Chapter 2
Human Influences

Traditional Uses, Management and Destruction

2.1 Introduction

Despite the apparent and perceived ‘naturalness’ of the studied systems, few saltmarshes are entirely free from human influence. For centuries, grazing by domestic animals and haymaking took place in Europe and North America. The erection of embankments helped extend the period when grazing could take place and facilitate haymaking. In the early days, these were no more than low earth banks. With improvement in engineering techniques, permanent exclusion of the tide became possible. Some of the subsequent uses have modified the original marsh helping to create new areas with different, but valuable ‘semi-natural’ assets. Other activities are more destructive. Overall, permanent enclosure removes the natural ability of the saltmarsh to respond to the forces of wind, waves and tidal actions, especially during storms. The description that follows provides a summary of the progressively more destructive changes brought about by human activities and the implications for their nature conservation values.

2.2 Traditional Management

Grazing and haymaking are traditional forms of management. Grazing is by far the most widespread activity, though haymaking still occurs in a few locations. Both activities can change the nature of the saltmarsh notably in relation to its component species. Other forms of management include *Salicornia europaea* (Samphire) gathering, turf-cutting and at the margins of saltmarsh, reed beds provide roofing material (thatch). These activities modify the saltmarsh habitat rather than destroying it.

2.1.1 Grazing

Grazing naturally occurs on saltmarshes involving a wide variety of species. Wintering ducks and geese together with other herbivorous animals such as hares and deer probably relied on these open areas long before human occupation began.

Figure 10 The effect of grazing – on the right, there is a low-growing grassy sward; on the left taller Sea Aster (*Aster tripolium*) helps provide denser vegetation. In the case of saltmarsh shown here from Bridgwater Bay, Somerset, UK the former provides valuable grazing for ducks and geese, the latter shelter for nesting birds and shelter and food for invertebrates

A variety of ducks and geese, such as wintering Wigeon (*Anas penelope*) in Western Europe, Brent geese (*Branta bernicla*) in the southern North Sea and breeding Lesser Snow geese in Canada continue to graze saltmarshes. Archaeological evidence from the intertidal Severn Estuary shows that prehistoric humans herded animals in these areas (Bell et al. 2000).

Domestic animals can improve the palatability of the swards, as grasses such as *Puccinellia maritima* and *Festuca rubra* are favoured over coarser herbs and shrubs including *Atriplex portulacoides*. The density, period of stocking and type of animal all influence the type of vegetation that develops. At high densities, sheep grazing can create a flat ‘bowling green’ turf with little structural diversity. Cattle do not graze the sward so tightly, leaving patches of denser vegetation interspersed with low growing areas where grasses are dominant. Visually, the difference between grazed and ungrazed saltmarsh can be dramatic (Figure 10).

2.1.2 Reed Cutting

Common Reed (*Phragmites australis*) is a plant, which grows towards the limits of tidal influence, especially where freshwater flows onto the marsh. It is tolerant of brackish, rather than full seawater. It can form extensive areas along the margins of unenclosed saltmarsh and at the upper limits of some estuaries.

The plant has a variety of uses. Prehistoric people along the shores of the Severn Estuary, in the south-west of the UK may have burnt reed to aid herding animals on saltmarsh (Bell et al. 2000). Grazed by domestic stock when young, it also provides fencing (partition fences), coarse mats, baskets, sandals, etc. The straight hollow stems, when cut and dried in autumn provided arrow shafts for American Indians (Duke 1983). However, its principal use is as thatch for roofing. Cutting the reed on a two or more yearly cycle helps maintain the reed at an early stage of its succession. This prevents the development of shrubs and ultimately fen woodland.

2.1.3 Samphire Gathering

Salicornia europaea (Samphire) is one of the first colonisers of tidal flats. It is a salt-tolerant succulent plant. Brent geese and other herbivores graze it. It has also been gathered and used as a vegetable in salads, or boiled. In developing countries, it is sometimes cultivated as an aid to improving the economic conditions of some coastal communities.

There is no evidence to suggest that Samphire gathering has any significant impact on the development of saltmarsh or its conservation value. However, it represents a human use that has the potential to modify the vegetation succession.

2.1.4 Saltmarsh 'Haying'

Haymaking is another human activity that appears to have been widely practised in Europe. It probably continued to take place in the Baltic up to about the 1960s (Dijkema 1990). The first European settlers exported the practice to the eastern USA. Here extensive *Spartina* spp. dominated marshes were a significant source of fodder for their animals (Daiber 1986). In the nineteenth century, saltmarshes in Nova Scotia were dyked in order to grow hay essential to maintain the horse-powered logging and mining industry. By the early 1900s, large tracts of coastal marshes were devoted to this activity. By the late 1930s, the hay market had all but ceased because of fossil-fuel technology (Nova Scotia Museum of Natural History, undated). Today the practice appears to have all but disappeared in both Europe and North America, except for a few isolated places such as New England where farmers have been 'haying' some saltmarshes for over 300 years (Ludlam et al. 2002). It still takes place on a large scale (over 400 ha regularly) throughout Plum Island Sound, northeastern Massachusetts (Williams et al. 2001).

2.2 Excavation

Excavating the surface of the marsh is an activity that has taken place for a variety of purposes. These lie somewhere in between the traditional use of the saltmarsh, where tidal inundation continues but where there is little or no modification of the surface and enclosure. As such, there are differing impacts on the saltmarsh as summarised below.

2.2.1 Turf Cutting

Heavily grazed saltmarshes can provide turf suitable for lawns, cricket pitches and bowling greens. The extent of this use is uncertain though a combination of fertiliser application, reseeding and intensive sheep grazing produced very short, dense matted turf in parts of north-west England. Once established the turf was periodically cut and sold commercially (Gray 1972). In the Netherlands, Germany and Denmark, turf-cutting provided material for covering and reinforcing sea walls (Kamps 1962). Today the activity continues on a local scale for dyke repairs. However, in Morecambe Bay, a nature conservation site in north-west England, it is one of a number of 'operations' requiring consent from English Nature*.

2.2.2 Sediment Extraction

Extraction of saltmarsh sediments, including clay was used to build sea walls in the Wadden Sea (Beeftink 1977a), the Wash, eastern England (French 1997, pp. 62–63) and for brick-making in the Medway in south-east England (French 1997, pp. 95–96). These more dramatic causes of habitat loss create low-lying surfaces where recolonisation takes place. The vegetation can take many years to recover, perhaps showing effects over decades (Beeftink 1977b). In the German Wadden Sea extraction of clay from pits, helps regenerate vegetation succession (including the development of natural creeks) in created, artificially drained saltmarsh (Dijkema pers.com.).

2.3 Summer Dykes, Grazing Marsh, Salinas and Rice Fields

Summer dykes and embankments to exclude the tide have progressively greater impact on saltmarshes. The former remove the saltmarsh from tidal influence for only part of the year, usually in the summer. The saltmarsh community remains, albeit with a modified tidal regime. The latter permanently encloses the saltmarsh completely removing it from tidal inundation. This form of enclosure, effectively results in 'land claim' and the creation of land for agricultural or other uses. It affects saltmarshes throughout the world.

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*English Nature is the Statutory Body responsible for promoting the conservation of wildlife, geology and wild places in England. It is a UK Government agency set up by the Environment Protection Act 1990 and funded by the Department of Environment, Food and Rural Affairs. In 2006, it became part of the wider 'Natural England' with its amalgamation with the Countryside Agency and the Rural Development Service (see http://www.naturalengland.org.uk/).

With permanent tidal exclusion, drainage and water table management are possible. The subsequent use of the land can include grazing, conversion to salinas, use for rice cultivation and with intensive drainage, cultivation with agricultural crops. Each of these creates a different nature conservation interest. This section briefly describes the history of embankment and the type of nature conservation interest surviving under the different types of management. The last of these developments, use for intensive agriculture, ensures the loss of all the saltmarsh features, with little or no replacement of the nature conservation interest. This is included in Section 2.4 dealing with 'land claim'.

2.3.1 Summer Dykes

Summer dykes (summerdikes; summerpolders), as the name implies, eliminate tidal flows and reduce sedimentation on saltmarshes, extending the period of grazing or other agricultural use, such as haymaking during the summer. They accompanied the colonisation of the lowlands of the North Sea, for example in the German Wadden Sea (Ahlhorn & Kunz 2002). Today some 1,200 ha in the Netherlands and 2,100 ha in north-west Germany of such partially enclosed saltmarsh remain (Bakker et al. 2002).

Summer dykes are today, more often associated with permanent embankments built to exclude the tide from the saltmarsh. In the Wadden Sea, they form part of the sea defence (Section 2.4.3).

2.3.2 Grazing Marsh

Grazing marsh is a habitat type recognised from Great Britain and found mostly in south-east England. It develops following the exclusion of the tide by the embankment of saltmarsh. The important aspect of the habitat is that although some artificial drainage may occur, the original surface of the saltmarsh remains virtually intact. This provides for the development of a suite of topographical features that help to define the habitat. These include remnant creeks (fleets), grassland and transitions between brackish water and fresh water. Gray (1977, p. 257) and Doody (2001, Chapter 11) provide a more detailed description of these features and their nature conservation value. Section 6.4.4 looks at the nature conservation value associated with this habitat in the relation to policies designed to re-create saltmarsh habitat, through realignment.

Grazing marsh thus forms the first of a series of habitats derived from saltmarsh, where modification rather than destruction of the nature conservation value has taken place. They cause progressively greater change to the 'natural' forms, whilst retaining some features of the original habitat (Figure 11).

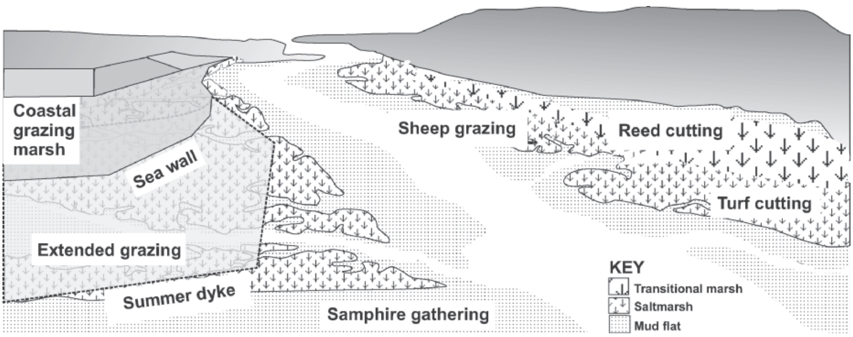

Figure 11 Some modifications made to the saltmarsh surface by human use, changing, rather than destroying nature conservation values

The next stages in modification result in much greater change and a loss in most of the features associated with saltmarsh.

2.3.3 Salinas

A special type of enclosed wetland occurs in warmer locations such as the Mediterranean. Here enclosure of tidal lagoons, which may or may not have saltmarsh, creates saline pools (salinas) for salt production. These may be relatively small 'artisan' salinas (including natural salt lakes) or large industrial complexes. As with coastal grazing marsh, the modified habitat can support important wildlife, though this is to some extent dependent on the intensity of the salt production.

Examples of these habitats include the smaller traditional salinas, largely derived from saltmarsh, such as those on the Algarve (Figure 12), western France and the industrial salinas of the Camargue, which occupy approximately 11,000 ha. The former, depending on the intensity of use (some are abandoned), support salt-tolerant plants such as *Salicornia* spp. and on the drier land Tamarisk (*Tamarisk gallica*). Animals include breeding birds such as Avocet (*Recurvirostra avosetta*) and Shelduck (*Tadorna tadorna*). These species along with several others are especially sensitive to water levels and management can have important consequences for successful breeding (Sadoul et al. 1998). For some birds, such as the Little Tern (*Sterna albifrons*), salinas have become a less favoured but relatively more important nesting habitat in some parts of Portugal, as nesting beaches are increasingly disturbed by tourists (Catry et al. 2004).

Salinas are also important feeding areas not only for birds breeding nearby, but also for those on migration. Water depth is crucial in determining which birds feed where. The Flamingo (*Phoenicopterus ruber roseus*), is often the dominant species and can number up to 10,000 individuals. With decreasing water depth species such as the

Figure 12 Traditional salinas in the Algarve, Portugal. Note the banks enclosing the pools, which provide nesting sites for a variety of birds. These may, in older and abandoned salinas support interesting plant communities, including species more typical of the surrounding saltmarshes (e.g. *Arthrocnemum macrostachyum*)

Avocet, Black-winged Stilt (*Himantopus himantopus*) are some of the characteristic and more easily recognised species. The shorter-legged Little-ringed Plover (*Charadrius dubius*) feed at the margins of the open water. For more information see Sadoul et al. (1998), Walmsley (1999) and Doody (2001, Chapter 11).

2.3.4 Rice Cultivation

Rice cultivation is another widespread activity, which utilises enclosed tidal land throughout the world. It is particularly important in warmer latitudes such as the Carolinas in the USA, parts of the Mediterranean, India and Malaysia. In many of these areas, this use provides important opportunities for intensive and highly productive rice cultivation as in southern Carolina in the USA (Trinkley & Fick 2003). As with salinas under certain circumstances even industrial scale rice cultivation, as in the Ebro Delta, Spain can provide valuable areas for wildlife, especially birds (Ibáñez 1999).

In the Mediterranean, some rice fields provide an alternative habitat for a range of birds threatened by the major loss of coastal wetlands that has taken place there (Fasola & Ruiz 1996). This is especially important for breeding herons in sites such as the Po Delta in north-east Italy, the Rhone Delta in France, the Axios Delta in Greece, and the Ebro Delta in Spain (Fasola et al. 1996). These areas also provide food for migrating birds. This varies seasonally, coinciding with periods of passage. However, agricultural practices may change, causing prey availability and abundance to decline at key stages in the migration cycle. This could result in serious impacts on local migratory water birds (Marques & Vicente 1999).

2.4 Enclosure and Habitat Loss – 'Land Claim'

Enclosure of mature saltmarsh, followed by conversion to intensive agriculture (principally arable cultivation and intensive rice fields) usually involves change to the marsh topography. Notwithstanding the value of rice fields for some birds, as identified above, these are generally of a much lower nature conservation interest than the habitats they replace. Enclosure, resulting in the total exclusion of the tide, normally causes a major loss of coastal habitat including saltmarsh and transitions to brackish and freshwater communities.

The use following enclosure has important implications for habitat re-creation (Chapter 6). Building roads or other infrastructure, or the erection of a sea wall followed by infilling, not only destroys the saltmarsh surface, but also leaves few opportunities for restoration to tidal land. Enclosure that allows the surface to remain at or near its original level has the potential for restoration. These activities (summarised in Figure 13) occur in many parts of the world become progressively more difficult to reverse.

Note that excluding the tide prevents the deposition of new sediment behind the sea wall. This, together with compaction due to drainage, results in lowering of the land surface. Sedimentation continues seaward of the sea wall, further increasing the difference between the two. This has important implications for the sustainability to the defences especially on coasts where sea levels are rising relative to the land (see Chapter 10).

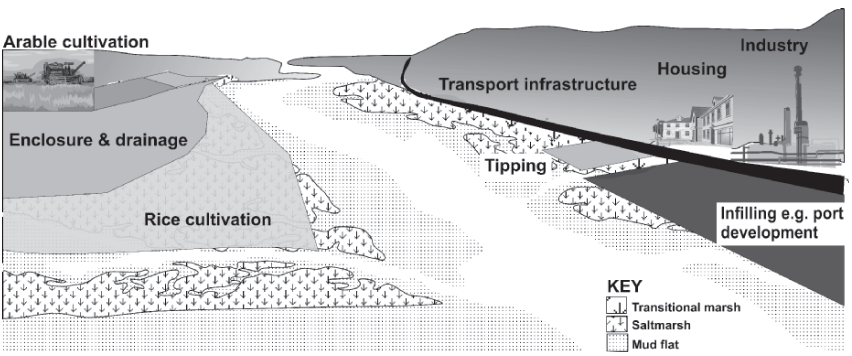

Figure 13 The main factors causing saltmarsh loss. Those on the left are reversible and habitat can be re-created; those on the right are, for the most part, irreversible

2.4.1 Saltmarshes, other Coastal Wetlands and Mosquitoes

Coastal wetlands (saltmarshes and fens) harbour many animals, including mosquitoes that are the vectors of disease, amongst which malaria is the most widespread. Deforestation and erosion of soils in the hinterland help to create vast coastal wetlands, such as those prevalent in the deltas of the Mediterranean. In the eyes of the local population these areas became 'wastelands' with the saltmarshes an important component of the 'mosquito and midge infested swamp'. In some parts of the world, people avoided the problem by settling inland away from these areas. In the Rhone Delta (Camargue), for example, the ancient towns are some distance inland. In other areas where people had already settled, the landscape changed around them. The Ombrone Delta lagoon (on the west coast of Italy) silted up because of deforestation inland. Together with the effects of malaria, the area became uninhabitable, causing abandonment of the harbour around 50 BC (Grove & Rackham 2001).

The same combination of factors may have helped cause the collapse of Greek and Roman civilisations. The process has been described as follows: deforestation results in erosion of soils in the hinterland. Rivers deliver the increasing amounts of sediment to the sea, resulting in the development of coastal lagoons and other wetlands. Mosquitoes breed and infect the local population with malaria. The coastal towns become depopulated and unsustainable (Jones 1907). This is probably only part of the story, nevertheless the effects and nuisance of mosquitoes have spurred on the destruction of saltmarshes and other coastal wetlands not only in Europe, but also in North America (Teal & Teal 1969).

Efforts to control malaria continued in Europe into the middle of the twentieth century. For example, in Albania during the communist period presided over by Enver Hoxha from 1944–1985, drainage of these areas became part of a mostly successful attempt to increase agricultural production and control mosquitoes (Figure 14). Today all the European countries, except Turkey, are free from the disease (World Health Organisation web site, see http://www.euro.who.int/malaria).

2.4.2 Enclosure and Drainage of Coastal Wetlands for Agriculture

With or without the incentive of malaria control, drainage of wetlands around estuaries, deltas and other coastal wetlands has taken place for centuries and probably dates back before Roman times. Expanding deltas in the Mediterranean became important places for agriculture, including rice cultivation (as in the Ebro Delta, Spain). Significant areas of coastal land became intensively cultivated land in the Netherlands, Denmark and in England.

The process of conversion varies between different countries. In eastern England, drainage of wetlands (freshwater to brackish water swamps) in the Fenland Basin probably occurred at least, from Roman times, though on a small

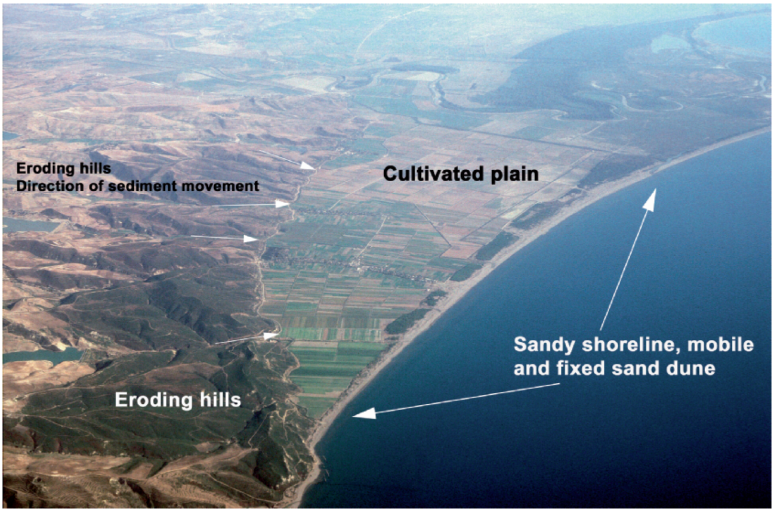

Figure 14 Coastal plain of northern Albania. A large expanse of sediments derived from erosion in the hills. The arrows show the direction of sediment movement from the hinterland. Much of the area behind the coastal dunes is drained swampland. Note the fringing sand dunes and the absence of towns (Photograph from 1993)

scale. In the 1600s a Dutch engineer, Sir Cornelius Vermuyden, introduced the Dutch methods of enclosure to Britain, and made the first important attempts to drain the area (Figure 15).

Nearer to the coast, successive smaller-scale enclosures in The Wash helped to create new agricultural land. Here a 'counter dyke' prevented the sea from flooding the saltmarsh allowing the excavation of material from a 'borrow dyke', which was used to construct the new earth embankment. The whole process relied on there being sufficient saltmarsh to build both the counter dyke and the embankment, thus the extent of new land was dependent on the rate and extent of saltmarsh development.

Taken together the total area of land drained, claimed and enclosed for agricultural use, amounts to over 130,000 ha. The saltmarsh alone, through piecemeal and cumulative enclosure, provided nearly 30,000 ha by the early 1950s (Dalby 1957). Enclosure continued, with relatively substantial areas of land claim taking place between 1953 and 1983 (Figure 16).

Similar enclosures occurred in the Dee Estuary, in the UK (Pye 1996), the Lower Elbe in Germany (Garniel & Mierwald 1996) and elsewhere in north-west Europe including France and the Wadden Sea (Allen 1997). In the USA, impoundments helped create land for haymaking and other agricultural uses, such as in Louisiana, beginning in the 1700s. A further tranche, promoted by the US Department of Agriculture, began in the early 1900s on the east coast and in Louisiana (Warren 1911). These enclosures are especially important to later discussions, as they present some of the best opportunities for restoration (Chapter 6).

Figure 15 Progressive and cumulative embankment and drainage in the Fenland Basin, in relation to the saltmarshes of the Wash, eastern England. Redrawn from interpretative material at the Flag Fen Bronze Age Centre, Peterborough, UK http://www.flagfen.com/. See also Brew & Williams (2002) for details of the changes in the extent of the shoreline before embankment. Note Joan Blaeu's map of 1643 also shows the extent of the fens in relation to the 'uplands' particularly well

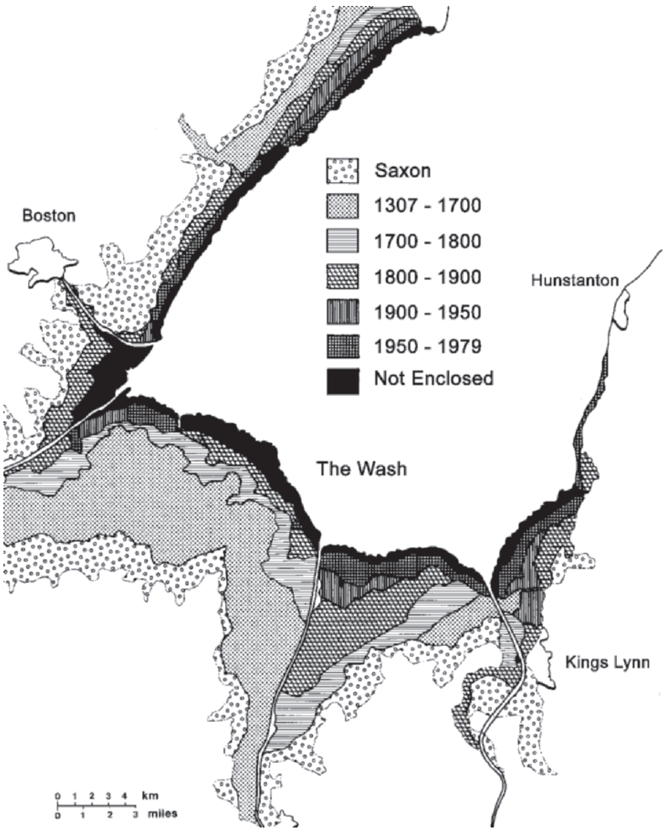

Figure 16 Sequential enclosure of saltmarsh around the Wash, Lincolnshire, eastern England (After Doody & Barnet 1987)

2.4.3 'Warping' and Sediment Fields

In the Wadden Sea (southern North Sea) techniques that are more aggressive were employed, which extended the saltmarsh beyond the normal limits imposed by sediment availability, tides and waves. The process, involved creating a system of 'sediment fields' made of brushwood groynes and low earth embankments intersected by ditches dug in the flats (Figure 17). The increase in sedimentation 'warping' resulting from the enclosed tidal flats with their restricted opening and planting saltmarsh plants such as *Spartina anglica*, helped to promote the establishment of vegetation. The labour-intensive process all but ceased in many areas, from the 1940s (Beeftink 1977a). Sediment fields continue to perform an important sea-defence function by promoting the development of a pioneer zone in front of an eroding cliffed saltmarsh. The brushwood fences aid the processes of sedimentation and plant succession.

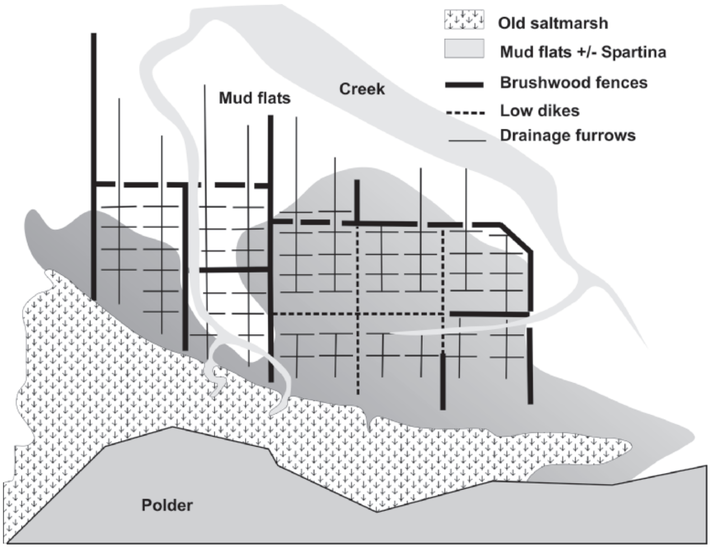

Figure 17 Sediment fields helping to create saltmarsh in the Netherlands and 'protect' the mature saltmarsh and enclosed 'polder' (after Beeftink 1997a)

Planting *Spartina anglica* to aid the process of colonisation and subsequent enclosure and for coastal protection began in the UK (Gray & Raybould 1997), became common throughout the world (Ranwell 1967), in Ireland (Nairn 1986), New Zealand (Allan 1930) and China (Chung 1990). The issues surrounding *Spartina* spp. its value or otherwise, including the effects on tidal flats, invertebrates, wintering birds and native saltmarsh plants is considered later (Chapter 9).

2.4.4 Enclosure for Infrastructure

Enclosure within estuaries and the creation of new land through infilling is a worldwide activity. In the Netherlands the area called the Zuiderzee, a saltwater inlet of the North Sea became an area of more than 150,000 ha of usable land by 1932 and a freshwater lake, the Ijsselmeer. Following the storm surge of 1953, building structures associated with the Delta Project resulted in the loss of large areas of intertidal land (d'Angremond 2003).

In the USA, the major causes of coastal wetland loss are urban development and encroachment by coastal waters caused by impoundments, dredging projects and rising sea level. Losses are concentrated in highly developed areas, such as the Gulf of Mexico and Chesapeake Bay (Johnston et al. 1995). Because of the scale of the enclosures, it is difficult to identify losses associated with saltmarsh (and mangroves) specifically, as opposed to tidal and freshwater wetlands more generally.

Figure 18 A scene from the 1980s, early 1990s in Great Britain illustrative of the 'view' of some local authorities and other organisations, of the 'value' of saltmarshes and tidal areas

The situation is similar when looking at the extent of the losses of saltmarsh on a worldwide basis. Most references are for tidal wetlands and there is no distinction made between saltmarshes, tidal lagoons, sand or mudflats. However, the losses associated with these enclosures are significant and there are major areas of 'reclaimed'* tidal land around the world (Wong 2005).

In addition to the major areas of enclosure, there is also a much more widespread pattern of piecemeal loss. This is often associated with a prevailing view that saltmarshes and their associated habitats are little more than 'wastelands'. A study of estuaries in Great Britain, for example, showed that in 1989 of 123 cases of estuary land claim, more than 50% affected intertidal or subtidal habitats. Of the approximately 1,000 ha of land affected, over 60% of the intertidal areas suffered from rubbish and spoil disposal (Davidson et al. 1991; Figure 18).

2.4.5 Summary of Enclosure

A key issue for the management, and more importantly restoration of saltmarshes lost through enclosure, is the after use of the land. Enclosure, for use in crop production, requires the removal of the saltmarsh from tidal influence. There need be little or no modification of the surface except for the infilling of tidal creeks and

*The use of the word 'reclamation' in the context of this book is inappropriate as the saltmarsh is not reclaimed (retrieved or recovered as defined by the Compact Oxford English Dictionary) but destroyed.

removal of other surface irregularities. Drainage is important and once the salt has leached out of the soil, planting takes place. The saltmarsh can, within just a few years become high-quality agricultural land. The key point here is that reversal of the process is possible.

By contrast, saltmarshes that have been dredged and infilled, developed for industry, airports or housing are lost forever. Large enclosures such as the significant areas of the land 'won' from the sea in the Netherlands are unlikely to become tidal again, because of their high social and economic values.

2.5 Other Influences

Many other factors influence saltmarshes and their development. Some, such as recreational activity have relatively little adverse impact. Bird watching, walking, boat access and wildfowling, may have localised effects on the saltmarsh, but are more likely to be positive assets when looked at in relation to the value of the habitat. Others, such as oil and litter pollution can be more damaging. Salt production, aquaculture, insect control (especially for the mosquito), tidal power, tidal barriers, water storage and introduced species all have direct and/or indirect effects on saltmarsh. The way in, which these activities influence the conservation, management and restoration of saltmarshes is discussed later.

The final and in some ways most significant human influence on saltmarshes is global warming and the effect this is thought to have on sea levels. Although some argue there is no direct relationship, sea-level change has an important influence on the direction of saltmarsh development. The combined effect of saltmarsh loss as a direct result of human activities and sea-level rise has a significant impact on the sequence of tidal habitats including saltmarshes (Section 3.5.2, the 'saltmarsh squeeze').

The deliberate reversal of enclosure in estuaries is known as 'managed realignment' in the UK and 're-integration with the sea' in Germany. This is a process, which includes flooding of previously defended land, in an attempt to encourage the re-creation of tidal land (Leggett et al. 2004). It is normally associated with sea-defence issues, but also has important implications for nature conservation. It forms part of the discussion in Chapter 6, on saltmarsh restoration.