2.3.5 **Impacts on the Coastline**

The physical processes that shape the coast combine to form a complex interrelated regime. Erosion in one place provides material for a beach or mudflat on another part of the coast. Similarly, prevention of erosion can (and has) led to the starvation of beaches elsewhere. The understanding of the coastal regime, and the development of strategies for coastal works which take this into account, are increasingly becoming part of shoreline management planning. Shoreline management, in turn, will need to become an integral part of the management of the entire coastal zone in respect not only of nature conservation, landscape and coastal defence, but also tourism and recreation, fisheries, commercial interests etc.

Global warming, in so far as it affects these coastal processes, will also need to be brought into shoreline and coastal management. The following discussion considers various coastal habitats and the impacts of global warming on these coastal habitats independently, and thus in isolation. In reality, of course, this will not be the case. The increase in global warming is likely to lead to increased erosion and hence to more littoral material being freed for transport into sheltered areas. Assuming such erosion is not prevented by man (e.g. by coast protection works), sediment necessary for the accretion of mudflats, sandflats, saltings and shingle beaches may be generated in at least as great if not greater quantities than at present. The littoral zone is, however, complex. In such a complex regime, the value of monitoring is high and represents a good return on investment. Relatively cheap yet effective forms of monitoring include:-

- tide records
- beach profiles
- coastline surveys
- soundings surveys
- wave records.

The need for monitoring, both of coastal processes and of ecological changes, cannot be overstated if climate change and sea level rise is to be both accommodated and managed in order to maximise opportunities and minimise threats.

2.3.6 **Sand Beaches and Dunes**

Sand dunes as a terrestrial habitat currently extend along 474 km of the English and Welsh coastlines, and dunes cover a total area of 16334 ha (see Figure 2.3.1(c)). Around 120 dune systems in Great Britain are within Sites of Special Scientific Interest (SSSI) (Doody, 1989a) and, out of 34 coastal National Nature Reserves in England and Wales, 15 include sand dune habitats as a primary feature (see Table 2.3.2).

Degradation and losses of sand dune systems have occurred in the past due to a variety of activities including afforestation, military operations, housing, golf courses, extraction and agriculture. Many sand dune systems are also under intense pressure from recreational activity, leading to extensive erosion within and at the edges of the dune system. Damage may also result from indirect pressures: development directly behind the dunes, for example, has caused serious problems by inhibiting the natural tendency of the dune system to migrate inland.

The sand dune system between Liverpool and Southport has been particularly seriously affected by a wide range of encroachments. As a result, only 10% of the original area of 15,000 ha now remains. Similarly, in Swansea Bay South Wales, only 776 ha of the 1260 ha present 100 years ago are still intact (Doody, 1989a).

Although most dune losses are due to human activities, it should be noted that natural phenomena can also cause damage and destruction, at least temporarily. At Brancaster in Norfolk, for example, 20m of dunes were lost during storms in 1990.

2.3.7 Sand beaches and dunes are widespread on exposed areas where there is an adequate supply of material from cliff erosion, rivers, offshore sources or from alongshore. Sand beaches respond rapidly to storms or changes in coastal conditions and can be expected to be modified by sea level rise as well as by change in storminess. Work by Bruun (US Army Corps of Engineers, 1962) postulates a method of determining the amount of beach retreat due to a given amount of sea level rise (The Bruun rule). Its validity has been questioned and tested in many situations and it is by far the most widely used method of assessing coastal erosion due to global warming.

In essence The Bruun Rule assumes that, in the event of sea level rise, the beach profile will readjust to the point where the wave induced shear stress acting on the sea bed is restored to present values. The new profile thus predicted, inevitably (in the case of sea level rise) shows a retreat of the coast. The actual magnitude of retreat is a function of the existing profile. As an example, however, Wind (1987) suggests that a sea level rise of 30cm could lead to beach retreat of 20-60m. This amount of retreat could, however, be further affected by other factors which are not included in The Bruun Rule, such as changes in longshore transport. As erosion proceeds, finer cohesive materials may be exposed as is currently happening on the Lincolnshire coast. Once eroded this material will pass into suspension, will be transported (probably) offshore, and will not be reworked into the new profile as assumed in The Bruun rule. Finally, increasing storminess will tend to increase the net offshore loss of sand from beaches and so increase erosion.

The sand beaches of the UK have already suffered widespread erosion and global warming could exacerbate this problem. Sand dunes are an integral part of the natural coastal defence system. In the event of beach retreat accelerating, dunes will be called upon to perform their vital coastal defence function which is to provide sand to the beaches in front of them when they are drawn down. If this becomes a chronic tendency one can expect dunes to decrease in size since, for the most part, rates of material eroded by the sea are substantially greater than the rates of aeolian supply.

The effect on sand beaches and dunes of relatively modest rises in sea level, even without any increase in storminess, could therefore be substantial. In the absence of human assistance (e.g. beach nourishment or structural works) this is likely to lead to significant erosion of both the beach and seawardmost dunes. The sand released would either:-

- become available via aeolian transport for new dune building further inland
- be removed from the dune system to feed the beach
- be removed and lost by the sea.

A number of factors will determine whether the dunes retreat landward or disappear. The susceptibility of individual dune systems will vary depending on:-

- their location and physical and biological characteristics including sand supply
- the balance between prevailing and dominant winds
- the strength and direction of the prevailing wind (Boorman et al., 1989) and also:-
- man's willingness to allow the dunes to retreat (see Section 2.3.6).

To some extent, instability within certain dune systems generated by climate change may not be detrimental. Coastal ecosystems are dynamic and change is important. Many sand dune systems might be expected to retreat inland under such a scenario, but where there is development immediately behind the dune, such retreat is likely to be prevented by man. Where the dune system does retreat significantly, the habitat behind the dunes may become susceptible to inundation by sand. Increased blowouts will cause instability and the saltwater flooding of fresh water slacks might have a detrimental effect on some important ecosystems including, ultimately, the overall ecology of the dunes. On the other hand, however, the area of slack communities might increase if a rise in sea level causes a subsequent rise in the fresh water table.

2.3.8 Sandflats and Sandbanks

The process behaviour of many of the offshore sandbanks around the coast of the UK is not fully understood. They often exist as part of the delicate balance (or imbalance) between divergent or opposing sediment transport mechanisms. They can also exist on exposed coasts such as those off Great Yarmouth and Lowestoft. In spite of lengthy studies, however, their future behaviour cannot be predicted, even in the absence of global warming. The effect of global sea level rise may well be significant, but whether it would lead to a net loss or gain of sandbanks cannot be ascertained. Among the biological implications of any disappearance of sandbanks, however, would be the loss of seal haul-out areas, notably around the East Anglian Coast, and the loss of low intertidal sand and shingle islands used by breeding terns.

Coastal sandflats are different from sand banks in geomorphological terms, as they lie in more sheltered areas. It is difficult to postulate the likely effects of global warming, but one would expect that any edges exposed to wave action may well suffer from a net erosion in a manner similar to that addressed by the Bruun rule. There may also be changes in the overall extent of sandflats, and in their location. If exposure times are changed or sandflats "drowned" as a result of sea level rise, the opportunities available for feeding birds will be lost or detrimentally affected. Sandflat invertebrates remain in contact with the water table and are subsequently very susceptible to changes in water level. The nature of the flats might also be altered by changes in sediment characteristics but, as with much of sediment transport, the coastal process regime is very site specific and it is therefore unwise to generalise.

2.3.9 Saltmarsh

Saltmarshes currently extend over 1,607 km of the English and Welsh coastlines (covering an area of 33,794 ha; see Table 2.3.1) and occur in at least twenty coastal National Nature Reserves. 87% of England's saltmarsh areas are designated SSSIs (Hollis et al., 1990). Saltings exist in sheltered areas, usually at the crest of muddy foreshores.

Despite their undeniable importance as roosting and feeding areas for birds and as fish nursery areas, saltmarshes are arguably Britain's most threatened coastal ecosystem. Over the last 500 years the area of saltmarsh in Britain has been reduced by 55000 ha (Gubbay, 1988), the majority of loss occurring in the 1800s. The remaining saltmarshes are still threatened in a variety of ways. Marsh losses are attributable to land drainage schemes and land claim for both agricultural and industrial purposes. Increased pollution from industrial and domestic sources also has a detrimental effect on saltmarsh vegetation.

In many parts of southern and eastern England, saltings appear to be eroding, a process which is not fully understood and which is being studied further. However, a prime factor in their demise when they do erode appears to be an increase in wave action which attacks the seaward edge of the saltings. This increase could result from the loss of adjacent mudflats due to change in sedimentation regime or an increase in water level allowing larger waves to reach the saltings edge.

On Dengie in Essex, approximately 10% of the total area of saltmarsh was lost between 1960 and 1981 (Harmsworth and Long, 1986). Although possibly related to changes in land-sea levels, this type of loss may also be indirectly caused to some extent by coastal protection work reducing the sediment available for accretion.

With an adequate supply of sediment Wind (1987) suggests that saltmarshes can accrete upwards by 2-6mm/year while Beeftink (1977) suggests 3-10mm/year. Providing rates of accretion do not exceed the ability of saltmarsh plants to colonise, some saltmarshes might therefore be expected to "keep up with" sea level rise. Without an adequate supply of sediment, however, saltmarsh plants would be detrimentally affected because they can only tolerate limited submergence. Further, as waterlogging increases, anaerobic conditions prevail. Organic substances are not oxidised and accumulate in the soil to the detriment of plants, particularly higher level marsh (Beardall et al., 1988).

Under a scenario of sea level rise the edges of saltmarshes are likely to become cliffed, and creeks might become steeper and wider (Boorman et al., 1989). Any change in sediment size (due, for example, to the predicted higher energy environment) will also affect saltmarshes detrimentally because certain species will not survive if sediment becomes coarser.

Existing higher level saltmarsh is important as a roosting and nesting site for waders, while low level marsh provides a significant feeding area for birds. Sea walls and other hard defence structures prevent the inland migration of saltmarshes in many areas. Sea level rise might therefore be expected to lead to a reduction in the overall area of saltings where they are backed by sea defence structures. Within a marsh a reversion to vegetation type characteristics of an earlier development phase might be expected (e.g. upper to lower marsh species; lower marsh to pioneer species; drowning of lower zones and/or reversion to mudflats). Any major reduction in the area of saltmarsh could therefore be expected to have a major adverse impact on coastal birds and other wildlife.

2.3.10 Mudflats

Mudflats, which are important intertidal habitats because their high organic matter content attracts dense populations of invertebrates and hence feeding brids, currently extend along 1513 km of the English and Welsh coastlines. Intertidal flats (including both muds and sands) cover an area of 181,705 ha (see Table 2.3.1) and are represented in more than thirteen National Nature Reserves. Hollis et al (1990) report that up to 90% of mudflats are protected by SSSI status, and fifty five estuaries containing intertidal mudflats meet the criteria for designation as Ramsar Convention Sites and as Special Protection Areas under the EC Birds Directive. Only sixteen of these, however, have been formally designated (RSPB, 1990).

Many intertidal flats exist within estuaries which have historically been subjected to human interference. Pressures from marinas, land reclamation, barrages and industry are often irreversible and reduce the area of intertidal habitats. The intertidal mudflats of Teesmouth, for example, have been reduced from 2,400 ha to 175 ha over the last hundred years (Greenpeace, 1987), the loss being largely attributable to industrial land-claim. In the Tyne, all intertidal flats have been lost (RSPB, 1990a), while in Suffolk the construction of the Felixstowe dock extension has destroyed prime mudflats at Faybury Creek in part of the River Orwell SSSI (RSNC, 1989). As well as these permanent losses, significant temporary disturbances to the ecology can be caused by uncontrolled bait-digging, cockle fishing and recreation activities.

Mudflats generally occur in sheltered areas. As estuarine features, whilst they can be part of long term deposition (as a drowned river valley fills with silt), they can also vary substantially over time as with the mud and sandflats in the Humber. The processes that shape mudflats are very site specific and it is not possible to generalise on how they will respond to global warming. One would expect that, simply due to rise in sea level, the extent and exposure of mudflats would decrease. Deposition would tend to counteract this tendency (Hollis et al., 1990), but only if there is an adequate supply of sediment.

As with sandflats, any reduction in the exposure time due to a rise in sea levels will reduce the value of mudflats to feeding birds because, although invertebrates remain in the upper layers of mud during low tide, the time during which the mud is exposed is critical to wading bird feeding cycles. Similarly, any change in the nature of the sediment could detrimentally affect invertebrate communities and hence birds. Sediments consisting only of coarse particles have very poor faunas because of the grinding action of the particles when they are moved by waves or currents. Eroding sediments, whether fine or coarse, have poor fauna when compared to those in areas of deposition, presumably because larvae have difficulty in settling (Boorman et al., 1989).

Within estuaries, mudflats are to a large extent shaped by tidal currents, and the position of mudflats along a tidal river is strongly influenced by the interaction between fresh and saline water. A rise in sea level could well cause changes in the position and shape of mudflats, and work in France suggests that the stability of mudflats may also be very sensitive to quite subtle changes in velocities. Overall, therefore, sea level rise could potentially have a significant impact on Britain's mudflats.

2.3.11 Shingle Features

Shingle currently extends over 640 km of the English and Welsh coastline and vegetated coastal shingle covers 3,527 ha (see Table 2.3.1). Three National Nature Reserves and thirty five SSSIs contain major shingle structures (P. Sneddon, personal communication, 1990).

Shingle structures such as Orfordness in Suffolk have suffered from human activities, primarily shingle extraction for construction work. Recreation pressures also inhibit colonisation of shingle by plants (Beardall et al, 1988). Shingle is a very mobile habitat and, although its species are adapted to these conditions, damage to shingle ecology may result from further disturbances. One further, albeit indirect, cause of damage to shingle features is man-induced or natural interference in sediment supply. Shingle transport along the coast may, for example, be interupted by harbour or sea defence structures (e.g. groynes, breakwaters).

Sea level rise is likely to have a variety of impacts on different shingle features. Trangressional adjustment at a few of the large shingle structures could compensate for sea level rise to some extent. At Dungeness for example, a rise in level would increase erosion along the south shore, but this would be compensated for by increased deposition along the east shore (Boorman et al., 1989). Many other shingle features, however, are effectively "fossil structures" with little contemporary shingle supply (Doody and Burd, 1990). These are, therefore, vulnerable to both erosion and breaching.

Many of the UK's shingle beaches extend only down to mean sea level, with a much flatter mud/sand foreshore below, although in places the steep shingle beach is founded much deeper. Shingle beaches do not generally suffer from offshore losses in the same way as sand beaches. Frequently, they rely on a continuing longshore supply of shingle, perhaps from cliff erosion or from ancient geological deposits. In time (perhaps over very long periods) the shingle decreases in size as a result of attrition.

In the event of global warming, an increase in sea level is likely to produce a net change in the beach profile. This will result in an effective erosion (as with sand beaches) and greater storminess would further increase this effect. Erosion by this mechanism would be less than in the case of sand beaches, because shingle beach profiles tend to be steeper (at say 1:7-8) than sand beaches say (1:20). Where the beach forms the front face of a shingle ridge, however, the retreat would not simply be a reworking of the profile.

Shingle ridges occur in various parts of Great Britain - for example at Porlock (Somerset), Westward Ho (Devon) and Cley (Norfolk). Naturally they tend to migrate landwards because shingle transported over the crest in storms is not returned. In the event of sea level rise and larger waves reaching the shore, overtopping of a ridge would become more frequent and the rate of retreat would increase accordingly. The action of retreat could, however, restore the ridge to its present effective level if the land onto which the ridge retreats slopes upwards to the extent that the level of the ridge is raised. The effect of retreat can reduce the cross section of the ridge when, as is often the case in an enclosed bay, one end of the ridge is held by some natural or artificial structure. In this case, as the ridge retreats, it stretches over a longer distance. The volume of shingle per length of ridge therefore decreases, the frequency of overtopping increases further and the rate of retreat accelerates. The logical conclusion of this process is a breach or a series of breaches in the shingle ridge.

Finally, it might be anticipated that many shingle vegetation communities will be lost due to a combination of increased inundation, storminess and particularly the general increased mobility of shingle under a scenario of sea level rise.

2.3.12 Coastal Lagoons

Two types of coastal lagoons are considered in this report: those which normally lie immediately landward of shingle ridges, and those which comprise sheltered tidal inlets protected by shingle or sand spits. In both cases the input of freshwater is significant in determining the mix of habitats. Britain has only 41 coastal lagoons of the first type making this a relatively rare habitat. All such lagoons are isolated behind barriers of shingle and most receive sea water influx only by percolation through, or occasional overtopping of, this shingle (Barnes, 1989). When considering possible losses in the event of global warming in respect of this lagoon type, perhaps the most significant impact is likely to be any increase in rate of retreat of the ridge (see Section 2.3.11) and a possible associated increase in overtopping. In addition, the general rise in water level will tend to increase saline intrusion into the lagoons. This is likely to disturb existing lagoons whilst possibly encouraging the formation of new ones. Breaching of ridges would of course threaten the existence of lagoons leading to their draining and possibly to their replacement by saltmarsh.

In the case of tidal inlets, the first potentially significant impact under a scenario of sea level rise is any increase in littoral transport due to higher waves reaching the spit. In extreme cases this could threaten the existence of the tidal opening to the lagoon. The second major aspect is the increase in tidal levels. This would increase tidal currents through the entrance and may counteract any tendency for closure. On balance therefore it would be expected that tidal lagoons would generally remain intact.

In both cases, the flora and macrofauna lagoon communities are very sensitive to salinity levels. Most lagoons are brackish and some are largely freshwater in nature. Increased salinity could therefore lead to significant changes in lagoonal species composition (Gubbay, 1988).

Lagoons are threatened by people as a result of utilisation for dock and harbour developments, quarrying, saltworks and waste disposal, as well as reclamation for agriculture (Gubbay, 1988). Eutrophication can seriously affect the value of the lagoon and the habitat can be easily damaged by pollution because of the characteristically low flushing rate. Indirect effects can also be caused by changes in land drainage patterns, affecting sedimentation and the water regime of the lagoons.

Lagoons can, however, develop and disappear naturally over relatively short time scales due to changes in the shingle spit or bar often found fronting the lagoon. It is therefore difficult to predict whether or not increased rates of sea level rise would lead to significant changes in the overall number and/or characteristics of Britain's coastal lagoons.

2.3.13 Reedbeds

Reedbeds are of nature conservation importance partly because they offer a sheltered sanctuary to many important bird species. Coastal reedbeds greater than two hectares cover 933 ha at a total of just 28 sites (Bibby and Lunn, 1982). Within the area of interest to this study, reedbeds are predominantly estuarine as they require a freshwater input. The pressures of land claim, industrial activity and recreation associated with estuaries all pose a potentially serious threat to reedbeds. Natural succession can also lead to reedbed loss: accumulation of silt and dead organic matter will raise the land level, enabling colonisation by more terrestrial species. This is particularly the case during drier years when lower water tables allow species such as willow (Salix spp.) to invade.

In the coastal zone, reedbeds occur where fresh water flows into tidal saline rivers. Sea level rise could influence these sites as a result of changes in salinity, currents and water depth. As with saltmarshes, however, if reedbeds have room to retreat upstream or landward they may well do so. There is likely to be some loss of existing reedbeds with sea level rise due to their preference for a water depth of between 0.5-1.0 m and salinity of less than 5 parts per thousand, but they are likely to colonise other areas. Reeds are, for example, often present in ditches, and the managed flooding of agricultural land could allow for the creation of new reedbeds. Coastal reedbeds could also be created behind sea defences if saline water entry was controlled by sluices.

2.3.14 Grazing Marsh

Grazing marsh is important from the point of view of nature conservation for several reasons. During the spring and early summer, such areas are used as breeding sites for many ground-nesting bird species. During the winter they are used by migratory birds as feeding areas. The low intensity agricultural regimes on many grazing marshes require a minimum input of fertilisers, pesticides and herbicides, and wetland plant communities frequently thrive in the unpolluted high water table environment. In some cases these marshes depend on freshwater, in others there is a marked brackish water influence. Halvergate Marshes on the Norfolk Broads offers an example of both types of interest. Saltwater intrusion through North Breydon flood wall creates a valuable brackish water habitat at the rear of the bank, while freshwater flowing off the upland produces a rich and diverse marshland habitat further inland. This type of salinity gradient may be extremely important to the diversity of invertebrate life on grazing marshes, as well as supporting a variety of botanical interest.

Grazing marsh, however, has been and remains susceptible to drainage, to the intensification of grazing regimes, and conversion to arable cultivation. In the Thames Estuary, for instance, 48% of the grazing marsh has been drained since 1935 (Greenpeace, 1987). 13% is due to urban development and the remaining 35% has been converted to arable cultivation (NCC, 1984). In Essex, only 20% of the grazing marshes present in 1930-39 remain (NCC, 1990), while between 1955-58 20% of the Suffolk grazing marshes were converted to arable (Beardall et al, 1988). Finally, the Yare Basin in Norfolk has shown a decrease of 31% in the area of grazing marsh between 1967 (19,000 ha) and 1982 (13,060 ha) (NCC, 1984).

A high proportion of existing coastal grazing marshes are on land previously claimed from the sea, and the breaching of sea walls may in fact lead to the reversion of these areas to inter-tidal or sub-tidal habitats depending on present elevation. The 1953 storm surge caused many bank failures along the East Anglian coast and in some places grazing marshes did revert to tidal regimes.

As with saltmarshes and coastal lagoons, grazing marshes are likely to suffer increasingly severe and frequent flooding under a scenario of sea level rise. The extent of saline influence, through both overtopping and intrusion would increase. If the topography is suitable, such areas may in time convert to saltmarsh or, with an adequate freshwater influence, to reedbeds. Whether adjacent land would then be available to convert into grazing marsh, however, would be dependent both on topography and the extension of human development including new flood defence structures.

Overall, the effects of sea level rise on coastal grazing marshes will depend on the frequency and duration of tidal inundation and the salinity range. In some coastal areas a small increase in tidal inundation may in fact increase the diversity of species/communities. On the south east coast of England certain grazing marshes with a brackish water influence already support upper saltmarsh communities in addition to brackish or freshwater species. A significant increase in the frequency or duration of saline inundation in brackish grazing marshes, or the seawater inundation of primarily freshwater marshes may, however, cause detrimental effects to the existing flora and fauna. On the other hand, however, those which revert to saltmarsh or mudflat may retain some, albeit changed, environmental interest.

2.3.15 Other Habitats

- **Cliffs**

Cliffs comprised of hard rock would be largely unaffected by global warming, their durability protecting them from marginal increases in wave attack. Softer rocks, on the other hand, might be expected to erode more rapidly than at present, providing more material for beaches and mudflats elsewhere unless, of course, man extends his coast protection activities.

The likely impacts of such increased rates of cliff erosion on nature conservation interests will be varied. Sites which are dependent on cliff falls to maintain their geological interest might benefit from the sea level rise. The impact on sites where the nature conservation interest is associated with exposures on the beach, however, is more difficult to predict (e.g. Chapel Point Geological Conservation Review Site on the Lincolnshire coast, or the submerged forest in Porlock Bay, Somerset). Such areas may become generally less accessible if they are inundated for a longer period of time. More important, however, they will be affected by any change in beach level. A fall in beach levels might lead to increased exposure to wave action and hence erosion, culminating in the loss of some sites. Alternatively, if sediment supply to the beach increases because of cliff erosion, the sites may no longer be exposed at all. They will therefore be better protected, but of rather less scientific interest.

Elsewhere on the coast, other Sites of Special Scientific Interest may be lost as a direct rather than indirect result of increased rates of cliff erosion. In the south west, for example, the ancient woodland on rising cliffs at Boscastle Dizzard would suffer from increased rates of erosion. Sites of conservation value because of their vegetation and invertebrate interest might also be lost if the frequency of cliff falls increases to the point where cliff communities are unable to become re-established.

- **Sub-tidal Habitats**

Sampling and surveying techniques for sub-tidal habitats are less well developed than those for terrestrial habitats. NCC are currently compiling a descriptive account of British marine flora and fauna.

Zostera seagrass beds, which are important in protecting certain coastal habitats by reducing wave strength and hence erosion, are found at a number of sites in Great Britain. The most important sites are the Isles of Scilly, The Fleet and Maplin Sands with the latter covering 325 ha (Gubbay, 1988). Physical damage can occur due to both trampling and anchoring in the sheltered shallow areas, but the most significant damage to Zostera beds in the last 50 years has been from an epidemic wasting disease which devastated these plant communities (Owen et al., 1986). Extensive areas of mudflat were lost as a consequence.

Other sub-tidal habitats, including oyster beds, clam flats, reefs, etc., are important in terms not only of their nature conservation interest, but also their contribution to the marine fisheries resource. Such habitats are unlikely to be severely affected by a rise in sea levels of the order discussed in Section 2.2. There may, however, be significant opportunities for the creation of new sub-tidal habitats under a scenario of sea level rise.

- **Rocky Shores**

Rocky shores occur along 1038 km of the English and Welsh coastline (see Table 2.3.1). Threats to these habitats from human disturbance are minor in comparison to those imposed on soft sediment communities, but damage through seaweed cropping, boulder disturbance and collection, pollution, and recreational activities can all affect the species composition. Increased rates of sea level rise might lead to the loss of flora and fauna through inundation and erosion, but the significance of this will generally be determined by site specific characteristics.

2.3.16 Effects on Coastal Landscapes and Amenity

Coastal landscapes are important for their amenity, recreation, and aesthetic value, natural beauty and diversity. Dramatic features such as chalky cliffs and shingle ridges add to the often unique landscape interest of certain stretches of coasts, for example, the spectacular "Seven Sisters" at Seaford in Sussex and impressive shingle spit at Blakeney in Norfolk.

In addition, parts of the coastline are designated for their unspoilt character, in particular Areas of Outstanding Natural Beauty (AONB) and Heritage Coasts. Forty three stretches of Heritage Coast have been defined covering one third of the coastline of England and Wales, some 1,460km. Most of these lengths also incorporate AONB's. The largest continuous stretch of Heritage Coast is along the north Northumberland coast, and the coastline of south west Britain is also particularly well represented. In other areas National Parks abut the coast (e.g. Exmoor and Pembrokeshire).

Increasingly, the coastal landscape is under pressure from recreation developments including marinas, and sea defence and coast protection projects, as well as other issues such as pollution and water quality. Such pressures have lead to visual intrusion and loss of valuable features.

The previous sections (2.3 to 2.3.15) discussed the likely impacts of sea level rise on coastal habitats. Concurrently, such impacts will have similar landscape implications primarily in terms of visual impact and loss or degradation of features of landscape interest. Such losses are likely to include "soft" cliffs; shingle banks; dune systems and areas of saltmarsh and mudflats. In other instances, however, sea level rise may have beneficial landscape impacts. Increased erosion, for example, may lead to establishment or enhancement of existing dune, shingle or beach features downstream (see Section 2.3.7).

The effects of sea level rise will be particularly detrimental if the coastal habitat is unable to retreat due to prohibitive development behind. In these cases it may be necessary to improve or construct coastal protection works which will further degrade the coastal landscape.

Loss or reduction of beaches and cliff tops have attendant recreation and amenity effects. Much of the coastline of England and Wales provides public accessibility via long distance paths (e.g. the South West Peninsula Path) and numerous footpaths. It is not desirable to lose any part of this network. Once a right of way is lost, in this instance to the sea, it ceases to exist and cannot legally simply take the route of the new coastline. Statutory mechanisms are, however, available to create footpaths through management agreements and/or the "dedication and acceptance" method which involves dedication by the owner and an acceptance of the right of way.

2.3.17 Regional Effects of Sea Level Rise

Sections 2.3.6 to 2.3.15 inclusive discuss the likely implications of increased rates of sea level rise for specific types of coastal habitat. Around the English and Welsh coasts, however, there are a number of potential consequences which are likely to be peculiar to a particular region. Table 2.3.3 summarises some such impacts which were raised as a result of the Regional meetings discussed in Section 1.3.4

Table 2.3.3 Regional Implications of Sea Level Rise

Region: Anglian

Site and Habitat	Implications
Kessingham Level, Thorpeness (grazing marsh); Benacre Broad (brackish lagoon)	Sites fronted by a natural shingle ridge. Liable to loss or redistribution of shingle and/or saline intrusion.
Minsmere (fresh and brackish water lagoons)	Protection is offered by a natural dune system of sand and shingle which is liable to loss or redistribution.
General	Eastern region is already prone to land loss, especially as most of the region is low lying with large areas of claimed land.

Region: North West

Site and Habitat	Implications
General	The high density of developed areas means that coastal habitats will be lost because of a lack of land onto which to retreat

Region: Northumbria and Yorkshire

Site and Habitat	Implications
Northumbria (sand dunes)	Significant scope for allowing natural migration inland as sea levels rise
Yorkshire (sand dunes)	No scope for migration inland due to both local topography and development behind dunes
Humber Estuary (general)	Erosion from the Holderness coast may produce increased sediment which feeds into the mouth of the Humber
Durham (general)	The rocky coastline means habitat creation opportunities are likely to be limited

Region: Southern

Site and Habitat	Implications
Solent Estuary	The tidal pattern in the western part of the Solent has a double tide giving an extended period of high water. Time for wave erosion at high tide will therefore become longer and ebb tide scour will be much more intense leading to increased erosion at the saltmarsh cliff.
Chichester Harbour and Southern harbours generally	Many harbours in Southern Region are carved out of raised beaches with low cliff edges which are susceptible to wave attack. Sea level rise and increased storminess could extend the harbour area especially in undefended harbours such as Chichester.
Hurst Spit	If the spit was breached or washed away it would increase the vulnerability of sea walls to the east by altering the water circulation and tidal regime in the intertidal area that is presently sheltered.
Lymington (river valley)	Increased risk of fluvial freshwater flooding as tidelocking would be greater due to sluices at the eastern side of the harbour.
Stanswood Bay (cliffs)	Presently subject to acute erosion which would increase and cause erosion of the Pleistocene terraced gravel/brick earth cliff.
Southampton Water (river estuary)	At the head of the estuary a natural salinity gradient exists. Historically sea level rise has led to the loss of a former grazing marsh and the development of Phragmites. This zone will steadily migrate up the valley.
Titchfield Haven (estuary)	The estuary was dammed off and sluiced. An increase in sea level rise would cause the marsh to migrate up the valley as increased freshwater inundation occurs alongside an increase in the rate of sea level rise.

Region: South West

Site and Habitat	Implications
Rivers Yealm and Dart (river estuaries)	Typical steep-sided wooded valleys where sea level rise would lead to the loss of fringing habitats.
Rivers Axe, Exe and Tamar (river estuaries)	Large areas of these estuaries are privately defended, but some would suffer habitat losses under sea level rise.
Loe Pool (shingle); Shapton Ley	Mobile shingle bar protecting the lagoon system. The SSSI may be threatened by increased salinity and/or the retreat of the bar inland.
Marazion Marsh (reedbed); South Milton Ley	Large reedbeds in Devon and Cornwall which are likely to be threatened by an increase in the frequency of saline inundation.
Fal Estuary	Maerl beds which occur in only a few British localities may be threatened because they require calm, shallow, turbidity-free conditions in the sub-tidal zone.
Isles of Scilly	Low-lying dune and boulder beach habitats could be breached with a dramtic impact on breeding storm petrels in "fossil" boulder beaches and rare plants e.g. Dwarf Pansy (Viola Kitaibeliana) on dune grassland. Also loss of freshwater and brackish lagoon habitats.

Region: Welsh

Brandy Brook and St. Brides Bay (wetland)	Shingle features protecting wetland SSSI (rushes, carrs, etc.) may be threatened.
General	Only 10% of the Welsh coastline is protected by NRA defences. British Rail is responsible for many embankments.

Region: Wessex

Severn Estuary (estuary and associated habitats)	A relatively small absolute increase in water level on a high tidal range will generally mean only limited habitat loss or inundation. Areas of low tidal range, however, will be more seriously affected.
Berrow Dunes (sand dune)	Dunes are liable to sand loss or roll back threatening both dunes and marsh behind, a Sedgemoor District Council reserve and SSSI.