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Restoring biodiversity to soft cliffs

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Restoring Biodiversity to Soft Cliffs

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Executive Summary

A no net loss policy for maritime cliff and slope habitats is unlikely to be successful, under the current legislation and policy framework. This is because the future demand for new coast protection schemes is predicted to exceed the availability of potential "free-up" sites (where defences could be removed or abandoned leading to renewed cliff recession and habitat restoration).

A survey of coast protection authorities has revealed that the future coast protection demand and "free-up" for the South and East coasts of England can be expected to be:

- a demand for some 22km of new coast protection works, mainly on the North Norfolk and North Yorkshire coast;
- the potential for freeing-up of 14km of currently protected cliffline, at some 16-18 sites.

This suggest that there would be a *net loss* of around 8km of maritime cliff and slope habitat over the next 50 years, compared with the current extent of the resource.

Although it is likely that there are many sites where it might be uneconomic to continue defending in the future, there are significant constraints to their delivery as actual restoration sites. These constraints include legal issues, health and safety issues, local political pressures and attitudes, potential environmental impacts and the limited availability of resources.

The possible solutions to the problems of restoring biodiversity include:

- *increasing the likelihood of the delivery of potential "free-up" sites*; this would probably require a partnership approach between coast protection authorities, private defence owners, planning authorities, English Nature and the Government. To be successful this will probably need trade-offs between the different interest groups, resources for removing defences and managing sites and financial incentives to landowners and cliff top property owners to encourage them to accept a higher level of risk (or shorter occupancy period) than might normally be expected.

- *reducing the demand for new coast protection structures;* this could involve greater co-ordination between coast protection and planning authorities, to ensure that further development is not permitted in unprotected areas at risk from coastal erosion, the introduction of some form of reimbursement of property owners in high risk areas. The latter might prove to be a more efficient use of national resources than providing expensive and environmentally damaging coast protection schemes that raise the expectation of provision of defence in the future.

Contents

1 Introduction

Background

The Government has set out its commitments to the Convention on Biological Diversity (the Rio Convention) in the document "Biodiversity: the UK Action Plan" (Table 1). The overall goal is "*to conserve and enhance the biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms*". In pursuit of this objective, the Government has published a series of Habitat Action Plans (HAPs) which contain habitat creation and rehabilitation targets.

Local authorities have permissive powers to undertake works to prevent erosion or encroachment by the sea, under the Coast Protection Act 1949 (the term "coast protection authority" is used to describe the responsible authority). In addition to other statutory obligations relating to the environment, coast protection authorities have specific High Level Targets in relation to biodiversity (Table 2). When carrying out works they must aim to ensure that there is no net loss to habitats covered by biodiversity action plans and seek opportunities for environmental enhancement (Ministry of Agriculture, Fisheries and Food 1999).

Table 1 Biodiversity

Article 2 of the 1992 Biodiversity Convention defines biological diversity as:
"*The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*".
Three levels of biodiversity are important:

- Diversity between and within ecosystems and habitats;
- Diversity of species;
- Genetic variation within individual species.

Changing a habitat will often affect the diversity of species contained within it, and conversely a change in the number and assemblage of species may affect the nature of the habitat.
The overall goal of the UK Biodiversity Action Plan (prepared in response to Article 6 of the Biodiversity Convention) is:

- To conserve and enhance biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms.

The objectives for conserving biodiversity are:

1. To conserve and where practicable to enhance:

- The overall populations and natural ranges of native species and the quality and range of wildlife habitats and ecosystems;
- Internationally important and threatened species, habitats and ecosystems;
- Species, habitats and natural and managed ecosystems that are characteristic of local areas;
- The biodiversity of natural and semi-natural habitats where this has been diminished over recent past decades.

2. To increase public awareness of, and involvement in, conserving biodiversity;
3. To contribute to the conservation of biodiversity on a European and global scale.

Table 2 High Level Targets for Biodiversity (MAFF, 1999)

Operating authorities have a High Level Target for biodiversity:

A. in addition to statutory obligations when carrying out coastal defence works:
- to avoid damage to environmental interest;
- to ensure no net loss to habitats covered by Biodiversity Action Plans as a result of their coastal defence operations;
- seek opportunities for environmental enhancement.

B. report to the Environment Agency on all losses and gains of habitats by Biodiversity Action Plans as a result of their coastal defence operations.

Habitat Action Plan targets are non-statutory i.e. do not have a legal status. However, they are Government policy. They are aspirational targets that all branches of Government need to be aware of and contribute to where that is possible. Through the MAFF High Level targets there is a requirement for all operating authorities to report to the Environment Agency on BAP losses and gains as a result of their flood and coastal defence operations on an annual basis. Where such losses associated with individual schemes are anything more than trivial English Nature will advise the operating authority that the scheme is environmentally damaging. Unless suitable mitigation is included it will not receive MAFF grant aid (unless approved through public inquiry).

The Maritime Cliff and Slope Habitat Action Plan contains five targets, three of which are directly related to coast protection (UK Biodiversity Group 1999; see Appendix A):

- to seek to maintain the existing maritime cliff resource of cliff top and slope habitat;
- to maintain wherever possible, free functioning of coastal physical processes acting on maritime cliff and slope habitats;
- to seek to retain and where possible increase the amount of maritime cliff and slope habitats unaffected by coastal defence and other engineering works.

Included within the HAP are a number of proposed actions agreed by various agencies and local government. These proposed actions include:

1. encourage a presumption against the stabilisation of any cliff face except where human life, or important natural or man-made assets, are at risk;

2. where stabilisation of a cliff face is necessary, ensure adequate mitigation and/or compensation to maintain the overall quantity and quality of maritime cliff and slopes habitat;

3. encourage the increased use of soft (e.g. foreshore recharge) rather than hard engineering techniques where some degree of cliff stabilisation is necessary;

4. consider the non-replacement of defences which have come to the end of their useful life.

The conservation value of Chalk cliffs are also addressed within the Littoral and sublittoral chalk HAP (see Appendix A) which has similar targets:

- seek to retain and where possible increase the existing extent of littoral and sub-littoral chalk habitats unaffected by coastal defence and other engineering works;

- allow natural coastal processes to dictate, where possible, the geomorphology of the littoral and sublittoral environment;

- adopt sustainable management practices for all uses on littoral and sublittoral chalk habitats.

In essence, the maritime cliff and slope and the littoral and sub-littoral chalk HAPs have introduced a "no net loss" policy for maritime cliff and slope habitats, with the aspiration of achieving, over time, a "net gain". The significance of this can be judged from the results of the Coast Protection Survey of England (Ministry of Agriculture, Fisheries and Food 1994). This survey concluded that over 90km of new coast protection works were likely to be needed over the next 10 years (i.e. the period 1994-2004), some of which will inevitably involve protecting currently undefended maritime cliff and slope habitats. If these defences were to be provided there would need to be an abandonment of a matching or greater length of defences elsewhere.

Restoring Biodiversity: Research Objectives

The availability of potential restoration sites is critical to the successful delivery of the biodiversity target. English Nature has, therefore, commissioned research to explore the potential for "freeing-up" currently protected clifflines. The objectives of this research are to:

- establish the potential for restoring biodiversity to soft cliff systems which have been subject to coastal defence or other engineering works;

- obtain an estimate of the scale on which restoration is likely to be possible;

- identify the main constraints and obstacles to undertaking such restoration;

- identify possible solutions to the problems associated with restoring biodiversity.

Research Methods

The research has involved the following tasks:

1 Contacting coastal engineers from coast protection authorities along the southern and eastern coasts of England (the SCOPAC coastline plus East Sussex and Kent authorities, Suffolk, Norfolk, East Riding and North Yorkshire) to identify, in general terms the following:

- estimated length of protected and unprotected cliffline (to the nearest 5km);

- lengths of cliffline where new coast protection schemes will be likely (i.e. a "best-guess") over the next 50 years (the number of sites and overall length of new defences);

- lengths of cliffline where the current coast protection schemes are unlikely to be maintained/improved beyond their current design life/residual life, by either the coast protection authority or private owner (Figure 1).

2. Undertake discussions with coast protection authorities on the issues likely to be involved in "freeing up" currently defended cliffs.

3. Undertake case studies of currently protected cliff sites, to identify issues that constrain the potential for restoring soft rock cliff habitats on the coast of England (Table 3; Figure 2). Each study has involved:

- Geomorphological assessment of the current cliff conditions and potential cliff behaviour after renewal of marine erosion.
- Establishing the age, condition and ownership of the defences, from the relevant shoreline management plans (SMPs) and Coast Protection Survey.
- Considering the practicalities and costs of removal of the defences.
- The likely impacts associated with a renewal of erosion, including risk to coastal assets and effects on adjacent sections of the coast.
- The benefits to biodiversity.
- The potential for using erosion reduction measures.
- Local political or other issues that would need to be addressed.

The results of this research have been presented as a general assessment of the issues associated with restoring biodiversity to soft cliffs (this Volume) and an separate report presenting details of the case study sites (Volume 2).

Structure of this Report

The report fulfils the objectives set out in the original brief. Section 2 provides background information on the nature and distribution of coastal cliffs, and coast protection. It draws on the Soft Cliffs research undertaken for the Ministry of Agriculture, Fisheries and Food (MAFF) by E M Lee (Rendel Geotechnics, in press). In Section 3 sets out the potential for restoring biodiversity, by considering the anticipated availability of "free-up" sites along parts of the south and east coasts of England. The potential constraints to "freeing-up" sites are considered in Section 4. Section 5 considers the feasibility of achieving the "no net loss" policy targets. The final Section offers possible solutions to the problems that are likely to be encountered in restoring biodiversity.

Table 3 The Case Study Sites

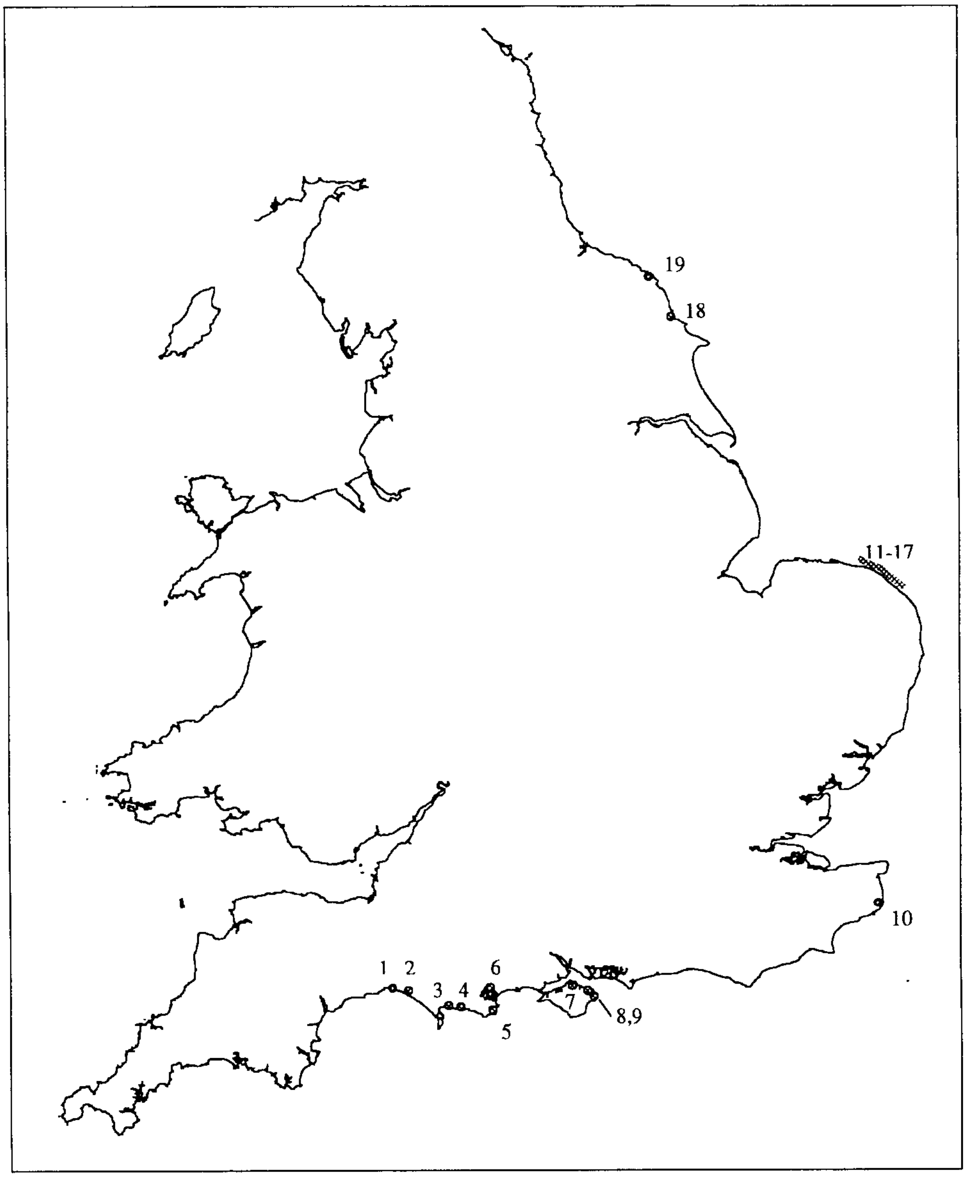
The following sites have been considered to identify the issues that might constrain the potential for restoring biodiversity (see Figure 2):

1. Charmouth, Dorset;
2. Seatown, Dorset;
3. Bowleaze Cove, Dorset;
4. Ringstead Bay, Dorset;
5. Durlston Cliff, Dorset;
6. Ham Common, Dorset;
7. Norris Castle estate, Isle of Wight;
8. Priory Bay, Isle of Wight;
9. Whitecliff Bay, Isle of Wight;
10. Kingsdown Rifle Range, Kent.

Note: inclusion on this list does not necessarily imply that the site has potential for "freeing-up" of currently protected cliffs or habitat restoration.

"Free-up" sites are defined here as lengths of cliffline where the current coast protection schemes are unlikely to be maintained/improved beyond their current design life/residual life, by either the coast protection authority or private owner.

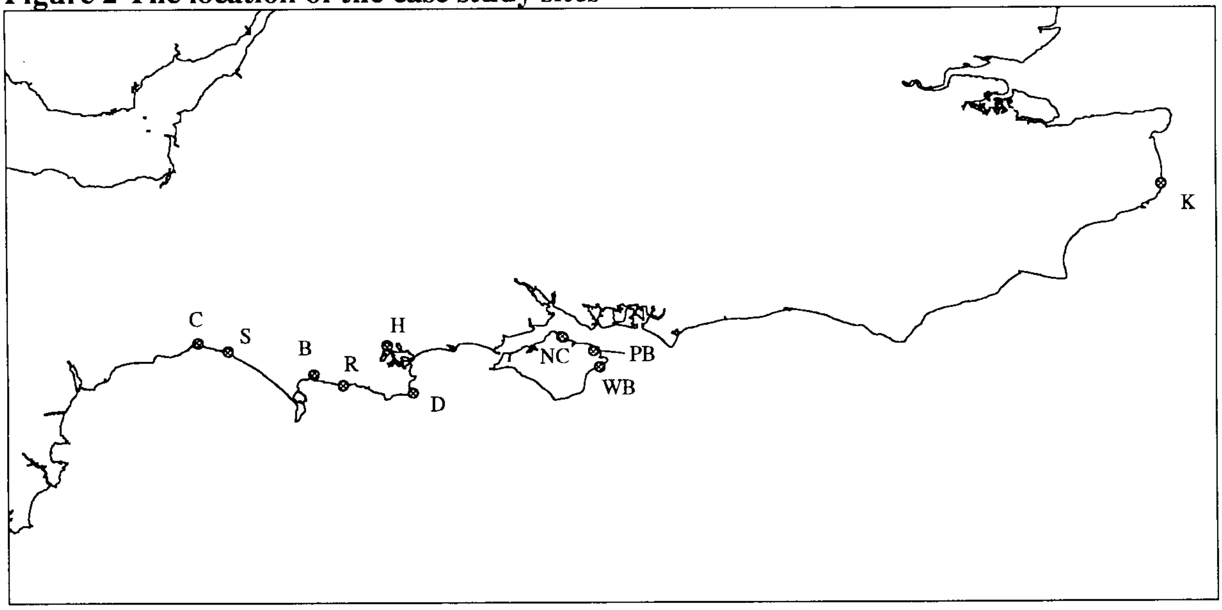
Figure 1 Location of potential "free-up" sites referred to in the text.



Location of potential "Free-up" sites referred to in the text

1. Charmouth
2. Seatown
3. Bowleaze Cove
4. Ringstead Bay
5. Durlston Cliff
6. Ham Common
7. Norris Castle
8. Priory Bay
9. Whitecliff Bay
10. Kingsdown Rifle Range
11. Happisburgh (S)
12. Walcott-Happisburgh
13. Mundesley-Bacton
14. Trimingham-Mundesley
15. Sidestrand
16. Cromer-Overstrand
17. Sheringham-West Runton
18. Cayton Bay
19. Port Mulgrave

Figure 2 The location of the case study sites



Location of case study sites		
C - Charmouth		
S - Seatown	D - Durlston Cliff	PB - Priory Bay
B - Bowleaze Cove	H - Ham Common	WB - Whitecliff Bay
R - Ringstead Bay	NC - Norris Castle	K - Kingsdown Rifle Range

2 Background: Coastal Cliffs and Coast Protection

Coastal Cliffs

Soft cliffs are formed through the exposure of rocks that have little resistance such as clays, shales or sandstone, or unconsolidated materials such as sands. Having little resistance they generally have shallower gradients than hard cliffs, which allows for greater colonisation of vegetation. The English coastline exhibits a wide variety of landforms. Coastal cliffs form the dominant erosional features along many parts of the North-east, East Anglian and the South coasts. Their variety reflects the complex interactions between rock character, geological structure and inland relief on the one hand and the applied forces of both marine and non-marine processes on the other.

A number of broad categories of cliff type can be recognised, on the basis of the geology and associated landslide types (Hutchinson, 1984; Jones and Lee 1994);

i. *cliffs developed in weak superficial deposits*; the east coast of England from Flamborough Head to Essex and parts of the Cumbrian coast are largely developed in thick sequences of glacial till interbedded with sands and gravels. These deposits can be rapidly eroded by the sea; for example, the entire 60km length of the undefended Holderness coastline (Humberside) has retreated at average rates of around 1.8m per year.

ii. *cliffs developed in weak superficial deposits overlying jointed rock*; much of the North-east coast, from Durham to Flamborough Head, is developed in glacial till overlying Jurassic sedimentary rocks. Cliff recession generally involves the relatively slow retreat of the rock cliff through falls and cave collapses, and shallow mudslide activity and surface erosion of the tills above. However, in certain places, these cliffs can be prone to major dramatic landslides; the Holbeck Hall failure of June 1993 in Scarborough was the most recent example.

   Much of the coast around the South-west peninsula comprises near vertical hard rock cliffs capped by thin periglacial head deposits. This combination which gives rise to the characteristic "slope-over-wall" cliffs of this area, with a steep, convex upper cliff section developed under periglacial conditions and a lower vertical sea cliff fashioned by contemporary wave action.

iii. *cliffs developed in stiff clay*; stiff clays are particularly prone to landsliding with classic examples occurring along the shore of the Thames estuary in parts of Essex and Kent, where cliffs up to 40m high developed in London Clay have repeatedly failed in response to marine erosion. This results in average retreat rates of up to 2m per year.

iv. *cliffs developed in weak sandy strata*; Along the south coast of England, cliffs developed in Tertiary sands and gravels occur at Newhaven (overlying Chalk), west of Lee-on-the-Solent and at Bournemouth. These materials are prone to rapid erosion, mainly through frequent small-scale slumps, seepage erosion, cliff falls and surface erosion by water.

v. *cliffs developed in sequences of stiff clays and weak sandy strata*; this geological setting can give rise to some of the most dramatic forms of cliff recession. There are major landslide complexes on the north coast of the Isle of Wight, especially at Bouldner, and at Fairlight Glen on the Sussex Coast. At Barton-on-Sea in Christchurch Bay landslides extend for 5km on 30m high cliffs developed in Barton Clay and Barton Sand overlain by Plateau Gravel.

The classic landslide areas of the West Dorset coast - Black Ven, Fairy Dell and Golden Cap - are developed in Lias clays overlain by relatively weak Upper Greensand Foxmound and head deposits.

This setting can also give rise to cliffs prone to seepage erosion (Hutchinson 1982), as at Chale, Isle of Wight and the eastern parts of Christchurch Bay.

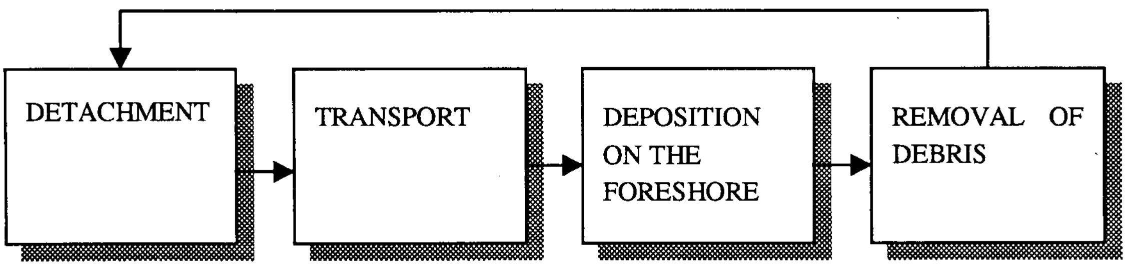
vi. *cliffs developed in stiff clay with a hard cap-rock*; the largest coastal landslides occur in situations where a thick clay stratum is overlain by a rigid cap-rock of sandstone or limestone, or sandwiched between two such layers. Amongst the most dramatic examples are Folkestone Warren, Kent, where the high Chalk cliffs have failed on the underlying Gault Clay, the Isle of Portland and the Isle of Wight Undercliff. The Landslip Nature Reserve, on the East Devon coast, is another such area and is the site of the famous 1839 Bindon landslide.

vii. *cliffs developed in bedded, jointed weak rock*; the steep, jointed Chalk cliffs of Kent, Sussex, Isle of Wight and Dorset are prone to frequent rockfalls weathering and relatively high rates of erosion. Less commonly, large falls occur on a number of coasts including the Triassic sandstone cliffs of Sidmouth, Devon. In some settings, sequences of sandstone, mudrocks and limestones can give rise to composite cliff profiles, because of the differences in erodibility between the rock types. Examples include the Wadhurst sandstones and overlying clays on the Sussex coast, east of Fairlight, and the variable sequences of Jurassic shales and sandstones on the North Yorkshire coast between Robin Hoods Bay and Saltburn.

Cliff Recession

Cliff erosion is a four stage process involving *detachment* of particles or blocks of material, the *transport* of this material through the cliff system, its *deposition* on the foreshore and its *redistribution* or *removal* by marine action (Figure 3). Behind this simple model is considerable complexity. A variety of mechanisms result in the detachment of material, including: mass movement, seepage erosion, surface erosion (i.e. rainsplash and wind erosion) and wave attack (including abrasion and hydraulic action, and fluid shear by uprushing waves during large storms).

Figure 3 The cliff recession process (after Rendel Geotechnics, in press)



In England, cliff recession and coastal landsliding present significant problems to many communities. Problems include the occasional injuries and deaths due to cliff falls and the cumulative loss of land, cliff top properties, services and infrastructure. Although individual failures generally tend to cause only small amounts of cliff retreat, the cumulative effects can be dramatic. The most intense marine erosion and cliff recession rates occur on the unprotected cliffs formed of soft sedimentary rocks and glacial deposits along the south and east coasts of England, respectively (May 1966; Table 4). For example, the Holderness coast has retreated by around 2km over the last 1000 years, including at least 26 villages listed in the Domesday survey of 1086; 75Mm^3 of land has been eroded in the last 100 years (Valentin, 1954; Pethick 1996).

On parts of the north Norfolk coast there has been over 175m of recession since 1885 (Clayton 1980, 1989). Rapid recession has also caused severe problems on the Suffolk coast, most famously at Dunwich.

Eroding cliffs, however, also be of considerable environmental significance for their biological, earth science and landscape value. The main benefits of cliff recession are (Lee 1995):

1. *creating and maintaining the landforms which support important habitats.* Numerous threatened species are found in cliff settings (e.g. Mitchley and Malloch 1991), such as hoary stock (*Matthiola incana*) found only on eroding chalk cliffs. Maritime grasslands occur on many cliffs and slopes, often comprising a maritime form of red fescue (*Festuca rubra*), thrift (*Armenia maritima*), sea plantain (*Plantago maritima*) and sea carrot (*Daucus carota* ssp *gummifer*). Soft cliffs provide important breeding sites for sand martins (*Riparia riparia*) and are particularly important for invertebrates such as the ground beetle *Cincindela germanica*, the weevil *Baris analis* and the Glanville fritillary buttlerfly (*Melitaea cinxia*). Seepages, springs and pools provide habitats for many species of solitary bees and wasp, the craneflies *Gonomyia bradleyi* and *Helius hispanius*, and the water beetle *Sphaerius acaroides* (Wicks and Cloughley 1998);

2. *stimulating change within cliffs through promoting instability* and ensuring that habitats evolve through natural successions, rather than remaining static. Many active landslides support a range of vegetation from pioneer communities on freshly exposed faces through grassland communities to scrub and woodland. Wet flush vegetation occurs in areas of seepage;

3. *providing prime breeding grounds for seabirds*, with cliffs from Flamborough Head north to Dunnet Head, Cape Wrath to Land's End and the Northern and Western Isles containing the bulk of Europe's seabird population. Many clifflines have been designated as Special Protection Areas (SPA) because of their importance for bird communities. Indeed, over 20% of the world's population of razorbills nest around the Great Britain coast. Some 70% of the international population of gannet *Morus bassanus* and significant proportions of the shag *Phalacrocorax aristotelis* and guillemot *Uria aalge* nest on cliff ledges.

4. *providing important geological exposures*, including international reference localities for vast periods of geological time, such as the Bartonian Stratotype between Highcliffe and Milford Cliff in Hampshire. Cliffs also provide opportunities for geological and geomorphological teaching and research.

Table 4 A selection of reported recession rates around the coast of England

Site	Average Erosion Rate (m/year)	Period	Source
Blue Anchor Bay, Somerset	0.2		Williams et al 1991
Downderry, Cornwall	0.11	1845-1966	Sims & Ternan 1988
St Marys Bay, Torbay	1.03	1946-1975	Derbyshire et al 1975
Bindon, E.Devon	0.1	1904-1958	Pitts 1983
Charton Bay, E.Devon	0.25	1905-1958	Pitts 1983
Black Ven	3.14	1958-1988	Chandler 1989; Bray 1996
Stonebarrow, Dorset	0.5	1887-1964	Brunsden & Jones, 1980; Bray 1996
West Bay (W), Dorset	0.37	1887-1962	Jolliffe 1979; Bray 1996
West Bay (E), Dorset	0.03	1902-1962	Bray 1996
Purbeck, Dorset	0.3	1882-1962	May & Heaps 1985
White Nothe, Dorset	0.22	1882-1962	May, 1971
Barton-on-Sea, Hampshire	1.9	1950-1980	Barton & Coles 1984
Highcliffe, Hampshire	0.27	1931-1975	Univ. Strathclyde 1991
Undercliff, Isle of Wight	0.05		Hutchinson 1991
Blackgang, Isle of Wight	5		Clark et al 1995
Chale Cliff, Isle of Wight	0.41	1861-1980	Hutchinson et al 1981
Shanklin, Isle of Wight	0.68	1907-1981	Clark et al 1991
Seven Sisters, Sussex	0.51	1873-1962	May, 1971
Fairlight Glen, Sussex	1.43	1955-1983	Robinson & Williams 1984
Beachy Head, Sussex	0.9		May & Heaps 1985
Warden Point, Kent	1.5	1865-1963	Hutchinson 1973
Studd Hill, Kent	1.5	1872-1898	So 1967
Beltinge, Kent	0.83	1936-1966	Hutchinson 1970
North Foreland, Kent	0.19	1878-1962	May, 1971
Walton-on-Naze, Essex	0.52	1922-1955	Hutchinson 1973
Covehithe, Suffolk	5.1	1925-1950	Steers 1951
Southwold, Suffolk	3.3	1925-1950	Steers 1951
Pakefield, Suffolk	0.9	1926-1950	Steers 1951
Dunwich, Suffolk	1.6	1589-1783	So 1967
Runton, Norfolk	0.8	1880-1950	Cambers 1976
Trimmingham, Norfolk	1.4	1966-1985	Univ. Strathclyde 1991
Cromer-Mundesley, Norfolk	4.2-5.7	1838-1861	Mathews 1934
Marl Buff-Kirby Hill, Norfolk	1.1	1885-1927	Hutchinson 1976
Hornsea-Withernsea, Holderness	1.8	1852-1990	Pethick 1996
Withernsea-Kilnsea, Holderness	1.75	1852-1952	Valentin 1954
Flamborough Head, N Yorks	0.3		Mathews 1934
Robin Hoods Bay, N. Yorks	0.31	1892-1960	Agar 1960
Saltwick Nab, N.Yorks	0.04	1892-1960	Agar 1960
Whitby (W), N.Yorks	0.5		Clark & Guest 1991
Whitby (E), N.Yorks	0.19	1892-1960	Agar 1960
Runswick Bay, N.Yorks	0.27		Rozier & Reeves 1979
Port Mulgrave, N.Yorks	1.12	1892-1960	Agar 1960
Crimdon-Blackhall, Durham	0.2-0.3		Rendel Geotechnics 1995

5. *creating landscapes of great cultural importance and scenic attractiveness.* Cliffs are amongst the nation's greatest landscape assets with many safeguarded by their inclusion in National Parks and AONB's or through their status as heritage coasts. At present around 1525km of coast in England and Wales has heritage coast status, with public enjoyment encouraged by the provision of recreation activities that are consistent with the conservation of the natural scenery and heritage features.

6. *supplying sediment to the coastal zone* and, hence, maintaining other coastal landforms such as beaches, sand dunes, mudflats and saltmarshes. These landforms absorb wave and tidal energy arriving at the coast and can form important components of flood defence or coast

protection solutions, either alone or where they front embankments or seawalls. Thus, continued cliff recession can be important in managing flood or erosion risks elsewhere on the coast.

Cliffs and Habitats

Maritime cliffs and slopes are the third ranked priority habitat in terms of the number of associated priority species (Simonson and Thomas 1999). A total of 36 priority species are associated with this habitat, with a further 59 priority species recorded as using the habitat (see Appendix B). Often these are amongst the most natural habitats in Britain, not relying on active management to maintain the habitat mosaics and species diversity. However, each cliff will be unique because of the overwhelming influence of site conditions on the recession process. The biological value of eroding cliffs can vary with cliff type (see Table 5 and Figure 4), with the characteristic habitats a product of the ground conditions (i.e. geological, soil type and drainage), the input from salt-spray, the microtopography (i.e. exposure), the character of and connectivity with cliff top communities (i.e. the input of species onto the cliff face) and the continued instability.

Salt-spray from breaking waves is often the dominant control on exposed cliffs, overriding the importance of lithology and soils variation (Rodwell 2000). The west and south coasts are more exposed to wave attack and, hence, appear to have a better developed maritime cliff vegetation than along the eastern coast. Spray deposition declines rapidly with the distance from the breaking waves. On the Lizard, for example, Malloch (1972) demonstrated that only 100m inland deposition rates were less than 20% of those at the cliff edge and, after 500m, deposition was very low. Such gradations tend to create pronounced vegetation zones on sea cliffs, from the more maritime crevice communities through grasslands to heath, scrub and inland vegetation.

Different *morphodynamic zones* can be expected to support a unique range of vegetation types, reflecting the way in which the original cliff top habitats are transformed, destroyed and replaced by the various mass movement and soil erosion processes. The corresponding vegetation zones are (Figure 5):

i. ***Zone I - the Cliff Top Communities***; the vegetation is influenced by factors such as land use and management, geology and soils, exposure, maritime influence etc.

ii. ***Zone II - Detached Communities***; the original cliff top vegetation dominates on the detached blocks but the zone may support a number of new habitats. These settings include:

Zone IIa - the landslide scar. This steep slope is usually bare, but may support some colonising species on cliffs where the recession process is intermittent. Occasionally important communities can develop when these slopes persist for significant lengths of time e.g. the Isle of Wight Undercliff. The vertical and near vertical faces can be important nesting sites for birds and solitary bees and wasps. For example, a number of sandstone cliffs support breeding colonies of sand martin. Chalk cliffs provide suitable conditions for a number of specialised maritime plants such as hoary stock and sea stock, and provide breeding grounds for sea birds as well as nesting sites for house martins.

Zone IIb - the detached blocks. The blocks will continue to support the cliff top communities, although deeper root systems may be severed causing die back of some species. As the land is no longer managed there may be a spread of higher species across the blocks.

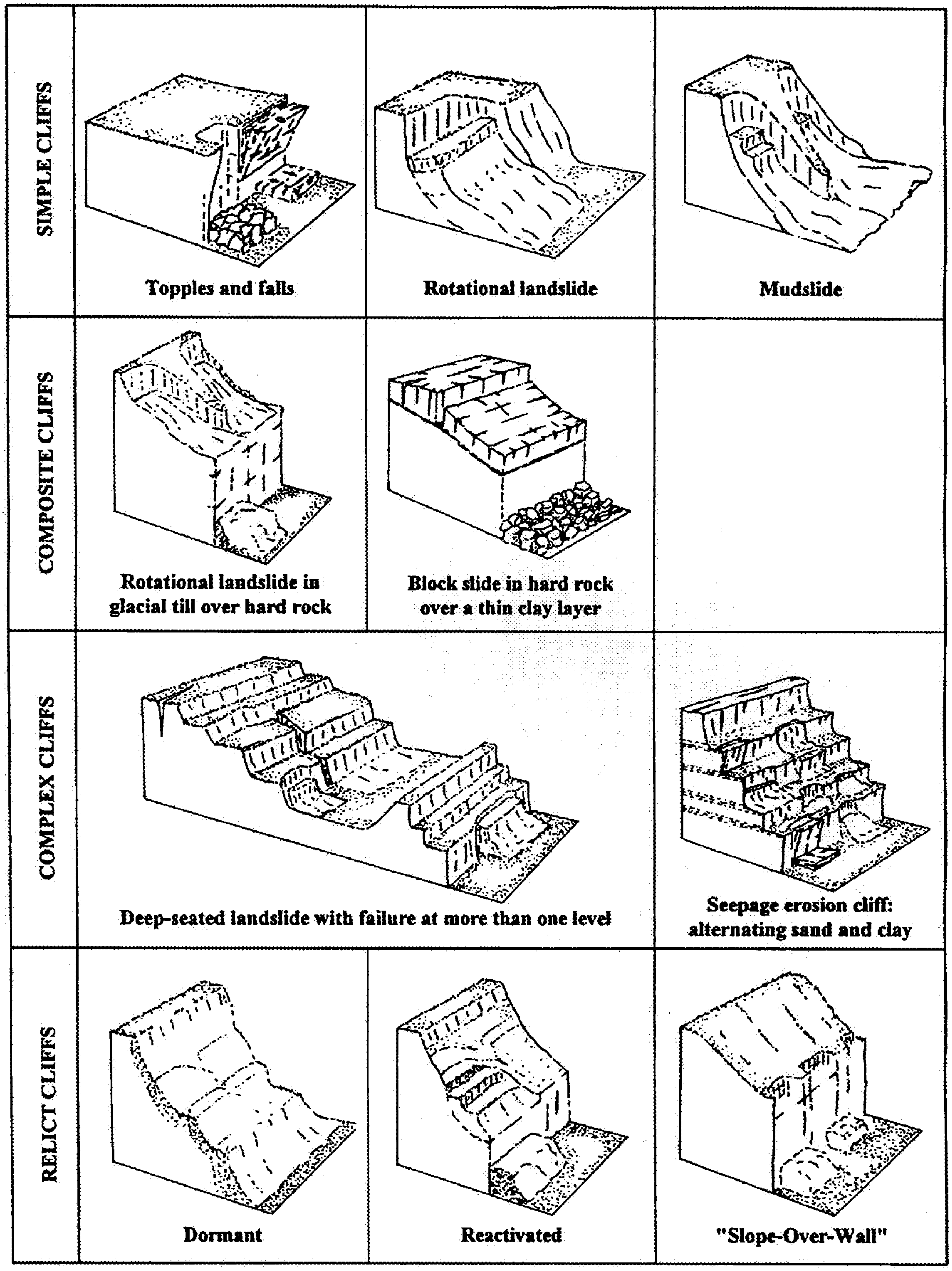


Figure 4 Cliff types (after Rendel Geotechnics, in press).

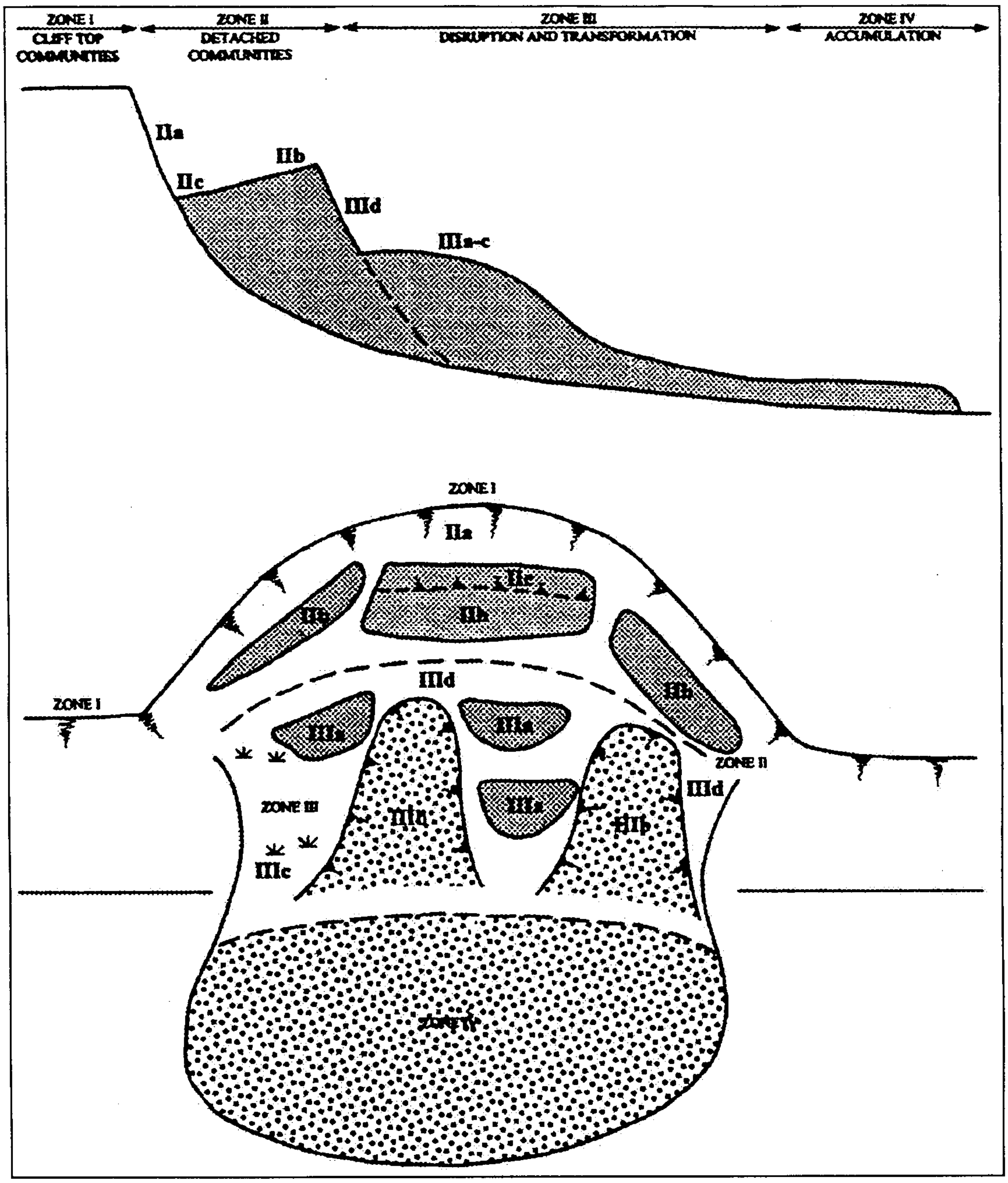


Figure 5 Cliff vegetation zones (after Rendel Geotechnics, in press)

Mature woodland develops on the most stable areas, such as the Landslip Nature Reserve between Axmouth and Lyme Regis. Unlike almost all other British woodlands many soft cliff woodlands are wholly natural, having never been either planted or harvested. There is considerable variation that relates to soil types and geographical position, although ash seems to be the most widespread tree species. Woodlands on soft cliffs also seem to be unusually rich in ferns.

Zone IIc - the base of the scar. This area is often characterised by poor drainage and surface water ponding, especially in rotational landslides where the detached blocks are backtilted. Wet ground species e.g. horsetails may colonise this zone. As the zone is more sheltered than the exposed cliff top it may support a more diverse range of species.

iii. ***Zone III - disruption and transformation***; this zone is characterised by the creation of new habitats by the mass movement processes. A number of settings can occur:

Zone IIIa - elements of the original cliff top vegetation may remain on the intact remnants of the detached blocks, although the communities may become progressively more modified by the spread of higher species.

Zone IIIb - extensive areas of bare ground can be created by landslide processes. These areas may be colonised by pioneer species such as coltsfoot. The open conditions are ideal for a wide range of invertebrate, especially solitary bees and wasps.

Zone IIIc - poorly drained areas often develop around the inner margins of landslide systems, as the natural slope drainage is disrupted. These areas may be colonised by wet ground vegetation, especially species which favour disturbance and fluctuations in the water table. Common reed often dominates such areas along with a variety of orchids. These seepage zones also support their own characteristic inspect species, including many rarities.

Zone IIId - as the landslide scars degrade, so communities can be moved downslope, en-masse. As these scars are older than those above they may support more mature communities.

iv. ***Zone IV*** - *Accumulation and Colonisation*; this zone is often marked by the complete replacement of the original cliff top vegetation, as the debris lobes provide completely different ground conditions than the in-situ materials on the cliff top. The lobes and spreads of debris may be colonised by strandline or beach species but may still support remnants of the communities developed upslope. An important factor in controlling the vegetation types encountered will be the deposition of sea-spray and salts; the salt deposition in this zone can be over 10 times that experienced elsewhere within a cliff (Moore & Brunsden, 1996).

The relative significance of the vegetation zones will vary with cliff type. However, the fundamental control on the development of these zones is the rate of erosion and landslide activity. In those cliffs that experience a rapid throughput of sediment the conditions may be too aggressive to support all but a few species. Greater opportunities for the development of a range of habitats supporting a diversity of species will occur in cliffs with an intermittent or low rate of sediment throughput i.e. there is sufficient time before the system is reactivated for vegetation to take hold and develop. It follows, therefore, that:

- an individual cliff may support a range of vegetation communities developed in different morphodynamic zones and reflecting local variations in soil drainage and instability.

- the vegetation supported by a cliff will be a complex mixture of communities "inherited" from the cliff top but modified by the end of the land management practices, and new communities that favour poor drainage and unstable ground, together with extensive areas of bare ground. This mixing of communities will be greatest in the block disruption and transport zone (III).

- the potential for species diversity is controlled by the rate and frequency of landslide activity. Some cliffs are so active that they can support only a limited number of species; others may remain relatively stable for sufficient time to allow the development of diverse communities.

- the potential for invertebrate species depends on substrate type, hydrology and material brought down from the cliff top in landslide events. For example, if there is a grassland or meadow habitat at the cliff top there would normally be greater potential than if arable land extended up to the cliff edge. Those invertebrates that are dependent upon particular plant species cannot colonise until those plants are present.

Of particular importance in maintaining or restoring viable habitats is the availability of suitable cliff top habitat, either as a source of species input into the cliff system or for supporting different life cycle stages of particular species. It is this mosaic of micro-habitats, from cliff top through the various morphodynamic zones described above, that tend to will support maximum biodiversity.

Coast Protection and Slope Stabilisation

There were no general statutory powers to protect the coast against erosion before 1949. However, many authorities and private landowners (e.g. railway companies) had provided defences under general local authority powers or local Acts. In Scarborough, the local authority constructed seawalls in the 1880s and 1890s to provide protection against erosion, along with landscaping and drainage works to stabilise the cliffs. The expansion of the railways was accompanied by the construction of seawalls to protect the lines, as along the Dawlish to Teignmouth line, Devon (Kay 1990).

The Coast Protection Act 1949 provides coast protection authorities (i.e. maritime district councils or unitary authorities) with permissive powers to carry out works (within or outside their areas) for the protection of any land in their area. Here, the following definitions are relevant:

1. *Coast protection*; protection against erosion or encroachment by the sea;

2. *Coast protection works*; any work of construction, alteration, improvement, repair, maintenance, demolition or removal for the purpose of the protection of any land, and includes the sowing or planting of vegetation for the said purpose.

Coast protection authorities have two functions: *promoting* their own schemes under the 1949 Act and *regulating* protection works by landowners, or bodies with their own statutory powers (e.g. Railtrack, harbour authorities, highways authorities etc.).

Coast protection works also require the following consents:

- express planning permission from the local planning authority (above LWM).

- a licence to deposit anything in the sea from the MAFF fisheries department, under the Food and Environment Protection Act 1985 Part II;

- a lease for use of the sea bed from the Crown Estate Commissioners;

Table 5 Types of Cliff System

A range of types of cliff system can be recognised on the basis of the throughput and storage of sediment within the system (Figure 2):

i. *Simple cliff systems*; comprising a single sequence of sediment inputs (from falls or slides) and outputs, with limited storage. A distinction can be made between cliffs prone to falls and topples and those shaped by simple landslides. The former is characterised by limited storage of sediment within the cliff system, with material from the cliff top and face reaching the foreshore in a single event. Examples include:

- "soft" unconsolidated sands and gravels, e.g. the Suffolk coast;
- "harder" rock cliffs, e.g. Chalk cliffs of East Sussex;
- cliffs developed in highly jointed or faulted rocks, e.g. the Jurassic cliffs of North Yorkshire.

By contrast, simple landslide systems comprise a single sequence of inputs and outputs with variable amounts of storage within the failed mass. Debris from the cliff may only reach the foreshore after a sequence of events involving landslide reactivation. Examples include rotational failures on the London Clay cliffs of north Kent, "soft" till failures e.g. the Holderness coast and mudslides on the north Norfolk and east Dorset coasts.

ii. *Composite systems*; comprising a partly coupled sequence of contrasting simple sub-systems. The output from one system may not necessarily form an input for the next (e.g. where material from the upper unit falls directly onto the foreshore). Examples include the Durham cliffs comprising mudslide systems developed in till over limestone cliffs prone to rockfalls and the cliffs at Flamborough Head where tills overlie near vertical Chalk cliffs.

iii. *Complex systems*; comprising strongly linked sequences of sub-systems, each with their own inputs and outputs of sediment. The output from one sub-system forms the input for the next. Such systems are often characterised by a high level of adjustment between process and form, with complex feedback mechanisms. Examples include landslide complexes with high rates of throughput and removal of sediment, such as the cliffs of Christchurch Bay and the west Dorset cliffs, and cliffs affected by seepage such as Chale Cliff, Isle of Wight;

iv. *Relict systems*, comprising sequences of pre-existing landslide units which are being gradually reactivated and exhumed by the progressive retreat of the current seacliff e.g. parts of the Isle of Wight Undercliff, the Landslip Nature Reserve, East Devon and East Cliff, Lyme Regis and the "slope-over-wall" cliffs of south-west England.

- permission from the Secretary of State for Transport to ensure that works in tidal waters do not affect navigation, under the 1949 Act S.34. This includes permission for the construction, alteration or improvement of any works on, under, or over any part of the seashore below spring HWM, or the removal or deposit of any object or materials below the level of spring HWM. This provision has been amended by the Merchant Shipping Act 1988, s 36, so that the requirement of a licence is no longer confined to situations where the operations themselves physically interfere with navigation, but also apply if the intended use of the works is likely to have that effect (reversing the decision in Harwich

Harbour Conservancy Board v Secretary of State for the Environment [1975] 1 Lloyd's Reports 334).

Grant-aid is made available to operating authorities by MAFF for schemes that are technically sound, environmentally acceptable, economically viable and cost-effective. The current level of grant-aid for coast protection is around £20M per year.

The Ministry of Agriculture, Fisheries and Food has produced a series of guides on the appraisal of flood and coastal defence in England and Wales. These are:

FCDPAG1	Overview
FCDPAG2	Strategic planning and appraisal
FCDPAG3	Economic appraisal
FCDPAG4	Approaches to risk
FCDPAG5	Environmental appraisal
FCDPAG6	Post project evaluation

These volumes are designed to provide an integrated suite of guidance on all aspects of project appraisal. Here, a number of points are worth highlighting with regard the scheme appraisal process:

- schemes should be sustainable, taking account of the interrelationships with other defences, developments and processes within a coastal cell, and should avoid as far as possible tying future generations into flexible and expensive options for defence;
- schemes should be based on an understanding of natural processes and, as far as possible, work with these processes;
- grant-aid will only be offered for schemes which are judged to be environmentally acceptable. In general, schemes will not be approved if they are considered unsatisfactory by English Nature, although MAFF reserve the right to take their own view on the balance of interests in meeting the overall policy aim;
- the potential impact on habitats and the environment generally is a key consideration;
- there is a presumption that natural coastal processes should not be disrupted except where life or important man-made or natural assets are at risk;
- where shoreline management plans (SMPs) are in place, MAFF will expect coast protection schemes submitted for grant-aid to be consistent with the plan policies;
- schemes should have a benefit:cost ratio of at least unity.

Construction of sea walls and other cliff foot structures (Table 6) has generally reduced the rate of recession. However, the prevention of marine erosion does not eliminate the potential for slope failure, because of the importance of internal slope factors in promoting instability. Whilst slope degradation behind defences generally involves relatively small and minor events, large-scale dramatic events do occur and can result in considerable loss of land. Examples include:

- the 1993 Holbeck Hall landslide, Scarborough which led to the destruction of the hotel and sea walls below with a loss of around 95m of land (Clark and Guest 1994);

- the landslide at Overstrand, Norfolk where around 100m of cliff top land was lost during a three year period between 1990-1993. The slope toe had been protected by wooden breastwork defences (Frew and Guest 1997).

Both these events were *first-time failures* of intact coastal slopes, with their dramatic nature probably reflecting the *brittleness* of the slope materials (i.e. a large difference between peak and residual strength). Less dramatic problems have arisen on some protected slopes where continued instability has led to the damage and abandonment of cliff top properties, as at Totland, Isle of Wight and in West Bay, Dorset. In both instances prevention of marine erosion has not eliminated the risk of recession events. Continued slope instability problems can also be experienced where cliff foot structures have been used to protect pre-existing landslides. For example:

- the major landslides at Barton-on-Sea during 1974 (Clark et al, 1976);

- the continued ground movement problems at Sandgate (Palmer 1991), the Isle of Wight Undercliff (e.g. Rendel Geotechnics, 1995) and the Isle of Portland (Brunsden et al 1996).

From these examples, it is clear that whilst toe protection can considerably enhance slope stability conditions it is not a panacea for preventing or reducing cliff recession, because of the complexity of many instability problems. Indeed, on cliffs affected by first-time or repeated failures, prevention of marine erosion can result in *free degradation* where the slope angle is too steep for the materials and ground water conditions.

The stability of protected cliffs may gradually decline with time, introducing the potential for delayed failures. The main factors involved are likely to be the recovery of depressed pore water pressures, strain-softening, weathering and progressive failure in plastic clays and mudrocks, and the deterioration of slope drainage systems.

The mechanisms involved are probably analogous to those experienced in the widely studied delayed failures (up to 100 years after excavation) in London Clay cuttings (e.g. Chandler, 1984; Vaughan, 1994).

It follows that effective erosion control (coast protection) schemes are likely to involve a combination of toe protection and slope stabilisation (Table 6). As marine erosion will be fundamental to most cliff recession problems, the preferred option typically includes some form of toe protection to prevent or reduce wave attack. Secondary treatment measures, involving slope stabilisation, will often be needed to prevent the deterioration of the protected cliffs.

Instability on protected slopes can present a significant threat to existing toe protection structures. Small-scale slope failures may, under certain circumstances, lead progressively to a decline in overall slope stability and , indirectly, cause a larger event. Such an event could cause a failure of the toe protection and result in a renewal of marine erosion at the cliff foot.

Table 6 Types of coast protection and slope stabilisation measures

Direct Protection Against Wave Attack

- concrete and masonry seawalls
- sloping asphalt walls
- sand mortar filled bags
- gabion baskets

Direct Protection - Wave Energy Dissipation

- rock revetments
- concrete armour units
- timber palisades
- rubber types
- gabion baskets, Reno mattresses
- detached breakwaters
- shore connected breakwaters
- beach sills

Dynamic structures

- beaches and groynes
- rock beaches
- headlands and pocket beaches

Slope stabilisation

- slope profiling by excavation and/or filling;
- drainage;
- retaining structures;
- soil/slope reinforcement;
- surface erosion control;
- slope vegetation.

Impact of Coast Protection on Biodiversity

Maritime cliffs and slopes are a priority habitat, supporting large numbers of priority species (see Appendix B; Simonson and Thomas 1999). However, over the last 100 years or so some 860km of coast protection works have been constructed to prevent coastal erosion (MAFF 1994; this figure probably includes some low-lying areas prone to erosion). It has been estimated that there remain some 255km of unprotected soft cliff in England (Pye and French 1992).

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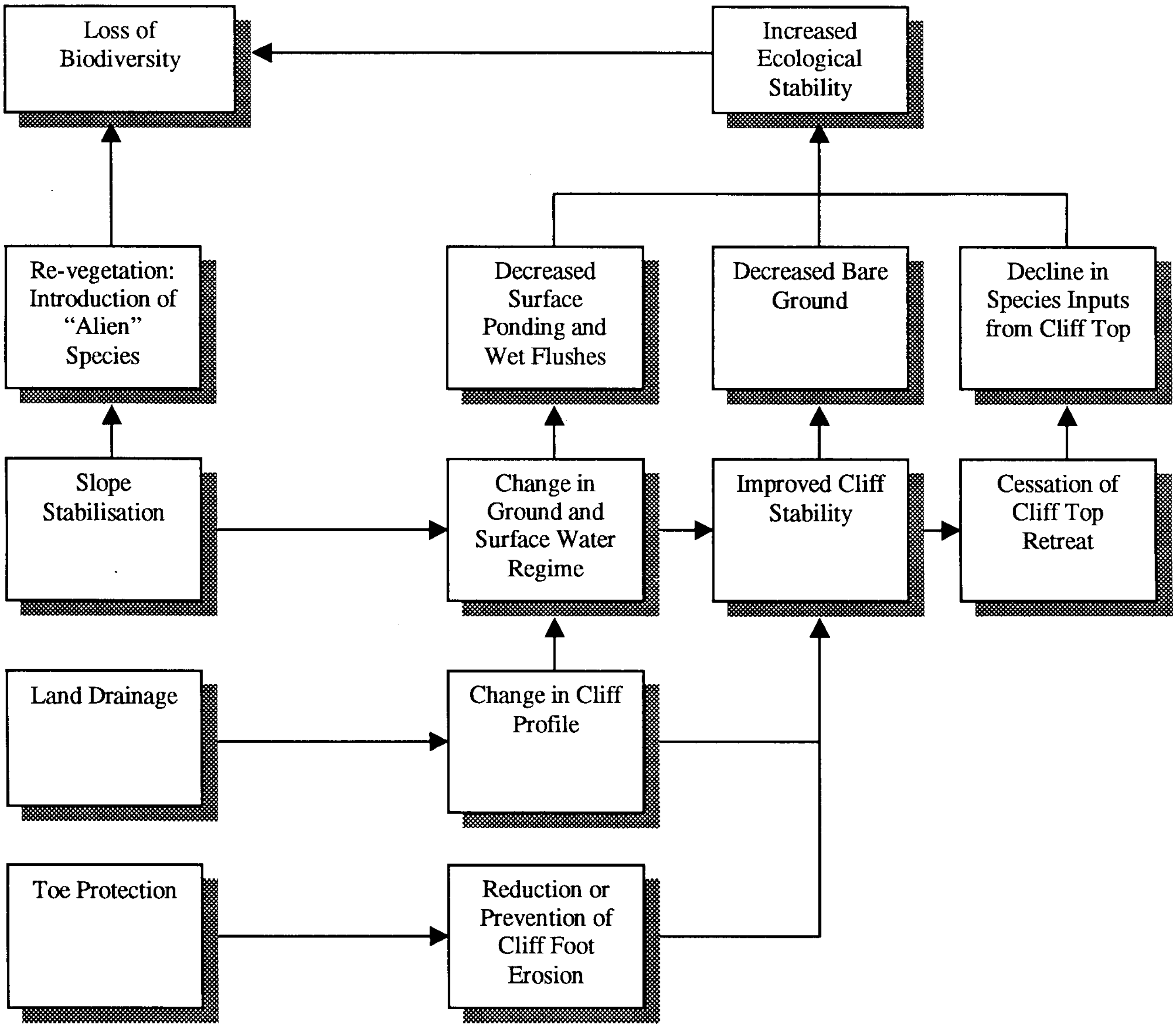
Many coast protection schemes are considered to have had significant impacts on the environment (Figure 6). Seawalls or rock revetments have been built which stop the recession process. Cliff faces have been stabilised by drainage works, regraded and landscaped. As a result, geological exposures have become obscured, hardy grasses of little or no conservation value have replaced bare soil and early pioneer stages, and wet flushes have dried out. A significant proportion of the soft cliff resource has been affected, with loss of degradation of biological sites of national and international conservation value. This has been accompanied by a reduction in the sediment supply to littoral cells from eroding coastal cliffs. Although difficult to quantify, sediment inputs could have declined by as much as 50% over the last 100 years (Rendel Geotechnics, in press).

Maritime cliff and slope habitats have also been affected by land use changes on the cliff top (e.g. arable farming, caravan parks etc.), reducing the potential for the maintenance of diverse mosaics of species with active links between cliff face and top habitats.

In places, important habitats have developed on protected slopes. At Tankerton, North Kent, for example, the nationally rare plant Hogs Fennel (*Peucedanum officinale*) is abundant on protected, but poorly drained London Clay slopes (Roberts 1989). The cliffs had been protected by a seawall in the 1900s. Elsewhere, coast protection works protect important cliff top habitats that would otherwise be lost because of cliff recession (e.g. Bestowe Hill SSSI, east of Sheringham on the North Norfolk coast).

Figure 6 A summary of the impacts on Biodiversity associated with coast protection

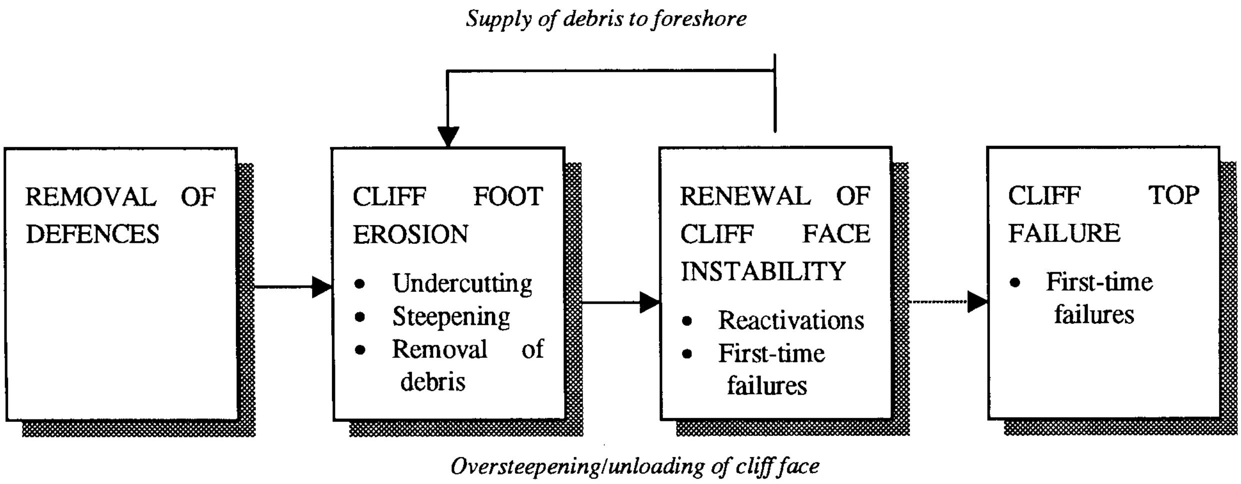


3 Opportunities for Restoration: the Availability of Potential "Free-up" Sites

The Potential for Restoration

Abandonment or removal of coast protection works will lead to the renewal of marine erosion at the cliff foot. This will result in the initiation of a new phase of cliff instability and thegeneration of a new suite of maritime cliff and slope habitats. Figure 7 presents a simple model of the restoration process, highlighting the progressive changes from protected cliff, through a period of increasing instability, to the onset of cliff top retreat and the development of a new *characteristic cliff form.*

Figure 7 A simple cliff reactivation model



However, a number of points are worth bearing in mind:

1. *the time taken to respond to the renewal of cliff foot erosion will vary between cliffs.* This complexity of response is a measure of the sensitivity of a cliff i.e. the likelihood that triggering events (e.g. storms) of a particular magnitude will produce significant recession. Here, a range of settings can be recognised, with two end members:

   - Highly sensitive cliffs; recession occurs in short, regular epochs. Such cliffs are characterised by a rapid decline in the margin of stability from a relatively low value after an event. The response to renewed cliff foot erosion is likely to be rapid, and may involve frequent small magnitude, high frequency events.

   - Insensitive cliffs; recession occurs in very long, highly irregular epochs. The cliffs are generally unresponsive to all but the most extreme triggering events, with extremely large margins of stability developing after a recession event. The response to renewed erosion is likely to be very slow, but may involve large-scale landslide events.

   Renewal of erosion may be followed by a period of *transient behaviour*, until the new characteristic cliff form is achieved i.e. a period of less predictable behaviour.

2. *the time taken to achieve the characteristic form will vary between cliffs.* There can be many phases of debris removal and landslide reactivation before there has been sufficient unloading of the rear cliff to initiate a new failure. There are, thus, considerable differences in the timescale over which the effects of marine erosion are transmitted through a cliff system to cause cliff top recession. In simple cliff and simple landslide systems there may be a direct and readily observable link between erosion and cliff recession. In complex and composite cliffs persistent and more regular sea cliff erosion through relatively small-scale events leads to intermittent movements in other parts of the system and rare large failures of the rear cliff. It follows that the timescale over which new habitats can be created will vary with cliff type (Table 5).

3. *Renewal of erosion may lead to the development of a new characteristic form;* some cliffs are relict features, probably inherited from previous periods of high sea-level or periglacial phases during the last glaciation (e.g. East Cliff, Lyme Regis, Norris Castle and Gunard cliffs, Isle of Wight). Their protection often coincided with the initial stages of reactivation i.e. these relict cliffs were beginning to "open-up" when coast protection works were constructed. It follows that renewal of marine erosion will resume this process. In time, the entire relict cliff system will become active, delivering a different habitat to that which had developed prior to the defences being put in place.

4. *Restoration may not necessarily lead to the species diversity that had been present prior to coast protection.* Although the restoration of maritime cliff and slope habitats will follow a similar pathway to the re-establishment of characteristic cliff forms (as described above), the diversity will depend on a range of factors including the fragmentation and isolation of the existing cliff and cliff top habitat mosaics in the area, land use changes and loss of national vegetation types.

The Availability of Potential Free-up Sites: the South coast

When totalling the figures provided by the coast protection authorities, the total soft cliff resource along the south coast is 334.7 km, representing some 30% of the maritime cliff resource in England of 1082km (UK Biodiversity Group 1999).

A survey of coast protection authorities has revealed between eight and ten sites, with a total length of 5.45 km, have been identified for possible free-up within the next 50 years along the south coast of England along the Dorset to Thames estuary frontage (Table 7). These sites are described in Volume 2. In some cases, such as the potential sites identified in West Dorset (*Seatown*, *Ringstead Bay* and *Charmouth*), the options are looking towards the end of the 50 year time-span, as recent works have taken place, whereas further along in the county at Poole Harbour, more immediate options exist, as decisions need to made in the near future whether or not to continue defending the frontage at *Ham Common.* At *Bowleaze Cove*, Dorset, the current SMP policy is to retreat the line along a 0.3km frontage protected by gabion baskets.

The Isle of Wight presents the longest length of possible free-up area of any of the districts, with 2.05 km of currently defended soft cliffs potentially available for 'free-up'. The areas for potential "free-up" mainly consist of "do-nothing" frontages where existing defences are in a state of disrepair. However, all the sites are located along private frontages.

The Availability of Potential Free-Up Sites: The East Coast

A survey of a number of coast protection authorities on the east coast of England (North Yorkshire to Essex; Table 8) has revealed the potential availability of around 8 sites where the existing defences are unlikely to be maintained or improved over the next 50 years, extending along some 9km of cliffline.

Potential free-up sites include the abandonment of the two breakwaters at *Port Mulgrave* and the seawall protecting the redundant *Cayton Sands Pumping Station*, both in North Yorkshire and a number of sites in North Norfolk: *Sheringham-West Runton, Cromer-Overstrand, Sidestrand, Trimingham-Mundesley, Mundesley-Bacton, Walcott-Happisburgh, Happisburgh South.*

Discussion

It should be noted that many coast protection structures were constructed prior to the current benefit:cost tests and priority scoring that are a pre-requiste for obtaining MAFF grant aid. For example, some schemes were financed by private investment (occasionally for reasons other than preventing cliff recession e.g. the works at *Norris Castle*) or directly through local authority funds, without Government grant-aid support. Some pre-1985 grant-aided schemes were not subject to rigorous economic evaluation (the policy responsibility for coast protection was transferred from the Department of the Environment to MAFF in 1985). It follows that in such instances the availability of public funds to maintain or improve some defences may not be readily justified on economic grounds. Over the next 50 years, therefore, it appears that there will be an increasing number of sites where the current defences might be abandoned as being too expensive to maintain. Such sites will probably be identified in future generations of SMPs. This suggests that there may be more potential restoration sites than indicated by Tables 7 and 8.

Table 7 Summary of the "best-guess" availability of "free-up" sites for a sample of coast protection authorities: the South coast (based on discussions and review of the relevant SMPs)

Coast Protection Authority (west to east)	Protected cliffs (km)	Unprotected cliffs (km)	Future no. of Free-up sites	Free-up overall Free-up length (km)
West Dorset DC	3.5	38.5	2-3	0.5
Purbeck DC	5	45	1	0.2
Weymouth & Portland BC	3	14	1	0.3
Poole BC	19.57	9.42	1	1
Bournemouth BC	11	1.2	0	0
Christchurch BC	1.6	0.7	0	0
DORSET TOTAL	**40.67**	**94.82**	**4-5**	**1.7**
I. OF WIGHT TOTAL	**24**	**58**	**3**	**2.05**
New Forest DC	3.5	0.5	0	0
Southampton CC	0	0	0	0
Eastleigh BC	0	0	0	0
Fareham BC	0	0	0	0
Gosport BC	0	0	0	0
Portsmouth CC	0	0	0	0
Havant BC	0	0	0	0
HAMPSHIIRE TOTAL	**3.5**	**0.5**	**0**	**0**
Chichester DC	0.35	0	0	0
Arun DC	0	0	0	0
Worthing BC	0	0	0	0
Adur DC	0	0	0	0
W. SUSSEX TOTAL	**0.35**	**0**	**0**	**0**
Brighton & Hove C	5.5	0	0	0
Wealden BC	0	5	0	0
Eastbourne	0	5.6	0	0
Lewes DC	5.95	9	0	0
Hastings BC	5	0	0	0
Rother	2.5	2.1	0	0
E. SUSSEX TOTAL	**18.95**	**21.7**	**0**	**0**
Shepway DC	5	1	0	0
Dover DC	10	7	1	1.4
Thanet DC	18.25	6.06	0	0
Canterbury	15	1.3	0	0
Swale	2.1	6.5	0	0
Medway C	0	0	0	0
KENT TOTAL	**50.35**	**21.86**	**1**	**1.4**
TOTAL – ALL COUNTIES	**140.82**	**210.88**	**8-10**	**5.45**

Table 8 Summary of the "best-guess" availability of "free-up" sites for a sample of coast protection authorities: the East coast (based on discussions and review of the relevant SMPs)

Coast Protection Authority	Protected cliffs (km)	Unprotected cliffs (km)	Future no. of Free-up sites	Free-up overall Free-up length (km)
Cleveland & Redcar	5	10	0	0
Scarborough BC	70	15	2	0.3
East Riding DC	12	95	0	0
North Norfolk DC	23.6	10.5	7	8.5
Tendring DC	6	2	0	0
TOTAL – ALL AUTHORITIES	**116.6**	**132.5**	**9**	**8.8**

4 Constraints to Restoration

Introduction

The overwhelming majority of coast protection structures were constructed to reduce risks from cliff recession or coastal landsliding (exceptions do exist, such as *Norris Castle estate*). In doing so, most structures have contributed to the Government's Strategy for Flood and Coastal Defence (MAFF 1993) which aims to reduce risks to people and the developed and natural environment. Almost all the capital works to maintain, improve or replace these structures are effectively funded out of general taxation. In order to ensure an efficient use of public resources, schemes have to be technically sound, environmentally acceptable and economically viable and cost-effective.

The decision whether to retain, improve, replace or abandon an existing coast protection structure involves a rigorous project appraisal process, from large scale planning (i.e. development of SMPs) to Strategy Plans, scheme development/design and post project evaluation. At each stage, the "do nothing" or "walk-away" option will be tested (i.e. abandon maintenance and repair of the structure, allowing nature to take its course). The benefit:cost ratio of this option is compared with a variety of "do something" options to establish the best approach to managing the risks at that site. Environmental and technical issues provide a framework for developing the nature of these "do something" options.

In practice, economics are often the over-riding factor in dictating the future management of protected clifflines. It is often a straightforward task to establish whether the "do something" option is:

- Clearly economically viable;
- Marginally viable;
- Clearly not economically viable.

Those sites that are clearly economically viable will not be potential free-up sites, as local pressures will ensure that the defences are kept in place. The majority of defences protecting urban coastlines will fall into this category, including towns such as Scarborough, Lyme Regis and Ventnor. In other instances, major landowners or private companies may have made a positive commitment to upkeeping the defences to protect their investments (e.g. the Ministry of Defence, Railtrack etc.).

Sites which are currently protected, but where further investment in defences is clearly not economically viable are likely to become free-up sites. Such sites are not common, and are often associated with long-standing private defences where the land use has changed, e.g. *Port Mulgrave* and *Cayton Bay*, North Yorkshire. In many cases there is unlikely to be a desire by the local authority or individuals to invest in the maintenance or repair of the structures once they have exceeded their residual life. Such structures will often be left to slowly deteriorate, with possible health and safety or environmental implications (see the discussion below).

Marginally viable sites present a more difficult problem. As outline in the previous Section, it is likely that there is a significant number of structures that were constructed before rigorous project appraisal procedures or benefit:cost tests. Such structures might protect locally important assets (e.g. roads, tourist and amenity facilities etc.) or low-density cliff top development. However, because of the relatively limited potential benefits the coast protection authority may not be able to justify maintaining or replacing such structures (once they have reached the end of their design life) on economic grounds alone. In such circumstances, the coast protection authority will be faced with a difficult decision as to whether there are non-economic grounds for continuing to protect the cliffs. Amongst the issues that they will need to take into account are:

- their legal responsibilities, as coast protection authority and/or landowner;
- the health and safety implications of allowing a structure to deteriorate;
- local attitudes and political pressures;
- the availability of resources;
- the environmental implications of abandoning the structures.

Legal Responsibilities

The removal of defences could result in coast protection authorities being faced with legal challenges, on a number of grounds, including:

1. *removal of support*; an occupier of land has the same duty of care to his uphill neighbour as that established by the "Leakey" case in favour of a downhill neighbour (Leakey v National Trust 1980 1 QB 485). This duty may require the occupier to take positive steps to avert damage to the neighbour, and conversely failure to take such steps may sound in damages.

   There is no obligation on the part of the servient occupier to take any active steps to maintain support; some positive act amounting to removal of support is required to found liability and failure to act is not enough. Gale on Easements states that "[the] *obligation of the servient owner is .... to refrain from any act which will diminish support*".

   The removal of defences might be construed as a positive act to remove support to property on the cliff top. This would be particularly apparent if the coast protection works were also acting as a toe weight to stabilise a pre-existing landslide system.

2. *breach of common-law duty*; landowners or occupiers have a "*measured duty of care*" to reduce or remove hazards to their neighbours (Goldman v Hargrave 1967 AC 645; see also Holbeck Hall Hotel Ltd v Scarborough B C 1995 ORB 561). In delivering the Goldman judgement Lord Wilberforce said: "*The owner of a small property who has a hazard which threatens a neighbour with substantial interests should not have to do so much as one with larger interests of his own at stake and greater resources to protect them.*"

   Leakey v National Trust for Places of Historic Interest or National Beauty (1978) 2 WLR 774, in conjunction with the subsequent ruling by the Court of Appeal *(Leakey v The National Trust (1980) 1 QB 485)*, provides a clear statement to date on the landowners responsibility for a natural hazard. The case concerned a slope failure in a mound located on National Trust land called Burrow Mump. Natural erosion of Burrow Mump over a number of years had led to 'soil and rubble' falling from the mound onto land owned by the plaintiffs and threatening their houses. The plaintiffs accordingly brought an action in nuisance calling for an abatement of the nuisance and for damages. In 1978 the court decided in favour of the plaintiffs but the defendants chose to appeal against the decision.

The 1980 appeal by the National Trust was dismissed because the court felt that an occupier of land owed a general duty of care to a neighbouring occupier in relation to a hazard occurring on his land whether such a hazard was natural or man-made. This is a fundamentally important decision as far as landslides and landslide hazards are concerned, not least because it arises from a case of slope failure. The general duty referred to the judgement was held to be: "*... to take such steps as were reasonable in all the circumstances to prevent or minimise the risk of injury or damage to the neighbour or his property of which the occupier knew or ought to have known.*"

The 'circumstances' in this case being described as including: "*... his knowledge of the hazard, the extent of the risk, the practicability of preventing or minimising the foreseeable injury or damage, the time available for doing so, the probable cost of the work involved and the relative financial and other resources, taken on a broad basis of the parties.*"

The question of the resources of the defendant was also broached by Lord Justice Megaw in the Appeal Court where he emphasised that the cost of the works must be considered when deciding whether or not the owner of the land which is causing the danger had discharged his duty of case. Megaw said:

"Take by way of example, the hypothetical instance of the landowners through whose land a stream flows. In rainy weather it is known the stream may flood and the flood may spread to the land of the neighbours. If the risk is one which can readily be overcome or lessened - for example by reasonable steps on the part of the landowner to keep the stream free from blockage by flotsam or silt carried down, he will be in breach of duty if he does nothing or does too little. But if the only remedy is substantial and expensive works, then it might well be that the landowner would have discharged his duty by saying to his neighbours, who also know of the risk and who have asked him to do something about it, "You have my permission to come on to my land and to do agreed works at your expense", or it may be, "... on the basis of a fair sharing of expenses".

On the basis of these judgements, it follows that operating authorities might be challenged if they carried out works (i.e. removal of defences) which were in breach of their measured duty of care. If defences were removed, local authorities could then be liable for compensation claims if asset values were reduced and landowners had not agreed with the removal. However, it is probably the Government view that abandonment of sites where continued protection cannot be justified should not give rise to any claim provided that reasonable procedures are followed and that due notice is given to the affected parties. This view has not been tested in a court of law.

In a review of the Holbeck case, the solicitors Dibb, Lupton and Alsop (1997) identified a number of issues that go well beyond the dispute between the Council and the hotel owners. Of particular importance is that the judgement implies a duty of care between neighbouring landowners in respect of an entirely natural loss of support. It may follow that if a landowner is aware of any natural or man-made ground hazard on his land this may make him liable in negligence for any subsequent damages.

In the subsequent appeal by Scarborough Borough Council over the Holbeck judgement, it was stated that although the landowner owed a measured duty of care that duty, depended on foreseeability. In this instance, the Council had not foreseen the magnitude of the risk and would not have done so without expert evidence derived from a geological survey. The duty might extend only to warning the owner of the dominant land of the foreseen risk and did not necessarily require expensive preventative works. Furthermore, it would be unfair and unreasonable to find liability in such circumstances where the danger had been equally apparent to the dominant owner.

3. *breach of covenant.* many local authorities acquired coastal cliffs and slopes at the turn of the 20th century, to landscape and create areas of public access. In some instances, this land purchase was accompanied by a covenant with the original owner. For example, Holbeck Cliff, Scarborough was covenanted with the following provisions.

   (a) That they [the grantees] will with all reasonable speed commence and carry out such works of drainage filling and banking up and other works as are in the opinion of [the grantees] or their Borough Surveyor necessary for the preservation of the said Undercliff and the public footpath therein and for the purpose of preventing the same from slipping or otherwise suffering damage.

   (b) And will at all times thereafter use their best endeavours to maintain and preserve the said Undercliff and footpath.

   (c) And also in the event of any damage at any time hereafter happening to the said Undercliff and public footpath by sinking slipping or from any other cause whatsoever [the grantees] will with all reasonable speed thereafter repair and make good so far as practicable such damage and reinstate so far as practicable the said Undercliff and footpath

   (d) Provided always and it is hereby expressly agreed and declared that [the grantees] shall not be liable for any damage that may be caused to any part of [the property retained by the grantor] owing to any slip or sinking that may take place in the said Undercliff or public footpath

   (e) And it is hereby further agreed and declared that in the event of any question arising out of any covenant or agreement herein contained such question shall be referred to two Arbitrators one to be appointed by [the grantor] his heirs or assigns owner or owners for the time being of [the retained property] and the other by [the grantees] or to an Umpire to be appointed by such two Arbitrators whose decision shall be final.

   Where similar covenants exist (the extent of such arrangements is not known; indeed, the arrangement was not "discovered" by Scarborough BC prior to the Holbeck case), there may be opportunities for landowners to challenge the ability of the coast protection authority to remove the defences.

The defence structure may currently provide a public amenity. In such circumstances the legal implications of its removal, or allowing it to deteriorate are unclear. Section 118 of the Highways Act (1980) ensures that no right of public access can be removed unless it can be proven that the public no longer uses it. It may, therefore, prove difficult to remove a structure which incorporates a public right of way, for nature conservation purposes, unless access was maintained.

With very few exceptions all footpaths and bridleways on definitive maps will be publicly maintainable, in accordance with The National Parks and Access to the Countryside Act 1949 S.47. If a path is maintainable at the public expense the highway authority (all public paths are highways) has a duty to keep it in a state which is safe and fit for ordinary traffic. If an authority fails to keep a path in proper repair any member of the public may force the issue by serving a notice on the authority under S.56 of the Highways Act. The authority may deny liability, in which case the matter may be referred to the Crown Court. But if, as is more likely, they admit liability to maintain, the authority must repair the path within a reasonable time. If they fail to do so the complainant may seek an order from the Magistrates Court requiring the authority to put the path in proper repair.

In areas where a path is too unsafe to maintain in a fit standard of repair, the highway authority may issue a *public path / extinguishment order*. This would also require an order for the "*cessation of duty of maintenance*" from the Magistrate's court so that the council no longer needed to maintain the path. This has already happened on the Isle of Wight at Chale, where cliff paths have fallen over the edge of the cliff due to erosion and landsliding.

Health and Safety Implications

Operating authorities and landowners need to be mindful of the obvious health and safety issues and liabilities associated with deteriorating structures on the foreshore. In this context, further issues may be relevant, including:

- *Occupier's Liability; Occupier's Liability;* Local authorities and landowners might also experience difficulties because of their responsibilities under the Occupier's Liability Acts of 1957 and 1984. The 1957 Act imposes upon the occupier of premises a duty of care to any visitor using the premises for the purposes for which he is permitted or invited to be there (the 1984 Act extends this duty to persons not being visitors, including trespassers). The "*premises*" has been interpreted through case law to mean the highway, railway track, adjoining land – as well as objects upon it (RoSPA & RLSS UK, 1993). This might include coast protection structures, and in such cases the local authority, or landowner could potentially be liable for injuries or damages caused by deteriorating structures.

  However, the operator of a natural beach will not automatically be exposed to liability, although the placing of an "attraction" ... upon the shore would certainly expose the operator to liability under the Act if the duty of care is breached (RoSPA & RLSS UK, 1993). This situation might be relevant in *Whitecliff Bay*, Isle of Wight, where the concrete structure placed by the owners forms an "attraction" for beach users. This is enforced by the fact that: "Any operators deriving income from the provision of services for visiting swimmers may well incur liability under the Occupier's Liability Act unless reasonable precautions are taken." (RoSPA & RLSS, 1993).

  It is also worth noting that, under this Act, the operator may be exonerated from liability if a danger is brought to the visitor's attention and the operator takes appropriate precautions. It is important, therefore, that clear notices communicate the presence of any dangers to visitors. Whilst some operators do prefer not to publicise hazards to the public, this approach is likely to incur liability in the event of an accident.

- *Navigation hazards*: In terms of both the material used to build the structure in the first place and the debris that would be washed into the sea.

Local Attitudes and Political Pressure

In most instances, removal of the existing defences would mean an increase in the level of risk to cliff top assets (i.e. a reduction in the life of such assets). The Government view, in such circumstances, appears to be that there would be no grounds for compensation, even if defences had been provided by the public purse over a period of time (it is, of course, difficult to be categorical about the Government view as there is no policy statement covering these issues). The defences could be seen as a subsidy for cliff top landowners and occupiers, allowing them an extended use of their assets rather than providing them with an absolute right of protection.

The local view is likely to be significantly different. In the absence of a mechanism for compensation, landowners and occupiers will place considerable pressure on their elected representatives to prevent abandonment of defences. The oft cited view is that The Crown has an historic common law duty to protect the coast. In the Isle of Ely Case (1609) 77 English Reports 1139, Lord Coke stated: *"by the common law ... the King ought of right to save and defend his realm, as well against the sea, as against the enemies, that it should not be drowned or wasted*". This principle was endorsed by the Court of Appeal in A-G v Tomline (1880) 14 Chancery Division 58, where it was held that a landowner may not act so as to expose another's land to invasion by the sea, since this would cause a breach of the Crown's duty.

It is widely felt that there will be local political pressure against abandoning defences, except at those sites where the structures in place have been built by private landowners, or without the consent of the coast protection authority, planning authority or MAFF. Another example could be those defences constructed before the Coast Protection Act, mainly by the Victorians, in less developed areas.

The perception of coastal erosion risks and the management response varies across society and is a central issue in trying to understand how conflicts between coast protection and Biodiversity have arisen. Society is not and cannot be free of risk; it operates within specific levels of tolerance to natural hazards that are defined by both law and common practice. However, the concept of risk and safety tends to be defined vaguely and inconsistently by society, as illustrated by Starr's four "laws" of the acceptability of risk (Starr, 1969):

1. acceptability of risk is proportional to the cube of the real or imagined benefits associated with the risk;

2. the public will accept risks derived from voluntary activities which are 1000 times greater than those it would tolerate from involuntary activities which would generate comparable benefits. Thus, the tolerance of risks created by hazardous sports is thought to be three orders of magnitude greater than that associated with flood events;

3. the acceptable level of risk is inversely proportional to the numbers of individuals exposed to it;

4. the level of risk tolerated for voluntary accepted hazards is similar to that resulting from disease.

These "laws" highlight the fact that risk involves both objective and subjective elements. Perceived risk - the subjective assessments made by individuals - can vary markedly from objective measures of risk. For example, despite the frequent threat of coastal erosion for many parts of the Holderness coast, or repeated coastal landslide movements at Luccombe on the Isle of Wight, people continue to live there. The high level of hazard awareness in these situations, and others, suggests that many residents have made their own judgements that the potential benefits of living there outweigh the risks; others, of course, may be unable to avoid the risk through financial constraints.

For many, coastal erosion is unacceptable, raising visions of a loss of national resources to a hostile invading power. As John Gummer (2000), former Minister at MAFF recently wrote:

"Of course it has happened before. It's just that the last time our shores were successfully invaded was 1066. Now the east coast is being crossed again, and more effectively than by Norman or Dane. East Anglia is threatened as far inland as Bedfordshire. Already, more than 70 per cent of its beaches are in retreat. If erosion goes on at its present rate, my own constituency of Suffolk Coastal will simply continue falling into the sea".

"Britain is proud of being an island, and her people of being an island race. The time has now come for us to pay the price of defending this blessed plot from the very sea which has been our defence so often in the past".

In this context, hazards might be considered in terms of two independent dimensions of risk: the degree to which management is considered to be a private or public issue, and the extent to which society accepts or lives with the problems. Figure 8 expresses this concept for a number of environmental risks and highlights the perception that, for many, coastal erosion is an unacceptable problem that society as a whole should address through Government expenditure. From this perspective, limited resources are the constraint to delivering complete protection.

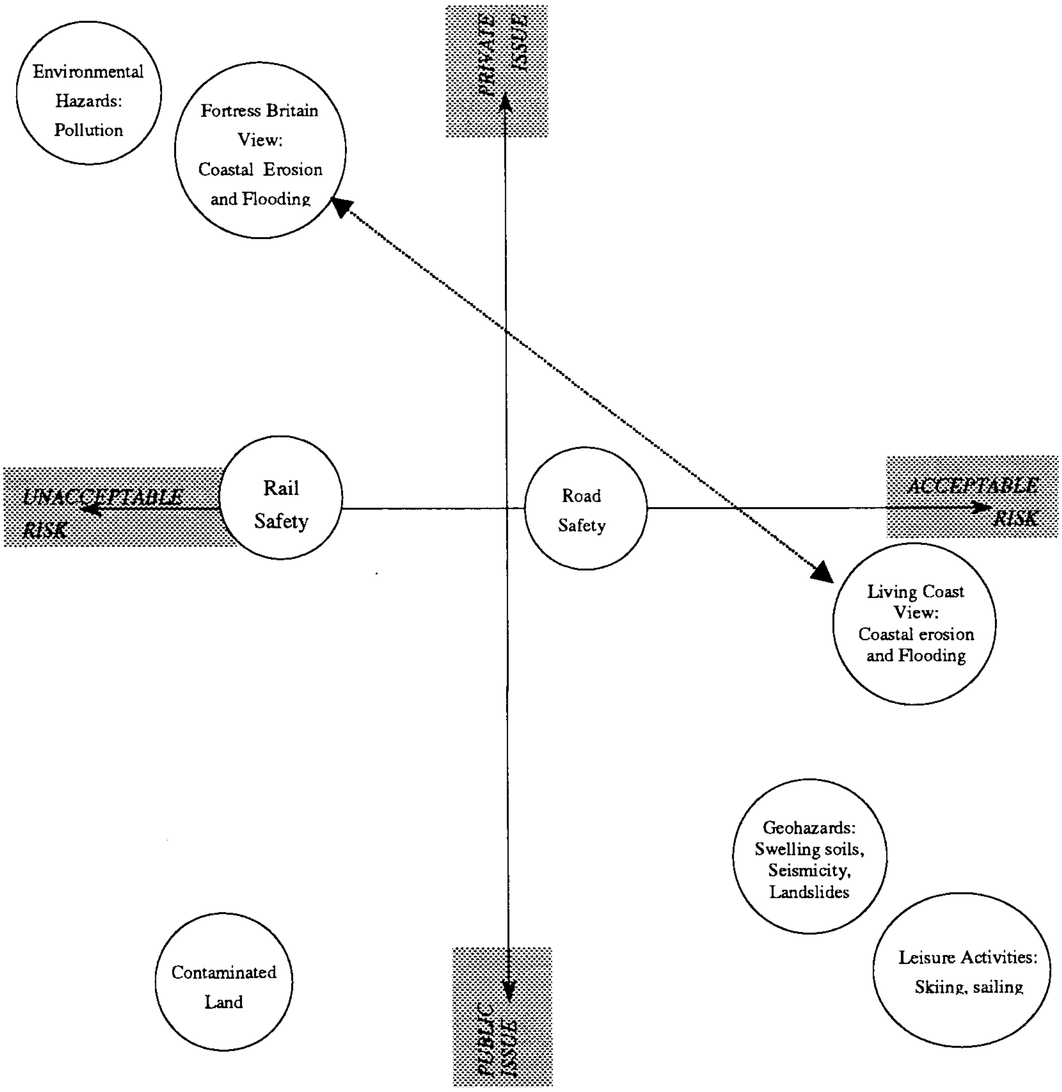
This *"fortress Britain"* view is in direct contrast to the environment-based view of erosion as an essential process in the functioning of the coastline and necessary for maintaining and sustaining many nationally and internationally valued landforms, landscapes and habitats. From this perspective (the *"living coast"*), erosion is an acceptable price to pay for conserving the wilderness and natural beauty of the coastline; public intervention should be limited to providing only essential and sustainable defences.

The "fortress Britain" view has great public, media and political (at least at a popular level) support, whereas the "living coast" view is supported by European and national legislation and targets. Trying to reconcile these two contrasting perspectives in managing coastal erosion risks will be a major challenge for coastal managers. The outcome will determine whether abandonment of currently defended sites and restoration of maritime cliff and slope habitats becomes a viable strategy.

Availability of Resources

The limited availability of resources is likely to prove a major constraint to freeing-up some potential restoration sites, particularly in those situations where it is unacceptable to let the structures deteriorate i.e. their removal would be necessary. As the situation currently stands, there will be great difficulty in obtaining MAFF funding for the removal of defences, who have indicated that they would not be willing to pay for the removal of coastal defences, especially if the original defences were constructed with Government money.

Figure 8: An attempt to illustrate the varying public perception of different risks. Note the significant difference between the "Fortress Britain" and "Living Coast" attitudes to coastal erosion and flooding.



However, grant-aid might be available where structures are to be removed to increase the efficiency of defences elsewhere. This might include situations where the renewal of sediment supply from the eroding cliffs would improve the natural defence components (e.g. beaches, dunes, saltmarshes, mudflats etc.) of schemes elsewhere.

In many situations it may appear more cost-effective to prolong the life of an "uneconomic" structure by maintenance and repair than to remove the structure. This is because of the high capital costs of the removal works and the fact that maintenance costs will be spread over many years and discounted to reach a Present Value (for example, £5,000 per year maintenance costs over a 50 year period have a Present Value of around £83,000).

The removal of defences can be costed into submissions for new schemes, but there exists no mechanism for the operating authority to receive grant-aid for the costs of removing existing defences. In addition, it is unlikely to be acceptable at a political level for local authorities to release public money to pay for the removal of defences, which could potentially increase risk to life and property on the grounds of increasing biodiversity.

Environmental Implications

The Town and Country Planning (General Permitted Development) Order 1995 allows for the removal of 'any gate, fence, wall or other means of enclosure' without the need for additional planning consent. Landowners are therefore permitted to remove seawalls and other 'means of enclosure' without notifying the local planning authority. However, the abandonment or removal of defences might cause a range of environmental impacts that operating authorities or landowners should be taken into account before implementing this course of action. These potential impacts might result in objections to any removal or abandonment from interested parties. Potentially significant impacts include:

1. *damage to the foreshore and nearshore habitats caused by the machinery used to remove the structures*;

2. *accelerated recession following removal of defences*; toe protection structures prevent cliff recession but not foreshore and shore platform lowering. At the same time, beach levels in front of the structures may have decline for a variety of reasons (e.g. scour, disruption of sediment transport pathways etc.). Thus, when the defences are removed the cliff foot may be exposed to a higher energy wave climate than before the structures were installed. Removal of the defences can, therefore, be followed by a period of unusually rapid recession until the cliffline reaches a new equilibrium orientation and retreat rate. For example, at *Happisburgh*, on the North Norfolk coast, over 50m of recession occurred in a 2-3 year period following the removal of timber revetments.

3. *potential increases in the delivery of sediment and changes in the sediment transport regime;* This may have adverse impacts on sensitive habitats downdrift. For example, at *Norris Castle*, Isle of Wight, renewed cliff instability may lead to an increased supply of fine sediments, to the detriment of landforms or habitats downdrift. The site is within the Solent Maritime SAC designated for its combined suite of estuaries. The adjacent coastline is also designated as changes in the sediment transport regime in this area may have a direct impact on the Medina Estuary. In this case, the removal of a wall would increase sediment input, which may affect the function of the estuary. Elsewhere, increased sediment supply may lead to a need for additional dredging within harbours or estuaries (e.g. the potential impact of removing defences at *Ham Common* on Poole Harbour)

4. *the environmental damage caused by deteriorating defence structures.* In many areas, the protected cliffs contain substantial amounts of land drainage, gabion baskets and small revetment walls which will be damaged by the erosion process following removal of defences. Renewed landslide activity could deliver an unsightly mess of rubble from gabions, walls and drainage fill, and broken pipes onto the foreshore. This situation has happened at *Osmington Mills*, where recent slope stabilisation works (gabion baskets) have failed and have been carried down the cliff onto the foreshore.

   At *Norris Castle*, Isle of Wight, renewed cliff instability will ultimately lead to mature trees being delivered onto the foreshore. If the trees were washed out into the Solent they would present a significant hazard to navigation.

At *Kingsdown Rifle Range*, Kent, removal of the defences would expose an area of fill to erosion. Potentially contaminated materials might be removed from the site and deposited elsewhere along the foreshore.

5. *loss of existing cliff habitats and species.* Many of the protected cliff areas along the south coast of England are already designated for their nature conservation importance, such as Tankerton SSSI in Canterbury, by virtue of rare plants growing on the sites. The removal of coastal defences would mean the loss of these rare species as the coastal slopes become increasingly unstable. This raises the question as to whether restoration would actually deliver a biodiversity gain in such circumstances.

6. *loss of historic and archaeological interests.* This is exemplified by the case of *Hengistbury Head*, a valuable habitat and earth heritage SSSI on the East Dorset coast. The Headland and surrounding area are designated as either a Scheduled Ancient Monument or of Archaeological Importance, being largely associated with Mesolithic campsites and the Bronze Age/Iron Age hill fort. Furthermore, the site is of great significance since it was used as an important port in the times of the Roman occupation till its abandonment in late Romano-British times. The archaeological record has barely been examined but what has been discovered has led to it being scheduled as an ancient monument.

   English Nature wished to see constantly eroding cliffs at the Headland, ultimately destroying the important Mesolithic and other sites. English Heritage, however, wished to see all coastal archaeological sites preserved for examination at a later date, rather than carrying out 'rescue digs'. This issue culminated in the creation of a Protocol signed by the then Chief Executives of both Government Agencies. The loss of coastal land will have to be managed in the future in such a way that all interested parties have an opportunity to complete academic research, studies of international importance or even rescue species known in a limited number of sites. (Bournemouth Borough Council, pers. comm.).

5 Restoring Biodiversity in Practice

Restoration Mechanisms

Under the current legislation and policy framework, there is a number of approaches available for restoring biodiversity to soft cliffs, including:

1. *"do nothing" or "walk-away" from existing defences* i.e. no further expenditure on maintenance and repairs (either by the coast protection authority or private owners). Over time the condition and performance of the defences will deteriorate, leading to structural failure, breaching and renewal of cliff foot erosion. This approach might be used where further investment in defences cannot be justified on economic grounds. The consequences of this approach are the potential environmental impacts of uncontrolled abandonment (e.g. health and safety, visual intrusion, loss of access, debris on the foreshore etc.);

2. *as mitigation for new coast protection schemes;* here, the full costs of restoring a site (land purchase, site development, removal operations and management costs) should be included with the overall scheme costs. This will allow a more rigorous appraisal as to whether the proposed scheme is economically viable. Mitigation should be planned at a strategic level, with biodiversity losses associated with scheme implementation and potential mitigation sites identified at an early stage in the decision-making process (i.e. within an SMP). Strategy studies could consider the biodiversity losses in more detail (i.e. through baseline surveys) and examine the issues that need to be resolve to ensure that mitigation sites can be efficiently and effectively restored.

3. *removal of defences paid for by local authorities*, under their general powers, with possible contributions from other bodies or organisations who might gain from the works. This is an untested mechanism and, to date, it is not clear whether or how the Government will make financial contributions to the implementation of HAPs.

4. *planned removal of new defences at the end of their design life;* here, the costs of future removal operations can be included within the application for grant-aid towards a proposed scheme. This, of course, is a longer-term solution. New defences have to be built (i.e. habitat loss) and come to the end of their life before the cliffs can be restored.

Ideally, the restoration process should involve a co-ordinated programme of activities, from strategic planning (SMPs and Strategic Implementation Plans), feasibility and options studies, planning the works to post-project evaluation. Clear and achievable goals need to be set. Amongst the key information/studies needed will be:

1. *baseline studies of the existing (i.e. defended) cliff and foreshore*, including:

- surveys of the existing habitats and biodiversity;

- assessment of geology/geomorphology, including slope conditions and foreshore character.

2. *prediction of the effects of renewal of marine erosion*, including:

- landslide/recession potential (i.e. what size, type and frequency of events might occur);

- the anticipated long-term cliff form and processes (i.e. a cliff behaviour model; see Rendel Geotechnics, in press);
- the consequences, in terms of increased risks and the habitats likely to develop;
- the need for introduction of species or whether a "do minimum" approach to habitat restoration would be needed.

3. *identification of the preferred approach to removing the defences and site management*; this should involve:

- assessment of the environmental implications of alternative working methods;
- assessment of the costs of alternative working methods;
- selection of the preferred option, including whether re-planting etc. might be necessary.

4. *establishment of a site monitoring programme*; clear objectives need to be defined (e.g. to monitor changes in cliff behaviour and habitats) before appropriate monitoring methods can be identified and selected.
5. *the site management works,* including defence removal works and any ground preparation.
6. *post-project evaluation*; periodic review of the effectiveness of the restoration process (based on the monitoring results) and identification of further operations that might be needed to secure the overall goals of the site restoration.

Simonson and Thomas (1999) identified a number of approaches for restoring or recreating lanscapes rich in biodiversity, from knowledge of the priority species-habitat associations:

- taking a particular *species* as a focus for considering a type of habitat mosaic, looking at what components of that mosaic are essential to that species. These can then be compared with the requirements of other species of the mosaic, and the landscape managed or designed on the basis of what these needs are;
- taking a priority or broad *habitat* and considering its associated species, together with other components in the landscape that these species use.

Effort should also be directed towards ensuring that cliff top habitats are managed in a manner that is sympathetic to the objectives of restoring the cliff habitats. For example, this might involve establishing buffer zone habitats or between the cliff top and arable land.

The Feasibility of A No Net Loss Policy

The Maritime Cliff and Slope HAP contains five targets, three of which are directly related to coast protection:

- to seek to maintain the existing maritime cliff resource of cliff top and slope habitat, of about 4000km;

- to maintain wherever possible, free functioning of coastal physical processes acting on maritime cliff and slope habitats;
- to seek to retain and where possible increase the amount of maritime cliff and slope habitats unaffected by coastal defence and other engineering works.

Table 9 Summary of the "best-guess" coast protection requirements for a sample of coast protection authorities: the South coast (based on discussions and review of the relevant SMPs)

Coast Protection Authority (west to east)	Protected cliffs (km)	Unprotected cliffs (km)	Future no. of protection sites	Protection overall length (km)	Future no. of Free-up sites	Free-up overall Free-up length (km)
West Dorset DC	3.5	38.5	0	0	2-3	0.5
Purbeck DC	5	45	2	1	1	0.2
Weymouth & Portland BC	3	14	0	0	1	0.3
Poole BC	19.57	9.42	0	0	1	1
Bournemouth BC	11	1.2	1	1.2	0	0
Christchurch BC	1.6	0.7	0	0	0	0
DORSET TOTAL	**40.67**	**94.82**	**3**	**2.2**	**4-5**	**1.7**
I. OF WIGHT TOTAL	**24**	**58**	**1**	**0.5**	**3**	**2.05**
New Forest DC	3.5	0.5	0	0	0	0
Southampton CC	0	0	0	0	0	0
Eastleigh BC	0	0	0	0	0	0
Fareham BC	0	0	0	0	0	0
Gosport BC	0	0	0	0	0	0
Portsmouth CC	0	0	0	0	0	0
Havant BC	0	0	0	0	0	0
HAMPSHIRE TOTAL	**3.5**	**0.5**	**0**	**0**	**0**	**0**
Chichester DC	0.35	0	0	0	0	0
Arun DC	0	0	0	0	0	0
Worthing BC	0	0	0	0	0	0
Adur DC	0	0	0	0	0	0
W. SUSSEX TOTAL	**0.35**	**0**	**0**	**0**	**0**	**0**
Brighton & Hove C	5.5	0	0	0	0	0
Wealden BC	0	5	1	0.05 – 0.2	0	0
Eastbourne	0	5.6	0	0	0	0
Lewes DC	5.95	9	1	1.5	0	0
Hastings BC	5	0	0	0	0	0
Rother	2.5	2.1	1	0.1	0	0
E. SUSSEX TOTAL	**18.95**	**21.7**	**3**	**1.65-1.8**	**0**	**0**
Shepway DC	5	1	0	0	0	0
Dover DC	10	7	0	0	1	1.4
Thanet DC	18.25	6.06	0	0	0	0
Canterbury	15	1.3	0	0	0	0
Swale	2.1	6.5	1	0.5	0	0
Medway C	0	0	0	0	0	0
KENT TOTAL	**50.35**	**21.86**	**1**	**0.5**	**1**	**1.4**
TOTAL – ALL COUNTIES	**140.82**	**210.88**	**8**	**4.85-5**	**8-10**	**5.45**

In order to achieve these targets, whilst retaining some flexibility, English Nature have advocated a policy of "no net loss". The success of this policy will be determined by the demand for new coast protection schemes (i.e. on what is now the undefended coast) and the actual realisation of "free-up" sites in time to mitigate against the effects of the new schemes.

Taking each of these factors in turn, a survey of coast protection authorities along the south coast (Dorset to the Thames) suggests a predicted demand for new coast protection works, probably in the order of 5km over the next 50 years (Table 9). When the absolute totals of future defended lengths are compared against future free-up (Table 7) the situation appears to be in balance, with a potential *net gain* in undefended cliff of around 0.25km, based on the assumption that the free-up sites identified could be implemented.

Table 10 Summary of the "best-guess" coast protection requirements for a sample of coast protection authorities: the East coast (based on discussions and review of the relevant SMPs)

Coast Protection Authority	Protected cliffs (km)	Unprotected cliffs (km)	Future no. of protection sites	Protection overall length (km)	Future no. of Free-up sites	Free-up overall Free-up length (km)
Cleveland & Redcar	5	10	1	0.3	0	0
Scarborough BC	70	15	4	1	2	0.3
East Riding DC	12	95	<5	Minimal	0	0
North Norfolk DC	23.6	10.5	10	15.1	7	8.5
Tendring DC	6	2	1	1	0	0
TOTAL – ALL AUTHORITIES	**116.6**	**132.5**	**21**	**17.4**	**9**	**8.8**

A similar survey of east coast authorities (Table 10) suggests a predicted demand for new coast protection works (i.e. on what is now the undefended coast), probably in the order of 17km over the next 50 years. This analysis suggests a *net loss* of some 8km over the next 50 years.

In summary, the future coast protection demand and "free-up" combined for the South and East coasts can be expected to be:

- a demand for some 22km of new coast protection works, mainly on the North Norfolk and North Yorkshire coast;
- the potential for freeing-up of 14km of currently protected cliffline, at some 16-18 sites.

This suggest that there would be a *net loss* of around 8km of maritime cliff and slope habitat over the next 50 years, compared with the current extent of the resource. However, it is possible that the future demand for schemes will be greater than that predicted by the coast protection authorities, primarily because of two trends:

1. *climate change and sea-level rise*; on the unprotected coast the average rate of erosion is likely to increase, possibly at a rate proportional to the ratio of the future sea-level rise to past sea-level rise. Bray and Hooke (1997) have predicted that soft cliff erosion on the south coast of England could increase by 20-130%, compared with current rates, over the next 50 years. Indeed, research undertaken by Ibsen and Brunsden (1993a,b) along the south coast of England concluded that "mass movement is seen to be increasing during the last century and that this is equally reflected in climatic data suggesting that the

landslide distribution is a real response to increasing precipitation". It seems likely that accelerated cliff recession and increased coastal landslide activity will lead to enhanced demands for coast protection.

2. *private schemes*; in recent years there has been an increasing number of privately funded schemes, reflecting the high values of cliff top properties and the relatively low cost of simple rock-armour revetment works (e.g. Cuckmere Coastguard Cottages and the proposed works at Birling Gap). This trend for increasing demand for private defences is likely to continue.

The above assessment assumes that all of the potential "free-up" sites are actually delivered as habitat restoration sites and at the right time to mitigate any habitat loss. However, this seems highly unlikely. There are signficant constraints to delivering even clearly uneconomic and marginal sites (Section 4). Table 11 provides a judgement of the likelihood of the 8-10 potential "free-up" sites on the South coast being delivered over the next 50 years (assuming the current legislation, policies and attitudes). Only the *Ham Common* site is considered "probable" to become a restoration site. It should also be noted that, in some cases, such as the potential sites identified in West Dorset (*Seatown, Ringstead Bay* and *Charmouth*) "free-up" probably would not occur (if at all) until towards the end of the 50 year time-span, as recent works have taken place.

Table 11 An indication of the likelihood of potential "free-up" sites becoming habitat restoration sites over the next 50 years (note these are judgements based only on a general awareness of the issues at each site, not a detailed appraisal).

Site	Likelihood	Comment
Seatown, Dorset	Possible	Scheme probably not economic beyond its design life.
Charmouth, Dorset	Possible-Unlikely	Although BCR is marginal, future erosion would affect the Heritage Centre and the access road to a small housing estate.
Ringstead Bay, Dorset	Possible-Unlikely	Scheme undertaken in the last 5 years, although it may not be repeated.
Bowleaze Cove, Dorset	Possible	Retreat is the SMP policy. However, studies required to identify how it can be achieved.
Durlston Cliff, Dorset	Probable-Possible	The SMP policy is "Hold the Line", but "Retreat the Line" in the long-term, once the building has reached the end of its life.
Ham Common, Dorset	Probable	No local resources available for removing the defences.
Norris Castle, Isle of Wight	Possible-Unlikely	Landowner would probably require compensation before agreeing to remove the wall.
Whitecliff Bay, Isle of Wight	Possible	Landowner would probably require "trade-offs" before agreeing to remove the structures. Caravan site would be at risk.
Priory Bay, Isle of Wight	Possible	Landowner would probably require "trade-offs" before agreeing to remove the structures. Caravan site would be at risk.
Kingsdown, Kent	Possible	Complex ownership and responsibility issues need to be overcome. Also increased risk to cliff top properties.

A significant issue that should not be overlooked is the feeling amongst some coast protection authorities that the potential "free-up" sites within their area represent "credit" for their own future schemes. The implications of this might include:

- an authority delaying the restoration of a site until it needs to provide mitigation measures for a proposed new coast protection scheme elsewhere within their area;
- there will be a reluctance to offer possible "free-up" sites as mitigation for proposed new schemes in other coast protection authority areas. Thus, what is available within a coast protection authority area, rather than the best "like-for-like" sites might drive the programme of mitigation.

It follows that a requirement for mitigation for proposed schemes might actually hinder the overall "no net loss" target, if coast protection authorities "bank" their potential "free-up" sites for future use in mitigation works.

Unless the current legislation, policies and attitudes change, it seems unlikely that the "no net loss" policy will be successful, because:

- future coast protection demand will keep pace with or, more likely, exceed the rate of restoration of maritime cliff and slope habitats through "free-up" of currently defended sites;
- "free-up" sites will not be available to directly compensate for coast protection schemes, as their release will be governed by decision-making over different timescales and by a range of interests;

It seems inevitable that there will be increased conflict between groups promoting coast protection and groups aiming to deliver HAP targets and other environmental objectives. As past experience has shown, a scheme that seeks to deliver a significant reduction in risk will have a significant impact on the cliff habitats. Thus, coast protection authorities are faced by difficult choices:

- not carry out coast protection measures and face considerable local political pressure;
- carry out environmentally unacceptable coast protection measures but provide replacement habitat elsewhere by abandoning existing defences or coming to agreement with another authority that they should abandon a section of their defences;
- seek to reduce the risks through other measures, such as the use of early warning systems. Such systems, however, are best suited to reducing risk to people, not property.

This highlights the rather limited tools available to local authorities for managing cliff recession and coastal landslide risks. At present, communities are either protected or they are not. This tends to intensify the pressure during the lobbying for defences. Often the argument is polarised between safeguarding local homes and businesses or contributing to national nature conservation targets, protecting people or solitary bees and wasps. To many it is clear that alternative risk management options are required. For example, the House of Commons Agriculture Committee wrote: "*we are firmly convinced of the need to put in place a robust financial mechanism for the reimbursement of property holders and landowners whose assets are sacrificed for the wider interests of the community*" (Agriculture Committee 1998).

Issues Associated with Restoring Biodiversity

Before considering possible ways forward in Section 5, it is necessary to raise and discuss a number of issues that should be important in shaping any future policies on restoring cliff habitats. These include:

1. *the potential biodiversity losses associated with "freeing-up" sites*; at a number of sites visited as part of this study, and many further sites around the coast, removal or abandonment of defences would lead to the loss of well-established habitats. For example, at Norris Castle, the defences protect a relict coastal slope that supports mature deciduous woodland. Elsewhere, recent breaching and loss of the defences at Gunard, Isle of Wight has begun to threaten a diverse habitat. At Tankerton, Kent, removal of the defences would lead to a loss of the important hogs fennel habitat. On the North Norfolk coast, cliff top habitat may also be lost if erosion re-commences.

2. *the timescales over which maritime cliff and slope habitats will develop*; as discussed in Section 2, the timescales over which a cliff will respond to renewed marine erosion will vary considerably. At some sites, the restoration of a "natural" habitat may occur within a few years. Elsewhere, it may require tens of years for the cliff system to develop a new characteristic form and suite of habitats. For example, at Black Ven, Dorset, the landslide system appears to operate on a 50-year cycle of slope steepening followed by mudslide activity (Brunsden and Chandler 1996).

3. *the limited biodiversity gains at some sites*; there is an assumption that biodiversity is high within soft cliffs and that by reactivating natural processes this will be increased. However, the biodiversity gain is likely to vary with cliff type. Common settings include:

    - rapidly eroding near-vertical simple cliffs (see Table 5), characterised by bare rock or soil with little vegetation (e.g. the sandy cliffs of Solent Breezes, Dunwich, Covehithe etc.);

    - slowly eroding landslide systems, characterised by extensive areas of bare ground and ponding. The relatively infrequent instability promotes natural succession (e.g. the London Clay cliffs of the Isle of Sheppey, Chale cliffs, Isle of Wight etc.).

    - inactive, relict landslide systems supporting mature vegetation (e.g. the Landslip Nature Reserve, East Devon).

    It follows that restoration of some sites may deliver only limited biodiversity gain.

    In addition, the diversity of the restored site will be influenced by the quality of the cliff top habitats.

4. *providing "like-for like" replacement habitat;* individual cliffs tend to be a unique, reflecting a combination of geology, geomorphology, climate, exposure and adjacent habitat "sources". In most instances, it will prove difficult to deliver comparable ground conditions and habitats to mitigate the effects of a coast protection scheme. For example, although 3 potential "free-up" sites have been identified on the Isle of Wight, none of them would provide similar habitats to those that might be lost at Castlehaven, within the Undercliff.

5. *the complementary earth science gains from restoring clifflines;* many cliffs are important for their earth science conservation value, as well as habitats. For example, some 75% of the eroding soft cliffs in England have geological SSSI designation along some of their length; 30% are internationally important, mainly stratotypes (sections which represent divisions of the geological column; Leafe and Radley 1994). Abandoning or removing defences will often generate important earth science conservation gains that should be taken into account. Indeed, in some instances, the earth science conservation gain might outweigh the biodiversity gain (e.g. Whitecliff Bay, Isle of Wight, where the existing defences prevent the opportunity to inspect the complete geological sequence from the Chalk to the Oligocene, including "type" horizons for the Bembridge Beds).

6. *the broader environmental damage associated with abandonment of defences;* the "do nothing" or "walk-away" option will often lead to significant adverse impacts on the environment, including:

   - the transport of fallen trees onto the foreshore and their subsequent removal by the sea will create a hazard to navigation (e.g. at Norris Castle);

   - the exposure of potentially contaminated fills and their subsequent erosion and transport along the foreshore (e.g. Kingsdown Rifle Range);

   - the negative visual impacts and health and safety implications of deteriorating structures on the foreshore (e.g. Whitecliff Bay).

   It follows that "controlled abandonment" would generally be preferrable to "do nothing". However, there exists no mechanism for the coast protection authority to receive resources for the costs of removing defences (note: removal of defences can be costed into applications for grant-aid for new schemes).

7. *the significant costs associated with removing defences;* it has not proved possible to develop reliable costings for removing defences, as costs will vary from site to site. As a general indication, a total figure of between £25-50per m^3 of defences would probably be appropriate for most sites. This estimate would include: general items (e.g. contractural items, site establishment, dayworks etc.), breaking and removal of materials from the foreshore (unless it had to be removed by sea), removal of slope works (e.g. retaining walls, drains etc.) and restoration works.

   However, it is clear that this would be a difficult operation at many sites, because of the limited access (materials may have to be removed by sea) and the need for breaking work on exposed foreshores. There may be additional costs associated with treatment and disposal of potentially contaminated fill materials (e.g. Kingsdown Rifle Range).

8. *the limited knowledge of soft cliff biodiversity*; at present very little information is available on the variability of biodiversity within different types of soft cliffs, apart from some individual site investigations. Before local authorities and English Nature can make decisions on the management and change of management for these cliff frontages, a full ecological assessment needs to be undertaken. Continued monitoring also needs to be undertaken to assess any change in biodiversity that has arisen through the change in management. Valuable information could be gained from an ecological assessment at the site of *Highcliffe* and *Naish Farm* cliffs near Christchurch. This site provides a defended and undefended stretch of soft cliff with identical geology, thus enabling to determine the

ecological impact of cliff stabilisation and drainage works. Comparative studies on sites such as this may provide the baseline data to some biodiversity improvements over time, these studies would also have to provide specific criteria for assessment and biological indicators to compare sites.

6 Discussion and Conclusions

The Way Forward

On paper, the solutions to the problems of restoring biodiversity are straightforward:

1. *increase the likelihood of the delivery of potential "free-up" sites*; this would probably require a partnership approach between coast protection authorities, private defence owners, planning authorities, English Nature and the Government. The aim would be to facilitate the abandonment or removal of uneconomic or marginally economic coast protection structures. To be successful this will probably need:

- trade-offs between the different interest groups. For example, private structures protecting a caravan site might be abandoned if the planning authority gave permission to develop adjacent landward areas i.e. they support a "*managed retreat*" strategy.

- resources for removing defences and managing sites. Here, it is probably important not to see "freeing-up" as a coast protection issue, rather a biodiversity restoration issue. It can be argued that if the nation wants to increase the biodiversity of soft cliffs, it should pay for it. Removing defences should not be done on an opportunistic basis, where MAFF grant-aid can be justified, rather given the backing of a dedicated source of funding.

- financial incentives to landowners and cliff top property owners to encourage them to accept a higher level of risk (or shorter occupancy period) than might normally be expected.

2. *reduce the demand for new coast protection structures;* this could involve:

- greater co-ordination between coast protection and planning authorities, to ensure that further development is not permitted in unprotected areas at risk from coastal erosion, over the lifetime of the development;

- the introduction of alternative cliff management strategies. For example, some form of reimbursement of property owners in high risk areas might prove to be a more efficient use of national resources than providing expensive and environmentally damaging coast protection schemes. Alternatively, mechanisms for facilitating the periodic re-siting of temporary development away from the cliff top risk zone may be necessary.

In practice, these solutions seem to be a long way off, requiring changes to both policy and attitudes. Perhaps the greatest barrier at present has the successive Government's reluctance to accept that "*compensation*" is in the national interest. In this context it is worth drawing attention to the recent (1998) decision of the US Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (OES) to provide a $1.3M grant to the property owners in Humboldt County, California. The money was allocated through the Hazard Mitigation Grant Program (HMGP; see Appendix A) for use to purchase 17 residential properties in the Big Lagoon landslide area that had been threatened by erosion as a consequence of the El Nino storms. The grant represented 75% of the appraised value. Any structures on the properties were demolished and the land, to be maintained by the County, will be kept as open space.

In France, the Law Barnier (2nd February 1995) authorises the ex-appropriation and compensation by the Government of all property threatened by natural risks when the remedial works are too expensive to undertake. Compensation is funded from a State Surcharge of 9% which is added to all property insurance premiums. A Risk Prevention Plan (PPR) determines the areas where a natural risk is foreseeable. The PPR is intended to allow action to be taken in advance by the proprietor and the local authority.

The PPR addresses natural risks such as flooding, avalanches, forest fires, ground movements, seismic activities and storms. The PPR can prohibit construction and other activities within a particular zone because it will be exposed to a risk or could aggravate it. Some remedial measures may be undertaken within such zones as long as the cost of the work does not exceed 10% of the total value of the asset. The PPR normally forms an appendix to the town planning document for the area concerned (a POS - Plan d'Occupation des Sols).

Attitudes of Key Interest Groups

Another significant barrier to overcome is the different attitudes of the key interests to coast protection. In general:

- *coast protection authorities* tend to have a presumption in favour of coast protection, provided the scheme can be shown to be technically sound, environmentally acceptable and economically viable. They are in the business of providing services for their local communities;

- *conservation bodies* tend to have a presumption against coast protection, unless it is in the over-riding national interest. They are advising the Government how best to deliver its environmental legislation, policies and targets.

In the past coast protection authorities have sought a compromise solution that delivers what is perceived to be an acceptable balance between risk reduction and environmental impacts. Hence, schemes have been put forward and then modified to address environmental objections. It is a common view that judgements have to be made about weight to be put on the environmental factors in particular cases. Sometimes the environmental costs (e.g. loss or degradation of nature conservation and earth heritage sites, and impacts on sediment budgets) may have to be accepted as the price for economic development, but on other occasions resources may be so valuable that they have to be protected from the potential effects of coastal defence works. The current conservation view appears to be that further environment losses are unacceptable and not to be traded off for limited gains in other areas. Solutions need to be found which provide an appropriate level of protection for both man-made and natural assets. The Habitats Regulations, HAPs and High Level Targets mark a shift in the conservation position, from minimising damage to ensuring that there is no net loss (and even net gain).

From a coast protection authority perspective, schemes such as Castle Cove, Isle of Wight, that include nature conservation objectives in the slope design may be viewed as a distinct improvement over "sterile" engineered cliffs i.e. a biodiversity gain. However, conservation bodies would tend to view such schemes as leading to a loss, albeit less of a loss than would otherwise have been the case. To use a simple metaphor, it is a question of whether the glass is half full or half empty.

There is a basic conflict between coast protection and Biodiversity (see Figure 6). It is not helpful to believe that there is an optimum scheme that can deliver acceptable risk reduction without environmental impact (see below). Where a compromise has been reached, this has reflected the need to reduce the scale and cost of the scheme on economic grounds than a willingness of the public to accept a higher level of risk (i.e. a shorter extension of life for their property) than would normally be the case, rather than the desire to protect or enhance the environment.

There are powerful obstacles to discouraging new coast protection works. From civil engineering consultants who help justify schemes, not from an independent perspective, but a biased one as they have an interest in generating income from design and construction projects. From local authorities, who have, on occasions, been more inclined to serve immediate local interests than longer-term national aspirations. From the public who, in general, tend to see erosion and loss of land as a "bad thing" which the nation should be able to "do something about". These attitudes are difficult to overcome. As O'Riordan (1981) and Penning-Rowsell (1986) have both suggested *"the invisible political power of influence through social and political connection is far more significant than the publicly documented expressions of pressures on decision-making".*

In contrast, others see coast protection as state intervention to address private problems, resulting in environmental degradation. From this perspective, coastal erosion is a predictable process for which the most appropriate response is avoidance.

These contrasting attitudes make partnership arrangements difficult to develop and sustain. Without agreed strategic positions on coast protection and restoring biodiversity, it is difficult to see beyond a continuation of the current site-by-site conflicts. Partnership between coast protection authorities and conservation bodies requires a convergence of views, not the polarisation that appears to have been taking place. Indeed, it is widely felt that an operating authority's permissive power to protect life and property is inconsistent with the mandatory duty to protect habitats.

Erosion Reduction Schemes

An often suggested solution to the conflict between coast protection and biodiversity loss is to construct schemes which slow down rather then stop cliff recession, providing a balance between risk reduction and maintaining conservation interest. Achieving such a compromise appears straightforward. Toe protection or slope stabilisation elements could be designed to be of lower efficiency than would be the case if "complete" protection were required. The crest heights of a revetment, breakwater or sill could be designed to permit overtopping by lower waves than would normally to the case, thus allowing cliff toe erosion to continue. Timber palisades or beach management could be used instead of seawalls.

There are, however, potential drawbacks to adopting a recession reduction strategy (Lee 1998):

1. it is difficult to define a predetermined rate of erosion that is acceptable to both property owners and conservationists. This is because there is no simple relationship between wave attack and the cliff foot erosion rate. In addition, it would be difficult to design a scheme that would deliver the target reduction in recession rate with any degree of confidence.

2. the cost of these recession reduction schemes may not decline as rapidly as their efficiency. Indeed, the performance of such schemes could be severely restricted if much of the erosion of the unprotected cliffs was in response to large waves or prolonged wet periods i.e. the scheme may control the regular small-scale recession events but not the less frequent larger events.

3. it is generally assumed that erosion reduction will maintain the conservation interest. But many soft cliffs are very sensitive to wave attack and there could be a significant reduction in landsliding even when only a limited amount of protection is provided. Once a slope is no longer seasonally active it can become heavily vegetated and degraded.

A note of caution is also raised by the practical experience of using "alternative" methods. At West Runton on the North Norfolk coast design modifications were agreed for two lengths of the wooden revetment which was to be installed 10 metres seaward of the toe of the cliffs, where an important section of Quaternary rocks was threatened by coast protection works in 1974 (Duff 1989). These involved the reduction in the number of facing planks in two lengths of the revetment, each about 150m long, in front of the two most critical parts of the geological section. The facing planks were reduced from 10 to 4, in the expectation that this would permit increased water flow through the revetment to allow the washing out of the sediment that would otherwise accumulate at the toe of the cliffs behind the revetment. The hope was that the revetment would substantially reduce the wave energy thereby slowing erosion, but would still allow gradual removal of fallen material. The scheme was monitored over a 3-year period (Clayton and Coventry 1986). It became apparent that neither the normal 10-plank nor the modified 4-plank revetments were successful in halting cliff erosion. The cliff was still attacked at the base sufficiently frequently to remain steep and unvegetated, and the geological exposures remained visible.

Conclusions

Maritime cliffs and slopes are the third ranked priority habitat in terms of the number of associated priority species (Simonson and Thomas 1999). A total of 36 priority species are associated with this habitat, with a further 59 priority species recorded as using the habitat. Often these are amongst the most natural habitats in Britain, not relying on active management to maintain the habitat mosaics and species diversity.

Over the last 100 years or so some 860km of coast protection works have been constructed to prevent cliff recession (MAFF 1994; this figure probably includes some low-lying areas prone to erosion). Many coast protection schemes are considered to have had significant impacts on the environment (Figure 6). Seawalls or rock revetments have been built which stop the recession process. Cliff faces and coastal slopes have been stabilised by drainage works, regraded and landscaped. As a result, geological exposures have become obscured, hardy grasses of little or no conservation value have replaced bare soil and early pioneer stages, and wet flushes have dried out. A significant proportion of the soft cliff resource has been affected, with loss of degradation of biological sites of national and international conservation value.

Maritime cliff and slope habitats have also been affected by land use changes on the cliff top (e.g. arable farming, caravan parks etc.), reducing the potential for the maintenance of diverse mosaics of species with active links between cliff face and top habitats.

Maritime cliff and slope and the littoral and sub-littoral chalk HAPs have introduced a "no net loss" policy for maritime cliff and slope habitats, with the aspiration of achieving, over time, a "net gain". In light of the continued demand for coast protection, there would need to be an abandonment of a matching or greater length of defences elsewhere i.e. habitat restoration.

This report has identified a number of key points that are relevant to the restoration of maritime cliff and slope habitats, including:

1. The restoration of maritime cliff and slope habitats can follow the abandonment or removal (i.e. *"free-up"*) of existing coast protection structures. In both cases, the renewal of marine erosion at the cliff foot will lead to the initiation of a new phase of cliff instability and generation of a new suite of habitats.

2. Under the current legislation and policy framework, there is a number approaches available for restoring biodiversity to soft cliffs, including:

- *"do nothing" or "walk-away" from existing defences* i.e. no further expenditure on maintenance and repairs (either by the coast protection authority or private owners);

- *as mitigation for new coast protection schemes;* here, the full costs of restoring a site (land purchase, site development, removal operations and management costs) should be included with the overall scheme costs;

- *removal of defences paid for by local authorities*, under their general powers, with possible contributions from other bodies or organisations who might gain from the works;

- *planned removal of new defences at the end of their design life.*

3. The restoration process should involve a co-ordinated programme of activities, from strategic planning (SMPs and Strategic Implementation Plans), feasibility and options studies, planning the works to post-project evaluation. Clear and achievable goals need to be set. Amongst the key information/studies needed will be: *baseline studies of the existing (i.e. defended) cliff and foreshore, prediction of the effects of renewal of marine erosion, identification of the preferred approach to removing the defences and site management; establishment of a site monitoring programme, the site management works and post-project evaluation.*

4. Effort should also be directed towards ensuring that cliff top habitats are managed in a manner that is sympathetic to the objectives of restoring the cliff habitats. For example, this might involve establishing buffer zone habitats or between the cliff top and arable land.

5. The new habitats generated after "free-up" will reflect a combination of the site geology, geomorphology, climate, exposure and adjacent habitat "sources" i.e. each site will tend to be unique. Cliff top habitats will need to be of good quality if they are to be a source of new vegetation or support life cycle stages of priority species.

6. As each site will be unique, it will prove difficult to deliver comparable (i.e. like-for-like) ground conditions and habitats to mitigate the effects of a coast protection scheme. For example, although 3 potential "free-up" sites have been identified on the Isle of Wight, none of them would provide similar habitats to those that might be lost at Castlehaven, within the Undercliff.

7. The biodiversity gains associated with "free-up" may be limited in some settings. For example, on rapidly eroding near-vertical simple cliffs (see Table 5) which will give rise to bare rock or soil with little vegetation.

8. There may be biodiversity losses associated with "freeing-up" sites. Defences may protect coastal slopes that support mature woodland habitats. In other settings, cliff top habitat may also be lost if erosion re-commences.

9. There is a limited number of potential "free-up" sites on the south and east coasts of England. Indeed, a survey of coast protection authorities suggested the potential for freeing-up of 14km of currently protected cliffline, at some 16-18 sites. However, there will be an increasing number of sites where the current defences will simply be abandoned as being too expensive to maintain, suggesting that there may be more potential restoration sites (i.e. uneconomic or marginally economic sites).

10. There are significant constraints to delivering potential "free-up" or other uneconomic or marginally economic sites. Notably these include legal issues (the potential implications of the Holbeck Hall judgement on local authorities should not be underestimated; Lee 1999), health and safety issues, local political pressures and attitudes, potential environmental impacts and the limited availability of resources.

11. The anticipated future demand for new coast protection schemes is for a further 22km of new coast protection works, mainly on the North Norfolk and North Yorkshire coast. This suggest that there would be a *net loss* of around 8km of maritime cliff and slope habitat over the next 50 years, compared with the current extent of the resource.

12. The future demand for schemes may be greater than that predicted by the coast protection authorities. This is because of two trends: *climate change and sea-level rise* (it has been suggested that soft cliff erosion on the south coast of England could increase by 20-130% over the next 50 years) and an increasing demand for constructing *private schemes* (e.g. Cuckmere Coastguard Cottages and the proposed works at Birling Gap). If this prediction proves true, the estimated net loss would be greater than that suggested above.

13. There is a prevailing view amongst some coast protection authorities that the potential "free-up" sites within their area represent "credit" for their own future schemes (i.e. site banking). The implications of this might include an authority delaying the restoration of a site until it needs to provide mitigation measures for a proposed new coast protection scheme elsewhere within their area. In other settings, there will be a reluctance to offer possible "free-up" sites as mitigation for proposed new schemes in other coast protection authority areas.

14. The possible solutions to the problems of restoring biodiversity appear relatively straightforward:

- *increase the likelihood of the delivery of potential "free-up" sites*; this would probably require a partnership approach between coast protection authorities, private defence owners, planning authorities, English Nature and the Government. To be successful this will probably need trade-offs between the different interest groups, resources for removing defences and managing sites and financial incentives to landowners and cliff top property owners to encourage them to accept a higher level of risk (or shorter occupancy period) than might normally be expected;

- *reduce the demand for new coast protection structures;* this could involve greater co-ordination between coast protection and planning authorities, to ensure that further development is not permitted in unprotected areas at risk from coastal erosion, the introduction of some form of reimbursement of property owners in high risk areas. The latter might prove to be a more efficient use of national resources than providing expensive and environmentally damaging coast protection schemes.

15. A major obstacle to achieving Biodiversity targets is the contrasting attitudes to coastal erosion within society. Many feel that loss of land is unacceptable and needs to be resisted by public investment in coast protection. This "fortress Britain" attitude is in marked contrast to the view that the erosion process is necessary for maintaining the natural beauty of the coastline (the "living coast" view). To this group coastal defence leads to environmental degradation and should only be contemplated where there is an over-riding national need. The "living coast" view reflects current legislation and Government policies. However, the "fortress Britain" view has considerable popular support, ensuring that there will be a continued demand for coast protection schemes and a resistance to the abandonment of current defences.

16. If Biodiversity targets, and other related environmental objectives are to be reached, there needs to be a convergence of attitudes and a partnership approach to delivering acceptable approaches to managing coastal erosion risks. Integrated Coastal Zone Management may prove to be the vehicle for achieving this.

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Appendix A: Habitat Action Plans

Maritime cliff and slopes

Habitat Action Plan

1. Current status

1.1 Physical and biological status

1.1.1 Maritime cliffs and slopes comprise sloping to vertical faces on the coastline where a break in slope is formed by slippage and/or coastal erosion. There appears to be no generally accepted definition of the minimum height or angle of slope which constitutes a cliff, but the zone defined as cliff-top (also covered in this plan) should extend landward to at least the limit of maritime influence (ie limit of salt spray deposition), which in some exposed situations may continue for up to 500 m inland. This plan may therefore encompass entire islands or headlands, depending on their size. On the seaward side, the plan extends to the limit of the supralittoral zone and so includes the splash zone lichens and other species occupying this habitat. Approximately 4000 km of the UK coastline has been classified as cliff.

1.1.2 Cliff profiles vary with the nature of the rocks forming them and with the geomorphology of the adjoining land. While most maritime cliffs have been formed by coastal erosion, steep slopes falling to the sea in mountainous districts may have been formed long before the sea level reached its present position; in such cases only the lower part of the slope will have been steepened by the sea.

1.1.3 Maritime cliffs can broadly be classified as 'hard cliffs' or 'soft cliffs', though in practice there are a number of intermediate types. Hard cliffs are vertical or steeply sloping; they are inclined to support few higher plants other than on ledges and in crevices or where a break in slope allows soil to accumulate. They tend to be formed of rocks resistant to weathering, such as granite, sandstone and limestone, but can be formed of softer rocks, such as chalk, which erode to a vertical profile. Soft cliffs are formed in less resistant rocks such as shales or in unconsolidated materials such as boulder clay; being unstable they often form less steep slopes and are therefore more easily colonised by vegetation. Soft cliffs are subject to frequent slumping and landslips, particularly where water percolates into the rock and reduces its effective shear strength.

1.1.4 The vegetation of maritime cliff and slopes varies according to several factors: the extent of exposure to wind and salt spray, the chemistry of the underlying rock, the water content and stability of the substrate and, on soft cliffs, the time elapsed since the last movement event. Cliff-top habitats can also be transformed by soil erosion processes.

1.1.5 Vegetation of a strictly maritime nature occurs where exposure to the waves and winds is at its greatest. In the UK, such conditions are found principally on the northern and south-western coasts. In extreme conditions, such as on the Isle of Lewis, saltmarsh vegetation can occur on cliff-tops. In other areas, where cliffs occur adjacent to sand dunes, sufficient wind blown sand can accumulate on the cliff-tops to allow cliff-top dune vegetation to develop (perched dunes). On exposed hard cliffs giving little foothold to higher plants, lichens are often the predominant vegetation. Ledges on such cliffs support a specialised flora with species such as rock samphire *Crithmum maritimum* and rock sea spurrey *Spergularia rupicola* in the south and Scots lovage *Ligusticum scoticum* and in the north. Seabird nesting ledges enriched by guano support a particular community characterised by oraches *Atriplex* spp and sea beet *Beta vulgaris* ssp *maritima*. Maritime grasslands occur on cliffs and slopes in less severely exposed locations; a maritime form of red fescue *Festuca rubra* is a constant component, together with maritime species such as thrift *Armeria maritima*, sea plantain *Plantago maritima*, buck's-horn plantain *P. coronopus* and sea carrot *Daucus carota* ssp *gummifer*. Species of inland grasslands which also commonly occur in maritime grasslands include ribwort plantain *Plantago lanceolata*, bird's-foot trefoil *Lotus corniculatus*, common restharrow *Ononis repens* and several species of grass.

1.1.6 On cliffs and slopes which are more sheltered from the prevailing winds and salt spray, the vegetation communities are more similar to those found inland, and are increasingly influenced by the chemistry of the substrate. Calcareous grassland communities with a few maritime specialist species occur on sheltered chalk or limestone cliffs. The upper sections and cliff-tops of hard cliffs on acidic rocks may support maritime heaths characterised by heather *Calluna vulgaris*. Mobile soft cliffs support a wide range of vegetation from pioneer communities on freshly exposed faces through ruderal and grassland communities to scrub and woodland. Wet flush vegetation commonly occurs on soft cliffs where groundwater issues as seepage.

1.1.7 Maritime cliffs are often significant for their populations of breeding seabirds, many of which are of international importance. Some 70% of the international population of gannet *Morus bassanus* and important proportions of the European populations of shag *Phalacrocorax aristotelis*, razorbill *Alca torda* and guillemot *Uria aalge* nest colonially on cliff ledges whilst significant populations of Manx shearwater *Puffinus puffinus* and puffins *Fratercula arctica* nest in burrows in turf on cliff-tops or slopes. Coastal cliffs are also important for crag nesting species, such as raven *Corvus corax* and peregine *Falco peregrinus*, and cliff-top vegetation may provide important feeding grounds for chough *Pyrrhocorax pyrrhocorax*.

1.1.8 Hard cliffs are widely distributed around the more exposed coasts of the UK, occurring principally in south-west and south-east England (the latter area having the bulk of the 'hard' chalk cliffs), in north-west and south-west Wales, in western and northern Scotland and on the north coast of Northern Ireland. Soft cliffs are more restricted, occurring mainly on the east and central south coasts of England and in Cardigan Bay and north-west Wales. There are also examples on the coasts of Fife and Skye in Scotland and Antrim in Northern Ireland.

1.1.9 Soft cliffs provide important breeding sites for sand martins *Riparia riparia*, which burrow into soft faces exposed by recent slippages, but they are particularly important for invertebrates as they provide a suite of conditions which are rarely found together in other habitats. The combination of friable soils, hot substrates and open conditions maintained by cliff slippages offer a continuity of otherwise very restricted microhabitats and these support many rare invertebrates which are confined to such sites. These include the ground beetle *Cicindela germanica*, the weevil *Baris analis*, the shore bug *Saldula arenicola*, and the Glanville fritillary *Melitaea cinxia*.

1.1.10 Seepages, springs and pools are a feature of many soft cliff sites and these provide the wet muds required by many species of solitary bees and wasps for nest building. They also support rich assemblages of other invertebrates including many rare species which are confined to this habitat. These include the craneflies *Gonomyia bradleyi* and *Helius hispanicus*, and the water beetle *Sphaerius acaroides*.

1.1.11 The hard coastal cliffs of west Britain supports a western oceanic invertebrate assemblage of European significance. Important species include the snail *Ponentina subvirescens*, weevils such as the highly restricted *Cathormiocerus attaphilus* and moths such as Barrett's marbled coronet *Hadena luteago*. Other species are confined to certain rock types. For example, the fiery clearwing *Bembecia chrysidiformis* is restricted to the chalk cliffs of Kent and Sussex and the water beetle *Ochthebius poweri* occurs predominantly in small seepages on red sandstone cliff faces in south-west England and south Wales.

1.1.12 The supralittoral zone represents the lowest belt of terrestrial vegetation on maritime cliffs and is usually exemplified by a zone of orange and grey maritime lichens. The zone tends to be dominated by species such as *Caloplaca marina*, *Ramalina siliquosa* and *Verrucaria maura*, but may also include uncommon species such as *Roccella filiformis* and *R. phycopsis*.

1.2 Links with other action plans

1.2.1 The lowland heathland and littoral and sublittoral chalk habitat action plans have objectives and actions which are relevant to this plan.

1.2.1 The following BAP priority species have significant populations on maritime cliffs:

Bombus humilis Brown-banded carder bee

Bombus ruderatus Large garden bumble bee

Lasioglossum angusticeps a mining bee

Osmia xanthomelana a mason bee

Cathormiocerus britannicus a weevil

Cicindela germanica a tiger beetle

Caloplaca aractina a lichen

Heterodermia leucomelos Ciliate strap-lichen

Acaulon triquetrum Triangular pygmy moss

Lygephila craccae Scarce blackneck

Polymixis xanthomista statices Black-banded moth

Zygaena loti scotica Slender scotch burnet

Zygaena viciae New Forest Burnet

Asparagus officinalis ssp prostratus Wild asparagus

Coincya wrightii Lundy cabbage

Euphrasia campbelliae an eyebright

Euphrasia rotundifolia an eye bright

Limonium (endemic taxa) Sea lavender

Rumex rupestris Shore dock

2. Current factors affecting the habitat

2.1 **Erosion**. Erosion is a highly significant factor in soft cliffs. High rates of erosion do not imply a loss of the cliff resource, either in geological or biological terms. Cliff face communities are able to retreat with the cliff line, and erosion is vital for constantly renewing geological exposures and recycling the botanical succession on soft cliffs. However, cliff-top vegetation may be destroyed where it is squeezed between a receding cliff face and cultivated land. Cliff erosion in many places provides an essential supply of sediment to coasts lying down-drift of the cliffs.

2.2 **Coastal protection**. Coastal protection systems have been built on many soft cliff coasts in order to slow or stop the rate of erosion and thus protect capital assets behind the cliff line. Cliff faces may also be re-profiled and sown with hardy grasses of little value for nature conservation. All such works have the effect of stabilising the cliff face, resulting in geological exposures being obscured, bare soil and early pioneer stages being progressively overgrown, and wet flushes drying out. A MAFF survey in 1994 identified over 90 km of new cliff protection works likely to be needed in the next 10 years, resulting in a potential loss of 36% of the remaining soft cliff resource. Additional effects of such defences include both accelerated erosion and sediment starvation at coastal sites down-drift of defended sites. It has been estimated that sediment inputs may have declined by as much as 50% over the past 100 years due to cliff protection works.

2.3 **Built development**. There have been many instances in the UK of urban or industrial development and holiday accommodation being built too close to cliff-tops. Where the cliffs are subsequently discovered to be eroding, there is often political pressure to build the type of defensive works described above. Built development also prevents cliff-top biological communities from retreating in response to cliff erosion, subjecting them to a form of 'coastal squeeze'.

2.4 **Agriculture**. In traditional low-intensity grazing systems, livestock were grazed on cliff grasslands where they maintained open maritime grassland vegetation. Post-war intensification of agriculture has led to maritime grassland on more level terrain being ploughed out, while that on sloping ground has been abandoned and, where not maintained by exposure, is frequently overgrown by scrub. Localised eutrophication can be caused by fertiliser run-off from arable land above and this encourages coarse, vigorous 'weed' species at the expense of the maritime species. Agricultural land drains discharging on the cliff face may cause local acceleration of erosion.

2.5 **Recreational use**. The siting of holiday accommodation on cliff-tops not only reduces the landscape value of a site, but can also cause heavy localised erosion and disturbance to nesting birds. An increase in the number of walkers and dogs along some coastal footpaths has increased livestock worrying and even losses and forced a number of farmers to remove their stock from these sites. Consequently, some of the sites are now suffering from a lack of appropriate grazing, and scrub encroachment is likely to become a problem.

2.6 **Introduced species**. Predators, such as cats and rats, can have a significant impact on populations of cliff or burrow nesting seabirds, particularly on island sites. Also the spread of certain alien, invasive plants, especially members of the flowering plant family Aizoaceae such as the hottentot fig *Carpobrotus edulis,* can have a devastating impact on indigenous maritime plant communities.

3. Current action

3.1. Legal status

3.1.1 A high proportion of the hard cliff coast in England has been notified as SSSIs, and in areas such as the south-west of England almost the whole cliffed coast has been notified. Notification of soft cliffs has been less extensive, but areas such as north-west Norfolk and the Isle of Wight have a high proportion of their soft cliffs notified. In Wales approximately half of the total maritime cliff resource has been notified as SSSIs, but as yet only a small proportion has been notified as ASSIs in Northern Ireland. Nine lengths of coastline in the UK have been nominated as 'Vegetated sea cliffs of the Atlantic and Baltic coasts' candidate Special Areas of Conservation (SAC) under the EC Habitats Directive for their cliff features (two of which include substantial representation of soft cliffs). Under the EC Birds Directive, 38 Special Protection Areas (SPA) in the UK have been designated which include cliff sites - these comprise 30 sites in Scotland, 5 in Wales, 2 in England, and 1 in Northern Ireland.

3.2 Management, research and guidance

3.2.1 The UK Government has set out its commitment to sustainable management of the coast in a number of publications. These include the DETR *Policy Guidelines for the Coast* and *Planning Policy Guidance - Coastal Planning* (PPG 20), the Scottish Office *Coastal Planning* (NPPG 13), and the Welsh Office Technical Advice Note 14 *Coastal Planning*. The DoENI *Planning Strategy for Rural Northern Ireland* has provisions relating to development, access and conservation of the coast. MAFF and the Welsh Office have also produced a *Strategy for Flood and Coastal Defence in England and Wales* and the DETR has produced *Coastal Zone Management - Towards Best Practice.*

3.2.2 The DETR Coastal Forum was set up in 1994; similar fora have recently been initiated in Scotland and Wales. Certain coastal fora have also been set up by the country nature conservation agencies. These include the Estuaries Initiative, in England, Focus on Firths in Scotland, and in Wales an independent partnership of coastal practitioners (Arfordir). More general countryside management initiatives (Tir Cymen and the Habitats Scheme in Wales and Countryside Stewardship in England) offer options applicable to grazing management of cliff grassland. Recent figures show that 104 ha of cliff grassland had been entered into Tir Cymen, and 184 ha in to the Habitats Scheme, but no separate figures are available for cliff land entered into Countryside Stewardship. The Tir Cymen pilot scheme which was restricted to just a few areas in Wales has been superseded by an all-Wales agri-environment scheme (Tir Gofal).

3.2.3 Over 700 km of cliff coastline in England, Wales and Northern Ireland is owned by the National Trust, who are actively reinstating grazing on many of these properties. Other non-governmental organisations, such as RSPB and the Wildlife Trusts, own or manage a number of other important maritime cliff sites. A large proportion of the cliff coast of south-west England and western Wales is within designated Heritage Coasts, while three National Parks (North York Moors, Exmoor and Pembrokeshire Coast) include cliffed coastlines. A number of cliff coasts in western Scotland are within National Scenic Areas. These designated areas often have the benefit of a warden/ranger service which encourages appropriate management and control of damaging activities, and provides interpretative and educational services.

3.2.4 Shoreline Management Plans and the work of their associated Coastal Groups will provide one of the main mechanisms for ensuring that the requirements of this plan are carried foreward.

3.2.5 A Sea Cliff Management Handbook was produced jointly by the University of Lancaster, JNCC and the National Trust in 1991, and in 1998 The National Trust produced a report entitled *Grazing Sea Cliffs and Dunes for Nature Conservation.*

4. Action plan objectives and proposed targets

The research and survey outlined in Section 5.5 will provide a basis for developing more specific targets and objectives. In particular, research into the options for removal/abandonment of existing defences may allow further definition of objective 4.3.

4.1 Seek to maintain the existing maritime cliff resource of cliff-top and slope habitat, of about 4000 km.

4.2 Maintain wherever possible free functioning of coastal physical processes acting on maritime cliff and slope habitats.

4.3 Seek to retain and where possible increase the amount of maritime cliff and slope habitats unaffected by coastal defence and other engineering works.

4.4 Increase the area of cliff-top semi-natural habitats by at least 500 ha over the next 20 years.

4.5 Improve by appropriate management the quality of at least 30% of the maritime cliff and slope habitats, including cliff-top vegetation, by 2010, and as much as possible before 2015.

5. Proposed action with lead agencies

5.1 Policy and legislation

5.1.1 Promote sea defence and coastal protection policies which encourage the free functioning of the coastal physical processes of maritime cliffs wherever possible. (ACTION: DANI, DoE(NI), EA, LAs, MAFF, NAW, SE)

5.1.2 In the light of research findings, give consideration to how planning policy might discourage new built development within appropriate buffer zones in the vicinity of retreating cliff-tops. (ACTION: CCE, DETR, DoE(NI), EHS, EN, LAs, NAW, SE, SNH)

5.1.3 Look into the feasibility of developing provisions within the planning systems to encourage the re-siting of housing and holiday developments which are vulnerable to cliff erosion. This will be initiated on completion of the research outlined in 5.5.3. (ACTION: DETR, DoE(NI), NAW, SE)

5.1.4 Where appropriate promote agri-environment schemes which encourage management and restoration of maritime grassland, heathland and other cliff-top habitats. (ACTION: CCW, DANI, MAFF, NAW, SE, SNH)

5.2 Site safeguard and management

5.2.1 By 2004 apply conservation designations to all remaining areas of maritime cliff and slopes which meet national or international criteria and ensure appropriate management of all designated sites. (ACTION: CCW, EHS, EN, SNH)

5.2.2 Encourage a presumption against stabilisation of any cliff face except where human life, or important natural or man-made assets, are at risk. (ACTION: DANI, DoE(NI), LAs, MAFF, NAW, SE)

5.2.3 Where stabilisation of a cliff face is necessary (as defined in 5.2.2), ensure adequate mitigation and/or compensation to maintain the overall quantity and quality of maritime cliff and slopes habitat. (ACTION: CCW, DANI, DoE(NI), EHS, EN, LAs, MAFF, NAW, SE, SNH)

5.2.4 Encourage the increased use of soft (eg foreshore recharge) rather than hard engineering techniques where some degree of cliff stabilisation is essential. (ACTION: MAFF, DANI, DETR, DoE(NI), LAs, NAW, SE)

5.2.5 Consider non-replacement of coastal cliff defences which have come to the end of their useful life. (ACTION: MAFF, DANI, DETR, DoE(NI), LAs, NAW, SE)

5.2.6 Promote the management of maritime grassland and heath habitats by scrub control and grazing where appropriate, through relevant agri-environment schemes and management agreements. (ACTION: CCW, DANI, EHS, EN, MAFF, NAW, SE, SNH)

5.2.7 Conduct operations to remove rats, cats or other introduced predators affecting breeding seabirds on maritime cliff and slope sites, identified by 'Seabird 2000' and other surveys. (ACTION: CCW, EHS, EN, SNH)

5.2.8 Assess the impact of agricultural land drainage on maritime cliffs and slopes, especially in SACs, and carry out a review of the effectiveness of the current consents procedure. (ACTION: MAFF)

5.3 Advisory

5.3.1 Encourage by 2002 the adoption of policies and practices in the engineering management of soft cliffs which are sympathetic to the nature conservation interest, by preparing and disseminating 'best practice' guidance material. (ACTION: DANI, EA, MAFF, NAW, SE)

5.3.2 Encourage by 2002 appropriate habitat management of maritime cliff and slope habitats by preparing and disseminating 'best practice' guidance material. (ACTION: CCW, EHS, EN, SNH)

5.4 International

5.4.1 Promote the exchange of information on maritime cliff ecology and management among European maritime states through the European Union for Coastal Conservation and Eurosite. (ACTION: CCW, EHS, EN, JNCC, SNH)

5.5 Monitoring and research

5.5.1 By 2003 commission a literature review and full survey of the maritime cliff and slope resource in the UK to assess its relative conservation value, how much can be improved by alternative management, and to what extend it is affected by coastal defence and engineering works. (ACTION: CCW, EHS, EN, JNCC, SNH)

5.5.2 By 2003 commission a study to identify areas in the UK suitable for the re-creation of maritime grasslands and heathlands. (ACTION: CCW, EHS, EN, JNCC, SNH)

5.5.3 By 2003 commission a study to identify possible coastal and sea defence strategies that may be more sympathetic to the nature conservation interests of maritime cliffs, and identify stretches of coastline where such sympathetic modifications are feasible. (ACTION: DoE(NI), EA, MAFF, NAW, SE)

5.5.4 By 2003 implement a baseline study to determine the extent and quality of the maritime cliff and slope resource in the UK in order to enable the effective assessment of progress towards meeting the objectives of this plan. (ACTION: CCW, EHS, EN, JNCC, SNH)

5.5.5 By 2003 complete an assessment of the maritime cliff sites in the UK where the native flora and fauna is being affected by introduced species. (ACTION: CCW, EHS, EN, SNH)

5.5.6 Carry out an evaluation of cliff erosion and how its contribution to the marine sediment budget could be affecting other key habitats. (ACTION: MAFF)

5.5.7 Carry out an assessment of how the conservation interest of maritime cliffs may be affected by climate change. (ACTION: CCW, EHS, EN, MAFF, SNH)

5.5.8 By 2003, in order to meet objective 4.3, develop an inventory of coastal defences that impact on maritime cliff and slope habitats and identify the most appropriate defences for removal. (ACTION: CCW, EA, EHS, EN, SNH)

5.6 Communications and publicity

5.6.1 Raise public awareness of the mobile nature of soft cliffs and the value of maintaining unrestricted coastal processes. (ACTION: CCW, EHS, EN, SNH)

5.6.2 Promote awareness of the implications of the policies outlined in this plan among coastal Local Authorities, and ensure that the relevant details are incorporated into coastal zone management plans including Shoreline Management Plans. (ACTION: CCW, DETR, EHS, EN, MAFF, NAW, SE, SNH)

5.6.3 Raise public awareness of the potential damage that can be inflicted on the native flora and fauna of maritime cliffs by introduced species. (ACTION: CCW, EHS, EN, SNH)

6. Costings

6.1 The successful implementation of this habitat action plan will have resource implications for both the public and private sectors. The data in the table below provide an estimate of the current expenditure on the habitat, primarily through agri-environment schemes, and the likely additional resource costs to the public and private sectors. These additional resource costs are based on the annual average over 5 and 10 years. The total expenditure for these time periods is also given. Three-quarters of the additional resources are likely to fall to the public sector.

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Costings for maritime cliff and slopes

	Current expenditure	**1st 5 yrs to 2004/2005**	**Next 10 yrs to 2014/2015**
Current expenditure /£000/Yr	416.8		
Total average annual cost /£000/Yr		330.1	596
Total expenditure to 2005/£000		1650.5	
Total expenditure 2005 to 2014/£000			5960

Littoral and sublittoral chalk
Habitat Action Plan

1. Current status

1.1 Physical and biological status

1.1.1 Chalk is a relatively soft and friable, easily eroded, sedimentary rock laid down in the Upper Cretaceous period. There are three main types of chalk (Upper, Middle, Lower) which differ in hardness and also content of flint (a siliceous rock deposited along bedding planes or vertical joints in chalk strata). Chalk at Flamborough Head (North Humberside) is notably different in being particularly hard due to compression by overlying strata and by glaciation. On the Isle of Wight and in Dorset, chalk is vertically bedded in contrast to horizontal bedding elsewhere.

1.1.2 Coastal chalk is exposed principally in the south and east of England from Dorset in the west to Flamborough Head in the north. Marine and subaerial erosion of chalk has resulted in the formation of vertical cliffs and gently sloping shore platforms. The most extensive areas of littoral and sublittoral chalk occur in Kent and Sussex. In Britain, chalk forms less than 0.6% (113 km) of the coastline. In Northern Ireland, Upper Cretaceous chalk deposits belong to the Ulster White Limestone Formation with exposures on the County Antrim coast. The Northern Ireland chalk forms extremely hard, low porosity deposits with subsequent erosion forming cliffs and shore platforms, dominated by cobble and boulder spreads with subtidal reefs. Faults on the seabed offshore have also exposed Cretaceous deposits.

1.1.3 The greatest proportion of European coastal chalk (57%) and many of the best examples of littoral and sublittoral chalk habitats are located on the coast of England and the UK has an international responsibility to ensure the conservation of this scarce habitat.

1.1.4 Characteristic features of chalk coastlines are their geomorphological formations, such as cliffs and reefs, which create a range of micro-habitats of biological importance. Littoral-fringe and supralittoral chalk cliffs and sea-caves support algal communities unique to the substrate which comprise members of the Chrysophyceae and Haptophyceae such as *Apistonema carterae* and *Chrysotila* spp. Their restricted presence may be due to physical characteristics of chalk particularly its porosity and ability to remain moist. The generally soft nature of chalk results in the presence of a characteristic flora and fauna, notably rock-boring invertebrates such as the spionid worm *Polydora* sp and piddocks. Littoral chalk also characteristically lacks species common on hard rocky shores (eg *Pelvetia canaliculata* and *Ascophyllum nodosum*), but supports distinct successive zones of algae and animals such as *Fucus* spp, kelps *Laminaria* spp and red algal turfs, or barnacles and mussels on wave-exposed shores.

1.1.5 In south-east England infralittoral communities are limited or absent, and animal-dominated circalittoral communities occur in relatively shallow waters due to local high turbidity. At Flamborough, the Isle of Wight and Studland, infralittoral communities are more diverse and extend into deeper waters. Chalk habitats, especially in south-east England, are intrinsically low in species-richness due to the unusual friable and easily eroded nature of chalk and the prevailing harsh environment, characterised by extreme water temperatures, high levels of turbidity, siltation and scouring.

1.2 Links with other action plans

1.2.1 The actions of this plan are linked closely to those of the maritime cliff and slopes habitat action plan. In both plans attention is drawn to the need for avoiding non-sustainable coastal defence works and of raising awareness of the biodiversity and dynamic nature of these habitats and their role in coastal processes.

2. Current factors affecting the habitat

2.1 A recent survey of chalk cliffs throughout England revealed that 56% percent of coastal chalk in Kent and 33% in Sussex has been modified by coastal defence and other works. On the Isle of Thanet (Kent) this increases to 74% and has resulted in the loss of a wide range of micro-habitats on the upper shore and the removal of splash-zone communities. There has been less alteration of chalk at lower shore and subtidal levels, although large ports have been developed at Dover and Ramsgate with harbour developments at Margate, Folkestone, Newhaven and Brighton Marina. Elsewhere in England, coastal chalk remains in a largely natural state.

2.2 The deterioration of water quality by pollutants and nutrients has caused respectively the replacement of fucoid dominated biotopes by mussel-dominated biotopes, and the occurrence of nuisance *Enteromorpha* spp blooms.

2.3 A potential factor affecting the chalk biota is human disturbance of littoral plant and animal communities especially by trampling, stone-turning, small-scale fishery, and damage to rocks through removal of piddocks. Chalk exposures in the Strait of Dover are also vulnerable to oil spills due to the proximity of major shipping lanes.

2.4 Research has indicated that native species along the English Channel have been displaced by the incursion of non-native species. For example, *Sargassum muticum, Polysiphonia harveyi* and *Undaria pinnatifida*.

2.5 Sea level rise and post-glacial land adjustment will submerge a greater area of littoral (intertidal) chalk platform. MAFF have predicted an increase of 6 mm per annum for south-east England.

3. Current action

3.1 Legal status

3.1.1 Through the Wildlife and Countryside Act 1981 a large proportion (75%, 17 sites) of coastal chalk has been notified as SSSIs. However, the SSSI designation does not confer protection to sublittoral habitats and until recently the conservation of important subtidal sites was dependent on non-statutory initiatives. For example, subtidal chalk habitat has been included within Sensitive Marine Areas and Voluntary Marine Conservation Areas (VMCA) such as the Seven Sisters VMCA off East Sussex.

3.1.2 The statutory protection of littoral and sublittoral chalk habitats is now possible at four sites, Flamborough Head, Thanet Coast, South Wight and Rathlin Island, through their candidature as SACs. These locations have been nominated as SACs under the EC Habitats Directive because they include the qualifying interests of reefs and submerged or partly submerged sea caves. A further candidate SAC that includes chalk habitats has been proposed for the South Wight Maritime.

3.1.3 Discharges to the sea are controlled by a number of EC Directives, including the Dangerous Substances, Shellfish (Waters), Integrated Pollution Control, Urban Waste Water Treatment, and Bathing Waters Directives. The Oslo and Paris Convention (OSPAR) and North Sea Conference declarations are also important. These commitments provide powers to regulate discharges to the sea and have set targets and quality standards to marine waters. An extensive set of standards covering many metals, pesticides and other toxic, persistent and bioaccumulative substances, and nutrients have been set under UK legislation.

3.1.4 The proposed European Water Framework Directive aims to rationalise much of the EC's water legislation with an overall purpose of providing a framework for the protection of surface waters including coastal waters. This will aim at preventing the deterioration of aquatic ecosystems with a strong emphasis on ecological quality targets.

3.2 Management, research and guidance

3.2.1 Integrated management of marine SACs will occur through the development of schemes of management by relevant authorities. Shoreline Management Plans (SMPs), which examine options for coastal defence, are also being produced for the entire English and Welsh coast.

3.2.2 Marine biological surveys of littoral and sublittoral chalk reefs were undertaken as part of the JNCC Marine Nature Conservation Review (MNCR), with additional survey work at Thanet candidate SAC. This information will contribute to the development of the SAC management schemes. The voluntary 'Seasearch' programme organised by the Marine Conservation Society, on behalf of JNCC, has also undertaken extensive sublittoral surveys on the chalk reefs of Sussex and provides useful information and data for use in subsequent management proposals for the Seven Sisters VMCA.

4. Action plan objectives and proposed targets

4.1 Seek to retain and where possible increase the existing extent of littoral and sublittoral chalk habitats unaffected by coastal defence and other engineering works.

4.2 Allow natural coastal processes to dictate, where possible, the geomorphology of the littoral and sublittoral environment.

4.3 Adopt sustainable management practices for all uses on littoral and sublittoral chalk habitats.

5. Proposed action with lead agencies

5.1 Policy and legislation

5.1.1 Influence the content of SMPs to recognise the dynamic nature of the littoral environment allowing, where possible, the natural processes of erosion. (ACTION: EHS, EA, LAs, MAFF)

5.1.2 Promote planning policy that includes a presumption against development that, due to the progress of natural erosion, will require coastal defence works. (ACTION: DETR, DoE(NI))

5.1.3 Harmonise the integration of Local Environment Action Plans with the proposed Water Framework Directive so that there is a comprehensive approach to securing water quality objectives for estuaries and coastal areas. (ACTION: EA, EHS)

5.2 Site safeguard and management

5.2.1 Ensure management schemes for Flamborough Head, Thanet coast and South Wight candidate SACs are complementary with the objectives of this plan. (ACTION: All relevant authorities)

5.2.2 Promote the use of both statutory and non-statutory initiatives to conserve nationally and internationally important examples of littoral and sublittoral chalk habitats. (ACTION: DETR, EA, EHS, EN)

5.2.3 Encourage a presumption against littoral stabilisation works except where human life, or important natural or man-made assets, are at risk. (ACTION: EA, EHS, LAs, MAFF)

5.2.4 Consider non-replacement of coastal cliff defences which have come to the end of their useful life.. (ACTION: DANI, DETR, DoE(NI), EHS, LAs, MAFF)

5.3 Advisory

5.3.1 Prepare, publish and distribute to local authorities and port and harbour authorities by 2002 a guidance manual which describes the dynamic and sensitivity characteristics of littoral and sublittoral chalk habitats. (ACTION: EHS, EN)

5.4 International

5.4.1 None proposed.

5.5 Monitoring and research

5.5.1 Commission research to identify coastal defence strategies that incorporate habitat conservation interests. The research should also identify locations where littoral stabilisation works may no longer be necessary in the future. (ACTION: EHS, EN, LAs, MAFF)

5.5.2 Assist in the development and implementation of monitoring programmes for littoral and sublittoral chalk habitats in line with the statutory reporting requirements for ASSI/SSSI and SAC management schemes. (ACTION: All relevant and competent authorities)

5.5.3 Implement a surveying and monitoring programme by 2003 to provide data on the changes in extent and quality of littoral and sublittoral chalk resources in England and Northern Ireland. This will enable progress towards the objectives of this plan to be assessed. The information derived from this programme should be collated in conjunction with data derived from surveying the national maritime cliff and slope resource. (ACTION: EA, EHS, EN)

5.5.4 Commission a research programme for completion by 2005 to investigate the effects of invasive non-native species on the local ecology of littoral and sublittoral chalk, and determine how to eradicate such species. (ACTION: DETR, EN)

5.6 Communications and publicity

5.6.1 Prepare and publish by 2000 a pamphlet for the general public describing the biodiversity of littoral and sublittoral chalk habitats and of the importance of allowing natural coastal processes such as erosion. (ACTION: EHS, EN, LAs)

6. Costings

6.1 The successful implementation of this habitat action plan will have resource implications for both the overleaf and private sectors. The data in the table overleaf provide an estimate of the current expenditure on the habitat and the likely additional resource costs. These additional costs are based on the annual average over 5 and 10 years. The total expenditure for these time periods is also given. Almost all the costs will relate to the public sector, although some costs (eg for research) will be met by the private sector/non-governmental organisations).

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Costings for littoral and sublittoral chalk

	Current expenditure	1st 5 yrs to 2004/2005	Next 10 yrs to 2014/2015
Current expenditure /£000/Yr			
Total average annual cost /£000/Yr		30.6	9.2
Total expenditure to 2005/£000		153	
Total expenditure 2005 to 2014/£000			92

Appendix B: Priority Species Associated with Maritime Cliff and Slope Habitats

Habitat/landscape category	Scientific Name	Common Name	Taxon
Woodland & Arable	Bombylius discolor	Dotted bee-fly	Fly
	Teloschistes chrysophthalmus	A lichen	Lichen
Grassland	Bombus humilis	Carder bumblebee	Bee
	Harpalus dimidiatus	Ground beetle	Beetle
	Harpalus parallelus	Ground beetle	Beetle
	Bombylius discolor	Dotted bee-fly	Fly
	Bembecia chrysidiformis	Fiery clearwing	Moth
	Idaea dilutaria	Silky wave	Moth
	Scotopteryx bipunctaria cretata	Chalk carpet	Moth
	Zygaena loti scotica	Slender Scotch burnet	Moth
Heathland and acid grassland	Anergates atratulus	Dark guest ant	Ant
	Bombus humilis	Carder bumblebee	Bee
	Anostirus castaneus	Click beetle	Beetle
	Harpalus parallelus	Ground beetle	Beetle
	Asparagus officinalis ssp. prostratus	Wild asparagus	Vascular plant
	Pseudocyphellaria aurata	A lichen	Lichen
Wetland	Acrocephalus palustris	Marsh warbler	Bird
Freshwater	Acrocephalus palustris	Marsh warbler	Bird
	Ochthebius poweri	Water beetle	Beetle
Upland	Zygaena loti scotica	Slender Scotch burnet	Moth
Natural rock exposures	Bombylius discolor	Dotted bee-fly	Fly
	Scotopteryx bipunctaria cretata	Chalk carpet	Moth
	Zygaena loti scotica	Slender Scotch burnet	Moth
Coastal	Acrocephalus palustris	Marsh warbler	Bird
	Bombus humilis	Carder bumblebee	Bee
	Lasioglossum angusticeps	A solitary bee	Bee
	Nomada errans	A cuckoo bee	Bee
	Osmia xanthomelana	A mason bee	Bee
	Anostirus castaneus	Click beetle	Beetle
	Bembidion nigropiceum	A ground beetle	Beetle
	Cathormiocerus britannicus	A broad-nosed weevil	Beetle
	Ceuttorhynchus insularis	A weevil	Beetle
	Cicindela germanica	A tiger beetle	Beetle
	Harpalus dimidiatus	Ground beetle	Beetle
	Harpalus parallelus	Ground beetle	Beetle
	Ochthebius poweri	Water beetle	Beetle
	Psylliodes luridipennis	Lundy cabbage flea beetle	Beetle
	Tachys micros	A ground beetle	Beetle
	Bombylius discolor	Dotted bee-fly	Fly
	Bembecia chrysidiformis	Fiery clearwing	Moth
	Hadena albimacula	White-spot	Moth
	Idaea dilutaria	Silky wave	Moth
	Lygephila craccae	Scarse black-neck	Moth
	Polymixix xanthomista	Black-banded	Moth
	Scotopteryx bipunctaria cretata	Chalk carpet	Moth
	Zygaena loti scotica	Slender Scotch burnet	Moth
	Zygaena viciae argyllensis	New Forest burnet	Moth
	Asparagus officinalis ssp. prostratus	Wild asparagus	Vascular plant
	Cochlearia scotica	Scottish scurvygrass	Vascular plant
	Coincya wrightii	Lundy cabbage	Vascular plant
	Euphrasia campbelliae	An eyebright	Vascular plant
	Euphraia rotundifolia	An eyebright	Vascular plant
	Limonium (endemic taxa)	Sea lavender	Vascular plant

Habitat/landscape category	Scientific Name	Common Name	Taxon
	Rumex rupestris	Shore dock	Vascular plant
	Caloplaca aractina	A lichen	Lichen
	Heterodermia leucomelos	Ciliate strap-lichen	Lichen
	Pseudocyphellaria aurata	A lichen	Lichen
	Teloschistes chrysophthalmus	A lichen	Lichen
	Petalophyllum ralfsii	Petalwort	Liverwort
	Acaulon triquetrum	Triangular pygmy-moss	Moss

Appendix C: The US Federal Emergency Management Agency

Hazard Mitigation Grant Programme

The Hazard Mitigation Grant Program (HMGP) was created in November 1988, by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP assists States and local communities in implementing long-term hazard mitigation measures following a major disaster declaration. In December 1993, the President signed the Hazard Mitigation and Relocation Assistance Act which amends Section 404 to increase Federal funding of HMGP projects to 75 percent of the project's total eligible costs. For disasters declared before June 10, 1993, the Federal share for the program is 50 percent.

The Program's objectives are:

- To prevent future losses of lives and property due to disasters;
- To implement State or local hazard mitigation plans;
- To enable mitigation measures to be implemented during immediate recovery from a disaster; and
- To provide funding for previously identified mitigation measures that benefit the disaster area.

Applicant eligibility is the same for the Hazard Mitigation Grant Program as it is for the Public Assistance Program. Applicants eligible for the HMGP are:

- State and local governments;
- Certain private non-profit organisations or institutions; and
- Indian tribes or authorised tribal organisations and Alaska Native villages or organisations.

The HMGP can be used to fund projects to protect either public or private property. Examples of projects include:

- Retrofitting, such as elevating or floodproofing structures to protect it from future damage;
- Acquisition and relocation of structures from hazard-prone areas.
- Development and implementation of State or local standards to protect new and substantially improved structures from disaster damage.

Eligible applicants must apply for the HMGP through the State since the State is responsible for administering the Program. The applicant should contact the State Hazard Mitigation Officer for specific details. Every State must develop a Hazard Mitigation Administrative Plan that explains the State's procedures for administering the HMGP.

The State must submit a letter of intent to FEMA to participate in the HMGP within 60 days of the disaster declaration. Applications for mitigation projects are encouraged as soon as possible after the disaster occurs so that opportunities to do mitigation are not lost during reconstruction. All new project proposals must be submitted for approval within 90 days after FEMA approves the State's Hazard Mitigation plan for the disaster.

FEMA can fund up to 75% of the eligible costs of each project. The State or local match does not need to be cash; in-kind services or materials may be used. With passage of the Hazard Mitigation and Relocation Assistance Act of 1993, Federal funding under the HMGP is now based on 15% of the Federal funds spent on the Public and Individual Assistance programs (minus administrative expenses) for each disaster.

The State's administrative plan governs how projects are selected for funding. However, proposed projects must meet minimum criteria. These criteria are designed to ensure that the most cost-effective and appropriate projects are selected for funding. Both the law and the regulations require that the projects are part of an overall mitigation strategy for the disaster area.