, Natural England and the Bumblebee Conservation Trust (BCT) has led to plans being drawn up for the more sympathetic management of sea walls to benefit bumblebees. So far, 16.8 km of sea wall are to be managed as 'bumblebee priority sections'. The bumblebee priority sections are to be cut in early April (before rare bees have emerged from hibernation) and then again in late September and early October to allow forage sources to remain uncut throughout the summer (see http://bumblebeeconservation.org/news/anthonys-blog/improving-sea-wall-habitats-for-rare-bumblebees). Creating a system of sea walls managed in this way, will help towards the initiatives which are already up and running such as Buglife's pioneering 'B-Lines' project in Yorkshire for example.

Chapter 5: Mowing

Introduction

The focus of this chapter is on the requirements for mowing to maintain the structural integrity of sea walls from a flood risk management perspective whilst taking into account the needs and responses of wildlife to mowing, considering plants, invertebrates, reptiles, amphibians, birds and mammals. Mowing is essential to prevent scrub encroachment of sea walls and to allow structural inspections. Best practice will be presented for offsetting impacts during mowing such as leaving the folding (or berm) uncut during summer mowing and rotational management. Grassland mowing may impact on wildlife on sea walls in several different ways: type of machinery used, timing of grassland cutting, height of grass cut, and the habitat left after cutting. Consideration will be given to specific regimes such as hay cutting and removal of cuttings in relation to species diversity. Practical advice is provided on the mowing techniques required to maintain a grassland sward on sea walls.

The majority of walls are earth banks dominated by coarse grasses such as False Oat-grass, Cock's-foot and Sea Couch. Grasslands on sea walls are predominantly unimproved (they have not been agriculturally improved by ploughing, fertiliser input or herbicide applications), and as such provide an extremely important wildlife resource (see Chapter 3 Wildlife Interest). Sea walls also form a continuous network of grassland habitat allowing species to disperse along the banks (Gibson 2000).

In some areas the current practice is typically to mow the majority of tidal flood defences once annually in August which is sufficient to control scrub encroachment. Scrub had become a problem on many sea walls rendering them vulnerable to scouring during an overtopping event. Water overtopping the sea wall can rip out the scrub exposing the wall to erosion and possible breaching. Where the presence of scrub poses a particular hazard on high consequence sea walls which protect people and properties, the frequency of mowing to further improve flood protection can be increased to two or three cuts per year. Mowing frequency and intensity has implications for:

- Nesting birds on sea walls, whose nests may be destroyed by mowing blades or cutting machinery 'squashing' nests;
- Individual lizards and snakes that might be injured or killed by the mowing machinery; and
- Important plant and insect communities found on sea walls.

The role of mowing

Mowing is a non-selective form of management in that all the vegetation is cut to a uniform height. In the case of sea walls, the aim of mowing is to:

- Encourage a healthy and compact sward to bind and protect the soil;
- Prevent the establishment of scrub and associated risks;
- Enable the sea wall to be inspected to check such aspects as its integrity and assess any risks, e.g. slumping, presence of burrowing animals such as Badgers and any erosion;
- Provide a grass crop (hay) of the cut material and possibly offset the costs of mowing;
- Foster a diverse flora and fauna.

Mowing is a relatively complex management technique in terms of its impact on biodiversity. It can lead to an overall reduction in the diversity of the plants and invertebrates. However, grasslands that are cut annually at about the same time for many years often have valuable species-rich swards (Benstead *et al*. 1997). On the other hand, many botanically diverse grasslands are the result of very irregular regimes with mowing at different times of the year or not at all in some years. Years without cutting may be particularly important for plants to set seed. Some selectivity can be achieved in effect by altering the time, frequency and height of mowing.

Mowing can be used in combination with grazing including some areas of the sea wall being mown and others grazed, the use of aftermath grazing, and alternating between mowing and grazing. Linked to grazing is the decision which needs to be made about whether or not to remove the arisings from mowing.

The Environment Agency has environmental standards for its mowing regimes. Figure 5.1 provides a summary of these regimes in the different cross sectional areas.

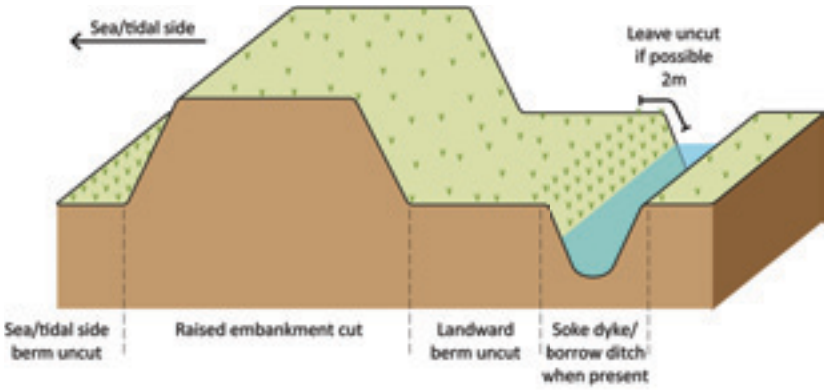


Figure 5.1. Environment Agency (2012) Delivering Consistent Standards for Sustainable Asset Management. FCRM Asset Management. Maintenance Standards, Version 3 March 2012)

Establishing objectives of management

Mowing is the most widespread means of managing the vegetation on sea walls. The following objectives are critical:

- Ensuring the integrity of the sea wall from a flood defence perspective;
- Enabling the inspection of the sea wall to check for any risks in terms of its integrity;
- Avoiding any contravention of relevant legislation with respect to killing or injuring reptiles and interfering with nesting of birds;
- Managing the sea wall to optimise its biodiversity potential; and
- Maintaining access along the sea wall.

Mowing management

The Kent surveys (RSK Carter Ecological 2008, see Case study Chapter 9) targeted notable species of plant such as Sea Barley, Sea Clover and Slender Hare's-ear, species which are also recorded on sea walls throughout the south-east and south coast of England. The main findings were that among plants specifically found in sea wall grassland (and not associated with vehicle ruts for example), there was an increase in species-richness associated with a regime of mowing with the removal of cuttings. Species such as Sea Barley and Knotted Hedge-parsley appeared to benefit from the removal of cuttings, which is generally considered a good management technique for maintaining and enhancing floristic diversity in meadows. Leaving cuttings *in situ* after mowing may lead to nutrient enrichment of the sward and smothering of lower growing plant species.

The authors of the Kent study concluded that the removal of cuttings encouraged the creation of a more open grassland sward with bare earth gaps in the vegetation, similar to that which may be established from hoof poaching under a livestock grazing regime (RSK Carter Ecological 2008). It is possible that cutter blades set very low may have caused the creation of this exposed soil due to contact between the machinery and the earth, as much as by the method of removing cuttings.

On particularly long stretches of coastline as in the Severn Estuary, it is largely impractical to remove the cuttings after mowing and they are generally left *in situ* which will favour the development of tall, grassland swards dominated by False Oat-grass and Sea Couch. Late summer cutting may avoid the main flowering season of many grassland plants on sea walls but the later a cut is undertaken, the more likely it is that competitive, coarse grass species will become dominant under a regime of leaving the cuttings *in situ*.

Assessing feasibility of mowing on a section of sea wall

Mowing is often a more practical vegetation management tool than grazing. It may also be the only option for sections of sea wall which are isolated or less accessible to livestock as they need to be checked regularly (see Chapter 6 Grazing). Whereas, livestock management requires daily input from skilled labour for a whole season, mowing can be carried out as a one-off operation, is much easier to contract out and the skill level is not as great.

Different types of mowing machinery used and method of harvesting

The three main types of mowing equipment are mowers, forage harvesters and toppers. There is also occasionally scope to use a strimmer or hand operated brush cutter.

Mowers are designed to cut at ground level and lay mown vegetation in dense, even swathes for later harvesting, e.g. a hay cut. If the intention is to cut the vegetation for hay, the cut material will need to be turned and dried prior to baling and dry storage. There are two main types of mower, a rotary mower and a flail mower. The rotary mower uses a rotating blade or blades of sharpened metal to cut vegetation in the form of a piece of tractor machinery that is either pulled behind the tractor or mounted in front, in either case, powered by the power take-off (PTO). A flail mower uses "flails" (knives or blades) attached to its rotating horizontal drum (also called a tube, rotor, or axle). The rows of flails are usually staggered to provide a complete cut. The rotating drum is powered by the PTO and is perpendicular to the axis of the tractor. As the drum rotates, centrifugal force pushes the flails outward.

▽ Front loaded flail mower

Sea walls are generally cut using a combination of rotary and flail mowers. Flail mowers have the most detrimental impact on insect populations (e.g. greatest mortality) when compared with rotary cutting blades (Humbert *et al*. 2009). A front mounted flail (e.g. cutting equipment in front of tractor) is used to mow sea walls in eastern England, compared to the traditional rear mounted attachments (e.g. flail at rear of tractor). The former may give animals including insects less time to move out of the path of the cutting flails leading to higher mortality, although the significance of this impact has not yet been proved. Whatever machinery is used to cut sea

walls, if the mowing takes place during periods of peak insect abundance (e.g. June-August), then there is likely to be significant mortality of bumblebees and grasshoppers due to contact with the cutting blades/ flails for example.

Strimmers and manually used brush cutters have a useful role to play in cutting vegetation in small or specifically targeted areas. This can reduce damage to vegetation which it is necessary not to cut or drive over, e.g. Hog's Fennel. Brush cutters are a good tool to use to deal with patches of scrub, e.g. where grazing or mowing has failed to prevent its regeneration.

A forage harvester is more typically used for cropping silage, the grass being chopped (single or double chop) and blown into an accompanying trailer for removal off site. Topping is used to remove coarse or excess vegetation, e.g. to control weeds like thistles, although thistles and other plant species are a useful nectar source for butterflies and forage for bees. Toppers have a violent cutting action with blades being set at up to 20 cm above ground level. The remaining material is typically of small volume and is usually left to rot down naturally. Topping can benefit grazing birds, e.g. geese (Owen 1983) although it is not widely used on sea walls and is generally to be discouraged as it reduces sward and invertebrate diversity (Benstead *et al*. 1997).

There have been very few studies on the effects of different types of mowing machinery on insects. However, we know that rotary mowers lead to mortality of grasshoppers through direct contact with the blades leading to decapitation or fatal damage to the abdomen of adults (Gardiner & Hill 2006; Gardiner 2009), particularly of the Lesser Marsh and Meadow Grasshoppers, two species commonly found on some sea walls. Indeed, studies have shown that mowing with a rotary blade can reduce Meadow Grasshopper adult density by approximately 63% in Essex hay meadows and 57% in Switzerland (Humbert *et al*. 2010). The Essex study also suggested that the larger size of the mature Meadow Grasshopper adults made them particularly susceptible to being killed by rotary mowing blades, as cutting only reduced the density of the smaller sized *Chorthippus* spp. nymphs by 13% in a hay meadow.

The impact of the harvesting of cut material (generally through baling of hay) is likely to be as detrimental to grasshoppers and bush-crickets as the actual mowing itself (Humbert *et al*. 2010), although it must be acknowledged that some live grasshoppers which are not killed by the cutting blades could be transported to other sites in the cut material (in green hay for example; Gardiner & Hill 2006). Roesel's Bush-cricket is negatively affected by hay mowing and subsequent raking/baling (mortality rate of between 74-91%) as is the Nationally Scarce Grey Bush-cricket (88% mortality rate; Humbert *et al*. 2010), an insect which could potentially utilise favourably managed sea walls in the county. Roesel's Bush-cricket benefits from leaving grass cuttings on site ('*in situ*') to degrade naturally, as the cut vegetation provides cover for bush-crickets that survive mowing, and the eggs laid in grass stems would be removed by the process of hay making/baling (Gardiner 2009).

Mowing height

It is possible that the cutting height could be raised to 15 cm from the ground to further protect populations of small mammals and reptiles, which can obviously 'duck' underneath the mowing blades if set high enough. Mammals and reptiles displaced by cutting should find refuge in the uncut grassland on the folding.

Timing of mowing

The timing of grassland mowing is important in conserving plant species. Grassland mowing during May and June (bird nesting season) is likely to eradicate a large number of plant species which flower and set seed early (such as Sea Clover) and should generally be avoided where at all possible. Even mowing in August could be very detrimental to late flowering plant species such as Slender Hare's-ear. Large populations of this species in Essex for example have shown dramatically reduced numbers in response to summer mowing. Where a sea wall has to be mown in mid to late summer (July-September) it is essential that strips of grassland are left unmown to allow notable plant species to flower and set seed.

Grazing and mowing

Mowing and grazing are used in conjunction at several sites, notably Old Hall Marshes in Essex. Here the sea wall is mown once a year on a rotation (different sections cut each year) in August, and the aftermath is then grazed through September and October, usually with sheep. This practice has allowed a fairly species-rich grassland flora to develop in places due to the poaching of the soil by hooves and the production of a more open sward of variable height without the dominance of coarse grasses (e.g. Sea Couch and False Oat-grass) that you can get with mowing alone (particularly if grassland is mown once a year late in September without collection of the arisings). Where there is a combination of mowing and grazing which has been undertaken for many years, the grassland flora is probably dependent on this regime and caution should be exercised when thinking of altering how the sea wall is managed (e.g. switching to mowing alone).

Case study

Home Farm, Yelland, Torridge, north Devon

http://www.gaiatrust.org.uk/properties/home-farm-marsh/

Home Farm Marsh, at Lower Yelland, was an intensive dairy farm with arable production of fodder crops. Situated on the Taw/Torridge estuary in north Devon, it borders the Tarka Trail, a popular long-distance path and cycleway. The Gaia Trust which owns the site is keen to enhance biodiversity within Home Farm Marsh, working to restore the Marsh to its former status as a wetland. This is important because it adjoins the Taw and Torridge Estuary SSSI, and it lies close to the Braunton Burrows International Biosphere Reserve, England's largest, and one of its best sand-dune systems. Home Farm Marsh lies between Salt Duck Pond and the RSPB's Isley Marsh Reserve, both of which are SSSIs. The Gaia Trust with support from a number of funding bodies acquired the 71 ha site in 2002.

The Environment Agency maintains the flood bank to the west and north of the Marsh. The bank was made from a range of soils brought in from all over north Devon and these favour many different types of plant. Some of these thrive on shell remains in the sandy soils that help to form part of the northern bank – plants such as Pale Flax *Linum bienne*, Yellow-wort and Wild Carrot.

The mass of flowers that grow on the flood banks provide nectar for many insects and these, in turn, are eaten by birds. The banks are cut each year to prevent scrub vegetation developing. This encourages the growth of flowers and helps them to set seed. The length of the flood bank between the north-western end of the access track across the Marsh and the Tarka Trail is closed to visitors at all times. This has to be done to prevent walkers from disturbing birds on Isley Marsh and those feeding or roosting on the western fields within Home Farm Marsh.

Case study

Hadleigh Marsh borrow dyke and sea wall Local Wildlife Site, Essex

In the Castle Point Borough Council Local Wildlife Site Review 2007 prepared by Essex Ecology Services Ltd. (EECOS 2007), the Local Wildlife Site CP27 Hadleigh Marsh Borrow Dyke and Sea Wall was deleted from the borough register. This was on the basis that the flora of the sea wall had deteriorated significantly, with the previously recorded suite of coastal grassland plants having been greatly reduced and replaced by a tall, weedy flora with large areas being dominated by Black Mustard, Cow Parsley and rough grasses and other herbs. Sea Clover and Slender Hare's-ear did still occur, but in very small quantity. The situation was considered not irredeemable, but some rigorous grassland management may be needed in terms of grazing or regular mowing in the short-term to improve the sward characteristics.

The importance of uncut grassland on sea wall foldings

Along the Colne Estuary at Lee-over-Sands in north-east Essex, surveys of bumblebees and butterflies were undertaken using a standardised transect count (sampling method for bumblebee abundance followed Carvell *et al*. (2007), and for butterflies it adhered to Pollard & Yates (1993)) along a 1 km long section of mown and 1 km stretch of unmown grassland on a sea wall folding, and a corresponding 1 km transect along both mown and unmown sea wall crest. The surveys showed that the overall abundance and species richness of bumblebees and butterflies were higher on the section of folding that remained uncut during the spring and early summer (April-July) (Gardiner 2012c). Indeed, where the folding had been mown in June, the abundance and species richness of bumblebees (1 species) and butterflies (6 species) was low, and the majority of insects were sighted along the crest of the wall which remained unmown at the time of the count. Several scarce insect species were only present on the unmown folding; these included the Moss Carder-bee and the Marbled White butterfly. These observations suggest that mowing of the folding may be a key determinant of the abundance and species richness of indicator species such as bumblebees and butterflies. For the section of sea wall where both the folding and crest were uncut, it was clear that the folding had the highest abundance and species richness of both insect groups, which indicated that abundant resources utilised by forage seeking insects persisted at the base of the wall in the absence of mowing. For bumblebees, there was an abundance of key summer forage plants such as Common Bird's-foot-trefoil and Red Clover on the uncut folding, which were absent from the section cut in June. It is also likely that insects displaced by the complete removal of their habitat from summer mowing of the folding may disperse to unmown areas of a sea wall, such as the crest in this instance, where there was a high species richness of butterflies (10 species) in particular.

At Paglesham along the Roach Estuary in south Essex, an experimental sea wall mowing regime was trialled in 2009 to ascertain whether leaving the folding uncut (apart from a mown 3m wide strip to allow safe vehicle passage for cutting machinery) in summer during annual maintenance, was beneficial for bumblebees or butterflies. The transect counts showed that the overall abundance and species richness of bumblebees (4 species) and butterflies (10 species) were higher on the folding than on the mown crest, where the former remained uncut in summer as part of the experimental cutting regime. Indeed, on the control section of sea wall, where the folding and crest remained uncut, there were much lower numbers of bumblebees and butterflies, and fewer species. The control sea wall had rarely been mown in recent decades and had developed a very tall and dense sward, with a large amount of litter and tussocky nature. This allowed very few forage plants for bumblebees and butterflies to persist in the sward (e.g. there was very little clover or Common Bird's-foot trefoil).

△ Uncut folding

A study of bumblebees species (using transect method of Carvell *et al*. (2007)) on an inland flood embankment at Tilbury showed that a much higher number of bees was present on adjacent unmown banks compared to the mown flood wall. Indeed, only three species were recorded from the mown flood embankment, compared to eight species on the unmown banks. Several Shrill and Brown-banded Carder-bees (both UK BAP priority species) were recorded foraging on the unmown embankments, despite the scarcity of forage resources such as Red Clover in the uncut grassland. Therefore, unmown grassland can be very important as habitat for bumblebees in certain circumstances, with tall herb species (e.g. Creeping Thistle) and scrub (Bramble) being used by foraging bees. In the Tilbury study it was clear that the mown embankment had very little suitable habitat for bumblebees due to the complete removal of forage sources because of midsummer cutting. Bumblebee nests can also be destroyed by mowing in summer.

The unmown embankments studied at Tilbury are also important for RDB plant species such as Hartwort *Tordylium maximum*, a large number of plants (> 100) of which were discovered during the bumblebee surveys (Gardiner 2009). It is likely that this population of Hartwort is the largest in the UK, with only two other sites currently known for this species in the wild in England. Therefore, the conservation of bumblebees by leaving unmown grassland on flood embankments can also promote the preservation of tall growing plant species in some instances. Benton (2000) suggests that unmanaged grassland which is not mown every year can form important nesting habitat for bumblebees, particularly scarce species such as the Moss Carder-bee.

△ Glow-worm (John Tyler)

The locally scarce Great Green Bush-cricket (an Essex Red Data List species; Gardiner & Harvey (2004)) was also heard stridulating along the unmown borrowdyke edge of both the mown and unmown embankments in similar abundance. It was only present along the borrowdyke edge where there was uncut tall vegetation (this was the only unmown vegetation that remained on the cut wall) which it requires as habitat. Therefore, where there is an intensive summer mowing regime (two or three-cuts), uncut grassland and scrub (difficult to cut on ditch edges) left along the borrowdyke banks should allow this scarce orthopteran to persist on sea walls.

Unmown grassland on sea walls can also provide suitable habitat for the most common glow-worm found in the UK: *Lampyris noctiluca*, which is actually a beetle. A flood defence at Creeksea on the Crouch Estuary for example has the last remaining sea wall population of the localised Glow-worm (Lampyridae) in Essex. Larval surveys (using reptile survey mats) for this insect in July/August 2010 showed that isolated Hawthorn bushes within open grassland on the sea wall were used by larvae, probably due to the presence of healthy snail populations upon which they prey. Small patches of scrub (e.g. 1-2m high bushes) form very useful edge (ecotone) habitat and the presence of them within unmown open grassland may be beneficial for the conservation of this declining beetle. Management to establish a mosaic of habitats (e.g. grassland and scrub) may therefore be particularly important for the Glow-worm at Creeksea.

Despite the seeming preference of bumblebees, butterflies and Glow-worms for grassland that is not mown in spring or summer, it appears that a lack of mowing on sea walls for many decades may lead to a loss of insect diversity associated with floristic resources. Even where the folding of a wall is to remain uncut, it is essential that occasional mowing takes place to preserve the abundance of forage resources such as clovers. It can be seen from quadrat surveys of a mown and unmown sea wall in Hamford Water that the floristic species richness was lower where cutting had not been undertaken (unmown species richness/m^2 = 4.9, mown species richness/m^2 = 5.9; Gardiner & Ringwood 2010). Key forage plants for bumblebees such as Red Clover and Tufted Vetch were also absent from the unmown swards due to the tall and dense nature of the grassland on the sea walls, with an abundance of litter that smothered any low growing herb species.

The Essex Sea Wall Survey (Eco Surveys 1990) underlined the value of the folding for vascular plants likely to be used as forage sources by bumblebees (Table 5.1). Key forage species for the Moss Carder-bee such as Narrow-leaved Bird's-foot-trefoil, Spiny Restharrow and Sea Clover (Benton 2000) were predominantly recorded on the folding, with only a few observations of them from the landward/

seaward slopes of the sea walls (Table 5.1). The folding is predominantly used for trafficking vehicles along a sea wall; therefore, it will receive occasional usage from tractor and off road vehicles, the wheels churning up the topsoil leading to the creation of bare earth and germination of plant species sensitive to soil disturbance (such as the Nationally Scarce annual plant species Slender Hare's-ear and Sea Barley). It is essential that some vehicles track along the folding each year (probably when mowing sea walls) to provide the soil disturbance required by these scarce plant species.

Table 5.1. Number of records of three plants used as forage by bumblebees and disturbance dependent species on differing sections of sea walls throughout Essex (source: Eco Surveys 1990)

Plant species	Borrowdyke edge	Folding	Landward/ seaward slope
Forage species for bumblebees			
Narrow-leaved Bird's-foot-trefoil	15	47	13
Spiny Restharrow	6	11	3
Sea Clover*	1	10	4
Disturbance dependent species			
Slender Hare's-ear*	7	22	12
Sea Barley*	0	68	24
Borrer's Saltmarsh-grass*	9	26	0
Total number of records	38	184	56

* Nationally Scarce species.

This indicates that the apparent preference of declining bumblebees such as the Moss and Shrill Carder-bees for the folding on sea walls on the Essex coast may be due to the greater number of forage plants on this section of the flood defences. The presence of plants such as Narrow-leaved Bird's-foot-trefoil also indicates that there are abundant nectar resources for butterflies on the folding of sea walls.

Grass height and flower availability

Some insect species such as the Glow-worm (and invertebrates such as the Wasp Spider) require tall, unmown grassland throughout the summer to maintain populations on sea walls. Scarce orthopterans such as the Great Green Bush-cricket require a complete absence of grass cutting and as such are likely to be restricted to the infrequently cut borrowdyke edge and seaward side of a sea wall, which receive little management or disturbance. Thick, undisturbed thatch (litter) is particularly valuable for invertebrates (Harvey & Smith 2006), but is probably undesirable from a flood risk management aspect due to the difficulty in inspecting and maintaining the integrity of the sea wall.

Therefore, it is desirable that the borrowdyke edge and seaward side of sea walls (likely to provide tall grassland habitat) should remain unmown, unless it is absolutely necessary to clear scrub to maintain the integrity of the wall (tree roots can damage the soil and lead to leakage of the bank). However, grass cutting may be essential to maintain floristic diversity and prevent plants such as Hog's Fennel (larval foodplant of Fisher's Estuarine Moth) from becoming smothered by scrub. Scarce bumblebees (e.g. Moss Carder-bee) are likely to need flowering clovers (and other forage plants) throughout the spring and summer (March-September), whilst uncut nectar sources are important for butterflies (Dover *et al*. 2010). Therefore, leaving a section of sea wall uncut every year will increase the availability of forage for bumblebees (Harvey & Smith 2006) and nectar for butterflies.

▽ Sea wall ruts

Timing and number of grass cuts

Mowing needs to be timed to allow important plant species to complete critical phases of their life cycle, e.g. flowering and setting seed. Late cutting, e.g. in September, favours tall-growing plant species, whilst lower growing plants tend to be promoted by earlier mowing, e.g. in June. Soil fertility is another factor to consider, it has been found that September cuts on less productive soils enhanced plant species richness whereas on more fertile soils, an earlier cut, e.g. in July, was more effective as it controlled competition from the more aggressive grasses (Bakker 1989).

There is an increasingly large body of evidence which suggests that mechanised mowing of grassland from June-August (a traditional hay cut) has a devastating impact on insects that are present in the sward (Gardiner & Hill 2006; Gardiner &

Hassall 2009; Dover *et al*. 2010; Humbert *et al*. 2010). For example, grasshoppers can be affected by cutting in hay meadows not only through direct mortality caused by the cutting machinery as described above (Wagner 2004; Gardiner & Hill 2006; Humbert *et al*. 2009, 2010) but also by the creation of a thermally hostile environment with excessively high microclimate temperatures (often more than 44°C). The latter may necessitate the movement of grasshoppers to taller vegetation with a higher occurrence of shade habitat (e.g. tussocks), and lower sward temperatures which are nearer the 'optimum' temperature for growth and development (35–40°C) (Gardiner & Hassall 2009). Cutting may also remove all nectar sources for butterflies (Dover *et al*. 2010; Field *et al*. 2005; 2006; 2007) and forage resources (e.g. flowering clovers) for bumblebees (Benton 2000). Cutting from June-August can also lead to a high number of deaths in bumblebee populations (Benton 2000).

△ Red Clover on the folding

Research by Potts *et al*. (2009) revealed that bumblebees could be more abundant in habitats mown with a single July cut or no summer cut at all, than in more intensively mown plots (cut in May and July) which provides some evidence of the impacts of the timing of grassland mowing. However, in a replicated trial in the Netherlands (Kohler *et al*. 2007), an agri-environment scheme aimed at enhancing habitat for birds by delaying cutting until after the breeding season (April-June) had no impact on diversity or numbers of bumblebees in wet meadow fields when compared with conventionally managed fields where mowing was not prohibited in the breeding season.

However, it is possible to alter the timing of grassland cutting so that the main period of insect activity is avoided; we suggest cutting the sward in September or October to minimise the effect on invertebrates. Despite the research by Kohler *et al*. (2007) showing that an absence of cutting in the bird breeding season does not lead to higher abundance of bumblebees, it is believed that their study may not necessarily be applicable to the situation on sea walls where in north Kent and Essex, for example, rarer species such as the Brown-banded and Shrill Carder-bees are present (Kohler's study only considered the commoner bumblebees). Therefore, if cutting has to be undertaken from June-August, a system of rotational mowing may be the best general option for insects, making sure to leave areas uncut every year as shelter for various species (particularly grasshoppers; Humbert *et al*. 2009; 2010). Generally, sea walls are not cut in the bird breeding season (April-July inclusive) to avoid destroying bird nests (a criminal offence under the Wildlife and Countryside Act 1981) and disturbing waders with high tide roosts. It is suggested that this prohibition of mowing in the bird breeding season, on balance, probably aids the conservation of insects on sea walls. Humbert *et al*. (2009; 2010) also suggest that the number of annual grassland cuts should be kept to a minimum (e.g. 1-2 cuts) to conserve grasshoppers and bush-crickets.

Case study

Cutting trials at Brightlingsea and Orford sea walls, East Anglia

A small-scale trial of three-cutting regimes was undertaken on a sea wall at Brightlingsea (Essex) in 2011. The three regimes had a 100m section of sea wall which was cut once in late September, a section cut twice (in late July and late September), and a final plot mown three times (in April, late July and late September). Numbers of bumblebees, butterflies and grasshoppers and bush-crickets were reduced on the plots mown three times during the spring and summer when compared with the adjacent uncut control section (Table 5.2). The number of bumblebees was much reduced on the three-cuts plot when compared with the control mainly due to the eradication of flowering forage plants. There were similar reductions in the numbers of grasshoppers and butterflies on the section of sea wall cut three times.

The difference between the number of insects recorded was more pronounced for the two-cut regime than the three-cut, suggesting that avoiding the early cut in April may be beneficial for grasshoppers but not necessarily for bumblebees, again the latter group may be restricted in frequency on sea walls mown in July due to the removal of flowering forage plants and destruction of nests in longer grass. These results suggest that a two-cut regime, with the first cut delayed until late July, would be a better choice than an early cut in April which may be detrimental to bumblebees. For the one-cut regime there was a reduced abundance of grasshoppers when compared to its paired control plot (Table 5.2). We attribute this to the tall and dense sward (> 50 cm) being of low suitability for *Chorthippus* species of grasshoppers which require a grass height of between 10-20 cm (Gardiner *et al*. 2002), which was established due to mowing of the sea wall in late July before it became too rank. For bumblebees though, the numbers were higher on the one-cut plot than in the control which suggests that continuity of flowering forage throughout the summer until the cut in late September was important. Mowing in midsummer may remove forage although the impact of this may be reduced by setting a cutting height greater than 10 cm which allows creeping forms of flowering Red Clover in particular to remain uncut as they are not tall enough to be removed by the cutting blades.

Table 5.2. Total numbers of bumblebees and grasshoppers and bush-crickets recorded on sections of sea wall mown three times (April, July, September), two times (July, September) and once (September) in 2011 and their paired unmown control plots at Brightlingsea, Essex

Mowing plot/time of cut	Grasshoppers	Bumblebees
Three-cuts control (uncut)	124	37
Three-cuts (April, July, September)	88	9
Two-cuts control (uncut)	146	152
Two-cuts (July, September)	161	130
One-cut control (uncut)	167	55
One-cut (September)	108	80
Total number	794	463

During the late July cut of a sea wall at Brightlingsea in Essex using a remote controlled rotary cutting machine, the height of the blades was set at 10 cm in 2011. The numbers of grasshoppers and bush-crickets (Orthoptera) were monitored one hour before and after mowing to see if there were any significant reductions in the abundance of insects due to mowing. Open quadrats were sampled at both survey sites (see Gardiner *et al*. 2005 for more detail of method). This survey revealed that there were reductions in the abundance of grasshoppers and bush-crickets on the cut folding and landward slope one hour after mowing (average decrease in numbers = 28%), when compared with pre-mowing numbers (Figure 5.2). Numbers of grasshoppers and bush-crickets on the cut crest, uncut folding and seaward slope increased dramatically one hour after mowing (average increase in numbers = 383%) suggesting that grasshoppers and bush-crickets were dispersing away from the mown grassland to the uncut refuges on the folding and seaward slope. During a search through the cut herbage left *in situ* one hour after mowing, no dead grasshoppers or bush-crickets were found, which coupled with the small decrease in numbers on the cut folding and landward slope, suggests that mortality of grasshoppers and bush-crickets was not an issue during cutting using a rotary mower. This is in contrast to findings elsewhere, e.g. Gardiner & Hill (2006).

▽ Remote controlled rotary cutting machine

△ Remote controlled flail mower

A cutting height of 15 cm was used during a July cut using a remote controlled flail mower at Orford in Suffolk. The response of grasshoppers and bush-crickets on the sea wall was more pronounced than at Brightlingsea. There were reductions in the numbers of Roesel's Bush-cricket and Short-winged Conehead on both the cut landward slope, upper folding and lower folding, which did not correspond with increases in numbers on sections of sea wall (front face and upper folding) which were not mown (Figure 5.3). This suggests that these bush-crickets of tall, unmown grassland had either dispersed to surrounding unmown sea wall swards or had been killed during mowing. The assertion that flail mowing had a deleterious effect was supported by the appearance of a dead Short-winged Conehead during inspection of cut herbage. At Orford, leaving the lower folding of the sea wall uncut may be essential to provide an unmown refuge during midsummer cutting with a flail. The average reduction in abundance from surveys one hour after mowing (when compared to one hour before) was 65% which compares unfavourably with cutting by a rotary mower set at 10 cm at Brightlingsea (28% reduction in abundance). It therefore seems that flail mowing of sea walls may have a more devastating impact on populations of grasshoppers and bush-crickets than rotary blades set at 10 cm. Whatever mowing machinery is used, it is important to leave uncut refuges for grasshoppers and bush-crickets during midsummer mowing so that those grasshoppers which are not killed by the mowing blades/flails can disperse to taller grassland.

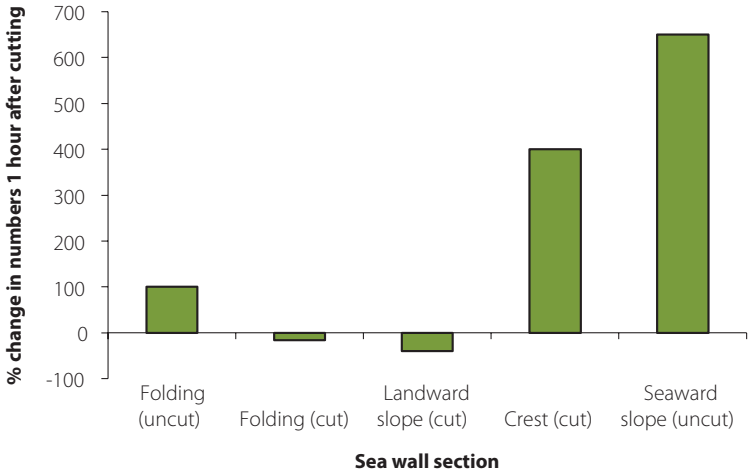


Figure 5.2. The percentage change in numbers of grasshoppers and bush-crickets from one hour before mowing to one hour after mowing on various sections of mown and unmown sea wall at Brightlingsea, Essex

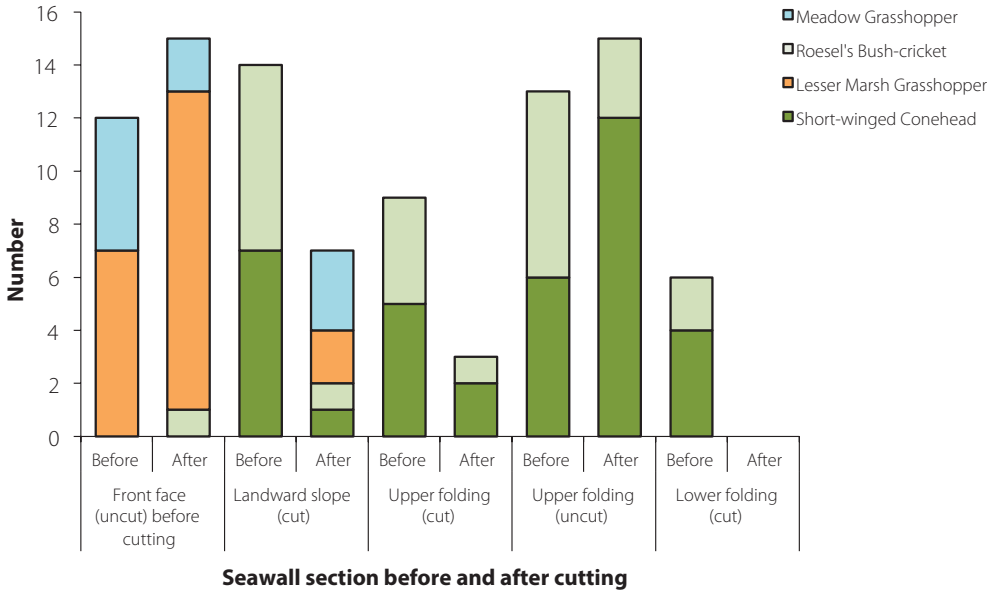


Figure 5.3. The numbers of Orthoptera species (grasshoppers and bush-crickets) one hour before mowing and one hour after mowing on various sections of mown and unmown sea wall at Orford, Suffolk

Height of grass cut

Studies undertaken at Writtle College near Chelmsford, Essex (Gardiner & Hill 2005) indicate that grasshoppers spend most of their time in the ground zone (less than 20 cm from the soil surface). This suggests that they are particularly prone to being killed by mechanised cutting blades which cut hay between 5-10 cm from the soil surface. Gardiner & Hill (2006) confirmed that cutting for hay and silage with a rotary blade set at 9 cm in July, does indeed lead to mortality of grasshoppers including the Lesser Marsh Grasshopper, commonly encountered on sea walls in Essex (Wake 1997). A cutting height of less than 10 cm should be avoided whilst mowing and is probably impractical on sea walls due to the presence of ant hills and uneven ground. However, the study by Potts *et al.* (2009) found that pastures mown with a higher cutting height (10 cm instead of 5 cm) did not necessarily support more common bumblebees than control plots managed for conventional silage production. It is believed that Pott's study (intensively managed farmland) probably does not relate to the situation on sea walls as they only recorded commoner bumblebees and not the rare bees, such as the Moss and Shrill Carder-bees, which are likely to have their nesting habitats destroyed by low cut heights on vegetated sea walls..

Removal of cuttings

It is recommended that cuttings should be removed after mowing. If left, the cuttings lead to nutrient enrichment of the soil and contribute to the development of a mat of litter. The latter prevents seeds from reaching the soil and reduces light levels at the soil surface, thus reducing grass growth and regeneration and suppressing small flowering plants and mosses. This can result in litter covered unvegetated patches which themselves may become exposed and open to erosion.

Removing cuttings is also important where aftermath grazing is practised as there is a possibility that cuttings may include toxic plants, e.g. Common Ragwort (Benstead *et al*. 1997). Where removal of cuttings is not practical, and toxic plants are present, aftermath grazing should not take place for at least six weeks. Raking (manual or mechanical) to remove cuttings can help to open up the sward for seed germination. However, some species such as Roesel's Bush-cricket benefit from leaving grass cuttings on site ('*in situ*') to degrade naturally, as the cut vegetation provides cover for bush-crickets that survive mowing, and the eggs laid in grass stems would be removed by the process of hay making/baling (Gardiner 2009).

Repeated removal of cuttings results in a gradual depletion of nutrients in the soil in marked contrast to their localised return in the dung and urine of livestock (see Chapter 6 Grazing). Eventually, the removal of cuttings will favour agriculturally less productive grasses and herbs (Crofts & Jefferson 1999).

▽ Sea wall cut at 10cm height (left)

The options for dealing with cut material are:

- Use a mower that gathers the arisings as part of the mowing process; the main problem being that this is not how mowing is undertaken on most sea walls and would require a significant change in equipment and an increase in expense;
- Allow the arisings to at least partially dry off and then collect them up either using machinery or manually by raking into piles; and
- Leave the arisings as cut and accept the disadvantages.

Where the arisings are removed or gathered up there are further considerations:

- Under some circumstances the cuttings could have a fodder value depending on quantity and quality;
- If the piles are strategically placed, e.g. in proximity to the borrowdyke, they can be used for Grass Snake (e.g. egg-laying sites, see Case study);

- Burn the arisings once dried, although this is not a popular approach with the public, and it must comply with legislation and any local bye-laws; burning in January and February is least damaging to conservation interest; or
- Class the arisings as waste and have them taken off site, preferably as 'green waste' for composting.

Case study

Creating suitable egg-laying sites for Grass Snakes

Most of the text for this case study has been taken from the Reptile Habitat Management Handbook (Edgar *et al*. 2010)

For many sites with Grass Snake present, creating egg-laying heaps is one of the most productive management measures. Egg-laying sites are often a limiting factor for Grass Snakes, and population declines may be traced back to a lack of such sites. Without such egg-laying sites, Grass Snakes are likely to only disperse along sea walls, creating an egg-laying site may encourage the snakes to form a new population centre (Edgar *et al*. 2010).

When seeking suitable egg-laying sites, key factors sought by female snakes are warmth and moisture. Both of these criteria are met by using decomposing organic matter as an incubation medium (Beebee & Griffiths 2000). Heaps of cut vegetation are favoured Grass Snake egg-laying sites, the female either burrowing into the heap or using existing tunnels excavated by small mammals. Several females often use a communal incubation site.

Eggs are laid in June or July and the time for incubation depends on temperature but usually takes six to eight weeks with the result that the hatchlings emerge in late August and September. Heaps that are used by Grass Snakes should not be interfered with between June and September, to avoid harming the animals. Replenishing is best done from April to May or in October, and normally should be done at least once every two years (though this depends on how quickly the material loses the capacity to generate heat, which can be tested easily by hand). Occasionally Grass Snakes (and Slow-worms) also hibernate in the heaps, so they are best left undisturbed over winter (Edgar *et al*. 2010).

Some Grass Snake egg-laying heaps have been constructed by piling vegetation (meadow cuttings) on top of a base, or framework, of brash. Whether this sort of construction improves conditions for Grass Snakes has not been rigorously tested. However, the brash is intended to create spaces within the heap to allow easy access to nesting females. It may also increase aeration, hence aiding decomposition of the organic material (Edgar *et al*. 2010).

Factors influencing the construction and siting of Grass Snake egg-laying piles are:

- Piles need to be large enough to ensure composting takes place with associated heat generation and that there is a gradient of temperature for the female to find the correct conditions - larger heaps of vegetation are more likely to be successful than smaller heaps. Heaps should be at least 1 m^3, but ideally much larger;
- Located in sun or partial sun and if any surrounding scrub or tree cover grows up and creates substantial shading, it should be cut back.
- Connected to vegetation that provides secure cover for adult and hatchling snakes moving to or from the site, e.g. logs on the folding and herbaceous vegetation;
- Egg-laying heaps should be constructed in locations on sea walls where local soil enrichment due to decomposing vegetation will not create a problem, e.g. away from the borrowdyke and botanically species-rich grassland;
- The location of piles should be such as to ensure that they will remain undisturbed as they will typically need to remain from post mowing until the next year when they will be used in early summer;
- Piles should also be positioned such that emerging hatchlings are away from grassland that will be mown and also away from paths and dogs; but
- Piles do not need to be near water, female Grass Snakes will travel hundreds of metres to find a suitable site.

Individual females tend to return to the same egg-laying site year after year. Therefore, new heaps are best located close to existing, used ones, or at least in high quality habitat where Grass Snakes are known to pass through.

Covering, or partially covering, a heap with a tarpaulin, or similar, weighed down to keep it in place, may help to retain heat and humidity. Such covers can also be useful in monitoring the egg-laying site. These covers should extend to the base of the heap to allow easy access for Grass Snakes.

It can take several years for Grass Snakes to start laying eggs in a newly created heap. To check if a heap is being used, site managers can either check around the heap in late August and September for hatchlings, or carefully dismantle the heap in October to check for egg shells, before reconstructing the heap.

If space allows, creating several egg-laying heaps may be beneficial. This may increase the chances of females locating a heap, whilst reducing the distances they have to move to do so. Multiple heaps are also likely to create a wider range of egg-laying conditions and ensure that not all of the eggs are in 'one basket'. Mass mortality of eggs may occur due to the weather (especially

if it is very hot and dry), predation, severe disturbance of the site, or due to disease, fungal infection or parasites. The impact of adverse factors may be reduced if eggs are spread over a number of egg-laying heaps. Locating several egg-laying sites in both full sun and partial shade can ensure that, whatever the weather over the course of the incubation period, some eggs should hatch.

Implications for the range of species groups/taxa

Higher plants

There are few specific studies on the impacts of grassland mowing on the plants of sea walls. One of the few long-term studies of grassland management on the vascular plant flora of sea walls was undertaken in the north Kent series of SSSIs (RSK Carter Ecological 2008, see Case study Chapter 9). The study focussed on several key aspects of grassland mowing, specifically the timing and number of cuts, removal of cuttings (e.g. method of harvesting) and disturbance to the soil surface during mowing. Also different plant species were found on the various structural components of a sea wall, e.g. the flora of the folding was different to that of the embankment slopes (Figure 2.1 in Chapter 2), which in turn received different mowing regimes. The impact of grazing on the flora was also investigated (see Case study: Grazing on sea walls in Kent and Essex).

Invertebrates

Unmown grassland can be very important as habitat for bumblebees in certain circumstances, with tall herb species (e.g. Creeping Thistle) and scrub (Bramble) being used by foraging bees. A study in Essex showed that a much higher number of bees were present on unmown flood defence banks compared to the mown flood wall. Only three species were recorded from the mown flood embankment, compared to eight species on the unmown banks.

Amphibians

Mowing has the potential to kill or injure amphibians due to contact with mowing blades and being run over by tractors or other vehicles. On the other hand mowing can keep the vegetation open and prevent shading of waterbodies, e.g. the borrowdyke used for breeding. The mortalities are likely to be greatest immediately before and after breeding when animals are actively moving to and from breeding waters.

In addition to not mowing before and after breeding periods, the height of the mowing blades is a significant factor. A higher cutting height helped to avoid mortality of Common Toads on a sea wall at Orford (Suffolk) where 15 Common Toads were observed alive next to the borrowdyke immediately after cutting. This indicates that the cutting height of 15 cm using a remote controlled flail mower avoided killing the amphibians. No dead Common Toads were found after cutting, indicating that mortality was low during this type of flail mowing.

Reptiles

Our knowledge of the impacts of mowing on sea wall reptiles is limited. We know that sea walls can have large populations of reptiles such as Common Lizards, Slow-worms and Adders. These species are threatened by inappropriate sea wall mowing regimes through either direct mortality due to contact with mowing blades, removal of tall grassland habitats during the active season (March-October), or/and destruction of hibernation sites if mowing is undertaken during the winter period.

Case study

The effects of mowing on reptiles, Brightlingsea, Essex

▽ A Slow-worm killed during cutting

To try to understand the impact that mowing may have on reptile populations during the active spring and summer seasons, a small-scale trial was set up in Brightlingsea, Essex, on a sea wall with a south to north alignment. The experiment was undertaken in 2011 and involved monitoring reptile populations using roof felt tiles (each 1m long x 0.5m wide) on six 100m long stretches of sea wall, three of which had a different number of cuts (1, 2 or 3 cuts), each of which were paired with an adjacent 100m section which was not cut and acted as a control sward. In each of the six sections, 10 roof felt tiles were placed on the landward slope (where cutting was undertaken) and 10 in the uncut folding. These tiles were checked on a weekly basis from early May until early October to see how reptiles responded to the three different mowing regimes.

Four reptile species were recorded. The most commonly observed species was the Slow-worm (75.6% of the total number of individuals), followed by the Common Lizard (23.4%). Adders and

Grass Snakes were rarely encountered on the sea wall at Brightlingsea. Slow-worms were more abundant on the landward slope of the sea wall, whereas, Common Lizards were more numerous on the folding (Table 5.3).

Table 5.3. Total numbers of four species of reptile recorded on the folding and landward slope at Brightlingsea, Essex

Common name	Landward slope	Folding	Total
Slow-worm	447	347	794
Common Lizard	111	135	246
Grass Snake	4	2	4
Adder	2	2	6
Total numbers	564	486	1050

Timing and number of grass cuts

The results showed that the total number of reptiles counted throughout the 2011 season for the three-cut plot was comparable to the paired control (Table 5.4). On both the three-cut plot and the control section the total numbers of reptiles counted were higher on the landward slope than on the uncut folding, indicating that the east facing slope had a more favourable microclimate for basking Common Lizards and Slow-worms. Where an early cut was not undertaken on the one-cut plot (cut in September) and its control section, there were still higher numbers of reptiles on the landward slope than in the uncut folding, suggesting that microclimate of the slope may be important even where grassland has remained uncut throughout the spring and summer.

Table 5.4. Total numbers of reptiles recorded on the landward slope and folding of sea wall plots mown three times (April, July, September), twice (July, September) and once (September) in 2011 and their paired unmown control plots at Brightlingsea, Essex

Mowing plot/time of cuts	Landward slope	Folding	Total
Three-cuts control (uncut)	105	74	179
Three-cuts (April, July, September)	112	78	190
Two-cuts control (uncut)	66	81	147
Two-cuts (July, September)	99	112	211
One-cut control (uncut)	96	80	176
One-cut (September)	86	61	147
Total numbers	564	486	1050

For the two-cut plot, which did not have an early cut, and its control section, the number of reptiles was higher in the uncut folding than on the landward slope. This may have been due to these two sections having a wider folding (and therefore greater area of grassland habitat) than the other plots. It is clear that total reptile counts varied between the six plots in relation to factors other than the mowing regime. To determine how mowing impacted on reptiles at Brightlingsea an inspection of the weekly count data is required.

If the numbers of reptiles counted per week are analysed, it can be clearly seen that for the three-cut plot there were higher counts on the landward slope on several occasions from May-early July (Figure 5.4). This shows that cutting of grassland in early April may provide an ideal spring and early summer basking environment for reptiles on the east facing landward slope of the sea wall when compared with uncut grassland on the sea wall folding. For the two-cut and one-cut plots, which were not mown in early April, there was no clear difference between the numbers of reptiles counted on the landward slope or folding from May-early July (Figure 5.4) suggesting that early cutting in the three-cut plot provided a favourable basking environment for reptiles on the landward slope (in this case mostly Common Lizards and Slow-worms).

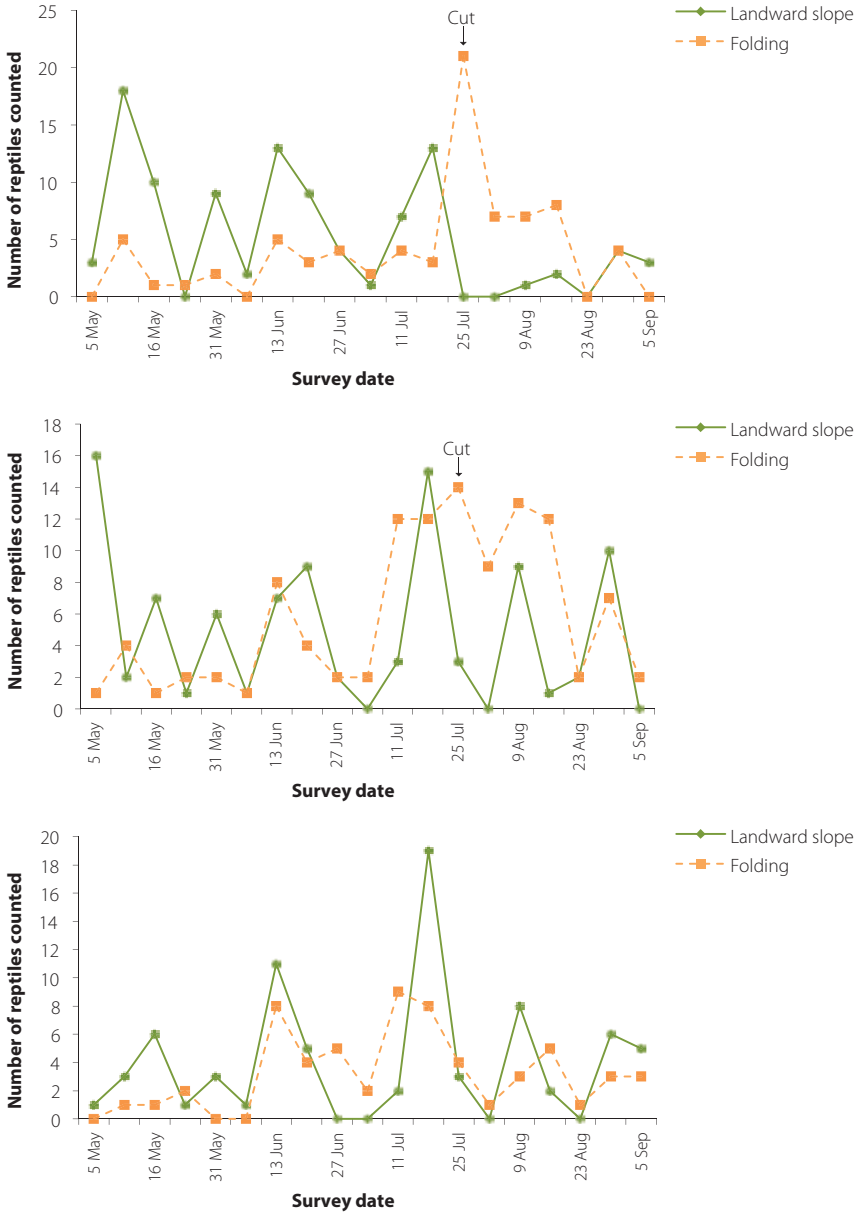


Figure 5.4. Number of reptiles counted under felt tiles on three sections of sea wall mown once in late September (bottom), twice in July and late September (middle) and three times in early April, July and late September (top) at Brightlingsea, Essex (July cut indicated where relevant)

Height of grass cut

Both the three and two-cut plots involved a cut of the landward slope on the 20th July when relatively large numbers of reptiles were present (Figure 5.4). The post-cut survey on 25th July revealed that numbers of Common Lizards and Slow-worms had increased slightly on the three-cut plot (albeit they were mainly recorded on the uncut folding and not on the cut slope). Unfortunately, a Slow-worm was killed during mowing on the 20th July, probably by being crushed by the tracked wheels of the mower, and subsequent slicing with the cutting blades. No other dead reptiles were found in the cut vegetation after mowing had occurred suggesting that mortality may be minimal during a summer cut if the cutting height is high enough (10 cm or above).

The ratio of dead to live Slow-worms as determined from the pre-cut surveys on both plots indicated a mortality rate of 3% (e.g. one dead Slow-worm out of 37 live individuals in pre-cut survey; Table 5.5). If mortality of reptiles is of concern during summer mowing (e.g. where there are known large populations) then a higher cutting height should be used (c. 15 cm). During cutting of the two-cut plot on the 22nd September, a Common Lizard was killed due to contact with the rotary blades. However, on this day, three live Common Lizards and four live Slow-worms were seen on the recently cut herbage of the two-cut plot suggesting that reptile population levels were low and that the chances of large-scale mortality were reduced.

Table 5.5. Numbers of live and dead reptiles counted for the three and two-cut plots before and after a cut on the 20th July 2011

Mowing plot/ species	Pre-cut survey (18th July)	Post-cut survey (25th July)	No. dead reptiles*
Three-cuts			
Common Lizard	5	8	0
Slow-worm	11	13	1
Two-cuts			
Common Lizard	1	5	0
Slow-worm	26	12	0
Total numbers	43	38	1

* As determined by inspection of cut vegetation immediately after cutting

Birds

A sea wall provides three main functions for birds:

- Nesting habitat, e.g. the tall grassland frequent on the sea walls provides habitat for two BAP species, Skylark and Meadow Pipit, which are not associated with scrub cover, but require more open grassland conditions;
- Feeding for raptors such as the Barn Owl and Kestrel; and
- Roosting areas for wading birds and wildfowl displaced by high tides.

In a study of Essex sea walls from April to August 2011, a Meadow Pipit, was found nesting on the landward slope of the sea wall where cutting takes place, the sward height ranging from 40 cm in April to 55 cm in August. A survey in 2007 of a sea wall at Walton-on-the-Naze, Essex, found two pairs of nesting Meadow Pipits, one along the borrowdyke edge and the other at the base of the landward slope where it meets the folding, reinforcing the potential risk of destroying nests of this species during mowing undertaken from April-July on the landward slope. Mowing during the bird breeding season poses a risk of destroying nests of Birds of Conservation Concern (BoCC) Amber List species such as Meadow Pipit. The only way to overcome this would be to commission pre-mowing walk through surveys by a qualified ecologist to determine the absence of nests.

Mowing can be used to maintain a suitable sward length for these species whilst recognising the importance of not cutting during the breeding season to avoid destroying bird nests, which is a criminal offence under the Wildlife and Countryside Act (1981) (as amended).

Mammals

Small mammals such as the Bank Vole *Myodes glareolus* and Field Vole use both the landward and seaward slopes of sea walls. There is a danger that small mammals may be killed through contact with the cutting blades or flails, however, in a recent mowing trial at Brightlingsea, Essex, a Bank Vole was observed to pass underneath rotary mowing blades unscathed (before the mower could be switched off). This was probably because the blades were set at 10 cm above the soil surface to avoid serious damage to the large population of reptiles also known to be present.

Key aspects of mowing of sea walls

Before commencing a mowing programme, it is essential to identify the objectives of using mowing (possibly in combination with other management techniques) and to ensure that mowing in the situation proposed is feasible, meets flood defence and sea wall integrity criteria as well as avoiding any risk of contravening wildlife legislation (e.g. damage to reptiles) and it optimises biodiversity potential.

Mowing, managed properly, is a valuable tool in keeping scrub under control and, in certain circumstances actually reducing its extent or removing it completely. This achieves both flood defence and certain biodiversity targets for restoration of floristically species-rich grassland.

To achieve floristically rich grassland, the sward must be at its longest in the summer and shortest in the spring and autumn when most grassland species germinate.

Management of species-rich grassland for bees, butterflies and moths involves:

- Leaving at least 15% of the sea wall section uncut to allow a taller and tussocky grassy sward to develop for overwintering invertebrates, nesting bees and feeding caterpillars, and rotating this area annually in order to prevent the development of rank grassland.
- Not cutting the sward before 1st September in areas where scarce carder-bees are a priority. In other areas, it must not be cut before 15th August.

Uncut grassland, rotationally mown, provides effective habitat for insects, under a two-cut scenario on the landward slope and crest (Figure 5.5). The uncut folding becomes a particularly important refuge for bees, butterflies and moths during the summer cuts in late July and August as all habitats are removed on the mown parts of a sea wall. In many cases, there is currently no provision for leaving the folding uncut (with the Environment Agencys MS1 cut, see Figure 5.5), so moving to a regime where it can be left uncut as a refuge during cutting would be a significant step forward for sustainable sea wall management. Under such a regime it would still be important to maintain a mown access track (approximately 3-4m wide) to ensure safety of vehicular passage but also to encourage scarce disturbance dependent plant species and insects. Importantly, the tidal slope would also remain uncut during summer cutting. To maintain the sea walls free of scrub and at an acceptable level for inspection purposes, it will be necessary to mow both the folding and tidal slope on a long rotation (perhaps once every three to four years), or in some cases where the folding is wide it may be possible to divide it into two sections and mow one half every year to maintain floristic diversity and prevent the growth of rank grassland and significant patches of scrub.

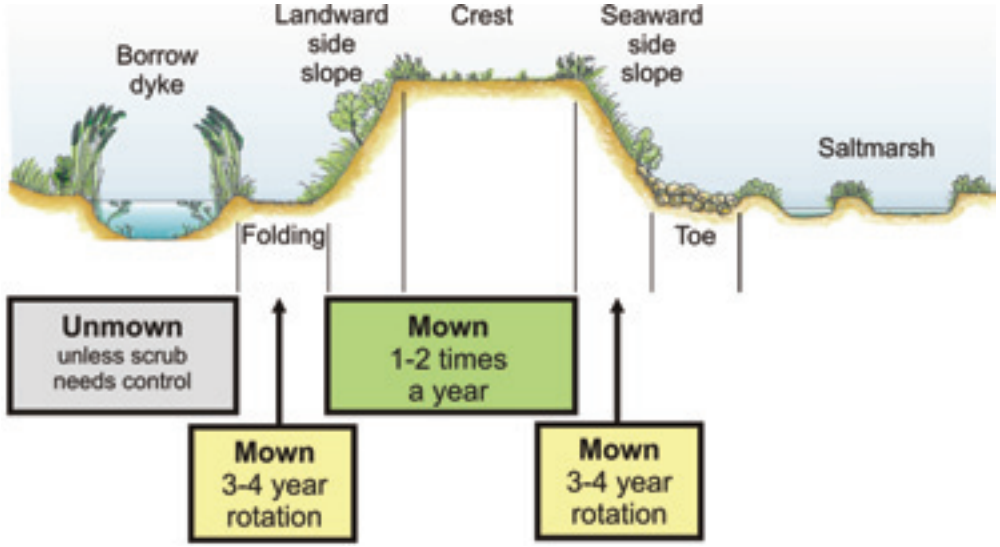


Figure 5.5: Cross section of a possible mowing regime for sea walls which incorporates rotationally mown grassland on the folding and seaward slope (wildlife refuges) and two-cuts a year on the crest and landward slope (to allow inspection and prevent scrub invasion)

A combination of mowing and grazing can achieve the better aspects of both approaches ensuring maximum integrity of the sea wall from a flood defence perspective whilst optimising the biodiversity potential.

Despite a large area of unmown folding being of likely importance for Moss Carder-bees in eastern and southern England (e.g. Gardiner & Benton 2011), it may also be essential for nesting birds and reptiles. In Essex for example, the mean folding width is 12 m, with an estimated total area of 406 ha (over 4 km^2). Therefore a very large area of habitat is available for nesting birds and reptiles on the folding of sea walls throughout the county. If the folding is mown on a long rotation (e.g. maybe once every 2-3 years) then it will form an important habitat for reptiles and nesting birds when the adjacent landward slope and crest are cut.

However, the mowing of a 3-4m wide access track each year will mean that sea walls with narrow foldings (e.g. < 6m wide) will have the majority of their unmown areas cut leaving very little refuge for insects, nesting birds or reptiles. Significantly, 321 km of sea wall had a folding present (67% of total length of sea wall in Essex and South Suffolk of 480 km), indicating that in these situations only the seaward face of

the flood defence would act as a refuge during spring/summer cutting. Hence there is a significant length of Essex sea walls where there is no folding present at all, indicating that the proposed mitigation will probably not be that effective on 33% of flood defences in the county. The actual mowing regime itself on the landward slope and crest needs to incorporate the requirements of as many different species as possible otherwise there could be significant declines in the abundance and distribution of wildlife on tidal flood defences.

Of the 321 km of sea wall with a folding present, only 54 km of sea wall had a folding less than 6m wide (17%) indicating that in the majority of situations a strip of uncut grassland at least 2-3m wide will be left fringing the borrowdyke during any cutting in these situations. It is likely that where a folding is present, a strip of grassland could be left uncut throughout the summer, only requiring a cut on a long-term rotation to prevent scrub encroachment or a serious decline in botanical diversity. Indeed, as has been noted for the Moss Carder-bee (Gardiner & Benton 2011), many sea walls had a very wide folding indeed (52% of sea walls had a folding >10m wide in Essex).

It is likely that rare invertebrate species such as the Bembridge Beetle *Paracymus aeneus*, a water beetle, which utilises the banks of borrowdykes will benefit from a buffer strip of grassland on the folding mown on a long rotation, as would the Glow-worm. Bush-crickets such as the Great Green Bush-cricket would also benefit from this rotational management. It must be stressed that those species of the borrowdyke banks (e.g. Bembridge Beetle and Great Green Bush-cricket as well as any nesting birds) would benefit from the lack of mowing of the borrowdyke banks.

Chapter 6: Grazing

Introduction

The focus of this chapter is on the effects of grazing on sea walls, and that in general grazing promotes floral diversity which in turn can provide the necessary conditions for a diversity of invertebrate species including a number of rare insects. On the other hand, grazing does not provide habitat that is optimal for certain species of reptiles, mammals and birds. The preference is for sheep over cattle grazing from a flood risk management perspective. Grazing is a relatively complex management tool given the different types of livestock that can be used (cattle, horses and sheep being the most likely options), the difference in intensity that can be employed and the temporal difference associated with grazing in different seasons. Rabbits can also exert significant grazing pressure on sea wall grasslands which could be desirable or undesirable depending on the management objectives.

Due to the limited direct evidence, the ecological implications of grazing on vegetated sea walls are gleaned from more general studies where necessary. Consideration will be given to plants, invertebrates, reptiles, amphibians, birds and mammals. The chapter outlines the response of wildlife to grazing based on what is known, including case studies on the plant species richness of sea walls in response to grazing management.

Establishing objectives of grazing

The grazing of sea walls is an extension of a natural process and can be a valuable tool in grassland management by:

- Maintaining an open grassland structure by removing plant biomass;
- Controlling scrub invasion to maintain or restore grassland habitat; and
- Keeping the effects of nutrient enrichment in check.

Plant species diversity is increased in sites managed by grazing, and grazing is critical for the maintenance of grasslands rich in plant species.

On the other hand, grazing can result in a simplified structure in terms of vegetation height and reduced ground cover, and one that is unable to support such a high diversity of animal species as one that is not grazed and has a more complex structure.

As with all management, determining the objectives is a key stage in the management process.

Grazing management

Assessing feasibility of grazing on a section of sea wall

Grazing animals have long been used as a tool of vegetation management, including to help maintain a desired ecological condition on sea walls through controlling (notably by eating and trampling) of certain plant species so that other plant species and the fauna they support are promoted. Wherever livestock are utilised in this way the prime consideration from the outset must be the welfare of the animals used to graze the sea walls. In England, the welfare of such animals is provided for under the Protection of Animals Act 1911.

Factors which could make a section of sea wall unsuitable are limited area of grazing, too well-drained and low nutrients to support grazing, poor ground stability including slope of banks, inability to fence off the section, any risk of flooding, and livestock potentially being worried by dogs, especially where there are public footpaths along the sea wall.

Most livestock will need some form of shelter as sea walls can be very exposed. This could be provided by patches of scrub. Fencing will be necessary to avoid the risk of animals straying outside of the grazing area and along the sea wall and/or to concentrate grazing in order to achieve the desired effect, e.g. scrub control. All livestock should have unrestricted and safe access to fresh drinking water, e.g. the borrowdyke. Fencing off the borrowdyke may be necessary to avoid extensive poaching. Regular inspection is essential.

Until the livestock are familiar with grazing a new area, the frequency of checking their welfare should be high. Worrying by dogs could well be a problem on sea walls especially for those sections near to parking and ready access. Some sections of sea wall may be unsuitable purely on the grounds of disturbance by dogs. Measures to help resolve this include appropriate signage and/or fencing, such as along the Kyson sea wall near Woodbridge on the Deben Estuary.

It is advisable to start grazing with low numbers and adjust the stocking rates as the results of the grazing become apparent. Careful monitoring is required to avoid overgrazing and poaching.

Choosing the right kind of livestock

It is important to choose the right kind of livestock to graze a particular section of sea wall as the varying grazing habits of the different types of livestock and even between different breeds have both advantages and disadvantages to sea wall management. The main advantages and disadvantages of the four main types of livestock are outlined:

Cattle

The advantages of cattle are:

- Cattle are ideal for removing long, coarse grass and are less selective grazers than either ponies and horses or sheep;
- At low/medium stocking density, cattle grazing results in a comparatively long tussocky sward of relatively uniform height which favours a diverse flora and many invertebrates and is potentially suitable for reptiles and small mammals; and
- Cattle trample down scrub and break up mats of dead litter and create pathways through tall, dense vegetation creating new habitat and helping to keep scrub down.

The disadvantages are:

- The combination of the pressure of the cattle on the ground and the relatively steep slopes of sea walls creates a risk of creating instability in the banks particularly over long periods of time; and
- Dung accumulation, turf damage and localised poaching around favoured rest spots and drinking sites can be a problem particularly on soft ground or in wet weather.

Sheep

The advantages of sheep are:

- At the correct grazing density, sheep can encourage a high floral diversity, typically grazing a sward to about 3 cm;
- Given grass, tall herb and scrub mosaics, sheep will preferentially graze the grass and tall herbs;
- Being lightweight and of small body size they are less of a risk to the structure of a sea wall and they can move easily around reaching areas inaccessible to cattle and horses;
- Rushes and sedges are eaten by sheep which can be an advantage where these species become dominant along the folding.

The disadvantages are:

- Sheep are of limited use in taller vegetation unless tracks are cut to encourage them to move into new areas;
- Poaching can occur in localised areas but is rarely a problem unless stocking rates are very high;
- Sheep need closer-knit fencing than cattle or horses; and
- Intensive grazing may result in a particularly short even sward with little structure and a consequent decrease in biodiversity, especially in invertebrates.

Some sheep, particularly traditional breeds, are very good at controlling scrub regrowth if put onto sea walls in the spring when new buds of regrowth are appearing. This may be desirable where scrub control is needed. Alternatively, it may lead to loss of scrub habitat and be a disadvantage.

Ponies and horses

The advantages of equines are:

- Low stocking densities over large areas creates a mosaic of shortly grazed lawns interspersed with areas of taller undisturbed vegetation for dunging (latrines) benefiting a range of species including invertebrates, reptiles, small mammals and raptors; and
- Where more intensive grazing is needed to prevent ungrazed areas becoming rank, the grazing density can be increased using fencing and/or by grazing equines with other livestock, e.g. sheep.

The disadvantages of equines are:

- Increased susceptibility to feeding by people and hence risk of dietary problems;
- Domestic horses are less hardy than some other types of livestock;
- Horses can be more prone to diseases, accidents and unsoundness than other types of livestock and may therefore require a higher level of supervision and support;
- Horses can damage the bark of trees and are prone to pulling plants up by the roots during grazing creating bare patches; and
- Horses will preferentially eat young, fresh or soft leaved plants and so encourage a coarse grass community to develop.

Goats

The advantages of goats are:

- They have access to a wider range of forage than sheep due to their greater agility which can be an advantage on steeper sea walls;
- Goats typically graze a sward to about 6 cm creating a different structure to that of sheep and cattle; and
- Given grass, tall herb and scrub mosaics, goats will only graze the tall herbs and shrubs tending to ignore the grass layer.

The disadvantages:

- Due to their agility goats are difficult to enclose.

Goats are not widely used in grazing sea walls and are not considered any further.

The problem with Rabbits

Rabbits were introduced into the UK in the 12th century. Escaping from captivity, Rabbits became an important grazing animal in the British countryside, keeping scrub encroachment under control on botanically species-rich chalk downland turf and heathland for example. However, the introduction of myxomatosis in the 1950s, led to a 99% reduction in Rabbit numbers in the UK. This led to irreversible losses of habitats kept open by the grazing pressure of Rabbits. For example, on Norton Heath Common in Essex, counts of annual tree rings after felling to restore open heathland habitats, showed that for 24 oak trees felled since 2007, a large proportion were between 31-40 years old (Gardiner 2010). The oldest tree was 56 years old suggesting that the encroachment of scrub and woodland onto the Common started in the 1950s around the time that myxomatosis was severely affecting the grazing population of Rabbits in the local countryside. The mean age of oak on the Common calculated from the annual tree ring sampling was 33 years, indicating that encroachment was greatest in the 1970s.

It is likely that a similar lack of Rabbit grazing and active grassland management by landowners and the Environment Agency predecessors on some sea wall habitats in the last 40-50 years, has led to the development of scrub and woodland. These wooded habitats are likely to conflict with maintenance of tidal and coastal flood defences (see Scrub Management Chapter 7) and have led to losses of botanically rich grassland communities. Dense scrub is also likely to favour the activities of burrowing animals such as Rabbits. For example, on a sea wall at Cattawade Marshes, recent scrub cutting has revealed numerous Rabbit holes which could be a risk to the integrity of the flood defences.

Where open grassland remains on sea walls, grazing Rabbits can provide some form of scrub control where numbers are reasonably high. They can also provide areas of bare ground and short vegetation, particularly in acid grassland where patches of Sheep's Sorrel indicate the presence of a reasonably high intensity of Rabbit grazing. These patches of short turf and bare ground can be important invertebrate habitats and can lead to the germination of scarce annual plant species (e.g. Sea Barley). However, high numbers of Rabbits can lead to a uniformly short grassland sward likely to be unsuitable for reptiles, small mammals and invertebrates which require shelter in the form of grass tussocks.

▽ Mottled Grasshopper (Ted Benton)

To summarise, the advantages of Rabbits are:

- In the absence of active grassland management, Rabbit grazing can control scrub encroachment where numbers are relatively high;
- Short-turf established where grazing intensity is high can lead to germination of scarce plant species and be important for invertebrates which require bare ground;

To summarise, the disadvantages of Rabbits are:

- Intensive grazing may result in a short even sward with little structure and a consequent decrease in biodiversity, especially in invertebrates;
- In areas of scrub, burrowing Rabbits can damage the structural integrity of sea walls.

Value of latrines (dunging areas)

Areas where dung has been deposited are generally avoided by grazing animals. Therefore, if the livestock density is relatively low, a patchwork of heavily grazed short grassland (lawn areas) and taller, ungrazed tussocks will become established. Latrines are important for a range of invertebrates. Grasshoppers for example will actively seek out this tall grassland avoided by grazing livestock for shelter (from avian predation and inclement weather/high microclimatic temperatures) and as suitable feeding areas (Gardiner & Hill 2004). However, these patches of tall grass are only a temporary habitat and may be removed at any time if grazing pressure increases, which may lead to frequent movements of grasshoppers between favourable areas of tall grass and potentially unfavourable areas in relation to the rate of defoliation by the grazing animal. From the point of view of horse welfare, regular removal of horse droppings is essential to help control the spread of gut parasites.

Whilst horses tend to avoid grazing near their own droppings, they will graze near the droppings of cattle and sheep. Likewise cattle and sheep will graze near the droppings of horses. There may therefore be benefits of mixed or rotational grazing with different types of livestock.

Disturbance and transport of insects by grazing animals

Grazing livestock, particularly sheep, may also play a role in the dispersal of insects on sea walls. Grazing animals may disturb insects such as grasshoppers and frequent disturbance could lead to dispersal of species such as the Meadow Grasshopper to undisturbed grassland. Grasshoppers typically jump in response to physical disturbance as an escape mechanism so frequent disturbance by livestock could have serious energetic costs for these and other basking insects. In the long-term the interaction of reduced sward height and increased disturbance under heavy grazing regimes could lead to dispersal of some species of insects away from grazed sea walls to those which are undisturbed (uncut) or infrequently cut.

Grazing animals such as sheep can lead to greater dispersal of certain species by acting as a transportation mechanism (Fischer *et al*. 1996). For example, grasshoppers have been found basking on sheep's wool and inadvertently travelled some distance on their backs. This could lead to localised dispersal of grasshoppers on sea walls, or perhaps even long distance movements if long stretches of sea wall are continuously grazed by sheep. The function of sea walls as green corridors for the dispersal of wildlife, particularly insects, cannot be overstated

Timing of grazing

Grazing at different times of the year has different effects on the sea wall vegetation, e.g. its impact on seed setting. Ground conditions will dictate when stock are introduced and removed, the latter ideally being before poaching becomes severe causing a problem for flood defence integrity.

Spring grazing has maximum impact on those plant species which start growing early and can be usefully employed to prevent regrowth of vigorous grasses such as False Oat-grass and Sea Couch, and scrub including willow and birch invasion. There is a problem, particularly at high stocking rates, of trampling of ground nesting birds' nests (e.g. Skylark and Meadow Pipit).

Grazing levels between June and August must be light; the aim is to maintain an uneven patchwork of short and tall vegetation between 5 and 25 cm with plenty of flowering heads.

Summer grazing can prevent flowering and seeding of key plant species (e.g. Slender Hare's-ear) and may also lead to trampling of birds' nests.

Restricting grazing to the autumn opens up the sward by removing summer growth, helping finer grasses and herbs to remain or become established and allowing plants to set seed.

Winter grazing removes coarse meadow grasses but is limited by the low food value and consequent increased need for supplementary feeding and can easily lead to poaching with associated problems.

Number of grazing animals (stocking density)

The number of grazing animals per hectare (otherwise known as stocking density) will have a key influence over the wildlife present on a sea wall. Generally, heavily grazed swards with high numbers of grazing livestock will have reduced ecological value, although botanically they can be species-rich. Conservation grazing tends to require a low number of animals per hectare, although this will depend on soil type, dominant plant species in a grassland and weather patterns for example. Quite often an assessment of sward heights can indicate whether overgrazing is becoming a problem. Site managers and landowners generally want to avoid a uniformly short sward (< 10 cm in height) without grass tussocks, as when the grassland becomes this heavily grazed there will be significant detrimental impacts on invertebrates in particular including severe poaching of the soil. In these instances, livestock should be removed from the sea wall and the sward allowed to recover, and any damage caused by poaching hooves repaired. Conversely, a sward grazed far too lightly, will be susceptible to scrub encroachment and development of rank grassland with a high amount of litter, also unlikely to be favourable to engineers or general biodiversity.

Case Study

Impact of sward height on grasshoppers and bush-crickets (Orthoptera) of grazed sea walls in Essex

Grasshoppers are generally known to be sensitive to changes in grassland sward height, certain species (three *Chorthippus* species are found on sea walls) being found in optimal abundance in swards 10-20 cm in height. In taller (> 20 cm) or shorter (< 10 cm) swards, numbers of grasshoppers are much lower (Gardiner *et al*. 2002), perhaps due to a lack of shelter from inclement weather/avian predation in shorter grass and cooler microclimate in longer vegetation. Grasshopper densities (numbers of adults per m^2 counted in five 2 x 2m quadrats at each site) were estimated on four grazed sea walls in Essex in June and July 2011 using an open quadrat method (Gardiner *et al*. 2005). The density estimates were then compared against numbers counted in four ungrazed control swards nearby.

The results showed that for the two cattle grazed sea walls, which had fairly short swards (< 10 cm in height) with few grass tussocks, numbers of grasshoppers were lower than on the ungrazed sea walls which had higher densities (Figure 6.1) and more variation in sward height (10-40 cm). This suggests that the impact of cattle grazing which leads to very uniformly short swards is not favourable for *Chorthippus* grasshoppers which require tussocks of tall grass for shelter and feeding. However, on the sheep grazed sea walls, which had greater variation in sward height (10-30 cm) than the cattle grazed sections, numbers of grasshoppers were higher than in the ungrazed control swards which were quite uniformly tall and rank in nature (> 40 cm in height). Therefore, it would appear that the impact of grazing on grasshoppers is likely to be through the establishment of suitable sward heights at appropriate stocking rates, light sheep grazing producing more variation in vegetation height than cattle grazing where swards can be uniformly short due to high stocking rates.

△ Cattle grazing can create a short sward, not ideal for grasshoppers

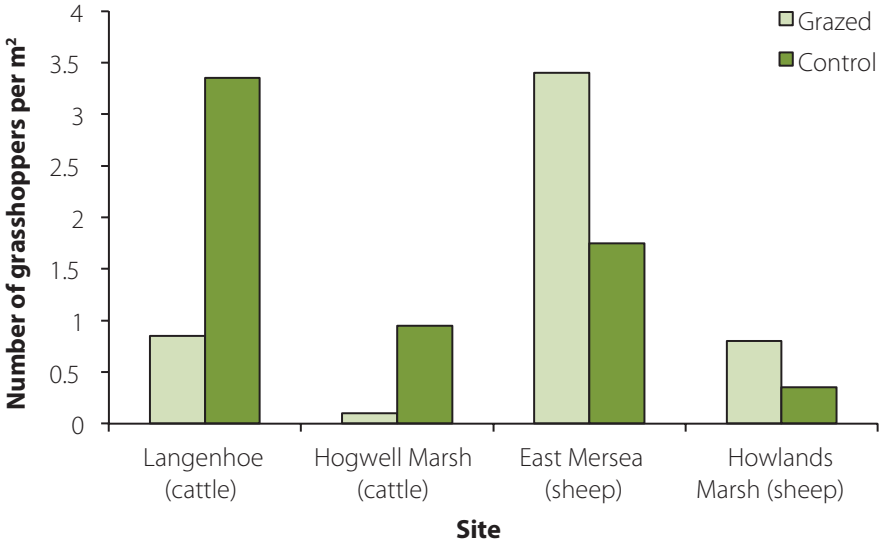


Figure 6.1: Estimates of the density of grasshoppers (Orthoptera: Acrididae) from open quadrat surveys on four grazed sea walls (with adjacent ungrazed control swards) on the Essex coast

Suggested conservation grazing stocking densities

Crofts & Jefferson (1999) gives appropriate stocking densities (number of animals per hectare) for conservation grazing regimes on acid, calcareous and neutral soils. The number of animals (and hence grazing pressure) is determined by the grazing duration, so the longer the duration, the fewer animals which should be present on a sea wall (Table 6.1). The figures presented in Table 6.1 are only intended as a rough guide to the number of cattle or sheep which should produce a favourable sward for conservation. For conservation purposes the aim would be for one livestock unit per hectare (taken to be one horse or cow but eight sheep) which would allow for relatively low intensity grazing, resting of sites, or rotational grazing.

Table 6.1: Number of animals (sheep and cattle) per ha for conservation grazing in lowland grassland on differing soil types (taken from Crofts & Jefferson 1999)

	Grassland type					
	Calcareous		*Neutral*		*Acid*	
No. of grazing weeks per year	*Sheep*	*Cattle*	*Sheep*	*Cattle*	*Sheep*	*Cattle*
2	60	15	100	25	50	12
4	30	8	50	12.5	25	6
6	20	5	33	8	16	4
8	15	4	25	6	12	3
10	12	3	20	5	10	2.5
12	10	2.5	17	4	8	2
14	8.5	2	14	3.5	7	1.5
16	7.5	2	12.5	3	6	1.5
20	6	1.5	10	2.5	5	1
24	5	1	8	2	4	1
36	3.5	1	5.5	1.5	3	0.5
52	2.5	0.5	4	0.5	2	0.4

Monitoring of sward height

Generally, monitoring of sward height either visually or by using direct measurements (see Chapter 9 Surveying and Monitoring) gives a good indication of how grazing may be affecting biodiversity. A sward of variable height, with shorter 'lawn' areas and ungrazed tussocks will generally be ideal for a range of species, whereas, a uniformly close cropped sward (< 10 cm in height) with few grass tussocks is indicating that the grazing pressure is too high and animals need to be completely removed from the sea wall, or the grazing pressure at least reduced, to allow the grassland to recover.

△ Sea Barley in poached habitat

Rare breeds

Between 1900 and 1973 we lost 26 breeds of livestock in the UK. The Rare Breeds Survival Trust is aiming to ensure that no more rare breeds of farm animal in the UK become extinct. Rare livestock breeds such as Red Poll cattle or Jacob sheep can be effective grazers and could be considered for use on a sea wall. These rare breeds may be better able to digest and remove unwanted woody species on sea walls such as Gorse, Hawthorn, willow scrub, coarse grasses and sedges. Grazing a conservation grassland with rare breed livestock brings dual benefits; increased environmental value of the grassland and a more secure future for the rare breed. For more information on rare breeds in the UK visit the Rare Breeds Survival Trust website https://www.rbst.org.uk/

Grazing and mowing

Consideration should be given to a combination or rotation of grazing and mowing. This can enable the better aspects of each to be combined and is another tool in the range of approaches that can be taken in the vegetation management of sea walls.

Aftermath grazing

At several coastal grazing marsh sites the grassland swards of the sea wall slopes are cut on rotation in August or September and then the 'aftermath' is grazed with sheep. This has often been practiced for many years and plant and animal communities are dependent on the continuation of this management practice. For example, the cutting prevents the development of a deep litter layer (unlikely to be favourable for structural integrity of the flood defence on the landward slope) whilst the aftermath

grazing of the short, cut sward creates lightly poached ground suitable for germination of scarce annual plant species (e.g. Sea Barley). However, aftermath grazing, where high numbers of sheep are present in particular can lead to even, short swards unlikely to be suitable for reptiles and invertebrates which need a well-developed tussock structure and litter layer.

On sites where aftermath grazing has been traditionally employed, the continuation of this regime is advised as the flora may be dependent on the regime. Any changes such as the introduction of aftermath grazing to a sea wall which has traditionally been cut should be carefully considered against the wildlife present.

Implications for the range of species groups/taxa

Higher plants

Plant species diversity is increased in sites managed by grazing, and grazing is often critical for the maintenance of grasslands rich in plant species.

Grazing animals may show active selection for, or against, particular plant species and plant species may exhibit differential vulnerability to being grazed, both of which may have cascading effects on other processes, often leading to substantial reductions in ecological function.

Case study

Grazing on sea walls in Kent and Essex

In a survey of vegetation of sea walls in Kent, those that were grazed were generally the most species-rich from a notable plant perspective (RSK Carter Ecological 2008) due to the poaching of soil from hooves creating disturbance for the germination of scarce annual species such as Sea Barley, and the control that grazing can have on the dominance of coarse grass species such as False Oat-grass and Sea Couch. This is mirrored by the Essex sea walls where the species richness of 10 notable plant species in 2011 (see Figure 7.4 for the list, Chapter 7) was higher on grazed (either by sheep or cattle) sea walls (2.5 species per sea wall section) than on those which were mown or unmanaged (1.3 species per wall). The 2011 Essex surveys also revealed that species such as Sea Barley favoured grazed sea walls (67% of records), but that other taller growing ruderal plant species such as Grass-leaved Orache

(only 15% of records from grazed sea walls) and Dittander (no records from grazed sea walls) have a strong aversion to livestock grazing. Therefore, it is difficult to advocate grazing across all sea walls for the conservation of plants, but at some particularly species-rich sites, which often have grazing marsh on the landward side of the sea wall, it may be practicable to graze sea walls lightly to conserve notable plant species of disturbed ground such as Sea Barley.

Invertebrates

A number of insects and invertebrates including bumblebees, moths, bush-crickets and grasshoppers benefit from grassland that has not been mown. This is due to such aspects as the floral diversity including key food plants and the structure of the grassland, e.g. presence of tussocks. Grazing is a valuable management tool to achieve the necessary maintenance standard from a flood defence perspective whilst also providing the habitat conditions necessary for a number of rare and threatened species (see Chapter 3 (Invertebrates section)).

Animal dung provides an important habitat and food source for a wide range of other invertebrates and in turn for their predators. In order to optimise on this aspect it may be necessary to avoid using certain worming drugs (e.g. Ivermectin) which can be detrimental to the invertebrates supported by dung. Ivermectin is used to control worms and other internal infestations in cattle, but is also effective against some external parasites such as lice. The problem is that it may remain effective even after it has passed through the gut of the animal, so resulting cowpats can be toxic to insects which would normally feed on them. In 1995, the National Trust banned the use of Ivermectin on some farms in the west of England, to benefit the Chough *Pyrrhocorax pyrrhocorax*, a bird that had disappeared from Cornwall.

Reptiles

Grazing has been found in general to be disadvantageous for reptiles. In sites where reptile conservation (of the four common species) is the primary objective, grazing by domestic livestock, particularly cattle and ponies, is not an appropriate form of habitat management as it will ultimately result in their eradication rather than their conservation. This is due to the reduction in sward height and density by grazing animals, particularly if numbers are too high, which can lead to shorter vegetation without tussocks which is unsuitable for reptiles in the long-term.

Reptiles require a suitable substrate in which to burrow, a dense ground vegetation to provide cover and an upper vegetation layer to give shelter against extremes of temperature during the summer and winter.

Livestock grazing tends to damage habitat structure which not only directly affects reptiles by reducing the availability of suitable ground cover, but also indirectly by negatively affecting their prey which includes invertebrates, other species of reptiles, amphibians and for some species of small mammals.

Amphibians

The borrowdyke edge and the folding provide terrestrial habitat for frogs, toads and newts emerging from the water. In the Common Toad (the most terrestrial of the widespread amphibians), adults move back into terrestrial habitat and can sometimes travel several kilometres from their breeding sites. On most sites supporting Natterjack Toads, grazing is used as a key method for maintaining the required short sward. Cattle are usually the most useful herbivore because they tend to break the turf to create bare ground more so than sheep. It is virtually impossible to overgraze a site for Natterjack Toad conservation (Baker *et al*. 2011).

Case Study

The Natterjack Toad, Norfolk and Suffolk

The Natterjack Toad occurs on the north Norfolk coast and at a protected site on the Suffolk coast where it was reintroduced as part of a species recovery programme (Denton & Beebee 1994). Grazing is the preferred management tool for this species.

Where grazing is not possible, then mowing needs to be used. As Natterjack Toads tend to remain underground during the day outside the breeding season, regular, low cut mowing can achieve the necessary habitat requirements. Where Natterjack Toads are present they tend to be the conservation priority over the needs of other species of amphibians, especially as by breeding earlier the tadpoles of these amphibians (e.g. Common Toad) can predate heavily on Natterjack Toad tadpoles (Denton & Beebee 1994).

Birds

A sea wall provides three main functions for birds: nesting habitat, e.g. Skylark, feeding for raptors such as Barn Owl and Kestrel, and roosting areas for birds, e.g. waders and geese. Livestock put nesting birds at risk through trampling of nests and eggs, and the likely reduction of prey items as a result of

grazing. The swards resulting from grazing are suboptimal for raptors as such habitat is unsuitable for small mammals. Waders and other birds using the sea wall for roosting are indifferent to livestock and grazing.

Case Study

Oystercatcher eggs trampled on cattle grazed sea wall, Langenhoe, Essex

In the bird breeding season of 2012, three Oystercatcher eggs were found in a cluster on the sea wall during engineering works at Langenhoe on the Colne Estuary in Essex. To prevent the destruction of the eggs, the nest was fenced off to prevent machinery crushing them or causing undue disturbance. Unfortunately, on a site inspection several days after the eggs had been found, no evidence of the nest was present. The fencing had been knocked over by grazing cattle and the eggs presumably trampled by the hooves. Therefore, livestock grazing could pose a serious trampling risk to ground nesting birds during the breeding season.

Mammals

Grazing results in an open and less complex vegetation structure than in ungrazed areas, less able to support a diverse animal community, mammals included. It also results in a more open and 'patchy' habitat with little or no litter layer exposing small mammals to foraging by predators, e.g. reptiles and raptors.

Key aspects/summary

Before commencing a grazing programme, it is essential to identify the objectives (possibly in combination with other management techniques) and to ensure that grazing in the situation proposed is feasible.

Grazing can be used to promote structural and floral diversity that in turn has significant benefits for certain invertebrates and other species such as the Natterjack Toad. Other species are less able to benefit from this change in structure such as reptiles, birds and mammals.

Grazing levels between June and August must be light; the aim is to maintain an uneven patchwork of short and tall vegetation between 5 and 25 cm with plenty of flowering heads.

Grazing, managed properly, is a valuable tool in keeping scrub under control and in certain circumstances actually reducing its extent or removing it completely. Ecotones can be created in extensive grazing systems, e.g. edge between scrub and grassland and along the margins of the borrowdyke/backditch. In year round grazing systems, animals make seasonal use of a section of sea wall, moving around and changing grazing patterns according to the season, as their dietary requirements adjust to the changing environment.

Localised overgrazing may be a problem on certain sections of sea wall. In contrast, some areas may be avoided by livestock allowing the vegetation to revert to an unwanted type, e.g. scrub.

The health and welfare of livestock can be seriously compromised if livestock are not used to harsh conditions, if the sward is of insufficient nutritional quality, or if there is a lack of shelter.

A combination of grazing and mowing can achieve the better aspects of both approaches ensuring maximum integrity of the sea wall from a flood defence perspective whilst optimising the biodiversity potential.

Chapter 7: Scrub

Introduction

The focus of this chapter is on reducing or removing scrub to enable the proper inspection of the condition of sea walls and to help maintain their structural integrity. A range of techniques is described, including manual and mechanical cutting, flailing of scrub margins, browsing and stump management, along with a review of their advantages and limitations in relation to sea walls. Detail is provided on the response of wildlife to scrub management, paying particular attention to species of conservation importance such as Shrubby Sea-blite. Brief consideration is also given to the benefits of compensatory planting to offset impacts where scrub is removed.

The growth of scrub on sea walls may need to be controlled for a number of reasons. These include:

- Forcing down the standards for sustainable flood risk asset management by a grade (Chapter 4) through preventing the sea wall being fully inspected;
- Threatening the integrity of the flood defences, notably by heavy woody growth causing drying-out and shrinkage cracks in the structural core of a sea wall such that under high water loading such a defence could be significantly weakened;
- Bare earth being washed away between woody stems in dense scrub on a sea wall in a storm event;
- Serious structural damage in the event of an overtopping event (where tidal water flows over crest of sea wall) due to trees and larger shrubs which could be ripped out by the force of the water leaving holes in the wall and potentially leading to its collapse;
- Dense thickets of scrub encouraging the presence of burrowing animals such as Badgers which could damage the integrity of sea walls, and risk causing tidal flooding if they were to burrow through completely;
- Obstructing footpaths and access routes for maintenance machinery.

Wildlife value of sea wall scrub

Scrub on sea walls has traditionally been regarded as an invasive problem to be addressed, often with little or no consideration given to its potential value for wildlife. However, the nature conservation importance of scrub communities and mosaic habitats which include scrub, especially for invertebrates, has increasingly been recognised (e.g. Kirby 1992, Fuller & Peterken 1995, Hopkins 1996, Davies *et al*. 2008) and today there is a much greater appreciation amongst flood risk managers, land owners and

conservation advisers of the value of scrub as habitat for wildlife, its place in ecosystems and its importance to landscapes. You only have to look at the concerns voiced by local people when plans are revealed to manage scrub on sea walls to realise the importance now placed on its presence.

The wildlife value of scrub communities lies not only in the rarity of some of the community types (notably Sea-buckthorn scrub and Shrubby Sea-blite drift line community), but also in the assemblages of other species groups present. Conservative estimates suggest around 10% of all terrestrial BAP Priority Species are associated with scrub (Mortimer *et al*. 2000).

The benefits of scrub are limited to the habitat it provides for various plant and animal species, some of which are relatively rare.

The two key resources on scrub management are the JNCC Report 308 *The Nature Conservation Value of Scrub in Britain* (Mortimer *et al*. 2000) and The Scrub Management Handbook (Day *et al*. 2003) produced by English Nature for the Forum for the Application of Conservation Techniques (FACT) partnership which can be downloaded from the Natural England website.

The definition of scrub used for this handbook is that used in the JNCC Report 308 as areas of woody vegetation dominated by shrubs or bushes usually less than 5m high, together with young saplings and occasionally a few scattered small trees. Whilst most areas of scrub are seral stages in succession from open habitat to woodland, others, particularly in more stressed environments such as those found on the coast, can be considered the climax vegetation. Scrub can be scattered with an understory of grassland and ruderal species, or have a more closed canopy under which there may be few other species.

The slopes or folding of a sea wall can support patches of scrub composed of a diverse range of woody species such as Blackthorn, Crab Apple *Malus sylvestris*, Dog Rose *Rosa canina*, Dogwood *Cornus sanguinea*, Field Maple *Acer campestre*, Hawthorn, oak, Tamarisk, and in rare cases the Nationally Scarce Sea-buckthorn. Some sea walls, particularly those near properties, can also have a range of more exotic species of scrub.

The type of scrub most commonly encountered on sea walls was described as thicket scrub by Tansley (1939). This usually becomes established in the absence of, or reduction in, grassland management, whether in the form of mowing or browsing by livestock (e.g. cattle) or wild mammals (e.g. Rabbit). Once established, the canopy of scrub can remain completely closed until such time that the stand develops more 'leggy' plants with bare earth and leaf litter beneath. In the absence of any management, dense thickets may remain as permanent features unless a niche is provided for trees to become established.

Five scrub National Vegetation Classification (NVC) scrub communities can be considered to principally occur on sea walls:

- W21 Hawthorn-Ivy (*Hedera helix*) scrub;
- W22 Blackthorn-Bramble scrub;
- W24 Bramble-Yorkshire Fog (*Holcus lanatus*) understorey;
- SD18 Sea-buckthorn scrub; and
- SM25 Shrubby Sea-blite drift line community.

The most ubiquitous scrub communities likely to be found on the sea walls of England are W21 Hawthorn-Ivy scrub and W24 Bramble-Yorkshire Fog understorey. They are most commonly associated with disturbed ground, including sea walls, spoil heaps and derelict land. They also feature in grasslands where the constraint on scrub development (such as mowing or browsing) has been removed.

The W22 Blackthorn-Bramble community is also widespread and occurs in similar habitats to W21, although tends to favour deeper and richer soils. It does though tend to have a more variable understorey than W24. For example, a typical example of a phase 1 habitat survey of approximately 150m of a 1.5 – 2.0m high earth sea wall against the River Tamar in Devon carried out for the Weir Quay Community Watersports Hub Club Ltd (Street 2011) found this supported a scrub community dominated by Blackthorn and Brambles with abundant Old Man's Beard, some Gorse and occasional Dog Rose. The herbaceous flora was considered to reflect that of a roadside verge with the addition of Oil-seed Rape, Burdock *Arctium lappa* and Hemlock.

The W22 Blackthorn-Bramble community frequently develops in rank, unmanaged neutral grasslands, such as those that develop on sea walls which are left unmanaged for any length of time, and is also tolerant of some exposure to sea spray where other woody species are less able to survive. In such locations, the Blackthorn-Bramble community may be considered the climax vegetation. The effects of environmental factors such as high wind exposure and salt spray conditions on the community composition and structure of scrub taken from The Scrub Management Handbook (Day *et al*. 2003) are summarised in Table 7.1.

Table 7.1. Effects of environmental factors on scrub composition and structure

Factor	Effect
Salt spray	Salt intolerant species absent; stunted growth, usually growing away from prevailing wind
High wind exposure	Stunted growth, usually away from prevailing wind
Cold climate / frost hollows	Frost sensitive species are absent
Soil pH	Modifies species composition of both scrub and herbaceous flora
Nutrient impoverished soils	Many species excluded
Very free draining soils	Drought resistant species dominate
Water-logging	Water-logging resistant species dominate

Whilst the NVC scrub community SD18 is dominated by Sea-buckthorn, this rarely occurs as a pure stand, instead tending to be mixed with low numbers of other woody species. It can form dense thickets, with sparse *nitrophilous* associates (plants preferring or thriving in a soil rich in nitrogen such as Common Nettle *Urtica dioica*) but generally few other plants due to the heavy shading, though it also occurs as more scattered bushes interspersed with various grasses. Whilst more a species of sand dunes, it can spread onto sea walls through its extensive root system which can give rise to many suckers.

▽ Shrubby Sea-blite community

The scrubby, *halophilous* (i.e. salt-tolerant) vegetation that most closely resembles the scrub vegetation of the Mediterranean is restricted to the uppermost levels of saltmarshes and along the seaward toe of sea walls in south and south-east England. This is formed predominantly of bushes of Shrubby Sea-blite and Sea-purslane (NVC type SM25 Shrubby Sea-blite drift line community). This vegetation type now occurs principally as a strandline community. In a few localities on the south and east coast of England a similar community develops, but with dense stands of Perennial Glasswort *Sarcocornia perennis* mixed with a small number of herbaceous species (NVC type SM7 stands).

Techniques

There are four main techniques for reducing or eradicating scrub on sea walls. The methods used will vary according to the aims of the management and the species of scrub present:

- Cutting;
- Flailing of scrub margins;
- Browsing; and
- Stump management.

△ Sea-buckthorn

Cutting

Cutting is one of the most common techniques used to manage scrub and can be carried out using a range of different tools and equipment. It is important that the tools and equipment chosen are appropriate to the task and tailored to achieving the site-specific objectives. Key considerations include the extent of scrub, the age and structure of scrub, the scrub species present, ground conditions, accessibility, steepness of the sea wall, availability of labour and any local interests.

Stands of sparse or scattered scrub can usually be tackled with hand tools such as loppers, bow saws and axes. Larger scrub may be more effectively dealt with using powered hand tools such as chainsaws, clearing saws or brush-cutters.

Advantages of hand cutting as a technique to manage scrub on sea walls include that it is very selective enabling the removal of individual plants and small stands or the trimming back of scrub alongside footpaths and on the crest and slopes of a sea wall which are otherwise inaccessible to machinery.

There are limitations to using hand cutting as a scrub management tool on sea walls. These include:

- Slow work rate means this technique is only really suitable for individual plants or small, specific stands of scrub on a sea wall;
- It can require a large labour force or a prolonged timetable to be effective over a large area or long length of sea wall;
- Powered hand tools can be noisy and require specialised training and certification before they can be used; and
- All cutting operations will require follow up treatment to prevent re-growth from stumps or underground plant structures.

- Cutting scrub will often generate considerable arisings. The storage, treatment and disposal of brash derived from cutting scrub on a sea wall can be subject to the Environmental Permitting Regulations (England and Wales) 2010 and the draft amendments published in 2013. Whilst dealing with the arisings generated by scrub cutting operations may therefore require an environmental permit, certain activities and operations, notably those which are relatively small scale, are exempt from requiring a permit. These activities are listed in Schedule 3 of the Regulations. Even when no permit is required there may still be a need to register an exemption. Whether a permit or an exemption is needed will depend on the activity being carried out and the types and quantities of wastes being handled.

Whilst the arisings from scrub cutting can be chipped, or even sometimes burnt on site where this is permitted, it is more common to stack brash into habitat piles away from the crest of a sea wall, access routes or areas that will be mown (e.g. stack along the unmown edge of a borrowdyke). Where possible, these piles should be placed in sunny locations or set within existing vegetation such as areas of long grass or areas of scrub being retained. These piles provide habitat for invertebrates, reptiles, birds and mammals.

Flail mowing of scrub margins

More extensive stands of scrub growing along a sea wall which are accessible to machinery can often be efficiently managed through flail mowing. This normally involves using motorised reciprocating blades mounted on a tractor. The terrain, including ground conditions, width of the folding and height and steepness of the sea wall banks can all influence the type of flail that should be used. Flails mounted on the front or rear of a tractor can be used in most conditions. Flails mounted on telescopic arms can reach scrub on steep banks or near the crest of a sea wall.

Advantages to flail mowing as a technique to manage scrub on sea walls include that the usually high work rate means it can rapidly clear large areas. Heavy-duty flails are available for dealing with more mature scrub and because flail mowing tends to pulverise stems, re-growth is normally slow. As such, flail mowing is particularly useful in controlling scrub that is encroaching onto open areas, pathways or access routes along a folding, trimming the edges of dense scrub, cutting down the early stages of scrub, and reducing the presence of less desirable species from a flood risk management perspective.

There are limitations to using flail mowing as a scrub management tool on sea walls.
These include:

- Access for machinery may be difficult at some sites, particularly when scrub is growing along the narrow crest of a sea wall;
- Risk of soil compaction and rutting damage from heavy machinery;

- Lacks selectivity in terms of which species of scrub are controlled leading to creation of uniform habitat stands;
- Flail mowers require specialised training and certification before they can be used;
- Careful consideration needs to be given to health and safety when scrub is growing on the slope or crest of a sea wall, or where there is a borrowdyke alongside the folding;
- Best results are obtained from smaller stands of scrub or where flail mowing is used to trim the edges of more established scrub;
- Some species, e.g. Blackthorn, increase suckering intensity in response to flail mowing resulting in the need for repeated control throughout the growing season;
- Can be local opposition due to the scale of change that can result;
- Whilst flail mowing normally incurs little risk to breeding birds when undertaken outside of the bird breeding season (generally March to August for most species), the impact on other fauna (e.g. invertebrates or small mammals) may be considerable at any time of the year; and
- Often generates significant amounts of mulched arisings which need to be spread either over a large area which may smother nearby habitats, or heaped in piles which can form a valuable habitat for invertebrates, reptiles, birds and mammals.

Arisings should ideally be collected and removed to prevent smothering or soil enrichment. However, in practice they are often left *in situ*. As with hand cutting, the storage, treatment and disposal of brash derived from flail mowing scrub on a sea wall can be subject to the Environmental Permitting Regulations (England and Wales) 2010 and the draft amendments published in 2013. Even when no permit is required there may still be a need to register an exemption. Whether a permit or an exemption is needed will depend on the activity being carried out and the types and quantities of wastes being handled.

Browsing

Browsing of scrub, re-growth and seedlings by livestock can be used as an effective management technique to control scrub encroachment on sea walls, thus helping maintain more open, grassland habitats. In addition to affecting the balance between the extent of open and scrub habitats present on particular stretches of sea walls, browsing can also help maintain or shape the structure of scrub stands at a finer level than can be achieved through flail mowing.

The three main factors determining the effectiveness of browsing on sea wall scrub are the type of livestock, the timing of browsing and the stocking rate.

Type of livestock

The two main types of livestock used to browse sea walls are cattle or sheep, though ponies are used more occasionally (see Chapter 6).

Cattle are relatively unselective browsers and will take palatable leaves and twigs of most scrub species. Preferred woody species are young Ash, Sycamore *Acer pseudoplatanus,* or oak saplings (Day *et al*. 2003). Less favoured species are birch, Alder *Alnus glutinosa* and notably thorny shrubs such as Hawthorn and Blackthorn. This may mean they are less effective in controlling the scrub typically found on sea walls. Due to their size, cattle can create passages through tall, dense stands of scrub which not only allows access to previously inaccessible areas of a sea wall but also increases the available marginal habitat.

Sheep by comparison are relatively selective in their feeding habits and will nibble around less palatable plant species. Preferred woody species are Ash, Elder and Old Man's Beard. Less favoured species are Alder and oak. On sea walls, sheep can be used to control re-growth and saplings, and due to their lighter weight tend to cause less poaching, particularly in any wet areas such as seepage lines, ruts on the folding or adjacent to borrowdykes.

▽ Old Man's Beard

Timing of browsing

The longer livestock browse scrub on sea walls the more effect they can have. However, the time of year that livestock browse can also have a major influence. Winter browsing for example can remove twigs and ground cover, as well as resulting in the stripping of bark from some species of trees and shrubs. In contrast, summer is the time when foliar browsing takes place, though this can result in the removal of seedlings. However, the response can vary greatly between different sea walls and even between different stretches or areas of a particular sea wall. As such, an assessment of the likely benefits against the possible risks is needed when considering whether to adopt this management technique for controlling scrub on sea walls.

Stocking density

In terms of browsing intensity, the stocking density required to achieve the desired degree of scrub control on sea walls depends on a number of factors including the accessibility, age and species of scrub, type of livestock and the extent of alternative, potentially more palatable forage available. Stocking densities therefore need to be carefully judged on a case by case basis. High densities (i.e. browsing by livestock at densities well in excess of normal carrying capacity), can be used for short periods to effect rapid change, such as reducing excessive, dense or mature stands of scrub (Day *et al*. 2003). Such rapid change though can be detrimental to any species of wildlife present that depend on the areas of scrub. Lower stocking densities can suppress the spread of scrub and thus help maintain the marginal habitats through the continual removal of side growth and any seedlings of both trees and shrubs (see Chapter 6). However, at low stocking rates there is a risk that livestock will tend to selectively browse on more palatable species thus promoting a change in the balance of scrub species. Whilst this may be considered detrimental, such preferential browsing can be used to encourage particular plants and the animal communities they support. Where it is going to be used, such as following scrub cutting to prevent re-establishment, it is generally better to start with a low stocking rate (e.g. 0.25 livestock units / ha) and slowly increase this until the desired effects on the scrub are being achieved.

There are limitations to using livestock as a scrub management tool on sea walls. These include:

- Livestock usually require daily, long-term inspection as well as considerable skill and care to manage. They are therefore very labour intensive;
- Fencing is required to control where livestock can forage. On sea walls this will often include adjacent areas of grassland or saltmarsh;
- Browsing seldom results in the removal of scrub from a sea wall unless it is very old or very young. It will only be an effective means of eliminating scrub if the browsing pressure is very high such that all the foliage is consumed or the bark is stripped;
- Many species of scrub will produce new growth from stems following browsing. As such browsing is only really effective at reducing the extent of scrub and preventing scrub encroachment;
- The crowns of more mature stands of scrub growing on sea walls may be out of reach of browsing livestock resulting in a distinct browse-line;
- It is seldom possible to have much control over what livestock will browse. As such, they may not control scrub in the way desired and may instead browse other species (e.g. rare plants) that need to be conserved;
- Different species of plants and plant structures (leaves, twigs, bark) can be browsed at different times of year resulting in varying effects;
- As livestock will browse what they like (usually the more palatable species) and leave what they like less (usually the more unpalatable species) this can lead to certain plant species (e.g. Hawthorn and Brambles) gaining a competitive advantage and therefore becoming more abundant. This may or may not be desirable;

- High stocking numbers (particularly of cattle) can lead to sea wall damage (see Chapter 6), over-grazing of adjacent grass and herbaceous swards hence reducing their value as invertebrate or reptile habitat, and in spring and summer disturb or destroy bird nests;
- Poaching of wet ground can cause lasting damage to soil structure, although light poaching can beneficially create opportunities for scarce annual plants and invertebrates; and
- Livestock can disperse seeds of scrub species via their coat, hooves and excrement.

Stump treatment

Stumps on sea walls are an important wildlife resource notably for insects, fungi and epiphytes, so should be retained wherever this is not in conflict with achieving flood risk management standards. The removal of stumps may also be necessary to enable subsequent machine mowing of the sea wall and without removal, most scrub species will regenerate from the stumps left behind after cutting, flail mowing or browsing. Treating stumps will therefore be required where the objective is to achieve the long-term absence of scrub from a particular stretch of sea wall.

There are seven main techniques for dealing with stumps on sea walls:

- Hand tools;
- Powered tools;
- Lifting out;
- Winching out;
- Grubbing;
- Stump grinders; and
- Herbicide.

Hand tools such as spades can be used to dig out small, shallow-rooted stumps and roots. A root-cutting chainsaw can be used to sever the roots and suckers of small stumps below ground level so that the stump can be rolled or lifted out. Where access allows, tree-lifting equipment can be used to remove stumps or even whole bushes. The most commonly used tree-lifting equipment comprises tractor-mounted spades. The spades are used to sever through and undercut the roots so that they can be lifted out. To limit damage to the structure of a sea wall, root-balling tree-lifting machines fitted with small diameter blades can be used to cut underground plant structures and lift out shrubs and tree saplings with minimal ground disturbance.

Stump removal by winching out can be an effective technique on sea walls, including where machine access is restricted through the use of a hand-winch. Where machine access is possible, a drum-winch mounted on a vehicle can be used. The easiest approach for small stumps in soft ground

is often to directly winch out the stump from a suitable fixed anchor. This can be a tractor, drilled steel plates that are secured to the ground with long metal pins or even a nearby tree if it is suitable and safe to use. A more indirect approach which relies on the cable passing through a block and tackle pulley can be used to remove larger stumps or those in more difficult locations. Regardless of approach, some digging out around stumps is likely to be required prior to winching out and where necessary filling the holes created.

Grubbing out scrub with the use of mechanical excavators will usually be a more efficient and cost effective approach to achieving the long-term absence of scrub on a sea wall than most other options. This will especially be the case where there are large stands of dense scrub. Removing scrub in this way often results in a dramatic change to the landscape, including the creation of large areas of bare ground, as well as causing considerable ground disturbance. Consequently, if there is a requirement to minimise damage to a sea wall, to retain vegetation cover on a sea wall or to conserve particular species, it may not be an appropriate technique. A wide range of machines are available from mini-excavators, through tractor-mounted buckets to large long-reach excavators. These all work by excavating out the rootstock, though the larger machines are capable of removing larger root plates.

A stump grinder can sometimes be used to destroy small or large stumps *in situ* with minimal soil disturbance, which can clearly be advantageous in terms of limiting damage to the structure of a sea wall. Stump grinders are available in a variety of different designs, including grinding teeth on fast rotating wheels and large grinding heads mounted on tractors.

Where access is difficult, herbicides can offer an alternative technique to treating stumps on sea walls. Indeed, there may be situations, such as where physical damage to the sea wall or the plant and animal communities they support needs to be kept to a minimum, that the use of herbicides becomes an essential tool, either alone, or as part of an integrated approach involving other techniques.

All land managers have an obligation to consider non-chemical methods of vegetation management before considering herbicide treatment. This is to comply with Government policy on reducing usage of pesticides to the minimum necessary to achieve effective control compatible with the protection of human health and the environment. As such, the use of herbicide to treat stumps or re-growth should only be considered where there are no alternatives and the benefits outweigh the risks. There are particular issues associated with applying herbicides near water. The Food and Environment Protection Act 1985 (as amended) places a special obligation on all pesticide users to prevent pollution of water. The Environment Agency must be consulted before any application of herbicides in the vicinity of water or watercourses and no pesticides (including herbicides) may be used in or near water unless the approval specifically allows such use. The number of herbicides with such approval has been reducing as product suppliers are no longer prepared to seek such approval.

Herbicides tend to act in one of two main ways. Either they start acting on contact with plant material (notably leaves) or they are absorbed by a plant and then translocated to other structures such as the roots. The two main techniques are therefore to spray an approved herbicide (such as a glyphosate based product) in dry, calm weather to low, in-leaf scrub between April to September or apply a herbicide directly to cut stumps to control re-growth. To be effective herbicide needs to be applied as soon after cutting as possible. Careful consideration needs to be given to the method of application to ensure there are no harmful effects, notably on non-target species. Hand held applicator sprayers or painting of stumps are targeted approaches.

There are limitations to stump removal as a scrub management tool on sea walls. These include:

- Careful consideration needs to be given to health and safety when stumps are present on the slope or crest of a sea wall, or where there is a borrowdyke alongside the folding;
- Removing stumps, especially manually with the use of hand or powered tools, can be a slow and laborious process, though this needs to be set against the time that would be taken to repeatedly deal with re-growth from untreated stumps;
- Lifting or winching out can be potentially dangerous and demand a high level of expertise and secure anchor points. The lack of safe anchor points to achieve the necessary leverage is likely to be a limiting factor on some sea walls and also leaves holes to be filled;
- Grubbing out with the use of excavators can be costly, even when hired in, though this may be offset by the high work rate;
- Access for machinery may be difficult at some sites, particularly when scrub is growing along the narrow crest of a sea wall;
- Use of machinery requires specialised training and certification before they can be used, with the success of an operation often reliant on a skilled operator;
- Risk of compaction and rutting damage from heavy machinery;
- There can be local opposition due to the scale of change that can result;
- Treating stumps with herbicide results in them remaining in the ground. Whilst this creates less ground disturbance initially, as the roots die off they can leave cavities which are undesirable in a sea wall; and
- All techniques other than herbicide treatment will produce root structures that require disposal.

Disposing of stumps can pose a problem on some sites, especially more remote stretches of a sea wall, as they are often heavy, decompose slowly and cannot be processed by most types of chippers, not least because stones and soil debris amongst the roots can damage the blades. Where possible and in particular where it is not going to interfere with flood risk management or access, roots can be left on site in the form of a log pile. Otherwise, they may need to be removed from site, which may be subject to the Environmental Permitting Regulations (England and Wales) 2010 and the draft amendments published in 2013.

Plants

Most of the plant species found in the scrub communities growing on sea walls are common and widespread and therefore generally of low nature conservation interest in themselves. Exceptions include Sea-buckthorn which is a Nationally Scarce plant and the Shrubby Sea-blite drift line community which is an Annex 1 habitat under the Habitats Directive.

Dense scrub casts a heavy shade, limits the amount of rainfall that reaches the ground and takes up much of the available soil moisture and nutrients. These combine to limit the species richness of the community, and where scrub invades areas of grassland it can lead to the eventual loss of the previous ground flora community. Whilst some of the affected species may have long seed viability, for most the seed bank deteriorates quickly under the closed canopy. Scrub encroachment can therefore be a distinct problem for botanical conservation where it threatens species-rich grassland plant communities. Scrub encroachment is a problem for rare plants such as Least Lettuce on flood defences at Fobbing Marshes, although it must be remembered that other factors such as climate clearly have a large influence on the occurrence of this plant (Hills & Fuller 2007).

Dense, especially thorny scrub can offer some protection to palatable plant species, especially those which exhibit a degree of shade tolerance. It can also provide a niche for taller plant species such as Common Meadow Rue *Thalictrum flavum* that would otherwise be vulnerable to grazing. However, most plant species of nature conservation interest associated with scrub are generally restricted to the margins of dense thickets, stands with a more open canopy, or scattered scrub. The margins in particular tend to be structurally more complex and therefore occupied by a wider range of plant species.

Some woody scrub species such as Elder can be an important substrate for epiphytic lower plants and coastal scrub on sea walls can also be of interest for its lichens and bryophyte flora, especially that associated with Blackthorn scrub.

The impact of scrub removal from sea walls on plants has two main considerations: firstly reduction in the abundance of woody species of conservation importance (e.g. Shrubby Sea-blite) and secondly the re-establishment of non-woody, grassland plants in the footprint of the cut scrub.

Case study

Response of Shrubby Sea-blite to cutting at Goldhanger, Essex

Shrubby Sea-blite is a halophytic (adapted to living in a saline environment), coastal evergreen shrub growing to a height of 1.2m (Stace 1991). Within the UK it is considered Nationally Scarce, with most stands restricted to the eastern counties of Norfolk, Suffolk and Essex, and the south coasts of Dorset and Kent. It principally grows on coastal shingle and the drier, upper areas of saltmarshes, especially where these adjoin shingle banks or sand dunes, but also grows along the drift line amongst the gaps between blockwork revetment on the seaward face of sea walls, particularly where they adjoin shingle banks or saltmarsh (Biological Records Centre 2012).

Shrubby Sea-blite flowers from July to September, with fruits appearing from September to November. The seeds are water-borne and can be washed up, accumulating in drift line debris where they can germinate in spring. Detached vegetative fragments (from storms or cutting) can also wash up and colonise new sites (Leach 1994). In places, such as the Steeple and Osea Island areas of the Essex coast, Shrubby Sea-blite had become so abundant on sea wall blockwork that it made inspection of the integrity of the sea wall very difficult (i.e. the dense bushy cover making it hard to ascertain whether large cracks were present in the sea wall). There was also a concern that the root system of Shrubby Sea-blite could damage the integrity of the blockwork revetment (e.g. concrete blocks becoming shifted out of place).

▽ Cut (left) and uncut (right) Shrubby Sea-blite

The shrub had established this dense cover in the absence of regular cutting of the seaward slope of the embankments. Whilst a control programme was recognised as necessary to be able to adequately inspect and thus protect the integrity of sea walls in Essex, it was also recognised this needed to be balanced against the need to conserve Shrubby Sea-blite which was listed in the citations of nature conservation designations on the Essex coast, including Sites of Special Scientific Interest (SSSIs), Ramsar sites and the Essex Estuaries Special Area of Conservation (SAC). The shrub was also included in the Essex Red Data List due to the significant, but localised, populations on the coast. There was also a need to consider the future of the species in Essex in the context of 'coastal squeeze' due to rising sea levels gradually reducing the available area of its saltmarsh and shingle habitats ultimately potentially limiting it to a narrow strip in the revetment on the seaward slope of sea walls.

Due to concerns about the response of Shrubby Sea-blite to management, and in particular the potential for this to have a detrimental effect on what was already a scarce species, in February 2010 a trial cut was undertaken along the seaward slope of a 2.8 km section of sea wall at Goldhanger on the Blackwater Estuary. The cut was carried out using a tractor mounted side-arm flail to a height of approximately 30 cm above the soil surface. It was hoped that, whilst allowing inspection of the integrity of the sea wall, this would also allow re-growth of Shrubby Sea-blite from the cut stems. Cuttings were also left in situ thus potentially allowing Shrubby Sea-blite fragments to regenerate, and to avoid further disturbance due to the difficulties of removal. Shrubby Sea-blite growing on the saltmarsh berm adjacent to the toe of the sea wall remained uncut so that some vegetation remained unaffected, especially where other notable plants of the Blackwater Estuary SSSI and Essex Estuaries SAC (e.g. Golden-samphire) were present.

A Shrubby Sea-blite survey along the 2.8 km section of sea wall was conducted in May 2010 (approximately three months after cutting). All Shrubby Sea-blite plants present in a 1m wide band (a continuous transect) were recorded as either showing signs of re-growth (young shoots sprouting or existing branches below 30 cm still alive) or not showing any indications of re-growth (no new shoots, stems brittle). The transect was situated on the seaward slope of the sea wall at the top of the blockwork revetment (high tide drift line) where most Shrubby Sea-blite bushes had been present. The results were related to type of revetment. In total, 1,548 (94%) of 1,644 Shrubby Sea-blite plants showed signs of re-growth (Table 7.2).

Table 7.2. Count of Shrubby Sea-blite plants along the 2.8 km long transect showing plant density (number per 100m length of 1m wide transect) and the proportion re-growing on the four different types of sea wall revetment three months after winter cutting (from Gardiner 2011b)

Revetment type	No. plants/ 100 m	No. plants with re-growth	No. plants without re-growth	% plants with re-growth
Canewdon Blocks	11	29	1	96.7
Essex Blocks (soil covered)	30	198	11	94.7
Essex Blocks (exposed)	103	1,308	83	94.0
Open Stone Asphalt	3	13	1	92.9
Means	59	387	24	94.2

The initial response of Shrubby Sea-blite to cutting was encouraging with 92-97% of plants (depending on revetment type) showing signs of re-growth after three months. Most re-growth was in the form of small shoots sprouting from cut stems. In a few cases, young shoots were arising from the soil (in gaps between concrete blocks in most instances) next to cut stems. A small number of cut plants (96 individuals or just under 6% of the total) showed no signs of re-growth (e.g. leaves shed, stems brittle) and may have been killed by cutting. Overall, the proportion of Shrubby Sea-blite re-sprouting was broadly similar between the different revetment types (Table 7.2). It should be noted that exposed Essex Blocks had the highest density of Shrubby Sea-blite plants on the transect count, with Open Stone Asphalt the lowest number of plants (mean per 100m transect length). Other notable plants of the front face of the wall such as Golden-samphire were noted as re-growing quite vigorously after cutting. Although not monitored, casual observations suggested that damage to these other locally occurring species due to cutting was mostly avoided.

A further survey was conducted in October 2010 (approximately eight months after cutting). This involved sampling the height and width of Shrubby Sea-blite plants on both the cut and uncut berm sections of the sea wall (Figure 7.1).

Figure 7.1. Mean height and width of Shrubby Sea-blite bushes on the Goldhanger sea wall eight months after cutting (standard error bars shown) (from Gardiner 2011b)

By October (eight months after cutting), the height of Shrubby Sea-blite bushes on the seaward slope of the sea wall (mean height 79.7 cm) was very similar to that of plants on the uncut tidal berm (mean height 82.1 cm), suggesting vigorous vertical re-growth after flailing (Figure 7.1). However, the width of plants was much greater on the uncut tidal berm than on the cut sea wall revetment, suggesting reduced lateral growth after cutting and as such at least temporary removal of the broader, sub-crown foliage. The side-arm flail used to cut the Shrubby Sea-blite may have led to branches of the plant being cut at an angle in some instances (due to the orientation of cutting flail on the slope) reducing the width of the bushes. The resulting low shrub width should therefore make it easier to inspect the condition of the sea wall in the first year after management.

It is intended to cut the seaward slope of the sea walls on a 3-4 year rotation (monitoring will be undertaken to assess if Shrubby Sea-blite can withstand this intensity of cutting), facilitating easier inspection of the sea wall whilst retaining this scarce species.

Invertebrates

In contrast to their generally low floristic value, areas of scrub on sea walls can support a diverse range of invertebrates. Notably, scrub can make a significant contribution to the invertebrate community found on sea walls through the growth form and age structure it provides in an otherwise open landscape and by the physical conditions it creates on the boundaries with other habitats (Mortimer *et al*. 2000). As such pockets of scrub, even quite small stands, can be of significant value. Not all species of invertebrates that use scrub will do so throughout their life cycle. Whilst some use it for feeding as adults on nectar from flowering shrubs, others use it as a food source during their larval stage. Others will use it for egg-laying or shelter before moving on to other species of plants. Recent work has emphasised that many species of invertebrates require a number of discrete habitats to complete each stage of their life cycle and that these habitats may or may not be spatially separated. To meet all their needs, some species of invertebrates rely on the relatively close proximity of suitable basking sites, sources of food, mating areas, shelter and shade.

The use made of scrub by invertebrates includes;

- Feeding;
- Nesting; and
- Shelter.

Feeding

Over 2,200 species of insects and mites have been recorded feeding on 31 species of woody shrub in Britain (Ward & Spalding 1993). These include butterflies, true bugs, bees, wasps, ants and two-winged flies. Whilst most species of invertebrate associated with scrub tend to specialise in utilising dead and decaying wood (Day *et al*. 2003), others feed on the associated lichens, algae and fungi of the bark and wood. Yet other species have larvae which eat the leaves of scrub communities. In addition to caterpillars, these include leaf-miners, gall formers and leaf rolling species. Most are specific to plant families, but relatively few are specific to a particular genus of plants, and even fewer are specific to a particular species of plant.

Flowering shrubs can also be important in spring as a source of nectar for invertebrates such as social and solitary bees, as well as for those species which emerge after hibernation. For early flying insects, Hawthorn is often the most important component of scrub and the ecology of many species of invertebrates has adapted to coincide with the peak time of flowering. Flowering shrubs such as Dog Rose and Brambles can be important food sources later in the year. For example, uncut scrub (particularly Brambles) left on a sea wall folding can provide valuable forage throughout the summer for bumblebees. This is particularly important when other food source plants have been mown on the rest of the sea wall.

Case study

Bumblebee usage of sea wall scrub as a foraging resource at Brightlingsea, Essex

▽ Open stone asphalt revetment on a sea wall

Counts of bumblebees at Brightlingsea in Essex revealed that uncut Bramble scrub on the sea wall folding next to the borrowdyke edge was a valuable foraging resource, particularly where bees such as the scarce and declining UK BAP Priority species of Moss Carder-bee and the Red-tailed Carder-bee have been recorded (Figure 7.2).

The once widespread Moss Carder-bee has undergone a serious decline in England and is now mainly a species of grasslands and disturbed sites in coastal districts, especially in the north and west of Britain. In Essex, it is now largely restricted to the linear habitats of tall, open grasslands close to sea walls, especially those where there is a wide folding with plenty of grassland and scrub habitat (Gardiner & Benton 2011). Whilst this species nests on or near the ground, often in sunny spots, it seems to prefer to feed in tall, flower-rich grasslands with abundant legumes such as clovers,

vetches and Common Bird's-foot-trefoil, together with other wildflowers. As a late emerging species, flowering Brambles can also provide a suitable food source for bumblebees (Figure 7.2).

The Red-tailed Carder-bee was also formerly considered widespread in England though its true distribution remains uncertain as it was probably confused in the past with the superficially similar Red-tailed Bumblebee *Bombus lapidarius*. The population does however appear to have suffered a similarly sharp decline as the Moss Carder-bee with confirmed records now concentrated in south-east England. Queens can be recorded in a variety of habitats, including scrub margins where they visit species such as White Dead-nettle, Kidney Vetch *Anthyllis vulneraria* and woody plants. Red-tailed Carder-bee workers seem to be much more localised and prefer similar flower-rich grasslands with scattered scrub similar to that used by Moss Carder-bee.

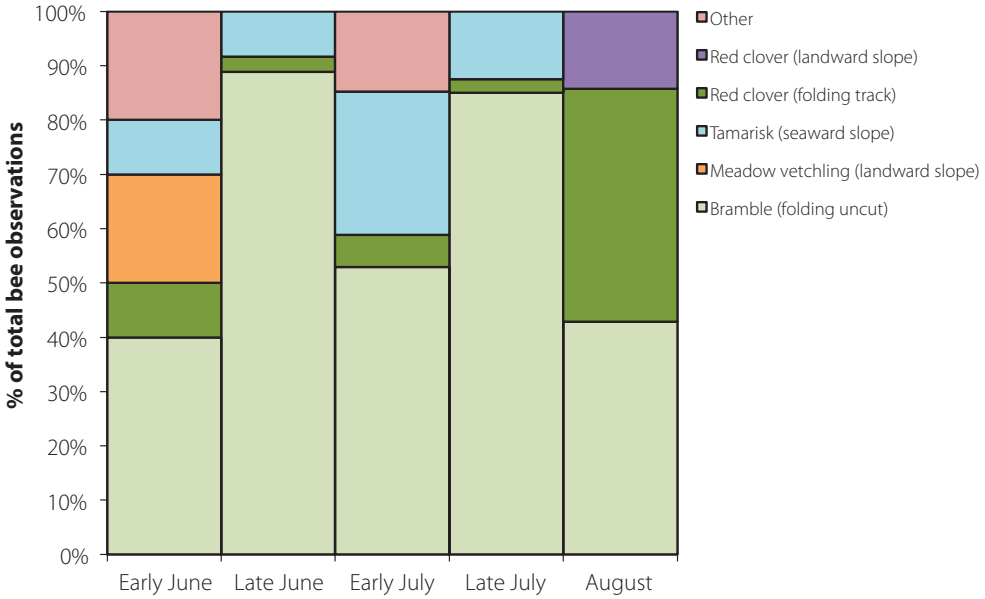


Figure 7.2. Percentage of bee observations (all *Bombus* species combined) on differing plant species on a sea wall at Brightlingsea, Essex

The height and structure provided by scrub is also important for the hunting techniques of some adult invertebrates, notably spiders, which do not eat the scrub plants themselves. One example of such a hunter found on sea walls is the Wasp Spider. This large yellow and black orb spider has only been

known in Britain since being found at Rye in Sussex in 1922 where it was at the northern limit of its European range. Since then, it has spread around the coast as well as inland and can now be found in many areas with suitable habitat in southern England (Harvey *et al*. 2002). This includes scrubland with rough grassland on sea walls where it builds its web close to ground level across small gaps in the vegetation to catch flying insects, though jumping grasshoppers may also be an important source of prey for this species (Gardiner & Hill 2005).

The Wasp Spider weaves a zigzag pattern known as a stabilimentum upwards from the ground below the centre of the web to the central point where the female spider normally rests. This zigzag structure is considered to be an excellent indicator for the presence of this species and has been shown to increase prey capture, though it may serve different functions in varying ecological contexts (Kim *et al*. 2012). This species is particularly noted from the sea walls of North Kent, including Oare Marshes on the Swale and Northward Hill adjacent to the Medway Estuary where it was first discovered in 2002 and has subsequently been found in areas of long grass at nearby Shorne, Cliffe and Higham Bight (KOS 2005).

Nesting and egg-laying

Scrub can provide a wide variety of potential nest sites for invertebrates. Holes in woody growth may indicate the presence of beetles feeding within and disused tunnels can be used as a nest site by insects such as solitary wasps.

Sea wall scrub may also be utilised by Glow-worms. The UK Glow-worm survey began in 1990 (see www.glowworms.org.uk). Information comes mostly from members of the public who see Glow-worms and want to know more about them. Before the survey started, it was thought that there were fewer than 100 sites where Glow-worms could be found in the UK. The survey has shown that they are present at hundreds of sites, with more being reported every year.

The commonest Glow-worm (*Lampyris noctiluca*) seen in Britain is not in fact a worm but a beetle. The wingless adult females glow to attract the flying males. As neither male nor female adult Glow-worms have any mouthparts, they can't feed and their brief adult lives, which may only last a few days, are a race to mate and lay eggs.

Glow-worm eggs are generally laid during the summer months, between mid-June and September. Although egg-laying may occur over a few days, it is very rare to find an egg-laying female in the wild. What reports there are suggest eggs are usually laid close to where the female has been displaying in fairly moist locations, such as on the underside of shady branches of trees and shrubs, underneath

logs and stones, at the base of grass stems, in moss or in holes in the ground. The eggs may be laid singly or in clusters of up to around 100. The number of eggs which a female can produce is roughly proportional to her size. A small female may be no more than about 12 mm in length, whereas a large one may be over 25 mm, so a clutch may vary from a couple of dozen eggs to well over 150, but a typical number is probably somewhere between 50 and 100.

The eggs hatch after about 30 days. The larvae may take almost two years to mature and feed during the summer months on the small snails and slugs which can be abundant in scrubby habitats, but appear to hibernate below ground or under logs or stones during the winter. For most of this time larvae are strictly nocturnal, but in the spring of their final year they will roam during daylight hours, possibly looking for new habitats (or snails) or seeking out a good spot in which to pupate.

△ Glow-worm larva (Howard Vaughan)

Case study

Glow-worms at Creeksea, Essex

A section of sea wall at Creeksea on the north bank of the Crouch Estuary in Essex was to be cleared of woody vegetation by the Environment Agency during the 2010/2011 winter in order to improve the ease with which the condition of the sea wall could be inspected and to ensure that tree roots did not damage its structural integrity (see Chapter 4).

The Creeksea sea wall supported the only known sea wall population of the Glow-worm in the county, which although not protected by law, was locally rare in Essex. Previous surveys had indicated that the numbers of glowing adult females on the sea wall were generally low, ranging from just one in 1996 to a record count of 12 in 2009. This suggested that the beetle maintained a small breeding population on the sea wall which had perhaps benefited from a lack of mowing leading to development of tall grassland, as well as some small dense thickets of Brambles, Blackthorn and Hawthorn scrub.

A survey of Glow-worm larvae in different habitats on the unmown sea wall using reptile survey mats (felt roof tiles) in the summer of 2010 confirmed the presence of a small breeding population (Table 7.3).

Table 7.3. Number of Glow-worm larvae on the unmown sea wall at Creeksea in the summer of 2010 (Gardiner 2011a)

	Open grass	Isolated scrub	Dense thicket
Glow-worm larvae	2	6	2

In total, ten larvae were seen on the sea wall under five individual reptile mats (28% of mats). In a very narrow section of sea wall with a footpath, two larvae were seen underneath a mat next to a small (less than 2m high) Hawthorn bush that was found along the fenceline bordering a garden. Two larvae were found in association with dense Blackthorn, elm *Ulmus* species, and Tamarisk on the edge of a thicket bordering the sea wall. Four larvae were recorded under a large (approximately 3m high) Hawthorn bush on the landward sea wall slope, and two in open grassland.

Without careful planning and implementation the proposed scrub clearance therefore risked eradicating the last remaining sea wall population of Glow-worms in Essex. As a result, during the clearance of woody growth from the crest, landward and seaward slopes of the sea wall over the winter of 2010/2011 as many stands of scrub as possible on those sections of folding where it was considered acceptable were left uncut. In addition, piles of logs were created in locations where Glow-worm larvae had been recorded the previous summer.

A total of 37 glowing adult females were seen in three surveys during the subsequent 2011 summer indicating that the management of scrub in this way may have benefited the Glow-worm population (Gardiner 2011a). The minimum and maximum counts of one and 20 females compared favourably with counts in previous summers. With 33 of the Glow-worms (89%) counted in summer 2011 on the sections of the sea wall cleared of woody growth the previous winter, it appeared the mitigation measures adopted by the Environment Agency were highly successful, possibly because cut scrub patches with a high amount of bare earth form excellent female display locations where they can be easily seen by flying males. The results were seen as encouraging considering the concerns expressed over large-scale scrub removal works on sea walls. In future years, scrub should remain uncut on the sea wall at Creeksea along the landward fenceline and in the existing thicket bordering the sea wall to provide habitat for Glow-worms.

Shelter

Scrub provides invertebrates with shelter from rain, shade from excessive sunlight and wind, especially where the scrub is on the 'windward' less sheltered side of a sea wall. Thermal microclimate resources (shelter and sunlight) have been found to be important to butterflies (Dover 1996, Corke 1997) and grasshoppers (Gardiner & Dover 2008) in the simplified landscape of arable farmland and are therefore also likely to be important in other situations such as sea walls. It has also been shown that species richness and abundance of grasshoppers, bush-crickets and allied insects are higher on the 'leeward' side of hedgerows and scrub. It is likely therefore that the presence of linear strips of woody vegetation on the folding between a sea wall and borrowdyke will also provide the sheltered conditions needed by species of Orthoptera in areas otherwise exposed to the prevailing wind direction. Whilst most species of Orthoptera found in Britain do not fly strongly and generally only achieve flights of 2 to 3m (Marshall and Haes 1988), it seems likely that they will favour sheltered conditions similar to flying insects such as butterflies (Dover *et al*. 1997), particularly as the dispersal of some species such as the Meadow Grasshopper (commonly found on sea walls) is reduced at high wind speeds (Gardiner 2009).

Reptiles and amphibians

There is relatively little information about the value of scrub habitat on sea walls for reptiles and amphibians. However, an understanding of general herpetofauna ecology suggests scattered scrub could provide foraging opportunities, create windbreaks and pockets of warm microhabitat which can be used as a refuge in hot weather, provide cover in heavy rain or overnight and even act as a winter hibernacula for species such as Adder which often hibernate communally in mammal burrows or under tree roots. Therefore it is important that any clearance of woody vegetation on sea walls over winter is undertaken sensitively, always leaving uncut woody vegetation along borrowdykes and on the folding wherever possible. As an alternative on sea walls known to support Adder populations, scrub should be cut back after the bird nesting season but before the onset of the reptile hibernation period (October).

The interface between scrub and other sea wall habitats generally contains a greater diversity of plant species and habitat structure, and hence the microhabitats and microclimates likely to be favoured by reptiles (Edgar *et al*. 2010). Common Lizard and Slow-worm for example are also reported to occupy a wide range of habitats, including rough grassland with Bramble scrub. Scrub-grassland interfaces with a southerly aspect are likely to be especially valuable for reptiles, as they provide good basking sites close to dense cover.

As the spread of dense scrub along sea walls can reduce its suitability for most species of reptile and amphibian, vegetation management in the form of scrub control is usually required to maintain the mosaic of grassland and scattered scrub communities characteristic of reptile habitat. However, excessive clearance of scrub can be equally damaging.

Birds

Scrub is an important habitat for breeding, migratory and wintering bird species. The use made of scrub by birds is complex and appears to be determined more by vegetation structure rather than actual species composition. As such, the number of species of bird using scrub is often higher in areas where there is greater diversity of vegetation structure and in particular where scrub forms a mosaic with other habitats.

The three main attributes provided by areas of scrub and their margins for birds are nesting sites, foraging habitat and shelter.

Nesting

Scrub can have value as nesting habitat for a range of bird species, including some UK BAP and Birds of Conservation Concern (BoCC) Red Listed species such as Linnet and Yellowhammer *Emberiza citrinella*. The Linnet in particular has concentrations along the east coast of England. Red List birds are those that have declined in numbers by 50% over the last 25 years, those that have shown an historic population decline between 1800 and 1995 and species that are of global conservation concern. The species on the Red List are of the most urgent conservation concern.

▽ Nightingale nesting habitat at Cattawade Marshes, Essex

Different species of birds tend to nest in different successional stages of scrub growth. For example, whilst Nightingale *Luscinia megarhynchos*, Bullfinch *Pyrrhula pyrrhula*, Blackcap *Sylvia atricapilla* and Garden Warbler *Sylvia borin* are often associated with more mature, dense stands of scrub, notably Blackthorn or Brambles, the Linnet, Whitethroat and Yellowhammer tend to use younger low-growing, scattered bushes (Mortimer *et al.* 2000). With its extensive growths of Gorse and Blackthorn, the West Wall of the Pagham Harbour Nature Reserve is considered particularly suitable

for breeding Yellowhammer. In good summers, adults may be seen carrying food to young until early or even mid-August, well outside the recognised breeding season (Sussex Nature 2012).

In some cases, birds will hold territories around widely separated patches of scrub. For example, species such as Blackbird *Turdus merula* and Song Thrush *Turdus philomelos* which feed in shorter vegetation but nest in thick scrub cover use an intimate mosaic of grassland and scrub. Certain species, such as Cetti's Warbler *Cettia cetti*, whilst found in damp scrub, appear to use areas where scrub is only a small proportion of the overall habitat mosaic, with birds found in coastal areas also tending to show a strong association with reedbeds, such as those often present within borrowdykes.

Foraging

Scrub can also be an important source of food for birds. This applies not only to resident species such as Blackcap which feed on invertebrates or berries, but also passage migrants and winter visitors such as the berry eating Redwing *Turdus iliacus* and the seed eating Twite. Mixed stands of scrub growing on sea walls will support a wider range of invertebrates as well as producing a greater variety of fruits, and hence providing more opportunities for feeding. Most birds will feed on a range of shrub species but can often show preferences based upon the availability of other food sources in the area. Seasonal availability of seeds and fruits means that whilst scrub usually provides only part of a resource, it is still important for maintaining survival and productivity.

Shelter

Scrub is also used by birds as a safe and valuable roost site offering vantage points away from potential predators or disturbance. Dense scrub of Hawthorn, Gorse and Brambles in particular can also act as an important landfall for migrating birds, including the occasional rare vagrants. Certain raptor species, such as the Long-eared Owl *Asio otus* habitually aggregate in scrub to roost in winter (RSPB 2012).

Case study

Breeding birds on the Snodland sea wall, Medway Estuary, Kent

The sea wall between Snodland and New Hythe on the upper Medway Estuary is within the Holborough to Burham Marshes SSSI. The citation includes reference to several areas of dense scrub, which on the sea wall consist mainly of Hawthorn, Blackthorn and Elder, with Alder in the wetter areas of the folding. Several species of birds are noted as breeding in these areas of scrub, including Nightingale and on occasions the rare Cetti's Warbler.

Nightingale is a summer visitor to Britain, with the first arrivals generally seen in early April. They are a scarce breeding bird in southern and eastern England, and listed as an Amber species of concern. Whilst most nest sites are in scrub near water where they generally use the middle stages (5-8 years) of scrub growth, Nightingales appear to be somewhat adaptable in their habitat preference.

Cetti's Warbler usually breeds in dense scrub on the margins of reedbeds and waterways. This little brown bird only started to breed in England in the 1970s and until recently was much more likely to be found breeding in the milder south-east and south-west of the country. The species has been spreading northwards in the last 40 years, possibly in response to the changing climate (Chen *et al*. 2011) and can now be found on the banks of the Humber. Kent and Medway in particular, have remained a stronghold. Unlike other warblers, Cetti's Warbler remains to winter in Britain and can therefore be susceptible to both cold winters and scrub management works over the winter.

Scrub on the crest of the sea wall at Snodland was cut back to facilitate improvements to the standard of defence provided in the early 1990s. Care was taken to minimise the amount of clearance undertaken. As a result, the majority of the dense scrub on both the seaward and landward slopes of the sea wall was retained. The length of scrub edge present on site was significantly increased through the creation of the 'ride' along the crest of the wall. This has been subsequently maintained through edge trimming during winter months and both Nightingale and Cetti's Warbler have continued to be recorded in the area. For example. Nightingale was confirmed as breeding and Cetti's Warbler probably breeding in the vicinity of the sea wall between 2008 and 2011 (KOS 2012).

Mammals

Areas of scrub and their margins can provide shelter, forage and breeding habitat for a variety of native mammals, notably woodland species that can adapt to using patches of scrub as well as those species which can utilise the linear tall herbaceous sward growing along the interface between scrub and grassland habitats. These include the Common Shrew and Wood Mouse. Dense, well developed scrub, notably Brambles, growing on sea walls, may also provide suitable habitat for species such as the Harvest Mouse. The Harvest Mouse is the only British mammal to build nests of woven grass well above ground in dense vegetation.

In autumn, some scrub species growing on sea walls, especially Brambles, produce prolific fruits. These are important in the diets of a range of mammals, and for some help secure body condition prior to hibernation. Whilst small mammals are generally the major food source for the Fox *Vulpes vulpes*, fruit (particularly blackberries) will also be eaten when available.

Dense thickets of scrub can hold less desirable species from a flood risk management perspective such as Rabbit, Fox and Badger, which can create sizeable burrows in a sea wall.

The numerous entrances associated with such burrowing can cause significant problems for the structural integrity of a sea wall and is inimical to their primary flood defence function. Where burrowing by mammals is a problem, control measures need to be compliant with wildlife legislation. For example, where Badgers had tunnelled into sea walls at Paglesham on the River Crouch in Essex, the Environment Agency undertook measures to safely exclude them from the sea wall under a sett closure licence issued by Natural England. Once Badgers had been excluded, the scrub was removed and the sea wall repaired (Tom Wallace personal communication).

△ Mammal burrows on the south side of the Swale, Kent (R Pilcher)

Case Study

Ground Penetrating Radar survey of Badger sett at Bradwell-on-Sea, Essex

A Ground Penetrating Radar (GPR) survey using a dual frequency system (250 MHz and 750 MHz) to scan the subsurface was undertaken on a sea wall in Essex to investigate Badger activity. The radar shows the depth of probable Badger sett chambers and tunnel as interference (Figure 7.3). Badgers had tunnelled right through the flood defence (a hole appearing on the tidal face) causing a risk of collapse and inundation of seawater during a storm surge. Their sett chambers and tunnels were also thought to lead to slumping of the crest, therefore lowering the standard of protection from tidal inundation. To investigate this, a GPR survey was undertaken which showed the presence of two possible sett chambers and a tunnel as suspected. The success of GPR is dependent on the presence of a measurable physical contrast between the target and surrounding materials. The target in this case will be any shallow voiding or loosely compacted soils with higher moisture content which may be related to burrowing activities by Badgers. The use of GRP allows particular areas of sea walls to be targeted when excluding Badgers under licence from Natural England (Figure 7.3). This avoids disturbance to sections of the sea wall without Badgers saving time, effort and unnecessary expenditure. The 20 or so sett entrances in this sea wall also illustrate how an absence of grassland management can lead to scrub encroachment and subsequent issues with the structural integrity of sea walls.

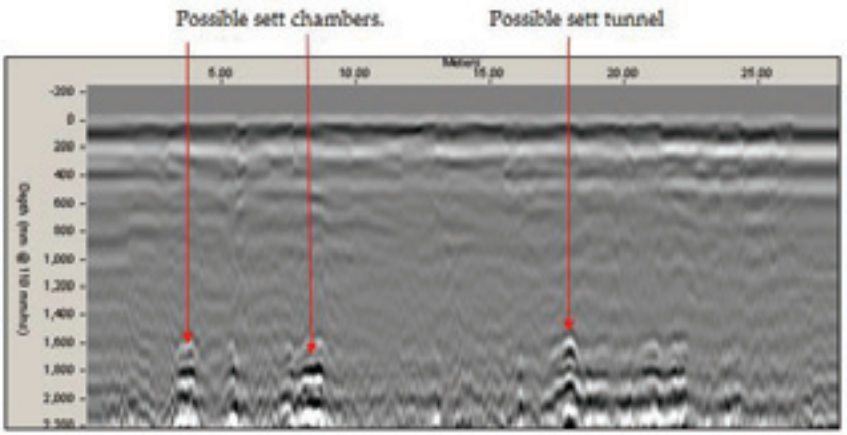


Figure 7.3. Longitudinal cross section of a sea wall in Essex (distance along sea wall crest on top axis and depth into the sea wall on side axis) using Ground Penetrating Radar (GPR).

Case Study

Scrub management on Suffolk and Essex sea walls

Where was scrub clearance undertaken?

The Environment Agency undertook significant tree and scrub clearance on lengths of sea wall throughout Suffolk and Essex over the winters of 2009/2010 and 2010/2011. Thickets of scrub were seen as encouraging the presence of burrowing animals such as Badger which could damage the integrity of sea walls and risk causing tidal flooding if they were to burrow completely through. It was also recognised that the removal of woody vegetation, and in particular its complete eradication, would lead to the loss of important scrub habitats from the sea walls, many of which were within sites designated for their nature conservation interest. Natural England agreement was obtained prior to clearance commencing, to ensure that the cutting of scrub was undertaken as sensitively as possible, and in particular that some invertebrate and bird nesting scrub remained on the sea walls.

Thus, whilst the complete clearance of woody vegetation, notably Blackthorn, Hawthorn and Bramble scrub, was carried out on the landward slope, crest and the seaward slope of Suffolk and Essex sea walls, scrub was only cut on the folding for a distance of some 5m from the toe of the landward slope to facilitate the safe passage of vehicles along the folding. This often meant that a 2-3m wide band of scrub, particularly Blackthorn, was left on the folding next to the borrowdyke edge on many sea walls. This band of scrub is important for scarce species such as the Sloe Carpet *Aleucis distinctata* moth at Old Hall Marshes in Essex for example. Veteran trees (trees which, because of their great age, size or condition, are of exceptional cultural, landscape or nature conservation value) have also been left in this band of scrub, for example, an oak near Bradwell-on-Sea in Essex and an Ash at Butley in Suffolk.

Scrub clearance methods

A generic approach was devised for sea wall scrub cutting. This involved the removal of scrub from the folding, landward slope, crest and seaward slope of a sea wall by hand using chainsaws, brush-cutters and hand tools, as well as through the use of a tractor-mounted flail or six-ton hydraulic excavator with a flail. Stunted oaks, most of which were less than 3m tall with trunks up to 200 mm diameter, though in some locations were up to 10m high with trunks up to 250 mm diameter, were felled using a chainsaw. In addition, grass cutting was carried out on the seaward slope of the sea walls using strimmers, tractor and flail, excavator mounted flail and self propelled mowers.

Disposal of arisings

All arisings from the scrub cutting were chipped. The strategy for dealing with the chippings was to avoid spreading them on grassland plant communities of the sea wall. As such, chippings from small amounts of clearance (e.g. Blackthorn, Brambles, and trees less than 100 mm diameter) were spread on the area that had been cleared (i.e. the footprint of the scrub) which was devoid of any plant interest.

Timing of works

All works were undertaken outside the bird breeding season (generally considered March – August inclusive) to avoid disturbing any nesting birds. Natural England's severe winter weather working guidelines advocated avoidance of undue disturbance to overwintering migrant birds on the adjacent mudflats and saltmarsh of the estuaries. As such, works ceased when there were seven consecutive days of night-time temperatures falling below zero and only restarted after three days of thaw (above zero night-time temperatures).

▽ Spiny Restharrow

Response of herbaceous plants

The response of selected target plant species was monitored and compared against historic surveys. For example, the results of a plant survey of the Essex sea walls undertaken from 1993-2001 (pre-scrub clearance) were compared against survey results collected in 2011 (post-scrub clearance). The results (Figure 7.4) revealed that of 10 selected target plant species, only two had shown any real decline (Sea Barley and Slender Hare's-ear). These two Nationally Scarce plant species were closely associated with disturbed, open ground, specifically ruts on the folding. Therefore it is possible their decline may be due to the scrub thickets that can develop in the absence of appropriate grassland management. It was also noticeable for sea walls where scrub thickets were present, that the soil disturbance associated with the cutting activities appeared to benefit species such as Dittander (present on 92% of the 58 stretches of sea wall cleared of scrub in Essex), Sea Barley (present on 67% of scrub cleared sea walls) and Spiny Restharrow (present on 73% of scrub cleared walls).

Least Lettuce has also benefited from scrub clearance undertaken by the Environment Agency (in liaison with Natural England) on a redundant sea wall at Fobbing Marshes in south Essex. Scrub was cleared by hand and chainsaws, chipped and then removed from site (which was a SSSI). Scrub was cut back (from the crest and both slopes) on approximately 150m of embankment in March 2012 before the onset of the peak bird breeding season. Several early bird nests were identified and the scrub left uncut where they occurred to avoid destruction of nests which would have been unlawful. It is hoped that reducing the scrub cover will allow grazing livestock to recreate the poached ground condition required by this rare plant. Grazing animals may also browse the regrowth of cut scrub therefore controlling its spread back onto the sea wall.

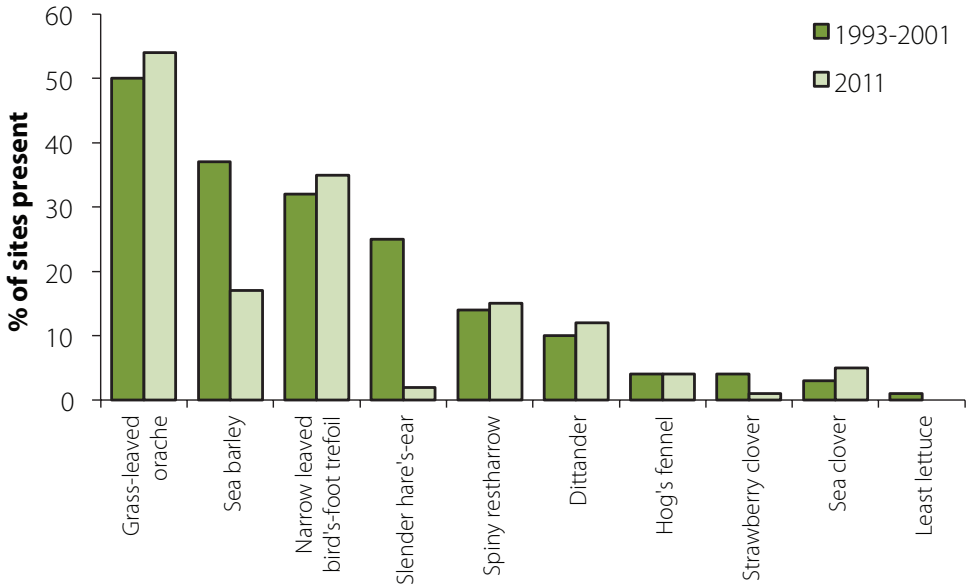


Figure 7.4. The percentage of sites (N = 100) at which 10 plant species characteristic of sea walls were recorded in a survey from 1993-2001 and in 2011

△ Compensatory trees on West Canvey Marshes in Essex

Compensatory Planting

With the permission of the landowner, planting scrub where it will not interfere with flood risk management operations may be an option to offset the adverse ecological effects of extensive scrub management. Ideally, this planting should be as close to where the scrub will be removed, though this may not always be possible as areas landward of sea walls will be in the coastal floodplain. It should also comprise native species of local provenance that could be expected to occur in the area (e.g. capable of tolerating both the generally exposed conditions and salt spray).

Transplanting of young trees and shrubs is generally best undertaken over the winter and they should be positioned to encourage hedgerows or small thickets to develop. They should be planted with supporting canes and Rabbit guards to improve the chances of successfully becoming established. The management regime should include replacing any losses to natural causes in the first three years.

Ash dieback

Ash dieback is a serious disease of Ash trees caused by a fungus called *Chalara fraxinea*. The disease causes leaf loss and crown dieback in affected trees, and it can lead to tree death. Ash tree dieback was first detected in the UK in February 2012. Advice must be sought before planting Ash in any compensatory schemes. An adequate substitute for planting on wet soils (e.g. along borrowdykes) is Alder which prefers damp ground similar to Ash.

Case study

Compensatory planting of trees to offset scrub clearance on Essex sea walls

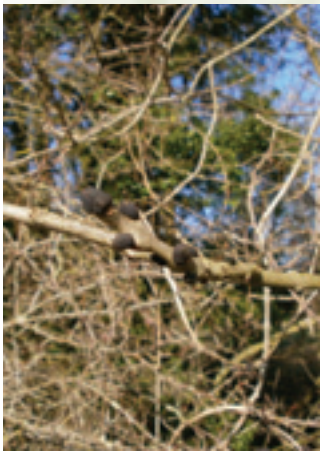
To try to compensate for the removal of a large amount of scrub from sea walls in Essex from 2009 to 2011, it was decided that tree planting should be undertaken at various sites on the Essex coast to provide some replacement habitat in the long-term. For example, 2000 trees were planted on West Canvey Marshes in liaison with the RSPB to compensate for the loss of scrub from the sea walls on Canvey Island in Essex. This took the form of planting patches of Blackthorn scrub and filling in gaps in existing hedgerows with Dog Rose, Field

Maple, Hawthorn and oak. These were tree and shrub species native to the area and known to be growing locally and expected to thrive on the seasonally wet clay soils of the site. The trees and shrubs planted were each 40-60 cm high and each one had a 60 cm plastic spiral Rabbit guard and 90 cm cane. Three seasons after planting, there has been a high survival rate of the trees. Similar tree planting schemes were undertaken throughout Essex. A summary is provided in Table 7.4.

Table 7.4. Number of trees planted at various locations throughout Essex to offset the removal of sea wall scrub

Location	Number of trees	SSSI/SPA/SAC	Habitat created
Maldon to East Mersea	6000	Blackwater/Colne Estuary (6 sites)	Hedgerow
West Canvey Marshes	2000	Holehaven Creek	Hedgerow
Little Oakley	1500	Hamford Water	Hedgerow
Brightlingsea	850	Colne Estuary	Woodland
Burnham Wick Farm	800	Crouch & Roach Estuaries	Hedgerow
Althorne	284	Crouch & Roach Estuaries	Woodland
Hythe Marshes	750	Colne Estuary	Scrub
Cattawade	10	Stour Estuary	Hedgerow
Total	12194		

▽ Black buds of Ash



Key aspects of scrub management on sea walls

Despite the diversity of protected and rare species found on sea wall habitats, it is possible to apply some broad principles that should help conserve the greatest range of wildlife during scrub removal operations. These are summarised in Table 7.5.

Table 7.5. Principles for managing scrub on sea walls

Principle	Key Considerations
Establish clear objectives	There can sometimes be a conflict between what a sea wall should look like from a flood risk management perspective and what it should look like from an ecological perspective. Before making a decision about where and how to manage sea wall scrub to maintain its flood risk management condition, an assessment should therefore be made of its nature conservation value. Scrub of high conservation value (i.e. that which supports a diverse range of associated flora and fauna) is likely to include a mixture of native species of local provenance across a range of ages and physical structure from young growth to decaying wood. The latter is particularly important as many species of invertebrate and bird are associated with particular 'niche' stages of scrub succession.
Conduct surveys	Because scrub can provide an important habitat for wildlife, including species of conservation interest, it is important to develop an understanding of how the various niches are used, including at different times of year, to help inform vegetation management.
Target ecological benefits	The spread of scrub can lead to a loss or reduction of some botanically rich grassland communities and their associated fauna. For example, scrub encroachment where sections of sea wall remained uncut appeared a significant problem for the Fisher's Estuarine Moth in Hamford Water, Essex, because Blackthorn was smothering the larval food plant, Hog's Fennel (Ringwood 2008). A targeted programme of scrub removal which maintains stands of scarce species (such as Hog's Fennel) or results in the re-establishment of grassland communities can therefore be ecologically beneficial on some sea walls. For example, Sea Barley and Least Lettuce are annual plant species which require open, disturbed habitats and may therefore benefit from disturbance to the ground associated with mechanical scrub cutting (e.g. they may appear in rutted ground or where cutting machinery has caused damage to the soil surface). Glow-worms also responded well to scrub clearance on sea walls on the Crouch Estuary.

	Grasshoppers used the bare earth in the footprint of the cleared woody growth as basking and oviposition habitat at sites such as Old Hall Marshes. Whilst a particular vegetation management regime may raise concerns in relation to one species, or even a suite of species, it may be beneficial to other species, or suite of species. The overall biodiversity losses and gains need to be weighed up in the context of long-term priorities.
Choose the right technique	It is important to use the most appropriate technique in relation to the size of the scrub management task and in the context of the ground conditions and limitations in access posed by sea walls. There may be concerns with particular techniques which need to be addressed or if necessary an alternative technique employed. Sometimes the technique merely needs to be applied at a lower intensity. This might mean, for example, cutting less frequently, lower intensity livestock browsing or removing less scrub. Particular care should be taken when herbicides are being considered to consider whether any alternative techniques may be more appropriate.
Tackle early	Preventing a problem from arising is usually better than trying to deal with it later. Scrub control is therefore best undertaken when shrub numbers are low and stands only small. Such early removal when trees and shrubs are still small (e.g. in the seedling or sapling stage) will make them easier to remove, require less resources, result in less material for disposal, and be more cost effective. Addressing scrub encroachment before the canopy closes over also means preferred plant communities (i.e. grassland) are likely to more quickly re-establish from the existing seed bank in the soil. It will often be better to periodically clear individual bushes to prevent overcrowding and closing of the canopy.
Timing	The timing of scrub management on sea walls is a key consideration and sometimes shifting the timing by just a few weeks can resolve any significant issues. In general, substantial scrub management should only be undertaken during the winter as this is outside the bird nesting season (generally from late March through to mid August), and when reptiles are hibernating. Even at this time, care should be taken to ensure that hibernation sites themselves are not damaged or left devoid of cover, and where possible only in January and February so that shelter and berries are available as a food source for birds and mammals for as long as possible. Where winter clearance is undertaken on sea walls (particularly in Ramsar sites and SPAs) it is important to observe the severe winter weather working guidelines issued by Natural England. This specifies cessation of works during extremely cold spells to reduce the risk of disturbing migrating bird species (particularly wading birds) which utilise habitats on both sides of the sea walls when they are most vulnerable.

Scale	Occasional patches of scrub, particularly Blackthorn and Brambles, are a valuable habitat on sea walls (e.g. for nesting birds, invertebrates such as the Sloe Carpet moth and potential hibernation sites for Adder). The negative ecological consequences of scrub management may be less significant where restricted to one small area, particular zones of a sea wall or defined stretches of a sea wall. As such, some uncut woody growth should be retained where it will not pose a threat to the structural integrity of a sea wall or interfere with flood risk management operations (e.g. as a band along the edge of a borrowdyke where space allows).
Diversity	Where possible, try to achieve a diverse structure to the scrub. This can be achieved by only cutting small patches at any one time or by cutting scrub on a rotational basis with the intention of retaining all age classes. Scrub typically matures in around 15 years, so for example rotational cutting programmes could be to cut 1/15th every year or cut 1/5th every third year. Where the seaward face of sea walls supports scarce woody shrubs such as Shrubby Sea-blite, they should only be cut back on a long rotation (perhaps once every 3-4 years) to allow inspection or repairs, but not every year as this may lead to a reduction in abundance or even eradication.
Margin	Where possible, scrub should have a scalloped edge. This is because the scrub margin is often an important source of fruits such as berries for mammals and birds, the tall herbs and grasses growing along the edge of scrub offer shelter for small mammals, and scrub margins can support a range of flowering plants and their associated invertebrate communities.
Disposal of arisings	Cut scrub should not be placed on areas of grassland on sea walls which may contain scarce plant species such as Dittander and Sea Barley for example.
Frequency	Sea walls with rapidly expanding stands of scrub are likely to be considered for frequent control. In other situations, where scrub only slowly becomes established it may be acceptable to carry out scrub control on a more occasional basis. In such cases, there will be a need for planning management on a medium to long term basis to ensure the amount of scrub or size of individual plants, especially woody plants, does not become a problem. It would appear that scarce shrubs of the seaward slope of sea walls such as Shrubby Sea-blite can re-grow after one-off cuts. This is particularly important where the blockwork revetment has become one of the main habitats for this plant in response to sea level rise and coastal squeeze.

Aftercare	In most circumstances it will be desirable to allow areas cleared of scrub to naturally colonise. Where this is likely to be slow or result in an unfavourable sward, e.g. allowing the establishment of Alexanders, an invasive species, there may be a need to sow a sea wall with a grass/wildflower seed mix. Most species of scrub will re-grow from stumps or underground root structures following cutting. As such, it will often prove more effective to prevent re-colonisation occurring than continually carrying out scrub management on a particular stretch of sea wall. To achieve this, it is necessary to identify what management, or lack of management, is leading to the development of scrub and then put measures in place to prevent its return. As such, before embarking on scrub management, it is important to ensure that a management regime is in place. For example this could be re-cutting of re-sprouting woody vegetation up to three times in the year following scrub management, followed by regular mowing or grazing to prevent, or at least slow down the development of scrub on a sea wall. Without such action, it is likely that there will be a need to repeatedly return to a sea wall to treat scrub.
Offsetting	It is good practice to implement a scheme of replacement planting of scrub species such as Blackthorn and Hawthorn to offset those removed in nearby suitable locations such as on the landward side of the borrowdyke.

Chapter 8: Other management techniques

Introduction

Whilst mowing and grazing are the two key tools for the management of vegetation on sea walls, there are other management techniques which could be important in conserving the biodiversity of sea wall habitats and where possible realising more of their potential wildlife value.

This chapter covers techniques such as herbicide applications and the targeted removal of undesirable species, as well as the circumstances in which they may be used. It also deals with the value of disturbance to the ground, e.g. vehicle wheel ruts and the management of people using the sea wall (trampling) and surfacing of footpaths to enable better access for the public.

Use of herbicides

Herbicides have a potentially valuable role to play in dealing with problem plant species. The blanket application of herbicides as a vegetation management tool should be avoided; mowing and/or grazing often provides a more appropriate solution. The use of a knapsack-sprayer or weed-wiper to spot treat undesirable plant species can be the most appropriate tool for selective weed control (a weed is a plant that is not valued where it is growing and is usually of vigorous growth tending to displace more desirable plants). Under suitable weather conditions the herbicide can be targeted specifically at the problem species avoiding more widespread effects when compared with mowing or grazing including the indirect damage resulting from driving over sensitive areas and the noise and disturbance associated with it.

Herbicides must only be applied by those who are suitably certified and under appropriate conditions, e.g. avoiding any drift onto sensitive vegetation including crops. The use of narrow spectrum herbicides will ensure accurate targeting of the weed species and minimal impact on surrounding vegetation, likewise, herbicides with minimal residual effect, e.g. glyphosate, should be used in preference to those that remain active in the soil for weeks and possibly months. The range of herbicides available for use near water is limited and appropriate agreement from the Environment Agency must be acquired before treatment can be undertaken near water. This also applies to the use of herbicides including weed-wipers in SSSIs and National Nature Reserves (NNRs). Consent or approval is required from Natural England.

Some species toxic to livestock, e.g. Common Ragwort, remain toxic after being killed by herbicide and where necessary, precautions should be taken to avoid livestock being poisoned.

For the management of scrub, the treatment of stumps with herbicide after cutting back shrubs and small trees can be a useful tool to prevent regeneration and kill the roots (see Chapter 7 Scrub Management).

Targeted removal of undesirable plant and animal species

On the whole, sea walls are not noted for the problem of undesirable species. Those problem species encountered can be usefully divided into notifiable weeds, invasive non-native species of plants and problem animal species.

Notifiable weeds

The Weeds Act (1959) specifies five injurious weeds (sometimes referred to as notifiable weeds): Common Ragwort, Spear Thistle, Creeping Thistle, Broad-leaved Dock *Rumex obtusifolius* and Curled Dock. Under the Weeds Act (1959) the Secretary of State may serve an enforcement notice on the occupier of land on which injurious weeds are growing, requiring the occupier to take action to prevent their spread. Enforcement of the Weeds Act is carried out by the statutory conservation agency. Whilst these species can be a problem from an agricultural point of view, they are also of value to wildlife, e.g. food plants for invertebrate larvae and seed-eating birds and all of them occur on sea walls and, for example, the Wall butterfly feeds on Common Ragwort and Carder-bees feed on Creeping Thistle. A decision needs to be taken about the risk they pose to any neighbouring agricultural land in the context of the extent of the plants and their biodiversity role. For example, they pose little threat to arable crops but would be undesirable adjacent to grazing marsh fields.

Common Ragwort is included due it being poisonous to horses, ponies and other livestock, and if ingested either if green and in particular when dried in hay can cause cumulative liver damage with potentially fatal consequences. It is also governed by The Ragwort Control Act (2003) which gives the Code of Practice on How to Prevent the Spread of Ragwort (Defra – Farm Focus Division, 2004 http://www.defra.gov.uk/publications/files/pb9840-cop-ragwort.pdf) and evidential status in any proceedings taken under the Weeds Act (1959). This means that a failure to follow this Code is not an offence but non-compliance may be used as evidence in any legal action. Equally, owners/occupiers should be able to establish a legal defence if they can demonstrate that they have adopted control measures that comply with the guidance given in the Code. Advice is also available on how to dispose of Common Ragwort (Defra 2005).

Invasive non-native species

Non-native species can be a problem because of their invasiveness, e.g. Tamarisk, Bastard Cabbage and Alexanders can all develop extensive patches adversely affecting other plants and the fauna.

There is also a responsibility on land owners and their tenants not to plant or otherwise cause to grow in the wild the non-native species listed in Schedule 9 of the Wildlife and Countryside Act (1981) (as amended). The plants listed in part 2 include Giant Hogweed *Heracleum mantegazzianum*, Hottentot Fig *Carpobrotus edulis*, Japanese Knotweed *Fallopia japonica* and Japanese Rose *Rosa rugosa*, all of which can be found growing on sea walls.

Giant Hogweed was introduced to the UK in the 19th century for ornamental reasons. It has since become widespread, particularly along riverbanks, and can form dense stands with little botanical diversity due to the intense shade of mature plants. It can grow to heights of 3m and has toxic sap which can cause blistering of the skin in bright sunlight making it an irritant to humans. Giant Hogweed can be found on sea walls, being recently discovered for example on a sea wall at Manningtree in Essex. More information on the ecology of Giant Hogweed and its control can be found in Booy & Wade (2007) and Nielsen *et al*. (2005).

△ Giant Hogweed

Japanese Knotweed is also known to occur on sea walls, particularly in urban areas. Similarly to Giant Hogweed it was also introduced in the 19th century for ornamental reasons and has since spread rapidly out competing native plant species. The Environment Agency has produced a Knotweed Code of Practice (Environment Agency 2013) which provides more information on the ecology and control of this species.

Measures to remove such species include pulling up the plants, the use of herbicides, mowing and grazing. The key is to determine what the mode of spread is for each species and to ensure that the chosen control method does not in any way risk the spread of the plant, e.g. through seeds or vegetative fragments.

Problem animal species

From time to time, sea walls may be colonised by undesirable animal species. An example is the Brown-tail Moth *Euproctis chrysorrhoea*, a tent/nest producing species, which can be found in scrub growing on sea walls. The caterpillars are voracious eaters of vegetation, especially shrubs in the spring. Although it prefers Hawthorn and Brambles, it will eat practically any type of bush or tree. The caterpillar releases irritant hairs into the air which can cause skin irritation, and can affect some people quite severely.

The caterpillars emerge particularly during warm weather in May and June and can be treated when they are out of their nests using a chemical spray. The most suitable and widely available chemical is called a pyrethoid (an organic compound similar to the natural pyrethrins produced by some flowers) sold under various names. It is not effective when the caterpillars return to their nests in the evening and during bad weather. At these times it is much better to physically remove the nests using secateurs to cut them and drop them into a plastic bag which should be sealed and either burnt, if it is safe to do so, or sealed in a second plastic bag and disposed of as general waste.

The caterpillars re-emerge in September and October and although not so apparent as in the spring, their feeding will cause leaves at the top of the tree or shrub to turn brown. They stay in their tents (nests) in the winter and as the leaves drop these become very visible. The tents can be cut out at this time of the year as at this time the insecticide spray is largely ineffective.

The importance of ground disturbance

Several notable plant species of sea walls are associated with soil disturbance established by the rutting of the ground by vehicle wheels. These plants include Sea Barley and Slender Hare's-ear. A study undertaken in Kent (RSK Carter Ecological 2008) found that these rut species were observed independently of the actual mowing or grazing regime, and are possibly reliant on saline seepage through the wall/wet conditions. The decline in rut dependent species in Kent may have been related to the grassing over of ruts, but the disappearance could also be due to other factors, such as weather patterns and climate change.

A key factor in the creation of soil disturbance through rutting is the weight of the machine used during mowing. As a general rule, the heavier a mowing machine is the greater the ground disturbance and rutting it will cause. Of course this will also depend on the weather (e.g. during and after wet weather soil disturbance will be greater) and soil conditions (e.g. dry or water logged). Winter works in wet weather could cause quite serious soil disturbance with the sward taking years to recover for example. The relative weights of machinery vary greatly from 540 kg for a remote controlled mower (such as Robo Flail), 4000 kg for a front-loaded Aebi flail mower to 8000-14000 kg for a side-arm flail mounted on an

excavator. During the planning of any vegetation management or maintenance activities on a sea wall, consideration should be given to the type and weight of any machine used. For example, if disturbance to botanically important grassland needs to be minimised during mowing then a lighter machine would be advisable. Conversely, if light rutting is desirable then heavier plant may be more acceptable. Quite often the creation of patches of bare earth is desirable in most grassland habitats particularly those with scarce annual species such as Slender Hare's-ear or Sea Barley.

With regards to Slender Hare's-ear on the Essex coast, thousands of plants appeared at Blue House Farm on the Crouch Estuary in summer 2010 after major sea wall repair works had been undertaken in the previous winter (Smith 2010). The implication is that soil disturbance from the works over winter was responsible for the large population that appeared in the following summer. According to the Essex botanist, Graham Smith, Slender Hare's-ear seems to need a reasonably wet summer (or at least, late summer) to germinate in any numbers. Disturbance is important, especially in temporary sites such as wheel ruts, but moisture seems to be the key in permanent seepage areas, where the salinity reduces the competition from coarse grasses (e.g. Sea Couch) to Slender Hare's-ear and also to Sea Barley and Annual Sea-blite. The apparent scarcity of Slender Hare's-ear in recent years may be due to some extent to the run of very dry summers since 2007. Away from seepage areas in Essex, the best sites along the Crouch Estuary for Slender Hare's-ear are grazed sea walls, as long, that is, as the grazing is not too severe at the time they germinate. Grazing could be the key to maintaining populations of rut species as long as the number of animals used is not too high during the flowering season (e.g. mid to late summer) which would remove most of the seed heads.

▽ Sea Barley flowering near a wheel rut

Case Study

Folding recovery after disturbance, Wallasea Island, Essex

In summer 2010, a public footpath on the crest of a sea wall at Wallasea Island in Essex was surfaced with road planings due to erosion caused by trampling feet leading to an issue with the structural integrity of the flood defence. There were over 100 vehicle movements along the folding by tracked dumpers and a 3-4m wide track devoid of vegetation was established. After the works had finished any deep ruts were levelled using an excavator and left to re-establish vegetation cover through natural regeneration. A survey in August 2011 using randomly positioned 50 x 50 cm frame quadrats on this regenerating track and an adjacent area of folding undisturbed by vehicle movements showed that there was 14% cover of unvegetated bare earth on the disturbed track, compared to just 0.1% on the undisturbed folding.

A large population of Sea Barley was present on the disturbed track (29% ground cover), being the most abundance species in the quadrat survey, whereas on the undisturbed folding it was absent. The overall plant species richness on the disturbed folding was 4.6 species per m^2, compared to just 2.9 species per m^2 on the undisturbed folding. The cover of Couch grass (*Elytrigia* species) was also much reduced on the disturbed track (23% cover) compared to the undisturbed ground (92%). Ruderals such as Grass-leaved Orache were also present in some abundance on the disturbed ground (24% cover for this plant), being absent from the undisturbed folding.

Therefore, this survey shows how the flora is completely altered after significant soil disturbance, and is richer in plant species. Scarce annuals such as Sea Barley may be entirely dependent on the disturbance of soil during mowing and sea wall repair works. This disturbance may be sporadic, but it appears that annuals such as Sea Barley can persist in the seed bank for many years waiting until soil disturbance occurs and the process of succession from bare earth to grassland and scrub can occur once more.

On a heavily rutted sea wall at Little Oakley near Harwich, Essex, the sparse vegetation with bare earth established as a result has been found to support large populations of the Small Heath butterfly two years after works were completed. The Small Heath is known to prefer sparsely grassy swards with patches of bare earth, therefore, the disturbance of the soil is likely to benefit this butterfly on sea walls until a rank grassland sward develops and the exposed ground is lost once more. A large number of grasshoppers were also found in vehicle ruts on the folding of the sea wall at Little Oakley.

It is important for sea wall managers to recognise that small amounts of soil disturbance which lead to the creation of bare earth is actually beneficial to the flora and invertebrates in particular and should be encouraged / permitted where not posing an unacceptable risk to the integrity of the sea wall.

Case Study

Ploughing of sea wall folding (berm), Alresford, Essex

The landward folding of a sea wall at Alresford in Essex was ploughed (there is no borrowdyke present so ploughing can occur up to the edge of the sea wall embankment) in 2011. Reinstatement of the ploughed folding was required of the farmer and new marker posts installed to prevent it happening again. A botanical survey of the ploughed folding in August 2011 (all plant species recorded in a 50m x 1m wide transect on ploughed and unploughed folding) showed that as expected the original flora had been lost from the ploughed area. This included the Nationally Scarce Dittander, as well as commoner saltmarsh plants such as Sea

Aster (in seepage zones) and glasswort. Interestingly though, the disturbance associated with the ploughing had led to the germination of the Nationally Scarce Sea Barley and several arable weeds (e.g. Black-grass *Alopecurus myosuroides* and Scarlet Pimpernel *Anagallis arvensis*) which were not present on the unploughed folding. It is likely that over time, the original flora will recover without further ground disturbance.

△ Ploughed folding at Aresford

Deliberate rotavation of the folding is unlikely to be feasible due to buried services and it could be quite destructive to grassland plant and insect communities which need undisturbed habitat (e.g. Yellow Meadow Ant *Lasius flavus*). Suitable amounts of bare earth should occur due to occasional soil disturbance associated with mowing operations or sea wall repair works. More importantly the restoration by levelling of lightly rutted ground on the folding should be resisted where at all possible to provide the bare earth habitat required. It should be recognised that where the folding is heavily rutted that levelling with an excavator will be required to allow access in case emergency repairs are required during the winter for example.

Re-establishment of grassland sward after scrub clearance

Occasionally, sea wall vegetation becomes denuded to such an extent that it is necessary to re-establish a grassland sward to bind the soil together from a structural integrity viewpoint, but also from a conservation perspective. Three options (in declining order of preference) exist for establishing/re-establishing a grassland sward on sea walls particularly after scrub clearance:

- Natural regeneration, letting sward develop under mowing or grazing regime. If not possible then;
- Green haying. If not possible; then
- Sow a wildflower mixture appropriate for the soil type.

Due to the specialist flora that exists on many sea walls, it is preferable to let the vegetation re-establish over time rather than introducing seed from wildflower mixtures that may not contain genuinely native plant species. A meadow mixture (for a range of soils and containing four grass and 14 wildflower species) was sown (at 4 g per m^2) on a rebuilt sea wall in autumn 2009 near Paglesham, on the Crouch Estuary in Essex. Early monitoring of certain wildflower species indicated poor establishment of the sown species. For example, in July 2010, only nine (50%) of the sown species were recorded on the rebuilt sea wall, including Yellow Rattle *Rhinanthus minor* and all four grass species. By summer 2011, 11 (61%) sown species were recorded, once again including Yellow Rattle and all four species of grass. However, the ground cover of these species was low suggesting that the mixture was establishing poorly. Yellow Rattle is not a typical wildflower of sea walls in Essex, but as it is virtually impossible to exclude particular species

△ Yellow Rattle

from mixes, plants may be introduced which do not naturally occur in an area. This could lead to confusing issues over the distribution of our native flora in the long-term and the genetic stock mixing with non-native sown species.

It may be more expedient to use green hay to establish a sward containing wildflowers on a sea wall. This will involve cutting an adjacent area of sea wall grassland in summer and spreading the hay onto the area of bare ground to be regenerated. This has been shown to be particularly effective at re-establishing swards (on areas previously scrubbed over) rich in forage plants for bumblebees (including Shrill Carder-bee) at Hadleigh Castle Country Park in Essex (Connop *et al.* 2009). As an option for re-establishing a sward after scrub clearance in particular, spreading green hay is often a better choice than sowing a wildflower mixture. Green hay containing Yellow Rattle seed has been sown on Dymchurch sea wall near Hythe.

The third option, and perhaps the most desirable for the conservation of the specialist flora of sea walls, is to allow the sward to develop under a cutting or grazing regime. Whilst a weedy sward will establish at first (as it would with green hay or sowing a wildflower mix), the natural regeneration of the sward through allowing the original seedbank to establish will allow the process of succession from bare ground to established grassland to occur. This will allow bare ground for invertebrates to persist for a few years and those disturbance dependent species such as Sea Barley and Slender Hare's-ear will also benefit.

Management of people

Sea walls with public rights of access are used by people for walking, cycling (and horse riding), recreation which carries with it the possibility for disturbance to sensitive species. Many sea walls have a public footpath on the crest and as such access is unrestricted at all times of day. Of particular significance is the disturbance caused by dogs to birds, especially when nesting. Solutions to reducing the negative effects of recreational disturbance include:

- Use of signage to raise awareness and encourage appropriate behaviour, e.g. keeping dogs on leads and not leaving the path;
- Design of paths to avoid sensitive areas and/or species;
- Vegetation management to encourage people to follow paths and if appropriate, screen sensitive areas and/or species;

- Use of fencing to keep people on paths and control dog movements, e.g. away from livestock or nesting birds;
- Kissing gates will be needed where fencing has been installed where there are grazing livestock; and
- Gates/motorbike inhibitors and fencing where illegal access by motorbike users is an issue, but it mustn't restrict the movements of legal rights of way users.

Footpath/bridleway surfacing

In situations where trampling pressure is too heavy and serious erosion of the crest of a sea wall has caused problems for the structural integrity of the flood defence then it may be appropriate to lay a surfacing material to prevent further deterioration. Common materials used to surface public footpaths on the crest of sea walls include crushed concrete, granite, limestone and road planings. Before any surfacing is undertaken a survey of the flora of the area to be covered with material should be undertaken. For example, the presence of any rare or notable plant species associated with the disturbance caused by trampling feet (e.g. Sea Barley) could be eradicated by the laying of a hard surface. However, surfacing with crushed material (e.g. concrete, granite or limestone) or road planings may allow vegetation to grow through the voids between chippings, even if the initial aesthetics of the path are of a hard engineered approach. Usually, for crushed material, a 10 mm chipping size with a dust topping (i.e. fine material) is used. Laying of tarmac should be avoided if possible due to the complete loss of vegetation cover with little chance of it growing through the material.

Case Study

Surfacing of a public footpath on Wallasea Island, Essex

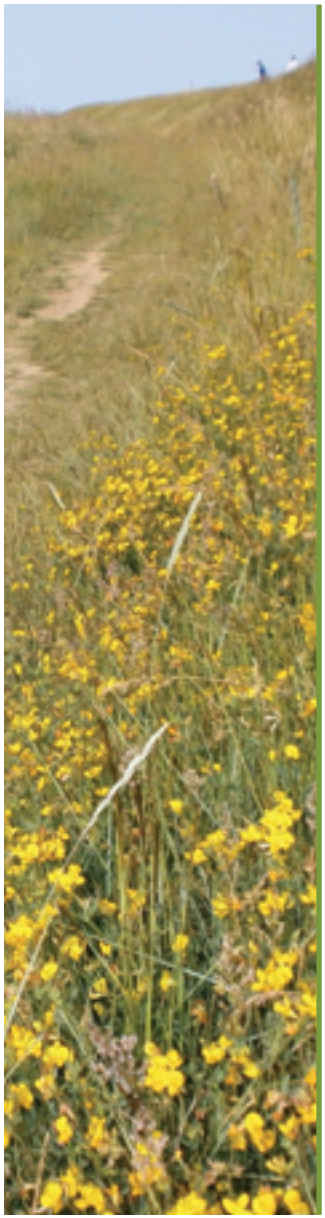
In summer 2010, a public footpath on the crest of a sea wall at Wallasea Island in Essex was surfaced with road planings due to erosion caused by trampling feet leading to an issue with the structural integrity of the flood defence. A botanical survey of the footpath undertaken the following summer (2011) found 20 species of plant had colonised the road planings laid the previous summer, including Sea Barley and Sea Wormwood, two scarce species. More common colonisers growing out of the road planings included Grass-leaved Orache, Sea Couch and Sea-purslane. This study showed that the planings allowed the original flora of the sea wall crest to re-establish and in time more species will colonise. However, concern has been expressed about the possible threats to the environment of leachates from road planings. Therefore, their use should be treated with caution, particularly if the area to be surfaced is near water, for example a borrowdyke, and leaching into the watercourse might be an issue.

Key aspects of the use of other management techniques on sea walls

In addition to mowing and grazing, other management techniques may be appropriate in dealing with particular situations, e.g. undesirable species. These measures can be important in conserving the biodiversity of the sea wall habitats and where possible realising more of their wildlife potential. For example, using a herbicide to rapidly remove plants of a non-native species gaining a stronghold on a seawall (e.g. Alexanders and Bastard Cabbage) could prevent significant habitat deterioration and reduce the costs of dealing with such an invasion.

Techniques other than the use of herbicides include disturbance to the ground, e.g. vehicle wheel ruts, and the management of people using the sea wall and their dogs in particular.

Chapter 9: Surveying and monitoring



Introduction

Ecological surveying and monitoring are essential in providing the evidence on which to base appropriate decision making about sea wall vegetation management. Despite this, many sea walls remain woefully under-recorded from a wildlife point of view except where they fall within nature reserves or have been studied as part of a development proposal. Relatively few stretches of sea wall have been subject to specific ecological research, and where they have, this is often only in relation to a single species or taxonomic group.

Ecological surveying can be considered the recording of qualitative or quantitative ecological data using standardised, fully described techniques. It is primarily used to gather baseline ecological information prior to works commencing, which is then used to inform management decisions.

Ecological monitoring on the other hand is the comparison of repeated surveys and needs to be put in place to provide a robust evidence base against which to assess change and hence whether the actions being taken are achieving the management objectives. This is especially important where protected species are present, to demonstrate support towards achieving BAP targets and on sites designated for their nature conservation interest.

Sea wall vegetation management decisions made without regard to such ecological considerations risks damaging or even eliminating local populations of species. For example, controlling scrub to prevent succession on a sea wall could cause the local loss of the Sloe Carpet moth, whereas inappropriate mowing of plant communities which contain Hog's Fennel could lead to the loss of Fisher's Estuarine Moth which feeds upon it.

It is important that each survey or monitoring programme has clear objectives. The objectives in relation to sea wall vegetation management generally fall into one of six main categories:

- Assess the extent of particular habitats on a sea wall to help inform decisions about when to tackle invasive communities, notably scrub, maintain habitat mosaics or increase particular habitats;
- Determine the age, structure and condition of scrub stands or grassland swards to identify whether intervention is required either from a biodiversity or flood risk management perspective;
- Identify the community composition and hence classification of habitats to help inform appropriate management decisions;
- Scope the potential for protected or otherwise notable species to be present on a particular stretch of sea wall in order to help refine what detailed surveys may be required;

- Conduct detailed species surveys to determine whether a given key species is present and where or in what numbers, to help establish which stretches or zones of a sea wall are important for a particular species as a precautionary measure to help avoid harming reptiles during the course of sea wall vegetation management for example; and
- Monitor the effects of particular management regimes to provide evidence on the consequences and whether the objectives are being achieved (e.g. progress towards creating a mosaic of uneven-aged swards).

Whilst it is theoretically possible to survey and monitor all wildlife found on a particular length of sea wall, including those species which only use it on occasion, this would be costly both in terms of time and expense. As such, the level of survey and monitoring effort needs to be balanced against the level of detail required and the degree of confidence needed in the results. It is also important to ensure that the survey and monitoring objectives are set in the context of the available resources and expertise. Whilst some programmes will be delivered in-house or through contracting out, many are likely to rely on amateur naturalists. In many coastal counties, LRCs hold an archive of historical data and can provide contact details of wildlife recorders. The NBN Gateway website (www.nbn.org.uk) also holds some data and provides links to all LRCs.

Undertaking pre-field work preparation is fundamental to the success of survey and monitoring programmes. The importance of this cannot be stressed too strongly as without it there is little chance of being able to conduct something ecologically worthwhile with meaningful results on a sea wall. It is therefore important to carefully plan survey and monitoring programmes to ensure the results are both valid (e.g. carried out in the most appropriate conditions and season of opportunity) and collected in a cost-effective way.

Pre-field work preparation for ecological survey and monitoring programmes on sea walls should include:

- A desk top study to review historical records of wildlife reported for the sea wall and its environs;
- Developing surveys and monitoring programmes which will provide the results to answer the questions being posed;
- Determining a realistic survey or monitoring schedule based on a realistic number of sampling points for the time and/or budget available, including establishing access and egress routes in advance;
- Ensuring surveys or monitoring programmes are conducted at the most appropriate time of year (e.g. breeding bird season) and most appropriate time of day, including in relation to high and low tide where this may affect the results (e.g. mammal numbers);
- Securing any necessary consents or permissions, including access permission, and abiding by any restrictions or conditions (e.g. biosecurity);

- Mobilisation of suitably trained, experienced and where required licenced ecologists;
- Provision of appropriate equipment, maps and field data sheets;
- Preparing generic and dynamic risk assessments and agreed method statements;
- An agreed communication plan; and
- A reporting framework to ensure data are collected in a manner which enables them to be easily analysed, including where appropriate for statistical tests.

Both surveying and monitoring need to be fully documented and focused towards providing the information required. Different techniques are deployed to survey and monitor different species of wildlife. By using standard, repeatable techniques, an initial survey can also become the baseline against which further monitoring is assessed.

This chapter covers some basic pre and post vegetation management surveying and monitoring techniques across the range of wildlife likely to be encountered on sea walls, including best times of year, differing options and the need for data to be carefully recorded and the benefits of passing this on to the relevant LRC, recording scheme or NBN. This chapter is broken down into sections as follows:

- Plants;
- Invertebrates;
- Reptiles and amphibians;
- Birds; and
- Mammals.

Detailed guidance is given in other publications (e.g. Goldsmith 1991; Foster & Gent 1996; Froglife 1999; Bibby *et al*. 2000; Tabor 2001; Gent & Gibson 2003; Wheater & Cook 2003; Sutherland *et al*. 2004; Hill *et al*. 2005; English Nature 2005; Sutherland 2006; Gurnell & Flowerdew 2006 and Drake *et al*. 2007). As such, only brief summaries of the main techniques and key considerations in relation to sea wall vegetation management are provided here.

Plant recording and monitoring techniques

Understanding which plant communities are present on a sea wall and their distribution and relative extent is fundamental to making appropriate decisions on vegetation management. This is particularly the case where rare or scarce species (e.g. Hog's Fennel or Shrubby Sea-blite) are present.

Phase 1 Habitat survey

Originally developed in the 1970s, a Phase 1 Habitat survey is now used throughout the UK as the first stage of an ecological assessment process. It is a relatively simple, rapid and standardised method for recording and mapping vegetation communities over large areas using 90 predefined broad categories (e.g. semi-improved grassland, scattered scrub), with target notes used to list dominant species and any features or matters of interest such as community type, age structure and condition.

A Phase 1 Habitat survey needs only basic plant identification skills and experience to complete and no specialist equipment other than a recording form on which to map the habitats present on a site using a standard colour scheme and alphanumeric habitat codes. The maps produced need to be as accurate as field conditions allow and the objectives of the survey require (e.g. the location of dense stands of scrub on a sea wall), though a hand-held field global positioning system (GPS) device can greatly increase both the speed and accuracy of the survey. They can also allow habitat boundaries and target note locations to be automatically transferred to a Geographic Information System (GIS) for reporting and analysis. Recording habitats with GIS is often invaluable, especially since they may change over time due to vegetation management or natural succession.

For more detail on the methods and analysis of Phase 1 Habitat surveys see the JNCC Handbook for Phase 1 Habitat survey (JNCC 2010b).

Typical examples of Phase 1 Habitat surveys on sea walls are as follows:

- East Anglia ONE Offshore Windfarm Phase 1 Habitat Survey Report (RSK 2011) which noted that the seaward face of the 2.5m high and 5m wide sea wall on the north bank of Martlesham Creek on the Deben Estuary in Suffolk (TN154) was dominated by Sea Couch. It was further noted that a footpath approximately 0.5m wide ran along the top of the sea wall which consisted of Cock's-foot, Perennial Rye-grass, Buck's-horn Plantain and Ribwort Plantain. It was further noted that this vegetation continued on the northern (landward) side of the sea wall, though occasional shrubs and small trees including the species Silver Birch *Betula pendula*, Evergreen Oak *Quercus ilex,* Pedunculate Oak and Gorse were also present. It was also noted (TN176) that the seaward and landward 30º slopes of the 2.5m high sea wall on the west side of the lower Deben Estuary at Falkenham were both dominated by Sea Couch. The landward side

had occasional Hawthorn shrubs on it and a 1m wide path running along the crest of the sea wall supported grassland containing abundant False Oat-grass with frequent Perennial Rye-grass. The herb species present were considered typical of mesotrophic grasslands (typically on moist mineral soils with a pH between 5 and 6) by the sea and included the species Sea Beet, Bristly Oxtongue, Dandelion *Taraxacum officinale* and White Clover. Elsewhere on the Deben Estuary, it was noted that the semi-improved vegetation on a 10m wide, 3m high sea wall embankment was dominated by Sea Couch with a sward height of approximately 50cm on the landward edge. The crest of the sea wall comprised abundant Sea Couch and False Oat-grass, with locally frequent Common Reed *Phragmites australis* and occasional Creeping Thistle. The seaward face was again dominated by Sea Couch with scattered Sea Beet.

- South Killingholme Phase 1 Habitat Survey Report (Applied Ecology 2010) which noted that the sea wall running the full length of the survey area along the south shore of the Humber Estuary was approximately 1m higher than the road level, approximately 0.75m wide and with a seaward slope that was concrete and stone-faced. This outer face was sparsely vegetated for much of its length with Common Reed growing through joints between the stones, and occasional Bramble and willow scrub.
- Preesall (underground gas storage) facility Phase 1 Habitat Survey Report (Hyder Consulting (UK) Ltd. 2009) which noted that sections of sea wall on the east bank of the River Wyre in Lancashire supported a mosaic of relatively species-poor coastal grassland, upper saltmarsh and ruderal communities. The target note for the sea wall (TN37) indicated the lower slopes supported Thrift *Armeria maritima*, Red Fescue, Common Sea-lavender *Limonium vulgare*, Sea Plantain, Sea Wormwood, Common Saltmarsh-grass, Common Orache *Atriplex patula*, Sea Couch and Sea Beet. The upper slopes of the sea wall were noted as supporting Sea Couch, Common Sea-lavender, Common Knapweed, Yarrow, Creeping Thistle, False Oat-grass, Japanese Rose, Wild Carrot, Sea Radish *Raphanus raphanistrum* ssp. *maritimus* and Common Bird's-foot-trefoil. It was further noted that Common Sea-lavender was listed as 'Sensitive' in the Provisional Lancashire Red Data List of Vascular Plants and that dense and scattered scrub was recorded, including along the sea wall.

National Vegetation Classification (NVC) Survey

The NVC system is the culmination of over twenty years of detailed survey and analysis of British vegetation. It defines communities based on a unique combination of plant species that are usually found growing together. With some 245 communities and over 500 sub-communities, an NVC survey delivers much more detailed and comprehensive information than a Phase 1 Habitat survey by determining the frequency and abundance of species within a habitat using quadrats and then comparing the results against the species listed in each NVC community to find the best match.

Conducting NVC surveys requires sound botanical skills and an in-depth understanding of plant communities. They can also be time consuming, though this depends on the habitat complexity.

The NVC users' handbook (Rodwell 2006) gives further details.

Ecological scoping survey

Where more information is required, and to make cost-effective use of ecologists being on site, a Phase 1 Habitat survey can be extended to identify the potential of the habitat present to support protected, or otherwise notable species of conservation interest. For example, it is possible with sufficient experience to map out areas of habitat with low, medium and high potential suitability for reptiles based on assessing the features important to them. However, whilst an objective habitat scoring system and suitability index exists for some species, it has yet to be developed for others, such as UK reptiles (Edgar *et al*. 2010).

A typical example of an ecological scoping survey on a sea wall is as follows:

- In May 2005, Andrew McCarthy Associates were commissioned to undertake a Scoping Study, Desk Study and initial Cetti's Warbler survey for the proposed National Cycleway Network (NCN) route around the Exe Estuary in Devon (Andrew McCarthy Associates 2006). It was noted that as much of the estuary, particularly along the east side, was defended, revetment and sea wall had become an important habitat feature in its own right, often supporting saltmarsh and other halophytic (a plant adapted to living in a saline environment) flora, such as Sea-purslane, Sea Couch and Sea Plantain. The west facing bank of the sea wall was comprised of a locally herb rich semi-improved neutral grassland that included Crested Dog's-tail, Common Bent, Smaller Cat's-tail, Perennial Rye-grass, Common Cat's-ear, Common Bird's-foot-trefoil, Common Vetch, Smooth Hawk's-beard, Selfheal, Creeping Cinquefoil, Ribwort Plantain, Lesser Trefoil, Yarrow and a species of Water-dropwort *Oenanthe* species. It was estimated that the proposed NCN route would result in the loss of approximately 4,500 m^2 of grazing marsh in a 3m wide strip along the landward foot of the sea wall, but that designing the route to run along the folding prevented users of the NCN from appearing against the skyline and thus disturbing estuarine birds on the seaward side.

▽ Corky-fruited Water-dropwort

- In October 2010, GPM Ecology produced an Ecological Scoping report on behalf of Yacht Haven (Hayling) Ltd to accompany their planning submission to Havant Borough Council to construct six dwellings, a new yacht club, pontoon mariner with 19 berths and new sea wall on a former boatyard on the east side of Hayling Island in Hampshire (GPM Ecology 2010). The site included an existing sea wall supporting a coastal footpath, and was located adjacent to: Chichester and Langstone Harbours SPA; Solent Maritime SAC; Chichester Harbour Ramsar site; Chichester Harbour SSSI and a LWS. The ecological scoping report included a detailed botanical survey to NVC level, a breeding bird survey where clearance was to take place during the bird nesting season, winter wildfowl and wader intertidal counts of the adjacent SPA, a bat survey of a shed on site and a reptile survey. The latter was considered necessary in light of the reports received of Common Lizard on site and that areas of coastal grassland and scrub that remained undisturbed at the time were capable of supporting reptiles.
- Just Ecology was commissioned by Able UK to carry out an Extended Phase 1 and Scoping Survey to begin to identify the key ecological receptors that might be affected by port-related development at Killingholme on the Humber Estuary in North Lincolnshire (Just Ecology 2006). The Extended Phase 1 and Scoping Survey were carried out on an area covering approximately 800 ha which included the study area plus a 500m buffer zone. Whilst parts of the survey area were heavily industrialised, it also included the sea wall and adjacent habitats within the Humber Estuary. It was noted that the communities formed a gradient from the sea wall to the low tide line zones. These were Common Reed and Sea Couch, becoming stand line vegetation with dock *Rumex* species, shingle and then Sea Aster saltmarsh, grading into mud further down the shore.
- Hundreds of Pyramidal Orchids *Anacamptis pyramidalis* were recorded in 2013 on sea walls during a scoping survey of Ministry of Defence (MOD) land at Foulness in Essex. The presence of so many orchids indicates that more detailed botanical surveys of the sea walls is required to fully document the flora which may contain other species of interest.

△ Pyramidal Orchid

Monitoring vegetation change

It can be useful to understand how the habitats present on a sea wall are changing in extent or condition over time. However, it can be difficult to monitor such vegetation change because sea walls are long, linear features, often with restricted access. One possible technique to measure the change in extent of habitats is to use a series of markers located along sea walls to act as reference points against which to measure the edges of habitats, such as scrub margins. Such markers need to be at least semi-permanent and as such located where they will be safe from damage by management operations. Alternatively, fixed-point photography can be used as a simple, cheap and quick method of monitoring vegetation change. Photographs are taken from exactly the same point and looking in the same direction at different times to show any trends.

Case study

Factors affecting scarce plant species on the sea walls of North Kent

A botanical survey carried out on behalf of the Environment Agency in September 2000 mapped the presence of Nationally Scarce vascular plant species (i.e. those confined to less than 100 ten kilometre grid squares nationally) along all the sea walls of the three SSSIs covering the north Kent marshes (Medway Estuary and Marshes; South Thames Estuary and Marshes and the Swale SSSIs).

The survey focused on those species of vascular plants considered by the Environment Agency to be particularly associated with the sea wall and coastal grazing marsh habitat in south-east England (RSK Carter Ecological 2008). A few of these species belong to higher classes of rarity, e.g. Least Lettuce which is listed on Schedule 8 of The Wildlife and Countryside Act 1981 (as amended). The survey also included a few species that whilst not Nationally Scarce, were uncommon in Kent away from sea walls, such as Knotted Hedge-parsley (Philp 1982). A list of the species mapped is shown in Table 9.1.

Table 9.1: Notable species mapped during the botanical survey of the North Kent sea walls

Common Name	Scientific Name	International	National	County
Bulbous Foxtail	*Alopecurus bulbosus*	-	NS	CR
Slender Hare's-ear	*Bupleurum tenuissimum*	V	NS	CS
Divided Sedge	*Carex divisa*	V	NS	-
Sea Barley	*Hordeum marinum*	V	NS	-
Golden-samphire	*Inula crithmoides*	-	NS	-
Least Lettuce	*Lactuca saligna*	EN	NR Sch8	CR
Corn Parsley	*Petroselinum segetum*	-	-	-
Hog's Fennel	*Peucedanum officinale*	-	NR	CR
Annual Beard-grass	*Polypogon monspeliensis*	-	NS	CS
Borrer's Saltmarsh-grass	*Puccinellia fasciculata*	V	NS	-
Stiff Saltmarsh-grass	*Puccinellia rupestris*	-	NS	CS
Knotted Hedge-parsley	*Torilis nodosa*	-	-	-
Bird's-foot Clover	*Trifolium ornithopodioides*	-	-	CS
Sea Clover	*Trifolium squamosum*	-	NS	CS

Key: International designations (IUCN category): V = Vulnerable; EN = Endangered
National designations: NR = Nationally Rare; NS = Nationally Scarce; Sch8 = listed on Schedule 8 of the Wildlife and Countryside Act 1981 (as amended).
County designations: CS = County Scarce; CR = County Rare

More detailed monitoring of these notable species was carried out using standard protocols in 2002, 2006 and 2008 at 30 randomly selected 100m stretches of the sea walls covering the North Kent Marshes. The aim was to collect reliable information on the changing population status of these species in relation to those environmental factors that might affect them, and in particular to elucidate any relationships there might be between the scarce species and potentially modifiable sea wall vegetation management practices. To assist with analysis, the 30 randomly selected sites were stratified so that levels of species-richness (e.g. sites with no scarce species, one scarce species, two scarce species, etc.) were equally represented.

The species were divided into two principle groups:

- A 'Grassland Group' comprising Corn Parsley, Knotted Hedge-parsley and Sea Clover. These are members of a guild of species (also containing the rare Least Lettuce) that is characteristically found in NVC vegetation type MG6 Perennial Rye-grass-Crested Dog's-tail grassland, Meadow Barley sub-community (Rodwell *et al*. 2000). In this instance, it reflected a heavily poached community historically maintained on the sea walls by grazing.
- A 'Rut Group' comprising Slender Hare's-ear, Sea Barley, Annual Beard-grass, Borrer's Saltmarsh-grass and Stiff Saltmarsh-grass. This was associated with rutted areas on sea wall foldings due to the passage of vehicles or livestock where saline water stood in winter, though which could also occur occasionally on the sea wall crest.

The results of this monitoring showed that the Grassland Group of species occupied appreciably more sites, though at slightly reduced levels of frequency between 2002 and 2006. Whilst Knotted Hedge-parsley and Sea Clover continued to spread between 2006 and 2008, Corn Parsley fell back to its original level of incidence. Overall, there was a further increase in the number of sites occupied by the Grassland Group with high levels of frequency attained within sites.

Rut Group species showed a very slight reduction in the number of occupied sites between 2002 and 2006 whilst levels of frequency changed little. However, between 2006 and 2008 there was a slight increase in the number of occupied sites, but a fall to lower levels of frequency and distinctly lower levels of abundance within sites. The species which contracted most between 2002 and 2008 were Annual Beard-grass, Borrer's Saltmarsh-grass and Stiff Saltmarsh-grass.

The first monitoring survey in 2002 revealed that the 2000 botanical survey had underestimated the incidence of notable species. However, it also found that overall species richness of the sea walls had declined between 2000 and 2002. There were marked changes in the vegetation management of sea walls between the two years, particularly relating to a decrease in grazing linked to an outbreak of foot-and-mouth disease, and a subsequent increase in the intensity of mowing.

With the occurrence of notable vascular plants on sea walls seemingly negatively correlated with the cover of cuttings left after mowing, the Environment Agency began monitoring one of four trial management regimes between 2002 and 2008 on sea walls in North Kent:

- Not cut;
- Cut with cuttings left or fate of cuttings unknown;
- Cut with removal of cuttings in 2008 (which may or may not have happened in 2006); and
- Sites where sward character was strongly determined by grazing.

The ten monitoring sites in the 'cut with removal of cuttings' management regime consistently showed a large and progressive increase in the incidence of Grassland Group species between 2002 and 2008, notably on the landward faces and foldings of sea walls. On seven of these sites where Grassland Group species were altogether lacking in 2002, they had become relatively abundant on most by 2008. There were especially large increases in the frequency and abundance of Grassland Group species on the remaining three monitoring sites where they had been present at low levels in 2002.

The increases in Grassland Group plants were generally considered related to the 'cut with removal of cuttings' management type tending to convert tall oat-grass swards into the MG6 Perennial Rye-grass-Crested Dog's-tail grassland, Meadow Barley sub-community (Rodwell *et al*. 2000) swards, and in particular allowing species associated with heavily poached ground (such as Knotted Hedge-parsley and Sea Clover) to become established and spread. Whilst poorly replicated, the increase in species richness noted on every site where the 'cut with removal of cuttings' regime was applied was most dramatic in the few sites where it was combined with grazing.

There were no such systematic increases in the incidence of Grassland Group species among sites in the three other management regimes. It was recognised that the data were best

understood on a site-by-site basis according to local circumstances. The increase in the Grassland Group of species noted in a monitoring site at Spitend on the south side of the Isle of Sheppey for example, was thought possibly linked to the introduction of grazing sometime after 2002.

Traditionally grazed sites were generally the most species-rich. Whilst Grassland Group species increased somewhat at sites where grazing was introduced between 2002 and 2008 (such as Spitend), the highest levels of Grassland Group species were associated with traditionally grazed sites which changed little between 2002 and 2008. Despite grazing therefore being identified as important for the maintenance of local populations of notable vascular plants, levels of replication and management change in the study were insufficient to fully explain the effects of grazing.

The Rut Group of species increased in 2006 but fell back to 2002 levels of frequency and abundance or lower in 2008. As these changes appeared to fluctuate independently of any management type it was not apparent from the data whether they related to vegetation management or were a response to other environmental factors such as the weather/climate. Field observation in 2008 suggested it was more likely that the decline was due to a general grassing over of older ruts. It was thought likely the Rut Group of species required larger patches of bare ground plus, ideally at least, wet and saline conditions. There was some evidence to suggest both grazing and 'cut with removal of cuttings' may help stem the natural decline of the Rut Group species by creating newly disturbed areas, but low levels of replication in the study meant this was not categorically proven.

The data did suggest Divided Sedge may be disadvantaged by the 'cut with removal of cuttings' management type as compared with the 'cut without removal of cuttings' type. With Divided Sedge being a perennial species that often forms dense swards, it was suggested that the greater disturbance of the swards that resulted under the former management regime could offer greater opportunities to allow other species, notably grasses, to become established.

With the exception of Divided Sedge all of the notable sea wall species generally occurred in small-scale gaps in the sward of vegetated sea walls. Management regimes such as grazing and 'cut with removal of cuttings' which created a more open sward, as well as creation of small-scale gaps through hoof poaching or where mowers skimmed the soil surface (such as on steep landward faces which posed some difficulty in handling machinery) could be seen as benefiting these species. It was also noted that whilst changes in net abundance of notable sea wall species clearly related to changes in those vegetation types of which they were important components (which in turn related to management), these large changes were nevertheless buffered to a degree by low-level occurrences in ruderal niches, such as along the edges of the paths on sea wall crests.

Invertebrate recording and monitoring techniques

A variety of techniques is available to survey and monitor invertebrate populations on sea walls. As invertebrates occupy differing niches during different stages of their lifecycles, detecting their presence on a sea wall is dependent on using the most suitable technique on the appropriate habitat feature at the right time of year.

Whilst some of the species of invertebrates found on sea walls, such as adult Grayling butterflies, can be relatively easy to identify, many other species, especially those that are rare or have restricted distribution, can be difficult to identify. As such, choosing the most appropriate technique for surveying or monitoring invertebrates on sea walls should be decided upon in consultation with invertebrate ecologists with the necessary fieldwork skills and expertise in identification.

The most common approach is to survey adult invertebrates as these are usually far easier to find and identify than other life stages. However, as the adults of different species will be present at varying times of day and at different times of year, to be successful, any survey or monitoring strategy will need to be based on an understanding of the ecology of the target species. Poor weather (e.g. high winds, low temperatures, or heavy rain) which suppresses adult activity should be avoided.

Commonly used techniques to sample invertebrates, which have been adapted from standard methods described fully in the literature, are:

- Visual searching;
- Line transects;
- Foliage beating;
- Sweep netting;
- Pootering;
- Pitfall traps; and
- Light traps.

Visual searching

This involves looking in suitable areas, for example amongst sea wall vegetation, for invertebrates, including those that may be otherwise hard to find. It can be used as a standalone technique, though it is commonly also used in conjunction with other techniques (e.g. between sweep netting sessions). Visual searching can provide information on behaviour such as foraging, mating and nesting, and on sea walls is most suitable for a wide range of species including grasshoppers and crickets, ants, butterflies and bees. Adult grasshoppers can be easily counted in 2 x 2m quadrats to

produce an estimate of their abundance in a particular habitat (Gardiner *et al*. 2005). The method reported in Gardiner *et al*. (2002) involves marking out the corners of the quadrat with poles (or defining boundaries with a rope), without disturbing the grasshoppers within the quadrat by casting shadows, and then moving from one edge of the quadrat to the other brushing the vegetation with a pole to cause any grasshoppers present to jump. The 'flushing' was conducted in a similar way to sweeping in that the observer moved from one edge of the quadrat to the other sweeping the vegetation in a 180° arc. Only grasshoppers within the quadrat at the start of the sweep were recorded by Gardiner *et al*. (2002) with those being 'flushed' into the marked area from outside being discounted. If the observer is familiar with the identification of Orthoptera, then the grasshoppers can be identified to species level, although in large populations this can be difficult due to the fast escape of 'flushed' individuals. Nevertheless, the method can produce an estimate of the overall number (density) of grasshoppers per m^2 (as a defined area has been searched, we suggest at least five quadrats are surveyed, i.e. 20 m^2 area). A high density of grasshoppers is three adults per m^2 and anything in excess of this level indicates a highly important habitat for grasshoppers.

△ 2 x 2 m quadrat marked with a rope (Christian Whiting)

Line transects

Transect surveys are usually undertaken to provide information on the presence or abundance of mobile, easily visible species, such as adult butterflies. Guidance on this technique is provided in Sutherland (2006). Counts of target species or taxa are made along a fixed route (e.g. along the crest of a sea wall), within a set corridor, and for a standardised length of time. They can be repeated periodically (either throughout the flight season or over subsequent years) to provide evidence of continued presence or an indication of change in abundance/species richness over time. Transects may be divided into defined sections (lengths) to provide greater information on the distribution of species. On sea walls, this technique is most suitable for species which are easy to see and identify by eye, such as grasshoppers and crickets, butterflies and bees (although some bumblebees can be hard to identify visually without closer examination of anatomical features).

Case study

Home Marsh Farm butterfly transects, Taw and Torridge Estuary, Devon

The Environment Agency maintains a sea wall to the west and north of the Home Farm Marsh reserve at Yelland on the south side of the Taw and Torridge Estuary in north Devon through mowing each autumn. This sea wall is a sandy embankment sheltered in places by a Four-stamen Tamarisk *Tamarix tetrandra* hedge that supports a variety of invertebrates, notably grasshoppers. The sea wall also supports summer wild flowers such as Pale Flax, Spiny Restharrow, Yellow-wort and Common Knapweed. These in turn attract a wide range of invertebrates, including butterflies such as Meadow Brown *Maniola jurtina* which nectars on the Common Knapweed growing on the sea wall and Common Blue *Polyommatus icarus*, as well as on occasion the uncommon Brown Argus *Aricia agestis*.

The Gaia Trust which owns and manages Home Marsh Farm has worked collaboratively with the National Butterfly Monitoring Scheme run by the Centre for Ecology and Hydrology (CEH) and Butterfly Conservation to record the butterflies and moths found on the reserve. Transects, including one divided into five sections along the sea wall, have been walked by local volunteers over a three month period in the summer for a number of years. These counts have revealed some interesting results, including large numbers of Common Blue butterflies and Six-spot Burnet *Zygaena filipendulae* and Silver Y *Autographa gamma* moths, including 12 of the latter on one stretch of sea wall. The apparent cycle of high and low numbers evident in the data is considered to closely reflect the biology of many of the UK's butterfly and moth species in terms of how they respond to changes in weather patterns and climate.

A record card with an annotated map has been issued to volunteers to encourage them to record what they see as they walk the paths (transects) around the reserve. These records are being compiled so they can be made available to the Devon LRC. The Gaia Trust encourages visitors to report any sightings of butterflies and moths on the reserve, including through the use of a recording form available on the Gaia Trust website. This is seen as not only helping improve understanding of the wildlife on the reserve, but also as a way of contributing to a nation-wide resource that is helping improve overall understanding of the ecology of British butterflies and moths.

Foliage beating

This is a relatively simple hand-collection technique used to acquire samples from scrub. The tree branches and foliage of scrub stands are bashed, causing some of the invertebrates present to fall out. These are collected in a 'beating tray', which can be as simple as a piece of pale cloth (to make the invertebrates that fall out easier to see) laid beneath the scrub in a way that ensures it sags in the middle. This technique is relatively quick and easy to carry out but like all invertebrate surveys and monitoring it requires a degree of identification skill. It can be used to simply assess the presence and absence of species, though where foliage beating is carried out using a standard number of beats or standard length of time; it can also be used to estimate the relative abundance of particular species between different areas of a sea wall.

On sea walls, this technique is most suitable for species that have larvae which feed on scrub, such as the Sloe Carpet moth.

Case study

Larvae of the Sloe Carpet moth at Old Hall Marshes, Essex

The Sloe Carpet is a locally distributed moth of woodland, hedgerows and scrub in the south and south-east of the UK. The moth is a species of principal importance in England under the NERC Act 2006, and also a UK BAP and Nationally Scarce species. Essex and Suffolk are its main strongholds, with a marked eastern distribution in both counties. In Essex, it is widespread but localised, with a fairly large population at Old Hall Marshes (RSPB reserve) on the Blackwater Estuary. The adult moth flies in April and the single generation of larvae feed on the leaves of Blackthorn from mid-May to early July.

As part of the management of the flood defences, Blackthorn scrub was cut back on the sea wall at Old Hall Marshes during the winter of 2010/2011. Scrub was cut back on the crest, landward slope and folding of the sea wall. Only a 4m wide section (to allow vehicular access at the toe of the embankment) was cleared of scrub along the folding leaving a 2-3m wide fringe of scrub along the edge of the landward side borrowdyke.

In May 2011, in conjunction with RSPB staff and Essex moth expert Don Down, a standard beating pole was used to dislodge moth larvae from the remaining Blackthorn scrub foliage at Old Hall Marshes. A record was kept of the larvae of all moth species beaten from the scrub. The areas of scrub beaten included: A) the 2-3m wide fringe of uncut woody vegetation along the folding of the sea wall

adjacent to the borrowdyke; B) scrub along a track running adjacent to the sea wall which had not been cut; and C) a green lane with dense Blackthorn on either side of a mown track. Approximately 30 minutes were spent beating for larvae at each location.

One Sloe Carpet larva was beaten from Area A along the sea wall suggesting that this scarce moth still persisted on the uncut scrub along the edge of the borrowdyke. The only other Sloe Carpet larva recorded during the survey was beaten from Blackthorn along the green lane (Area C). The larvae of a total of 11 species (including the Sloe Carpet) were beaten from the uncut Blackthorn and Dog Rose scrub on the sea wall folding (Area A). These were mostly common species such as the Early Moth *Theria primaria*, Emperor Moth *Saturnia pavonia*, Winter Moth *Operophtera brumata* and Yellow-tail *Euproctis similis*, although the declining Figure-of-eight *Diloba caeruleocephala* was also beaten. Other insects recorded from the uncut scrub on the folding included early instar nymphs of the Speckled Bush-cricket and the Red-and-black Froghopper *Cercopis vulnerata*. In fact the uncut scrub on the folding (Area A) had larvae of a number of moth species that were not beaten from the adjacent track (Area B) on the landward side of the borrowdyke (Table 9.2).

Table 9.2: Macro-moth larvae (identified by Don Down) recorded in three habitats at Old Hall Marshes, Essex

Moth species	A: Sea wall folding	B: Track	C: Green lane
Common Emerald *Hemithea aestivaria*	-	x	-
Common Quaker *Orthosia cerasi*	-	-	x
Dotted Border *Agriopis marginaria*	x	x	-
Early Moth *Theria primaria*	x	x	x
Emperor Moth *Saturnia pavonia*	x	-	-
Figure-of-eight *Diloba caeruleocephala*	x	-	-
Magpie *Abraxas grossulariata*	x	x	-
March Moth *Alsophila aescularia*	x	-	-
Mottled Umber *Erannis defoliaria*	x	-	-
Scarce Umber *Agriopis aurantiaria*	x	x	x
Sloe Carpet *Aleucis distinctata*	x	-	x
Winter Moth *Operophtera brumata*	x	x	-
Yellow-tail *Euproctis similis*	x	-	-
Number of species	11	6	4

Key: Area A: Uncut scrub on the sea wall folding adjacent to the borrowdyke
Area B: Woody vegetation along a track on the landward side of the borrowdyke
Area C: Nearby green lane

Although not a scientific study, it appeared that the larvae of the Sloe Carpet moth were very thinly distributed at Old Hall Marshes, with their presence on the uncut scrub on the folding suggesting that woody vegetation along the borrowdyke edge could be an important habitat for this and other moth species. As such, it was considered a fringe of woody, notably Blackthorn, scrub should be retained along the borrowdyke edge during any future cutting of sea wall scrub.

Sweep netting

This is another relatively simple and rapid technique, though it is usually used to acquire samples from less rigid vegetation, such as grasses or ruderal vegetation growing on a sea wall. Vigorous sweeps through vegetation are made with a stout, long-handled, robust fine-mesh net to dislodge resting insects. Like foliage beating, sweep netting results in the live capture of invertebrates. It can be used to simply assess presence and absence of species, though this survey technique may also be used semi-quantitatively by timing the number of sweeps through vegetation of a similar type and counting selected groups of species. Sweep netting can therefore allow interrogation of different habitats on a sea wall, whilst repeated sweep netting of specific areas provides a broad indication of the relative abundance of particular species over time.

Although a commonly used, rapid technique, if employed carefully, sweep netting can capture large numbers of invertebrates. Whilst many can be screened visually inside the net others may need to be collected for subsequent identification, notably under a microscope to identify the minor differences between some species which can be very time consuming (Falk 2010). As such, sweep netting requires a degree of expertise in both technique and the identification of caught invertebrates, with voucher specimens retained where appropriate to back up identification of difficult species.

This technique is effective for many invertebrates, including several beetle families, most plant bug groups and a large number of other insects that live in vegetation on sea walls. However, it does not sample invertebrates that are confined to dense stands of vegetation in lower levels such as the litter layer.

Pootering

This involves capturing small ground dwelling invertebrates using a suction tube with an attached collecting bottle. Invertebrates are usually captured alive and identified in the field before being released. However, specimens may be taken for subsequent confirmation of identification. For more quantitative results which can be used to help monitor species composition and relative abundance over time, pootering can be conducted through timed searches, along set transects or within fixed quadrats on a sea wall.

This technique is time consuming and on sea walls is likely to be most suitable for searching at ground level and amongst blockwork revetment of the seaward face for invertebrates such as spiders.

Light traps

Many nocturnal flying invertebrates, notably moths, are attracted to light. As such, those flying along or over sea walls can be caught using an artificial light source mounted above a funnel to draw invertebrates into a collecting box. Smaller boxes inside the collecting box act as refugia so that invertebrates can if necessary be identified and counted later in daylight before release. Alternatively, experienced entomologists can catch flying invertebrates which land on a white sheet illuminated by the light source and keep these in collecting jars until released at the end of the trapping session once identified and counted.

Two of the most common commercially available light sources are mercury vapour bulbs and ultra-violet fluorescent bulbs. Running off a portable generator, mercury vapour bulbs are the more powerful and can attract insects from up to a mile away (Day *et al*. 2003). This means that whilst they tend to attract more flying invertebrates, they are not really appropriate for assessing invertebrate usage of a sea wall or the distribution of invertebrates along a sea wall. They are however very useful at indicating which flying invertebrates are present in the vicinity. Less powerful, ultra-violet fluorescent bulbs can be run from batteries and tend to attract flying invertebrates from a much more local area.

Timed trapping in the same position can be used to assess changes in relative abundances over time or for comparing similar times between years. On sea walls, this technique is likely to be most suitable for searching for nocturnal flying invertebrates such as moths. Further guidance is provided in Fry & Waring (2001) and Anglian Lepidopterist Supplies (2004). It must be noted that some moths are not strongly attracted to light (e.g. Fisher's Estuarine Moth) and torch surveys are required to detect adults at night.

Pitfall traps

Pitfall traps are usually a steep sided container sunk to ground level with a cover to prevent rain getting into the trap or non-target species (e.g. reptiles) being caught. They are effective at live trapping active soil-surface dwelling species, though can also trap burrow-searching species such as bumblebees. After a specified time period, the contents of the trap are collected, identified and counted. Without care, predatory invertebrates which fall into the trap can significantly influence the results by consuming at least part of the catch before it is analysed.

Pitfall traps that are distributed at regular intervals along a sea wall are likely to provide the most useful data, though they can also be located to provide detailed information about a specific area. However, if catches are to be compared between different stretches, or different zones of a sea wall, then the number of traps and trapping technique will need to be standardised for the results to be meaningful.

Baited traps can be highly efficient at attracting specific species or sex of one species and can attract insects from a considerable distance. The use of lethal traps (through the use of water or a preservative/killing agent such as antifreeze) should only be done for approved research or to control a particular non-native species which has invaded a sea wall. For example, pitfall traps containing antifreeze were used to sample invertebrates at Colne Point in Essex, and led to the rediscovery of the Nationally Scarce Grey Bush-cricket after several decades with an absence of visual sightings in the county (Harvey & Gardiner 2006).

On sea walls, pitfall trapping is likely to be most suitable for searching for crawling invertebrates, such as spiders and beetles. Further guidance is provided in McWilliam (2000).

Mark-release recapture

Whilst population abundance can be assessed using mark-release recapture techniques, these are time-consuming and of little use for all but the smallest scale studies. Typically recapture rates of marked individuals are low, for example, in a study of grasshoppers at Writtle College in Essex over the course of one day, only 44% of adult Meadow Grasshoppers were recaptured (Gardiner & Hill 2004). Recapture rates of grasshoppers were also related to sward height and topography, as directional movement uphill into taller, ungrazed vegetation was noted.

Therefore, a range of sampling techniques may need to be deployed to provide a robust indication of numbers or density of invertebrates. Reviews providing helpful suggestions on which methods may be most applicable to particular study sites are available in the literature. Gardiner *et al*. (2005) for example review a selection of the extensive literature reporting studies estimating the abundance of grasshoppers,

bush-crickets and crickets, in a wide range of grassland ecosystems. This concluded that the most rapid and inexpensive sampling methods, such as transect counts which involved 'flushing' grasshoppers, were fairly accurate in short, open swards (<50 cm in height) and where grasshopper densities were low (less than two adults per m^2). At higher population densities, methods which required the capture of grasshoppers such as sweep netting were considered likely to be more appropriate. It was also noted there was a need to develop standard sampling techniques that could produce comparable data from studies with differing vegetation structures and invertebrate densities.

Reptile and amphibian recording and monitoring techniques

Reptiles and amphibians are usually relatively difficult to see on sea walls due to their retiring habits when in terrestrial habitats and because they can be hard to locate amongst vegetation. Whilst amphibians are commonly surveyed during the breeding season when they move to waterbodies, two commonly used methods of surveying and monitoring both amphibians and reptiles whilst in their terrestrial habitats are visual searches and refugia surveys, though these are often most effective when used together. Both are relatively easy to carry out but tend to only provide coarse relative abundance data. Egg and hatchling searches can also be conducted to confirm breeding.

Visual searches

Visual searches (also known as visual encounter surveys) require inspecting likely areas of habitat at an appropriate time of year and in suitable weather conditions. The most effective time to carry out a visual search is when reptiles are basking. Reptiles generally bask when the air temperature is between approximately 10-20ºC. There can however be differences in basking behaviour between different individuals and age groups of the same species, and between species, seasons, habitats and different parts of the country. For example, Common Lizard and Adder are often more commonly observed at lower temperatures than Grass Snake (Edgar *et al*. 2010).

Visual searches for amphibians and reptiles on sea walls are likely to be most effective in the early spring, shortly after they have emerged from hibernation. At this time of year ground vegetation cover is often at a minimum and reptiles tend to spend a considerable amount of time basking in open areas, such as more sheltered locations on the crests of sea walls or south facing slopes. Whilst amphibians tend not to bask in the sun to raise their body temperature, they will occupy places which warm up sufficiently for them to become active. At other times of the year visual searches are likely to only be useful for more active species such as Common Lizard and Grass Snake. Visual searches are not appropriate for detecting some species such as the Slow-worm which almost invariably can only be found by searching under refugia.

It is important for results to be meaningful that a methodical approach is taken to visual searches. For example, slowly walking along a transect through potentially favourable habitat on a sea wall at the same time of day can be one way of surveying more obvious species such as Common Lizard. Ideally, though this will not always be possible on a sea wall, the sun should be behind the surveyor to aid viewing provided shadows falling on potential basking areas can be avoided. The surveyor should look some 2-3m ahead of where they are walking so as to potentially see any reptiles before they move away. Therefore, whilst this is a simple technique, an experienced surveyor is likely to record more amphibians and reptiles.

Refugia surveys

Reptiles are attracted to items lying on the ground that offer both cover and a warm microclimate through being heated by the sun. Placing out artificial refugia on a sea wall can therefore offer a way of surveying even the more secretive species of reptiles. Three of the most commonly used materials for artificial refugia are roofing felt, carpet tiles and sheets of corrugated metal. The differing thermal properties of each of these materials affect their attractiveness to reptiles, though relative attractiveness can vary under differing environmental conditions (Edger *et al*. 2010). For example, whilst sheets of corrugated metal generally seem more attractive, especially to snakes, than roofing felt, as the latter retain more heat they may be more attractive later in the survey season when air temperatures are lower. However, the differences between the type of refugia used does not appear relevant in terms of providing meaningful results to inform the management of vegetation on sea walls. What is more important are both the size of refugia, their positioning, the density at which they are laid out and the timing of checks.

▽ Checking reptile refugia (Christian Whiting)

Larger refugia tend to attract more reptiles than smaller ones. As such, artificial refugia should ideally be as large as is practical to transport to a sea wall, handle into location and rapidly search under when lifted. It should be noted that artificial refugia can attract other, non-target species of conservation interest, including invertebrates such as Glow-worm (Lampyridae) larvae (and their snail prey), ants and small mammals.

Artificial refugia used for surveying and monitoring of amphibians and reptiles on sea walls should be placed at locations where they are most likely to be used, for example in tussocky grassland, or along the edge of scrub. Rather than placing them on areas of bare ground (e.g. on the crest of a sea wall), the best results are often obtained by laying artificial refugia in vegetation where a

greater range of microclimatic conditions are likely to be created underneath. On long lengths of sea wall or where vegetation may become tall later in the season, even on a linear feature like a sea wall it is best if the location of each refugia is GPS referenced to aid subsequent finding.

Whilst amphibians and reptiles may find artificial refugia very quickly, especially on sites with high population densities, there is some evidence in the literature to suggest that refugia are more readily used if they are left to 'bed in' for several days before surveying commences. This is particularly warranted where population densities may be low (as is often the case on sea walls), when it may take several weeks or even months for amphibians and reptiles to start using artificial refugia.

In simple terms, the more refugia that are put out the greater the chance of detecting any amphibians and reptiles that are present. Where survey information is required on a long length of sea wall, refugia should ideally be set out in a fixed grid pattern. Alternatively, they can be focused on a particular area, zone or habitat type if more specific information is required.

Amphibian and reptile surveys generally seek to determine the presence or likely absence on a particular stretch of sea wall. However, as amphibians and reptiles can be elusive, the lack of detection during a single check of refugia does not necessarily mean they are not present. Current advice suggests five to seven checks spread over the survey season are needed to provide a reasonable degree of certainty that lack of detection equates to absence, but that 15-20 visits are needed for a relative population estimate (Froglife 1999, Natural England 2011b).

The survey effort required to provide a more definite answer on the use made of any given sea wall by amphibians and reptiles will vary with the character of the habitats present, time of year, species of interest and numbers present. Adder and Grass Snake may for example only use a particular area of a sea wall for part of the year. To evaluate site use by these species, refugia checks will therefore need to be spread over the course of the entire active season.

Care is needed when lifting refugia on sites known to support Adders as they may inflict a poisonous bite when alarmed such as when disturbed through the lifting of the item they are under. Care will also be needed where surveys are planned on sea walls with public footpaths, as refugia may be investigated by curious members of the public, especially children.

Case Study

Bonners Barn reptile survey, the Strood near Peldon, Essex

A reptile translocation exercise was undertaken on behalf of the Environment Agency prior to the renewal of a section of the sea wall at Bonners Barn, the Strood, near Peldon, Essex. In total, 224 Slow-worms, 147 Common Lizards and six Adders were moved between July and September 2004 to a release area (Essex Amphibian & Reptile Group 2007).

A brash pile on the sea wall and three purpose built hibernation banks on an adjacent field margin were provided in mitigation as suitable habitats for the resident reptile population. No reptiles were released onto the sea wall or field margin directly, rather it was planned to allow them to migrate from the release site.

The sea wall and field margin were subsequently monitored for reptiles each summer for three years using standard survey techniques. This involved recording visual encounters and placing out corrugated tin sheets and roofing felt at 10m intervals along the crest, landward slope and folding of the sea wall, as well as along the field margin. These were put out in March each year and after being allowed to settle were inspected at intervals between April and October.

The results indicated that Slow-worms were mainly found on the field margin, though a few, including young animals, were recorded on the sea wall. Common Lizards were associated with the long grass of the sea wall. Several Adders were found, including near the brash pile and the survey showed that the purpose built banks were used as a summer basking site by this species. The survey also noted the presence of Grass Snakes on the sea wall, with good numbers of adults in spring 2006 apparently pairing up under the sheets of corrugated tin. The presence of an adult female Grass Snake on the sea wall in October 2005 confirmed the theory that it may be used as an over-wintering site.

It was concluded that reptiles were moving to and from the sea wall during the course of the year. The sea wall was considered to be the winter habitat for Adder, Grass Snake and Slow-worm. The Common Lizard was considered to have a stronger association with the sea wall over the course of the year in that it appeared not to venture too far from this habitat. Such behaviour is considered typical of this species which generally has been shown to have a small home range.

Egg and hatchling searches

These may be carried out in late summer to confirm that a particular species is breeding. It involves searching suitable nesting sites for the eggs of species such as Grass Snake, neonates (individuals immediately post-hatching) or hatchlings. Such searching requires considerable experience and has a very limited seasonal window of opportunity, but provides valuable additional information.

Reptile surveys on sea walls, as elsewhere, are normally best undertaken during relatively warm weather and either in the morning or evening when they are basking and easiest to see. Basking is more prolonged in the spring and early autumn when the sun's angle is relatively low (Day *et al*. 2003). South-east facing slopes of sea walls are likely to be favoured for basking as they offer the greatest exposure to the sun in the morning. Reptiles on sea walls which run north to south may show a preference for basking on different faces in the morning and evening.

The ideal conditions under which to conduct a reptile survey are given by Gent & Gibson (2003) as:

- April and May when the sun's low angle in the morning keeps temperatures cooler for longer;
- Mid morning (09:00 – 11:00) before the sun's angle is too high (and again mid evening);
- Temperatures in the range 10–17°C;
- Broken cloud or hazy conditions so that reptiles do not achieve their required temperature too quickly and then move away; and
- Little or no wind.

▽ Common Lizard (Christian Whiting)

Where more detailed, long-term information is needed, counts from repeatable surveys (e.g. walking a defined transect in a set time or lifting a standard number of refugia at a given time of day) will often be the best approach. Results can be expressed as encounter rates (number of individuals per hour, or per visit if this is standardised) or used to generate a population index for a particular stretch of sea wall. Where this is done, comparisons between surveys may allow trends to be identified.

However, interpreting trends during a single season has major limitations. Whilst higher counts may indicate reptiles have moved onto a sea wall and similarly lower counts indicate reptiles have moved away from a sea wall, such changes in numbers may equally merely represent changes in reptile detectability. This could be because a survey was carried out in more, or less, favourable environmental conditions or be a response to changes in vegetation

structure. For example, survey results can decrease as vegetation becomes taller and hence reptiles are less easy to see, or increase immediately after scrub clearance when reptiles become more visible. Hence, count data should be interpreted cautiously, using all contextual information, and ideally be collected over at least five years to allow proper assessment (Edger *et al*. 2010).

Unfortunately, there are no reliable means of relating the numbers of animals recorded in typical surveys to actual population size. The most reliable method of estimating population size is a mark-release-recapture study (Edger *at al*. 2010). Whilst such studies can be time consuming, especially on larger sites or longer lengths of sea wall, or when multiple sea wall sites are being studied, they reduce the limitations imposed on surveys associated with differences in detectability.

Bird recording and monitoring techniques

Birds are one of the easiest taxonomic groups of fauna to survey on a sea wall as they are relatively visible, vocal and readily identifiable, though identifying birds by their songs alone requires considerable experience. Sea walls can provide both nesting sites and foraging/roosting sites for birds.

Nesting sites

Most species of bird hold territories and mapping these allows their breeding distribution and abundance to be assessed. Unlike other fauna, there are formally adopted standardised techniques. Three commonly used methods of surveying and monitoring breeding birds on sea walls are:

- Breeding bird survey;
- Point counts; and
- Line transects.

Breeding Bird Survey

During the breeding season of most species of wild birds found in Britain (generally considered March to August though some start as early as February) most adult male birds tend to stay within a territory which can be identified by song or display behaviour (such as the rising and falling flight of the Skylark). This is found particularly amongst passerines, where territories are often marked by conspicuous song, display, and periodic disputes with neighbouring individuals.

To record this behaviour, up to ten site visits are made to a defined stretch of sea wall during the main breeding season between March and July. Where time is limited, fewer visits may be used, though for results to be comparable the number of visits should ideally be standardised between years. Each visit is conducted in good weather usually between dawn and 09:00 am (as this is when territorial behaviour is at its peak) and usually lasts between two and three hours. Where there are eight or fewer survey visits during the period when a species is expected to be present, it is necessary to use at least two registrations of a bird, in the same area, as the minimum required to assume a breeding territory.

All registrations are mapped using standard British Trust for Ornithology (BTO) species and territorial behaviour codes on a suitably scaled map of the survey area. Ideally this should be directly onto a GIS enabled handheld Personal Data Assistant (PDA) loaded with a suitably scaled Ordnance Survey base map. The data are then used to determine the number of territories of each species, usually through standard territory (registration) mapping techniques detailed in Bibby *et al*. (2000) and data analysis following the procedures detailed in Gilbert *et al*. (1998). Together, these provide a relatively accurate assessment of the abundance and composition of the breeding bird community.

Whilst a breeding bird survey is relatively time consuming, as it provides very detailed information about bird distributions and abundance in relation to habitat types and quality on a sea wall, it can be highly useful in obtaining robust evidence to inform vegetation management practices.

Point Counts

This involves recording all birds heard singing or displaying breeding behaviour from one or more specific locations along a sea wall over a set period. Again, each visit is conducted in good weather usually between dawn and 09:00 am and typically lasts between two and three hours. However, in contrast to a breeding bird survey, point count surveys usually involve between two and four visits and, as such, are less time consuming.

The points from which to conduct the counts on a sea wall can be chosen at random, or, for more specific studies, can be focused on particular zones (e.g. along the edge of a borrowdyke or a particular stand of scrub). It can sometimes be difficult to identify suitable locations, especially where there are dense stands of scrub or a need to view both sides of a sea wall. Where long term monitoring of breeding bird activity is being undertaken through the application of this survey technique, it is important that point counts are conducted from the same place, at the same time of year and for the same length of time to ensure comparability of the results between years.

Line Transects

This involves slowly walking a defined route along a sea wall recording singing birds and signs of breeding bird activity. To aid with interpretation, a sea wall can be divided into counting sections, such as on a stretch, habitat or sea wall zone basis. As with point counts, line transects surveys should normally involve between two and four visits conducted in good weather between dawn and 09:00 am, and usually last between two and three hours. The results can provide information on the relative abundance of the bird species encountered, provided each count is repeated to the same standard.

Case study

Breeding bird study on Essex sea walls

In response to the Environment Agency reviewing the practice of mowing the majority of sea walls in Essex only once per year, a study (RPS 2012) was undertaken to assess the implications to nesting birds of bringing the vegetation management regime into line with the 2-3 cuts per year recommended in national guidance.

Nesting birds are protected under the Wildlife and Countryside Act 1981 (as amended) which prohibits the damage and destruction of bird nests, eggs and young in the nest. Whilst it was not known just how important the tall grassland on sea walls was for nesting birds, it was considered that they could potentially provide good nesting habitat for some species, particularly UK BAP species such as the Skylark and Meadow Pipit. Skylark is also a species of principal importance in England under Section 41 of the NERC Act 2006. A survey in 2007 of an Essex sea wall at Walton-on-the-Naze for example revealed two pairs of nesting Meadow Pipit, one along the borrowdyke edge and the other at the base of the landward slope where it meets the folding.

Increasing the frequency of sea wall mowing to 2-3 cuts each year was seen as posing two potentially significant issues:

- Firstly, it was likely that one cut would have to occur during the bird nesting season (April to August) and as such risk destroying bird nests; and
- Secondly, there could be a reduction in the quality of the sea walls as nesting habitat due to short swards throughout April-July.

The study involved establishing a trial area of interconnected sea wall habitats near Brightlingsea on the Colne Estuary in north-east Essex. All the sea walls in the trial area largely comprised rough grassland dominated by coarse grasses, most notably Sea Couch, and all had received a single

annual cut in October 2010. They were also relatively similar in character with a borrowdyke on their landward side, and saltmarsh and mudflat on the seaward side. A control site was also identified on the Dengie Peninsula in Essex where there was a similarly long, straight sea wall that, like the Brightlingsea site, was fronted by saltmarsh and had a flat berm and borrowdyke on its landward side.

The trial involved assessing the effects of mowing the landward slope and crest on five sections of the trial sea walls near Brightlingsea in 2011. These were either mown once, twice or three times, together with an area left uncut, as follows:

- Section 1: three cuts a year (April, July, October);
- Section 2: two cuts a year (July, September);
- Section 3: one cut in Feb, cut if necessary in September;
- Section 4: one cut as per current practice; and
- Section 5: uncut control section.

The folding was only to be mown on a 3-4 year rotation on all walls, except for a 3-4m wide access track mown annually to allow safe passage of cutting machinery. Vegetation on the seaward slope was also only to be cut on a 3-4 year rotation to control scrub growth and allow inspections of the sea wall condition.

A 500m length of sea wall was selected from each section (1-5) in which to monitor bird activity. As far as possible these lengths were chosen to be representative of that section of sea wall in order to limit any confounding factors to bird nest site location such as adjacent land use and any limitations to the planned delivery of the mowing regime. The control site on the Dengie Peninsula sea wall was also divided into 500m sections to enable a comparison with the Brightlingsea sea wall sections.

Due to their close proximity, all survey lengths of sea wall within the Brightlingsea trial were visited on the same day. The Dengie Peninsula control sea walls were visited on a different day so that all surveys began in the morning when bird territorial and feeding activity is at its peak. This avoided surveying one site in the morning / middle of the day and the second site in the afternoon to evening when potential bias in recorded bird activity due to the timing of visits could occur. The plan was that the two sites were surveyed no more than seven days apart in each monthly period so as to minimise seasonal and bird breeding cycle changes occurring between visits to the two sites.

Each sea wall transect was slowly walked with all bird species seen mapped directly onto an Arcpad GIS enabled PDA using standard registration techniques to record behaviour, notably anything suggestive of breeding activity, such as carrying nesting material or food, singing, display or aggression. Where breeding behaviour was noted, a focal watch of the individual(s) was undertaken to establish, where possible, the location of the nest. No detailed nest searches were undertaken

and if a bird was seen taking food into a patch of suitable vegetation that was recorded as sufficient evidence for the presence of a nest. All site survey visits were undertaken on days of good weather when bird territorial and feeding activity was considered to be at its greatest. After each survey, the collected data were downloaded into ArcGIS software.

Surveys were undertaken between April and August 2011 with a total of four survey visits (one each in April, May, June and July) being made to the Brightlingsea trial sea walls and five to the Dengie control sea walls. The additional visit to the Dengie site in August 2011 was made because of the presence of Corn Bunting *Miliaria calandra* that continue to nest later in the summer than many other species and for which research has shown that being able to raise a second brood late in the season is important to the maintenance of the population.

Territory (registration) mapping and data analysis was undertaken using standard techniques to provide an assessment of the abundance and composition of the breeding bird populations along the two sea walls. A total of 65 species were recorded. Of these, 38 species were confirmed to be breeding (i.e. species for which territories were positively identified as a result of the number of registrations, the location of an active nest, presence of recently fledged young or presence of downy young). A further six species were considered to be probably or possibly breeding. This included species where a pair was observed in suitable nesting habitat and demonstrated agitated behaviour or anxiety calls from adults suggesting the probable presence of a nest or young nearby but where behaviour was observed on insufficient occasions to confirm the presence of a territory. It also included species observed in the breeding season in suitable nesting habitats, or singing males present (or breeding calls heard) in suitable breeding habitat. The remaining 21 species were considered to relate to non-breeding records of fly-over birds suspected to be still on migration and those summering in the area.

The analysis was undertaken on all bird observations and as a result included territories that in reality did not involve birds breeding in sea wall habitats. A total of 14 species were recorded as showing signs of definite nesting activity related to the sea wall. Of these, 11 species were found to be nesting on the Brightlingsea sea walls and six nesting on the Dengie sea walls. The vast majority of nest locations were identified as being either along the borrowdyke edge or on the folding. Only one nest was actually located on the structure of the sea wall. This was located on the Dengie sea wall and consisted of a Meadow Pipit nest considered to be located on the landward slope of the sea wall at the southern end of the study area.

In addition to gathering data on bird breeding behaviour habitat data were also recorded. The grass sward height was measured at 100m intervals across the sea wall cross section (Chapter 2, see Figure 2.1). Grass sward height was also measured at points as close as possible, without causing undue disturbance, to sites where bird nesting activity was indicated. Grass sward height was measured by the 'direct measurement

method' listed in Stewart *et al*. (2001) that was found to be suited to ecological research on sites with short cut and ungrazed swards. The sward height recorded on the Dengie sea wall in the vicinity of the Meadow Pipit nest on the landward slope ranged from 40 cm in April to 55 cm in August.

The numbers of breeding birds recorded and nests located on both the Dengie and Brightlingsea study areas would appear to indicate that relatively few birds use the sea walls for nesting. The various cutting regimes trialled at the Brightlingsea site would also appear to have no specific influence on nesting birds. Given that no birds were recorded nesting on the sea wall itself at Brightlingsea (including the control uncut area) the survey would indicate that the number of cuts per year is not the controlling factor in the attractiveness of the sea wall to nesting birds. Whilst other environmental variables would therefore appear to make sea walls unfavourable to nesting birds, the data were too few to draw any further meaningful conclusions based on these surveys alone.

Foraging and roosting birds

Field survey methods should be based upon, and adapted from, generic bird monitoring methods given in Gilbert *et al*. (1998). The two principle survey methods to assess foraging or roosting by birds, notably over the winter, involve vantage point counts and line transects.

Vantage Point Counts

Vantage point counts involve recording birds from two or more positions selected to provide clear views over the relevant section of sea wall. Each vantage point count should last a specified time ranging from a few minutes to a full tidal cycle, with information on species seen or heard, numbers of birds, time they were recorded and their behaviour (e.g. flight, hunting, feeding, roosting, etc.) noted on standard maps and forms. Vantage point counts should be undertaken on a regular basis (e.g. weekly or monthly) and either completed at similar or different times of day such as dawn and dusk, or different states of the tide, as required to meet the objectives of the study.

Line Transects

This involves slowly walking a defined route along a sea wall recording birds seen or heard within or near the study area on standard recording maps and forms. To aid with interpretation, a sea wall can be divided into counting sections and as with vantage point counts, line transects surveys should involve a series of visits.

All foraging and roosting surveys should be undertaken by experienced ecologists and avoid days with extreme weather conditions of wind or rain.

Mammal recording and monitoring techniques

The two main mammal surveys likely to be carried out on sea walls are in relation to Badgers and small mammals (small mammals generally refer to any non-flying mammal weighing less than 1 kg as an adult).

Badger survey

A Badger survey involves systematically searching a length of sea wall for signs of Badger activity. This can be carried out at any time of year though is generally best conducted between November and April when there is less vegetation to obscure any signs. The survey involves looking for footprints, dung pits, snuffle holes and distinctive runways through the vegetation. Distinctive boundary features such as scrub alongside borrowdykes should also be specifically searched for latrines indicating a territory boundary as well as stray hairs. Sea wall banks and any areas of scrub habitat need to be searched for any signs of active sett building activity, including large, D-shaped holes, dung pits and hairs close to sett entrances, discarded bedding and spoil heaps from recent digging.

Any sett entrances located should be evaluated to indicate their likely level of usage. Commonly used categories are:

- Well used sett with an entrance free of leaf litter and showing recent signs of excavation;
- Partially used sett with an entrance that has some leaf litter and debris around the hole but also shows some signs of recent digging; and
- Disused sett with an entrance entirely or partially filled with debris and leaf litter which shows no recent signs of digging or a hole that exhibits the characteristics of a Badger sett but shows no other signs of recent activity.

The number of entrances and level of Badger activity at each sett can also be classified as follows:

- Main sett - large, well used and well established sett used for breeding (there is usually only one such sett within each clan of Badgers);
- Annex sett - additional setts located close to the main sett to which it is connected by well worn paths;
- Subsidiary sett - additional setts located some distance (often up to 150 m) from the main sett which may be used for breeding but do not have obvious paths connecting them to other setts and may not always be active; and
- Outlier sett - usually smaller in size than the other setts, located some distance from them and do not have obvious paths connecting them to other setts as only intermittently used.

- As Badgers can range over a large area, in order to establish the use being made of any Badger holes found on sea walls it will usually be necessary for the survey to also cover suitable adjacent and nearby habitats on the landward side of the sea wall.

Small mammal survey

Surveys aimed at investigating the relationships between small mammal abundance and diversity and the habitat characteristics of sea walls usually involve live trapping along a transect within rough grassland habitat.

Key considerations for successful trapping include:
- Size and type of trap;
- Placing of traps; and
- Timing of trapping.

Size and type of trap

The size and type of trap will determine the species of small mammals that can be caught. Although several different sizes and types of trap are available, the Longworth is the most commonly used small mammal live trap in the UK (Barnett & Dutton 1995). The Longworth trap has a long history (e.g. Chitty & Kempson 1949) and a wealth of guidance on its use now exists (e.g. Gurnell & Flowerdew 2006).

Each Longworth trap is 14 cm x 6.5 cm x 8.5 cm in size and comes in two parts comprising a metal tunnel section and a metal nest section which serves as a refuge for the captured animal. The Longworth is generally quite a robust trap, but due to its small size, it is only suitable for trapping mammals of less than 700 grams in weight.

For live trapping and re-release studies, bedding and food should be provided in the nest section of the trap to cover the period of incarceration. Bedding can be anything non-toxic and warming, but should not include anything sharp, wet or damp as this could chill a trapped small mammal, possibly causing its death. Old torn up newspaper and hay are commonly used. Non-absorbent cotton wool is especially useful in wetter environments, such as near borrowdykes or in areas subject to sea spray and has the added advantage of reducing mortality in shrews (Gurnell & Flowerdew 1990). Food suitable for the species of mammal likely to be caught can be placed with the nesting material to avoid small mammals starving whilst in the trap. This can be a particular problem for insectivorous mammals such as shrews. It is not generally necessary to provide water.

Placing of traps

Small mammals will seldom randomly be distributed across sea wall habitats, tending instead to preferentially use the edges of paths, scrub or a borrowdyke. They will also generally move around the edge of more open areas, though inevitably may have to cross the crest of a sea wall, which is when many are actually reported. Consequently, well placed traps can significantly enhance trapping success.

A preliminary habitat survey of a sea wall can help identify the most suitable trap locations, including any small mammal runs through thick grass, dense areas of vegetation or the base of any tree or stands of scrub. Signs of mammal activity, such as chewed food or faecal deposits, as well as any areas supporting obviously favoured foods are also likely to be suitable trapping locations. More open or exposed areas of a sea wall should be avoided and the base of traps set flush with the surface of the soil as small mammals tend to prefer not to step up (Barnett & Dutton 1995). Where traps are placed on steep sea wall slopes they need to be angled to face at least partially downwards so that the bedding will be kept dry if it rains and where necessary held in place by pegs. Particular care is needed over the placing of traps to limit capture of non–target species such as reptiles and ground foraging birds.

Whilst the number of traps needed to provide meaningful data on population levels will often be determined by the trapping success rate, most small mammal surveys will involve deploying more than one trap. Experience has shown that a maximum of 200-300 traps can usually be inspected and re-set each day, depending on the catch and provided each trap is easily located. To assist with this, traps are usually arranged in transects or a grid pattern. Transects can be particularly useful when covering linear habitats such as sea walls, a range of habitats, or trying to detect movement between adjacent habitats (Barnett & Dutton 1995).

Timing of trapping

Most species of small mammal likely to be found on sea walls are nocturnal or crepuscular (active at sunrise and sunset). As traps must not be left unattended in the capture position for more than 12 hours, a sea wall survey will normally comprise a number of consecutive evening and morning inspections. Where this is not possible (such as over a break in the survey, e.g. over a weekend), traps should be retrieved or left in the closed position if likely to remain undisturbed. A mid-day check can be worth adding to the programme where a sea wall is likely to support significant numbers of diurnally (day time) active small mammals, though it is not general practice to check traps during the night as this can disturb mammal behaviour as well as pose additional health and safety risks, especially on more remote sea walls.

The two main survey periods for small mammals coincide with peak abundance (September-November) and low abundance (March-May). There can also be considerable day-to-day variation in activity and hence the ease with which small mammals can be caught. For example, small mammal activity may be reduced on colder or more bright, moonlit nights, as well as when there is heavy rain (Barnett & Dutton 1995).

Whilst the length of time required to complete a small mammal survey depends on the objectives, where this includes an estimate of the population size, provided caught animals are marked, the optimum survey effort can be calculated by plotting the number of new individuals trapped against the number being re-caught to generate a return-for-effort graph.

Bat survey techniques

Although sea walls are unlikely to be prime habitats for bats, the adjacent borrowdykes (open water foraging habitat for insects) and presence of large trees (for roosting) means that they could form important habitats in some areas. Given that the borrowdyke is excluded from consideration in this Handbook as it's covered in other handbooks, we shall not focus on surveying of foraging bats at night using bat detectors, but will briefly outline where further surveys may be needed for roosting bats in trees on sea walls, particularly important if they are to be removed during clearance of woody growth.

▽ Veteran oak with high bat roost potential

Bats can require different roosting conditions during the course of a year. Some bats prefer to roost in hollow trees, whilst others choose buildings or caves. For a few weeks in the summer a maternity roost may be formed for female bats and their young. During the winter a hibernation roost will be formed whilst the bats go into a deep sleep (torpor).

Roosts in trees

Trees provide shelter and a feeding habitat (as trees attract a large range of insects) for some species of bats. Specfic species will also use the cracks, holes and gaps present in trees as roost sites. Therefore, if a tree is present on a sea wall which could be suitable for a bat roost, then a full survey by a licenced bat surveyor may be required. Trees such as Ash and oak are often used by roosting bats, but any tree or woody growth has bat roosting potential, particularly if it has hollows in the trunk/branches, holes, loose or flaking bark, splits, large cracks or is covered in Ivy. It can be difficult to find tree roosts from the ground, so we suggest if a tree has the potential for a bat roost then, unless a professional ecologist is involved, further advice should be sought from the Bat Conservation Trust's Bat Helpline (see http://www.bats.org.uk/index.php for more details).

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Glossary

Acrididae: the family of orthopterous insects which includes grasshoppers with short antennae (see Orthoptera)

aftermath: new grass growing after mowing or harvest

annual: a plant which completes its lifecycle in one year, growing from seed, flowering, fruiting and then dying

arisings: waste products from a process such as excavation

armouring: hard protection for a built structure which is either periodically or permanently underwater

ash dieback: a fungal disease of the European Ash, characterised by blackened leaves, dark lesions, black and shrivelled tips of shoots and the progressive death of the branches of mature trees due to the fungus *Chalara fraxinea*

backditch: ditch dug behind a parapet such as a sea wall, also known as borrowdyke

berm: the relatively level area of a sea wall between the toe of the landward face and landward boundary (see folding)

biodiversity: the variety of life in the world or in a particular ecosystem, habitat or area

Biodiversity Action Plan (BAP): an internationally, nationally or locally recognised programme of actions addressing threatened species and habitats which are designed to protect and restore biological systems or populations

Birds of Conservation Concern (BoCC): those species of birds in the United Kingdom, Channel Islands and the Isle of Man which have been assessed against a set of objective criteria to place each on one of three lists, green, amber and red, indicating an increasing level of conservation concern

borrowdyke: see backditch

brash: in a stand of trees, especially conifers, the lower branches that are dead and either fallen naturally or pruned by brashing; or the tops, small-diameter branchwood, needles and other woody material remaining on the forest floor in a felled area

browsing: to eat, nibble at, or feed on leaves, tender shoots or other soft vegetation

brush cutter: a power tool carried on a shoulder harness consisting of a rotary head with a small circular saw at the end of a boom, for clearing various kinds of rank or low woody growth

bryophyte: any member of the phylum Bryophyta which comprises small, green, rootless, non-vascular plants, including mosses and liverworts, and hornworts

Bryozoa: a phylum of aquatic invertebrates, commonly known as moss animals, typically about 0.5 millimetres in size

bush-cricket: a species in the family Tettigoniidae of the order Orthoptera

'Canewdon' blocks: a type of revetment comprising 1.14 m x 1.90 m concrete blocks laid in grid formation at toe of a sea wall

centrifugal: proceeding or acting in a direction away from a centre or axis

chrysalis: the pupa state of certain insects, especially of Lepidoptera, from which the adult insect emerges

climax: the final stage in a succession of natural plant communities in one area under a particular set of conditions

Coleoptera: an order of insects, the beetles, characterised by the possession of a pair of hard, horny wing covers overlying a pair of delicate membranous flying wings

coppice: an area of woodland in which the shrubs or trees are periodically cut back to ground level to stimulate growth and provide firewood or timber

coppicing: a method of exploiting woodland in which all the trees except for an open network of mature trees are felled leaving space for hazels and other underwoods to grow and be cut or coppiced at intervals of 10 to 15 years to provide stakes and other such products

Diptera: an order of insects with one pair of flight wings, the second pair being modified into balancing organs

drift line: an accumulation of water-carried debris along a contour that provides direct evidence of prior inundation, such as high tide, and often indicates the directional flow of flood waters

EC Habitats Directive: a European Union Directive adopted in 1992 aiming to protect about 220 habitats and around 1,000 species listed in the Directive's Annexes which led to the setting up of a network of Special Areas of Conservation (SAC)

ecotone: a border between two habitats, for example the borrowdyke and the folding

endemic: a species of plant or animal confined to a particular country, region or island or having originated there

Essex blocks: a type of revetment comprising 30 x 30 cm concrete blocks laid in grid formation at toe of sea wall

family: a group in the classification of living organisms consisting of related genera: in botany the family usually ends in –aceae and in zoology, –idea

fauna: the animal population of a region

flailing: using a flail mower

flail mower: a type of powered agricultural equipment used to cut heavier grass/scrub which a normal mower could not cope with, many being power take-off (PTO) driven implements, which can attach to the three-point hitches found on the rear of most tractors

flora: the plant population of a region

folding: the relatively level area of a sea wall between the toe of the landward face and landward boundary (see berm)

forage (foraging): the act of looking or searching for food

forage (food): plants or grasses eaten by grazing animals

forage harvester: a farm implement that harvests forage plants usually to make silage

Geographical Information System (GIS): a computer system for capturing, storing, checking, interrogating, interpreting and displaying data related to positions on Earth's surface, which can show many different kinds of data on one map enabling people to more easily see, analyse, and understand patterns and relationships

gleaning: a feeding strategy by bats (and birds) in which they catch invertebrate prey by plucking them from foliage or the ground, from crevices such as rock faces and under the eaves of houses

glyphosate: a broad-spectrum systemic herbicide used to kill weeds, especially annual and perennial broadleaf flowers and grasses, which requires the agreement of the Environment Agency before use in or near water

green hay: herbage cut at or just before hay stage which is then collected without prior wilting or turning and spread immediately on the receptor site

green haying: the process of using green hay

green lane: an unpaved road/public byway in country areas, many of which were ancient highways abandoned after the building of new roads in the 18th and 19th centuries

halophilous: preferring or habitually growing in soil impregnated with salt, or various salts, as maritime plants

halophyte: a plant that can grow in soil or water with a high concentration of salt, for example saltmarsh and some borrowdykes

Hemiptera: an order of insects most often known as the true bugs including species of aphids, planthoppers, leafhoppers, shield bugs

herbaceous: having a soft green texture like a leaf

herbage: herbaceous vegetation such as grass especially when used for grazing

herbicide: a chemical used to kill weeds

herpetofauna: the reptile and amphibian population of a region

Hymenoptera: an extensive order of insects which includes the bees, wasps, sawflies and ants, most members of which have two pairs of membranous naked wings, and all members show a marked division of the body into head, thorax and abdomen

Insulated Render and Cladding Association (INCA): the recognised trade association for the external wall insulation industry, representing the major system designers, a nationwide network of specialist installers and the key component suppliers

invertebrate: an animal without a backbone including the insects

ivermectin: a drug mixture that is used in veterinary medicine as an anthelmintic, acaricide, and insecticide

Joint Nature Conservation Committee (JNCC): the public body that advises the United Kingdom Government and devolved administrations on UK-wide and international nature conservation

kissing gate: a small gate hung in a U- or V-shaped enclosure, usually designed to let one person through at a time, but not livestock

lawn: closely grazed area within a grassland

Lepidoptera: an order of insects that comprises butterflies and moths

litter: dead leaves, twigs and other vegetable detritus lying on the surface of the soil, its topmost horizon

livestock unit (LSU): a reference unit which facilitates the aggregation of livestock from various species and age as per convention, via the use of specific coefficients established initially on the basis of the nutritional or feed requirement of each type of animal, for example a dairy cow = 1 LSU and a lowland ewe = 0.1 LSU

Local Nature Reserve (LNR): a place with wildlife or geological features that is of special interest locally and is for the benefit of both people and wildlife, offering people special opportunities to study or learn about nature or simply to enjoy it

Local Record Centre (LRC): a service which collects, collates, manages and disseminates information on species, habitats, protected sites and geodiversity in a county, counties or other such region

Local Wildlife Site (LWS): defined areas outside statutorily protected sites such as Sites of Special Scientific Interest (SSSIs) and Special Areas of Conservation (SACs) identified and selected locally as the most significant areas in terms of their nature conservation value, the selection of which takes into account the most important, distinctive and threatened species and habitats within an area, usually a county

mesotrophic (soils): soils with a moderate inherent fertility, an indication of which is its base status, which is expressed as a ratio relating the major nutrient cations (calcium, magnesium, potassium and sodium) found there to the soil's clay percentage

mesotrophic (waterbodies): waterbodies with an intermediate level of productivity typically with clear water and beds of submerged aquatic plants and medium levels of nutrients

metamorphosis: the process of transformation from an immature form to an adult in animals

microclimate: the climate of a very small or restricted area, especially when this differs from the climate of the surrounding area, referring to areas as small as a few square metres or as large as many square kilometres

Mollusca: a phylum of animals comprising those soft-bodied animals such as slugs, snails and mussels, some are naked and unprotected but the great majority are provided with an exoskeleton or shell

MS1-4: four mowing options (MS1, MS2, MS3 and MS4) devised by the Environment Agency which can be applied to the management of vegetation on sea walls

myxomatosis: a virus disease of Rabbits introduced into England in 1953 and which by 1956 had almost completely eliminated the rabbit population after which there was a slow recovery interspersed with fresh outbreaks of the disease which has become endemic

National Biodiversity Network (NBN): a collaborative venture committed to making biodiversity information for the United Kingdom available through various media, including on the internet via the NBN Gateway

NBN Gateway: the data search website of the National Biodiversity Network

National Nature Reserve (NNR): a nature reserve in Britain designated under Part III of the National Parks and Access to the Countryside Act 1949 that is deemed to be of national importance may be designated as a statutory 'National Nature Reserve' by the relevant national nature conservation body (Natural England, Scottish Natural Heritage or Natural Resources Wales) using section 35(1) of the Wildlife and Countryside Act 1981

National Trust: the National Trust for Places of Historic Interest or Natural Beauty, is a conservation organisation dedicated to preserving the cultural and environmental treasures of England, Wales and Northern Ireland (the Trust does not operate in Scotland)

National Vegetation Classification or NVC is a British system of classifying natural habitat types in the United kingdom according to the vegetation they contain

Natural England: the non-departmental public body of the government responsible for ensuring that England's natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved, coupled with a responsibility to help people enjoy, understand and access the natural environment

niche: the place or position, in both a physical and functional sense, of a population in an ecosystem as determined by the full complex of interacting and limiting environmental factors

nitrophilous: flourishing in or preferring locations with abundant nitrogen

nymph: a young insect in one of the more primitive groups such as dragonflies, damselflies and mayflies resembling small wingless adults

Open Stone Asphalt: a continuous layer of asphalt revetment at the toe of a sea wall with no gaps

Orb-web spider: a spider that builds orb-shaped (spiral) webs. Many species are large and brightly coloured (for example the Wasp Spider), and wait either in the centre of the web or in a retreat at the edge

order: one of the groups in the classification of living organisms consisting of closely related families

Orthoptera: an order of insects with incomplete metamorphosis, including the grasshoppers, crickets, bush-crickets and groundhoppers many of which produce sound (known as a stridulation) by rubbing their wings against each other or their legs

overtopping: water carried over the top of a coastal defence due to wave run-up or surge action exceeding the crest height

ovipositing: egg-laying using a specialised organ, the ovipositor, in insects

perennial: a plant that continues its growth from year to year

pH: the pH scale from 0-14 is used to denote the range from acid (1) through neutral (7) to alkaline (14)

phylum: a principal zoological taxonomic category that ranks above class and below kingdom, equivalent to the division in botany

planings: the broken up asphalt surface of a road produced during remaking a road

poaching: damage caused to sodden pasture by the hooves of cattle, horses, sheep and other livestock typically in clay soils

pollarding: the process in which a tree, especially Crack *Salix fragilis* and White Willows *Salix alba*, has been cut at about 2-2.5 m from the ground in order to produce a crop of thin branches suitable for basketry, fencing and fuel which typically encourages a large root system relative to height in pollarded trees

power take-off (PTO): a device which transfers mechanical power from an engine to another piece of equipment, especially on a tractor or similar vehicle

provenance: the place of origin or earliest known history of something, for example a species

pyrethrin (pyrethroid): any of a group of potent insecticidal compounds present in pyrethrum flowers

ragstone: a hard, coarse sedimentary rock that can be broken into thick slabs

Ramsar site: a wetland site of international importance, especially as waterfowl habitat, the name deriving from an international conference held in 1971 in Ramsar in Iran

rank: (as in rank grassland) luxuriant and vigorous in growth; grown to immoderate height, as in rank grass or rank weeds

raptor: a bird of prey, for example Sparrowhawk, Hobby and Hen Harrier

Red Data Book (RDB): a list of species whose continued existence is threatened, each Red Data Book usually dealing with a specific group of animals or plants such as reptiles, insects, mosses, and within which Red Data Book species are classified into different categories of perceived risk from a conservation perspective

revetment: a retaining wall or facing as of masonry or other material, supporting or protecting a wall or other such structure, for example, an embankment

riparian: of or inhabiting the bank of a water body

rotary mower: a mower with a single blade attached in the middle that rotates as the mower is moved

rotavation: mechanically tilling soil using a rotavator

rotavator: a power-driven agricultural machine having an axle on which are mounted L-shaped blades which rotate faster than the supporting wheels, so that the blades chop and stir the surface of the soil

Royal Society for the Protection of Birds (RSPB): Britain's largest nature conservation charity, inspiring everyone to give nature a home, which together with its partners protects threatened birds and wildlife playing a leading role in a worldwide partnership of nature conservation organisations

ruderal: a plant of waste places and other disturbed habitats, usually associated with human disturbance and not necessarily a nuisance, as distinguished from weeds

saltmarsh: an area of vegetated sand and mud covered by the sea at high tide and exposed at low tide with a characteristic fauna and flora

sawfly: any one of numerous species of Hymenoptera belonging to the family Tenthredinidae, the female of which usually has an ovipositor containing a pair of saw-like organs with which she makes incisions in the leaves or stems of plants in which to lay the eggs, hatching into larvae resembling those of Lepidoptera

scrub: an area dominated by low shrubs and bushes with no tree more than 8 m tall, the bushes often colonising open ground and typically followed in succession by woodland

sea wall: any engineered flood defence earth embankment or retaining wall other than sand dune defences which front the open sea or tidal waters

seedbank: the natural storage of seeds, often dormant, within the soil of most ecosystems

seepage: percolation of water through the soil from ditches, watercourses, unlined canals or water storage facilities or from the sea or estuary through the sea wall

sere (adjective: seral): a stage in natural succession of plant communities leading to a climax state (for example woodland)

sett: the burrow or burrows of a family badger group

silage: grass which is mown, wilted, chopped and put into a clamp where anaerobic fermentation takes place in order to maintain most of the nutrient, the main use of silage being in cattle feed

Site of Special Scientific Interest (SSSI): a conservation designation denoting a protected area in the United Kingdom; SSSIs are the basic building block of site-based nature conservation legislation with most other legal nature/geological conservation designations in the United Kingdom being based upon them, including National Nature Reserves, Ramsar sites, Special Protection Areas, and Special Areas of Conservation

Special Area of Conservation (SAC): an area protected under the EC Habitats Directive 1992 for the purpose of conserving Europe's rarest species/habitat types and may be designated both on land and at sea

Special Protection Area (SPA): an area identified as important habitat for rare and vulnerable birds under the EC Council Directive on the Conservation of Wild Birds 79/409/EEC as amended and codified in Directive 2009/147/EC

stabilimentum: a conspicuous silk structure or web decoration on the webs of some orb-weaving spiders, whose function is still not well understood

strandline: a mark left by the high tide, typically a line of seaweed and other debris washed onto the shore by the tide

strimmer: a mechanical (or electric) tool that is held in the hand and is used for cutting grass in places that are difficult to reach with a larger machine

sward: an area of land covered with grass, an expanse of grass

succession: the observed process of change in the species' structure of an ecological community over time

systemic herbicide: herbicides which are translocated through the plant, either from foliar application down to the roots, or from soil application up to the leaves, which are capable of controlling perennial plants and although may be slower-acting, are ultimately more effective than contact herbicides

toe: the base or foot of an embankment

topper: a machine that cuts the tops of weeds

topping: using a topper to cut the tops of weeds

transect: a line on the ground along which sample plots or points are established for collecting ecological information , for example vegetation data and sometimes other data such as soil type and hydrology

translocate (translocated): to transport a dissolved substance within an organism, especially in the phloem of a plant, or actively across a cell membrane, or move an individual, species or community from one place to another

tussock: a dense hummock, tuft or bunch of grass or sedge usually well separated from neighbouring tussocks

weed: a plant considered undesirable in a particular situation

Wildlife Trusts: local organisations of differing size, history and origins, which share a common interest in wildlife and biodiversity, rooted in a practical tradition of land management and conservation, most being significant landowners, with many nature reserves. Collectively they are the third largest voluntary sector landowners in the United Kingdom and also often have extensive educational activities, and programmes of public events and education. Each of the 47 Wildlife Trusts is an independent, autonomous charity with its own trustees, whose primary concern is the conservation of nature within its own geographical area. Wildlife Trusts are split into regions; a single Trust covers Scotland; Wales has six Trusts which work increasingly closely together; there are Trusts for Ulster, the Isle of Man, Alderney and the Isles of Scilly and 36 Trusts across England largely based on the old county boundaries or small groupings of such counties

Species index

Tim Gardiner, Biodiversity Officer at the Environment Agency, Rob Pilcher, Ecology Team Leader for North West England at AECOM and Max Wade, Technical Director (Ecology) at AECOM, have a long standing interest in the ecology and management of sea wall habitats. Their handbook on sea wall biodiversity brings together a wealth of knowledge about this Cinderella habitat based on the authors' experience of practical management and the flora and fauna of sea walls.

The handbook highlights the breadth of plant and animal species living and relying on sea walls and provides practical guidance for managers of sea defences to ensure that their biodiversity value is conserved and enhanced.

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