Coastal Defence

Report on the Salt Marshes at Marshside, Southport.

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1.0 Introduction

This report is part of a series of reports designed to give a detailed account of a particular feature on the Sefton Coast as part of the process of updating the Sefton Coast Database. Updating of the database includes analysis and interpretation of existing materials held by the Council which will identify gaps in knowledge and future works that could be undertaken to improve our understanding of the geomorphology of the Sefton Coast. This particular report discusses the natural processes occurring within the salt marsh at Marshside, the evolution of the salt marsh system over time, and the nature of the current situation.

2.0 Background to the Sefton Coast

The Sefton Coast, which extends over 34 kilometres (21 miles), is comprised of soft and granular deposits of sand, silt, clay and peat. There are no outcrops of rock on the shoreline. Hence, the forces of nature readily mould it, so the shoreline is constantly changing in response to the fluctuating influence of wind and water and as a result of human activity. Its overall shape derives from two major river estuaries, the Mersey and the Ribble. The River Alt and the Crossens Channel, each have important local zones of secondary influence.

Figure 2.1: Generalised Sefton Coast landscape.
The coast is a long wide arc of sand (Figure 2.1) with a hindshore dune system, which at one time would have stretched from the Mersey Estuary to the Ribble Estuary. Human use of the dune system over several centuries has created a dune landscape of great variety. To the north of the Sefton Coast is an extensive area of Saltmarsh extending into the Ribble estuary; other smaller areas of Saltmarsh also occur at the River Alt and Smiths Slack (located on the foreshore between Birkdale and Ainsdale). Several towns have developed along the coast; at Crosby, to the south, and Southport, to the north, artificial defences have been put in place. In-between these areas towns such as Formby rely upon the sand dunes to provide protection from the sea.

The sand dunes, beaches and marshes of the Sefton Coast are one of the most important areas for nature conservation in Europe. The entire Coast is designated as either Special Protection Area (SPA) to the north of the pier at Southport or Special Area of Conservation (SAC) to the south of the pier, notable species include Sand Lizards and Natterjack Toads with the estuarine area being very important for birds. The Sefton Coast is also an important visitor destination with popular bathing beaches, open countryside, and the seaside resort of Southport.

According to JNCC (2006), 75% of the wetland of the Sefton Coast is tidal flat, with 16% being salt marsh, 8% is sandy shore, with 1% being freshwater marsh. The intertidal flats and salt marshes that comprise the Marshside salt marshes are located on the southern edge of the southern shore of the Ribble Estuary, to the north of the town of Southport (Figure 2.2).
3.0 Introduction to Salt Marshes

The intertidal zone is the area of coastline that is covered by the sea during tidal inundations (sometimes only during very high tides), but is exposed to the air during low tide. Salt marshes are areas within this zone that are sufficiently high up in the intertidal zone to be exposed to the air for long enough periods of time to become vegetated by specialised plant species.
3.1 Salt Marsh Morphology

There are three different environments or 'zones' that can commonly be seen within salt marshes (Plate 3.1). These are generally determined on the basis of the vegetation present, and can be divided up as:

- **'Low' or 'pioneer' salt marsh.** This area is generally nearest to the sea, and at lower elevations, and receives the greatest number of tidal inundations compared to other salt marsh zones. Large areas of bare mud are usually still visible. The vegetation in this zone is often limited to a very small number of species.

- **'Mid' salt marsh.** Vegetation in this zone remains generally very short, but covers a much greater percentage of the ground, with a higher number of different species, leaving less bare mud visible. Characteristic salt marsh features such as creeks become more apparent.

- **'High' or 'mature' salt marsh.** Plants are much more terrestrial in their nature, being taller, and often flowering in summer. There is often complete coverage of vegetation with no bare mud visible. The elevation of the marsh surface is usually higher than in the previous two zones, so tidal inundations in this zone can be relatively rare.

These zones are not static, and over time, given the right conditions for salt marsh growth, the low marsh can gradually become mid marsh then eventually high marsh. Similarly, if the conditions are unfavourable for marsh growth, the zonations can revert from high or mid marsh back to low marsh. These conditions are determined by a number of factors, including mean local sea level, sediment supply and the management strategies being undertaken, such as realignment. On a large scale, salt marshes appear to be flat expanses of land sloping towards the sea, but close-up, there are many features that make the surface far from flat and uniform.
Plate 3.1: The three commonly differentiated zones within a salt marsh: a) low or pioneer zone; b) mid marsh; c) high or mature marsh.
Characteristic features of salt marshes, particularly of the mid and high marsh zones are creeks (Plate 3.2). These are effectively channels that cut across the marsh surface that fill up at high tide and drain at low water. They are similar to river drainage channels, forming dendritic, meandering patterns across the marsh, but with the water flowing through them in two directions depending on the state of the tide, flowing inland during an incoming tide, and flowing out to sea with an outgoing tide. Creeks can range from just a few centimetres to many metres across and be over a metre deep. In the low marsh zone, the drainage is more commonly via wide, shallow gullies (Plate 3.3).

Running along the edges of creeks are features called ‘levees’. These are small mounds of sediment that have built up slightly higher than the surrounding flat plains between the creeks. They form by the deposition of sediment that is held in suspension in the water flowing up the creek. When the creek becomes full and the water floods over the adjacent flat marsh plain, it instantly loses energy, so the sediment that was held in suspension in the faster flowing water of the creek is deposited on the levee. The coarser sediment of the levees results in them having a higher percentage of air space within the sediment, and draining more quickly than the adjacent plains (Long and Mason, 1983).
A second feature of salt marshes are ‘pans’. These can be classified as either ‘primary pans’ or ‘channel pans’. The former are roughly circular depressions on the surface of the marsh. There are a number of theories as to how and why they form, potentially due to either debris swirling around during tidal inundation preventing vegetation from growing, or due to a localised build-up of salt. Channel pans, as their name suggests, are formed from creek channels that have become cut-off from the creek system, keeping their elongated shape but effectively becoming an isolated feature (Plate 3.4 and 3.5). They can become waterlogged following inundation by the tide, or during periods of high rainfall or high groundwater, but can dry out in intervening periods.
Plate 3.4: Two flooded adjacent channel pans at Marshside that had previously been part of the creek system, but which have become blocked by vegetation.

Plate 3.5: A channel pan at Marshside.
3.2 Salt Marsh Sedimentology

Salt marshes have a characteristic sedimentology. The mean grain size of salt marsh sediments generally decreases landwards, with higher concentrations of silt and clay size particles with increasing distance from the sea (Postma, 1961; Evans, 1965; Allen, 1996). This is due to the velocity of the incoming tide decreasing as the tide advances up the intertidal zone, so the heavier sand particles being deposited in the higher energy conditions further down the intertidal zone, with the finer sediment being able to be held in suspension for longer, so being able to be transported further up the intertidal zone before being deposited.

In addition, the concentration of sediment held in suspension decreases landwards, as sediment is deposited as the tide comes in, so there is gradually less held in suspension as the tide moves further up the intertidal zone. This results in the low marsh zones building up ('accreting') at a faster rate than the high marsh zones that receive less tidal inundations and hence less sediment deposition.

3.3 Salt Marsh Ecology

Plants that colonise salt marshes are termed ‘halophytes’, meaning that they are tolerant of the salt conditions. Two species in particular are associated with the initial colonisation of the low marsh zone, *Salicornia europaea* (Glasswort or Samphire) and *Spartina anglica* (Common Cord Grass) (Plate 3.6). The zonation within the salt marsh is strongly reflected in the vegetation present. In mid and high marsh the number of species increases, and as the conditions become more terrestrial in nature, so this is reflected in the nature of the plants. Within individual zones, some species of vegetation favours specific habitat, for example, *Halimione portulacoides* (Sea Purslane) can often be found on the slightly higher creek banks rather than on the lower flatter marsh plains.
Plates have to tolerate very specific and harsh environmental conditions on salt marshes. These include:

- Growing in unstable sediment, particularly during tidal inundations;
- Being covered by sea water, potentially for hours at a time in the low marsh;
- Being disturbed by the action of the tide, with water and sediment moving around the plants. Most plants have adaptations to cope with such conditions, for example *Salicornia* is a succulent with fleshy rounded leaves, which is believed to help against mechanical damage.
• Waterlogging during and after tidal inundations (Popham, 1966; Packham and Willis, 1997). Even after the tide has receded, it can take a long time for water to drain away from the muddy sediment.

• High salt concentrations within the sediment. Levels are not only high during inundation, but can also concentrate even higher as the water dries out of the sediment leaving the salt behind. Halophytes require a salt concentration in excess of 100-200 mM sodium chloride to survive (Flowers et al., 1986; Packham and Willis, 1997).

• Anaerobic conditions where there is very little or no oxygen present within the sediment. These conditions often occur within only a few millimetres of the surface, and are associated with black or grey colouration to the sediment as a result of iron sulphides present (van Straaten, 1952) (Plate 3.7).

The vegetation is a key factor in the development and continuance of salt marsh. Its presence reduces the energy of the waves during an incoming tide, resulting in sediment being deposited which allows the salt marsh to develop further. The presence of the leaves and stems also physically traps sediment, both from suspension during inundation and wind blown sediment (Stumpf, 1983; Packham and Willis, 1997) (Plate 3.8). The roots of vegetation also help to bind sediment together to give it greater stability during tidal action (French, 1997). When leaves, stems and roots die, they are also incorporated into the sediment or surface of the marsh which adds organic matter.
Plate 3.7: Black or grey discolouration just below the surface of the salt marsh at Marshside due to anaerobic conditions.

Plate 3.8: The sediment trapping ability of vegetation.
The fauna of the salt marsh is also key to its survival. Intertidal flats and salt marshes have been identified as some of the most biologically productive environments, with primary production being in the region of 500 g m\(^{-2}\) a\(^{-1}\) of organic matter in an average estuary (Nelson-Smith, 1977). It is because of this high productivity that such large numbers of wading birds migrate to salt marshes, as they are rich in invertebrate food sources. Each tidal inundation brings a replenished supply of sediment and food for invertebrates, which are predominantly made up of burrowing species. Lower down the intertidal zone only one or two species may be predominant, such as *Arenicola marina* (Lugworm) and *Hydrobia ulvae* (a mollusc), with species diversity increasing up the intertidal zone as the sediment becomes finer (Yates *et al.*, 1993). The invertebrates, along with microscopic organisms such as algae and diatoms that exist within the sediment, also secrete slimes and films that are important to bind fine sediment together (van Straaten and Kuenen, 1957; Coles, 1979; Frostick and McCave, 1979; Adam, 1990; French, 2007).

### 4.0 Historic Evolution of the Marshside Salt Marshes

#### 4.1 Pre-1970s

The area around the Marshside salt marshes has experienced notable human influence since the development of the town of Southport in the 1800s. Developments have included urbanisation with associated infrastructure development; land reclamation, predominately for agriculture; port development with related estuarine channel training and dredging associated with the Port of Preston to the east; tourism and recreation; and increases in industry and commerce directly impacting upon the coastal zone.

Such developments within the Ribble Estuary have had implications for the evolution of the salt marshes. Particularly, the tendency of the estuarine environment to ‘infill’ with sediment has resulted in numerous reclamation schemes along the coastline. A series of reclamation schemes were made throughout the 19th century (Figure 4.1). Gresswell (1953) recorded the scale of the reclamation, when he calculated that in the 50 years between 1830 and 1880, over a mile in width of salt marsh had been reclaimed. In 1932, to further encourage sedimentation, ‘saltings’ or evenly spaced clumps of *Spartina townsendii* were planted to promote sedimentation at Marshside (Gresswell, 1953; Berry, 1967) (Plate 4.1). Reclamations continued throughout the 20th century, with the most recent being an enclosure just north of Marshside at Hesketh Out Marsh in 1980 (Smith, 1982), which is however, due to be breached as part of a realignment scheme in the near future.
The reclaimed land has been used predominantly for agriculture (arable and grazing land), for urban development, and for leisure activities (Pye and French, 1993b). The reclamations that have been most significant for the Marshside marshes were those to enclose the Marine Lake and construction of the Coast Road during the 1960s and 1970s. The latter enclosed marshes at Marshside, that are now brackish marshes and are an important RSPB reserve. This enclosure, however, now provides an engineered sea wall to the landward side of the active salt marsh and intertidal flats. This therefore potentially has implications for allowing the process of ‘coastal squeeze’ to occur (French, 1997; Haslett, 2000). This would result in the restricted opportunity for landward migration of the salt marsh if local sea level rise is occurring at a rate with which the salt marsh cannot keep pace.

Accretion in the Ribble estuary has long been of interest to the decision makers of Southport. As far back as 1936, A.E. Jackson, the Borough Engineer of Southport, reported that:

“The Ribble Estuary…on the south side of which Southport is situated, has been the subject of much interest and inquiry as to the source of the great accretion which is taking place there, probably unequalled anywhere in the British Isles except the Wash”. [A.E. Jackson, 1936; from a paper given at the Health Congress of the Royal Sanitary Institute].

It is this continued accretion that has permitted the large scale of reclamations along the coastline. It is calculated that there has been 2,320 hectares of marshland reclaimed since 1800, with the active marsh area in 1993 being 2,134 hectares, (Pye and French, 1993b). Evidence from aerial photographs and previous studies (e.g. Pye and French, 1993b; Ribble Shoreline Management Partnership, 1997; Coastal Engineering UK Ltd, 2005) indicate the marshes are continuing to accrete laterally and subsequently vertically.

However, changing attitudes towards the positive sedimentation along the coastline have been indicated by the accretion of muddy sediments in a southerly direction towards Southport Pier being considered a major aesthetic issue by the local community. French (1997) remarked that Southport was experiencing problems with *Spartina* encroachment and sediment accretion. The Ribble Estuary Shoreline Management Plan (2002) also identified sea-level rise and salt marsh spread as two major issues along the coast. However, the presence of the reclamations indicates that this negative approach to the presence of the salt marsh was not always necessarily present.
Figure 4.1: Map showing embankments and probable dates of reclamation on the southern shore of the estuary. Image produced by SMBC. (Barron, 1938; Gresswell, 1953).
4.2 Evolution of the salt marsh, 1970s – Present

Figures 4.2 and 4.3, and Plate 4.2 demonstrate the changes in the location of the marsh edge at the study location over time. In 1976 the southerly marsh edge was restricted to a small area concentrated around the sand-winning plant, with a reasonable assumption being that it was the presence of the plant boundary that provided an agreeable environment for this initial extension of the marsh. It should be borne in mind that the final Coast Road extension was only completed in 1974, two years prior, so the marsh may still have been adjusting to the presence of the sea wall. Subsequent expansion of the marsh has continued to such an extent that any further influence from the plant itself is highly unlikely. The track adjoining the plant, however, appears to continue to exert an influence over the positive marsh growth.

In a report by R.J. Holliday of the University of Liverpool in 1976, the ‘problem’ of the spread of Spatina townsendii towards the Southport foreshore is considered. In which, reference is made to previous attempts to control the Spatina by spraying with Dalapon (a herbicide), but which
Figure 4.2: Changes in marsh edge over time taken from aerial photography. Image courtesy of SMBC. Aerial photograph © Cities Revealed.
Figure 4.3: Expansion of salt marsh edge over time taken from aerial photography. Illustration courtesy of SMBC.
Plate 4.2: Photographs of the same area south of the sand winning plant (Coast Road to the left of both pictures) highlighting the expansion of the salt marsh at Marshside; a) approximately 1970s; b) March 2007. Image a) held in SMBC archive.
had failed, assumed at the time to be due to insufficient application of the herbicide (Holliday, 1976). The report suggests all *Spartina* south of Marshside Road (near to the sand-winning plant) be eradicated by chemical control. The spread of salt marsh vegetation was subsequently controlled between 1977 and 1988 by the aerial spraying of Dalapon (Smith, 1982), with additional recent herbicide treatment in subsequent years (Tomlinson, 1997).

By 1992, the marsh edge displayed a notable expansion in the area to the north of the sand-winning plant. The salt marsh had also extended along the sand-winning track by over 1 kilometre, compared to the relatively small area in 1976. The sheltered area between the southerly side of the track and Coast Road experienced sizeable expansion of the marsh (around 80-200 metres lateral growth). To the north of the track, the marsh edge had prograded northwards approximately 50 metres along the outer length of the track, and by more than 200 metres in a north westerly direction. In just three years between 1992 and 1995, an increase in the density of the vegetation was evident to the north of the sand-winning track, and to the southern edge of the marsh alongside Coast Road (Plates 4.3 and 4.4).

Between 1997 and 1999, although some expansion of the salt marsh was evident south of the track (10 – 20 metres), the majority of the expansion was seen to the north, with around 100 metres additional marsh, and with marsh flanking the track having grown laterally by approximately 250 metres. Tomlinson, in his vegetation survey of 1999 / 2000 reported the growth of *Salicornia* had been particularly prolific during 1999 (Figure 4.4). Further north, the salt marsh continued to prograde seawards, extending by 60 – 200 metres around the north west edge of the Marshside marshes, reaching a maximum additional growth of 300 metres. Areas of least expansion of the marsh edge appear to coincide with major drainage channels, with the sections of marsh furthest from these channels demonstrating the greatest expansion.

The marsh edge had extended only very marginally along the majority of the previous edge by 2002. South of the sand-winning track, however, there was a relatively consistent expansion of the width of the marsh of around 100 metres, with the most noticeable change being the southward expansion of the marsh parallel with Coast Road by over 700 metres. Here, the marsh retained its existing shape, curving around the triangular piece of land between the road and the track, but it was by now three times its previous width from Coast Road. The tip of the salt marsh shown at the defined edge of the track in 1992 and 1999 subsequently did not change in 2002, following the line of the Ordnance Survey marked Mean High Water. This suggests that, under the current conditions, the salt marsh has reached its seaward extent at this particular point.
At time of writing, the sand-winning plant at Marshside / Horse Bank has ceased operations due to non-renewal of the extraction licence. Proposals for the site are to include extended facilities for the Royal Society for the Protection of Birds (RSPB), and reinstating a proportion of the site to the level of the surrounding salt marsh, to allow colonisation of the area by salt marsh vegetation.

Plate 4.4: Aerial photograph of Marshside salt marsh in 1995. Photograph courtesy of SMBC © Cities Revealed.
Figure 4.4: Expansion of *Salicornia* spp. At Marshside, March 1998 to February 2000. (Taken from Tomlinson, 1999 and 2000).
5.0 Current Situation of the Marshside Salt Marshes

The adjacent intertidal flats of the north Sefton coast are an integral part of the functioning of the salt marsh system, so will be considered alongside the ‘true’ salt marsh of Marshside. The intertidal flats have very little vegetation, and are mainly comprised of sand particles (Plate 5.1). The low marsh or pioneer zone has a finer texture of sediment towards silty sand, and is characteristically comprised of *Salicornia* and *Spartina* species of vegetation (Plate 5.2). The mid marsh zone of Marshside includes the floral species of *Halimione (Atriplex) portulacoides* (sea purslane), *Puccinellia maritima* (sea meadow grass) and *Aster tripolium* (NVC, 2002). There is usually complete ground coverage by vegetation in this zone (Plate 5.3). The vegetation becomes much more terrestrial in nature in the high marsh zone at Marshside, with species such as *Juncus maritimus*, but with continuing considerable coverage by *Puccinellia maritima* and *Aster tripolium*. The vegetation tends to be notably taller in the high marsh, up to tens of centimetres (Plate 5.4). The sediment is predominantly fine silt (Pye and French, 1993b).

Plate 5.1: Typical environment of the intertidal flats adjoining Marshside salt marshes.
Plate 5.2: *Spartina anglica* and *Salicornia europaea* as early colonisers of the pioneer zone at Marshside. (Body of tape measure = 60 mm).
Plate 5.3: Mid marsh vegetation at Marshside, including a) *Aster tripolium*; b) *Puccinellia maritime*; c) *Halimione portulacoides*; d) *Limonium vulgare*. (Body of tape = 60 mm).
Plate 5.4: a) *Aster tripolium* on the high marsh at Marshside, measuring around 60 cm; b) The highlighted marker post stands approximately 60 cm tall.
The rate at which a salt marsh can build up (its sedimentation or accretion rate) can vary depending upon the localised environment, the stage of development that the marsh is already at, the local hydrology, tidal energy, the quantity and characteristics of the inorganic sediment supply, and levels of organic input from vegetation (Carter, 1988; Reed, 1988; Adam, 1990; Reed, 1990; Orson et al., 1998; Woodroffe, 2002; Goodman et al., 2007). The stage of marsh development is important as it can influence the elevation of any given location, it reflects the species and extent of vegetation that are likely to be present, which in turn controls the amount of sediment that can be trapped by each tidal inundation (Gleason et al., 1979), and wind blown sources if such a supply is available. The input of fresh sediment in turn brings nutrients, which encourages plant growth. This increased vegetative growth further increases the amount of sediment that can be trapped during tidal inundations (DeLaune et al., 1989).

Areas such as low and mid marsh zones that experience regular tidal inundations tend to build up by a mixture of inorganic sediment deposition and organic deposition from the vegetation. However, areas such as the high marsh, that receive relatively little tidal inundation tend to build up more through organic input from the leaves, stems, seeds and roots of the vegetation on and below the surface than through the deposition of fresh sediment (Hatton et al., 1983; Bricker-Urso et al., 1989; Neubauer et al., 2002).

Recent studies by the author on the Marshside salt marshes have shown that the average rates of sediment build up (accretion) across the entire marsh are between 10 and 28 mm per year, with their being negligible erosion. However, over time, this build up of sediment becomes compacted by its own weight, and so the annual accretion is effectively compressed to result in a much reduced level of sediment accretion. The highest levels of sedimentation are found within the low marsh environment. This is in accordance with other published studies that show that low marsh areas build up more rapidly than the other salt marsh zones, as they are at a lower elevation, so receive more tidal inundations, whilst having some vegetation (compared to the largely un-vegetated intertidal flats) that are able to help accumulate sediment (Steers, 1948; Pethick, 1981; Temmerman et al., 2003). Accordingly, the intertidal flats demonstrate the next highest levels of sediment build up, as although they are at a lower elevation than the low marsh, they experience higher energy conditions from waves, so cannot support sufficient vegetation. The intertidal flats also contain higher numbers of invertebrates that feed on micro-organisms that produce biofilms that help to adhere sediment particles together, hence the less micro-organisms, the less able the sediment is to accrete (Coles, 1979; Adam, 1990; Andersen, 2001). The mid marsh shows the next highest level of accretion, with high marsh areas demonstrating the lowest levels. This can be accounted for by the relative elevation of the environments, which is an important factor in the level of sediment deposition, due to it determining the number and length of tidal inundations, which subsequently influences the level of sediment deposition from the water column (Richards, 1934; Carter, 1988; Stoddart et al., 1989; Allen,
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1990; Allen and Duffy, 1998; Neubauer et al., 2002; Woodroffe, 2002; van Proosdij et al., 2006).

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<th>Author</th>
<th>Location</th>
<th>Environment</th>
<th>Method</th>
<th>Accretion Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gresswell, 1953</td>
<td>1930 Southport embankment (near P27)</td>
<td>‘Beach’</td>
<td>Marker post</td>
<td>25.4 mm a⁻¹</td>
</tr>
<tr>
<td>Berry, 1967</td>
<td>Possibly Lytham</td>
<td>Low marsh</td>
<td>Unknown</td>
<td>18 mm a⁻¹</td>
</tr>
<tr>
<td>Mamas et al., 1995</td>
<td>Lytham Main Channel, Nazemount, &amp; Preston Docks.</td>
<td>Intertidal sediments</td>
<td>¹³⁷Cs/¹³⁴Cs</td>
<td>15 – 120 mm a⁻¹</td>
</tr>
<tr>
<td>Brown, 1997</td>
<td>Warton and Banks</td>
<td>Salt Marsh</td>
<td>Artificial turf</td>
<td>1.3 – 6.9 mm a⁻¹</td>
</tr>
<tr>
<td>Holden, 2008</td>
<td>Marshside</td>
<td>Intertidal Flats and Salt Marsh</td>
<td>Various Artificial Marker Horizons</td>
<td>10 – 28 mm a⁻¹</td>
</tr>
</tbody>
</table>

6.0 The Future

6.1 Potential Future Changes

A rise in local sea level and its effects is potentially one of the major factors that will impact naturally upon the Marshside salt marshes in the future. It has been predicted that there will be a global sea-level rise of approximately 1 metre over the next 100 years, (Dyer, 1994; McLean and Tsyban, 2001), equating to an averaged 10 mm per year. The case along many northern European coasts at the present day however, is a much more propitious 1-2 mm per year (Woodworth, 1999).

Salt marshes can respond to sea-level rise in one of three ways. Provided there is sufficient sediment supply and other conducive physical factors, they can accrete vertically and develop horizontally and effectively continue to grow and develop at a rate beyond that of local sea-level rise. Alternatively, there can be a form of equilibrium, whereby the salt marsh keeps pace with the sea-level rise. The final alternative is that salt marsh cannot develop sufficiently either vertically or horizontally to remain within the zone between High Water Spring Tide (HWST) and High Water Neap Tide (HWNT) and if unable to migrate landwards (e.g. due to the presence of a sea wall or other hard sea defence), then the salt marsh will be lost to the sea (Orson et al., 1985; Patrick and DeLaune, 1990; Reed, 1995; Haslett, 2000; Masselink and Hughes, 2003).
It is anticipated that the long-term effects of sea-level rise will cause a gradual landward encroachment of both the high and low water marks, leading to increased erosion, increased siltation, raised groundwater, drainage impedance, saline intrusion and migration of ecological zones (Haslett, 2000; Pethick, 2001; Valiela, 2006).

Although still debated, studies have shown that as an estuary naturally infills with sediment, so the volume of water that enters the estuary at each high tide is reduced, which results in an associated reduction in water velocities, thereby enabling further accretion (van der Wal et al., 2002). Seaward development of salt marsh is generally accepted to be indicative of the positive ability of a particular salt marsh system to be able to accrete sediment at a rate greater than that of relative sea level rise (Doody, 2001; Hughes and Paramor, 2004). This situation has been confirmed at Marshside, with analysis of historical data, predominantly aerial photographs and map evidence, showing a development of the salt marsh in both a seaward and a southerly (towards the outer estuary) direction, which has been continuous, but has slowed in recent decades.

With an anticipated rise in sea level, so each of the zones within salt marshes are expected to move landwards, so the whole salt marsh effectively migrates inland so that it retains its same position within the intertidal zone between low and high tide marks. As the sea level rises, so at any given elevation there will be an increase in the number of tidal inundations, with the deeper water in the estuary increasing the amount of energy available to waves (Dijkema et al., 1990; Siefert, 1990). This leads to erosion of the seaward sediments of the salt marsh, and their deposition higher up the intertidal zone. This process is responsible for the gradual landward movement of the salt marsh.

Previous studies have shown that as sea level rises, so salt marshes can generally build up by sedimentation at a rate that is sufficient to keep pace with the rise in sea level (e.g. Orson et al., 1985; Bricker-Urso et al., 1989; Childers et al., 1993; Orson et al., 1998; French and Burningham, 2003).

An important factor at Marshside is the presence of the Coast Road sea wall. If the environmental conditions lead to the salt marsh migrating landwards, then the presence of the wall will prevent this. In extreme conditions, this would mean that the marsh reverted back to low marsh or even intertidal flats, and could lead to the loss of the salt marsh, and subsequently its effectiveness as a sea defence. An initial sign of deterioration of a marsh system is when the vegetation composition reverts to more salt tolerant plant species (van Wijnen and Bakker, 2001). However, the photographic evidence collected by the author at Marshside over four years, and the SMBC archive of aerial photography indicates that this is not occurring at Marshside, with the salt marsh continuing to develop (Plate 6.1).
Plate 6.1: Development of the Marshside salt marsh over time: the left hand photograph shows a point on the marsh during June 2004; the right hand photograph shows the same site in May 2006. The Coast Road is to the right of the image, with the sea to the left, showing that the marsh at this point has continued to develop and become increasingly vegetated in a seaward direction.
With an increase in sea level, so sediment deposition within the estuarine channels will be expected to increase due to the increased water depth resulting in a decreased drag on the channel bed (e.g. as shown by Pethick (1993) in the Blackwater Estuary). Deposition within the Ribble navigation channel will additionally be in all probability increased due to the termination of the dredging operations within the channel. For the Mersey estuary, an increased deposition rate within the channel would require increased dredging, which would result in increased dumping of dredge spoil offshore in Liverpool Bay, which from documentary evidence would potentially increase the available supply of sediment to the foreshore at Southport.

Pethick (1993) identified that widening of estuarine channels is the natural response to sea level rise within an estuary. Although prevented in many situations due to the presence of training walls, within the Ribble this may be a feasible adjustment in the long term due to the abandonment of maintenance of the training walls along the navigation channel. If this response can occur, it may alleviate potential flooding within the coastal zone and prevent salt marsh loss.

6.2 Management

Of all the coastal environments, salt marshes are one of the most susceptible to a rising sea-level (Reed, 1990). As many areas of salt marsh are backed at present by land and buildings of economic value, they have a substantial value as a sea defence, with the vegetation being an important factor in wave attenuation (King and Lester, 1995).

In contrast to the human pressures that have been placed upon the Marshside salt marshes, they are nationally and internationally recognised as being of major importance for their habitat provision, being designated a Site of Special Scientific Interest (SSSI), a National Nature Reserve, a Special Protection Area (SPA), and a RAMSAR site. The area has a number of landowners, with many other stakeholders, such as the Royal Society for the Protection of Birds (RSPB) and golf clubs, involved in the management of the area. The various bodies work together under the banner of the Sefton Coast Partnership, created in 2001 from the Sefton Coast Management Scheme.

There is now a fundamental change in thinking by policy makers, whereas previously, coastal flooding would have seen the building of defences and attempts being made to keep coastal water away from the land, now there is a shift towards flooding being more ‘controlled’, with compromises being made to re-create and encourage wetland environments to allow for the increased coastal inundations that are to be expected with rising sea levels and climate change. The presence of the soft defences of the salt marsh along the north Sefton coast are therefore of great consequence to the future planning and policy development, not only in terms of their value as a sea defence, but also as a habitat for wildlife. The need to understand the processes concerning the salt marsh specific to this area is therefore central to developing the most viable, informed policies concerning the coastline and its future development.
As the estuary’s natural tendency is towards infilling, so the ability of the intertidal zone to accept a given volume of water is reduced, particularly in the case of reclaimed land that occupies an area that was once intertidal. Therefore, it is not unreasonable to suggest that the ‘excess’ water that no longer enters the estuary must be directed elsewhere along the coastline. When sea level rise and increased water volumes are added to this natural trend, so the importance of having environments that can readily accept the water, such as salt marsh, become increasingly important.

Similarly, as management strategies are required along adjacent stretches of the coastline, such as the management of coastal erosion at Formby Point, so the actions taken along the coastline need to be considered carefully, as it has been shown historically, that actions in one area of the coast have resultant effects in other areas.

Salt marshes are known to be a sink for many pollutants, such as heavy metals and radionuclides, particularly adsorbed to the fine sediment that characterises the environment (Plater et al., 1991; Berry and Plater, 1998; Ridgway and Shimmield, 2002). The pollutants can originate from industrial activity releasing waste products into fluvial or coastal waters, and from airborne deposition. Should erosion of the marsh surface occur, stored pollutants can be re-mobilised in biologically available forms that can be re-suspended and redistributed via tidal waters (Adam, 2002). Therefore, the continued existence of the salt marsh is important in preventing such pollutants from re-entering the marine system. Adam (2002) highlights the importance of estuarine fringing salt marshes in intercepting terrestrially derived nitrogen, thereby preventing eutrophication in other habitats within an estuary. As a larger proportion of the land immediately adjacent to the Marshside salt marshes is agricultural land, there is potential for a significant quantity of agricultural run-off to enter the salt marsh system, which will then be retained within the system rather than entering coastal waters.

Under conditions of rising sea level, a landward migration of the Marshside salt marshes would not be feasible under the present land use approach, due to the presence of the sea defences that form the Coast Road, with the various historic reclamationshat have agricultural uses, or indeed have importance as brackish marsh for habitat provision and increased biodiversity. Although the presence of the Coast Road as a solid, immovable feature may in theory lead to the phenomenon of coastal squeeze, so at present the growth of the salt marsh in a southerly and seaward direction, at rates of accretion above local relative sea level rise, it can be concluded that at present, future management should continue to encourage the salt marsh as an important and valuable habitat, whilst being mindful of changes that may occur in the wider environment of Liverpool Bay, which may impact upon the condition of the marsh. Continued monitoring of the salt marsh area by aerial and topographic surveys, along with the condition and operating of the marsh, by accretion and vegetation monitoring, is an important step in recognising any changes that may occur in the area, and allow for management to be enhanced accordingly.
7.0 Summary

All the evidence collated and analysed suggests that the salt marsh at Marshside has been expanding spatially and stratigraphically for at least the last 200 years. Until recently, much of this expansion has been actively encouraged by human intervention to enable reclamation of land. It is estimated that approximately 2,230 hectares of land has been reclaimed in the estuary since 1800 (Pye and French, 1993(b); Healy and Hickey, 2002). The majority of salt marsh at Marshside is relatively immature, fronting the Coast Road embankment that constructed between 30 and 70 years ago.

The rates of vertical sediment accretion at Marshside, recorded by high resolution monitoring over the last four years, have been in the region of 10–28 mm per year, with the lower rate generally applying to the high marsh environment, with the higher rate being recorded in the low marsh. As the rates of sediment accretion are usually more rapid in younger salt marshes (Steers, 1948; Pethick, 1981), so the rates at Marshside can be expected to slow down over time.

Between 1860 and 1980, the relative mean sea level at Liverpool increased by an average of 1 mm per year (Blott, et al., 2006). If the current rate of local relative sea-level rise (1-2mm) remains constant, then it would appear that the salt marsh at Marshside will be able to continue to develop. This is, however, reliant upon the continued supply of sufficient sediment. Therefore, any change in the current sediment transport processes within the wider estuary may have a detrimental effect on the ability of the salt marsh to continue to accrete sufficiently to maintain a rate of development in line with relative sea level rise.

Although not anticipated by current trends, if increase in the rate of sea level rise occurs, then the ability of the salt marsh to maintain its position within the tidal frame may be compromised. This may ultimately lead to a reduction in the area of salt marsh, with a regression in the environment and vegetation away from high marsh species back towards low marsh species (Lefevre, 1990). This would result in a reduction in the ability of the marsh to further accrete through the addition of both sediment and organic matter (Day and Templet, 1989; Reed, 1995). A subsequent reduction in the ability of the marsh to act as a sea defence, would be compounded by the presence of hard defences, particularly at Marshside by the Coast Road sea wall, which would prevent dissipation of wave energy, and hence lead to further erosion of the reduced salt marsh. A similar situation could be anticipated should a sufficient supply of sediment be precluded from the salt marsh system. A reduction in the salt marsh area would have consequences for the salt marsh environment, with marked changes in the range of intertidal habitat available. If the situation arose, then adoption of an appropriate coastal strategy such as managed retreat may be required.

With the closure of the sand-winning plant at Marshside, so the site of the plant may be allowed to develop both ecologically and morphologically with minimal human
interference. Monitoring of the evolution of this site may prove beneficial when considering similarities to managed realignment sites.

8.0 References


RIBBLE ESTUARY SHORELINE MANAGEMENT PLAN (2002)


