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**Essex Coastal SSSIs:
Assessment of Changes in Extent of
Saltmarsh Over the Period 1997 to 2008**

VOLUME 1

Report to Natural England

Institute of Estuarine and Coastal Studies
University of Hull

8th June 2011

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THE UNIVERSITY OF HULL

Institute of Estuarine and Coastal Studies (IECS)

Natural England

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VOLUME 1**

17th May 2011

Reference No: ZBB745-D-2011

For and on behalf of the Institute of Estuarine and Coastal Studies	
Approved by:	_____
Signed:	_____
Position:	_____
Date:	_____

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1. BACKGROUND

1.1 Condition Assessments

Under the Environmental Protection Act (1990), the country agencies and the Joint Nature Conservation Committee (JNCC) are required to establish Common Standards throughout Great Britain for the monitoring of nature conservation on statutory sites. The condition of special interest features of a Site of Special Scientific Interest (SSSI) are monitored in a rolling programme by Natural England (at least every 6 years) using what is termed as the UK Common Standards Monitoring approach.

Condition monitoring is used to determine the conservation status of interest features on statutory sites and to determine whether the conservation objectives for particular sites are being met (JNCC, 2007). Monitoring of SSSIs provides a health check of the condition of sites against scientific criteria and provides information for the Government's PSA (Public Service Agreement) target that 95% of all SSSIs should be in 'favourable' or 'recovering' condition by 2010.

The features to be monitored are known as the interest features for which the site has been notified or designated. They include individual habitat types and species, and also complex features such as habitat mosaics and species assemblages. Each interest feature must be identified, monitored, assessed and reported on separately.

1.2 Estuarine Coastal SSSIs & Study Rationale

The coastal saltmarshes of Essex are a valuable international, national, regional and local natural resource due to both their inherent coastal defence and nature conservation properties. However saltmarsh in Essex has been undergoing erosion due to coastal squeeze and losses are estimated to be occurring at a rate of 40 hectares per year. Losses of this feature are therefore significant and are important in determining the condition of units containing this feature. As it is unfeasible to obtain an accurate assessment of changes in saltmarsh extent in the field, orthorectified aerial photos can be used as an alternative to aid accurate reporting. Previous studies carried out by Burd (1992), Cooper et al (2000) and Royal Haskoning (2006) mapped and digitised individual aerial photographs to identify and quantify the extent/presence of saltmarsh in various years, and secondly to identify and quantify areas of change.

This report investigates the changes in saltmarsh within seven Essex coastal SSSIs between 1997/2000 and 2007/2008 (depending on availability of aerial photographs). Two key saltmarsh attributes within the studied management units will be assessed including:

Saltmarsh extent - The Essex saltmarshes have been undergoing erosion due to coastal squeeze. Natural England will be undertaking condition monitoring looking at the key attribute of 'extent'. Extent of the saltmarsh is a fundamental attribute to be assessed in determining condition of the saltmarsh feature and will allow an assessment of the erosion (through coastal squeeze and erosion) or any areas which have advanced (JNCC, 2004).

Target: *No decrease in extent from the established baseline, subject to natural change.*

Assessment: *A baseline map should be prepared to show the distribution of saltmarsh vegetation, using orthorectified aerial photography.*

Saltmarsh creek network - Along with habitat extent, another key attribute to be monitored within this assessment is changes in extent of the saltmarsh creek network. Creeks and pans vary in size and density. Creeks absorb tidal energy and assist with the delivery of sediment into saltmarshes. Major erosion of saltmarsh is indicated by internal dissection and enlargement of the drainage network, ultimately leading to the creation of mud basins.

Target: *No further anthropogenic alteration of creek patterns or loss of pans compared to an established baseline. Realignment of creeks absent or rare.*

Assessment: *Aerial photography*

1.3 Aims & Objectives

The project therefore has the following aims and objectives:

1. To assess changes in saltmarsh extent and changes in physical structure of the creek network between 1997/2000 and 2007/2008¹ by comparing orthorectified aerial photographs (See Appendix 1 for sources).
2. To present the data in a format which will allow Natural England to undertake a condition assessment of the features on individual SSSI units to contribute to Natural England's unit-based recording system
3. To present the data in a format that will allow site assessment of changes in these attributes to be made on a unit by unit basis.
4. To report on the current assessment of changes in saltmarsh extent (1997/2000 and 2007/2008) and compare with the previous studies dating back to the original baseline of 1973 (Burd, 1992; Copper et al 2000)
5. To report on the change in creek network from 1997/2000 and 2007/2008.

¹ Depending on aerial coverage for respective years.

2. METHODS

2.1 Study Area / Management Units

Figure 1 shows the geographical areas of the Essex coastal SSSIs which have been covered by this report. The management units chosen for the assessment by Natural England within the seven SSSIs include:

- Benfleet & Southend Marshes SSSI – Units 6, 7, 8 and 10
- Blackwater Estuary SSSI & Orplands Realignment Site (west) - Units 1-4, 6-13, 18-20, 25-27, 29-33, 36, 37, 39, 40, 43-45, 47*, 48-65, 67-71, 74-77, 80*, 88 & Orplands (west)
- Colne Estuary SSSI – Units 1, 3, 5, 6, 7, 9, 14, 16, 17*, 18, 20, 21, 23, 27-37
- Crouch & Roach SSSI – Units 1, 2, 4, 5, 7-9, 11, 14, 15, 17, 19, 22, 24 25*, 26, 28-32, 34-39, 41, 43-50, 52-54, 56 & 57
- Dengie SSSI - Units 5 6, 7 & 8
- Foulness SSSI – Units 2, 3, 5, 14, 17, 19, 22-24, 26, 28, 29 & 31-33
- Hamford Water SSSI – Units 2-10 & 13

Of a total 159 units included in the original specification, 155 units were assessed.

*Four units were excluded from the study either because there was insufficient aerial coverage (unit 47, Blackwater – Osea Island; Unit 17 – Colne) or because the units did not contain saltmarsh (ie unit 80, Blackwater; unit 25 Crouch and Roach). The areas of saltmarsh represented in Unit 47 (Blackwater) and Unit 17 (Colne) have therefore not been considered. However a condition assessment was carried out by Natural England for both of these units and a view is given on the current condition and extent of the saltmarsh, compared with previous studies, and included in the results section (section 3).

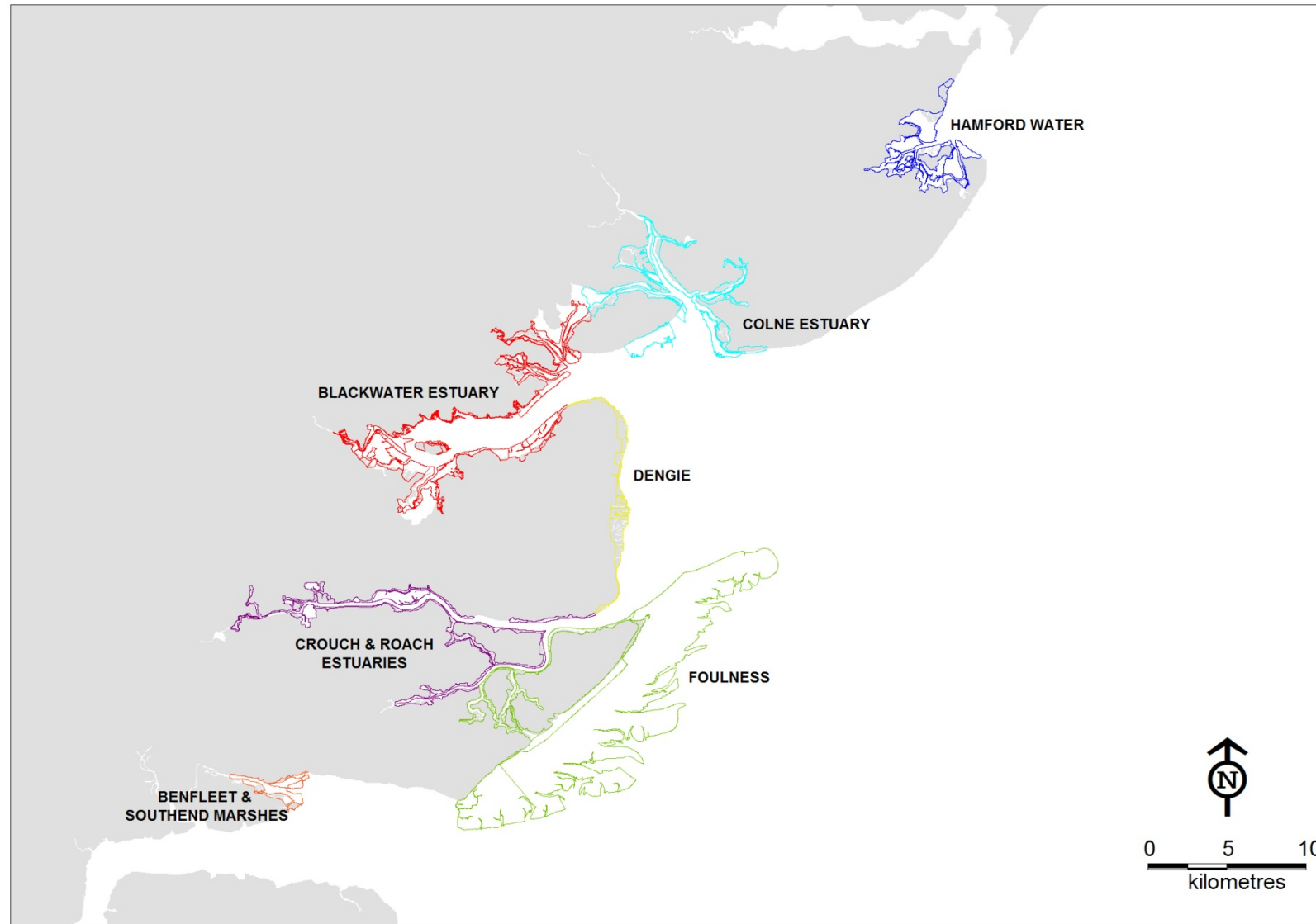


Figure 1 Location of the seven Essex Coastal SSSIs

2.2 Assessment Period

Based on the available aerial photographs and the coverage they provide across the area, it was decided by Natural England that the following years would be used to carry out the assessment:

- Either 1997 or 2000 were used as a baseline for all management units depending on suitability and availability. See Appendix 1 for the aerials used within this study.
- Either 2007 or 2008 aerials were used for the comparative year for all management units subject to aerial coverage.

2.3 GIS Techniques

2.3.1 MAPPING

A decision was taken by Natural England at the start of this project not to use the findings of earlier aerial studies as a baseline but, instead, to obtain orthorectified aerials for the study years. Orthophotographs are geometrically corrected to reduce distortions caused by terrain relief and camera tilt and provide an accurate representation of the earth's surface. They can therefore be used to measure true distances. However, like other techniques, there are inherent problems and these are discussed in Appendix 2.

Aerial photographs were provided by Geostore and the Environment Agency's Shoreline Management Team and consisted of black and white photographs for the coastal strip and colour for the estuaries. These had generally been captured at a scale of 1:10,000 and a resolution of 25cm and were provided to IECS fully orthorectified and in MapInfo format. Full details of the aerial photographs used can be found in Appendix 1. The SSSI boundaries and management units were provided by Natural England.

Both the aerials and SSSI GIS tables for the seven SSSIs were uploaded into Mapinfo (v.9.0). Within the management units selected, the boundaries of the saltmarsh / intertidal interface were digitised as enclosed polygons with sufficient detail to be accurately represented at a viewing scale of 1:700m. Where the saltmarsh extended to the boundary of the management unit, the polygon was 'snapped' onto this line. Upon completion of the digitisation, the line work was cleaned to ensure all saltmarsh areas were represented by distinct enclosed polygons in accordance with NE guidelines.

A number of rules were followed to ensure comparability between years and the complexity of the saltmarsh mapped. All channel/creek systems greater than 3m in width at the mouth and down to the point of less than 3m were digitised and large creek pans and barren areas within the saltmarsh polygons were removed from the overall area calculation if thought to be significant. Where areas of fragmented saltmarsh occurred, a decision was taken to either map as one discreet polygon or as individual polygons based on the degree of fragmentation. In general, no saltmarsh area less than 5m² was mapped.

Distinctions had to be made between saltmarsh, reedbed, grassland, algae and other mudflat characteristics based on pixel colour and relief of saltmarsh from the aerial photographs available. No additional height relief maps, LiDAR data or interpolative software was used in this study. Transition zones to seaward and landward of the marsh extent were mapped based on pixel colouring and texture.

This report considers changes in the overall area of saltmarsh habitat in each SSSI management unit, but it should be noted that no assessment was made of the quality of the saltmarsh e.g. degraded or good quality, but only of its presence. In addition, this report does not consider relative changes in different saltmarsh communities within each unit.

The limitations of the mapping methodology described above, and the quality of the aerial photographs available, have been discussed in Appendix 2.

2.3.2 SPATIAL ANALYSIS

Once the saltmarsh within each management unit was digitised, the polygons were analysed to:

- identify and quantify all of the saltmarsh present in the baseline and comparative year.

The queries ran on each SSSI area produced polygons for:

1. Saltmarsh which was only present in the baseline year (representing eroded saltmarsh);
2. Saltmarsh which was only present in the comparison year (representing accreted saltmarsh);
3. Areas of saltmarsh present in both the baseline *and* the comparative year (representing stable saltmarsh).

These results are represented on a map layer showing the extent of saltmarsh losses and gains within each management unit for each SSSI. Losses are shown in red and gains in green, with stable saltmarsh shown in yellow. The overall changes in each management unit within each SSSI were tabulated presenting:

- Total area of saltmarsh present in the baseline year (hectares)
- Total area of saltmarsh present in the comparative year (hectares)
- Net saltmarsh losses in each unit (hectares)
- Net saltmarsh gained in each unit (hectares)
- Stable saltmarsh in each unit (hectares)

A second set of maps show the overall extent of saltmarsh losses and gains within each of the seven Essex coastal SSSIs. Again, losses are shown in red, gains in green and stable saltmarsh in yellow.

From the digitised maps, some assessment has been made in the text to changes in creek morphology, planform and density between the baseline and comparative aerial photographs. Any changes in the creek network have been analysed in relation to the status of the surrounding saltmarsh extent.

All maps of the individual SSSI management units and overall extent of saltmarsh losses and gains within each SSSI can be found in Volume 2 of this report.

2.4 Ground truthing

Natural England has provided ground truthing sections beneath the aerial interpretation summaries for the individual units, where information was available. The ground truthing elements are based on a combination of condition assessment field notes, observations made during field visits, and site knowledge. Only recent condition assessments have been

used ie. 2009 and 2010. These were undertaken independently of the aerial study and some simply provide an account of the field observations, with no reference to the aerial survey text, though there may be evidence in the site condition summaries which reflect the findings from the aerial study. Other assessments and field observations have been considered in the light of the aerial interpretation and reference is made to the findings. In some instances it has been possible to verify, dispute and/or account for the outcome of the aerial interpretation. Field observation and a knowledge of the history of the sites has been particularly helpful in considering the changes brought about by human intervention, such as the placement of recharge material sourced from channel dredgings and the development of the managed realignment sites.

2.5 Limitations on saltmarsh aerial coverage imposed by the project remit

The SSSIs selected for this report are those where saltmarsh 'extent' is a reportable feature for condition monitoring. Realignment sites generally lie outside the SSSI boundary. The exceptions to this are the Northey Island set-back site and the eastern section of the Orplands realignment, both within the Blackwater Estuary SSSI. However, as the western area of the Orplands realignment (Orplands West) is immediately adjacent to its eastern SSSI counterpart, it has been reported on here and the results have been referred to within the Blackwater Estuary SSSI section. Other realignments ie Tollesbury and Abbot's Hall on the Blackwater Estuary, and the Wallasea site on the Crouch, are referred to in the unit summaries but the areas of these sites have not been assessed for inclusion in this study.

SSSI boundaries are fixed based on saltmarsh extent according to OS map publications at the time of notification. In some cases over the study period, saltmarsh accretion has extended beyond these unit boundaries into adjacent units where this accretion is credited. In very occasional instances saltmarsh may have encroached into a unit excluded from the study, but this is thought to represent an insignificant area.

3. RESULTS

This section presents the results from the saltmarsh mapping and spatial analysis for each management unit within each SSSI, and includes ground truthing assessments and observations. All maps can be found in Volume 2 – Maps, with the GIS files on the accompanying DVD.

3.1 Benfleet and Southend Marshes SSSI

Benfleet and Southend Marshes SSSI comprise an extensive series of saltmarshes, mudflats, scrub and grassland which support a diverse flora and fauna. Wintering wildfowl and waders reach both nationally and internationally important numbers within this site. Nationally uncommon plants occur in all of the habitats and parts of the area are of outstanding importance for scarce invertebrates.

Between 1620 and 1625, a large extent of saltmarsh was reclaimed on Canvey Island, with other smaller-scale reclamations continuing into the nineteenth century (Cooper et al, 2000). By comparing historic OS maps, Pethick and Stapleton (1994) reported that the remaining saltmarshes of the Thames estuary were starting to fragment from 1909 due to the onset of erosional processes. Seawalls have been breached at various dates to allow the hinterland to revert back to saltmarsh; examples include Leigh Marshes (Two Tree Island), Newland Marshes and Canvey Point (Burd et al, 1994).

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 1 shows the location of the SSSI units within the Benfleet and Southend Marshes SSSI. By digitising and comparing the extent of saltmarsh in 1997 and 2008, Table 1 shows the overall calculations for Benfleet and Southend Marshes SSSI, breaking down the total extents, gains and losses, net change, and average rate of change within each unit.

Management Unit 6

Map 2 shows the large area covered by Unit 6, covering the inner Benfleet Creek in the west down to Oyster Creek on Canvey Island in the south-east and along Leigh Creek north of Two Tree Island in the northeast. A net gain of saltmarsh has been mapped in this unit between 1997 and 2008. Of the 28.76ha of saltmarsh mapped in 1997, a total of 1.25ha was lost to erosion, but an additional 5.33ha was gained elsewhere through natural accretion resulting in a net gain of 4.08ha by 2008. This gave an overall extent of 32.84ha in 2008 accreting at an average of 0.37ha/yr over the study period. There has been very little change within the main bodies of saltmarsh across the unit, with 27.51ha remaining stable over the eleven years. The predominant changes have occurred along the seaward edges across most of the saltmarsh areas, particularly along the saltmarsh on the north bank of Benfleet Creek south of Castle Point, and also a large accretionary area to the south of the mid-channel island within Hadleigh Ray. Some erosion was also experienced on the northern marsh edge of this mid-channel island.

Ground truthing: A condition assessment by Natural England, carried out in 2009, described a vegetation structure of pioneer, low-mid marsh and mid-upper marsh zones with sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*) being the dominant marsh communities. Signs of erosion were reported with cliffing of the saltmarsh edge and rills bordering Benfleet Creek. The survey bears out the findings of the

aerial survey of accreting marsh adjacent to the saltmarsh island in Hadleigh Ray and identifies this as common cord grass (*Spartina anglica*). The growth pattern seen on the aerial photographs is suggestive of common cord grass.

Management Unit 7

Management Unit 7 lies on the outer southern bank of Benfleet Creek extending north and west of Tewkes Creek and running south of this channel between Sunken Marsh and Canvey Point (Map 2). Saltmarsh in this unit is considerably divided by channels which lead to infilling mudpans. Accretion has also been recorded on the outermost seaward edge of the saltmarsh. Erosion has occurred to seaward at the south-westernmost extent of the saltmarsh and within various creeks. The unit has experienced an overall net gain of 5.2ha over the eleven-year study period (1997 to 2008) totalling 98.31ha in 2008.

Ground truthing: The condition assessment carried out in 2008 by Natural England described the saltmarsh as a mosaic of pioneer and mid-marsh communities with the mid-upper marsh mostly absent (largely confined to sea walls). The existing saltmarsh and adjacent mud/sandflats around the Canvey Point area showed signs of eroding at the seaward edge and were suffering internal degradation. Erosion of the saltmarsh was mainly located along the seaward edge. However, the shell chenier ridges on the south-eastern extents of the saltmarsh showed less signs of erosion and were regarded as being more stable. It is suggested that the chenier ridges are providing a degree of protection to the saltmarsh from wave and tidal processes, and fine sediments may be depositing on the lee side.

Until 2003, a derelict concrete barge had been present on the muds and saltings of the south-westernmost area of Canvey Point. The removal of this structure initially reduced the area of saltmarsh through direct impact, but since then the marsh has recovered to an area comparable to the pre-2003 extent, supporting a reasonable diversity of saltmarsh plants on this rubbly, sandy substrate. There is also anecdotal evidence that the area immediately east of the 'old concrete barge' site has been subject to significant saltmarsh losses during storm events in the past.

Accretion in the creeks, such as Smallgain, was noted. These creeks are prone to silting up and are dredged periodically.

No significant signs of common cord grass (*Spartina anglica*) were observed.

The accretion mapped in the aerial photograph has mostly developed on a large mud pan within the marsh south of Hadleigh Ray, and on the seaward margins south-west of Canvey Point. The growth pattern is indicative of common cord grass. These areas are difficult to observe from the land.

Management Unit 8

Unit 8 lies to the north of Two Tree Island between Leigh-on-Sea Station and Hadleigh Marsh (Map 2). This unit has experienced a net gain of 1.55ha of saltmarsh between 1997 and 2008 averaging a gain rate of 0.14ha/yr over the eleven-year period. The saltmarsh extent was mapped at 8.34ha in 1997, of which 0.33ha was lost to natural erosion and 1.88ha was gained through accretion over the study area. 8.01ha has remained stable throughout the study period, with accretion concentrated mainly along the seaward marsh

edges within Leigh Creek. These areas of accretion have been identified from the aerial photographs as common cord grass (*Spartina anglica*) and represent an expansion of this saltmarsh community which was observed on the 1997 aerals.

Ground truthing: Natural England reported, in a condition assessment conducted in 2009, that the saltmarsh in this unit is characteristic of sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*) communities. Signs of erosion and resultant cliffing of the marsh edge, in Leigh Creek and its associated rills, were described. Pioneer marsh was observed to be developing east of Two Tree Island bridge and this was identified as common cord grass (*Spartina anglica*). The aerial survey also records accretion in this area and the growth pattern identifies this as common cord grass.

Management Unit 10

Of the 32.54ha of saltmarsh present in 1997, a total of 1.02ha was lost to erosion, but 2.20ha gained elsewhere through natural accretion resulting in a net gain of 1.18ha to total 33.72ha by 2008. Some erosion has occurred along the seaward edge of this unit, particularly east of the slipway along Leigh Sand and at the edge of Leigh Marsh. However, saltmarsh extent has been gained predominantly within the main body of saltmarsh through the accretion of creek systems and mud pans, most notably in the upper marsh area south of Two Tree Island (Map 2). Accretion has also occurred on the marsh edge at the entrance to the large creek immediately east of the slipway. The saltmarsh change over the eleven-year period has been calculated averaging a net gain of 0.11ha/yr.

Ground truthing: Natural England's condition assessment, dated 2008, confirms the findings of the aerial survey exercise noting continuing erosion of the seaward marsh edge. The saltmarsh constitutes a mosaic of pioneer and mid-level marsh and limited mid-upper marsh. Common cord grass (*Spartina anglica*) is described as locally dominant in Leigh Marsh. The accretion mapped in the aerial survey in the upper marsh south of Two Tree Island, to arrest erosion where mud basins were forming, was not described in the condition assessment but is considered to be attributable to the Essex Wildlife Trust management practice of placing faggot bunds within the saltmarsh rills.

Summary

Table 1 Summary statistics for the Benfleet and Southend Marshes SSSI management units

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 2008 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
6	28.76	32.84	4.08	1.25	5.33	27.51	0.37
7	93.11	98.31	5.20	3.56	8.76	89.55	0.47
8	8.34	9.89	1.55	0.33	1.88	8.01	0.14
10	32.54	33.72	1.18	1.02	2.20	31.52	0.11

3.2 Blackwater Estuary SSSI

The Blackwater is a macrotidal estuary (tidal range 5.2-5.8m) and is the largest in Essex. Its western border is at Maldon, in the upper reaches, and the eastern border lies at the confluence with the River Colne. For the majority of its length the Blackwater is bordered by

flood defences and, although the upper channel is narrow, the lower channels are considerably wider, thus exposing substantial littoral areas at low water. Extensive intertidal flats are exposed at low water around Osea and Northey Islands. Mudflats are fringed by saltmarsh on the upper shores, with shingle, shell banks and offshore islands also being a feature of the tidal flats. The diversity of estuarine habitats results in the sites being of importance for a wide range of overwintering waterbirds, including raptors, geese, ducks and waders. The site is also important in summer for breeding terns (JNCC, 2001a).

Extensive marsh was mapped along the Blackwater Estuary in 1777, however Ordnance Survey maps showed this had been reduced substantially after 1874. Van der Wal and Pye (2000) reported a net loss of saltmarsh of c.2ha/yr for the period 1874 to 1998. Burd (1992) reported that by 1988, 23% of the total area of saltmarsh in the Blackwater had been lost to erosion, with over 70% of the pioneer zone and nearly 30% of the low-mid marsh zone reducing in extent. The largest areas of erosion have occurred on the seaward edge of many marshes, notably on the north-east facing edge of Osea Island and in St Lawrence Bay. Pethick & Stapleton (1994) compared historic OS maps to identify that the greatest erosion has occurred along the north shore of the estuary within the narrow channel reach between Bradwell and Mill Point. Cross-shore transects of the higher intertidal zone from the period 1991-1999 suggest that lateral retreat of the marsh edge occurred at a rate of 0.5-1m/yr (van der Wal & Pye, 2004). Although saltmarsh erosion has continued over the past decade, significant areas of saltmarsh habitat has been created through the implementation of managed realignment schemes – Northey Island being within the SSSI, Orplands, partly within the SSSI (eastern section), and Tollesbury and Abbot's Hall both lying outside the SSSI boundary. Although the western section of the Orplands realignment site is outside the boundary of the SSSI, because it is contiguous with the SSSI realignment it has been included in this study and treated as a 'unit', referred to as 'Orplands West'.

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 3 shows the location of the SSSI units considered within the Blackwater Estuary SSSI. By digitising and comparing the extent of saltmarsh in the chosen baseline (either 1997 or 2000) and the comparative year (2008), Table 2 shows the overall calculations for the Blackwater Estuary, breaking down the total extents, gains and losses, net change and average rate of change within each unit.

Note: *denotes unit where saltmarsh was digitised from 2000 aerial photographs. These aerials were misaligned by approx 3-4m thereby not matching the saltmarsh present in 2008 and resulting in incorrect records of gain and loss. In this case it is therefore of more value to consider the total areas in each year and the net change rather than the total area of loss and gain.

Management Unit 1

Map 4 shows the saltmarsh within Unit 1 at St Peter's Well, West Mersea. Of the 1.06ha of saltmarsh present in 1997, a total of 0.14ha was lost to erosion, with only 0.02ha gained elsewhere through natural accretion resulting in a net loss of 0.12ha by 2008. Saltmarsh was lost along the seaward marsh edge.

Ground truthing: Natural England report that the loss recorded by the aerial survey on the seaward edge is likely to be due to natural coastal processes moving sand over the saltmarsh.

Management Unit 2

Unit 2 covers the area of Cobmarsh Island and surrounding mudflats (Map 4). The saltmarsh on Cobmarsh Island was mapped at 6.19ha in 1997, experiencing a net loss of 0.57ha to give a revised extent of 5.62ha by 2008. Of this original total, 5.54ha remained stable between 1997 and 2008, with no change to the internal creek systems of the Island, however erosion occurred along much of the seaward marsh edge around the Island. A total of 0.65ha was lost to erosion, with only 0.08ha gained elsewhere through natural accretion resulting in an average rate of loss of 0.05ha/yr.

Natural England comment: Coarse material of sands and gravels, sourced from the Harwich ports capital dredge, was placed at the south-eastern tip of Cobmarsh in 1998. This has acted as a wave break in this exposed area. Some of this material has migrated northwards along the eastern edge of the island.

Management Unit 3

The saltmarsh in Unit three is located in five discrete areas: two saltmarsh embayments lie on the east bank of the Strood Channel, separated by a series of polders containing relict saltmarsh; a further section is located at the south-western end of Mersa Island between Besom Fleet and Coast Road; and Packing Shed Island is situated in the Mersea Quarters between Thorne Fleet and Mersea Fleet. Erosion is impacting the channel edges of the saltmarsh throughout the unit and this is particularly prominent at the north Mersea Island. Saltmarsh is recolonising the oyster pits on Packing Shed Island. There has been a net change of 0.89ha over the study period equating to an average rate of loss of 0.08ha per year.

Ground truthing: A condition assessment was carried out by Natural England in 2009 which supports the findings of the aerial study. The saltmarsh in the embayment located in the lower Strood, north-west of Firs Chase caravan park, is generally fairly stable and supports predominantly mid-level marsh of sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*). However, erosion is evident along the seaward fringes. The marsh at the north-east end of this section lies between an artificial drainage channel and the sea wall, and appears to have reduced in height, indicated by the predominance of low marsh vegetation. There is evidence of internal erosion of the creek network here with slumping of the creek edges where higher marsh vegetation has been succeeded by pioneer species. The south-eastern tip of this marsh is considerably eroded, just north of the Dabchicks sailing club. The marsh between the polders/sedimentation fences, north-east of this embayment, has all but disappeared and only mud mounds remain. There is localised erosion on the east side of the hard at Coast Road but south-east of this a sand/shingle spit is extending into Besom Fleet and is protecting the saltmarsh. As the spit builds and stabilises it is being colonised with saltmarsh scrub vegetation, shrubby sea-blite (*Suaeda vera*) which grades into stable saltmarsh.

Packing Shed Island was a recipient site for sands and gravels dredged from the navigation channel at Harwich in 1998. The material was placed at the southern tip and absorbs wave energy as it is pushed shorewards.

Management Unit 4 *

Unit 4 lies to the west of the Strood causeway which crosses to Mersea Island. It includes the Ray Island and Bonner's Saltings Nature Reserve (Map 5). The unit is generally stable with erosion indicated on the seaward edge, particularly to the south of Ray Island. Areas of shrub and grassland are present within the nature reserve on the Ray Channel side, the boundaries of which merge into the saltmarsh and are therefore difficult to define. A total of 64.51ha of saltmarsh was present in 2008 showing a net loss of 1.45 ha over the eight-year study period.

Management Unit 6 *

Saltmarsh is present for almost the entire length of this unit, covering an area of 7.62ha in 2008 and showing a net loss of 0.31ha over the eight-year study period. The marsh fringes the sea wall between Sampson's Farm and Sampson's Creek (Map 5). Enlargement of channels appears to be leading to erosion within the main body of the saltmarsh. Although slight erosion is also recorded on the outer boundaries of the saltmarsh, this could be attributable to the poor quality of the aerial photographs in 2000 where the seaward interface appears hazy.

Management Unit 7*

Saltmarsh extends from Sampson's Creek in the north of the unit and runs southwards alongside the Ray Channel where small gains and losses of saltmarsh have been recorded (Map 6). The saltmarsh has remained stable where it extends around the southern tip of Feldy Marshes and north-west into Little Ditch. A small net loss of 0.17ha has occurred over the study period leaving 12.07ha in 2008.

Management Unit 8*

Unit 8 incorporates Copthall Saltings, located east of Abbot's Hall Saltings (Map 6). Saltmarsh is generally stable to the north of the unit with fragmented marsh associated with several large channels to the south. Erosion is also evident at the more exposed south-eastern end of Copthall Saltings. The saltmarsh in this unit totalled 20.19ha in 2008, showing a net loss of 0.56ha over the eight-year study period.

Management Unit 9*

Unit 9 includes Sunken Island which is colonised entirely by saltmarsh vegetation totalling an area of 12.32ha in 2008 (Map 7). The main body of the saltmarsh is stable but erosion is recorded on the fringes, particularly on the north-western edge. There are sunken areas in the middle of the island where significant accretion has been recorded resulting in a net gain of 0.71ha over the study period.

Management Unit 10*

Map 8 shows the extent of saltmarsh in Unit 10 within the Salcott Creek and Salcott Channel area of the Blackwater Estuary. The saltmarsh within Abbot's Hall Saltings has remained stable between 2000 and 2008 with some accretion within the saltmarsh body of creek channels. Some erosion along the marsh edge of Abbot's Hall Saltings is shown on the map

with some accretion along the marsh edge of the saltmarsh south of Decoy Pond. To the west of the unit, the saltmarsh has, in the main, remained stable but with notable erosion along the narrow channel of Salcott Creek. Of the 41.24ha of saltmarsh mapped in 2000, a total of 1.81ha was lost to erosion, but 2.45ha gained elsewhere through natural accretion resulting in a net gain of 0.63ha by 2008.

Natural England comment: The Abbot's Hall managed realignment site lies to the north of this unit. The site was breached in 2002 creating 49ha of intertidal habitat. The area of saltmarsh establishment can be seen on Map 8. The site is outside the SSSI boundary and the saltmarsh area has not been assessed in this report.

Management Unit 11*

The saltmarsh in Unit 11 runs along the west bank of Salcott Creek and totalled 1.8ha in 2008, remaining relatively stable over the study period (Map 8). The channel side of the saltmarsh has accreted in places occasionally extending beyond the unit boundary into Unit 12. The landward edge of the saltmarsh is predominantly stable.

Management Unit 12*

The saltmarsh in Unit 12 stretches for approximately 4.5km from Marsh Farm and Salcott Creek in the west, along the southern edge of Salcott channel - north of Old Hall Marshes - terminating north-west of Old Hall Point (Map 9). Slight erosion has been recorded on the channel side of the saltmarsh and small areas of saltmarsh gain have been mapped around the more sheltered southern end of the unit. The saltmarsh has remained generally stable throughout the study period experiencing a small net loss of 0.54ha to total 30.81ha in 2008.

Management Unit 13

The saltmarsh in Unit 13 encompasses both Great Cob and Little Cob Islands which lie between the North and South Channels in the Tollesbury Fleet (Map 10). The saltmarsh in the unit totalled 5.99ha in 2008, having experienced a net loss of 1.41ha since 1997. Enlargement of creeks accounted for the majority of the erosion on Great Cob Island, whilst the erosion on Little Cob Island was restricted to the outer fringes.

Management Unit 18*

Map 11 shows the extent of saltmarsh in the western half of Unit 18 within Tollesbury Fleet, with Map 10 showing the eastern half of this extensive unit. The main bodies of saltmarsh within the Tollesbury Fleet area represent the largest extent of marsh within the Blackwater Estuary SSSI and have remained stable with some accretion of creek channels within the main body of the extensive marsh areas. However erosion of the seaward marsh edge has occurred throughout, notably along both banks of Old Hall Creek. To the east of the unit, the exposed marsh edge along the north bank of North Channel has experienced some erosion, particularly south-west of Old Hall Point. Of the 79.73ha of saltmarsh present in 2000, a total 4.56ha was lost to erosion, but an additional 2.61ha was gained elsewhere through natural accretion resulting in a net loss of 1.95ha by 2008. This resulted in a rate of loss of 0.24ha/yr.

Ground truthing: A condition assessment was undertaken by Natural England in 2009 and the results verify the findings of the aerial survey. The marsh north of Old Hall Creek is very

degraded and characterised by unvegetated mud mounds, particularly in the Joyce's Head area. Pioneer marsh was present at the creek edges which, in places, had slumped into the creeks. The widest vegetation zone was the low-mid marsh. Brands Saltings to the south of Old Hall Creek is fairly stable internally, in the upper part of the creek.

Old Hall Point received sand and gravel recharge material from the Harwich Approaches deep channel dredge in 1998 and this has been effective in protecting the point.

The Tollesbury managed realignment site is located at the head of Tollesbury Fleet. It was breached in 1995 and has developed c.6ha of saltmarsh, as evidenced on the aerial photograph. It is not included within the SSSI boundary and therefore does not contribute to this assessment.

Saltmarsh surveys undertaken in Unit 18, as part of the Tollesbury pre and post breach monitoring, showed that common cord grass (*Spartina anglica*) increased from 1.5% in 1994 to 13.9% in 2007, encroaching into saltmarsh grass (*Puccinellia maritima*)/sea purslane (*Atriplex portulacoides*) communities (A.Garbutt, pers comm).

Management Unit 19

Unit 19 lies north-east of Tollesbury, flanked by Woodrolfe Creek to the east (Map 11). The saltmarsh is penetrated by a few large channels and has a fragmented pattern but has remained stable. The overall trend is that of gain through the narrowing and infilling of creeks. Saltmarsh in this unit totalled 50.86ha in 2008, having experienced a net gain of 1.01ha over the eleven-year study period.

Management Unit 20

Map 12 shows the extent of saltmarsh within Unit 20 surrounding the Tollesbury Wick Marshes. 20.80ha of saltmarsh was present in 1997 of which 2.28ha was lost to erosion, with 2.11ha gained by natural accretion. This resulted in a net change of -0.17ha by 2008 to 20.63ha of saltmarsh. Changes have predominantly occurred along the marsh edges with very little internal change of the creek systems. A notable area of accretion is evident at Shinglehead Point. Erosion of the marsh edges has occurred within the mosaic/fragmented saltmarsh at the mouth of Woodrolfe Creek and within the extent along South Channel.

Natural England comment: Recharge material of sands and gravels, arising from the deepening of the Harwich Approaches channel, was placed at Shingle Head Point in 1998 and may have helped to stabilise the point sufficiently to support vegetation growth. The recharge has migrated south-westwards and lies on the outer foreshore parallel to the Tollesbury Wick Marshes sea wall.

Management Unit 25

Unit 25 shown on Map 13 covers the saltmarsh to the east of Mill Creek, Tollesbury. Of the 7.26ha of saltmarsh present in 1997, a total of 0.62ha was lost to erosion, with only 0.32ha gained elsewhere through natural accretion resulting in a net loss of 0.27ha by 2008. This has resulted in a 6.99ha extent being mapped in 2008, averaging a 0.02ha/yr loss over the eleven years. Although the saltmarsh remained relatively stable within the sheltered environment of Mill Creek, the marsh exposed to the main estuary channel experienced erosion along the seaward edge.

Management Unit 26

Unit 26 covers the lower area of intertidal from the creek at Tollesbury Wick Marshes to the west of Mill Creek (Map 13). Only 0.55ha of saltmarsh was mapped in 1997, but a net gain of 0.05ha increased the extent to 0.61ha by 2008. This mainly occurred along the outermost edges of the main saltmarsh bodies within Mill Creek.

Management Unit 27

Map 13 also shows the extent of saltmarsh within Unit 27, which incorporates the intertidal areas along the main Blackwater Channel south of Mill Farm Marshes and also the main body of saltmarsh to the west of Mill Creek. The saltmarsh extent was mapped at 9.05ha in 1997, however this reduced to 8.13ha by 2008. Of this 1997 total, 1.28ha was lost to erosion with only 0.36ha gained through natural accretion throughout the unit. The main areas of erosion occurred along the exposed seaward marsh edge within the main Blackwater Channel and also along the marsh edges of the saltmarsh at the mouth of Mill Creek. Further losses had also occurred by 2008 through the fragmentation of the saltmarsh on the landward side of the marsh area at the head of Mill Creek, resulting in small islands of unstable marsh.

Management Unit 29

The saltmarsh extent within Unit 29 between Thistly Hard and Mill Point was mapped at 4.20ha in 1997. Map 14 shows erosion along the seaward marsh edge along its entire length, and on the south side of the saltmarsh area at Mill Point. This erosion has led to a net loss of 0.50ha over the assessment period averaging a loss of 0.05ha/yr. Although the majority of the marsh areas have remained stable (3.60ha), some internal creek channels had narrowed by 2008.

Management Unit 30

The saltmarsh extent within Unit 30 (Map 15) is restricted to the west of the unit to the south-east of Rolls Farm. A small area of saltmarsh (0.02ha) was mapped at the top of this inlet in 1997, and by 2008 0.06ha of saltmarsh had accreted southwards along the shoreline, giving a new extent of 0.07ha.

Management Unit 31

This unit contains two distinct areas of saltmarsh to the south-east and southwest of Rolls Farm (south of Tollesbury) (Map 15). The area to the south-east shows a large area of erosion of 0.1ha at the southern edge, adjacent to Thirslet Creek. Further areas of erosion occur on the outer edge of the saltmarsh fringing the sea wall. The main body of the saltmarsh to the south-west of Rolls Farm is stable but, again, erosion has been recorded on the seaward edge. The saltmarsh in the unit totalled 1.9ha in 2008, experiencing a net loss of 0.26ha since 1997.

Management Unit 32

The saltmarsh in Unit 32 is a westward continuation of the saltmarsh in Unit 31, covering an area of 1.19ha in 2008 (Map 16). The overall trend is, again, that of erosion but in this case erosion is occurring within the main body of the saltmarsh - creating new creeks and

enlarging existing ones - as well as on the outward edge. There has been a net loss of 0.46ha over the eleven-year study period averaging a loss of 0.04ha/yr.

Management Unit 33

Unit 33 covers the saltmarsh within Gore Saltings on the Blackwater Estuary. Map 16 shows 2.82ha of stable saltmarsh mapped between 1997 and 2008, with natural accretion outweighing erosion within the fragmented/mosaic marsh areas. Of the 3.42ha of saltmarsh present in 1997, a total of 0.60ha was lost to erosion, with 0.88ha gained elsewhere within the unit through natural accretion. The overall result was a net gain of 0.48ha by 2008.

Management Unit 36*

Maps 16 & 17 show the saltmarsh south of Joyce's Farm, Goldhanger. The extent was mapped as 1.21ha in 2000 and it retained the same extent in 2008. Over the eight years, 0.97ha of saltmarsh remained stable with equal gains and losses of 0.25ha.

Ground truthing: The section of saltmarsh lying south-west of Lauriston Farm was ground truthed by Natural England in 2009 during a condition assessment visit. This saltmarsh lies between a protective, vegetated shingle spit - supporting shrubby sea-blite (*Suaeda vera*) - and the seawall. Map 17 shows that the saltmarsh in the west of this section is stable, currently, and this is verified by ground truthing. Localised slumping of the marsh was noted to the east unit, where the tide runs between the saltmarsh and the sea wall.

Management Unit 37*

The majority of the saltmarsh in this unit consists of fragments in an inlet adjacent to Joyce's Farm, situated to the south-east of Goldhanger (Maps 17 & 18). The saltmarsh appears dynamic with many small areas of both loss and gain. The average rate of loss between 2000 and 2008 was 0.03ha/yr. It should be noted that the poor quality of the aerials used for this unit made it difficult to define the saltmarsh boundaries.

Management Unit 39*

This unit hugs the sea wall south-east of Gardener's Farm extending to the playing fields at Goldhanger (Maps 17 & 18). A thin strip of saltmarsh running southwards appears to have degraded significantly in this unit. The full extent of this is difficult to determine due to the poor colour definition of the 2000 aerial photographs. The saltmarsh to the western end of the unit appears dynamic with areas of both gains and losses recorded. The unit experienced an overall net loss of 0.29ha of saltmarsh over the study period averaging a loss of 0.04/yr.

Ground truthing: The saltmarsh located in the upper part of the embayment in Unit 39, south-east of Gardener's Farm, is fragmented (Map 17). Mud pans are developing adjacent to areas where saltmarsh is degrading into mud mounds. The dominant vegetation on the remaining higher areas is sea purslane (*Atriplex porulacoides*) and saltmarsh grass (*Puccinellia maritima*). The pioneer species, annual sea-blite (*Suaeda maritima*) is present on the lower, sloping edges of the marsh. Common cord grass (*Spartina anglica*) is also present within the marsh and at the base of the sea wall. Shrubby sea-blite (*Suaeda vera*) is confined to the base of the sea wall at this location.

The section of saltmarsh mapped to the south-east of Bound's Farm supports vegetated shingle strips, with *Spartina anglica* (common cord grass) growing on the mud between the shingle banks. This may partly account for the accretion shown on the aerial photographs.

Management Unit 40*

This saltmarsh is situated to the north of the Osea Island causeway and is severely fragmented by a complex creek system (Map 19). The marsh area totalled 7.23ha in 2008 with an overall erosion rate of 0.10ha per year over the study period. In addition to the anomalies introduced due to the discrepancy between aerials, infilling of channels has been recorded as well as distinct areas of both gain and loss of saltmarsh on the outer edges. The area also has a large covering of algae.

Ground truthing: Natural England's condition assessment visit (2009) confirms the findings of the aerial survey. The field survey notes that the saltmarsh adjacent to the sea wall is very fragmented and badly eroded. This is likely to be due to scouring by the tide as it cuts between the marsh and the sea wall. Sparsely vegetated mud mounds are present and cord grass (*Spartina* sp) has encroached since the Posford Haskoning survey (2003), which mapped saltmarsh communities. The saltmarsh as a whole shows marked internal dissection. The higher saltmarsh communities, comprising sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*), are generally confined to the tops of narrow plateaus with sloped or cliffed edges. Areas of accretion and 'infilling' of channels reported by the aerial survey is likely to be due to slumping of the marsh edge into the channels. The high marsh transitional vegetation is restricted to the base of the sea wall.

Management Unit 43*

Unit 43 is comprised of fragments of marsh situated around Decoy Point. Total saltmarsh was mapped at 0.14ha in 2000 with a 0.04ha net loss by 2008 to 0.1ha. Erosion has occurred along the marsh edges (0.05ha) with only minimal accretion (0.01ha) (Map 20).

Ground truthing: Natural England undertook a field visit here in 2009. The fragments of marsh here have mostly been eroded to mud mounds and vegetation is sparse on other fragments - mostly consisting of *Spartina anglica* (common cord grass) with patchy sea purslane (*Atriplex portulacoides*) on remaining higher areas. The accreted areas marked on the aerials are likely to denote patches of common cord grass which has established on the lower mounds, which can no longer support native saltmarsh vegetation.

A recent visit by Natural England (2011) noted a band of common cord grass growing on the foreshore next to the sea wall, immediately north of the Osea Island causeway. The outline can be seen on the aerial photograph but it is very faint. This has not been defined and measured by the aerial survey.

Management Unit 44*

Within this unit there are very small, scattered patches of common cord grass (*Spartina anglica*) adjacent to the caravan parks to the south of Barrow Marsh and east of Heybridge Basin (Map 20). Ground truthing was necessary here in order to distinguish the saltmarsh from algae and upper shore debris. Although a loss of 0.01ha and a gain of 0.02ha has been recorded this is thought to be entirely due to the discrepancies in the orthorectification

of the aerial photographs used. The saltmarsh vegetation in this unit, represented by common cord grass, could therefore be considered stable throughout.

Management Unit 45*

The largest area of saltmarsh in Unit 45 lies to the south-east of Mill Beach. This extent shows natural accretion along the seaward edge over the eight years (see Map 20). The saltmarsh extent was mapped at 0.45ha in 2000 with only a minimal change in extent (0.02ha gain) by 2008 to a total area of 0.47ha. Large areas of saltmarsh have remained stable (0.39ha) with only a slight loss mapped at the landward boundary.

Ground truthing: A field visit by Natural England in 2009 describes the saltmarsh in unit 45 as a raised area of foreshore adjacent to the Osea Road caravan site. *Spartina anglica* (common cord grass) grades into mid-level to higher marsh – with *Puccinellia maritima* (saltmarsh grass) and *Atriplex portulacoides* (sea purslane) – which is superseded by *Suaeda maritima* (shrubby sea-blite) on the shingle area behind. Erosion was evident at the eastern end of this raised section. Otherwise, the marsh within this area appears stable.

The area of accretion shown on the aerials, based on ground truthing and the pattern of vegetation growth on the aerial photographs, is likely to be common cord grass marsh.

Management Unit 47

Only partial aerial coverage was available in any baseline year for Unit 47. Therefore no assessment of change could be made.

Natural England condition assessment summary, 2010: Unit 47 includes the saltmarsh around Osea Island. Field observation indicates that common cord grass marsh (*Spartina anglica*) recorded by Posford Haskoning (2003) on the north side of Osea Island, east of the causeway, has disappeared. Saltmarsh is eroding eastwards with further erosion of common cord grass, and low transitional marsh on the seaward edge degrading to unvegetated mud mounds. Common cord grass has established within the oyster pits located within this saltmarsh. At the eastern end of the island the sea purslane marsh (*Atriplex portulacoides*) is protected by shingle banks and appears stable.

Cooper et al (2000) identified an area of erosion at the south-eastern tip of the island where sea purslane marsh (described by Posford Haskoning, 2003) extended eastwards marking the seaward limit of the saltmarsh. This strip of marsh has disappeared and the shrubby sea-blite (*Suaeda vera*) marsh is now exposed and is eroding. Cooper et al (2000) indicated that erosion of the marsh on the south side of the island outweighed accretion.

Overall, there appears to have been a net loss of saltmarsh in this unit. The approximate area of this unit c.2000 was 16.4ha.

Management Unit 48*

The main area of saltmarsh in this unit is situated to the north of Heybridge Basin (Map 21). There is both gain and loss in this unit which is partly attributable to the misalignment of the 2000 aerial photographs. In 2008 considerable growth of common cord grass was evident in the area, which has resulted in a net gain of 0.11ha.

Management Unit 49*

The majority of saltmarsh in this unit lies to the north of Heybridge Creek (Maldon) where saltmarsh is stable and accreting (Map 21). The accreting marsh shows the growth pattern characteristic of common cord grass. Other saltmarsh in this unit comprises overspill from unit 50 where fringing areas show both accretion and erosion. A total of 2.95ha was recorded in 2008 after deducting a net loss of 0.07ha over the study period.

Management Unit 50*

The saltmarsh in this unit lies north of the main channel in the upper Blackwater and south of Heybridge Creek (Map 21). The majority of this saltmarsh is stable but erosion is evident on the saltmarsh edges where large creeks and channels cut into the saltmarsh.. Accretion has, however, occurred in the north, adjacent to the flood bank, and at the southern end of the marsh, leading to a net gain of 0.35ha over the study period.

Ground truthing: Natural England's condition assessment of 2009 supports the aerial photograph interpretation. The assessment reported that the marsh immediately south of Heybridge Creek supports a wide zone of upper marsh to grassland transitional vegetation. South of this there are extensive areas of sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*). There is a small network of narrow creeks within this expansive area. At the southern end, the marsh divides in two and there is erosion at the margins. On the section along the sea wall here, sea purslane marsh is being succeeded by common cord grass (*Spartina anglica*).

Since 2001, Essex and Suffolk Water has commissioned annual dredging in Maldon Port and reused the material to recreate saltmarsh within Unit 50 (Walker, 2008). The dredging was undertaken as a good will gesture in the event that water abstraction might increase siltation in the port area. The saltmarsh strip adjacent to the channel has been annually recharged at the southern end with silts obtained from the upper estuary. This has established stable saltmarsh on former mud flats both on the channel margins and the inside edge of this marsh. Small areas of accretion are noted on the aerial map in the recharge area located east of The Hythe. Essex and Suffolk Water estimated that the new regenerated saltmarsh might constitute an area of c.1ha.

Management Unit 51*

The majority of the saltmarsh in this unit is situated south-east of the Maldon Promenade, on the south bank of the estuary (Map 22). The assessment of the gains and losses in this unit is skewed by the misalignment of the aerial photographs and the resulting shift in the digitised saltmarsh. However, net change in saltmarsh has been recorded as a very slight loss of 0.02ha over the eight-year study period.

Management Unit 52*

Unit 52 contains 5.19ha of stable saltmarsh and is located to the east of the Battle of Maldon site, west of Northey Island (Map 23). There are areas of gain and loss both on the outer edges of the saltmarsh and within the creek system, resulting in a net gain of 0.21ha and a total area of 6.25ha in 2008.

Natural England comments: The saltmarsh gain in this unit is almost entirely attributable to silt recharge in this area (Map 23). Since 1989, silts derived from boatyard maintenance dredging have been recycled at this site under licence. Dredgings are transported to the site by barge and placed using a hydraulic grab. The silts consolidate between loads until a height capable of supporting saltmarsh growth is reached.

Management Unit 53*

Unit 53 lies to the south of the Northey Island causeway (Map 23) and contains a 620m stretch of fragmented saltmarsh. In 2000, the area was mapped at 6.37ha with a net loss of 0.54ha by 2008 to 5.84ha. This equates to an average rate of loss of 0.07ha/yr. These small islands of unstable marsh will probably experience further losses as the marsh mounds become smaller and more easily eroded.

Management Unit 54*

Unit 54 covers Northey Island and contains one of the largest areas of saltmarsh within the Blackwater Estuary SSSI. 70.53ha was mapped in 2000, but only 67.94ha of saltmarsh was mapped in 2008, resulting in a net loss of 2.59ha (Map 24). Although large areas of saltmarsh have remained stable (62.66ha), losses were observed along the seaward marsh edges, particularly around the fragmented marsh islands, and internal disintegration of saltmarsh and creek widening is evident within more stable areas, representing a total loss of 7.87ha. Some areas of saltmarsh have shown natural accretion along the seaward edge and the narrowing of former creek systems, particularly to the south and east of Northey Island. Please note, the 2008 aerial photographs were of poor quality and could therefore account for some of the mapped changes. Over eight years the rate of loss has averaged 0.32ha/yr.

Natural England comment: the Northey Island managed realignment site constitutes an area of 0.8ha and is located south of the grassland on the western side of the island. Since the sea wall was lowered in 1991 and a small breach excavated, it has developed stable saltmarsh.

Management Unit 55*

The saltmarsh in this unit lies east of Limbourne Creek, downriver of the Northey Island causeway (Map 23). The saltmarsh is penetrated by large channels but is generally stable. Change has been misrepresented by the poor alignment of the aerial photographs. The total area of saltmarsh was recorded as 6.7ha in 2008 - a net reduction of 0.06ha over the study period.

Ground truthing: Natural England visited the unit in 2009 to monitor the condition of the saltmarsh. The field notes record that the saltmarsh at the eastern end of the unit (on the east side of the channel that divides the two sections) was more stable and supported abundant sea purslane (*Atriplex portulacoides*). Saltmarsh erosion was observed west of Limbourne Creek and there was erosion of the marsh edges along the main channel. Erosion within the marsh appears to be travelling eastwards through the creeks and channels adjacent to the sea wall. The distribution of common cord grass (*Spartina anglica*) reflected this erosive trend; it has a c.40% cover at the Limbourne Creek end and an

occasional to frequent distribution towards Mundon Wash. The upper saltmarsh was confined to the base of the sea wall with the transition zone on the low grassy sea wall.

Management Unit 56*

The saltmarsh in Unit 56 lies along the south bank of Southey Creek, immediately east of Mundon Wash (Map 25). The marsh is largely stable with a net loss of only 0.03ha recorded over the study period, mostly associated with the seaward edge. The difference between the comparative years has, however, been misrepresented on the maps by the misalignment of aerial photographs.

Natural England comment: Observation of the aerials suggests that the saltmarsh edge is chiefly represented by a zone of common cord grass ranging from between c.11 metres and 30 metres wide.

Management Unit 57*

The saltmarsh at Cooper's Creek, west of Mundon Stone Point, is characterised by two large channels (Map 25). The boundaries of the saltmarsh are poorly defined in the 2000 aerial photographs, particularly on the landward edge where there is a transition to grass and scrub habitat. In 2008 a total of 38.32ha was recorded, showing an overall net gain of 0.49ha over the study period.

Natural England comment: The saltmarsh on the main channel edge at the west end of this unit is represented by a zone of common cord grass marsh (*Spartina anglica*) of between c.19 and 40 metres in width. This pioneer saltmarsh species is also the dominant community on the outer saltmarsh fringing the farmland on the east side of the unit. This saltmarsh type is evident from the aerial photographs and has been present at this location for at least five years – it was described by the Posford Haskoning (2003) national vegetation classification survey.

Management Unit 58*

The saltmarsh in Unit 58 runs along the west bank of Lawling Creek, which narrows to Mundon Creek in the upper reaches (Map 26). There are a few areas of saltmarsh gain where channels have infilled, as well as slight accretion on the outer edge of the main saltmarsh body. A total of 50.91ha was recorded in 2008, representing a net gain of 0.12ha since 2000.

Natural England comment: The main channel edge leading to Mundon Stone Point is fringed by a zone of common cord grass marsh (*Spartina anglica*). As Posford Haskoning's national vegetation classification survey mapped this saltmarsh type in 2003 and this zone of saltmarsh was showing in the 2008 aerial photographs, we know this to have been present for at least five years.

Management Unit 59*

The saltmarsh in this unit lies in two distinct zones. One section is situated at the head of Mundon Creek, adjacent to the west end of the Esplanade, Maylandsea. The other section is sited to the east of this, north-east of the Blackwater Marina (Map 26). The gains and losses recorded for this unit in 2000 show the characteristic shifts created by the

misalignment of the aerials. However, the net loss of 0.06ha can be taken as an accurate representation of net change.

Management Unit 60*

Unit 60 covers an area of saltmarsh to the west of Mayland Creek, Maylandsea (Map 27). 33.36ha of saltmarsh was mapped in 2000 showing a net gain of marsh of 0.78ha, by 2008, to 34.14ha. Large areas of saltmarsh have remained stable (32.20ha) with only slight erosion mapped at the northern extent of the saltmarsh expanse. Some accretion of the internal creek channels could account for the overall net gain in this unit. The rate of change within this unit amounts to an average gain of 0.1ha/yr over the eight years.

Management Unit 61

This unit runs down the channel of Mayland Creek, south of Steeple Bay caravan park (Map 27). The saltmarsh on either side of the channel is incorporated into the adjacent management units, 60 and 63. The majority of saltmarsh in this unit is therefore accreted saltmarsh on the margins of the other units. The unit shows a net gain of 0.14ha over the study period, totalling 1.11ha in 2008.

Management Unit 62

The saltmarsh in this unit is situated at the head of Mayland Creek (Map 27). Of the 1.80ha recorded in 1997, 0.27ha was lost, 0.55ha was gained, and 1.53ha remained stable over the eleven-year study period, resulting in an overall net gain of 0.03ha. On the channel edge of the marsh, accretion has occurred mostly on the west bank with erosion on the east bank. Both loss and gain was evident to the landward side of the marsh suggesting a shift in the transition between saltmarsh and grass/shrub.

Management Unit 63

The saltmarsh in this unit runs along the east bank of Mayland Creek (Map 27). The saltmarsh has remained relatively stable with small areas of erosion (totalling 0.32ha) evident on the channel edge counteracted by larger areas of accretion (totalling 0.54ha) recorded on the landward edge. Areas of landward 'accretion' could possibly be attributable to a reduction in shrub/grass cover along the landward edge of the marsh. The saltmarsh totalled 5.59ha in 2008, showing a net gain of 0.22ha over the study period (1997–2008).

Management Unit 64

Saltmarsh in this unit is located at the mouth of Mayland creek, on the east bank where it joins the larger Lawling Creek (Map 28). Erosion is evident on the outer, more exposed parts of the saltmarsh but accretion has occurred at the landward edge and within the creeks. Over the study period a net loss of 0.03ha was recorded resulting in a total area of 0.68ha in 2008.

Management Unit 65

Despite the large size of unit 65, the saltmarsh accounts for a small area located in a recessed section of Steeple Marsh (Unit 67) (Map 28). In 2008 saltmarsh in this unit totalled 0.82ha, having experienced a net gain of 0.14ha since 1997.

Management Unit 67

Unit 67 covers Steeple Creek and is an area which has shown accretion over the eleven - year time span (Map 28). The saltmarsh extent was mapped at 9.79ha in 1997 increasing to 10.12ha by 2008. The most notable area of erosion has been mapped at the north-western edge of the marsh where the marsh has experienced fragmentation resulting in small islands of unstable marsh. However the accretion/infilling of some of the internal creek channels will account for the overall net gain in this unit of 0.34ha over the eleven years, averaging a gain of 0.03ha per year.

Ground truthing: A condition assessment was carried out by Natural England in 2010 which verifies the findings in the aerial photograph. The saltmarsh in this unit has traditionally been sheep grazed and shows a varied structure supporting a good diversity of species and plant communities, with annual *Salicornia* sp (glasswort) growing where poaching has occurred, and around creek margins. The eastern half of the marsh appeared to have lower grazing pressure than the western half. The field survey noted a zone of common cord grass (*Spartina anglica*) in the south-west corner of the saltmarsh and this may account for an area of accretion shown in the aerial interpretation.

Management Unit 68

Map 28 shows the saltmarsh extent in Unit 68 which extends along the eastern bank of Steeple Creek. Mapping of this unit has shown a net loss of saltmarsh of 0.05ha between 1997 (1.76ha) and 2008 (1.70ha).

Management Unit 69

Unit 69 covers an area of intertidal from Stansgate Abbey Farm to the west of Ramsey Marsh (Map 28). Only a small area of saltmarsh was mapped within this unit which remained stable over the eleven years, with the extent mapped at 0.03ha in both 1997 and 2008. Slight erosion on the western seaward marsh edge was balanced by accretion to the east.

Management Unit 70

Saltmarsh exists in a very narrow strip between Ramsey Marsh and Ramsey Island within Unit 70 (Map 29). Of the 0.27ha of saltmarsh present in 1997, a total of 0.04ha was lost to erosion, but 0.10ha was gained elsewhere through natural accretion resulting in a net gain of 0.05ha by 2008. Accretion was mapped in the saltmarsh area at Ramsey Marsh and also to the marsh area west of St Lawrence. Some erosion was mapped along the seaward marsh frontage in the middle of his unit.

Management Unit 71

Unit 71 covers an area of intertidal at the front of Ramsey Marsh (Map 29). Only a small area of saltmarsh was mapped within this unit which remained stable over the eleven years, with the extent mapped at 0.08ha in both 1997 and 2008. Slight erosion to the west of the marsh frontage was balanced by accretion to the east.

Management Unit 74

Two areas of saltmarsh exist in Unit 74: the smaller area just west of St Lawrence Stone, and the larger area north of Beacon Hill Leisure Park in St Lawrence Bay (Map 29). Of the 3.71ha of saltmarsh present in 1997, a total of 0.24ha was lost to erosion, but 0.14ha was gained elsewhere through natural accretion, resulting in a net loss of only 0.10ha by 2008. This resulted in the extent in 2008 being mapped at 3.61ha, averaging a rate of loss of only 0.01ha/yr over the eleven years. The smaller area of saltmarsh, west of The Stone, experienced some accretion of the marsh frontage, whilst the larger area in St Lawrence Bay experienced erosion along the majority of the seaward marsh frontage. However, an area of accretion was mapped to the west of this larger extent with some gains also mapped along the landward transition zone.

Management Unit 75

The saltmarsh within Unit 75 lies to the south of St Lawrence Creek (see Map 30). The extent was mapped at 12.34ha in 1997 with only a minimal decrease in extent by 2008 to 12.29ha (a net loss of 0.05ha). Although the majority of the saltmarsh remained stable at 11.64ha throughout the mapping period, with little change to the internal saltmarsh structure, losses of 0.70ha occurred on the outer marsh edge along the full extent of the marsh. This was balanced by 0.65ha of accretion particularly to the west of the site.

Management Unit 76

Map 30 shows the extent of saltmarsh at Pewet Island within Bradwell Creek and along the shore outside the Orplands managed realignment site (Unit 88). Of the 10.03ha of saltmarsh present in 1997, a total of 1.20ha was lost to erosion, with only 0.37ha gained through natural accretion resulting in a net loss of 0.83ha by 2008. This resulted in the extent in 2008 being mapped at 9.19ha, averaging a loss of 0.08ha/yr over the eleven years. Erosion was mapped around the whole seaward marsh edge of Pewet Island and on the edge of the saltmarsh extending along the foreshore outside the Orplands site. No changes occurred within the internal bodies of saltmarsh, with 8.82ha remaining stable over the mapping period. Small areas of accretion were noted on the landward edge of the marsh body to the south-west of the unit (see Map 30).

Ground truthing: Natural England undertook a field visit along this section in 2009 and the assessment reflects the findings of the aerial survey. Pewet Island was viewed from the mainland at Bradwell Waterside and erosion of the saltmarsh was noted along the Bradwell Creek edge – cliffing was evident and a section, about 1metre wide, had broken away. Saltmarsh scrub was present on the higher areas of the island.

Sand and gravel material from the Harwich Approaches dredge was discharged at the western point of Pewet Island in 1998 and may have helped to arrest erosion here.

Management Unit 77

This saltmarsh is situated north-east of Bradwell Marina, between Bradwell Waterside and Pewet Island (Map 30). The marsh here is predominantly stable with a small area of erosion to the north. A slight net loss of 0.03ha was recorded over the study area, leaving a total area of 2.00ha in 2008.

Ground truthing: Natural England assessed this unit in 2009. The saltmarsh is generally a low to mid-level marsh which is dominated by sea purslane (*Atriplex portulcooides*) with saltmarsh grass (*Puccinellia maritima*) and sea aster (*Aster tripolium*). The marsh to the north-east of the Bradwell Waterside slipway has a more stable internal structure than the marsh on the west side. However, as indicated by the aerial interpretation, the saltmarsh has eroded badly at the eastern end, adjacent to an obsolete polder – one of several that follow the coastline round to the east – and unvegetated mud platforms are features of the foreshore here. This erosive influence appears to be travelling south-westwards. The polders were constructed by the Environment Agency in the late 1980s/early 1990s to try and encourage sediment deposition in eroding areas. The saltmarsh on the west side of the slipway is degenerating and the pioneer zone is dominated by common cord grass (*Spartina anglica*).

Management Unit 88 – Orplands Realignment Site – eastern section

The Orplands realignment site consists of two discrete areas both of which were breached in 1995. The eastern section lies within the Blackwater estuary SSSI and comprises Unit 88 (Map 30). The western section has been analysed and discussed separately. In 1997 an area of only 0.49ha of saltmarsh was mapped. However in the following eleven years saltmarsh had colonised the site increasing the extent, in 2008, to 11.66ha. This net gain of 11.17ha of saltmarsh averages 1.02ha/yr.

Orplands Realignment Site – western section outside the SSSI (Orplands West)

The western section of the Orplands realignment site does not lie within the Blackwater SSSI but has been considered here because, although separate from the eastern realignment, it is contiguous with it (Map 30). This section was also breached in 1995. Although some early pioneer saltmarsh colonisation was present in 1997 (Plate 1), saltmarsh had not developed sufficiently to allow mapping in the baseline year. By 2008 the saltmarsh had colonised and an area of 10.77ha was recorded.



Plate 1: Orplands Realignment Site (West), 1997.

Summary

Table 2 Summary statistics for the Blackwater Estuary SSSI management units & Orplands West

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 2000 (ha)	Total Saltmarsh area in 2008 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
1	1.06		0.94	-0.12	0.14	0.02	0.92	-0.01
2	6.19		5.62	-0.57	0.65	0.08	5.54	-0.05
3	19.43		18.54	-0.89	1.15	0.26	18.28	-0.08
4		65.96	64.51	-1.45	1.97	0.52	63.99	-0.18
6		7.93	7.62	-0.31	0.55	0.24	7.38	-0.04
7		12.24	12.07	-0.17	0.44	0.27	11.80	-0.02
8		20.75	20.19	-0.56	0.72	0.16	20.04	-0.07
9		11.61	12.32	0.71	0.45	1.15	11.16	0.09
10		41.24	41.87	0.63	1.81	2.45	39.42	0.08
11		1.83	1.80	-0.03	0.05	0.02	1.78	0.00
12		31.35	30.81	-0.54	1.01	0.47	30.34	-0.07
13	7.41		5.99	-1.41	1.44	0.03	5.96	-0.13
18		79.73	77.78	-1.95	4.56	2.61	75.17	-0.24
19	49.85		50.86	1.01	0.68	1.68	49.17	0.09
20	20.80		20.63	-0.17	2.28	2.11	18.52	-0.02
25	7.26		6.99	-0.27	0.62	0.32	6.66	-0.02
26	0.55		0.61	0.05	0.14	0.22	0.39	0.00
27	9.05		8.13	-0.92	1.28	0.36	7.77	-0.08
29	4.20		3.70	-0.50	0.60	0.10	3.60	-0.05
30	0.02		0.07	0.05	0.01	0.06	0.01	0.00
31	2.16		1.90	-0.26	0.32	0.06	1.84	-0.02
32	1.65		1.19	-0.46	0.53	0.07	1.12	-0.04
33	3.42		3.90	0.48	0.60	0.88	2.82	0.04
36		1.21	1.21	0.00	0.25	0.25	0.97	0.00
37		1.77	1.55	-0.22	0.58	0.36	1.19	-0.03
39		1.39	1.10	-0.29	0.61	0.32	0.78	-0.04
40		8.00	7.23	-0.77	2.13	1.35	5.88	-0.10
43		0.14	0.10	-0.04	0.05	0.01	0.09	0.00
44		0.02	0.03	0.00	0.01	0.02	0.01	0.00
45		0.45	0.47	0.02	0.06	0.08	0.39	0.00
47	Could not be assessed due to insufficient aerial coverage							
48		1.41	1.52	0.11	0.32	0.43	1.09	0.01
49		3.02	2.95	-0.07	0.79	0.72	2.23	-0.01
50		14.93	15.28	0.35	0.68	1.03	14.25	0.04
51		2.26	2.24	-0.02	0.61	0.59	1.65	0.00
52		6.03	6.25	0.21	0.85	1.06	5.19	0.03
53		6.37	5.84	-0.54	1.57	1.04	4.80	-0.07
54		70.53	67.94	-2.59	7.87	5.28	62.66	-0.32
55		6.77	6.70	-0.06	0.78	0.72	5.99	-0.01
56		10.28	10.24	-0.03	0.69	0.66	9.59	0.00
57		37.83	38.32	0.49	1.23	1.72	36.60	0.06
58		50.79	50.91	0.12	2.51	2.63	48.28	0.02
59		11.68	11.62	-0.06	0.57	0.51	11.11	-0.01
60		33.36	34.14	0.78	1.16	1.95	32.20	0.10
61	0.97		1.11	0.14	0.39	0.54	0.57	0.01
62	1.80		2.08	0.28	0.27	0.55	1.53	0.03
63	5.38		5.59	0.22	0.32	0.54	5.05	0.02
64	0.71		0.68	-0.03	0.09	0.07	0.61	0.00
65	0.68		0.82	0.14	0.11	0.25	0.57	0.01
67	9.79		10.12	0.34	0.74	1.08	9.04	0.03
68	1.76		1.70	-0.05	0.16	0.30	1.60	0.00
69	0.03		0.03	0.00	0.01	0.00	0.03	0.00
70	0.27		0.32	0.05	0.04	0.10	0.22	0.00
71	0.08		0.08	0.00	0.01	0.01	0.07	0.00
74	3.71		3.61	-0.10	0.24	0.14	3.47	-0.01
75	12.34		12.29	-0.05	0.70	0.65	11.64	0.00
76	10.03		9.19	-0.83	1.20	0.37	8.82	-0.08
77	2.04		2.00	-0.03	0.11	0.07	1.93	0.00
80	No saltmarsh found in this unit							

3.3 Colne Estuary SSSI

The Colne Estuary is a narrow classical funnel-shaped estuary approximately 12km long with a total area of 2,335ha. It is a comparatively short and branching estuary, with five tidal arms that flow into the main channel of the River Colne (JNCC, 2001b). It extends southwards from Colchester to join the mouth of the River Blackwater at Brightlingsea Reach. The intertidal area covers 2,002ha comprising 700ha of mudflats and 300ha of saltmarsh. Currently, the largest extent of saltmarsh in the Colne Estuary lies within the Fingringhoe, Brightlingsea, Mersea triangle. Many of the individual saltmarsh areas are extensive and largely undisturbed, such as the saltings at Geedon and Fingringhoe, and the Essex Wildlife Trust reserve at Colne Point.

Large areas of intertidal have been lost in the Colne estuary to land claim, notably along the west side between 1800 and 1840, however a relatively large area of saltmarsh still remains (van der Wal & Pye, 2004). Maps show that there has been little change in saltmarsh area since 1840, although several marsh areas have undergone internal dissection with creek widening (Carpenter & Pye, 1996). In 1973, the Colne estuary supported 791.5ha of saltmarsh, which represented a good transition between pioneer species to upper more stable communities (ITE, 1974). Between 1973 and 1988, the Colne Estuary lost only 11.7% of saltmarsh habitat. Although, this included 53% of the pioneer zone, the original area of this zone was only 12ha. With the low-mid and mid-marsh zones occupying the largest area in the 1973 survey, these areas experienced the highest losses of 13% and 8% respectively. By 1988 (Burd, 1992) reported the highest loss of saltmarsh habitat at Colne Point due to the expansion of creek systems within the marsh.

The following assessments have been made for each management unit, referenced to the maps in Volume 2 - MAPS. Map 31 shows the location of the SSSI units within the Colne Estuary SSSI. The results gained from digitising and comparing the extent of saltmarsh in the baseline year of 1997 and the chosen comparative year of 2008 are provided. Table 3 shows the overall calculations for the SSSI, breaking down the total extents, gains and losses, and net change and average rate of change within each unit.

Management Unit 1

Management Unit 1 covers an extensive area, although saltmarsh occurs only in the section around Mersea Stone (Map 32). Of the 8.97ha of saltmarsh present in 1997, a total of 1.79ha was lost to erosion, with 0.37ha gained through natural accretion, resulting in a net loss of 1.42ha by 2008. 7.18ha remained stable throughout this period. Extensive erosion occurred along the fronting marsh between the Cudmore Grove Country Park and Mersea Stone; erosion along the seaward marsh edge to the north of Ivy House is also evident. Although the internal creek systems remained relatively stable, a large internal area of saltmarsh west of the sluice at Mersea Stone had eroded by 2008 creating a large mud pan area measuring 0.17ha*.

Ground truthing: *The large mud pan referred to west of Mersea Stone has been indicated as a loss in the aerial survey, however Natural England can confirm that the existence of the mud pan pre-dates the 1997 aerial and has not been 'lost' during the study period.

The saltmarsh between Cudmore Grove Country Park and Mersea Stone lies north-east of a groyne which was constructed in 1998. It is possible that the groyne could be having a direct impact on the saltmarsh along this frontage. Alternatively the disappearance of saltmarsh could be due to roll over of sands and gravels onto the marsh.

Management Unit 3

Unit 3 covers an area of saltmarsh at East Mersea, located south of Fen Farm caravan site and west of Cudmore Grove Country Park (Map 33). Of the 1.38ha of saltmarsh present in 1997, a total of 0.28ha was lost to erosion, with 0.08ha gained through natural accretion resulting in a net loss of 0.20ha by 2008. 1.11ha remained stable throughout this period. Erosion and accretion was mapped along the seaward edge of the main marsh extent, however the main losses occurred on the saltmarsh islands on the lower shore.

Management Unit 5

Unit 5 stretches along the south bank of Pyefleet Channel between Maydays Marsh in the west and Mersea Stone in the east. Saltmarsh occurs as a fringing marsh along most of its length (Map 32). The majority of the marsh has remained relatively stable (7.80ha) but losses have been experienced along the seaward marsh edge. In 1997 the saltmarsh was mapped at 8.63ha, reducing to 8.26ha in 2008. This has led to an overall net loss of 0.37ha over the eleven years averaging 0.03ha/yr.

Management Units 6 and 7

The saltmarsh in these units forms wide bands on either side of the upper Pyefleet channel (Map 34). The saltmarsh is characterised by a complex system of creeks and mudpans with a number of wide channels which have undergone a small degree of widening over the study period. In addition, a small area of saltmarsh has been replaced through natural succession to grass and shrub, particularly to the south of Unit 6, north of Barrow Hill. Small strips of saltmarsh have been lost from the channel edges in both units, contributing to an overall net loss in the two units. Unit 6 has suffered a net loss of 0.68ha, leaving a total area of 66.49ha in 2008. Unit 7 showed a net loss of 0.49, leaving a total area of 75.34ha in 2008.

Management Unit 9

The saltmarsh in this unit forms a narrow zone along the north bank of the Pyefleet Channel, and includes Pewit Island and the saltmarsh around Langenhoe Point (Map 35). The majority of saltmarsh in this unit has remained stable throughout the study period (2000 to 2008) with small amounts of erosion recorded on the channel edges, resulting in a net loss of 0.06ha.

Management Unit 14

The saltmarsh in this unit is represented by Fingringhoe Marsh and the Geedon Saltings and includes a thin strip which runs along the south bank of the South Geedon Creek (Map 36). Creeks and channels diverge throughout Fingringoe Marsh and the Geedon Saltings leading to numerous small mud pans. The general structure of the marsh has remained stable throughout the study area although, overall, a net loss of 0.99ha was recorded resulting in a 209.86ha extent in 2008.

Ground truthing: Natural England report that the saltmarsh fringing the South Geedon Creek, towards Langenhoe Point, is badly eroded. The tides are cutting along the marsh interface with the toe of the sea wall. In the early 2000s, the Ministry of Defence placed small boulders on the foreshore in an effort to protect the seaward face of sections of saltmarsh in this area but this has not been successful in arresting erosion.

Management Unit 16

Unit 16 runs alongside the Geedon Saltings and encompasses Rat Island and an area of saltmarsh (c.5ha) east of Fingringhoe Wick (Map 36). The seaward boundaries of the saltmarsh are difficult to define from the 2000 photos but it is possible that these have eroded. The saltmarsh of Rat Island has a stable drainage structure comprising narrow creeks. An overall net loss of 0.72ha was recorded for the unit leaving a total area of 19.45ha in 2008.

Management Unit 17

This unit could not be assessed as digital aerial photographic coverage was not available in any year between 1994 and 2000. However this unit has been surveyed by Natural England and their comments are given below.

Natural England condition assessment: A condition assessment was carried out by NE in 2010. The unit is located on the west bank of the upper Colne between the Essex Wildlife Trust Fingringhoe reserve and Frog Hall Marsh sluice, south of Ballast Quay. In order to assess changes in saltmarsh type and distribution, this survey was compared with the results of earlier surveys ie. Cooper et al (2000) and Posford Haskoning (2003).

The 2010 survey noted lowering of the marsh towards the seaward edge indicated by a change in vegetation type from the higher marsh vegetation recorded by Posford Haskoning (2003) to low, transitional marsh. The outfall at Frog Hall Marsh (TM 049207), south of Ballast Quay appears to have caused considerable scour around the sluice gut. This impact may have extended south and contributed to erosion of the marsh edge where mud mounds are evident. *Spartina anglica* (common cord grass) is the dominant vegetation type in this northern section and there are zones of this marsh type along the seaward edge to the south, some of which has separated from the body of the marsh. Comparison of cord grass distribution with the Posford Haskoning (2003) survey indicates it has been present at the same location for at least seven years, and is likely to be encroaching into the natural marsh vegetation at the northern end of the unit. It is noted that in two places, areas of accretion recorded by the Cooper et al (2000) survey are dominated by common cord grass, notably around the Frog Hall Marsh outfall, suggesting secondary succession at this location. Historical soil winning adjacent to the sea wall appears to have affected hydrology.

Though there are changes in the saltmarsh communities in this unit, indicating a lowering of the marsh height, and an erosive trend, overall there did not appear to be any significant change in extent when compared with the earlier surveys mentioned here. The approximate area of this unit in c.2000 was 5.10ha.

Management Unit 18

The saltmarsh in this unit is situated on the east bank of the River Colne, west of Arlesford, and covers two discrete areas (Map 37). The area to the north has very few creeks but has four distinct channels leading into the marsh. This area remained unchanged over the study period. The saltmarsh to the south of the unit is more fragmented in nature, yet generally stable. Overall the unit has experienced a net loss of 0.06ha, leaving a total area of 5.01ha in 2008.

Management Units 20 & 21

These units run along the banks of Alresford Creek (Map 37). There are small areas of gain and loss on the fringes of the saltmarsh showing no obvious trend. There is a significant area of change at the eastern end of Unit 21 where saltmarsh has been replaced in the upper reaches of the creek by either reedbed or grassland resulting in a net loss of 0.12ha for the unit. Unit 20 experienced a net gain of 0.1ha over the study period resulting in a total area of 7.11ha.

Ground truthing: A field visit carried out by Natural England in 2009 noted that the vegetation at the head of Alresford Creek is significantly influenced by freshwater flows from Tenpenny Brook and the Mill Dam at Thorrington Mill, and includes reed bed and upper saltmarsh transitional vegetation. Tree canopy cover on the marsh edge may also be overshadowing the marsh.

Management Unit 23

The saltmarsh in this unit forms two distinct sections on the east bank of the River Colne, between Brightlingsea and Arlesford, and covered an area of 30.42ha in 2008 (Map 38). The majority of the saltmarsh present in 2000 remained stable throughout the study period but the unit as a whole has experienced a loss of 0.92ha, mainly to the saltmarsh fringing the river. Another area of change has occurred to the north of the unit where shrubby vegetation is colonising a raised area supporting transitional grassland.

Ground truthing: Natural England carried out a condition assessment of Unit 23 in 2010 and concluded that there is an erosive trend within these saltmarshes but that there had not been a significant decline in extent. The inner half of the Arlesford marsh retains an embankment which has breached in places, with a wide channel having formed at the northern end leading into the mouth of Arlesford Creek. This exposed area is characterised by cliffing creek edges. The embankment supports shrubby sea-blite (*Suaeda maritima*) and sea couch grass (*Elytrigia atherica*) and protects the saltmarsh to the east. This section of marsh is less dissected by creeks than the marsh lying outside the retaining wall, particularly when compared with the exposed north-western edge. The survey considered that 85 per cent of this marsh was predominantly stable supporting sea purslane marsh (*Atriplex portulacoides*). Erosion of the seaward edge was evident and the southern tip of the marsh was eroded to bare mud or supporting pioneer and low marsh species.

The Brightlingsea section of marsh was also fairly stable with vegetated shingle areas on the seaward edge in places. The dominant marsh type was sea purslane (*Atriplex portulacoides*) with saltmarsh grass (*Puccinellia maritima*). The marsh at the northern end of this section was fragmented and was being covered on a rising spring tide.

Management Unit 27

Unit 27 is located on the north bank of Brightlingsea Creek and covers the area of marsh incorporating the disused oyster pits (Map 39). Of the 26.15ha of saltmarsh present in 1997, 25.50ha remained stable throughout the eleven years. A total of 0.66ha was lost to erosion, with 0.84ha gained through natural accretion resulting in an overall net gain of 0.18ha by 2008 (averaging a rate of gain of 0.02ha/yr). Erosional losses were observed along the seaward edges, particularly associated with the widening of some creeks. Gains were mapped within the internal body of the marsh and along the landward transition zone.

Management Unit 28

Unit 28 stretches along the west bank of Flag Creek incorporating the saltmarsh within Eastmarsh Point (Map 39). Of the 17.40ha of saltmarsh present in 1997, 0.56ha of loss and 0.51ha of gain was mapped throughout the unit. The gains were mapped from Eastmarsh Point further north, where accretion was the dominant trend on the seaward marsh edge. The main internal structure of the marsh remained stable throughout the ten-year period at 16.84ha, but the section of marsh between Brightlingsea Creek and Eastmarsh Point showed the greatest losses. Here the creek systems along the seaward edge have increased in width with some further disintegration of the marsh observed due to the widening of creeks in the upper marsh. In 2008 the saltmarsh extent was mapped at 17.4ha, representing a net loss of 0.06ha throughout the unit and an average rate of loss of 0.01ha/yr.

Management Unit 29

Map 39 shows the saltmarsh extent in Unit 29 at the head of Flag Creek. Of the 4.55ha of saltmarsh present in 1997, 4.24ha remained stable throughout the eleven years, but a total of 0.32ha was lost to erosion, with 0.75ha gained through natural accretion. This resulted in an overall net gain of 0.43ha by 2008 to 4.98ha (averaging a gain of 0.04ha/yr). Although saltmarsh was eroded along the seaward edge, gains were observed along the landward boundary and in the tributary creek adjacent to Hollybush Hill.

Management Unit 30

Map 39 shows the saltmarsh extent in Unit 30 which stretches along the entire east bank of Flag Creek, Brightlingsea Creek, and south into St Osyth Creek. The saltmarsh within this unit occurs in discrete areas within Flag and Brightlingsea Creeks, with a more substantial area on the south bank of St Osyth Creek. Of the 13.04ha of saltmarsh present in 1997, 12.22ha remained stable throughout the survey period, with a total of 0.83ha lost to erosion, but with 1.09ha gained through natural accretion. This resulted in an overall net gain of 0.26ha by 2008 to 13.31ha (averaging a gain of 0.02ha/yr). Although the majority of the saltmarsh remained stable, some changes were observed in the creek widths, particularly south of the Hollybush Hill holiday centre and in the marsh within Brightlingsea Creek. The most stable extent of saltmarsh was mapped within St Osyth Creek which had experienced very few changes to the internal structure of the marsh. Erosion and accretion were mapped along the seaward edge, with saltmarsh gains along the landward transition zone and on the north bank of the creek west of Mill Dam Lake.

Management Unit 33

Unit 33 covers a stretch of marsh which extends along the south bank of Flag Creek and fringes the north bank of St Osyth Creek (Map 40). The saltmarsh extent was mapped at 6.74ha in 1997, decreasing to 6.55ha in 2008 (a net loss of 0.19ha). Losses were observed along the seaward marsh edge towards the mouth of the Creek, with accretion of the marsh edge towards the head of the creek.

Ground truthing: During a field visit by Natural England, carried out in 2010, it was observed that the internal structure of the marsh, at the mouth of St Osyth Creek, was fairly

stable and supported mid-level marsh of sea purslane (*Atriplex portulacoides*) with common sea lavender (*Limonium vulgare*).

Management Unit 35

Cindery Island and the island east of The Folly are two mid-channel islands within Brightlingsea Creek covered by Unit 35 (Map 40). The extent was mapped in 1997 at 17.06ha but, by 2008, a net loss of 0.41ha had occurred, reducing the extent to 16.65ha. Of the 1997 total, 16.46ha remained stable, 0.60ha was lost to erosion and only 0.19ha was gained through accretion. Erosion was observed along the northern and south-eastern seaward edges of Cindery Island, with accretion elsewhere. Losses outweighed accretion along the entire seaward edge of the island to the east of The Folly, with widened creeks along the south-eastern edge.

Management Unit 36

Map 40 shows the saltmarsh extent in Unit 36, which stretches along the south bank of Brightlingsea Creek. Of the 20.06ha of saltmarsh present in 1997, total losses and total gains were almost equally balanced at 0.67ha to 0.64ha, resulting in a net loss of only 0.03ha over the study period. Erosion was observed on the seaward marsh edge along the length of this unit, with some gains along the landward boundary. The internal structure of the saltmarsh remained unchanged.

Management Unit 37

Unit 37 contains a small amount of saltmarsh on the east bank of Ray Creek. Map 41 shows the 4.88ha extent of stable saltmarsh mapped between 1997 and 2008, with natural accretion outweighing erosion within the marsh areas. Of the 5.07ha of saltmarsh present in 1997, a total of 0.19ha was lost to erosion, with 0.24ha gained elsewhere within the unit through natural accretion, resulting in a net gain of 0.05ha by 2008.

Management Unit 39

Unit 39 contains the greatest extent of saltmarsh on the Colne Estuary SSSI, mapped at 130.38ha in 1997, which only reduced to 130.09ha in 2008 (a net loss of 0.29). Of the 1997 extent, 129.25ha remained stable throughout the eleven years with 1.12ha lost to erosion and 0.83ha gained. Some losses occurred on the seaward marsh edge south-east of Sandy Point and also at the northern edge of Colne Point Nature Reserve (Map 41). Changes were observed to creek widths within the marsh, however the losses and gains were reasonably balanced resulting in a stable saltmarsh extent.

Management Unit 40

Unit 40 covers a very thin area of lower shore along the banks of Ray Creek (Map 41). Only 0.19ha of saltmarsh was mapped within this unit in 1997, which recorded a net gain of 0.07ha, by 2008, to 0.26ha. Of this 1997 total, 0.17ha remained stable over the eleven years, with 0.02ha lost and 0.09ha gained.

Management Unit 41

Map 41 shows the saltmarsh extent in Unit 41 which stretches from Colne Point to St Oysth Beach. Of the 34.88ha of saltmarsh present in 1997, 33.27ha remained stable throughout the eleven years, but a total of 1.61ha was lost to erosion at the eastern extremity of the unit behind the St Oysth Beach frontage. Only 0.18ha was gained through natural accretion. This unit experienced an overall net loss of 1.42ha resulting in a total area of 33.45ha by 2008. Of the units studied for this estuary, this unit showed the greatest rate of change at a net average loss of 0.13ha/yr.

Additional Notes

Shadows cast towards the landward edge in some of the units made it difficult to discern the saltmarsh boundary. Examples of this included the 1997 aerials for Units 28 and 30. This is discussed further in Appendix 2.

Summary

Table 3 Summary statistics for the Colne Estuary SSSI management units

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 2000 (ha)	Total Saltmarsh area in 2008 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
1*	8.97		7.55	-1.42	1.79	0.37	7.18	-0.13
3	1.38		1.19	-0.20	0.28	0.08	1.11	-0.02
5	8.63		8.26	-0.37	0.83	0.46	7.80	-0.03
6		67.17	66.49	-0.68	0.82	0.14	66.35	-0.08
7		75.84	75.34	-0.49	0.93	0.43	74.91	-0.06
9		13.81	13.76	-0.06	0.38	0.33	13.43	-0.01
14		210.85	209.86	-0.99	2.66	1.67	208.19	-0.12
16		20.17	19.45	-0.72	0.92	0.19	19.26	-0.09
17	Could not be assessed as no baseline coverage in any year							
18		5.07	5.01	-0.06	0.23	0.18	4.83	-0.01
20		7.00	7.11	0.10	0.20	0.31	6.80	0.01
21		12.85	12.73	-0.12	0.21	0.09	12.64	-0.02
23		31.34	30.42	-0.92	1.06	0.14	30.28	-0.11
27	26.15		26.34	0.18	0.66	0.84	25.50	0.02
28	17.40		17.35	-0.06	0.56	0.51	16.84	-0.01
29	4.55		4.98	0.43	0.32	0.75	4.24	0.04
30	13.04		13.31	0.26	0.83	1.09	12.22	0.02
33	6.74		6.55	-0.19	0.37	0.18	6.37	-0.02
35	17.06		16.65	-0.41	0.60	0.19	16.46	-0.04
36	20.06		20.03	-0.03	0.67	0.64	19.39	0.00
37	5.07		5.12	0.05	0.19	0.24	4.88	0.00
39	130.38		130.09	-0.29	1.12	0.83	129.25	-0.03
40	0.19		0.26	0.07	0.02	0.09	0.17	0.01
41	34.88		33.45	-1.42	1.61	0.18	33.27	-0.13

*Natural England ground truthed Unit 1 and report that there has been no change since the baseline year – the mud pan shown as a loss pre-dates the 1997 baseline year.

3.4 Crouch & Roach Estuary SSSI

The Crouch Estuary and its southern tributary, the Roach, form a single estuarine system which is long and narrow, reaching the Essex coast at the northern end of Foulness Island. Land claim, mostly prior to 1774, resulted in the enclosure of a wide belt of marshland by an almost continuous flood embankment. Consequently the estuaries have relatively deep and highly canalised channels, bordered by a narrow intertidal zone, with only a small, fragmented zone of active saltmarsh (van der Wal & Pye, 2004).

Only relatively small areas of saltmarsh have never been embanked within the SSSI, including Woodham Fen, White House Farm, Lion Creek, and the upper section of Paglesham Creek. With the exception of Lion Creek, these sites are notable in that they exhibit a natural transition from saltmarsh to grassland, a rare feature on the Essex coast. Other saltmarshes have formed naturally as a result of unplanned breaches in the sea defences, including Bridgemarsh Island, Brandy Hole and North Fambridge Marsh. These are three important and extensive stretches of saltmarsh which have developed during the course of the 20th century, but a significant proportion of these saltmarshes have also been

lost to natural erosion (English Nature, 2000; Essex County Council, 2005). Saltmarshes in the Roach have a similar distribution to those in the Crouch, fringing both the main subtidal channel and the tidal channels such as Paglesham Creek (Pye & French, 1993).

By comparing historic OS maps, Pethick and Stapleton (1994) identified that relatively little erosion had occurred within the Crouch and Roach complex, primarily due to its limited distribution. With the exception of losses due to reclamation, the only other significant areas of natural loss occurred towards the mouth of the complex, e.g. Holliwell Point, Foulness Point and Wallasea Ness. Maps show little change in marsh area between 1777 and 1873, followed by slow erosion after 1895. The Crouch experienced a net loss of saltmarsh area of 8ha/yr, all lost due to erosion in the period 1978-1988 (Burd, 1992) and a net loss of 4ha/yr in the period 1988-1998 (Cooper et al, 2000).

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Maps 42 & 43 show the location of the SSSI units within the Crouch and Roach Estuaries SSSI. By digitising and comparing the extent of saltmarsh in 2000 and 2007, Table 4 shows the overall calculations for the Crouch and Roach Estuarine systems, breaking down the total extents, gains and losses, and net change and average rate of change within each unit.

It should be noted that many of the units are showing a false gain along the saltmarsh seaward edge and a loss along the landward boundary, however this is an inherent error in the orthorectification of these aerial photographs, leading to a shift in the mapping of between 3 and 6.5m generally from north to south. This does not however affect the total area of saltmarsh calculations within the units, but may give a false impression of total saltmarsh losses and gains.

Management Unit 1

Unit 1 is characterised by a pre-war revetment which runs most of the length of the unit in front of the sea wall on the north bank of the River Crouch, south of Holliwell Farm (Map 44). Between this and the sea wall are areas of relatively stable saltmarsh. Where there is a break in the revetment the saltmarsh behind is showing signs of loss due to shell/sand deposition. There has however been an overall net gain of 2.78ha at an average gain rate of 0.4ha per year between 2000 and 2007.

Management Unit 2

The saltmarsh in Unit 2 extends along the northern bank of the River Crouch, south of Burnham Wick (Map 45). Erosion of the seaward marsh frontage has occurred along the length of the marsh extent, with some gain at the landward boundary. Of the 1.77ha of saltmarsh present in 2000, a total of 0.33ha was lost to erosion, with only 0.20ha gained through natural accretion resulting in a net loss of 0.13ha by 2007.

Management Unit 4

The unit runs along the north bank of the River Crouch westwards of Burnham-on-Crouch. The saltmarsh has colonised predominantly in sheltered inlets (Map 46). Slight erosion here is evident particularly in the north of the unit but this is exaggerated by the misalignment of photographs. The unit overall has experienced a gain of 0.01ha.

Management Unit 5

Unit 5 fringes the north bank of the River Crouch adjacent to the eastern end of Bridgemarsh Island. There are three small areas of saltmarsh in this unit totalling 0.13ha in 2000 and 0.17ha in 2007 (Map 47). The rate of change has been recorded as 0.01ha although this will actually be less if the misalignment of the photographs is taken into account.

Ground truthing: Unit 5 was ground truthed in 2010. A condition assessment recorded that there was no evidence of significant erosion. The saltmarsh is a mosaic of pioneer saltmarsh plants (glasswort - *Salicornia* sp), with saltmarsh grass (*Puccinellia maritima*) and sea purslane (*Atriplex portulacoides*) communities, and sea wormwood (*Artemisia maritima*), an upper saltmarsh species. The rill structure was limited.

Management Unit 7

Unit 7 lies on the northern bank of Althorne Creek and contains three distinct areas of saltmarsh (Map 48). With the displacement of the aerial photographs, it appears as if accretion has occurred on the seaward margin of the marsh with erosion noted at the landward edge and along the marsh to the west of the unit. The internal structure of the saltmarsh has remained stable (2.21ha) but with some gains and losses around the creek edges and oyster beds. Of the 2.76ha of saltmarsh present in 2000, a total of 0.55ha was lost to erosion, but, with 0.67ha gained through natural accretion, a net gain of 0.12ha had resulted by 2007.

Management Unit 8

This unit lies on the north bank of Bridgemarsh Creek opposite Bridgemarsh Island (Map 49). In 2007 5.16ha of saltmarsh was present in the unit, representing a 0.13ha gain since 2000, when the area was 5.03ha. The saltmarsh has a complex system of small creeks which lead to larger internal sunken mud pans where saltmarsh is eroding. The saltmarsh appears to be accreting on the creekward edge while losses have been recorded on the landward edge possibly due to succession from saltmarsh to grass and scrub.

Management Unit 9

Unit 9 extends along the north bank of Bridgemarsh Creek (Map 50). The saltmarsh within this management unit has remained relatively stable over the seven years with its extent calculated at 0.85ha in 2000, decreasing slightly by 0.09ha to 0.76ha in 2007 (-0.01ha/yr). Although Map 50 shows signs of accretion along the seaward edge and accretion along the landward edge of the marsh, this is an artefact of the orthorectification process.

Management Unit 11

Map 51 shows the extent of saltmarsh within Unit 11 along the western bank of Bridgemarsh Creek and along Longpole Reach on the main channel of the River Crouch. The saltmarsh extent in 2000 was mapped at 2.46ha, experiencing a net loss of 0.11ha by 2007. The 6m shift in the aerials photographs between the comparative years makes it difficult to discuss total losses and gains, however the most significant area of erosion was mapped in a block of saltmarsh north of Longpole Reach. This resulted in the extent mapped in 2007 at 2.35ha, averaging a loss of 0.02ha/yr over the seven years.

Management Unit 14

Unit 14 covers a large expanse of saltmarsh southwest of North Fambridge, including the marshes at Fambridge Yacht Haven and Port Moor Cottage (Map 52). The saltmarsh in this area is divided into a series of blocks created by the alignment of the drainage system, with the blocks criss-crossed by parallel drains. Stability of the marsh extent has been maintained over the seven-year mapping period (27.38ha). The total extent was mapped at 29.46ha in 2000, increasing by 0.95ha in 2007.

Management Unit 15

Parallel drains are also present in Unit 15, located south of White House Farm. The saltmarsh extent was mapped at 1.52ha in 2000, increasing to 1.61ha by 2007 giving an average rate of change of 0.01ha/yr (Map 52). The majority of the saltmarsh (1.50ha) remained stable throughout the seven years. In the absence of a sea wall embankment in this unit, there is a natural transition from saltmarsh to grassland in the north-eastern section.

Management Unit 17

Unit 17 lies to the north of Stow Creek and west of Groom's Farm, North Fambridge (Map 53). The saltmarsh is cut by parallel drains which are characteristic of the marshes in this area of the estuary. Of the 23.69ha of saltmarsh present in 2000, a total of 2.45ha was lost to erosion, but an additional 3.46ha was gained through natural accretion resulting in a net gain of 1.03ha by 2007. This resulted in the extent mapped in 2007 at 24.73ha, averaging a 0.15ha/yr gain over the seven years. Although the 5m displacement of the aerial photographs makes it difficult to define the locations of erosion and accretion, some internal creek and bare mud areas had obviously recolonised by 2007, particularly to the north of the unit, accounting for the overall net gain in saltmarsh.

Management Unit 19

The saltmarsh in the unit comprises two distinct sections (Map 54). The first stretches along the north bank of Clementsgreen Creek and the second covers the west bank of Stow Creek. The saltmarsh in Stow creek is stable and characterised by a series of large oyster pits. The saltmarsh along Clementsgreen Creek is also quite stable. Overall the unit has undergone a small net gain of 0.01ha between 2000 and 2007.

Management Unit 22

The saltmarsh in this unit is situated on the south bank of Clementsgreen Creek (Map 54). It is generally stable with a small net gain of 0.02ha being evident through the slight accretion of small creeks and basins.

Ground truthing: This unit was ground truthed by Natural England in 2009. It was noted that the saltmarsh in Hawbush Creek was fragmented and had undergone erosion, as indicated on Map 54. Degrading marsh supported pioneer species (glasswort - *Salicornia* sp) or had formed into mud mounds. Common cord grass (*Spartina anglica*) was noted at the marsh edges. More stable plateaus of saltmarsh supporting higher marsh communities, of sea purslane (*Atriplex portulacoides*) and sea couch (*Elytrigia atherica*) had cliffed edges.

The aerials show that the main body of the marsh was once enclosed and the pattern of parallel drainage is evident.

Management Unit 24

This unit runs around the boundary of an 'island' of fields located at the confluence of the River Crouch and Clementsgreen Creek (Map 54). The saltmarsh is fragmented with wide enlarged channels with areas of gain and loss both on the outer edge of the saltmarsh and within the creeks and channels. The unit as a whole has experienced a net gain of 0.02ha.

Management Unit 26

Unit 26 lies on the north bank of the River Crouch, south of Marsh Farm Country Park (Map 55). Saltmarsh is confined to the eastern end of the unit. This saltmarsh is fragmented and has experienced a degree of erosion totalling a net loss of 0.04ha.

Management Unit 28

This unit runs the entire length of Fenn Creek and has large continuous areas of saltmarsh on both banks forming a dense sward (Map 56). Where sections of marsh have been excavated to win soil or dug to create oyster pits, long continuous channels have formed, parallel with the sea wall. The tide has cut creeks into these channels at right angles linking them to the main creek channel. The saltmarsh has remained stable throughout the period of study with an overall net gain of 0.0046 ha (46m²).

Management Unit 29

Unit 29, located on the upper Fenn Creek and immediately east of Tabrums Farm, contains a relatively stable area of saltmarsh within the Crouch Estuary. At the northern boundary of the saltmarsh there is a natural transition into dry grassland. 5.13ha of marsh was mapped in 2000, increasing to 5.23ha in 2007 (Map 57). Of the 5.13ha of saltmarsh present in 2000, a total of 0.12ha was lost to erosion, with 0.23ha gained through natural accretion, resulting in a net gain of 0.10ha by 2007. 5.01ha remained stable throughout this period.

Management Unit 30

The most continuous stretch of saltmarsh within this unit lies to the south and south-east of Hayes Farm (Map 58). Of the 0.78ha of saltmarsh present in 2000, a total of 0.17ha was lost to erosion, with 0.29ha gained through natural accretion, resulting in an overall net gain of 0.08ha by 2007. 0.57ha remained stable throughout this period. This resulted in an extent of 0.85ha being mapped in 2007, averaging a gain of 0.01ha/yr over the seven years.

Management Unit 31

Unit 31 is located to the east of Gosse's Farm, Battlesbridge, and is shown on Map 58. Of the 9.07ha of saltmarsh present in 2000, a total of 0.16ha was lost to erosion, particularly along the front edge, with 0.37ha gained through natural accretion throughout the unit resulting in a net gain of 0.20ha by 2007. 8.91ha remained stable throughout this period. An area of saltmarsh gain has been mapped at the landward transition zone of this extent.

Management Unit 32

Unit 32 is located on the south bank in the upper reaches of the River Crouch, east of Battlesbridge. It extends around Oldtree Point into Spitty's Reach, then turns east to Short Reach and terminates at the western boundary of Hullbridge (Map 58). The saltmarsh has remained stable throughout the study period with an overall net gain of 0.05ha accrued in small areas throughout the unit.

Ground truthing: A condition assessment, undertaken by Natural England in 2010, verifies the stability of this marsh reporting that there was no realignment or significant alterations of creek structure, and that the saltmarsh supported a mosaic of pioneer, transitional low - mid marsh, upper marsh and drift-line communities.

Management Unit 34

Unit 34 contains a large expanse of saltmarsh situated to the south of Brandyhole and Brandyhole Reach. Much of the saltmarsh area shows the historical drainage configuration of straightened main creeks and a series of connecting parallel drains. It is again apparent from Map 59 that there is some displacement of the aerial photographs with a general pattern of erosion along the north of the saltmarsh blocks and accretion along the southern edges. However, the mapping has shown an overall net gain of 2.15ha within this extensive saltmarsh area, averaging an increase of 0.31ha/yr. Of the 67.27ha of saltmarsh present in 2000, a total of 6.20ha was lost to erosion, with 8.33ha gained through natural accretion and 61.09ha remaining stable throughout this period. Even with the shift in the aerial photographs alignment, some internal accretion of the marsh body has been observed where creeks have narrowed or mud pans have become recolonised.

Natural England comment: The Environment Agency created a 12ha realignment site in the vicinity of this unit in 2002. This was undertaken as compensation for sea wall defence works in the area. The site was expected to develop mud flats, saltmarsh and transitional grassland.

Management Unit 35

Unit 35 contains only a small area of saltmarsh situated to the west of South Fambridge (Map 60). In 2000 the extent was mapped at 0.50ha reducing to 0.47ha in 2007.

Ground truthing: This unit was visited by Natural England in 2009 when a condition assessment was carried out. The saltmarsh here showed marked signs of erosion (cliffing of marsh edges, lowering of parts of the marsh surface, internal dissection and enlargement of the drainage network and mud basins). Pioneer saltmarsh was restricted to a few patches a metre or so wide on slumped creek edges. The upper marsh transition zone, which grades into the less salt-tolerant maritime grasses and shrubs, was reduced to a narrow band next to the sea wall. Despite the eroded state of the marsh, upper marsh species were present and there was very little *Spartina anglica* (common cord grass).

Management Unit 36

Map 61 shows the narrow extent of saltmarsh east of South Fambridge in Unit 36. In 2000 the extent was mapped at 0.68ha reducing to 0.63ha in 2007, giving a rate of loss of

0.01ha/yr. With the displacement of the aerial photographs it is difficult to assess where the losses occurred.

Ground truthing: The condition assessment made by Natural England in 2009 reported that erosion was evident on the seaward edge with marsh-edge cliffs at least 2 metres high on this exposed stretch. The pioneer marsh zone was almost completely absent except at the badly eroded east end of the saltmarsh strip. Scouring by the high tide along the base of the sea wall had created extensive patches of bare mud. Common cord grass had a scattered distribution and extended to the base of the sea wall.

Management Unit 37

Saltmarsh in this unit is present on the south bank of the River Crouch to the south of Bridgemarsh Island, below Raypits Reach (Map 62). A net loss of 0.24ha was recorded for this unit during the study period. The main body of the marsh has a complex creek system which was not digitised in detail but it can be seen from the photographs below that it has remained fairly stable over the survey period.



a) 2000



b) 2007

Plate 2: Complex creek system in Unit 37

Ground truthing: A condition assessment carried out by Natural England in 2009 noted mud basins and marked internal dissection at the east end of the saltmarsh area shown above, to the right of the photo. Seaward edge erosion was also apparent. The pioneer zone marsh was restricted to patches of up to c.5 metres wide and these were noted on creek edges which had slumped to a level where only primary colonisers could grow. The upper zone saltmarsh close to the sea wall was dominated by sea purslane marsh (*Atriplex portulacoides*), with the upper saltmarsh/driftline transition zone ranging from 2 to 8 metres wide. Common cord grass (*Spartina anglica*) had only a c.5% cover overall.

Management Unit 38

Saltmarsh in this unit is present on the south bank of the River Crouch, to the south of Bridgemarsh Island, below Easter Reach (Map 62). The saltmarsh has undergone a net loss of 0.09ha over the study period through erosion of the seaward edge.

Ground truthing: Unit 38 was assessed by Natural England in 2009 and corroborates the findings of the aerial survey. Severe signs of erosion were reported on the outer edge of the saltmarsh forming marsh-edge cliffs, particularly along the section west of Black Point. The section north of Upper Raypits Farm contained pioneer species in patches up to 10metres wide, mainly on the lower front edge. Wave action had scoured the marsh to bare mud at the base of the sea wall. The pioneer species, common cord grass, was abundant in all areas of the marsh.

Management Unit 39

The saltmarsh is present in two main sections in Unit 39 extending southwards from Black Point on the River Crouch (Map 63). The total saltmarsh area was mapped at 2.90ha in 2000, experiencing a loss of 0.17ha resulting in an extent of 2.73ha by 2007. Erosion has occurred on the seaward marsh edge along the full length of the extent with very little change to the internal body of the marsh. Saltmarsh has been lost at an average rate of 0.02ha/yr over the seven-year study period.

Ground truthing: The condition assessment survey undertaken by Natural England in 2009 confirms the findings of the aerial survey, describing severe seaward edge erosion with marsh-edge cliffs over 2 metres high. The width of the upper marsh/driftline transition zone alongside the sea wall ranged from between 3 and 20 metres. The pioneer zone marsh was found in patches up to c.4metres wide on slumped sections.

Management Unit 41

The saltmarsh within Unit 41 lies within the Lion Creek Nature Reserve (Map 64). This continuous extent of marsh was mapped at 14.43ha in 2000, experiencing a net loss of 0.07ha by 2007 to 14.35ha. Of the 14.43ha of saltmarsh present in 2000, a total of 0.92ha was lost to erosion, with 0.85ha gained through natural accretion resulting in an average rate of loss of 0.01ha/yr over the seven years. 13.51ha remained stable throughout this period.

Ground truthing: Natural England's condition assessment (2009) reported that the condition of the saltmarsh, in terms of total extent and the extent of the mid-level to higher marsh, was significantly better than the units to the west abutting the main channel of the River Crouch. Erosion was also less severe. At the southern end of Lion Creek extensive areas of mid-level to upper zone marsh, ie sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*), were present, with a short, diverse sward and many salt pans. Areas of upper marsh transitional vegetation were well represented here (up to c.10metres wide). The nationally scarce *Spartina maritima* (small cord grass) was present in this section. However, in all areas saltmarsh showed clear signs of erosion with enlargement and dissection of the creek network and cliffing at the marsh edge. Mud basins were noted in the sections at the lower and outer stretches of the creek, as indicated in Map 64. Pioneer species, in patches of up to c.3 metres wide, were mainly confined to slumping creek edges. Coverage of common cord grass (*Spartina anglica*) was low in this unit, averaging c.1 per cent.

Management Unit 43

There are small fragments of saltmarsh in this unit located to the east of Essex Yacht Marina, at the western end of Wallasea Island. Larger areas are however present behind the management unit boundary (Map 59). Saltmarsh in this unit is considered to have been stable during the study period.

Ground truthing: The findings of a condition assessment carried out by Natural England in 2010 support the aerial survey result, reporting no significant realignment or alterations of creek structure. The saltmarsh community is described as a sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*) mosaic supporting transitional low marsh communities. The distribution of *Spartina anglica* (common cord grass) is described

as rare. The areas around the marina and at the eastern end of the unit support pioneer and low – mid saltmarsh types.

Management Unit 44

Map 66 shows the extent of saltmarsh in Unit 44 along the north coast of Wallasea Island on the River Crouch. The saltmarsh areas to the west of the unit between Gardenness Point and Ringwood Point have remained relatively stable, with minimal losses and gains, and the internal structure of the saltmarsh bodies has remained similar between the comparative years. However, the greatest changes have been mapped at the eastern end of the unit between Ringwood Point and Wallasea Ness with saltmarsh being replaced by intertidal mudflat opposite breaches 4, 5 and 6 of the Wallasea Island realignment site. The location of the breaches is indicated in the environmental statement for the Wallasea Island North Bank Realignment (Scott, 2004). The site was breached in 2006 and aims to deliver 22 hectares of saltmarsh on Wallasea Island. Of the 14.96ha of saltmarsh present in 2000, 13.56ha remained stable throughout the seven years, but a total of 1.41ha was lost to erosion throughout the unit, with only 0.74ha gained through natural accretion. This resulted in an overall net loss of 0.67ha by 2007 (averaging a loss of 0.10ha/yr).

Management Unit 45

Unit 45 covers an area on the eastern coast of Wallasea Island from Wallasea Ness round to the south-west corner of Wallasea Island on the River Roach (Map 66). The total saltmarsh extent in 2000 was mapped at 23.46ha which increased to 24.02ha by 2007 (a net gain of 0.56ha). Erosion was mapped on the outer marsh edge to the north of the unit with the widening of one creek to over 3m by 2007. However, on moving south along the unit, the outer marsh edge shows some accretion with a significant area of accretion mapped opposite Smallgains Point.

Management Unit 46

Unit 46 covers an area of intertidal to the west of Wallasea Island along the north bank of Paglesham Pool upriver to Paglesham Creek (Maps 67 & 68). In 2000, this continuous extent of marsh was mapped at 37.15ha, experiencing a net loss of 0.83ha by 2007 to 36.31ha. As this unit has not been significantly affected by the displacement of the aerial photographs, an assessment can be made of the losses and gains. A total of 2.21ha was lost to erosion throughout the unit, with 1.37ha gained through natural accretion, resulting in an average rate of loss of 0.12ha/yr over the seven years. 34.94ha remained stable throughout this period. Saltmarsh loss was mapped along the seaward marsh edge and also along the landward boundary in some places. Further losses and gains were mapped within the internal body of the saltmarsh due to the widening of some creeks and narrowing of others.

Management Unit 47

Map 68 shows the extent of saltmarsh in Unit 47 within Paglesham Creek. The saltmarsh on the western side of this unit has never been embanked. In 2000, this continuous extent of marsh was mapped at 13.81ha, experiencing a net loss of 0.60ha by 2007 to 13.21ha. As this unit has not been significantly affected by the displacement of the aerial photographs, an assessment can be made of the losses and gains. Of the 13.81ha of saltmarsh present in

2000, a total of 0.79ha was lost to erosion throughout the unit, with 0.19ha gained through natural accretion resulting in an average rate of net loss of 0.09ha/yr over the seven years. 13.02ha remained stable throughout this period. Saltmarsh loss was mapped along the seaward marsh edge with widening of the creek channels within the main internal body of the marsh.

Management Unit 48

Unit 48 covers an area of saltmarsh on the south bank of Paglesham Creek (Map 68). In 2000, the marsh extent was mapped at 7.74ha, experiencing a net loss of 0.71ha by 2007 to 7.02ha. As this unit has not been significantly affected by the displacement of the aerial photographs, an assessment can be made of the losses and gains within the unit. A total of 0.94ha was lost to erosion throughout the unit, with only 0.23ha gained through natural accretion. 6.79ha remained stable throughout this period. Saltmarsh loss was mapped along the seaward marsh edge with widening of some creek channels within the main internal body of the marsh.

Ground truthing: A condition assessment was carried out by Natural England in 2009. The survey noted that despite the sheltered position of the marsh, the creek network appeared to be undergoing internal dissection and enlargement, as indicated by the aerial survey. Mud basins were present, though less numerous in the upper creek, and marsh-edge cliffs were noted along the lower creek. The pioneer saltmarsh zone was narrower on the more exposed section of marsh at the east end of the unit and overall varied from 0 to c.7metres in width. It was predominant on the degraded, slumped marsh edges. The high marsh transitional zone increased in width towards the more sheltered upper reaches of the creek to the west.

Management Unit 49

Unit 49 covers an area of intertidal which extends along the south bank of Paglesham Pool, around the point, to the boatyard at Paglesham Eastend (Map 67). In 2000, this continuous extent of marsh was mapped at 11.71ha, experiencing a net loss of 2.14ha by 2007 to 9.57ha. As this unit has not been significantly affected by the displacement of the aerial photographs, some assessment can be made of the losses and gains within the unit. Of the 11.71ha of saltmarsh present in 2000, a total of 0.76ha was lost to erosion throughout the unit, with 0.31ha gained through natural accretion resulting in an average rate of net loss of 0.31ha/yr over the seven years. 9.26ha remained stable throughout this period. Saltmarsh loss was mapped along the full extent of the marsh frontage with no notable changes to the internal saltmarsh body.

Ground truthing: The Natural England condition assessment (2009) verified the establishment of pioneer saltmarsh on accreting mud near the creek mouth, as indicated in Map 67, and speculates that this material may have been washed down from the upper creek. Elsewhere pioneer species were patchy and an indicator of secondary succession where they had colonised slumped creek edges. Erosion was most marked at the northern end of the unit indicated by cliffing of the marsh edge with enlargement of the drainage network and a more dissected creek pattern. To the south of the unit the marsh body was more stable with a wider high marsh/driftline transitional community on higher ground, particularly around old oyster pits.

Management Unit 50

Unit 50 covers an extent of saltmarsh between the boatyard at Paglesham Eastend and the south of Stannetts Creek (Map 69). In 2000, the extent of marsh was mapped at 6.73ha, experiencing a net loss of 0.41ha by 2007 to 6.32ha. This equates to an average rate of net loss of 0.06ha/yr over the seven years. As this unit has not been significantly affected by the displacement of the aerial photographs, some assessment can be made of the losses and gains within the unit. A total of 0.74ha was lost to erosion throughout the unit, with only 0.33ha gained through natural accretion. 5.99ha remained stable throughout this period. Saltmarsh loss was mapped along the seaward marsh edge, particularly notable at the northern end of the unit close to the boatyard. Further losses have also occurred affecting the fragmented saltmarsh patches at Blackedge Point and to the south of Stannetts Creek.

Ground truthing: Natural England's condition assessment (2009) verified the aerial interpretation describing seaward edge erosion with fragmented marsh most evident to the west of Blackedge Point. The field survey also noted that secondary succession pioneer marsh was predominant on the eroding creek edges. The triangle of marsh at the northern end of the unit, at Paglesham Eastend, supported upper marsh transitional communities extending c.20 metres out from the sea wall around disused oyster pits.

Management Unit 52

The saltmarsh within Unit 52 extends from west of Stannetts Creek round to the north bank of Bartonhall Creek on the River Roach (Map 76). The 10.19ha of saltmarsh present in 2000 had undergone a reduction in area to 9.92ha by 2007 - a net loss of 0.27ha. A total of 0.84ha was lost to erosion with 0.57ha gained through natural accretion. 9.35ha remained stable throughout this period. Saltmarsh had eroded along the marsh frontage, with the internal creek systems remaining relatively stable. The mapping of saltmarsh was difficult in this unit, particularly within the Bartonhall Creek area due to the quality of the aerial photographs.

Ground truthing: The condition assessment survey by Natural England (2009) reported 'severe' signs of erosion throughout the unit, particularly in the upper reaches of Bartonhall Creek. The width of the upper marsh transition zones ranged from c.5 to 30 metres particularly in the wider marsh bordering the outer creek and in stable areas in the upper creek. Pioneer species were characteristic of the slumped creek edges. Common cord grass (*Spartina anglica*) covered an area of less than 5 per cent overall but was abundant at the extreme upper end of Bartonhall Creek.

Management Unit 53

Map 71 shows the saltmarsh within Unit 53, extending along the south bank of Bartonhall Creek west to Broomhills at the head of the Roach channel at Rochford. The high saltmarsh within this unit is heavily fragmented which has exposed it to further erosion. In 2000 the extent of the marsh was mapped at 13.06ha, but by 2007 this had reduced to 12.33ha (a net loss of 0.73ha). Of this total, 11.05ha remained stable throughout the seven years but just over 2ha was lost through natural erosion of both the marsh edge and the fragmented marsh.

Management Unit 54

Unit 54 covers an expanse of saltmarsh on the south bank of the River Roach, north of Muckinghall (Map 71). In 2000, the extent was mapped at 12.30ha, recording a net loss of 0.68ha in 2007, resulting in a total area of 11.61ha. The saltmarsh is very fragmented and most of the erosion has been mapped around the small saltmarsh islands.

Management Unit 56

The saltmarsh in this unit is on the south bank of the River Roach, west of Paglesham Reach, on the north side of Barling Marsh (Map 72). The saltmarsh is fed by wide channels and recorded an overall net loss of 0.38ha.

Ground truthing: Natural England's condition assessment, undertaken in 2009, reported that the saltmarsh was showing clear signs of erosion throughout the unit, including lowering of the marsh surface with partial or complete destruction of vegetation. These changes were particularly severe in the sections west of Barling Ness and north of Sand Pit. The survey also records enlargement of the creek system and the presence of mud basins at the Sand Pit location and to the west of this area. A high percentage of common cord grass cover (30-40 per cent) was noted in the eastern section of the unit.

Management Unit 57

Bridgemarsh Island is characterised by an extensive network of parallel drains and creeks. The saltmarsh in the unit totalled 150.37ha in 2007 having experienced a net gain of 1.87ha since 2000 (Map 73). The pattern of loss and gain in the unit suggests a misalignment of aerials making an accurate assessment of accretion and erosion difficult.

Summary

Table 4 Summary statistics for the Crouch & Roach Estuarine SSSI management units

Management Unit	Total Saltmarsh area in 2000 (ha)	Total Saltmarsh area in 2007 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
1	5.20	7.97	2.78	0.33	3.10	4.87	0.40
2	1.77	1.64	-0.13	0.33	0.20	1.44	-0.02
4	3.86	3.88	0.01	0.31	0.33	3.55	0.00
5	0.13	0.17	0.04	0.04	0.08	0.09	0.01
7	2.76	2.88	0.12	0.55	0.67	2.21	0.02
8	5.03	5.16	0.13	1.05	1.19	3.98	0.02
9	0.85	0.76	-0.09	0.41	0.32	0.44	-0.01
11	2.46	2.35	-0.11	0.97	0.87	1.48	-0.02
14	29.46	30.40	0.95	2.08	3.03	27.38	0.14
15	1.52	1.61	0.09	0.02	0.11	1.50	0.01
17	23.69	24.67	0.98	2.46	3.44	21.23	0.14
19	4.22	4.23	0.01	0.95	0.97	3.27	0.00
22	3.89	3.92	0.02	1.20	1.22	2.70	0.00
24	1.63	1.65	0.02	0.65	0.67	0.98	0.00
25	No saltmarsh was found in this unit						
26	0.26	0.22	-0.04	0.18	0.14	0.08	-0.01
28	6.46	6.47	0.00	0.59	0.59	5.87	0.00
29	5.13	5.23	0.10	0.12	0.23	5.01	0.01
30	0.67	0.85	0.18	0.11	0.29	0.57	0.03
31	9.07	9.28	0.20	0.16	0.37	8.91	0.03
32	3.68	3.73	0.05	0.30	0.36	3.37	0.01
34	67.38	69.46	2.08	6.26	8.35	61.11	0.30
35	0.50	0.47	-0.02	0.18	0.16	0.31	0.00
36	0.68	0.63	-0.05	0.32	0.27	0.36	-0.01
37	4.72	4.49	-0.24	0.51	0.27	4.21	-0.03
38	1.54	1.45	-0.09	0.45	0.37	1.08	-0.01
39	2.90	2.73	-0.17	0.26	0.08	2.65	-0.02
41	14.43	14.36	-0.07	0.92	0.85	13.51	-0.01
43	0.04	0.03	0.00	0.00	0.00	0.03	0.00
44	14.96	14.30	-0.67	1.41	0.74	13.56	-0.10
45	23.46	24.02	0.56	0.64	1.20	22.81	0.08
46	37.15	36.32	-0.83	2.21	1.37	34.94	-0.12
47	13.81	13.21	-0.60	0.79	0.19	13.02	-0.09
48	7.74	7.02	-0.71	0.94	0.23	6.79	-0.10
49	9.86	9.57	-0.29	0.60	0.31	9.26	-0.04
50	6.73	6.32	-0.41	0.74	0.33	5.99	-0.06
52	10.19	9.93	-0.26	0.84	0.58	9.36	-0.04
53	13.06	12.33	-0.73	2.01	1.28	11.05	-0.10
54	12.30	11.61	-0.68	2.05	1.37	10.24	-0.10
56	3.64	3.26	-0.38	0.46	0.09	3.17	-0.05
57	148.50	150.37	1.87	7.04	8.92	141.46	0.27

3.5 Dengie SSSI

The Dengie Flats are situated at the eastern end of the Dengie peninsular and form a linear coastline between the Blackwater Estuary to the north and the Crouch and Roach Estuaries to the south. The Dengie Flats are part of the Essex Estuaries Special Area of Conservation (SAC), which includes the Dengie SSSI and Dengie National Nature Reserve (NNR). The SSSI is bounded in the north by Bradwell power station and extends 17.5km south to Holliwell Point, at the northern entrance to the River Crouch. The extent of the intertidal area measures 2,986ha with widths of over 3km. The saltmarsh is the largest continuous example of its type in Essex. The flats are crossed by a number of shallow drainage channels flowing from reclaimed marsh sluiced-outfalls and exhibit an interesting series of stratigraphic bands suggesting an erosional surface that has experienced decreased slope gradients (Boyes et al, 2008). Foreshore, saltmarsh and beaches support an outstanding assemblage of rare coastal flora. It is of importance for wintering populations of Hen Harrier *Circus cyaneus*, wildfowl and waders (JNCC, 2001c).

The saltmarshes along the Dengie Peninsula have been gradually enclosed since the 15th Century (Gramolt, 1961). The saltmarsh is over 1km wide in some places along this coastline and at Sales Point and Marshhouse, chenier ridges occur at the marsh edge, giving extra protection from wave action (Richards & Pye, 2001). By studying maps and charts, Greensmith and Tucker (1965) calculated that the marshes had prograded between 1870 and 1953, especially in the central part of the Dengie Peninsula. However since 1953, the marsh edge has been eroded and the topography is characterised by cliffing and mud mounds. Pye & French (1993b) calculated an overall net loss of saltmarsh area between 1955 and 1990 at c.12 ha/yr. The saltmarshes on the upper intertidal have been eroded away in the south of the area but an area of 474ha remains between Deal Hall and St Peter's Church (Cottle et al, 2002). Harmsworth and Long (1986) reviewed aerial photographs of the peninsula taken during the years 1960, 1970, 1973, 1978 and 1981, and concluded that there had been a major loss of saltmarsh from the Dengie since 1970, which had amounted to almost 80ha or 16% of the total. They also noted that further periods of rapid erosion occurred between 1970 and 1973 (at 16ha/yr) and between 1978 and 1981 (at 9ha/yr). Lateral erosion continued to occur along the peninsula, but with a moderate rate of 3ha/yr between the periods 1973 to 1988 (Burd, 1992) and 1988 to 1998 (Cooper *et al.*, 2000).

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 74 shows the location of the SSSI units within the Dengie SSSI. By digitising and comparing the extent of saltmarsh in 1997 and 2008, Table 5 shows the overall calculations for the Dengie, breaking down the total extents, gains and losses and net change and average rate of change within each unit.

Management Unit 5

Two distinct areas of saltmarsh exist within Unit 5, one to the north of the unit west of Sales Point, with the second forming part of a continuous body of marsh south of Sales Point down to Glebe Outfall (Map 75). Of the 96.91ha of saltmarsh present in 1997, 7.86ha was lost to erosion with only 1.29ha gained through natural accretion throughout the unit. This resulted in a net loss of 6.57ha by 2008 to give a revised extent of 90.34ha. Erosion was observed along the entire seaward marsh edge with no changes to the internal saltmarsh body with 89.04ha remaining stable over the eleven year period. A small area of accretion was

mapped at the northern edge of the marsh extent south of Sales Point. The rate of loss within this unit averages 0.60ha/yr.

Ground truthing: A condition assessment of Unit 5 was carried out by Natural England in September 2010 and this verifies the findings described above. The unit features a wave-built ridge of cockleshell (chenier ridge) at Sales Point which extends south for approximately 2.5 km. The shell ridge encroaches inland over saltmarsh forming hooks and banks mostly in the St Peter's Flat area (TM034084). The cockle shell ridges and sand support vegetation on more mobile as well as stable areas and diverge between eroding saltmarsh at the seaward edge and stable saltmarsh behind the shell bank. The saltmarsh fronting the ridge has been scoured by wave action and cliffed platforms of bare mud and clay are exposed here.

Management Unit 6

Unit 6 covers two continuous areas of marsh between Glebe Outfall and Howe Outfall (Map 76) on the Dengie Peninsula. In 1997 the saltmarsh extent was mapped at 97.19ha, but by 2008 this had reduced to 94.11ha (a net loss of 3.08ha). The internal structure of the saltmarsh remained stable throughout the eleven years (93.22ha) with erosion mapped predominantly along the seaward marsh edge, particularly to the south of the unit at Howe Outfall. Total saltmarsh loss equated to 3.97ha with only 0.89ha of accretion gained throughout the unit. The rate of change within this unit averaged a loss of 0.28ha/yr over the eleven years.

Management Unit 7

Unit 7 covers the saltmarsh between Howe Outfall to just south of Bridgewick Outfall (Map 77). In 1997 the saltmarsh extent was mapped at 202.44ha, experiencing a net loss of 3.83ha giving a revised extent of 198.61ha in 2008. Over 5ha of erosion was mapped within this unit, particularly along the seaward facing edge, with only 1.26ha gained throughout the unit. The internal marsh was relatively stable at 197.35ha between the baseline and comparative years, with some widening and narrowing of the primary creek systems running through the marsh. This unit has an average rate of loss of 0.35ha/yr.

Management Unit 8

Map 78 shows the two areas of saltmarsh within Unit 8, the first extending between Bridgewick Outfall and just south of Coate Outfall, and the second lying south of Holliwell Point. In 1997 the total extent of marsh was mapped at 58.93ha, but by 2008 the extent had reduced to 56.81ha (a net loss of 2.12ha). Of this total, 56.68ha remained stable throughout the eleven years but 2.25ha was lost through natural erosion with only 0.13ha gained through natural accretion throughout the unit. Erosion was observed along the seaward edge of both marsh areas. This unit has experienced an average rate of loss of 0.19ha/yr.

Additional Points

In Units 6, 7 and 8, the poor quality of the 1997 photographs made it difficult to differentiate the saltmarsh edge from the mud mound topography. In some places it appeared that saltmarsh extended beyond the unit boundary. If this was the case, then it is likely that the area of loss incurred is greater than the areas given here.

Summary

Table 5 Summary statistics for the Dengie SSSI management units

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 2008 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
5	96.91	90.34	-6.57	7.86	1.29	89.04	-0.60
6	97.19	94.11	-3.08	3.97	0.89	93.22	-0.28
7	202.44	198.61	-3.83	5.09	1.26	197.35	-0.35
8	58.93	56.81	-2.12	2.25	0.13	56.68	-0.19

3.6 Foulness SSSI

Foulness lies on the north shore of the Thames Estuary between Southend in the south and the Rivers Roach and Crouch in the north. The site is part of an open-coast estuarine system comprising grazing marsh, saltmarsh, intertidal mudflats, cockle-shell banks and sandflats. It includes one of the three largest, continuous sand/silt flats in the UK. The diversity of high quality coastal habitats supports important populations of breeding, migratory and wintering waterbirds, notably internationally important concentrations of Dark-bellied Brent Goose *Branta bernicla bernicla*.

The narrow fringe of saltmarsh around Foulness Point experienced severe erosion between 1884 and 1891, and by 1938 the marsh bordering the Crouch Estuary had been totally eroded. After 1938, high wave energy events resulted in the landward movement of shells to form a series of dynamic chenier ridges to the north and east of Foulness Point (Richards & Pye, 2001). Stoodley (1998) calculated a rate of marsh edge retreat at the south of Foulness point of 16m/yr between 1977 and 1988, and 4m/yr between 1988 and 1996, using aerial photographs.

Map 79 shows the location of the SSSI units within the Foulness SSSI. The extent of saltmarsh in the available baseline years of 1997 or 2000 was digitised and compared against the aerial data set for 2007. Table 6 shows the overall calculations for Foulness, breaking down the total extents, gains and losses, and net change and average rate of change within each unit. The following assessments have been made for each management unit, with reference to the maps in Volume 2 - MAPS.

Management Unit 2

The saltmarsh in Unit 2 forms only a small area at Poynter's Point (Map 80). This marsh remained stable throughout the eleven years with a total extent of 0.04ha in both years.

Management Unit 3

Management Unit 3 is the most extensive unit within the Foulness SSSI covering a large area of the Maplin Sands, which fronts the Foulness coastline. The majority of saltmarsh was mapped towards the northern end of this unit, south of Foulness Point and adjacent to Unit 32 (Map 81). A second smaller area of saltmarsh was mapped at Fisherman's Head. A series of chenier ridges exist along this intertidal area, and the quality of the aerials in both years made it difficult to detect the presence of saltmarsh amongst the mud/shell formations.

Of the 0.12ha of saltmarsh present in 1997, a total of 0.09ha was lost to erosion with 0.12ha gained through natural accretion resulting in a net gain of 0.03ha by 2007.

Management Unit 5

The saltmarsh in Unit 5 lies on both banks of Havengore Creek, between the creek mouth and Havengore Bridge (Map 82). Of the 21.84ha of saltmarsh present in 1997, a total of 0.71ha was lost to erosion, with only 0.22ha gained through natural accretion, resulting in a net loss of 0.49ha by 2007. No observable changes occurred to the internal structure of the marsh, with 21.13ha remaining stable throughout the mapping period. Erosion of the seaward marsh edge was noted along both banks, with the greatest area of erosion occurring on the most exposed area of marsh ie on the south bank at the mouth of Havengore Creek. The marsh at Haven Point, at the mouth of Havengore Creek, also showed the area of greatest accretion along the seaward edge of the marsh.

Ground truthing: The condition assessment carried out in 2010 by Natural England described a saltmarsh structure of creeks, pools and pans dominated by low-mid marsh with sea purslane (*Atriplex portulacoides*) and sea aster (*Aster tripolium*), with some areas of pioneer saltmarsh (*Salicornia* sp) interspersed in rill edges and muddy footings near Havengore Bridge. The mid-upper marsh was colonised by saltmarsh grass (*Puccinellia* spp), golden samphire (*Inula crithmoides*), and sea couch (*Elytrygia atherica*). Cord grass (*Spartina* sp) was also present. The saltmarsh was broadly favourable in habitat terms.

Management Unit 14

This unit runs along the east bank of the outer Roach and turns east into the mouth of the River Crouch (Map 83). Of the 2.20ha of saltmarsh present in 1997, 0.39ha was lost to erosion and only 0.03ha gained from accretion, leaving a total extent of 1.84ha in 2007. The majority of the loss has occurred on the south bank of the River Crouch with 1.62ha, on the east bank of the River Roach, representing the only significant area of saltmarsh in the unit.

Ground truthing: Natural England visited this unit in 2010. The condition assessment survey reported that the low-mid marsh was dominant, supporting sea purslane, saltmarsh grass and sea aster. Pioneer saltmarsh (glasswort – *Salicornia* sp) had a scattered distribution throughout the sea purslane marsh. The mid-upper marsh contained sea lavender (*Limonium vulgare*) and the nationally scarce golden samphire, and was confined to the base of the sea wall along with driftline vegetation represented by sea couch and sea beet (*Betal vulgaris*). Common cord grass (*Spartina* sp) was notably abundant at the north-east end of the River Roach.

Management Unit 17

This unit extends east from the mouth of The Middleway, along the channel of the River Roach, north-east of Whitehouse Hole (Map 84). There is 17.54ha of stable saltmarsh located to the east of The Middleway entrance – where the saltmarsh edge is accreting - and to the north of Horseshoe Corner. Though saltmarsh in the middle section of the unit has eroded, an overall net gain of 0.13ha in has been recorded.

Ground truthing: The Natural England survey to report on site condition was undertaken in 2010. The low-mid marsh had a diverse range of species including: sea purslane, saltmarsh grass, sea aster, sea spurrey (*Spergularia* sp), sea rush (*Juncus maritimus*), sea thrift

(*Armeria maritima*) and sea lavender (*Limonium* sp). Glasswort had a patchy distribution throughout the marsh on the lower areas. The mid-upper marsh, of golden samphire and sea couch, had a linear distribution at the base of the sea wall.

Management Unit 19

This unit runs from the east bank of the outer Middleway southwards into Shelford creek (Map 85). There is 15.06ha of stable saltmarsh in this unit with small areas of gain and loss throughout. An area of significant change has been recorded on the seaward edge of the saltmarsh in the upper Middleway, which has accreted in width by up to 20m. The total area of saltmarsh in 2007 for the unit was 16.22ha, having undergone a net gain of 0.45ha since 1997.

Ground truthing: Natural England's condition assessment in 2010 observed that the low-mid marsh, the dominant saltmarsh community within the unit, supported sea purslane, saltmarsh grass, sea aster, sea plantain (*Plantago maritima*) and sea lavender (*Limonium* sp) with a scattered distribution of pioneer saltmarsh (glasswort). The mid-upper marsh of golden samphire and sea couch was largely confined to the toe of the sea wall. Cord grass (*Spartina* sp) was limited to the southernmost part of the unit adjacent to the road.

Management Unit 22

Unit 22 covers an area of saltmarsh within Narrow Guts, a channel to the east of Rushley Island (Map 86). 10.28ha of saltmarsh was present in 1997, experiencing a net loss of 0.25ha by 2007 to give a revised extent of 10.04ha. The majority (9.82ha) of the saltmarsh extent remained stable throughout the ten-year period, with 0.47ha of loss and 0.22ha of gain throughout the unit. This resulted in an average rate of loss of 0.02ha/yr over the ten years. Areas of erosion and accretion were evident along the majority of the marsh edge, with significant areas of erosion occurring in the central area of Narrow Guts and to the extreme north of the unit at the marsh edge close to New England Creek Dam. Saltmarsh gains were also observed on the west bank of this middle channel section.

Ground truthing: Natural England's condition assessment (2010) described the vegetation zones present in the marsh. Low-mid marsh, consisting of saltmarsh grass, sea purslane and sea aster, was the dominant saltmarsh community, interspersed with pioneer saltmarsh, glasswort (*Salicornia* sp). The mid-upper marsh of sea couch was confined to the toe of the sea wall. Discrete clumps of cord grass (*Spartina* sp) were also present.

Management Unit 23

A continuous band of saltmarsh in this unit bounds Rushley Island. Small areas of both loss and gain occur throughout, particularly at the landward transitional boundary between saltmarsh and grassland; whereas the outward edge of the saltmarsh has mainly experienced erosion, especially to the south-east (Map 86). Overall, the unit has experienced a net loss of 0.70ha over the ten-year study period leaving a total extent of 25.45ha in 2007.

Ground truthing: The condition assessment visit by Natural England was carried out in 2009. Pioneer saltmarsh (glasswort) was interspersed with the characteristic species of the low-mid marsh community – sea purslane, saltmarsh grass, sea aster and sea lavender. The mid-upper marsh transition was dominated by sea couch which was located at the base

of the sea wall. Separate clumps of common cord grass (*Spartina* sp) were also evident. The saltmarsh lining The Middleway channel edge, on the west side of Rushley Island, was undergoing cliffing.

Management Unit 24

The saltmarsh in this unit lies along the south bank of Havengore Creek between Mill Head and Havengore Bridge (Map 87). The unit also contains saltmarsh encroaching from Unit 23. A total of 7.18ha of saltmarsh was recorded in 2007, a net gain of 0.10ha since 1997. A misalignment of approximately 2.5m accounts for much of the total accretion and total loss calculations for this unit and should therefore be discounted.

Ground truthing: Natural England's condition assessment of 2010 noted cliffing of the channel edges on saltmarsh bordering the west side of Rushley Island. Low-mid marsh was the most well-represented saltmarsh community containing the dominant species of this marsh type, sea purslane and saltmarsh grass, with sea aster. There were areas of pioneer glasswort marsh interspersed among the low-mid marsh. Discrete patches of cord grass (*Spartina* sp) were also evident.

Management Unit 26

The saltmarsh in Unit 26 is situated at Mill Head at the southern end of Potton Creek (Map 88). Over the ten-year study period the saltmarsh has experienced a small net gain of 0.02ha, increasing from 0.45ha, in 1997, to 0.47ha in 2007. Losses of 0.08ha were recorded predominantly on the creek edge north of Mill Head, whereas gains, totalling 0.10ha, were recorded partly on the landward edge of the marsh but also around Mill Head

Ground truthing: Natural England carried out a condition assessment in this unit in 2009. Creeks and pans were present within the marsh and the saltmarsh feature was dominated by low-mid marsh with saltmarsh grass, sea purslane, and sea aster, with a patchy distribution of pioneer saltmarsh (glasswort - *Salicornia* sp). The mid-upper marsh of sea couch was restricted to the base of the sea wall. Clumps of cord grass (*Spartina* sp) were present.

Management Unit 28

This large unit extends from Potton Point on the River Roach, and follows the north bank of Potton Island continuing south into Potton Creek (Map 89). It also includes Barlinghall Creek and the creeks and marshes in the upper reaches - Fleethead and Little Waking Creeks and the Brimstone Saltings. Throughout the eight-year study period, 97% of the saltmarsh present in 1999 (42.64ha) remained stable. Losses of 1.27ha and gains of 1.22ha were recorded, leading to an overall net loss of 0.05ha.

Ground truthing: Natural England's condition assessment of this unit, in 2010, noted that creeks and pans were present within the marsh and that the saltmarsh feature was dominated by low-mid marsh with representative plants: saltmarsh grass, sea purslane, sea aster, sea plantain (*Plantago maritima*), sea arrow grass (*Triglochin maritima*), and sea lavender (*Limonium* sp). There was a patchy distribution of pioneer saltmarsh (glasswort - *Salicornia* sp) and annual sea-blite (*Suaeda maritima*) on the lower areas of the marsh. The mid-upper marsh was largely confined to the base of the sea wall. Clumps of cord grass (*Spartina* sp) were observed.

Management Unit 29

This unit is situated on the west and south banks of Little Wakering Creek (Map 89). The saltmarsh here is predominantly stable with 99% of the marsh area remaining constant over the eight-year study period. A small loss of 0.04ha has been redressed by a gain of 0.15ha, resulting in an small overall net gain of 0.10ha and a total area of 4.59ha in 2007.

Ground truthing: Natural England carried out a condition assessment of this unit in 2010. The saltmarsh feature is dominated by low-mid marsh with typical species, including saltmarsh grass, sea purslane, sea aster, sea arrow grass, sea plantain, and sea lavender (*Limonium* sp). Patches of pioneer saltmarsh (glasswort - *Salicornia* sp) were also present. The mid-upper marsh, extending to the sea wall, comprises scurvy grass (*Cochlearia* sp), sea thrift (*Armeria maritima*), sea wormwood (*Artemisia maritima*) and sea couch. Clumps of cord grass (*Spartina* sp) are present.

Management Unit 31

Unit 31 is an extensive unit surrounding Potton Island (Map 89). Of the 40.90ha of saltmarsh present in the unit in 1999, a total of 2.26ha was lost to erosion, 1.91ha was gained through natural accretion and 38.64ha remained stable. Overall the unit experienced a net loss of 0.35ha over the eight years to give a new extent, in 2007, of 40.54ha. Natural erosion has occurred along the marsh frontage, particularly along the central western shore of Potton Island, adjacent to confluence of Potton Creek with Bullman's Reach. Both losses and gains were mapped within the main saltmarsh body north of the swing bridge in Potton Creek. Prominent areas of accretion occurred along the frontage south of Potton Point ie to the north-east of Potton Island, adjacent to The Middleway; and around the southern point of Potton Island.

Ground truthing: Natural England carried out a condition assessment in this unit in 2010. The saltmarsh feature is dominated by low-mid marsh with representative plants, saltmarsh grass, sea purslane, sea aster and sea lavender (*Limonium* sp), with a patchy distribution of pioneer saltmarsh (glasswort - *Salicornia* sp). The mid-upper marsh of sea couch is restricted to the toe of the sea wall. Clumps of cord grass (*Spartina* sp) are present.

Management Unit 32

The saltmarsh in Unit 32 extends from Foulness Point in the north to Northern Corner in the south (Map 90). Erosion of the seaward marsh frontage has occurred along the entire length, with some small pockets of accretion recorded. The most significant loss is located around Foulness Point to the north of the unit. Of the 37.22ha of saltmarsh present in 1999, a total of 4.54ha was lost to erosion, with only 0.92ha gained through natural accretion, resulting in a net loss of 3.62ha by 2007 to leave 33.59ha. This rate of change averages a loss of 0.45ha/yr. The main body of the marsh has remained relatively stable (32.68ha) throughout the thirteen-year review period, with only a few creeks to the north of the unit becoming wide enough to map by the comparative year.

Ground truthing: Natural England carried out a condition assessment in this unit in 2010. The survey noted that the variety of saltmarsh types typical of the site were evident. The most well represented marsh was low-mid marsh, with sea purslane and sea aster. The lower areas within this marsh community supported pioneer saltmarsh (glasswort - *Salicornia* sp) throughout. Mid-upper marsh species, sea couch and golden samphire, were

established at the toe of the sea wall. Discrete patches of cord grass (*Spartina* sp) were present.

Management Unit 33

The saltmarsh in Unit 33 extends intermittently along the open sea coast of the Foulness Peninsula from Northern Corner (north-east of Fisherman's Head), south-west to Poynter's Point (located south-east of Great Wakering; Map 91). In 1997, the saltmarsh extent was mapped at 52.45ha, experiencing a net loss of 2.58ha over the ten years to give a new extent, in 2007, of 49.87ha. A total of 4.22ha was lost to erosion throughout the unit, 1.63ha was gained through natural accretion and 48.24ha remained stable throughout this period. Erosion occurred along the majority of the seaward marsh edge throughout the length of the unit, with small pockets of accretion observed at Morrin's Point - where the saltmarsh is accreting over the intertidal mud - and also south of Shelford Head.

Ground truthing: The condition assessment carried out in 2010 by Natural England described the saltmarsh as dominated by low-mid marsh (sea purslane), with a few areas of pioneer saltmarsh (glasswort – *Salicornia* sp) interspersed throughout. The mid-upper marsh of sea couch and golden samphire is largely confined to the sea-wall toe. Cord grass (*Spartina* sp) clumps are present.

Points of note

A series of chenier ridges exist along the middle shore within this SSSI and the quality of the aerals in the comparative years made it difficult to distinguish saltmarsh within the mud/shell formations.

Summary

Table 6 Summary statistics for Foulness SSSI management units

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 1999 (ha)	Total Saltmarsh area in 2007 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
2	0.04		0.04	0.00	0.01	0.01	0.04	0.00
3	0.12		0.15	0.03	0.09	0.12	0.04	0.00
5	21.84		21.35	-0.49	0.71	0.22	21.13	-0.05
14	2.20		1.84	-0.36	0.39	0.03	1.81	-0.04
17	17.82		17.95	0.13	0.28	0.41	17.54	0.01
19	15.77		16.22	0.45	0.71	1.16	15.06	0.05
22	10.28		10.04	-0.25	0.47	0.22	9.82	-0.02
23	26.14		25.45	-0.70	1.48	0.78	24.67	-0.07
24	7.08		7.18	0.10	0.66	0.76	6.42	0.01
26	0.45		0.47	0.02	0.08	0.10	0.37	0.00
28		42.64	42.60	-0.05	1.27	1.22	41.38	-0.01
29		4.49	4.59	0.10	0.04	0.15	4.44	0.01
31		40.90	40.54	-0.35	2.26	1.91	38.64	-0.04
32		37.22	33.59	-3.62	4.54	0.92	32.68	-0.45
33	52.45		49.87	-2.58	4.22	1.63	48.24	-0.26

3.7 Hamford Water SSSI

Hamford Water is a tidal inlet protected by The Naze, to the north of Walton. Although estuarine in appearance, Hamford Water is more accurately described as an embayment since it does not have any major freshwater inputs (Pethick & Stapleton, 1994).

Hamford Water contains the greatest extent of saltmarsh of the eastcoast estuaries with approximately 80% of the intertidal comprised of marsh. However the natural development of saltmarsh has been interrupted by the reclamation of large areas. The first enclosures were undertaken prior to 1574 along the Dovercourt shore (Gramolt, 1961). The north-east corner of Horsey Island was first reclaimed in 1665, and the whole of Pewit Island was reclaimed in 1688. The largest area of reclamation during the 19th century was to the north and west of the Walton peninsula, including Stone Marsh (Gramolt, 1961). Some of these areas have been subject to breaches in the seawalls and have reverted back to saltmarsh. The most obvious loss of saltmarsh is recorded around Stone Point. Pethick and Stapleton (1994) compared the 1838 OS map with current maps reporting a significant recession of the marsh.

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 92 shows the location of the SSSI units within the Hamford Water SSSI. The extent of saltmarsh in 1997 and 2008 was digitised and a comparison was made between the two years. The results have been tabulated (Table 7) to show the total extents, gains and losses, and the net change and average rate of change within each unit.

Management Unit 2

Unit 2 encompasses the breached sea wall embankment around Skippers Island (encircling Unit 10). The majority of the saltmarsh lies adjacent to Landermere Creek (Map 93). Over the study period 98.5% of the 30.84ha of saltmarsh present in 1997 remained stable, with only 0.45ha being lost to erosion along the seaward marsh edge, particularly to the north-west of the unit bordering Landermere Creek. A small degree of accretion occurred (0.36ha) within the enclosed area of marsh to the west of the island resulting in an overall net loss of 0.09ha.

Ground truthing: Natural England comment that the accretion noted in the aerial survey is probably due to the slumping of creek edges. The sea wall embankment supports saltmarsh and transitional high marsh species.

Management Unit 3

Unit 3 runs along the southern edge of Hamford SSSI and is bounded to the north by Kirby Creek, The Wade and The Twizzle (Map 94). Large areas of saltmarsh in the unit have remained stable throughout the study period. Overall, there has been a net loss of 2.46ha leaving a total area of 51.55ha. As well as small scattered patches of loss there are several large distinct areas of erosion located mainly on the creek edge between Marsh House and Peter's Point and also to the north of Titchmarsh Marina on the channel edge. Accretion has occurred between Titchmarsh Marina and Coles Creek, adjacent to the bank, and also in satellite patches between Island Lane and Coles Creek. There was a significant covering of algae on the elevated areas of the unit in both years.

Ground truthing: The area of saltmarsh accretion to the west of the marina has developed as a result of pumping marina dredgings here in 2007. The requirement to dredge silt from

the marina inspired a positive reuse project in collaboration with Natural England; the adjacent area was bunded to contain the dredgings and encourage the establishment of saltmarsh. Pioneer and mid-level saltmarsh is developing here including – glasswort (*Salicornia* sp), sea aster (*Aster tripolium*), sea purslane (*Atriplex portulacoides*) and saltmarsh grass (*Puccinellia maritima*).

Management Unit 4

This small unit is situated north of Southall Creek at Middle Beach, to the south of Harwich (Map 95). This area of marsh has several stable, well-established creeks but erosion has occurred at the mouth of some of the larger creeks and along the north-east boundary abutting the sea wall where a 0.2ha area of saltmarsh has been covered by sand. However, a total of 0.67ha of saltmarsh has accreted in the unit predominantly on the north-eastern seaward edge, with a small area of gain at the mouth of the primary creek bisecting the site.

Ground truthing: Natural England consider that the area described as ‘accreting’ along the north-eastern seaward edge is likely to be the result of re-exposure of the marsh following sand movement. The source of this is likely to be coarse-grained sediment recharge which has redistributed following placement in front of the Foulton Hall sea wall to the south, in 1998 (a full account of this is given below under Unit 5).

Management Unit 5

This large unit contains nearly 300ha of saltmarsh and stretches along the north banks of Hamford Water and Landermere Creek. It includes Garnham’s Island, Pewit Island, New Island and the saltmarsh north of Dugmore Creek. It also extends northwards to join Unit 4, east of Foulton Hall (Maps 95, 96 & 97). The marsh is generally stable showing a net accretion of 6ha over the study period. The saltmarsh incorporates established creeks and channels leading to extensive mud pans which have changed slightly over the study years, notably at Bull’s Ooze and Garnham’s Island. However, significant changes have been recorded on the open coast /Hamford Water frontage, running from the Foulton Hall section, south of South Hall Creek, down to the southern part of Pewit Island. Apart from an area of sand deposition onto the saltmarsh at the northern end of this section, the majority of this stretch has experienced accretion of saltmarsh on the channel margins inshore of a sand bank. This accretion has further extended into the mouth of the channel running between Pewit Island and New Island. It has also appears to have spread northwards into Unit 4.

Accretion has also occurred in the extreme northern section of the unit, on the seaward edge south of South Hall Creek. Again, this has developed inside a sand bank. There appears to have been narrowing of the upper reaches of South Hall Creek, although the aerials used for this area were of poor quality.

Natural England comment: The protective sand bank referred to above may include redistributed sands and gravels sourced from the Harwich Approaches capital dredge and discharged along the exposed sea wall frontage between Irlam’s Beach and Foulton Hall in 1998. Natural processes appear to have moved the material north and south of the placement site. There is also the possibility that material placed along the Naze to Stone Point frontage, also derived from the channel dredge in the same year, has been transported onto Pye Sands (north of Stone Marsh) and may contribute sediment to this area.

The accretion shown on the aerial photograph along the Irlam's and Pewit Island frontage and the area of saltmarsh accretion indicated below South Hall Creek on the Foulton Hall section, may represent saltmarsh that has either been re-exposed or has recolonised following the seaward migration of the sand and gravel recharge due to natural processes. In the 1997 aerial photograph the coarse material appeared to have migrated landwards over the saltmarsh. This stretch (including the frontage in Unit 4) showed as an area of erosion on the maps in the Cooper (2000) report.

Management Unit 6

In 2008, this large unit positioned at the south-western end of Hamford Water SSSI, contained an area of 63.81ha of saltmarsh (Maps 98, 99 & 100). This saltmarsh is extremely fragmented by a complex channel system fed by Landermere, Moze and Kirby Creeks. Small patches of accretion and erosion are mapped throughout the unit, with large mud pans also evident from the aerial photographs. The saltmarsh has generally remained stable and undergone a net gain of 0.64ha over the eleven-year study period.

Ground truthing: Natural England have confirmed the aerial survey findings.

Management Unit 7

Unit 7 lies south of the confluence of Walton Channel and the Dardanelles and encompasses Hedge-end Island to the south and Sandcreek Salts, to the north, separated by Salt Fleet. Both areas retain embankments from historical reclamations: Sandcreek Salts is enwalled along its eastern fringe, facing onto the Walton Channel, while Hedge-end has a sea wall on three sides but is exposed along most of its interface with the Walton Channel (Map 101). The embankments support saltmarsh vegetation. There was a total saltmarsh area of 80.21ha in the unit in 2008, having accreted at an average rate of 0.29ha/yr since 1997 when the area covered 76.96ha. Accretion has occurred, infilling large channels, with saltmarsh eroding both within the body of these marshes and on the fringes. In total 4.13ha of saltmarsh was lost over the study period and 7.37ha was gained resulting in an overall net gain of saltmarsh totalling 3.24ha.

Ground truthing: The flood embankments are indicated on the aerial photograph as zones of accretion. However, although they support saltmarsh-type vegetation, they do not represent new areas of accretion

Management Unit 8

Unit 8 encircles Horsey Island, with the exception of the north-west section of foreshore occupied by Unit 13 (Map 102). The saltmarsh in this unit represented an area of 80.93ha in 2008. The majority (78.38ha) remained stable throughout the study period with a total loss of 1.36ha and a total gain of 2.55ha. Two prominent areas of gain were recorded to the north of Horsey Island. Overall the unit remained stable experiencing a small net gain of 1.20ha over the study period and averaging a gain of 0.11ha/yr.

Ground truthing: Natural England report that the two prominent areas of saltmarsh gain have developed following the placement of silt dredgings. Saltmarsh accretion shown in the north-east section of unit 8 has established from silts which have migrated from unit 13, following the discharge of recycled silts behind the sand recharge on the Hamford Water

foreshore. (A full account of the coastal protection measures undertaken along this frontage is provided in the unit 13 ground truthing section below.).

The second area of accretion is located in the embayment on the north side of Horsey Island and has developed following the pumping of silts to raise the level of existing eroding marsh in this area. Some of this sediment has migrated into an existing mud pan at this location, where pioneer saltmarsh vegetation (glasswort – *Salicornia* sp) has established.

The silt recharge over the adjacent saltmarsh was carried out by the Environment Agency (EA) in partnership with Harwich Haven Authority in 2005/6, using silts derived from navigation dredging. This was one of several schemes supported by the ComCoast project (COMBined functions in COASTal defence zones), a collaborative European Union-funded project examining the value of new flood defence techniques, which involved the EA as a participating partner and Natural England as a support partner.

Management Unit 9

The saltmarsh in Unit 9 extends north from The Naze to Stone Point, and south along the east bank of Walton Channel to the marsh below the southern bend of The Twizzle channel. The majority of saltmarsh lies along the North Sea shore at Stone Marsh (Map 103). The main body of marsh here is stable, penetrated by only a few large creeks. However, the marsh has undergone significant change, due to sand deposition over the surface, particularly on the seaward edge between the Naze and Stone Point. Saltmarsh has eroded along the east bank of the Walton Channel adjacent to Walton Hall marshes. Some accretion has occurred within the main body of the marsh and, in places, along the seaward edge of Stone Marsh. Overall, the unit has recorded a loss of 7.83ha of saltmarsh, with gains totalling 3.05ha. 57.37ha of saltmarsh remained stable throughout the study period. The net loss for the unit totalled 4.78ha over the eleven-year study period, leaving 60.41ha in 2008.

Ground truthing: The observations made from the aerial photographs on the North Sea frontage have been accounted for by Natural England: the Naze to Stone Point stretch of foreshore received sands and gravels obtained from the Harwich Approaches dredge in 1998, as part of a mitigatory package to offset possible impacts on sediment transport in the area. This material has migrated northwards with a certain amount of roll over onto the existing marsh, and this has been recorded as a 'loss' by the aerial survey.

Management Unit 10

Unit 10 encompasses the innermost areas of Skippers Island (Map 93). Due to the protection afforded by the sea wall embankment in Unit 2, the marsh in this unit is largely continuous and has remained stable throughout the study period. A total of 12.76ha of saltmarsh was recorded for 2008 having sustained a net loss of only 0.01ha over the eleven-year study period. However, outside the protection of the embankment, the unit was particularly vulnerable on the north-western boundary with Landermere Creek.

Management Unit 13

This small unit is located on the north-west shore of Horsey Island, directly adjacent to Hamford Water (Map 102). The saltmarsh in this unit has undergone significant change over the eleven-year study period. Of the 2.08ha of saltmarsh recorded in 1997, 1.02ha (49%)

eroded and 1.06ha remained stable. A further 0.60ha of marsh accreted, however, resulting in an overall net loss of 0.42ha, to leave an area of 1.67ha in 2008.

Ground truthing: Coast protection work has been undertaken on the tidal flats on this exposed north-east corner over a number of years. Thames lighters were placed here in 1988 in an effort to dissipate wave energy. In 1990, this scheme was followed up by recharging with sands and gravels between the barges, using material from the Harwich Approaches capital dredge - part of a series of measures to mitigate the impact of the channel deepening. Although this reinforced the protection, the level of the foreshore behind the sand barrier was too low to support saltmarsh development. In 1998 and 2005 silts from Harwich port were discharged into the area between the sand barrier and the sea wall. Saltmarsh vegetation has colonised the silt layer and this area is indicated on the aerial map as stable and accreting saltmarsh. The area coloured red and denoting a loss represents sand deposition over the newly generated marsh. However, this is a light cover of wind-borne sand from the adjacent sand recharge which occasionally accumulates here. Ground truthing has confirmed that the vegetation is still present and has not been lost as described here.

Summary

Table 7 Summary statistics for Hamford SSSI management units

Management Unit	Total Saltmarsh area in 1997 (ha)	Total Saltmarsh area in 2008 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change (ha/yr)
2	30.84	30.75	-0.09	0.45	0.36	30.39	-0.01
3	54.01	51.55	-2.46	3.55	1.10	50.46	-0.22
4	16.61	16.53	-0.08	0.75	0.67	15.86	-0.01
5	293.44	299.52	6.08	8.18	14.26	285.26	0.55
6	63.17	63.81	0.64	3.48	4.12	59.68	0.06
7	76.96	80.21	3.24	4.13	7.37	72.84	0.29
8	79.74	80.93	1.20	1.36	2.55	78.38	0.11
9	65.20	60.41	-4.78	7.83	3.05	57.37	-0.43
10	12.77	12.76	-0.01	0.05	0.04	12.72	0.00
13	2.08	1.67	-0.42	1.02	0.60	1.06	-0.04

4. DISCUSSION

For the purposes of future management and scientific review, comparisons have been made between the current study, a recent study and historical accounts of change reported for the Essex coastal sites. This chapter reports on how other studies have calculated saltmarsh change within the seven study sites- and makes some comparison with the results of the current work.

4.1 Previous Studies

Cooper et al (2000) undertook a study of the Essex estuaries on behalf of the Environment Agency and compared saltmarsh between the years 1973, 1988 and 1998, using baseline saltmarsh extents derived from two previous studies carried out by the Institute of Terrestrial Ecology (ITE) in 1973 and Burd in 1992.

In 1973, the ITE was commissioned to carry out ecological studies of the coastal areas of Essex, Suffolk and Kent which would potentially be affected by a proposed airport development on Maplin Sands. To underpin this study, the saltmarshes of these three counties were mapped using panchromatic vertical aerial photographs flown at a 1:10,560 scale. The maps were then traced directly onto ordnance survey base maps with no orthorectification applied (ITE, 1974).

The 1988 data was derived from a study carried out by Burd (1992) which investigated erosion and vegetation change on the saltmarshes of Essex and north Kent between 1973 and 1988. Burd's work used the maps produced from the ITE study described above and commissioned panchromatic vertical aerial photographs to be flown at a 1:5000 scale, in 1988. From these aerials, saltmarsh extents were again traced and digitised. A series of spatial analysis queries were undertaken to compare the 1988 coverage with the digitised datasets of the 1973 study. However several limitations were highlighted by Cooper et al (2000) on the methodology adopted by Burd (1992). These included:

- 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 was included on the 1973 mapping exercise, but excluded on the 1988 mapping;
- In order to overlay maps of different dates and scales, a mathematical transformation was applied to stretch the data to a common scale, which may have resulted in some errors;
- The discrepancies in scale and level of detail mapped may have given rise to considerable 'apparent losses' of saltmarsh between 1971 and 1988.

Using the data from the two previous studies as baseline years, the saltmarsh extent within a number of Essex estuaries was digitised by Cooper et al (2000) from aerials flown in 1998 at a scale of 1:5000. Areas of algae and eelgrass were excluded from the survey, however reedbed was included. Spatial analysis was undertaken to compare the 1998 coverage with the digitised datasets of the 1988 and 1973 studies.

A study by Royal Haskoning (2006) for English Nature also looked at the saltmarsh cover and change in a number of Special Protection Areas for Wild Birds (SPAs), including six of

the seven estuaries within this report, comparing the area of marsh present at the SPA designation date and the area mapped in 2004. However, this assessment was based on previous bodies of work with no new mapping of saltmarsh.

4.2 Previous Results

The results of the Cooper et al (2000) and the Royal Haskoning (2006) studies are shown in Table 8.

Table 8 Results from previous studies

	Total saltmarsh area (ha)			Net change in saltmarsh (ha & %)	Rate of Change (ha/yr)
Cooper et al (2000)	1973	1988	1998	1973-1998 (ha & %)	Rate of Change (ha/yr)
North Thames (including Benfleet and Southend Marshes SSSI)	365.9	307 (original) 197 (revised)	181	16ha (8.1%) loss (Cooper et al (2000) calculated net change from 1988 to 1998)	-1.60
Blackwater Estuary	880.2	738.5	683.6 (1997)	196.6ha (22.3%) loss (1973-1997)	-8.19
Colne Estuary	791.5	744.4	694.9	96.6ha (12.2%) loss	-3.86
Crouch & Roach Estuaries	467.1	347.4	307.8	159.3ha (34.1%) loss	-6.37
Dengie	473.8	436.5	409.7	64.1ha (13.5%) loss	-2.56
Foulness	No data	No data	218.4	No data	No data
Hamford Water	876.1	765.4	621.1	255ha (29.1%) loss	-10.20
Royal Haskoning (2006)	Designated year	Area at designation (ha)	Area in 2004 (ha)	Designated year – 2004 (ha & %)	Rate of Change (ha/yr)
Benfleet and Southend Marshes	1994	140.2	126.4	13.8 (9.8%) loss	-1.38
Blackwater Estuary	1995	684.2	621.1	63.1 (9.2%) loss	-7.01
Colne Estuary	1994	692.2	635.9	56.3 (8.1%) loss	-5.63
Crouch and Roach Estuaries	1998	410.9	344.6	66.3 (16.1%) loss	-11.05
Dengie	1994	420.0	393.1	26.9 (6.4%) loss	-2.69
Foulness	1996	No data	No data	No data	No data
Hamford Water	1993	686.4	527.8	158.6 (23.1%) loss	-14.42

4.2.1 BENFLEET AND SOUTHEND MARSHES SSSI

Between 1973 and 1988, a total of 46.7ha of natural saltmarsh accretion occurred, but this did not offset the losses due to reclamation (22.3ha) and natural erosion (83.3ha). The net result was a loss of 58.9ha of saltmarsh. Saltmarsh losses occurred through the internal disintegration of saltmarsh on the east side of Canvey Island, and, the two most exposed areas of marsh, at Canvey Island and Two Tree Island, experienced losses at their seaward edges (Burd, 1992). Cooper et al (2000) reported that the greatest changes in saltmarsh extent occurred at the exposed seaward edges of Two Tree Island and the eastern edge of Canvey Island. The greatest accretion was observed towards the head of Benfleet Creek.

4.2.2 BLACKWATER ESTUARY SSSI

880.2ha of saltmarsh was recorded in 1973 in the Blackwater representing the largest area of marsh in Essex. Despite 58.5ha of natural accretion between 1973 and 1988, a total of 200.2ha of marsh was lost to erosion. Burd (1992) reported the greatest losses along the seaward edge of many marshes, most notably on the north-east facing edges of Osea Island and St Lawrence Bay. There was also internal saltmarsh erosion resulting in small islands of unstable marsh and mud-mounds. Between 1988 and 1997, the estuary experienced a total loss of 149.3ha of saltmarsh, but during this time an additional 94.34ha of saltmarsh was created due to natural accretion and the implementation of three large managed realignment sites (Cooper et al, 2000). The areas which experienced natural accretion were located either towards the head of the main Blackwater channel or towards the heads of smaller creeks. The largest areas of erosion were reported along the seaward edge of many marshes, e.g. Pewit Island and along St Lawrence Bay, and internally within the marsh bodies, e.g. Ray Island, Old Hall marshes and Tollesbury Wick.

4.2.3 COLNE ESTUARY SSSI

The Colne estuary lost a comparatively small proportion of saltmarsh between 1973 and 1998. Although a total of 97.7ha of the original 791.5ha was lost due to both erosion and reclamation, natural accretion of 50.6ha had also occurred, resulting in a net loss of 47.1ha. Burd (1992) reported that the largest single area of erosion was located at the northern end of the large area of marsh at Colne Point. Whilst several other smaller areas of erosion were observed at the seaward edge of some marshes, further erosional losses were observed to be due to an increase in creek widths within the marsh. By 1998, Cooper et al (2000) reported that a further net loss of 49.5ha had been experienced within the Colne. This was due to erosion along the edge of the main channels and creeks throughout the entire estuary - the latter ensuing through processes of creek widening within the marsh - and additionally on the exposed south-east facing marshes on Rat and Pewit Islands.

4.2.4 CROUCH & ROACH ESTUARIES SSSI

In 1973, 467.1ha of saltmarsh was recorded in the River Crouch. However following 22.1ha of landclaim and 120ha of erosion, and with only 26.4ha of accretion, Burd (1992) reported a net loss of 119.7ha by 1988. The majority of losses occurred through the process of internal disintegration of the marsh, most notably on Bridgmarsh Island and marshes situated north and south of Fambridge. Cooper et al (2000) reported that of the 347.4ha of saltmarsh recorded in the River Crouch in 1988, a total of 80ha was lost but an extra 45.5ha was gained through natural accretion. Again, the main areas recording loss were Bridgmarsh Island, where the internal creek network was degrading, and at north and south Fambridge.

The most notable area of natural accretion was within Clementsgreen Creek towards the head of the estuary.

4.2.5 DENGIE SSSI

Dengie was observed to have experienced both the lowest total erosion (46.7ha) and the lowest total accretion (9.4ha) of saltmarsh between 1973 and 1988, indicating that the majority of the marsh area was relatively stable despite evidence of losses at the seaward edge (Burd, 1992). Cooper et al (2000) also reported small losses and low accretion rates on the Dengie between 1988 and 1998, corroborating Burd's findings that Dengie is a relatively stable marsh which suffers from erosion at its seaward face. Although some of the primary creeks increased in width, particularly at the mouth, accretion often occurred towards the heads of these creeks.

4.2.6 FOULNESS SSSI

No data were available for comparative purposes in any previous study.

4.2.7 HAMFORD WATER SSSI

In 1973, 876.1ha of saltmarsh was recorded in Hamford Water but by 1988 this had reduced to 765.4ha. Although there was considerable accretion over this time period (59.9ha in total), erosion predominated with a total loss of 170.6ha recorded, representing a net loss of 110.7ha of saltmarsh over the fifteen years. The erosion was recorded along the more exposed coastlines of Horsey Island and the eastern side of Pewit Island (Burd, 1992). Between 1988 and 1998, Hamford underwent a net loss of 144.3ha of saltmarsh, representing 18.9% of the area present in 1988. The areas subject to severe erosion were again the easterly facing edges close to the mouth of Hamford Water at Pewit Island and Stone Point (Cooper et al, 2000). Marshes in the vicinity of the Wade experienced losses at the seaward margins, while most of the marshes towards the head of the Water experienced significant internal losses.

4.3 Comparison to Current Study

A direct comparison of saltmarsh extent within the seven SSSIs cannot be made between the current study and the results obtained by Cooper et al (2000) and Royal Haskoning (2006) due to the application of different geographical criteria regarding the areas calculated. The current work focuses on specific SSSI management units within each coastal SSSI, where the SSSI is notified for saltmarsh extent, and not the whole area of each estuary. For instance the Upper Colne Marshes SSSI is not included in this study because it has not been notified for saltmarsh 'extent'. In addition, the studies followed different specifications with regard to the type of vegetation to be included. The Cooper assessment mapped reedbed as part of the saltmarsh classification whereas the current study has excluded areas of transitional reedbed habitat. The Royal Haskoning report was limited to the area of the rivers and estuaries designated as Special Protection Areas (SPAs), and therefore the areas will also be different to the Cooper report, though perhaps more comparable to the current study.

Similarly, net gains and losses cannot be compared directly due to the different study periods covered both within the current study and those of the comparable studies. However, some basic comparisons can be made by assessing the average annual rates of change. The results of the current study are provided in Table 9. Broadly, this study has reported a net gain of saltmarsh in the management units mapped for Benfleet and

Southend Marshes, the Blackwater Estuary, the Crouch and Roach Estuaries and Hamford Water; but a net loss of saltmarsh has been recorded within the Colne Estuary, Dengie and Foulness SSSIs. The studies undertaken by Royal Haskoning and Cooper found net losses for all SSSIs, with the exception of Foulness which was outside the study remits.

Table 9 Current study results

SSSI	Total Saltmarsh area (ha) in baseline year calculated within the Man. Units considered	Total Saltmarsh area (ha) in comparative year calculated within the Man. Units considered	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change in current study (ha/yr)	Rate of change in Cooper (*) & Royal Haskoning (**) reports (ha/yr)
Benfleet & Southend Marshes ⁽¹⁾	162.76	174.76	12.00	6.17	18.17	156.59	1.09	-1.60 (*) -1.38 (**)
Blackwater Estuary* ⁽²⁾	724.02	724.96	0.94	49.73	50.67	674.29	-0.13	-8.19 (*) -7.01 (**)
Colne Estuary ⁽³⁾	719.63	714.30	-5.33	14.35	9.03	705.27	-0.62	-3.86 (*) -5.63 (**)
Crouch & Roach ⁽⁴⁾	505.33	508.97	3.64	41.47	45.11	463.86	0.52	-6.37 (*) -11.05 (**)
Dengie ⁽⁵⁾	455.48	439.88	-15.60	19.18	3.58	436.30	-1.42	-2.56 (*) -2.69 (**)
Foulness ⁽⁶⁾	279.45	271.89	-7.56	17.19	9.63	262.26	-0.85	No data
Hamford Water ⁽⁷⁾	694.82	698.13	3.32	30.80	34.11	664.02	0.30	-10.20 (*) -14.42 (**)

⁽¹⁾ 4 units (1997 – 2008); ⁽²⁾ 58 units (1997/2000 – 2008); ⁽³⁾ 24 units (1997/2000 – 2008); ⁽⁴⁾ 40 units (2000 – 2007);

⁽⁵⁾ 4 units (1997 – 2008); ⁽⁶⁾ 15 units (1997/1999 – 2007); ⁽⁷⁾ 10 units (1997 – 2008).

* Orplands West not included

Percentage of total saltmarsh area excluded from survey due to unavailability of Unit 17 (Colne) and Unit 47 (Blackwater) aeralis is c.0.60% (from c.2000 aerial photographs).

4.3.1 BENFLEET AND SOUTHEND MARSHES SSSI

Map 2 shows the saltmarsh changes mapped within the Benfleet and Southend Marshes SSSI management units. Of the 162.76ha of saltmarsh present in 1997, a total of 6.17ha was lost due to erosion throughout the SSSI, but an additional 18.17ha was gained through accretion by 2008. This resulted in a net gain of 12ha by 2008 representing a 7.4% increase over the study period (Table 9). It is difficult to make any comparisons of the rates of change of this current study to the Cooper and Royal Haskoning reports due to the different geographical extents used. The four units assessed within this current study have each shown a net gain whereas the estuary as a whole showed a net loss in the previous studies.

4.3.2 BLACKWATER ESTUARY SSSI

Maps 4 - 30 show the saltmarsh changes mapped within the Blackwater Estuary SSSI management units. Table 9 shows that for the 58 units compared between 1997/2000 and 2008, of the 724.02ha of saltmarsh present in 1997/2000, by 2008 a total of 49.73ha was lost due to erosion throughout the SSSI, with 50.67ha gained through accretion (10.77ha of which was directly attributable to the Orplands managed realignment scheme (eastern SSSI component only). This resulted in an overall net gain of 0.94ha by 2008.

Despite the overall net gain, the average rate of change in saltmarsh over the studied area equates to an average loss of 0.13ha/yr despite the gain at the managed realignment site at Orplands. These figures are significantly different to the high rates of loss of 8.19ha/yr and 7.01ha/yr reported by Cooper et al (2000) and Royal Haskoning (2006) respectively. It is of note that despite these high net losses the Cooper et al (2000) study included the gains at Northey Island, Tollesbury and Orplands realignment sites. Royal Haskoning (2006) only included the sites within the Blackwater Estuary SPA (Orplands East and Northey Island).

4.3.3 COLNE ESTUARY SSSI

Maps 32 - 41 show the saltmarsh changes mapped within the Colne Estuary SSSI management units. The Colne Estuary SSSI has also suffered a net loss of saltmarsh within its management units over the study period (1997/2000 – 2008). Of the 738.61ha of saltmarsh present in the SSSI in 1997/2000, a total of 17.25ha was lost due to natural erosion throughout the SSSI, with only 9.94ha gained through natural accretion by 2008. This resulted in a net loss of 7.31ha by 2008 equating to a 1% loss from the baseline figure. The rate of change of saltmarsh within this current study has been calculated at a loss of 0.8ha/yr, and is significantly lower than the respective losses of 3.86ha/yr and 5.63ha/yr reported by Cooper et al (2000) and by Royal Haskoning (2006).

4.3.4 CROUCH & ROACH SSSI

Maps 44 - 73 show the saltmarsh changes mapped within the Crouch and Roach SSSI management units. Table 9 shows that of the 505.33ha of saltmarsh present in the Crouch and Roach SSSI in 2000, a total of 41.46ha was lost due to natural erosion throughout the SSSI, but an additional 45.11ha was gained through natural accretion. This resulted in a small net gain of 3.65ha by 2007 equating to a 0.7% increase in the total area since 2000. The results indicate that, on average, the units within this SSSI are relatively stable with 91% of saltmarsh in 2007 remaining unchanged since 2000. The rate of change is currently reported as a gain of 0.52ha/yr. These findings are in contrast to those of Cooper et al (2000) and Royal Haskoning (2006) who reported losses of 6.37ha/yr and 11.05ha/yr respectively.

4.3.5 DENGIE SSSI

Maps 75 - 78 show the saltmarsh changes mapped within the Dengie SSSI management units. The Dengie SSSI has suffered the greatest net loss of saltmarsh over the eleven year study period compared with the other six SSSIs surveyed. Table 9 shows that of the 455.48ha of saltmarsh present in 1997, a total of 19.18ha was lost due to natural erosion throughout the SSSI, with an additional 3.58ha gained through natural accretion. This resulted in a net loss of 15.60ha by 2008 representing 3.4% of the baseline total area. The average rate of change in saltmarsh area is currently reported as a loss of 1.42ha/yr between 1997 and 2008, in contrast to a rate of loss of 2.56ha/yr reported by Cooper et al (2000) between 1973 and 1998. However this difference could be attributed to the different

geographic areas assessed. Cooper did not include the saltmarsh at Holliwell Point in the Dengie assessment. Also the rate of change average only applies over the period stipulated – a large storm event could significantly affect the yearly rate of change.

4.3.6 FOULNESS SSSI

Maps 80 - 91 show the saltmarsh changes mapped within the Foulness SSSI management units. Table 9 shows that for the 15 units compared between 1997/1999 and 2007, of the 279.45ha of saltmarsh present in 1997/1999, a total of 17.19ha was lost due to natural erosion throughout the SSSI, with only 9.63ha gained through natural accretion. This resulted in a net loss of 7.56ha by 2007 which represented 2.78% of the total area in 1997. The current study calculated that the average rate of change represented a loss of 0.85ha/yr. No assessment had previously been made by Cooper et al (2000) or Royal Haskoning (2006) for the Foulness SSSI and therefore no comparison could be made.

4.3.7 HAMFORD WATER SSSI

Maps 93 - 103 show the saltmarsh changes mapped within the Hamford Water SSSI management units. Table 9 shows that of the 694.82ha of saltmarsh present in the Hamford Water SSSI in 1997, a total of 30.80ha was lost due to erosion throughout the SSSI, with 34.11ha gained through accretion. This resulted in a net loss of 3.32ha by 2008, representing 0.5% of the total area in 1997. The rate of change in saltmarsh was recorded as a gain of 0.30ha/yr in the current study. This was a significantly different outcome compared to the losses of 10.20ha/yr and 14.42ha/yr recorded by Cooper et al (2000) and Royal Haskoning (2006) respectively in previous years.

4.4 Consideration of the aerial survey conclusions compared with field observations and previous work

As discussed in Section 4.3, the results show that the rate of change is considerably different, compared with the findings of previous studies. It is outwith the remit of the current work to speculate on the possible reasons for this, apart from comparing the methods adopted and areas covered by the previous studies (Section 4.1). Net gains have occurred in the Blackwater, Crouch and Roach, Hamford Water, and Benfleet and Southend SSSIs.

Within the sites that suffered net erosion, ie the Dengie, Foulness and the Colne, it was the exposed open coast units which accounted for the most significant losses. For the Dengie, all SSSI units were affected on the seaward face, with the greatest loss being recorded immediately south of Sales Point (Unit 5). On Foulness, Units 32 and 33 - running the length of Maplin Sands, and including Foulness Point - were the worst affected, while the Colne incurred a substantial loss (1.61ha) at the outer mouth at St Osyth Beach (Unit 41).

The net gain recorded overall for the Blackwater is achieved by the significant development of saltmarsh in Unit 88 within the Orplands East realignment site. Vulnerable areas included Units 13 and 18, exposed to the North Sea at the entrance to the Virley Channel and the Mersea Quarters, which once received the full protection of the Nass Spit. Marked loss was also recorded in the upper reaches at Northey Island (Unit 54).

Accretion within Benfleet and Southend Marshes SSSI is mostly attributable to an increase in common cord grass (*Spartina anglica*) and this is discussed in more detail in Section 4.4.1.

Hamford Water appears to have benefitted from sediment recharge placements.

The aerial survey reports that throughout the sites large areas of saltmarsh remained stable, for example, Fingringhoe Marsh and the Geedon Saltings on the Colne (Unit 14). The large expanse of stable saltmarsh at Colne Point Nature Reserve in Brightlingsea Reach, is protected by the Colne spit, but this could potentially be threatened in the future if erosion recorded at St Osyth Beach were to advance westwards (Unit 39). Field observations support the conclusions here. The Crouch and Roach remained relatively stable overall, though it would be difficult to obtain this perspective on the ground.

However, taking an overview of the aerial survey report and the field observations provided, erosion continues to be a feature on all the Essex SSSIs. The condition assessments verify the aerial study findings that saltmarsh is eroding particularly on the channel margins and also at the creek edges.

4.4.1 CONDITION OF THE ESSEX SALTMARSHES

The aerals simply provide an interpretation of the extent of vegetation cover and cannot report on the quality and condition of the saltmarsh. Field surveys frequently refer to the marginalisation of the lower pioneer marsh and the higher transitional marsh due to coastal squeeze and this cannot be construed from the aerial photographs. The aerals cannot provide information on the height of the saltmarsh, and cannot pick up changes in vegetation type associated with this. However, the growth pattern of common cord grass (*Spartina anglica*) was recognisable from the aerial assessment.

Common cord grass (*Spartina anglica*) appears to have proliferated between Leighbeck Point and Canvey Point (Unit 7, Benfleet and Southend SSSI). The absence of saltmarsh vegetation from the 1997 aerals suggests that silts could be building up here and this has raised the flats sufficiently to support saltmarsh growth. However, in many cases common cord grass is the last species to colonise the saltmarsh as part of a degenerative process. When this species establishes it can persist over several years. An example of this is illustrated in Unit 57 of the Blackwater (refer to Section 3 under Natural England comments). Observations of the 2007/08 aerals, when compared with the Posford Haskoning survey (2003), show that a zone of common cord grass has persisted along the seaward edge at Cooper's Creek for at least five years. Recent field observations have been compared with the Posford Haskoning (2003) survey in Unit 17 on the Colne (though there was no aerial coverage for this unit). Again, common cord grass distribution matches the earlier saltmarsh community mapping and was noted along the margins of the saltmarsh between the Essex Wildlife Trust Reserve, at Fingringhoe, and Ballast Quay. This suggests that there has been sustained growth of common cord grass at this location for at least seven years.

Though common cord grass may perform a protective function in the situations quoted above, it invariably persists as a 'monoculture' once established.

Examples of saltmarsh vegetation change associated with changes in height, reported in the ground truthing sections of the current survey, are provided below.

Field observations report a change in the level of the marsh indicated by the saltmarsh vegetation type and this has been noted on many of the condition assessment summaries provided in the results section. Sometimes the change can be quite subtle ie from a higher level sea purslane (*Atriplex portuclacoides*) marsh to low, transitional marsh. This type of change is referred to in Natural England's condition assessment for Unit 3 on the Blackwater (Section 3.2). There are many references to marsh reverting to pioneer vegetation, as part of

the erosive process in the ground truthing/condition assessment summaries for the Crouch and Roach.

Slumping and cliffing of saltmarsh and the development of mud mounds are commonplace both at the seaward edge and within some creek systems. Field observation notes that pioneer species although part of the low-mid marsh complex are frequently associated with secondary succession rather than the building phase of a saltmarsh. As the saltmarsh slumps, pioneer species colonise as inundation by sea water becomes more frequent. Though it has not been verified from the aerial interpretation, the slumping of saltmarsh into creeks may create the appearance of 'accretion', and an increase in extent, and this may be reported as a 'gain'. This is difficult to determine on the ground as internal marsh creeks are often inaccessible.

4.4.2 EVIDENCE OF CHANGE DUE TO COASTAL INITIATIVES TO PROTECT AND CREATE SALTMARSH

The aerial photographs have proved valuable in highlighting the changes resulting from the placement of sediment recharge.

Sands and gravels from the Harwich Approaches dredge have been reused extensively in Hamford Water SSSI, particularly, as well as the Blackwater SSSI. Silt recharge has also been undertaken within these sites. Both of these management techniques have been supported by Natural England.

Saltmarsh accretion, due to the reuse of silts, has shown very clearly on the aerials in Hamford Water in Unit 3, adjacent to Titchmarsh Marina, and on the north bank of Horsey Island (Units 8 and 13). Recycled silts have also been used to successfully regenerate saltmarsh in Units 50 and 52 in the upper Blackwater. The details of these schemes are provided within the individual unit assessments in Section 3 of this report.

Coarse-grained sediment has been successful in reducing wave energy in vulnerable areas, for example on the exposed south-eastern margins of Cobmarsh Island in the Blackwater (refer to Unit 2 in Section 3).

In Hamford Water, sand and gravel recharge has migrated landwards along the Naze to Stone Point frontage and this is recorded by the aerial study as a loss. Nevertheless this is testament to the role that recharge plays in absorbing wave energy. Sand and gravel recharge has been redistributed by natural processes along the Pewit Island/Irlam's Beach/Foulton Hall frontage in (Units 4 and 5) and a band of accretion is reported behind this material along most of this stretch. As there has been no ground truthing along this section, it is not known whether the accretion represents newly established marsh. The same area showed some sand deposition over the saltmarsh in the 1997 aerials (in the current study) and the Cooper (2000) study recorded losses of saltmarsh here. This suggests that both landward and seaward migration may be occurring as coastal processes rework the material. If the advance and retreat of this material is very dynamic, saltmarsh may be covered and uncovered at different times and the aerial photographs may be capturing these different states depending on when they are flown.

4.5 Recent and planned realignment and sediment reuse projects

The Environment Agency undertook a realignment at Devereux Farm on Hamford Water in 2009, and a second realignment is proposed to take place adjacent to this site. The realignment is located between Island Lane and Rigdon's Lane, south of Unit 24, and aims

to create 49ha of intertidal habitat. The RSPB's Wallasea Island Wild Coast Project received planning consent in 2009 with plans to create 274ha of saltmarsh within an area of 677ha. The scheme will be under development over the next seven years. The site location is adjacent to Units 44 and 45 of the Crouch and Roach Estuaries SSSI.

Brightlingsea Harbour Authority are using silts dredged from the harbour to recreate saltmarsh on Cindery Island in the Colne (Unit 35), discharging into disused oyster pits.

5 CONCLUSION

The current survey can be used as a baseline to inform Natural England's condition assessments and assess the effectiveness of existing coastal initiatives. It can also be used as an aid to forecasting long-term trends.

In simplistic terms, the current rates of change for saltmarsh in each SSSI can be used to generate the following estimates of the area of saltmarsh likely to be present in 2060 and 2110 respectively (Table 10).

Table 10 Predicted saltmarsh area within the Essex SSSIs over the next 50 to 100 years.

Estuary	Total saltmarsh area in most recent year mapped calculated within the management units considered (ha)	Rate of change in current study (ha/yr)	Area of saltmarsh predicted for 2060 (ha)	Area of saltmarsh predicted for 2110 (ha)
Benfleet & Southend Marshes	174.76	+1.09	229.26	283.76
Blackwater	724.96	-0.13	718.46	711.96
Colne	714.30	-0.62	683.6	652.6
Crouch & Roach	508.97	+0.52	534.97	560.97
Dengie	439.88	-1.42	368.88	297.88
Foulness	271.89	-0.85	229.39	186.89
Hamford	698.13	+0.30	713.13	728.13

However, this is oversimplistic as it makes the broadest assumption that the rate of change in saltmarsh extent over the last 10 years is linear, and that it is likely to continue to follow a linear trend at the same rate. In reality, there are many factors, both environmental and human, affecting the rates of gain and loss of saltmarsh communities, and therefore predictions of change are difficult to make. Factors include erosion and accretion, land claim, presence of an embankment, storm events, and sea level change. Some factors can be managed through the application of coastal management initiatives. However in considering long-term change, sea level rise is an important factor. The natural response provoked by sea level rise is a gradual migration of saltmarsh communities up the shore relative to the shifting tidal range. However, much of the coastline is altered in some way by sea defences, thereby physically restricting this landward shift leading to the enlargement of existing channels and the erosion of intertidal mudflats and saltmarsh areas.

In order to mitigate against potential effects, the locations and extent of losses directly attributable to sea level rise should first be assessed. If affirmative predictions are to be made, an elevation model would be necessary to calculate the change in intertidal area based on sea level rise scenarios. From this, calculations could be made for:

- a) the total area within a tidal range suitable for saltmarsh colonisation both at present and in the future;
- b) the area currently colonised by saltmarsh as a percentage of the total area currently suitable for saltmarsh (in terms of tidal inundation); and
- c) the area of existing saltmarsh which, according to current sea level rise predictions, would be submerged and lost by 2060 and 2110 respectively.

In addition, any known or expected plans related to managed realignment or sea defence improvement could also be incorporated into the predictive model thereby improving its accuracy.

Sea level rise scenarios exist for both the UK as a whole and the east of England. In a report carried out by Pye (2005), relative sea level rise was calculated taking into account the effects of geographical variations in land subsidence and uplift, and current best estimates of future relative sea level change in eastern England. Table 11 shows the results for four UKCIP02 scenarios using the Hadley Centre models.

Table 11 Sea level rise predictions in eastern England.

UKCIP02 Scenario	Relative sea level change (cm)		
	2020s	2050s	2080s
Low emissions	12 (10-20)	24 (17-40)	36 (22-61)
Medium- Low emissions	13 (10-20)	25 (17-42)	39 (24-67)
Medium - High emissions	12 (10-20)	25 (18-42)	43 (26-72)
High emissions	12 (10-20)	28 (19-46)	49 (29-82)

Taking the average value for the High Emissions Scenario, the predictions imply an average maximum rate of sea level rise in East Anglia of about 5mm/yr over the next century. Allowing for the effects of greater local crustal subsidence in the Outer Thames estuary, this figure increases to 6mm/yr. However, it needs to be stressed that these are extreme values and are likely to be subject to wide margins of error. Taking the low emissions scenario gives a predicted average rate of rise for East Anglia of 3.6mm/yr, but with a possible range of 2.2 to 6.1mm/yr. The lower error limit is only slightly higher than recent historical rates (Pye, 2005).

Current predictions by UKCP09, presented in Table 12, are central estimates for each decade of relative sea-level changes (cm) with respect to 1990 levels for the UKCP09 high, medium and low emissions scenarios for London.

Table 12 Sea level rise predictions for London (UKCP09)

	London (cm)		
	High	Medium	Low
2020	11.5	9.7	8.2
2050	25.8	21.8	18.4
2080	43.3	36.3	30.5

Each of the above scenarios vary considerably but ultimately all indicate that sea level rise, at some point in the future will adversely affect existing saltmarsh.

5.1 Recommendations for future work

Future studies on the Essex coast might consider monitoring changes in the quality of saltmarshes and changes in extent in target areas, based on the information provided in this study.

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*Abstraction Licence 8/37/*S/0140 Re: River Chelmer, Blackwater Estuary, Hanningfield Reservoir, Langford Recycling Plant, Essex and Suffolk Water.*

APPENDIX 1 - AERIAL PHOTOGRAPHS USED IN THIS STUDY

Location	Unit No	Date	Scale	Details of Aerial Photographs used	Source & Comments
Benfleet and Southend Marshes	All units	1997	1:10000	B&W	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team. - No coverage available of the western tip of Unit 6 in 2008, and so 2007 aerals were used for this small area..
	All units	2008		Colour	
Blackwater Estuary	1-3, 13, 19, 20, 25-27, 29-33, 61-65, 67-71, 74-77, 88 & Orplands West	1997	1:10000	Colour	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team. - No coverage was available in any baseline year for Unit 47 and was therefore excluded from the assessment..
	4, 6-12, 18, 36, 37, 39, 40, 43-45, 48-60	2000		Colour	
	All units	2008		Colour	
Colne Estuary	1,3,5,27-30, 33, 35-37, 39-41	1997	1:10000	Predominantly Colour	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team - No coverage was available in any baseline year for unit 17 so it was therefore excluded from the assessment. - Western end of Unit 7 not available for 2008 so 2006 aerals used.
	6, 7, 9, 14, 16, 18, 20, 21, 23	2000		Colour	
	All units	2008		Colour	
Crouch & Roach Estuaries	All units	2000	1:10000	Colour	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team - Errors in the orthorectification of the aerial photographs has led to a shift in the mapping of extents between 3 and 6.5m generally from north to south. This does not however affect the overall saltmarsh extent calculations within the units, but may give a false impression on total saltmarsh losses and gains.
	All units	2007		Colour	
Dengie	All units	1997	1:10000	Mixture of B&W and Colour	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team - A small section of Unit 5 uses a 2007 tile where no coverage is available in 2008.
	All units	2008		Colour	
Foulness	2, 3, 5, 14, 17, 19, 22, 23, 24, 26 & 33	1997	1:10000	Colour	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team

Location	Unit No	Date	Scale	Details of Aerial Photographs used	Source & Comments
	28, 29, 31 & 32	1999		Colour	
	All units	2007		Colour	
Hamford Water	All units	1997	1:10000	B&W	<ul style="list-style-type: none"> - Source: Environment Agency's Shoreline Management Team - 0.05km² triangular area missing from Units 2 and 10 in all possible comparative years – therefore area mapped as baseline extent. - Missing areas of 1997 coverage have been substituted by 2000 coverage.
	All units	2008		Colour	

APPENDIX 2 – LIMITATIONS OF THE MAPPING METHODOLOGY

The reliability of the analysis of aerial photographs depends on two key factors: the suitability and quality of the aerial photographs available and the inherent difficulties associated with interpreting them.

Due to restricted availability of digital aerial photographs, a number of different baseline and comparative years were used between the seven Essex SSSIs. Although all aerials were confirmed as being orthorectified, the accuracy of this process is variable and problems were found for some of the areas potentially leading to unrepresentative net differences in saltmarsh between the baseline and comparison years.

For example, some of the aerial photographs for the Crouch and Roach displayed a slight shift of between 3 and 6.5m to the Ordnance survey reference and the SSSI boundaries based upon it (Plate 3). Although this did not affect the total extent of saltmarsh calculated in each year, the areas of net accretion and erosion between the baseline and comparative years have been significantly skewed. Due to the nature of orthorectification, these discrepancies are not uniform and therefore cannot be easily accounted for or corrected.



Plate 3 – Variable orthorectification between baseline and comparison years

The brightness and colour balance varied slightly between some of the aerials – the boundaries between saltmarsh and other vegetation such as green algae (*Enteromorpha* sp) were more difficult to differentiate in the darker photographs as subtle colour differences and textures were less evident (Plate 4). Aerials between years also varied in clarity due to either atmospheric haze or photograph resolution (Plate 4).



Plate 4 Differences in atmospheric haze, photograph resolution and colour saturation.

All photographs were taken at the lower stages of a tide exposing most saltmarsh habitats sufficiently. There were however cases where the tide was intruding into the saltmarsh potentially inhibiting boundary identification.

Most aerals appear to have been taken during midday hours and therefore shadows are generally small. In some cases shadows can be useful for distinguishing elevated vegetation such as saltmarsh from mudflats and algae. However, shadows can also cause problems when defining the boundaries of vegetation particularly where the saltmarsh is dark in colour. In some extreme cases large shadows were cast by trees obscuring upper saltmarsh boundaries.

Finally, fragmentation of some areas of saltmarsh which were previously mapped as one polygon in one year has led to the decrease in extent by the comparison year. An example of this can be seen in Plate 5 where the area was digitised as one polygon in a baseline year, as the individual saltmarsh patches were too close together for individual polygons. However by the comparative year, the saltmarsh patches had further eroded, becoming more fragmented, with wider creeks, requiring the digitisation of the individual fragments. In cases such as these, under this method, the losses calculated are often larger than are actually the case.



Plate 5 Further fragmentation of saltmarsh between years leads to differences in mapping technique and subsequent area/extent calculated