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# Coastal squeeze, saltmarsh loss and Special Protection Areas

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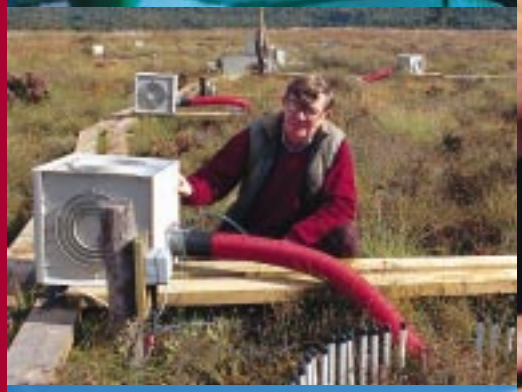

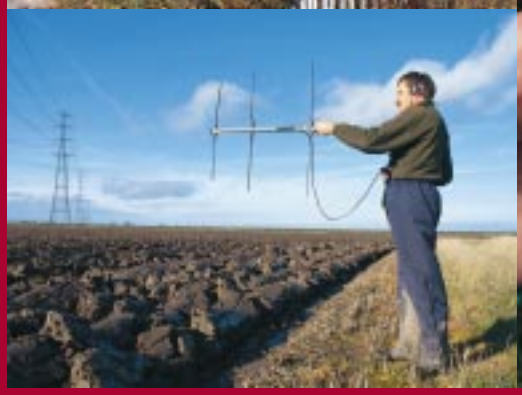

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# Coastal squeeze, saltmarsh loss and Special Protection Areas

Royal Haskoning

From October 2006, English Nature, the Landscape, Access and Recreation division of the Countryside Agency and the environmental land management functions of the Rural Development Service have been brought together to form a new independent body - Natural England. This research report was completed by English Nature, but has been published by Natural England to complete the *English Nature Research Reports* series.



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# Summary

English Nature is currently providing advice to Defra and the Environment Agency as part of the development of a policy to address the issue of coastal squeeze of saltmarshes in Special Protection Areas (SPAs) resulting from Environment Agency flood and coastal defence works. This report has been commissioned to utilise work undertaken in previous studies, including the existing CHaMPs, to consider past changes in saltmarsh extent since SPA designation in a number of specific SPAs, and provide a summary of potential future changes.

## Historic change

A search was undertaken for all available data relating to historic saltmarsh extent in each SPA. These data sets were assessed and the most suitable used for analysis. Consideration was given to the purpose for which the data was collected, the methods used and the associated consistency and comparability of the data for assessing historic rates of change. For each SPA, the most suitable data set is used to assess change in total saltmarsh extent over the period of record. These rates are linearly extrapolated to estimate saltmarsh change since the date of SPA designation (see table below). These rates should be viewed in the context of the potential errors highlighted sections 2.1 to 2.7 and 3.1 to 3.7 of this report.

**Summary table of estimated saltmarsh areas (ha) at the date of first designation of each SPA and in 2004[1] (-ve = loss, +ve = gain).**

| SPA Name | Designation year | Area at Designation | Area in 2004 | Change in area |
|---|---|---|---|---|
| Deben Estuary | 1996 | 231.8 | 214.8 | -17.0 |
| Stour and Orwell Estuaries | 1994 | 180.0 | 117.1 | -62.9 |
| Hamford Water | 1993 | 686.4 | 527.8 | -158.6 |
| Colne Estuary | 1994 | 692.2 | 635.9 | -56.3 |
| Blackwater Estuary | 1995 | 684.2 | 621.1 | -63.1 |
| Dengie | 1994 | 420.0 | 393.1 | -26.9 |
| Crouch and Roach Estuaries | 1998 | 410.9 | 344.6 | -66.3 |
| Foulness | 1996 | No data | No data | No data |
| Benfleet and Southend Marshes | 1994 | 140.2 | 126.4 | -13.8 |
| Thames Estuary and Marshes | 2000 | 30.5 | 27.8 | -2.7 |
| The Swale | 1982 | 254.1 | 284.5 | +30.4 |
| Chichester and Langstone Harbours | 1987 | 563.7 | 431.9 | -131.8 |
| Portsmouth Harbour | 1995 | 70.5 | 44.1 | -26.4 |
| Solent and Southampton Water[2] | 1998 | 465.6 | 391.2 | -74.4 |
| Humber Flats, Marshes and Coast | 1994 | 624.1 | 643.6 | +19.5 |
| The Wash | 1988 | 3939.9 | 4586.9 | +647.0 |
| Severn Estuary (south shore only) | 1995 | 557.6 | 577.5 | +19.9 |

## Prediction of change

In most SPAs, the only form of prediction for saltmarsh change over the next 50 years, without any new predictive analysis, is direct linear extrapolation of historic trends. However, it is unlikely that saltmarsh will continue to change at the historic rates in the long term, particularly because of the uncertainty and dynamic nature of the factors influencing erosion

[1] Calculated by linear extrapolation of historic rates of change.
[2] Data excludes the coast of the Isle of Wight.

and accretion. The linear extrapolations presented in the table below are therefore only a broad estimate of the possible future change in saltmarsh area, and a low level of confidence needs to be attached to them. They should be viewed in the context of the potential errors highlighted in sections 3.1 to 3.7 and 4.2 to 4.8 of this report.

For a small number of the SPAs the regime method has previously been applied to predict saltmarsh extent over the next 50 years. The regime method considers the stable dimensions of an estuary to predict the likely response of the estuary under future conditions, including increases in tidal prism associated with future sea-level rise. This method may therefore provide a more accurate estimate of future change. The results of the regime method are also provided in the table below.

**Summary table of saltmarsh areas (ha) in 2004 and 2054 based on linear extrapolation of historic rates of change and using the regime method (-ve = loss, +ve = gain).**

| SPA Name | Area 2004 | Area 2054 Linear | Area Change Linear | Area 2054 Regime | Area Change Regime |
|---|---|---|---|---|---|
| Deben Estuary | 214.8 | 108.8 | -106.0 | | |
| Stour and Orwell Estuaries | 117.1 | None | -314.5 | | |
| Hamford Water | 527.8 | None | -721.0 | | |
| Colne Estuary | 635.9 | 354.4 | -281.5 | 519.9 | -116.0 |
| Blackwater Estuary | 621.1 | 270.6 | -350.5 | None | -1040.0 |
| Dengie | 393.1 | 258.6 | -134.5 | | |
| Crouch and Roach Estuaries | 344.6 | N/A | N/A | None[3] | -321.0[3] |
| Foulness | No data | No data | No data | | |
| Benfleet and Southend Marshes | 126.4 | 57.4 | -69.0 | | |
| Thames Estuary and Marshes | 27.8 | None | -34.0 | | |
| The Swale | 284.5 | 348.5 | +64.0 | 333.5 | +49.0 |
| Chichester and Langstone Harbours | 431.9 | 44.4 | -387.5 | | |
| Portsmouth Harbour | 44.1 | None | -146.5 | | |
| Solent and Southampton Water[4] | N/A | N/A | N/A | | |
| Humber Flats, Marshes and Coast | 643.6 | 741.1 | +97.5 | 529.0[5] | -139.0[6] |
| The Wash | 4586.9 | 6608.9 | +2022.0 | | |
| Severn Estuary (south shore only) | 577.5 | 688.5 | +111.0 | | |

In most of the SPAs, the total area of saltmarsh has decreased over the period of record. In some of the SPAs (Stour and Orwell Estuaries, Hamford Water, Blackwater Estuary, Thames Estuary and Marshes and Portsmouth Harbour), one or both of the predictive methods indicate that saltmarsh could be completely lost from the SPA area within the next 50 years. The Swale, Humber Flats, Marshes and Coast, The Wash and Severn Estuary (southern shore only) SPAs were the only areas examined where saltmarsh extent has historically increased.

In some locations, no data was available to support comparative analysis and calculation of saltmarsh change. For the Foulness and the Severn Estuary (north shore) SPAs, this study provides recommendations and costings for saltmarsh mapping from aerial photographs to calculate change in historic saltmarsh extent.

[3] Crouch Estuary only.
[4] Incomplete data. See Tables 4.1 and 4.2.
[5] Area of saltmarsh predicted in 2050.
[6] Amount lost in 50 years from a baseline estimate of 668 ha in 2000.

## Contents

# 1. Introduction

## 1.1 Report background

Over the last four years the Environment Agency and English Nature have been working together on the 'Living with the Sea' LIFE Nature project. The project studied the impact of flood and coastal defence works on European designated intertidal habitats. As part of this project, seven pilot Coastal Habitat Management Plans (CHaMPs) were produced to provide information on habitat change and recommendations for future management of habitat losses.

In many coastal and estuarine environments, flood and coastal defences constrain the ability of intertidal habitats (notably saltmarsh) to naturally move landward in response to sea-level rise. This effect results in intertidal habitat loss, and is commonly termed 'coastal squeeze'. English Nature is currently involved in providing advice to Defra and the Environment Agency as part of the development of a cross-government policy approach to address the issue of coastal squeeze of saltmarshes in Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) resulting from Environment Agency flood management works. In order to inform this advice it is necessary to ascertain both the past changes in saltmarsh extent since each SPA was designated and to predict potential future losses in each SPA currently subject to coastal squeeze. The aim of this study is to use work undertaken in previous studies, including the existing CHaMPs, to evaluate habitat losses within SPAs and assist in addressing the scale of the impact of 'coastal squeeze' in each SPA. The objectives are to analyse available data to:

- determine the change in saltmarsh extent in a number of specific SPAs (Figures 1.1 to 1.4) since their first designation (**Table 1.1**).

**Table 1.1** SPAs investigated in this study

| SPA Name | Date of first designation |
|---|---|
| Deben Estuary | 11.03.1996 |
| Stour and Orwell Estuaries | 13.07.1994 |
| Hamford Water | 08.06.1993 |
| Colne Estuary | 28.07.1994 |
| Blackwater Estuary | 12.05.1995 |
| Dengie | 24.03.1994 |
| Crouch and Roach Estuaries | 29.06.1998 |
| Foulness | 04.10.1996 |
| Benfleet and Southend Marshes | 14.02.1994 |
| Thames Estuary and Marshes | 31.03.2000 |
| The Swale | 31.08.1982 |
| Chichester and Langstone Harbours | 28.10.1987 |
| Portsmouth Harbour | 28.02.1995 |
| Solent and Southampton Water | 01.10.1998 |
| Humber Flats, Marshes and Coast | 28.07.1994 |
| The Wash | 30.03.1988 |
| Severn Estuary | 13.07.1995 |

- provide a prediction, as far as practical, of likely saltmarsh loss (or gain) for each of the SPAs in **Table 1.1** over the next 50 years (to 2054).

This report considers changes in the overall area of saltmarsh habitat in each SPA, but does not consider relative changes in different saltmarsh communities. In addition, this report does not consider in detail the relative changes in different parts of each SPA. Where this has been reported (eg Humber Flats, Marshes and Coast SPA), saltmarsh change has been variable across the SPA, indicating that overall trends may not reflect local changes.

This study does not consider changes in the extent of mudflat habitat. Loss of mudflat could indicate early trends for erosion of intertidal areas, which could later generate loss of saltmarsh. Similarly, increases in mudflat habitat would indicate an accretionary system and potentially long term increase in saltmarsh habitat.

### 1.2 Report structure

This report is divided into a further five sections. Section 2 describes the search and evaluation of existing data sets for potential use in the analysis. Section 3 outlines details of the methods adopted for each SPA and estimates historic change in saltmarsh extent since SPA first designation. Section 4 provides predictions of saltmarsh change over the next 50 years. Section 5 looks at the area of intertidal habitat created by managed realignment since the first date of designation of each SPA. Section 6 provides conclusions.

## 2. Data discovery

This section describes the data sets currently available relating to historic saltmarsh extent in each SPA, and justifies the selection of the data set(s) used for analysis. Data sets were screened through a process of consultation with experts and organisations familiar with the available saltmarsh data. Questions were asked regarding details of existing data sets that the consultees may be aware of and any issues or problems with data quality.

### 2.1 Suffolk

Fojt (1985) published the results of a saltmarsh survey for all the estuaries of Suffolk. The saltmarshes of the Orwell Estuary and northern half of the Stour Estuary were surveyed in 1973/74 using aerial photographs and ground validation. The Deben Estuary saltmarshes were surveyed in 1985. The survey provided data on the distribution and area of different saltmarsh communities at each site. A further survey was undertaken for the Deben, Alde/Ore and Blyth estuaries in 1993 by Suffolk Wildlife Trust (1993), but no comparative analysis was carried out to determine changes in saltmarsh extent.

Cooper and Cooper (2000) compared 1:10000 scale aerial photographs flown in 1971 and 1986, and 1:5000 scale photographs flown in 1998. The saltmarsh extents in the Blyth, Alde/Ore/Butley and Deben Estuaries were traced from each photograph and digitised into a GIS. Areas of stable, eroded and accreted saltmarsh were then mapped for each time period.

Under the English Nature 'Lifescapes' project, saltmarsh habitats of the Suffolk Coast and Heaths area were digitally mapped into a GIS from aerial photographs flown in 1999. As part of the same work, 1937 Dudley Stamp land-use maps were also digitised into the GIS. The accuracy of the 1937 data is likely to be low as the digitisation was carried out from 1 inch to 1 mile maps. No comparative analysis was carried out with historical data to determine saltmarsh change.

The data set of Cooper and Cooper (2000) provides the most comprehensive and consistent record of saltmarsh cover and has therefore been used in this study to analyse historic saltmarsh change in the Deben Estuary SPA (section 3.1.1). The Stour and Orwell Estuaries SPA is discussed in the Essex section of this report.

## 2.2 Essex

A comprehensive assessment of saltmarsh change in Essex was undertaken by Burd (1992). She quantified the rates of erosion and vegetation change of Essex (and north Kent) saltmarshes between 1973 and 1988 using aerial photographs, a GIS and field-based ground calibration techniques. The 1973 baseline data was a series of maps produced by tracing saltmarsh areas directly from aerial photographs (1:10560 scale) on to Ordnance Survey base maps with no photogrammetric rectification. The 1988 saltmarsh extents were mapped from 1:5000 scale unrectified aerial photographs. Cooper and others (2000) highlighted several limitations of the methodology adopted by Burd (1992).

- both the 1973 and 1988 aerial photographs were unrectified and had different scales;
- the 1973 baseline involved 'broadbrush' mapping with only primary creeks mapped, whereas the 1988 mapping was extended to include most creeks;
- degraded and scattered saltmarsh were included on the 1973 mapping, but excluded on the 1988 mapping;
- in order to overlay the maps of different dates and scales within the GIS, a mathematical transformation process was used to stretch the data to a common scale, and some errors may have resulted from this transformation.

The discrepancies in scale and level of detail mapped may have given rise to considerable 'apparent losses' of saltmarsh between 1973 and 1988 which are greater than the 'actual losses'. However, despite these limitations, Cooper and others (2000) used the 1988 map as a baseline for a comparison of saltmarsh change in Essex (apart from the Roach Estuary and Foulness) between 1988 and 1997/1998. The 1997/1998 maps were created using tracings from 1:5000 scale aerial photographs flown in 1998 for Hamford Water, Colne Estuary, Dengie, Crouch Estuary, Roach Estuary, Foulness and North Thames, and 1:10000 scale aerial photographs flown in 1997 for the Stour and Orwell Estuaries, and Blackwater Estuary. All of the 1997/1998 aerial photographs were used unrectified to be consistent with the 1988 data set, and the data was compared in a GIS. Cooper and others (2000) also provided a re-assessment of the Burd (1992) saltmarsh change data from 1973 to 1988, to include areas of accreting saltmarsh. The data from Cooper and others (2000) was used in the Essex Coast and Estuaries CHaMP (Posford Haskoning, 2002b) as a baseline to assess future saltmarsh change.

This data discovery investigation has not been able to find any data for saltmarsh cover or change in the Foulness SPA. Cooper and others (2000) noted that the River Roach/Foulness complex had not been mapped prior to 1998 due to access constraints on the Ministry of Defence owned land.

Data on saltmarsh extent in the Crouch and Roach Estuaries using aerial photographs flown in 2000 has been reported as part of the Essex Estuaries Flood Management Strategy. The

results are compared with the 1998 data set of Cooper and others (2000) and presented as areas of saltmarsh that have accreted, remained stable or eroded over the 2-year period.

Posford Haskoning (2002d) undertook a survey of NVC saltmarsh communities in the Essex Estuaries. The different focus and methods of this study compared with the results of Cooper and others (2000) make it unsuitable for direct comparison.

The results of Cooper and others (2000) are used in this study in the assessment of historic saltmarsh change in the Stour and Orwell Estuaries, Hamford Water, Colne Estuary, Blackwater Estuary, Dengie, and Benfleet and Southend Marshes SPAs. However, problems remain with the data set, and these are outlined in more detail in section 3.2. The GIS data for the Essex Estuaries Flood Management Strategy is used to evaluate historic change in the Crouch and Roach Estuaries SPA.

This study is unable to provide comparisons of historic saltmarsh extent for the Foulness SPA because of a lack of suitable data.

## 2.3 North Kent

Burd's (1992) assessment of saltmarsh erosion between 1973 and 1988 included north Kent (South Thames, Medway and Swale Estuaries). The limitations in the Essex data highlighted by Cooper and others (2000) therefore similarly apply to the north Kent data.

University of Newcastle (2002) carried out a GIS comparison of saltmarsh change between 1961, 1972, 1988 and 2000. Saltmarsh extents were mapped from rectified aerial photographs flown in 1961, 1972 and 2000, and from the original 1988 GIS layers of Burd (1992). Spatial coverage of these comparisons is limited to the smallest area of aerial photograph coverage (in this case 2000) so that a small amount of saltmarsh has been omitted from the analysis, particularly in the smaller tributaries of the Swale Estuary.

Kent County Council (Blair-Myers 2003) has since re-assessed the Burd (1992) and University of Newcastle (2002) analyses and further mapped saltmarsh extent from aerial photographs flown in 2002. This work considered the limitations of the Burd (1992) and University of Newcastle (2002) data and suggested new values for saltmarsh coverage that incorporated corrections for mapping errors and spatial coverage. Although Blair-Myers (2003) provides a recent and detailed comparison of all available data, no GIS layers were available for these corrections, making it impossible to determine the proportion of the data that falls within the SPA boundary.

The University of Newcastle (2002) GIS layers have therefore been chosen in this study as the most suitable data set for assessment of change within the Thames Estuary and Marshes and The Swale SPAs (section 3.3). However, the limitations of this data set in terms of spatial coverage must be recognised. The data from University of Newcastle (2002) was used in the North Kent CHaMP (Posford Haskoning, 2002c) as a baseline to assess future saltmarsh change.

## 2.4 West Sussex and Hampshire

Baily and Pearson (2002) published maps and a GIS of saltmarsh extent in West Sussex and Hampshire along the south coast of mainland England. Areas were calculated from rectified

1:10000 scale aerial photographs flown in 1971, 1984 and 2001 with additional data from 1950 in Pagham Harbour and 1956 in Langstone Harbour. Unfortunately, Baily and Pearson (2002) were unable to acquire aerial photographs from the Isle of Wight and no analyses were made of saltmarsh along its coast. The data from Baily and Pearson (2002) was used in the Solent CHaMP (Posford Haskoning, 2003a) as a baseline to assess future saltmarsh change.

This data discovery investigation has been unable to find any other suitable data for West Sussex and Hampshire and so the data set of Baily and Pearson (2002) is used in this study to determine historic saltmarsh change in the Chichester and Langstone Harbours and Portsmouth Harbour SPAs (section 3.4). Historic change in the Solent and Southampton Water SPA is limited to the Baily and Pearson (2002) data for south coast England (there is no data for the Isle of Wight). However, this data has limitations in that in some areas (particularly the Rivers Hamble and Beaulieu) the spatial coverage is limited to the smallest area of any one set of aerial photographs so that some saltmarsh has been omitted from the analysis. More details of these limitations are provided in section 3.4.3.

## 2.5 Humber Estuary

Pethick (1994) used Ordnance Survey maps to estimate areas of saltmarsh in the Humber Estuary between 1824 and 1977. Results indicated a decrease in saltmarsh coverage from 1826 ha in 1824 to 1148 ha in 1977. This covered a period of time when major land-claim occurred, which contributed significantly to overall changes in saltmarsh extent.

ABP (1997) carried out a detailed analysis of more recent saltmarsh extent by analysis of aerial photographs flown in 1976 and 1995. The analysis covered the area between Trent Falls and Spurn Head, which is within the Humber Flats, Marshes and Coast SPA. The reported coverage should therefore represent saltmarsh within the SPA. However, small areas, particularly in the SPA upstream from Trent Falls, may be missing from the analysis, making any values a slight underestimate. This is difficult to check as no GIS layers are available of the Humber Estuary saltmarsh extents. In addition, aerial photographs of different scales, taken on slightly different dates and at varying stages of the tide were used in order to obtain full coverage of the Humber Estuary. This variable quality limits the accuracy of the mapping.

Despite these limitations, and in the absence of any other identified data, the ABP (1997) data set is used in this study to analyse historic saltmarsh change (section 3.5). The data from ABP (1997) was used in the draft Humber CHaMP (Black and Veatch, 2004) as a baseline to assess future saltmarsh change.

## 2.6 The Wash

Hill (1988) provided a comparison of saltmarsh vegetation communities in The Wash recorded on 1:10000 scale aerial photographs flown in 1971 and aerial photographs flown in 1982 (1:15000 scale) and 1984 (1:20000 scale). Boundaries between vegetation types were confirmed in the field (1974 and 1985). The 1982/1985 survey was carried out using NVC classification, whereas the 1971/1974 survey was using dominant species.

Since this original work, no further analyses of The Wash saltmarsh took place until 2001/2002 when Posford Haskoning (2003b) described the NVC saltmarsh communities

through field survey. The communities were mapped mainly during 2001 using quadrat data (supplemented by target notes) and fourteen transects perpendicular to the coastline. Aerial photographs (1:5000 scale flown in 1999) were then used to determine boundaries between each community. The Posford Haskoning (2003b) results allow a broad comparison to be made against the historic patterns of saltmarsh change described in Hill (1988). This method, although subject to potential errors (section 3.6) has been adopted in this study.

## 2.7 Severn Estuary

Posford Haskoning (2004) described saltmarsh change between Sharpness and Lynmouth on the south bank of the Severn Estuary (and Bristol Channel). The analysis was undertaken by GIS comparison of aerial photographs flown in 1946/1948 and 2000. Another source of information was 1998 habitat maps of the estuary by Dargie (1999). No search has been made for saltmarsh data along the northern shore of the Severn Estuary.

Saltmarsh habitat was digitised in a GIS from the aerial photography at a scale of approximately 1:5000 for the Severn Estuary and Bridgwater Bay areas and at 1:2500 for the Rivers Parrett, Brue, Avon, Yeo and Axe. The accuracy of the 2000 digitising is higher than that of the 1946/1948 series due to the small scale (1:5000) of the 2000 imagery. In addition, the 1946/1948 photographs were collected at different states of the tide, different times of the year and at a variety of scales, making interpretation difficult.

In the absence of any other identified data, the results of Posford Haskoning (2004) are used in this study to assess historic saltmarsh change along the southern shore of the Severn Estuary SPA (section 3.7). Due to a lack of suitable data, this report does not provide comparisons for the northern shore of the Severn Estuary SPA.

# 3. Historic saltmarsh change since SPA designation

This section provides estimates of historic saltmarsh change for each SPA listed in **Table 1.1**, since designation. The calculations for each SPA are described separately below and a summary table is provided at the end of the section (**Table 3.53**).

## 3.1 Suffolk

### 3.1.1 Deben Estuary SPA

The Deben Estuary data set comprises GIS layers of saltmarsh extent in 1971, 1986 and 1998 (Figure 3.1), mapped from aerial photographs, and analysed and interpreted by Cooper and Cooper (2000). Not all of the saltmarsh recorded in the Cooper and Cooper (2000) analysis falls within the SPA boundary. Therefore, the reported values of saltmarsh area have been adjusted ('clipped') to the area within the SPA boundary. In the Deben Estuary, between 12.9 and 37.8 ha of saltmarsh occurred outside the SPA between 1971 and 1998. The results for the Deben Estuary SPA are shown in

**Table 3.1** and **Table 3.2**. The 1971, 1986 and 1998 saltmarsh extents are provided as polygon shapefiles in the GIS (CD at the back of the report).

**Table 3.1** Areas (ha) of saltmarsh in the Deben Estuary SPA in 1971, 1986 and 1998

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1971 | 311.7 | 273.9 |
| 1986 | 265.9 | 253.0 |
| 1998 | 240.7 | 227.6 |

**Table 3.2** Saltmarsh loss in the Deben Estuary SPA between 1971, 1986 and 1998

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1971-1986 | 20.9 | 1.39 |
| 1986-1998 | 25.4 | 2.12 |
| 1971-1998 | 46.3 | 1.71 |

The area of saltmarsh present in 1971 within the Deben Estuary SPA was 273.9 ha. By 1986, around 20.9 ha had been lost. This equates to an average loss of 1.39 $hayr^{-1}$ over the 15 year period. By 1998, a further loss of 25.4 ha had taken place at a rate of 2.12 $hayr^{-1}$ to leave 227.6 ha. Overall, between 1971 and 1998, a net loss of 46.3 ha of saltmarsh occurred in the River Deben SPA at an average rate of 1.71 $hayr^{-1}$. Cooper and Cooper (2000) noted that of all the surveyed estuaries in Suffolk, the Deben Estuary experienced the greatest absolute net loss of saltmarsh between 1971 and 1998, and the greatest percentage loss in terms of its original area.

The 1986-1998 rate of loss has been used to estimate the extent of saltmarsh in 2004 and for the analysis of future change discussed in section 4.2. The Deben Estuary SPA was designated on 11 March 1996. If the saltmarsh erosion rate of 2.12 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1996 would have been 231.8 ha. If the same rate is extrapolated then the estimated saltmarsh extent in 2004 is 214.8 ha (**Table 3.3**). These values equate to a loss of 17.0 ha of saltmarsh over the eight year period since designation.

**Table 3.3** Estimated saltmarsh area (ha) in the Deben Estuary SPA in 1996 (date of designation) and 2004 based on extrapolation of the 1986-1998 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1996 | Estimated saltmarsh area 2004 | Saltmarsh loss 1996-2004 |
|---|---|---|---|
| 2.12 (1986-1998) | 231.8 | 214.8 | 17.0 |

## 3.2 Essex

Apart from the Crouch and Roach Estuaries and Foulness SPAs, the SPAs of the coast and estuaries of Essex have been analysed using the data set of Cooper and others (2000). This data includes the Stour and Orwell Estuaries SPA (the Orwell Estuary is strictly in Suffolk). Cooper and others (2000) estimated saltmarsh extents from 1988 and 1997/1998 aerial photographs. They also re-assessed Burd's (1992) estimates of saltmarsh change between 1973 and 1988. The 1988 and 1997/1998 saltmarsh extents are provided as polygon shapefiles in the GIS (CD at the back of the report). Only paper versions of the 1973 saltmarsh extents were produced. It is therefore not possible to establish the proportion of the reported 1973 saltmarsh area that lies within the SPAs, making it difficult to use this data set to calculate change rates. This data has therefore been excluded from the analysis of Essex saltmarsh change.

Several complications were encountered with the Cooper and others (2000) data. The most significant was inconsistencies in the saltmarsh extent values between those quoted in the report (Cooper and others, 2000) and those compiled by interrogation of the GIS layers (particularly the 1988 layers). The 1988 values derived from the GIS are generally higher than those quoted in the report. There is no written record outlining the reasons for these inconsistencies. Instead they were discussed during the consultation phase of this study. Indications are that the 1988 GIS values are higher than the reported values due to the way in which the saltmarsh extent was initially mapped. In the analysis provided in the Cooper and others (2000) report the saltmarsh extents originally mapped into the GIS (by Burd, 1992) were re-assessed and any bare patches and small creeks within large areas of mapped saltmarsh were taken into consideration (they weren't originally). However, the GIS layers were not amended to take these changes into consideration, thus the GIS values are higher than the reported values. This indicates that the reported values are more reliable than the GIS values, and hence the reported values are used in this study for the calculations of historic saltmarsh change.

Some of the saltmarsh areas reported by Cooper and others (2000) do not fall within the SPA boundaries and so they have been 'clipped' to the boundary in the GIS. However, it was not possible to directly clip the reported values of saltmarsh area from Cooper and others (2000), so where necessary they have been adjusted to represent the area within the SPA boundary by applying the same proportional reduction resulting from the GIS interrogation. This approach has been adopted for Hamford Water, the Colne Estuary, Blackwater Estuary and Dengie SPAs.

Saltmarsh change in the Crouch and Roach Estuaries SPA has been analysed using data from the Essex Estuaries Flood Management Strategy. The change in saltmarsh extent was assessed using a comparison of aerial photographs flown in 1998 and 2000. The 1998 and 2000 saltmarsh extents are provided as polygon shapefiles in the GIS (CD at the back of the report). There are no data presented in this study for the Foulness SPA.

### 3.2.1 Stour and Orwell Estuaries SPA

All of the saltmarsh recorded in 1988 and 1997 (Figures 3.2a and 3.2b) in the Cooper and others (2000) analysis of the Stour and Orwell Estuaries falls within the SPA boundary, and so it was unnecessary to clip. The results are shown in **Table 3.4** and **Table 3.5**.

**Table 3.4** Areas (ha) of saltmarsh in the Stour and Orwell Estuaries SPA in 1988 and 1997

| Year | Saltmarsh area GIS[7] | Saltmarsh area report[8] |
|---|---|---|
| 1973 | No data | 363.7 |
| 1988 | 242.3 | 217.7 |
| 1997 | 161.1 | 161.1 |

**Table 3.5** Saltmarsh loss in the Stour and Orwell Estuaries SPA between 1988 and 1997

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1988-1997 | 56.6 | 6.29 |

[7] Saltmarsh area interrogated from GIS layers provided for this study
[8] Saltmarsh area taken from Cooper and others (2000) report

Of the 217.7 ha of saltmarsh in 1988, 56.6 ha had been lost by 1997 to leave 161.1 ha, equating to an average loss rate of 6.29 $hayr^{-1}$ over the nine year period. The Stour and Orwell Estuaries SPA was designated on 13 July 1994. If the saltmarsh erosion rate of 6.29 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1994 would have been 180.0 ha. If the same rate is extrapolated to 2004, then the estimated extent is 117.1 ha (**Table 3.6**), equating to a loss of 62.9 ha over the ten year period since designation.

**Table 3.6** Estimated saltmarsh area (ha) in the Stour and Orwell Estuaries SPA in 1994 (date of designation) and 2004 based on extrapolation of the 1988-1997 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1994 | Estimated saltmarsh area 2004 | Saltmarsh loss 1994-2004 |
|---|---|---|---|
| 6.29 (1988-1997) | 180.0 | 117.1 | 62.9 |

### 3.2.2 Hamford Water SPA

Not all of the saltmarsh recorded in Hamford Water (Figures 3.3a and 3.3b) in the Cooper and others (2000) analysis falls within the SPA boundary, making it necessary to clip the GIS layers. The results for Hamford Water SPA are shown in **Table 3.7** and **Table 3.8**.

**Table 3.7** Areas (ha) of saltmarsh in Hamford Water SPA in 1973, 1988 and 1998

| Year | Saltmarsh area GIS[7] | Area inside SPA GIS | Saltmarsh area report[8] | Estimated area inside SPA report |
|---|---|---|---|---|
| 1973 | No data | No data | 876.1 | No data |
| 1988 | 787.1 | 780.0 | 765.4 | 758.5 |
| 1998 | 622.6 | 615.8 | 621.1 | 614.3 |

**Table 3.8** Saltmarsh loss in Hamford Water SPA between 1988 and 1998

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1988-1998 | 144.2 | 14.42 |

The area of saltmarsh present in Hamford Water in 1988 is estimated at 758.5 ha. In 1998, 144.2 ha had been lost to leave 614.3 ha, equating to an average rate of loss of 14.42 $hayr^{-1}$ over the ten year period. Hamford Water SPA was designated on 8 June 1993. If a saltmarsh erosion rate of 14.42 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1993 would have been 686.4 ha. If the same rate is extrapolated to 2004, then the estimated extent is 527.8 ha (**Table 3.9**). This equates to a loss of 158.6 ha over the eleven year period since designation.

**Table 3.9** Estimated saltmarsh area (ha) in Hamford Water SPA in 1993 (date of designation) and 2004 based on extrapolation of the 1988-1998 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1993 | Estimated saltmarsh area 2004 | Saltmarsh loss 1993-2004 |
|---|---|---|---|
| 14.42 (1988-1998) | 686.4 | 527.8 | 158.6 |

### 3.2.3 Colne Estuary SPA

Not all of the saltmarsh recorded in the Colne Estuary (Figures 3.4a and 3.4b) in Cooper and others (2000) falls within the SPA boundary, and so the data has been clipped. In the Colne Estuary, between 18.5 and 25.2 ha of saltmarsh was mapped in the original GIS outside the SPA in 1988 and 1998. The results for the Colne Estuary SPA are shown in **Table 3.10** and **Table 3.11**.

**Table 3.10** Areas (ha) of saltmarsh in the Colne Estuary SPA in 1973, 1988 and 1998

| Year | Saltmarsh area GIS[7] | Area inside SPA GIS | Saltmarsh area report[8] | Estimated area inside SPA report |
|---|---|---|---|---|
| 1973 | No data | No data | 791.5 | No data |
| 1988 | 748.8 | 730.3 | 744.4 | 726.0 |
| 1998 | 694.1 | 668.9 | 694.9 | 669.7 |

**Table 3.11** Saltmarsh loss in the Colne Estuary SPA between 1988 and 1998

| Years | Saltmarsh loss (ha) | Loss rate (hayr$^{-1}$) |
|---|---|---|
| 1988-1998 | 56.3 | 5.63 |

The area of saltmarsh present in the Colne Estuary in 1988 was approximately 726.0 ha. Of this, an area of 56.3 ha was lost by 1998, to leave 669.7 ha, equating to an average loss rate of 5.63 hayr$^{-1}$ over the ten year period. The Colne Estuary SPA was designated on 28 July 1994. If a saltmarsh erosion rate of 5.63 hayr$^{-1}$ is applied then the estimated saltmarsh extent in 1994 would have been 692.2 ha. If the same rate is extrapolated to 2004, then the estimated extent is 635.9 ha (**Table 3.12**), equating to a loss of 56.3 ha over the ten year period since designation.

**Table 3.12** Estimated saltmarsh area (ha) in the Colne Estuary SPA in 1994 (date of designation) and 2004 based on extrapolation of the 1988-1998 erosion rate

| Saltmarsh erosion rate (hayr$^{-1}$) | Estimated saltmarsh area 1994 | Estimated saltmarsh area 2004 | Saltmarsh loss 1994-2004 |
|---|---|---|---|
| 5.63 (1988-1998) | 692.2 | 635.9 | 56.3 |

### 3.2.4 Blackwater Estuary SPA

Not all of the saltmarsh recorded in the Blackwater Estuary (Figures 3.5a and 3.5b) in the Cooper and others (2000) analysis falls within the SPA boundary, and so the GIS layers have been clipped. In the Blackwater Estuary, 13.5 ha of saltmarsh was mapped in the original GIS outside the SPA in 1997. The results for the Blackwater Estuary SPA are shown in **Table 3.13** and **Table 3.14**.

**Table 3.13** Areas (ha) of saltmarsh in the Blackwater Estuary SPA in 1973, 1988 and 1997

| Year | Saltmarsh area GIS[7] | Area inside SPA GIS | Saltmarsh area report[8] | Estimated area inside SPA report |
|---|---|---|---|---|
| 1973 | No data | No data | 880.2 | No data |
| 1988 | 746.1 | 740.8 | 738.5 | 733.3 |
| 1997 | 688.6 | 675.1 | 683.6 | 670.2 |

**Table 3.14** Saltmarsh loss in the Blackwater Estuary SPA between 1988 and 1997

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1988-1997 | 63.1 | 7.01 |

The area of saltmarsh recorded in 1988 amounts to around 733.3 ha. By 1997, 63.1 ha had been lost to leave an area of 670.2 ha, equating to an average loss rate of 7.01 $hayr^{-1}$ over the nine year period. The Blackwater Estuary SPA was designated on 12 May 1995. If a saltmarsh erosion rate of 7.01 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1995 would have been 684.2 ha. If the same rate is extrapolated to 2004, then the estimated extent is 621.1 ha (**Table 3.15**), equating to a loss of 63.1 ha over the nine year period since designation.

**Table 3.15** Estimated saltmarsh area (ha) in the Blackwater Estuary SPA in 1995 (date of designation) and 2004 based on extrapolation of the 1988-1997 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1995 | Estimated saltmarsh area 2004 | Saltmarsh loss 1995-2004 |
|---|---|---|---|
| 6.98 (1988-1997) | 684.2 | 621.1 | 63.1 |

### 3.2.5 Dengie SPA

Not all of the saltmarsh recorded in the Cooper and others (2000) analysis falls within the Dengie SPA boundary (Figure 3.6), and so the data has been clipped. The results for the Dengie SPA are shown in **Table 3.16** and **Table 3.17**.

**Table 3.16** Areas (ha) of saltmarsh in the Dengie SPA in 1973, 1988 and 1998

| Year | Saltmarsh area GIS[7] | Area inside SPA GIS | Saltmarsh area report[8] | Estimated area inside SPA report |
|---|---|---|---|---|
| 1973 | No data | No data | 473.8 | No data |
| 1988 | 451.9 | 451.5 | 436.5 | 436.1 |
| 1998 | 420.2 | 419.7 | 409.7 | 409.2 |

**Table 3.17** Saltmarsh loss in the Dengie SPA between 1988 and 1998

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1988-1998 | 26.9 | 2.69 |

About 436.1 ha of saltmarsh existed in the Dengie SPA in 1988. In 1998, 26.9 ha had been lost at an average loss rate of 2.69 $hayr^{-1}$ over the ten year period. The Dengie SPA was designated on 24 March 1994. If a saltmarsh erosion rate of 2.69 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1994 would have been 420.0 ha. If the same rate is extrapolated to 2004, then the estimated extent is 393.1 ha (

**Table 3.18**). This equates to a loss of 26.9 ha over the ten year period since designation.

**Table 3.18** Estimated saltmarsh area (ha) in the Dengie SPA in 1994 (date of designation) and 2004 based on extrapolation of the 1988-1998 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1994 | Estimated saltmarsh area 2004 | Saltmarsh loss 1994-2004 |
|---|---|---|---|
| 2.69 (1988-1998) | 420.0 | 393.1 | 26.9 |

### 3.2.6 Crouch and Roach Estuaries SPA

Data on saltmarsh extent in the Crouch and Roach Estuaries SPA (1998 and 2000) (Figure 3.7) is taken from the Essex Estuaries Flood Management Strategy. Data has been clipped to provide results within the SPA area, and results show approximately 10 ha of saltmarsh mapped outside the SPA during both years. The results are summarised in **Table 3.19** and **Table 3.20**.

**Table 3.19** Areas (ha) of saltmarsh in the Crouch and Roach Estuaries SPA in 1998 and 2000

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| Crouch 1998 | 303.2 | 296.5 |
| Roach 1998 | 118.7 | 114.4 |
| Crouch/Roach 1998 | 421.9 | 410.9 |
| Crouch 2000 | 282.0 | 275.7 |
| Roach 2000 | 116.2 | 113.1 |
| Crouch/Roach 2000 | 398.2 | 388.8 |

**Table 3.20** Saltmarsh loss in the Crouch and Roach Estuaries SPA between 1998 and 2000

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| River Crouch (1998-2000) | 20.8 | 10.40 |
| River Roach (1998-2000) | 1.3 | 0.65 |
| Total (1998-2000) | 22.1 | 11.05 |

The data shows that of the 410.9 ha of saltmarsh recorded in the Crouch and Roach Estuaries SPA in 1998, 22.1 ha had been lost by 2000, at a rate of 11.05 $hayr^{-1}$ over two years. The Crouch and Roach Estuaries SPA was designated on the 29 June 1998. The area of saltmarsh measured in 1998 within the SPA was 410.9 ha. If the saltmarsh erosion rate of 11.05 $hayr^{-1}$ is extrapolated to 2004, then the estimated extent is 344.6 ha (Table 3.21). This equates to a loss of 66.3 ha over the six year period since designation.

**Table 3.21** Estimated saltmarsh area (ha) in the Crouch and Roach Estuaries SPA in 1998 (date of designation) and 2004 based on extrapolation of the 1998-2000 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Measured saltmarsh area 1998 | Estimated saltmarsh area 2004 | Saltmarsh 1998-2004 |
|---|---|---|---|
| 11.05 (1998-2000) | 410.9 | 344.6 | 66.3 |

### 3.2.7 Foulness SPA

There is a paucity of historical change analysis for the Foulness SPA, and therefore no saltmarsh change information is provided as part of this study. Consultation with the Environment Agency shows that aerial photographs were flown in 1993 and 1997 that appear

to cover the saltmarsh that may exist along the Foulness peninsula. These photographs are 1:5000 scale, hard copy and unrectified. An estimated 50 photographs for each year (although this could be more or less) cover the potential saltmarsh along the open coast and along the creeks between the Roach Estuary and the coast.

Based on 100 prints (of a contiguous area) and producing 12.5 cm pixel resolution imagery, the cost estimate for scanning and rectifying the photographs, mosaicing and importing them into a GIS would be around £3,500. To map out the saltmarsh extent from the GIS, provide GIS layers of saltmarsh extent and report would be an additional £2,500. The total estimated cost would therefore be around £6,000. These costs are only a guide and a more detailed breakdown can be provided once the true nature and size of the data set is established.

### 3.2.8 Benfleet and Southend Marshes SPA

Not all of the saltmarsh recorded in the Cooper and others (2000) analysis falls within the Benfleet and Southend Marshes SPA boundary (Figure 3.8). The reported values of saltmarsh area from Cooper and others (2000) match the GIS data provided, and have been clipped to provide areas within the SPA boundary. In Benfleet and Southend Marshes, between 46.3 and 48.5 ha of saltmarsh was mapped outside the SPA boundary in 1988 and 1998. The results for the Benfleet and Southend Marshes Estuary SPA are shown in **Table 3.22** and **Table 3.23**.

**Table 3.22** Areas (ha) of saltmarsh in the Benfleet and Southend Marshes SPA in 1988 and 1998

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1988 | 197.0 | 148.5 |
| 1998 | 181.0 | 134.7 |

**Table 3.23** Saltmarsh loss in the Benfleet and Southend Marshes SPA between 1988 and 1998

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1988-1998 | 13.8 | 1.38 |

The amount of saltmarsh present in 1988 within the Benfleet and Southend Marshes SPA was 148.5 ha. In 1998, around 13.8 ha had been lost to leave 134.7 ha. This equates to an average loss rate of 1.38 $hayr^{-1}$ over the 10 year period. The Benfleet and Southend Marshes SPA was designated on 14 February 1994. If a saltmarsh erosion rate of 1.38 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1994 would have been 140.2 ha. If the same rate is extrapolated to 2004, then the estimated extent is 126.4 ha (**Table 3.24**), equating to a loss of 13.8 ha over the ten year period since designation.

**Table 3.24** Estimated saltmarsh area (ha) in the Benfleet and Southend Marshes SPA in 1994 (date of designation) and 2004 based on extrapolation of the 1988-1998 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1994 | Estimated saltmarsh area 2004 | Saltmarsh loss |
|---|---|---|---|
| 1.38 (1988-1998) | 140.2 | 126.4 | 13.8 |

## 3.3 North Kent

The study of University of Newcastle (2002) is used to analyse saltmarsh change in north Kent between 1961, 1972, 1988 and 2002. The data from all years are provided as polygon shapefiles in the GIS (CD at the back of the report). Not all of the saltmarsh recorded in University of Newcastle (2002) falls within the boundaries of the Thames Estuary and Marshes (Figures 3.9a and 3.9b) and The Swale SPAs (Figures 3.10a, 3.10b and 3.10c), so areas have been clipped in the GIS to represent saltmarsh within the SPAs only.

### 3.3.1 Thames Estuary and Marshes SPA

The results for the Thames Estuary and Marshes SPA are shown in **Table 3.25** and **Table 3.26**.

**Table 3.25** Areas (ha) of saltmarsh in the Thames Estuary and Marshes SPA in 1961, 1972, 1988 and 2000

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1961 | 51.1 | 50.6 |
| 1972 | 39.3 | 38.8 |
| 1988 | 39.2 | 38.7 |
| 2000 | 31.0 | 30.5 |

**Table 3.26** Saltmarsh loss in the Thames Estuary and Marshes SPA between 1961, 1972, 1998 and 2000

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1961-1972 | 11.8 | 1.07 |
| 1972-1988 | 0.1 | 0.01 |
| 1988-2000 | 8.2 | 0.68 |
| 1961-2000 | 20.1 | 0.52 |

The amount of saltmarsh present in 1961 within the Thames Estuary and Marshes SPA was 50.6 ha. In 1972, 11.8 ha had been lost, to leave 38.8 ha, equating to an average loss rate of 1.07 $hayr^{-1}$. Very little change occurred between 1972 and 1988 (0.1 ha eroded). Of the 38.7 ha of saltmarsh left in 1988, 8.2 ha had been lost by 2000, equating to an average loss rate of 0.68 $hayr^{-1}$. Overall, between 1961 and 2000, a net loss of 20.1 ha of saltmarsh occurred in the Thames Estuary and Marshes SPA at an average rate of 0.52 $hayr^{-1}$.

The Thames Estuary and Marshes SPA was designated on 31 March 2000. The saltmarsh extent measured in 2000 was 30.5 ha. If an erosion rate of 0.68 $hayr^{-1}$ (between 1988 and 2000) is applied, then the estimated extent in 2004 is estimated at 27.8 ha (

**Table 3.27**). This equates to a loss of 2.7 ha over the four year period since designation.

**Table 3.27** Estimated saltmarsh area (ha) in the Thames Estuary and Marshes SPA in 2000 (date of designation) and 2004 based on extrapolation of the 1988-2000 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Measured saltmarsh area 2000 | Estimated saltmarsh area 2004 | Saltmarsh loss 2000-2004 |
|---|---|---|---|
| 0.68 (1988-2000) | 30.5 | 27.8 | 2.7 |

### 3.3.2 The Swale SPA

The results for The Swale SPA are shown in **Table 3.28** and **Table 3.29**.

**Table 3.28** Areas (ha) of saltmarsh in The Swale SPA in 1961, 1972, 1988 and 2000

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1961 | 222.0 | 220.5 |
| 1972 | 238.8 | 237.5 |
| 1988 | 264.9 | 264.0 |
| 2000 | 280.8 | 279.4 |

**Table 3.29** Saltmarsh gain in The Swale SPA between 1961, 1972, 1998 and 2000

| Years | Saltmarsh gain (ha) | Gain rate ($hayr^{-1}$) |
|---|---|---|
| 1961-1972 | 17.0 | 1.55 |
| 1972-1988 | 26.5 | 1.66 |
| 1988-2000 | 15.4 | 1.28 |
| 1961-2000 | 58.9 | 1.51 |

Change in saltmarsh area in The Swale SPA is different to the other SPAs studied in Suffolk, Essex and north Kent, in that there has been a consistent accretion of saltmarsh between 1961 and 2000. The area does not appear to be suffering coastal squeeze. The amount of saltmarsh present in 1961 within The Swale SPA was 220.5 ha. In 1972, 17.0 ha had been gained, resulting in a total of 237.5 ha, equating to an average gain rate of 1.55 $hayr^{-1}$. By 1988, another 26.5 ha of saltmarsh had accreted to increase the total extent to 264.0 ha, equating to an average gain rate of 1.66 $hayr^{-1}$. By 2000, another 15.4 ha of saltmarsh had been added to increase the area to 279.4 ha, equating to an average gain rate of 1.28 $hayr^{-1}$. Overall, between 1961 and 2000, a net gain of 58.9 ha of saltmarsh occurred in The Swale SPA at an average rate of 1.51 $hayr^{-1}$.

The Swale SPA was designated on 31 August 1982. If a saltmarsh accretion rate of 1.66 ha $hayr^{-1}$ (between 1972 and 1988) is applied, the estimated saltmarsh extent in 1982 would have been 254.1 ha. If the more recent rate (1.28 $hayr^{-1}$ from 1988-2000) is extrapolated to 2004 (from 1988), then the estimated extent is 284.5 ha (**Table 3.30**). This equates to a gain of 30.4 ha over the 22 year period since designation.

**Table 3.30** Estimated saltmarsh area (ha) in the Swale SPA in 1982 (date of designation) and 2004 based on extrapolation of historic accretion rates

| Saltmarsh accretion rate ($hayr^{-1}$) | Estimated saltmarsh area 1982 | Estimated saltmarsh area 2004 | Saltmarsh gain 1982-2004 |
|---|---|---|---|
| 1.66 (1972-1988)<br>1.28 (1988-2000) | 254.1 | 284.5 | 30.4 |

## 3.4 West Sussex and Hampshire

### 3.4.1 Chichester and Langstone Harbours SPA

The GIS data set of Baily and Pearson (2002) is used for the Chichester and Langstone Harbours SPA analyses. The Chichester Harbour data were compiled through analysis of aerial photographs flown in 1976 and 2001 (Figures 3.11a and 3.11b). The Langstone Harbour data were compiled through analysis of aerial photographs from 1956, 1971 and 2001 (Figures 3.12a and 3.12b). Not all of the saltmarsh recorded in the Baily and Pearson (2002) analysis falls within the SPA boundary. The data sets have therefore been clipped in the GIS to reflect only saltmarsh within the SPA area. Within Chichester and Langstone Harbours, up to 14.2 ha and 19.5 ha of saltmarsh was mapped outside the SPA respectively, between 1956 and 2001. The data from all years are provided as polygon shapefiles in the GIS (CD at the back of the report).

**Chichester Harbour**

The results for Chichester Harbour are shown in **Table 3.31** and **Table 3.32**.

**Table 3.31** Areas (ha) of saltmarsh in Chichester Harbour in 1976 and 2001

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1976 | 552.1 | 537.9 |
| 2001 | 396.5 | 384.1 |

**Table 3.32** Saltmarsh loss in Chichester Harbour between 1976 and 2001

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1976-2001 | 153.8 | 6.15 |

The amount of saltmarsh present in 1976 within Chichester Harbour was 537.9 ha. In 2001, around 153.8 ha had been lost to leave 384.1 ha. This equates to an average loss rate of 6.15 $hayr^{-1}$ over the 25 year period. The Chichester and Langstone Harbours SPA was designated on 28 October 1987. If a saltmarsh erosion rate of 6.15 $hayr^{-1}$ is applied to Chichester Harbour then the estimated saltmarsh extent in 1987 would have been 470.3 ha. If the same rate is extrapolated to 2004, then the estimated extent is 365.7 ha (**Table 3.33**). This equates to a loss of 104.6 ha over the 17 year period since designation.

**Table 3.33** Estimated saltmarsh area (ha) in Chichester Harbour in 1987 (date of designation) and 2004 based on extrapolation of the 1976-2001 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1987 | Estimated saltmarsh area 2004 | Saltmarsh loss 1987-2004 |
|---|---|---|---|
| 6.15 (1976-2001) | 470.3 | 365.7 | 104.6 |

**Langstone Harbour**

The results for Langstone Harbour are shown in
**Table 3.34** and **Table 3.35**.

**Table 3.34** Areas (ha) of saltmarsh in Langstone Harbour in 1956, 1971 and 2001

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1956 | 273.0 | 253.5 |
| 1971 | 123.0 | 119.0 |
| 2001 | 75.3 | 71.0 |

**Table 3.35** Saltmarsh loss in Langstone Harbour between 1956, 1971 and 2001

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1956-1971 | 134.5 | 8.97 |
| 1971-2001 | 48.0 | 1.60 |
| 1956-2001 | 182.5 | 4.06 |

The amount of saltmarsh present in 1956 within Langstone Harbour was 253.5 ha. In 1971, 134.5 ha had been lost, to leave 119.0 ha. This equates to an average loss rate of 8.97 $hayr^{-1}$. Of the 119.0 ha of saltmarsh left in 1971, a further 48.0 ha had been lost by 2001, to leave 71.0 ha. This equates to an average loss rate of 1.60 $hayr^{-1}$, a significantly lower rate of loss than between 1956 and 1971. Over the whole time period, a net loss of 182.5 ha of saltmarsh occurred in Langstone Harbour at an average rate of 4.06 $hayr^{-1}$.

The Chichester and Langstone Harbours SPA was designated on 28 October 1987. If a saltmarsh erosion rate of 1.60 $hayr^{-1}$ (between 1971 and 2001) is applied to Langstone Harbour then the estimated saltmarsh extent in 1987 would have been 93.4 ha. A rate of 4.06 $hayr^{-1}$ (between 1956 and 2001) cannot be applied because the result would suggest more saltmarsh being present in 1987 than was present in 1971. If the rate of 1.60 $hayr^{-1}$ is extrapolated to 2004, then the estimated extent is 66.2 ha (**Table 3.36**). This equates to a loss of 27.2 ha over the 17 year period.

**Table 3.36** Estimated saltmarsh area (ha) in Langstone Harbour in 1987 (date of designation) and 2004 based on extrapolation of the 1971-2001 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1987 | Estimated saltmarsh area 2004 | Saltmarsh loss 1987-2004 |
|---|---|---|---|
| 1.60 (1971-2001) | 93.4 | 66.2 | 27.2 |

Combining the data for both harbours provides an estimate of 563.7 ha for the saltmarsh extent in 1987 for the whole of the Chichester and Langstone Harbours SPA. In 2004 the estimated area is 431.9 ha, equating to a loss of 131.8 ha over the 17 year period (7.75 $hayr^{-1}$) since designation (**Table 3.37**).

**Table 3.37** Estimated saltmarsh area (ha) in Chichester and Langstone Harbour SPA in 1987 (date of designation) and 2004

| Estimated saltmarsh area 1987 | Estimated saltmarsh area 2004 | Saltmarsh loss 1987-2004 |
|---|---|---|
| 563.7 | 431.9 | 131.8 |

### 3.4.2 Portsmouth Harbour SPA

The GIS data set of Baily and Pearson (2002) was used for the Portsmouth Harbour analyses. The data were compiled through analysis of aerial photographs from 1971 and 2001 (Figures 3.13a and 3.13b). Not all of the saltmarsh recorded in Baily and Pearson (2002) analysis falls within the SPA boundary and so the data sets have been clipped in the GIS. The data is provided as polygon shapefiles in the GIS (CD at the back of the report). The results for Portsmouth Harbour are shown in **Table 3.38** and **Table 3.39**.

**Table 3.38** Areas (ha) of saltmarsh in the Portsmouth Harbour SPA in 1971 and 2001

| Year | Saltmarsh area | Area within SPA |
|---|---|---|
| 1971 | 142.1 | 140.8 |
| 2001 | 53.1 | 52.8 |

**Table 3.39** Saltmarsh loss in the Portsmouth Harbour SPA between 1971 and 2001

| Years | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|
| 1971-2001 | 88.0 | 2.93 |

The amount of saltmarsh present in 1971 within the Portsmouth Harbour SPA was 140.8 ha. In 2001, 88.0 ha had been lost to leave 52.8 ha. This equates to an average loss rate of 2.93 $hayr^{-1}$ over the 30 year period. The Portsmouth Harbour SPA was designated on 28 February 1995. If a saltmarsh erosion rate of 2.93 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1995 would have been 70.5 ha. If the same rate is extrapolated to 2004, then the estimated extent is 44.1 ha (**Table 3.40**). This equates to a loss of 26.4 ha over the nine year period since designation.

**Table 3.40** Estimated saltmarsh area (ha) in the Portsmouth Harbour SPA in 1995 (date of designation) and 2004 based on extrapolation of the 1971-2001 erosion rate

| Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1995 | Estimated saltmarsh area 2004 | Saltmarsh loss 1995-2004 |
|---|---|---|---|
| 2.93 (1971-2001) | 70.5 | 44.1 | 26.4 |

### 3.4.3 Solent and Southampton Water SPA

The data for the Solent and Southampton Water SPA is incomplete in two ways. First, no data is available for saltmarsh extents on the Isle of Wight, which covers a large proportion of the SPA (Figure 1.2). Second, some of the data collated by Baily and Pearson (2002) for the south coast of England part of the SPA does not cover the entire area of saltmarsh. This is because the different years of available aerial photographic coverage varies and the comparison of saltmarsh extent had to be based on the smallest area covered by all photographs in the collection. Some areas of saltmarsh that fall within the SPA are therefore not included in the calculations. So the saltmarsh values for the Eling to Marchwood, River Hamble and River Beaulieu parts of the SPA are underestimates of the actual areas of saltmarsh within the SPA. However, these values do provide a useful insight into overall trends. The data in Baily and Pearson (2002) was compiled separately for different areas of the Solent and Southampton Water SPA and these are reported in this study (**Table 3.41**).

The data for all years are provided as polygon shapefiles in the GIS (CD at the back of the report).

The Solent and Southampton Water SPA was designated on 1 October 1998. The saltmarsh erosion rates from **Table 3.42** are extrapolated to provide estimates of saltmarsh extents for parts of the SPA in 1998 and 2004 (

**Table 3.43**).

**Table 3.41** Areas (ha) of saltmarsh in 1971, 1984 and 2000/2001 for parts of the Solent and Southampton Water SPA, excluding the Isle of Wight. The locations marked with (PL) indicate that mapping was restricted by incomplete aerial photograph coverage

| Location | Year | Saltmarsh area |
|---|---|---|
| Eling to Marchwood (PL) | 1971<br>1984<br>2001 | 36.7<br>27.8<br>18.7 |
| Beaulieu River (PL) | 1971<br>1984<br>2001 | 127.4<br>100.0<br>54.5 |
| Keyhaven and Lymington | 1971<br>1984<br>2000 | 378.0<br>300.9<br>202.0 |
| Calshot | 1971<br>1984<br>2001 | 221.1<br>184.1<br>146.4 |
| River Hamble (PL) | 1971<br>1984 | 36.9<br>26.6 |

**Table 3.42** Saltmarsh loss for parts of the Solent and Southampton Water SPA, excluding the Isle of Wight, between 1971, 1984 and 2000/2001

| Location | Year | Saltmarsh loss (ha) | Loss rate ($hayr^{-1}$) |
|---|---|---|---|
| Eling to Marchwood (PL) | 1971-1984<br>1984-2001 | 8.9<br>9.1 | 0.68<br>0.54 |
| Beaulieu River (PL) | 1971-1984<br>1984-2001 | 27.4<br>45.5 | 2.11<br>2.68 |
| Keyhaven and Lymington | 1971-1984<br>1984-2000 | 77.1<br>98.9 | 5.93<br>6.18 |
| Calshot | 1971-1984<br>1984-2001 | 37.0<br>37.7 | 2.85<br>2.22 |
| River Hamble (PL) | 1971-1984 | 10.3 | 0.79 |

**Table 3.43** Estimated saltmarsh areas (ha) for parts of the Solent and Southampton Water SPA in 1998 (date of designation) and 2004. All erosion rates are from 1984-2000/2001 except for the River Hamble, for which only 1971-1984 data is available

| Location | Saltmarsh erosion rate ($hayr^{-1}$) | Estimated saltmarsh area 1998 | Estimated saltmarsh area 2004 | Saltmarsh loss 1998-2004 |
|---|---|---|---|---|
| Eling to Marchwood (PL) | 0.54 | 20.2 | 17.0 | 3.2 |
| Beaulieu River (PL) | 2.68 | 62.5 | 46.4 | 16.1 |
| Keyhaven and Lymington | 6.18 | 214.4 | 177.3 | 37.1 |
| Calshot | 2.22 | 153.0 | 139.7 | 13.3 |
| River Hamble (PL) | 0.79 | 15.5 | 10.8 | 4.7 |
| Isle of Wight | No data | No data | No data | No data |
| Total | | 465.6 | 391.2 | 74.4 |

The values provided in

**Table 3.43** indicate an overall loss of saltmarsh in the Solent and Southampton Water SPA, but the total absolute values of extent and loss are underestimates because of the limitations described above. However, the Solent CHaMP (Posford Haskoning, 2003a) has published estimated areas of saltmarsh in 2001 including the Isle of Wight (**Table 3.44**). These estimates are based on the data of Baily and Pearson (2002) and other data gathered from the literature (eg JNCC publications, Pye and French, 1993) and are used as a baseline for prediction of future saltmarsh changes in the SPA (section 4.5).

**Table 3.44** Estimated areas (ha) of saltmarsh in 2001 in the Solent and Southampton Water taken from the Solent CHaMP (Posford Haskoning, 2003a)

| Location | Saltmarsh area |
|---|---|
| West Solent (Hurst-Calshot) | 257 |
| Southampton Water (Calshot-Gilkicker) | 254 |
| North West Isle of Wight (Cliff End to Cowes) | 199 |
| North East Isle of Wight (Cowes to Culver) | 26 |
| Total | 736 |

## 3.5 Humber Flats, Marshes and Coast SPA

Results of saltmarsh mapping by ABP (1997) are provided in

**Table 3.45** and used to approximate saltmarsh change in the Humber Flats, Marshes and Coast SPA. No GIS layers are available for the Humber Estuary. However, a visual comparison of the saltmarsh locations against the SPA suggests that all the saltmarsh falls within the SPA boundary.

**Table 3.45** Areas (ha) of saltmarsh in the Humber Flats, Marshes and Coast SPA in 1976 and 1995 (-ve = loss, +ve = gain).

| Location | Saltmarsh area 1976 | Saltmarsh area 1995 | Saltmarsh gain | Gain rate (hayr$^{1}$) |
|---|---|---|---|---|
| Inner | 168 | 226 | +58 | +3.05 |
| Middle | 64 | 67 | +3 | +0.16 |
| Outer | 357 | 333 | -24 | -1.26 |
| Total | 589 | 626 | +37 | +1.95 |

In 1976, 589 ha of saltmarsh was mapped in the Humber Flats, Marshes and Coast SPA. This increased to 626 ha by 1995, equating to a rate of gain of 1.95 hayr$^{-1}$. The Humber Flats, Marshes and Coast SPA was designated on the 28 July 1994. If a saltmarsh accretion rate of 1.95 hayr$^{-1}$ is applied then the estimated saltmarsh extent in 1994 would have been 624.1 ha. If the same rate is extrapolated to 2004, then the estimated extent is 643.6 ha (**Table 3.46**). This equates to a gain of 19.5 ha over the nine year period since designation.

**Table 3.46** Estimated saltmarsh area (ha) in the Humber Flats, Marshes and Coast SPA in 1994 (date of designation) and 2004 based on extrapolation of the 1976-1995 accretion rate

| Saltmarsh accretion rate (hayr$^{-1}$) | Estimated saltmarsh area 1994 | Estimated saltmarsh area 2004 | Saltmarsh gain 1994-2004 |
|---|---|---|---|
| 1.95 (1976-1995) | 624.1 | 643.6 | 19.5 |

ABP (1997) reported changes in saltmarsh extent over different parts of the Humber Estuary. Their results show that although there is an overall increase in the area of saltmarsh over the whole estuary, saltmarsh in the outer estuary is eroding whilst it is relatively stable in the middle estuary (

**Table 3.45**). The overall increase observed is therefore attributable to larger gains in saltmarsh area in the inner estuary than losses in the outer estuary.

## 3.6 The Wash SPA

The Wash is a large embayment, and the saltmarshes represent the largest single area of this habitat type in the United Kingdom (Posford Haskoning, 2003b) (Figure 3.14). Hill (1988) surveyed saltmarsh areas between 1971/1974 and 1982/1985 and calculated that the net area of saltmarsh in The Wash decreased from 4241 ha to 4158 ha (

Table 3.47). However, this decrease is largely due to enclosure of 864 ha (20% of original area). If land-claim is excluded from the calculation, then active saltmarsh area increased by 781 ha at a rate of 71 $hayr^{-1}$.

Table 3.47 shows a net loss of saltmarsh along the sections of The Wash where large land-claims have occurred. A net loss of 184 ha was recorded along the Gibraltar Point-River Witham shore and 228 ha between the Rivers Nene and Great Ouse. Along sections of coast where no land-claim has taken place since 1971/1974, the area of saltmarsh has remained relatively stable, increasing by 44 ha on the east coast and by 18 ha around the Rivers Witham and Welland outfalls.

**Table 3.47** Areas (ha) of saltmarsh in The Wash in 1971/1974 and 1982/1985 subdivided by shoreline section ( Hill, 1988) (-ve = loss, +ve = gain)

| Location | 1971/74 | Enclosed | 1982/85 | Net change | Gain outside enclosure |
|---|---|---|---|---|---|
| Gibraltar Point-Witham | 1112 | 527 | 928 | -184 | 343 |
| Witham-Welland | 826 | 0 | 844 | +18 | 18 |
| Welland-Nene | 1204 | 59 | 1473 | +269 | 328 |
| Nene-Ouse | 676 | 278 | 448 | -228 | 50 |
| Ouse-Hunstanton | 422 | 0 | 466 | +44 | 44 |
| Total | 4241 | 864 | 4158 | -83 | 781 |

In 2001/2002, saltmarsh communities were surveyed in The Wash by Posford Haskoning (2003b). Table 3.48 compiles the areas of saltmarsh sub-features identified in The Wash (Hill, 1988; Posford Haskoning, 2003b) and shows the total saltmarsh area based on a summation of these sub-feature areas. However, caution should be exercised due to the extrapolation of sampled (quadrat) data to imply overall aerial coverage. This is because a specific aerial or ground-truthed survey was not utilised to determine habitat extent. In addition, a number of errors relating to NVC survey work of this type were identified:

- the positioning of vegetation boundaries (due to the complex nature of the vegetation mosaics)
- the accuracy of GPS readings arising from satellite tracking
- the difficulties of mapping inaccessible areas such as MoD land.

**Table 3.48** Areas of saltmarsh sub-features (ha) in The Wash in 1971/1974, 1982/1985 and 2001/2002

| Sub-feature | Saltmarsh area 1971/74 | Saltmarsh area 1982/85 | Saltmarsh area 2001/2002 | Area inside SPA 2001/2002 |
|---|---|---|---|---|
| Pioneer | 378 | 213 | 969 | |
| Pioneer/Cordgrass | Not Used | 81 | 282 | |
| Cordgrass | 207 | 97 | 21 | |
| Cordgrass/Atlantic | 70 | 287 | 53 | |
| Atlantic | 3224 | 2804 | 3049 | |
| Mediterranean | 0 | 0 | 4 | |
| Other | 361 | 676 | 508 | |
| Total | 4241 | 4158 | 4886 | 4485.8 |

The total area of saltmarsh in 2001/2002 is provided as a polygon shapefile in the GIS (CD at the back of the report). The 1971/1974 and 1982/1985 data is paper only.

Between 1982/1985 and 2001/2002, the total saltmarsh area increased by 728 ha, equating to an average gain rate of 40.44 $hayr^{-1}$. This rate has been used to calculate the likely extent of saltmarsh at the date of designation (1988) as the pre-1980s land-claim activities that influenced earlier trends have now largely stopped.

A total of 400.2 ha of the saltmarsh recorded in the 2001/2002 survey lies outside the SPA area, so the GIS data has been clipped to provide an area of saltmarsh within the SPA

boundary (Table 3.48). GIS layers for earlier data are not available so the rate of change from the unclipped data (40.44 $hayr^{-1}$) is applied to the 2001/2002 clipped area of saltmarsh to provide estimates for saltmarsh area within the SPA in 1988 (3939.9 ha) and 2004 (4586.9 ha). This equates to a gain of 647.0 ha over the 16 year period since designation. The Wash SPA has experienced an increase in total saltmarsh area, and is therefore not subject to overall coastal squeeze. However, despite this increase, local areas of saltmarsh are likely to have been lost due to local coastal squeeze effects.

**Table 3.49** Estimated saltmarsh area (ha) in 1988 (date of designation) and 2004, based on extrapolation of unclipped data from 1982/1985 and 2001/2002

| Saltmarsh accretion rate ($hayr^{-1}$) | Estimated saltmarsh area 1988 | Estimated saltmarsh area 2004 | Saltmarsh gain 1988-2004 |
|---|---|---|---|
| 40.44 | 3939.9 | 4586.9 | 647 |

## 3.7 Severn Estuary SPA

Posford Haskoning (2004) summarised the extent and distribution of saltmarsh change along the English coast of the Severn Estuary SPA between 1946/1948 and 2000, based on analysis of rectified aerial photographs (Figure 3.15a and 3.15b). The data is provided as polygon shapefiles in the GIS (CD at the back of the report). No study has been undertaken of saltmarsh change along the Welsh coast of the SPA.

Not all of the saltmarsh recorded in the Posford Haskoning (2004) analysis falls within the SPA boundary. The data sets have therefore been clipped in the GIS to reflect only saltmarsh within the SPA. Notably, the area of saltmarsh recorded in 1946/1948 was greatly reduced when clipped to the SPA boundary, indicating large areas (194.0 ha) of saltmarsh present in 1946/1948 outside the more recently designated SPA. In 2000, only 23.4 ha of saltmarsh was recorded outside the SPA boundary. The most significant of these areas is at Avonmouth, where large areas of saltmarsh have been lost to development prior to SPA designation. These changes outside the SPA boundary mean that although there was an overall decrease in total saltmarsh area recorded in the two surveys, there was a net increase within the SPA.

The results for the Severn Estuary SPA (excluding all saltmarsh on the north shore of the estuary) are shown in **Table 3.50** and **Table 3.51**.

**Table 3.50** Areas (ha) of saltmarsh along the southern shore of the Severn Estuary in the Severn Estuary SPA in 1946/1948 and 2000

| Year | Saltmarsh area | Area inside SPA |
|---|---|---|
| 1946/1948 | 645.0 | 451.0 |
| 2000 | 591.9 | 568.5 |

**Table 3.51** Saltmarsh gain along the southern shore of the Severn Estuary in the Severn Estuary SPA between 1946/1948 and 2000

| Year | Saltmarsh gain (ha) | Gain rate ($hayr^{-1}$) |
|---|---|---|
| 1946/1948-2000 | 117.5 | 2.22 |

The amount of saltmarsh present in 1946/1948 along the southern shore of the Severn Estuary within the Severn Estuary SPA was 451.0 ha. By 2000, the area of saltmarsh had increased by 117.5 ha to 568.5 ha. This equates to an average increase of 2.22 $hayr^{-1}$ over the 53 year period.

The Severn Estuary SPA was designated on 13 July 1995. If a saltmarsh accretion rate of 2.22 $hayr^{-1}$ is applied then the estimated saltmarsh extent in 1995 would have been 557.6 ha. If the same rate is extrapolated to 2004, then the estimated extent is 577.5 ha (**Table 3.52**). This equates to in increase in saltmarsh area of 19.9 ha over the nine year period since designation. It should be noted that these estimates are for the southern shore of the estuary only.

**Table 3.52** Estimated saltmarsh area (ha) along the southern shore of the Severn Estuary in the Severn Estuary SPA in 1995 (date of designation) and 2004 based on extrapolation of the 1946/1948-2000 accretion rate

| Saltmarsh accretion rate ($hayr^{-1}$) | Estimated saltmarsh area 1995 | Estimated saltmarsh area 2004 | Saltmarsh gain 1995-2004 |
|---|---|---|---|
| 2.22 (1946/1948-2000) | 557.6 | 577.5 | 19.9 |

### 3.7.1 Further work in the Severn Estuary SPA

The study of Posford Haskoning (2004) only incorporated saltmarsh change along the southern shore of the Severn Estuary SPA. A large data gap exists along the northern shore. In addition, the southern shore data analysis used 1946/1948 photographs that were collected at different states of the tide, different times of the year and at a variety of scales, making interpretation difficult.

Consultation with the Environment Agency indicates that a set of digital rectified aerial photographs (1:5000 scale) exists for the northern shore of the Severn Estuary flown in 2000/2001. These photographs are in a GIS. Historical aerial photograph data that covers the SPA is more difficult to find. However, if an earlier set of photographs can be found (it would be around 200 based on the 2000/2001 data set), the estimated cost to scan the photographs, digitally rectify and mosaic them and import them into a GIS would be around £5000. To map out the saltmarsh extent, provide GIS layers of saltmarsh extent and report would be an additional £4,000. The total estimated cost would therefore be around £9,000. These costs are only a guide and a more detailed breakdown can be provided once the true nature and size of the data set is established.

It may also be worth considering further analysis of the southern shore of the SPA, due to the inherent problems with using a 1946/1948 aerial photograph data set as a baseline for comparison. Advice and costings could be provided in line with the analysis of the northern shore.

## 3.8 Summary

**Table 3.53** summarises the data compiled in sections 3.1 to 3.7.

**Table 3.53** Estimated saltmarsh areas (ha) at the date of first designation of each SPA and in 2004[9] (-ve = loss, +ve = gain)

| SPA Name | Designation year | Area at designation | Area in 2004 | Change in area |
|---|---|---|---|---|
| Deben Estuary | 1996 | 231.8 | 214.8 | -17.0 |
| Stour and Orwell Estuaries | 1994 | 180.0 | 117.1 | -62.9 |
| Hamford Water | 1993 | 686.4 | 527.8 | -158.6 |
| Colne Estuary | 1994 | 692.2 | 635.9 | -56.3 |
| Blackwater Estuary | 1995 | 684.2 | 621.1 | -63.1 |
| Dengie | 1994 | 420.0 | 393.1 | -26.9 |
| Crouch and Roach Estuaries | 1998 | 410.9 | 344.6 | -66.3 |
| Foulness | 1996 | No data | No data | No data |
| Benfleet and Southend Marshes | 1994 | 140.2 | 126.4 | -13.8 |
| Thames Estuary and Marshes | 2000 | 30.5 | 27.8 | -2.7 |
| The Swale | 1982 | 254.1 | 284.5 | +30.4 |
| Chichester and Langstone Harbours | 1987 | 563.7 | 431.9 | -131.8 |
| Portsmouth Harbour | 1995 | 70.5 | 44.1 | -26.4 |
| Solent and Southampton Water[10] | 1998 | 465.6 | 391.2 | -74.4 |
| Humber Flats, Marshes and Coast | 1994 | 624.1 | 643.6 | +19.5 |
| The Wash | 1988 | 3939.9 | 4586.9 | +647.0 |
| Severn Estuary (south shore only) | 1995 | 557.6 | 577.5 | +19.9 |

# 4. Prediction of saltmarsh change over the next 50 years

## 4.1 Introduction

There have been a range of methods applied in the CHaMPs to predict future change in saltmarsh extent. These methods include the use of linear extrapolation of historic trends, regime methods, Mudpack modelling, and expert geomorphological assessment. This section provides estimates of future saltmarsh change for each SPA listed in **Table 1.1**, between 2004 and 2054. The analysis for each SPA is described separately below and a summary table is provided at the end of the section (**Table 4.3**).

### 4.1.1 Linear extrapolation

The simplest method to provide a prediction of likely change in saltmarsh extent is direct extrapolation of historic trends. If good data is available to indicate that trends in saltmarsh change are ongoing and relatively consistent, direct extrapolation is an effective method of prediction. However, the broad range of drivers for change in saltmarsh habitat extent and the associated variability in trends makes the accuracy of this method limited in practice. Typical influences that interfere with direct extrapolation of historical change rates are potential accelerated sea-level rise and major and periodic changes such as land-claim or channel stabilisation.

[9] Calculated by linear extrapolation of historic rates of change.
[10] Data excludes the coast of the Isle of Wight.

### 4.1.2 Regime theory

The regime method applies known relationships between physical attributes of an estuary in order to predict long-term changes. The method is based on the assumption that an estuary will achieve some form of dynamic equilibrium and that there is a characteristic function that describes the equilibrium relation. The generic regime relationship is applied to the basic tidal prism/channel cross section relationship, and allows a theoretical planimetric form to be calculated for a given estuary. This can be applied to predict change in existing channel width, changes in estuary width or cross section in response to sea-level rise or the impact of changes such as dredging, land-claim or managed realignment.

### 4.1.3 Mudpack

The Mudpack model predicts mudflat elevation changes on a specific profile over periods of between 1 and 100 years. The model is designed to replicate the response of a mudflat profile to storm events producing erosion, interspersed with periods of calm conditions, producing deposition. The model compares the rate at which the mudflat surface recovers from erosion with the frequency of storm events, as well as the relationship between water depth and wave stress (and associated deposition or erosion).

### 4.1.4 Expert geomorphological assessment

Historical trend analysis involves the interrogation of time series data to identify directional trends and rates of processes and morphological change, over varying time periods (section 4.1.1). The expert geomorphological assessment method incorporates output from historical trend analysis, but also takes account of information about current physical processes, geological constraints and sediment properties, and general relationships between processes and morphological responses.

### 4.1.5 Futurecoast

Futurecoast (Halcrow, 2002) provides a summary of physical processes and trends around the open coastline of England and Wales and provides a basic prediction of likely future shoreline change under current (and unconstrained) management, driven by future climate change and associated sea-level rise.

## 4.2 Suffolk

No predictive modelling has been carried out as part of the Suffolk Coast and Estuaries CHaMP (Posford Haskoning, 2002a) and so linear extrapolation has been applied to the Deben Estuary SPA.

### 4.2.1 Deben Estuary SPA

A direct extrapolation of the 1986-1998 rate of erosion (2.12 $hayr^{-1}$) forwards from 2004 would result in a further loss of 106.0 ha of saltmarsh by 2054, leaving a total area of 108.8 ha (**Table 4.3**). This rate has been calculated from change observed since 1986, after which most land-claim activities had ceased.

## 4.3 Essex

Predicted changes to the saltmarsh extent in the Colne Estuary, Blackwater Estuary and Crouch Estuary over the next 50 years using the regime method are provided in the Essex Coast and Estuaries CHaMP (Posford Haskoning, 2002b). No regime analysis was carried out for the Stour and Orwell Estuaries, Hamford Water, Dengie or Benfleet and Southend Marshes and so linear extrapolation has been applied. The overall results of Posford Haskoning (2002b) indicate that Essex saltmarshes will continue to erode and that significant areas of saltmarsh will have been lost by 2054. These changes will be mostly driven by channel widening and mudflat/saltmarsh erosion associated with rising sea level, and associated increases in tidal prism.

### 4.3.1 Stour and Orwell Estuaries SPA

If the 1988-1997 rate of saltmarsh loss in the Stour and Orwell Estuaries SPA (6.29 $hayr^{-1}$) is linearly extrapolated from 2004, there would be a further loss of 314.5 ha by 2054 (**Table 4.3**). The estimated total area of saltmarsh in 2004 in the Stour and Orwell Estuaries SPA is only 117.1 ha, so if the 1988-1997 rate continues, there would be no saltmarsh left by 2023.

### 4.3.2 Hamford Water SPA

If the 1988-1998 rate of saltmarsh loss in Hamford Water SPA (14.42 $hayr^{-1}$) is linearly extrapolated from 2004 to 2054, there would be a further 721.0 ha of loss (**Table 4.3**). This is more than the estimated 2004 coverage of 527.8 ha, so at the 1988-1998 rate, there would be no saltmarsh left within the Hamford Water SPA by 2041.

### 4.3.3 Colne Estuary SPA

If the 1988-1998 rate of saltmarsh loss in the Colne Estuary SPA (5.63 $hayr^{-1}$) is linearly extrapolated to 2054, there would be a 50-year 281.5 ha of further loss beyond 2004 (**Table 4.3**). This would leave 354.4 ha of saltmarsh remaining in the Colne Estuary SPA in 2054. Using the regime method for the Colne Estuary the predicted loss of saltmarsh over a 50 year period with a sea-level rise of 6 $mmyr^{-1}$ is 116 ha (Posford Haskoning, 2002b). This would leave 519.9 ha of saltmarsh remaining in 2054 (**Table 4.3**). This result is interesting in that the predicted loss using the regime method (with a sea-level rise of 6 $mmyr^{-1}$) is less than the loss predicted by extrapolating historic erosion rates.

### 4.3.4 Blackwater Estuary SPA

If the 1988-1997 rate of saltmarsh loss (7.01 $hayr^{-1}$) is linearly extrapolated, there would be further loss of 350.5 ha 50 years beyond 2004 to leave 270.6 ha of saltmarsh in the Blackwater Estuary SPA in 2054 (**Table 4.3**). Using the regime method the predicted 50 year loss of saltmarsh with a sea-level rise of 6 $mmyr^{-1}$ is estimated to be 1040 ha (Posford Haskoning, 2002b), which represents total loss of saltmarsh from the Blackwater Estuary SPA before 2054 (**Table 4.3**).

### 4.3.5 Dengie SPA

If the 1988-1998 rate of saltmarsh loss in the Dengie SPA (2.69 $hayr^{-1}$) is linearly extrapolated from 2004, a further loss of 134.5 ha would occur in 50 years time, leaving a total area of 258.6 ha in 2054 (**Table 4.3**).

No regime analysis has been undertaken for Dengie but predictions were made of changes in the cross-shore profile along the shoreline using the Mudpack model. The model predicts a gradual decrease in the rate of horizontal saltmarsh edge recession at Dengie and after a period of around 30 years the saltmarsh edge is predicted to advance (Posford Haskoning, 2002b).

Dengie is one of the few areas in which saltmarshes exist on the open coast. It is one of only two SPAs (the other being Foulness) in this study that were included in Futurecoast (Halcrow, 2002). Halcrow (2002) predicted that the foreshore would continue to narrow over the next 50 years because of coastal squeeze. This result contrasts with that of Posford Haskoning (2002b) which shows a recovery of the saltmarshes of Dengie within the next 50 years.

### 4.3.6 Crouch and Roach Estuaries SPA

Given the short period over which the saltmarsh data was available, the use of the results of the 1998 and 2000 aerial photograph comparisons must be treated with care, particularly when they are extrapolated forward to estimate future saltmarsh loss. The extrapolation of 2-years worth of data is not sufficient to obtain reasonable accuracy, and a longer record of data is needed. For this reason, a linear extrapolation of the Crouch and Roach Estuaries SPA is not provided.

Using the regime method for the Crouch Estuary only the predicted loss of saltmarsh over a 50 year period with a sea-level rise of 6 $mmyr^{-1}$ is estimated to be 321 ha (Posford Haskoning, 2002b), which is more than the existing area of saltmarsh in the Crouch Estuary. Regime analysis has not been carried out for the Roach Estuary.

### 4.3.7 Foulness SPA

Only qualitative assessments of likely saltmarsh change in the Foulness SPA have been made and are summarised here.

Futurecoast (Halcrow, 2002) provides predictions that cover the Foulness SPA area as well as the Dengie coast. Halcrow (2002) predicted that due to the presence of flood defences under increased rates of sea-level rise, the foreshore will narrow due to coastal squeeze. According to Posford Haskoning (2002b), the results of the Mudpack modelling of the Dengie coast (recovery of saltmarsh over a 50 year period) could be applied to the Foulness coast. This prediction for a long term recovery of saltmarsh is in contrast to the prediction of continued erosion of Halcrow (2002).

### 4.3.8 Benfleet and Southend Marshes SPA

If the 1988-1998 rate of saltmarsh loss in Benfleet and Southend Marshes SPA (1.38 $hayr^{-1}$) is linearly extrapolated from 2004 to 2054, there would be a further 69 ha of loss, leaving 57.4 ha in 2054 (**Table 4.3**). No regime analysis has been undertaken for the Benfleet and Southend Marshes SPA.

## 4.4 North Kent

### 4.4.1 Thames Estuary and Marshes SPA

The results of University of Newcastle (2002) suggest that there has been a slow trend of saltmarsh loss (0.68 $hayr^{-1}$) within the Thames Estuary and Marshes SPA between 1988 and 2000. If this rate is linearly extrapolated beyond 2004, then in 2054, a further 34.0 ha of saltmarsh would be lost (**Table 4.3**). This loss is greater than the estimated 2004 saltmarsh coverage within the SPA (27.8 ha), and at this rate there would be no saltmarsh remaining by 2045.

### 4.4.2 The Swale SPA

In The Swale SPA, the University of Newcastle (2002) measured net accretion of 58.9 ha of saltmarsh between 1961 and 2000. If the recent rate of gain (1.28 $hayr^{-1}$ between 1988 and 2000) is linearly extrapolated from 2004 to 2054 then The Swale SPA saltmarsh would increase in extent by 64 ha to 348.5 ha (**Table 4.3**).

Prediction of saltmarsh change using the regime method has been carried out for The Swale SPA in the North Kent CHaMP (Posford Haskoning, 2002c). Only linear extrapolation of historic trends has been undertaken for the Thames Estuary and Marshes SPA. This is because of the large size of the whole Thames Estuary relative to the small area within the Thames Estuary and Marshes SPA. Using the regime method the predicted increase in saltmarsh area over a 100 year period under a future sea-level rise of 6 $mmyr^{-1}$ is 98 ha (Posford Haskoning, 2002c). If this is treated as a linear trend, the increase predicted by regime analysis for 2054 would be 49 ha producing a total saltmarsh cover of 333.5 ha (**Table 4.3**). This is a slightly lower gain than the prediction based on linear extrapolation of historic trends.

## 4.5 West Sussex and Hampshire

A prediction of future change in the saltmarshes of West Sussex and Hampshire over the next 100 years has been carried out using expert geomorphological assessment in the Solent CHaMP (Posford Haskoning, 2003a) (**Table 4.1**). These predictions suggest a consistent reduction in saltmarsh area and in some cases almost complete loss of the saltmarsh by 2101.

**Table 4.1** Predicted change in saltmarsh area (ha) in West Sussex and Hampshire (Posford Haskoning, 2003a) (-ve = loss, +ve = gain)

| Location | Saltmarsh area 2001 | Saltmarsh area 2101 | Predicted change |
|---|---|---|---|
| Chichester and Langstone Harbours | 472 | 145 | -327 |
| Portsmouth Harbour | 53 | 3 | -50 |
| West Solent (Hurst-Calshot) | 257 | 17 | -240 |
| Southampton Water (Calshot-Gilkicker) | 254[11] | 35 | -219 |
| North West Isle of Wight (Cliff End-Cowes) | 199 | 63-228 | -136 to +29 |
| North East Isle of Wight (Cowes-Culver) | 26 | 21 | -5 |

[11] Includes 89 ha for the Hamble Estuary

Posford Haskoning (2003a) also extrapolated the percentage rate of loss from mapped data (therefore excluding the Isle of Wight) to provide predictions of saltmarsh area through to 2101. Estimates for saltmarsh area in 2054 extrapolated using the Posford Haskoning (2003a) data are presented in **Table 4.2**.

**Table 4.2** Predicted change in saltmarsh area (ha) in West Sussex and Hampshire using extrapolated rates of annual percentage loss (Posford Haskoning, 2003a)

| Location | Saltmarsh area 2001 | Estimated area saltmarsh 2054 | Predicted loss |
|---|---|---|---|
| West Solent (Hurst-Calshot) | 257 | 48.0 | 209.0 |
| Southampton Water (Calshot-Gilkicker) | 254[11] | 86.0 | 168.0 |
| Chichester and Langstone Harbours | 472 | 219.2 | 252.8 |
| Portsmouth Harbour | 53 | 2.6 | 50.4 |

The estimates for Chichester and Langstone Harbours and Portsmouth Harbour can be compared with those derived from linear extrapolation of historic rates of change in the SPAs.

### 4.5.1 Chichester and Langstone Harbours SPA

If the present rate of saltmarsh loss in the Chichester and Langstone Harbours SPA (7.75 $hayr^{-1}$) is linearly extrapolated from 2004 to 2054, there would be a further loss of 387.5 ha (**Table 4.3**). The estimated saltmarsh area in 2004 is 431.9 ha, so using this rate, in 2054, around 44.4 ha would remain.

### 4.5.2 Portsmouth Harbour SPA

If the 1971-2001 rate of saltmarsh loss in the Portsmouth Harbour SPA (2.93 $hayr^{-1}$) is linearly extrapolated to 2054 from 2004, there would be a further loss of 146.5 ha (**Table 4.3**). The estimated saltmarsh area in 2004 is 44.1 ha, so at this rate of loss, there would be no saltmarsh left by 2020.

### 4.5.3 Solent and Southampton Water SPA

A prediction using extrapolation of historical rates of change in the Solent and Southampton Water SPA has not been attempted because of the incomplete data from the Isle of Wight. However, estimates for West Solent and Southampton Water (Posford Haskoning, 2003a) are given in **Table 4.2**.

## 4.6 Humber Flats, Marshes and Coast SPA

A prediction of future change in the saltmarshes of the Humber Estuary between 2000 and 2050 has been carried out in the draft Humber CHaMP (ABPmer, 2003; Black and Veatch, 2004). A baseline figure of 668 ha of saltmarsh was used in the calculations, which predict that between 2000 and 2050, around 139 ha of saltmarsh will be lost (**Table 4.3**). This is radically different to the value based on linear extrapolation. In this case, if the 1976-1995 rate of gain (1.95 $hayr^{-1}$) in the Humber Flats, Marshes and Coast SPA is linearly extrapolated between 2004 and 2054, there would be a gain of 97.5 ha, increasing the total area of saltmarsh to 741.1 ha (**Table 4.3**).

## 4.7 The Wash SPA

No predictive modelling has been carried out for The Wash. In addition, because numerous significant potential errors have been identified in the estimation of total saltmarsh area from the 2001/2002 NVC survey (section 3.6), the use of linear extrapolation is fraught with difficulties. Therefore, the following estimate of saltmarsh in The Wash in 2054 has to be viewed in the context of these potential large errors.

If the 1982/1985 to 2001/2002 rate of gain (40.44 $hayr^{-1}$) in The Wash SPA is linearly extrapolated from 2004 to 2054, there would be further accretion of 2022.0 ha, increasing the total area of saltmarsh to 6608.9 ha (**Table 4.3**).

## 4.8 Severn Estuary SPA

No predictive modelling has been carried out for the Severn Estuary and so linear extrapolation has been applied. If the 1946/1948 to 2000 rate of gain (2.22 $hayr^{-1}$) in the Severn Estuary SPA is linearly extrapolated from 2004 to 2054, there would be further accretion of 111.0 ha, increasing the total area of saltmarsh to 688.5 ha (**Table 4.3**).

## 4.9 Summary

**Table 4.3** summarises the data compiled in sections 4.2 to 4.8.

**Table 4.3** Saltmarsh areas (ha) in 2004 and 2054 based on linear extrapolation of historic rates of change and using the regime method (-ve = loss, +ve = gain)

| SPA Name | Area 2004 | Area 2054 Linear | Area Change Linear | Area 2054 Regime | Area Change Regime |
|---|---|---|---|---|---|
| Deben Estuary | 214.8 | 108.8 | -106.0 | | |
| Stour and Orwell Estuaries | 117.1 | None - 2023[12] | -314.5 | | |
| Hamford Water | 527.8 | None - 2041 | -721.0 | | |
| Colne Estuary | 635.9 | 354.4 | -281.5 | 519.9 | -116.0 |
| Blackwater Estuary | 621.1 | 270.6 | -350.5 | None | -1040.0 |
| Dengie | 393.1 | 258.6 | -134.5 | | |
| Crouch and Roach Estuaries | 344.6 | N/A pre 2054 | N/A | None[13] | -321.0[13] |
| Foulness | No data | No data | No data | | |
| Benfleet and Southend Marshes | 126.4 | 57.4 | -69.0 | | |
| Thames Estuary and Marshes | 27.8 | None - 2045 | -34.0 | | |
| The Swale | 284.5 | 348.5 | +64.0 | 333.5 | +49.0 |
| Chichester and Langstone Harbours | 431.9 | 44.4 | -387.5 | | |

[12] Predicted date when saltmarsh will reach zero.
[13] Crouch Estuary only.

| SPA Name | Area 2004 | Area 2054 Linear | Area Change Linear | Area 2054 Regime | Area Change Regime |
|---|---|---|---|---|---|
| Portsmouth Harbour | 44.1 | None - 2020 | -146.5 | | |
| Solent and Southampton Water[14] | N/A | N/A | N/A | | |
| Humber Flats, Marshes and Coast | 643.6 | 741.1 | +97.5 | 529.0[15] | -139.0[16] |
| The Wash | 4586.9 | 6608.9 | +2022.0 | | |
| Severn Estuary (south shore only) | 577.5 | 688.5 | +111.0 | | |

In many of the SPAs, the only form of prediction available for future saltmarsh change is direct extrapolation of existing trends. Where regime analysis was undertaken, the nature of the predicted change (ie loss or gain) is generally consistent with extrapolation of existing trends (apart from the Humber Estuary), but the scale of the predicted change is different. It is unlikely that saltmarsh will continue to change at the historic rates in the long term, particularly because of the uncertainty and dynamic nature of the factors influencing erosion and accretion. The linear extrapolations presented in this study are therefore only a broad estimate of the possible future change in saltmarsh area, and a low level of confidence needs to be attached to them.

The regime method considers the stable dimensions of an estuary to predict the likely response of the estuary under future conditions, including increases in tidal prism associated with future sea-level rise. This method may provide a more accurate estimate of future change, but has been undertaken for only a small number of the SPAs in this study.

# 5. Managed realignments since SPA first designation

This section briefly describes the managed realignment schemes that have been implemented since SPA designation, and the amount of intertidal habitat (saltmarsh, mudflat and saline lagoons) created. A summary of the schemes and their size is provided in **Table 5.1**.

### 5.1.1 Orplands - Blackwater Estuary SPA

The Orplands realignment scheme was implemented in April 1995 and has created 38 ha of mostly saltmarsh (85%) including high saltmarsh. The other 15% is mudflat.

### 5.1.2 Tollesbury - Blackwater Estuary SPA

The Tollesbury realignment scheme was implemented in July 1995 and has developed into 21 ha of intertidal habitat divided into around 6 ha saltmarsh and 15 ha mudflat.

[14] Incomplete data. See Tables 4.1 and 4.2.
[15] Area of saltmarsh predicted in 2050.
[16] Amount lost in 50 years from a baseline estimate of 668 ha in 2000.

### 5.1.3 Abbotts Hall - Blackwater Estuary SPA

The sea wall at Abbotts Hall was breached in October 2002, producing up to 81 ha of mudflat, pioneer saltmarsh and coastal grassland. Pioneer saltmarsh vegetation established within twelve months.

### 5.1.4 Paull Holme Strays - Humber Flats, Marshes and Coast SPA

The Paull Holme Strays managed realignment site was completed in 2003. By setting back coastal defences, 80 ha of new intertidal habitat will be created.

### 5.1.5 Freiston Shore - The Wash SPA

The Freiston Shore managed realignment site was breached in September 2002, and was at the time the largest realignment site in the United Kingdom (Rawson and others, 2004). The site includes 66 ha of intertidal area and 11 ha of lagoon. Since breaching, the area has rapidly colonised with pioneer saltmarsh species.

**Table 5.1** Managed realignment schemes implemented since first date of designation and the area of potential intertidal habitat

| SPA | Realignment | Year | Area (ha) |
|---|---|---|---|
| Blackwater Estuary | Orplands | 1995 | 21 |
| Blackwater Estuary | Tollesbury | 1995 | 38 |
| Blackwater Estuary | Abbotts Hall | 2002 | 81 |
| Humber Flats, Marshes and Coast | Paull Holme Strays | 2003 | 80 |
| The Wash | Freiston Shore | 2002 | 66 |

# 6. Conclusions

**Table 6.1** and **Table 6.2** list the SPAs that have historically either lost or gained saltmarsh. Foulness is not included as data is limiting in the determination of loss or gain. Quantification of these losses or gains is provided in **Table 3.53**. Most of the SPAs studied have experienced loss of saltmarsh.

**Table 6.1** SPAs subject to historic saltmarsh loss

| Historic saltmarsh loss |
|---|
| Deben Estuary |
| Stour and Orwell Estuaries |
| Hamford Water |
| Colne Estuary |
| Blackwater Estuary |
| Dengie |
| Crouch and Roach Estuaries |
| Benfleet and Southend Marshes |
| Thames Estuary and Marshes |
| Chichester and Langstone Harbours |
| Portsmouth Harbour |
| Solent and Southampton Water[10] |

**Table 6.2** SPAs subject to historic saltmarsh gain

| Historic saltmarsh gain |
|---|
| The Swale |
| Humber Flats, Marshes and Coast |
| The Wash |
| Severn Estuary (south shore only) |

**Table 6.3** shows the SPAs which are predicted to lose parts of their saltmarsh area over the next 50 years, and those which are likely to lose all their saltmarsh if current rates of erosion continue. Quantification of these losses is provided in **Table 4.3**.

**Table 6.3** SPAs that are predicted to either lose part or all of their saltmarsh area over the next 50 years based on linear extrapolation of historic rates of loss

| Predicted partial saltmarsh loss | Predicted total saltmarsh loss |
|---|---|
| Deben Estuary | Stour and Orwell Estuaries |
| Colne Estuary | Hamford Water |
| Blackwater Estuary | Thames Estuary and Marshes |
| Dengie | Portsmouth Harbour |
| Benfleet and Southend Marshes | |
| Chichester and Langstone Harbours | |

Care needs to be taken with respect to the use of the predicted losses (and gains) of saltmarsh based on linear extrapolation of historic rates. Due to uncertainty in the processes driving future saltmarsh erosion and accretion, particularly sea-level change and sediment supply, the estimates of loss should not be quoted out of context. A simple linear extrapolation into the future will not take into consideration the complex nature of natural coastal systems where future conditions may differ from the past. Future conditions are likely to be better understood using one or more of the predictive methods currently available, including regime methods and expert geomorphological assessment.

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## Coastal Squeeze, Saltmarsh Loss and Special Protected Areas

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Keywords: Coastal squeeze, saltmarsh, sea-level rise, habitat loss, SPA.

# Introduction

In many coastal and estuarine environments, flood and coastal defences constrain the ability of intertidal habitats (notably saltmarsh) to naturally move landward in response to sea-level rise. This results in habitat loss commonly termed "coastal squeeze". English Nature has been providing advice to Defra and the Environment Agency as part of the development of a policy to address the issue of coastal squeeze of saltmarshes in Special Protection Areas (SPAs) resulting from Environment Agency flood and coastal defence works. In order to inform this advice it was necessary to ascertain both the past changes to saltmarsh extent in SPAs and predict future losses in SPAs subject to coastal squeeze.

# What was done

This report uses previous studies, including the existing Coastal Habitat Management Plans (CHaMPs), to determine past changes in saltmarsh extent in a number of SPAs since their designation and summarise potential future changes. The report covers:

- Existing data on historic saltmarsh extent in each SPA was gathered and reviewed for accuracy.
- The best of this data was used to make linear extrapolations to estimate changes in saltmarsh extent since designation of the site as an SPA.
- A summary of the extent of intertidal habitat created up to the end of 2004 by managed realignment schemes is also presented.
- Using the best of the historic data, linear extrapolations of change in extent of saltmarsh were used to give an estimate of possible change over the next 50 years.
- For a few SPAs where the information was available, these estimates were then compared with those derived from the more complex, and potentially more accurate, Regime Method (which considers an estuary's dynamic equilibrium state to predict likely future responses).

The report does not consider relative changes in different saltmarsh vegetation communities.

# Results and conclusions

In most of the SPAs, the total area of saltmarsh decreased over the period of record, including since designation as an SPA. In some (Stour and Orwell Estuaries, Hamford Water, Blackwater Estuary, Thames Estuary and Marshes and Portsmouth Harbour – and possibly the Crouch and Roach

**Continued …..**

Estuaries), one or both of the predictive methods indicate that saltmarsh could be completely lost from the SPA area within 50 years. The Swale, Humber Flats, Marshes and Coast, The Wash and Severn Estuary (southern shore only) SPAs were the only areas examined where saltmarsh extent has historically increased. To improve geographical coverage of predictions of saltmarsh change, for the Foulness and the Severn Estuary (north shore) SPAs this study provides recommendations and costings for saltmarsh mapping from aerial photographs to calculate change in historic saltmarsh extent.

The report emphasises that the estimates of loss and gain should not be quoted out of context. Linear extrapolations of change in extent cannot take account of the complex nature of natural coastal systems where future conditions may differ from the past.

# English Nature's viewpoint

The results of this study provide further evidence of the extent of loss of saltmarsh habitat in England as a result of coastal squeeze. This reinforces English Nature's view that coastal squeeze is a major threat to intertidal habitats on the east and south coasts of England, and a cause for their unfavourable condition. For most of the estuaries along this part of the English coast, saltmarsh has been lost to coastal squeeze since designation as SPA. Changes to current coastal flood risk management programmes are therefore needed if such losses are to be halted in the future.

Within the context of whole estuary strategies developed by the Environment Agency, English Nature believes there is a need for managed realignment of some flood defence structures to create additional intertidal habitat to compensate both for past losses and for predicted future losses. Saltmarsh habitat also makes an important contribution to the effectiveness of such flood risk management structures.

Reflecting the consequences of coastal squeeze on European designated sites, Defra has, through a High Level Target (4F), already set the Environment Agency a target of creating at least 100 hectares of new saltmarsh or mudflat per annum. The information from this report, along with the results of Coastal Habitat Management Plans (CHaMPs), will help English Nature advise the Environment Agency on how this habitat creation effort should be distributed around the coast, and should inform the Environment Agency's Regional Habitat Creation Programmes. Further information, though, still needs to be collected on all estuaries in order to better understand their dynamics and the implications for biodiversity.

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