Cambridge University Press
978-0-521-11699-2 - Saltmarshes: Morphodynamics, Conservation and Engineering Significance
Edited by J. R. L. Allen and K. Pye
Excerpt
More information

1

Coastal saltmarshes: their nature and importance

J.R.L. ALLEN AND K. PYE

Introduction

Coastal saltmarshes are environments high in the intertidal zone where a generally muddy substrate supports varied and normally dense stands of halophytic plants. These environments grade seawards into mudflats or sandflats, to which they are genetically related, and from which they are often separated by either a ramp or cliff, and may grade upwards and landwards into freshwater marshes and coastal woodland communities. Saltmarshes are widely developed on low-energy coasts in temperate and high latitudes, but in the tropics and sub-tropics they are replaced by mangrove communities. The approximate latitudinal limit for the growth of mangrove species is determined by a mean minimum temperature in the coldest month of 10°C (Chapman, 1977).

Saltmarshes have long been viewed by scientists as intrinsically interesting environments on account of their variability and the rapidity with which physical, chemical and biological processes operate. A number of reviews have been published during the course of the past century (Carey and Oliver, 1918; Chapman, 1960; Ranwell, 1972; Beeftink, 1977; Long and Mason, 1983; Frey and Basan, 1985; Adam, 1990). However, much of the published work has been ecological or geochemical in character, and physical processes have been relatively neglected.

The occurrence of saltmarshes is to a large extent controlled by coastal physiography, since under most circumstances mud can accumulate only in relatively low-energy environments where wave action is limited. Consequently mudflats and marshes are usually found in sheltered embayments and estuaries, and in the lee of barrier islands and spits. An exception occurs in areas where very large amounts of fine sediment are supplied to the coastal zone by major rivers, resulting in the formation of a wide and shallow nearshore zone which absorbs much of the incoming wave energy. In such circumstances, such as occur in the Mississippi Delta and northwest

Fig. 1.1. Generalised distribution of active saltmarshes around the British coast (modified after Burd, 1989).

of the mouth of the Amazon, muddy sediments can accumulate on parts of the open coast and may evolve into saltmarshes or mangrove forests.

The total area covered by active saltmarsh in Great Britain amounts to approximately 44,370 ha, being concentrated largely in eastern and southeastern England, northwest England and the area of the Bristol Channel (Burd, 1989; Fig. 1.1). Active saltmarshes are also locally important in Northern Ireland. Major areas of reclaimed marsh are found in East Anglia, Kent, Somerset, and northwest Lancashire (Gray, 1977). The active marshes can be classified into five main types on the basis of their physical setting: (1) open coast marshes, (2) back-barrier marshes, (3) estuarine fringing marshes, (4) embayment marshes, and (5) loch or fjord-head marshes. True open-coast marshes are poorly developed in Britain on account of the relatively high wave energy experienced along most of the coast, examples being found mainly in Essex along the Dengie Peninsula and on Foulness Island. Open-coast back-barrier marshes are well developed on the shores of north Norfolk (Pye, Chapter 8, this volume) and in south Lincolnshire, but are also otherwise poorly developed in the UK. Estuarine fringing marshes occur in virtually every estuary, including the Severn (Allen, Chapter 7, this volume), Dee, Mersey, Ribble and Solway on the west coast, and the Medway, Thames, Crouch, Blackwater, Humber and Tay on the east coast. Embayment marshes are found in relatively large, shallow coastal embayments which often have a restricted entrance and receive a relatively limited freshwater input. In some instances the entrance to the embayment is partly protected by a sand or shingle barrier. Several examples are found on the south coast of England, including Portsmouth Harbour, Langstone Harbour, Chichester Harbour, Pagham Harbour and Poole Harbour. An east-coast example is provided by Hamford Water, while The Wash and Morecambe Bay marshes can also be regarded as variants of embayment-type marshes. Loch- or fjord-head marshes are typically restricted in size and occur mainly on the predominatly rocky coasts found in northwest Scotland.

The location, character and dynamic behaviour of saltmarshes is governed essentially by four physical factors: sediment supply, tidal regime, wind-wave climate, and the movement of relative sea level. To these may be added the variable but secondary role played by marsh vegetation in acting both as a source and as a trapper and binder of sediment. Colonisation of sand or mudflats by vegetation can only begin once the level of the surface has been raised to a sufficiently high level in the tidal frame by physical sedimentation processes. Once vegetation is established, the rate of sedimentation frequently increases as more of the incoming sediment is intercepted and trapped by the greater surface roughness (Stumpf, 1983; Stevenson *et al.*, 1988), resuspension of deposited material is reduced for the same reason, and organic matter is added to the marsh surface.

Sediment supply

The immediate sources of the sediment found beneath saltmarshes are the tidal waters (which provide mainly mineral matter) and the marsh plants themselves (which supply organic matter). The composition and grain size of the mineral matter varies from sandy silt to clayey silt according to marsh location and marsh height, but is normally referred to as 'mud'. A predominance of mud in the supply leads to the formation of a *minerogenic* marsh, whereas a predominance of organic matter supply (litter, root biomass) leads to the formation of an *organogenic* marsh. The saltmarshes actively forming in Great Britain today are mostly of the minerogenic type.

Relatively little is known about the sources and budgets of fine sediment in British saltmarshes, or about the manner in which these have varied over time during the Quaternary. Potential sources of minerogenic sediment include river catchments, estuarine and coastal cliffs, and offshore mud deposits. Since mud is easily transported in suspension in tidal waters, it may travel considerable distances from its source, and be mixed with material derived from other sources, before arriving at its ultimate site of deposition. The major rivers which drain into the North Sea and Irish Sea at the present day supply relatively small amounts of sediment (McCave, 1987; Eisma and Kalf, 1987; Kirby, 1987), and much of the mud suspended in tidal waters appears to be derived from erosion of unconsolidated Pleistocene glacial sediments exposed in coastal cliff exposures. During the early Flandrian period, when sea level rose rapidly, wave and tidal current reworking of Pleistocene sediments on the floor of the North Sea and Irish Sea probably provided a major source of sediment which was reworked landwards and deposited in protected estuaries and embayments. Most British estuaries have acted as long-term sediment sinks throughout the Flandrian period and many have experienced a marked reduction in estuarine capacity, due in part to natural sedimentation processes but enhanced by human activities which have included reclamation and dredging (Kestner, 1979; O'Connor, 1987).

The margins of certain estuaries, for example, the Severn, expose substantial thicknesses of postglacial silts which, representing earlier marshes and mudflats, are now undergoing vigorous erosion. Part of the sediment derived from these sources finds its way onto younger marshes further up the estuary (e.g. Allen, 1990).

The availability of suspended fine sediment, and the maximum productivity of marsh plants, together strongly affect the character of saltmarshes and their ability to respond to changing environmental conditions.

Tidal regime

Mud accumulates high in the intertidal zone of tide-dominated coasts because it is only at stages close to high water level that tidal current velocities are sufficiently low to allow fine suspended particles to settle out and remain undisturbed. Since much of the coastline of Britain is either mesotidal or macrotidal, the vertical range of saltmarshes within the high intertidal zone is typically 1–4 m. In most areas, marsh vegetation is limited to the zone between mid neap tide level and high water spring tide level. Most of the British coast experiences a simple semi-diurnal tidal regime, although on parts of the south coast the tidal regime is more complex.

The combination of a macro- or mesotidal regime and comparative shallowness means that most British barrier coasts, embayments and estuaries are dominated by a flood-tide regime which favours the landward movement of sediment from the offshore zone and which encourages the retention of river-borne sediment close inshore.

Due to the fact that saltmarsh and mudflat sediments are exposed to the atmosphere at low tide, their geotechnical characteristics differ from those of fine sediments which accumulate wholly subaqueously. Drying between tides and during the summer season of comparatively low tides gives intertidal muddy sediments a head start on the path to consolidation before any significant load has been experienced. Additionally, drying creates fractures which frequently influence the pattern of erosion during subsequent high tides. Such fractures can play a major role in determining the nature and rate of marsh cliff retreat (Allen, 1989).

Cambridge University Press
978-0-521-11699-2 - Saltmarshes: Morphodynamics, Conservation and Engineering Significance
Edited by J. R. L. Allen and K. Pye
Excerpt
More information

Wind and wave climate

Although tide-dominated, the barrier coasts, embayments and estuaries of Great Britain and Northern Ireland are not devoid of wave influences. The effectiveness of waves in these environments depends on wind strength and directional variability, fetch (distance of open water over which waves can be generated), and on the frequency distribution of water stages. Powerful waves can quarry large blocks of sediment and cause undercutting and collapse of saltmarsh cliffs. They may also destroy the integrity of the surface vegetation, particularly near the seaward marsh edge, leading to widespread scouring of the underlying mud surface and promoting a generally unstable local environment. Waves and wave-induced bottom currents may prevent the settlement of mud at high tide, and may resuspend material deposited by earlier tides. Storm waves may also influence saltmarshes through the construction or destruction of shingle barriers (Fig. 1.2).

Although wave height tends to increase linearly with wind speed, wave energy varies as the square of wave height; consequently relatively modest fluctuations in local wind-wave climate may bring about substantial changes in the high intertidal zone.

Instrumental and proxy records demonstrate that climate in the British Isles has experienced considerable temporal variability on a variety of timescales during the last few thousand years (Lamb, 1982). Saltmarshes and the mudflats from which they evolve may well prove to afford a sensitive historical record of the local effects of these fluctuations (Allen, Chapter 7, this volume).

Movements of relative sea level

The behaviour of relative sea level can have a major influence on the medium and long-term evolution of saltmarshes (Reed, 1990). The causes of relative sea-level movements can be divided into three main groups: (1) eustatic factors, which are essentially global in extent, including changes in ice volume, thermal expansion/contraction of the oceans, and changes in ocean volume due to sea floor spreading and hydrostatic loading (Warrick and Oerlemans, 1990; Wigley and Raper, 1991); (2) regional factors, including subsidence/uplift due to crustal movements and sediment compaction/dewatering, geoid changes and tidal variations; and (3) local factors, including changes

Fig. 1.2. Storm-generated shingle washover fan, composed largely of shell debris, transgressing over marsh vegetation, north side of the Blackwater Estuary, Essex.

in coastal, estuarine and shelf morphology, which may affect tidal regime (Woodworth *et al.*, 1991), and changes in barometric pressure and wind field, which in turn have an influence on mean water levels (Woodworth, 1987, 1990; Pugh, 1990).

Relative sea-level movements in the British Isles over at least the past few centuries appear to have been dominated by regional neotectonic factors, but the eustatic contribution due to thermal expansion of the oceans and decreasing ice volume may become more significant in the next century (Warrick and Oerlemans, 1990; Warrick and Wigley, 1991) The present net sea-level trend remains downward in northwest Britain, where the land is still rising isostatically following removal of the former ice load approximately 10,000 years ago, but in the southern part of the country the trend is upward, albeit apparently locally variable (Fig. 1.3; Woodworth, 1987, 1990; Tooley, Chapter 2, this volume). This rise in relative sea level can in part be attributed to long-term subsidence of the southern North Sea Basin, but the relative contribution of other factors remains a matter of controversy. A zone of neutral crustal movement (and, effectively, sea-level movement) has been identified running across the country

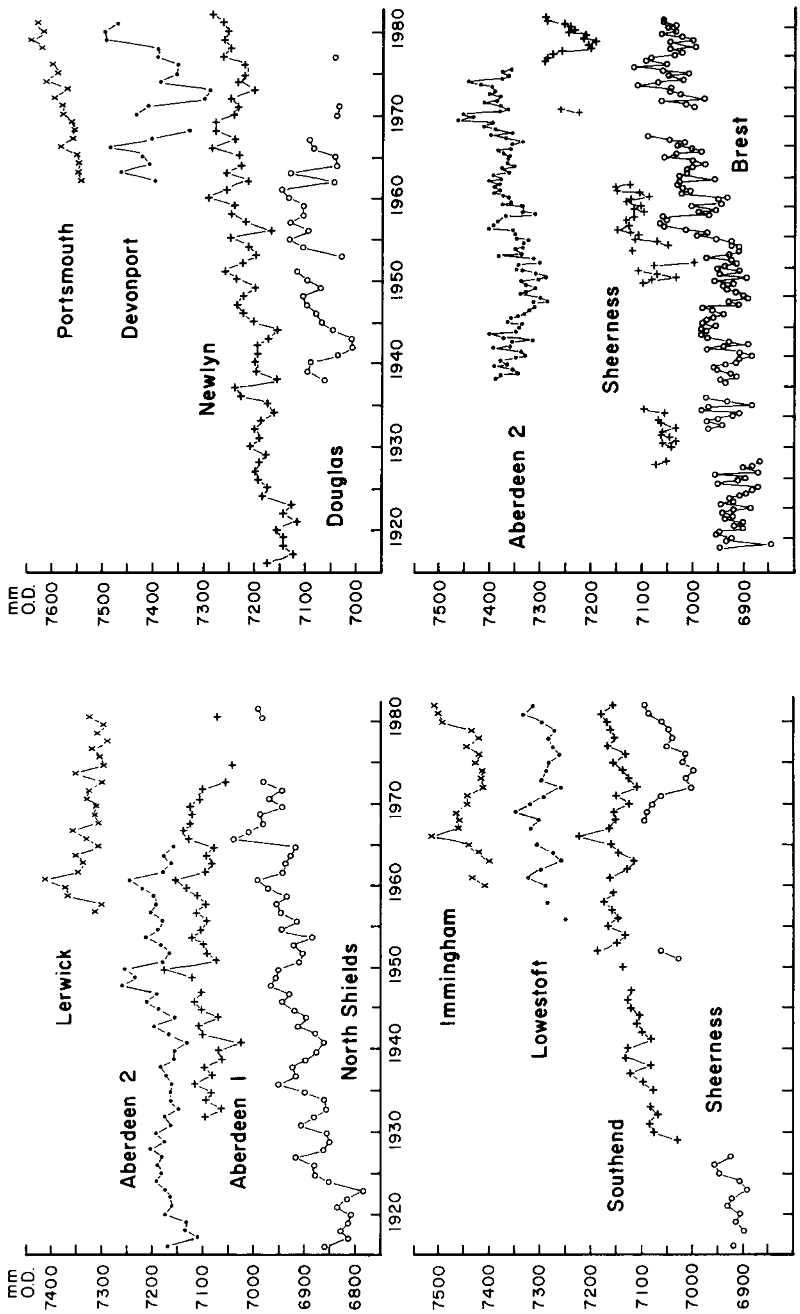

Fig. 1.3. Trends in mean sea level at a number of UK stations (after Woodworth, 1987).

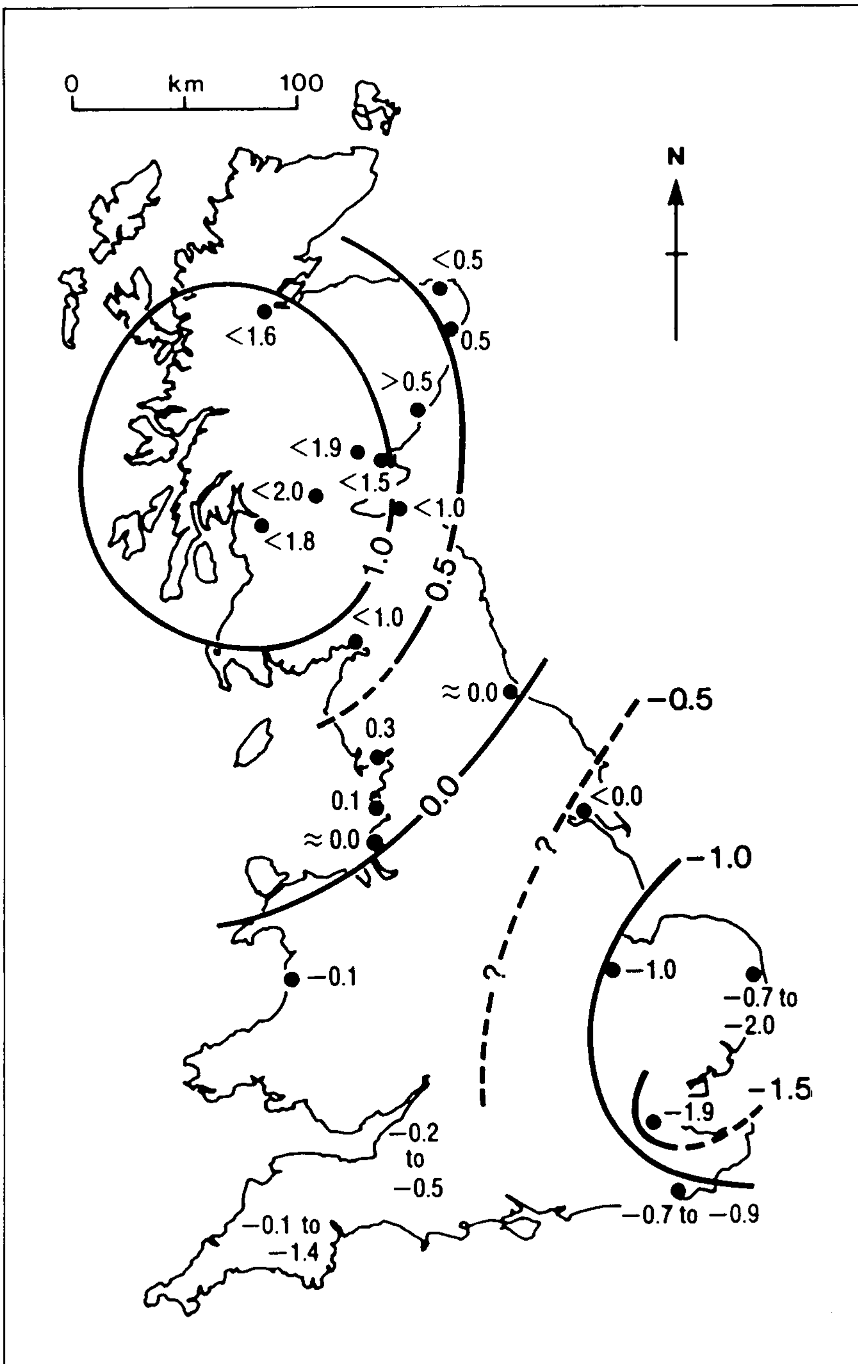

Fig. 1.4. Holocene crustal movements in the UK (after Shennan, 1989).

Fig. 1.5. Wave-eroded marsh cliff, Stiffkey, Norfolk.