

**Suffolk Estuarine SSSIs –
Assessment of Changes in Extent of
Saltmarsh Over the Period
1999/2000 to 2006/2007**

VOLUME 1

Report to Natural England

Institute of Estuarine and
Coastal Studies
University of Hull

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Natural England

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For and on behalf of the Institute of Estuarine and Coastal Studies
Approved by: _____
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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. 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)¹. 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 Suffolk Estuaries & Study Rationale

Suffolk saltmarshes are important for several nationally rare, scarce or threatened species of plant including the Dittander (*Lepidium latifolium*), Cord Grass (*Spartina maritima*) and Shrubby Seablite (*Suaeda fruticosa*). As part of the estuarine ecosystem, saltmarshes help to support significant numbers of breeding waders such as Redshank and Oystercatcher and are grazed by wildfowl such as Wigeon and Teal. Twite spend the winter on Suffolk saltmarshes and are listed on the red list of Birds of Conservation Concern in the UK. The Deben Estuary is internationally important for the overwintering Dark-bellied Brent Geese which feed on saltmarsh. One of Britain's rarest land snails, the Narrow-mouth Whorl Snail (*Vertigo angustior*) (a Suffolk BAP species), occurs in the transition zone just above saltmarsh at Martlesham Creek on the Deben Estuary (Suffolk Wildlife Trust, 2007).

Saltmarsh in Suffolk has been undergoing erosion due to coastal squeeze and it is important to assess any changes in extent to determine the condition of the management units. As it is unfeasible to obtain an accurate assessment of changes in saltmarsh extent in the field, and therefore orthorectified aerial photos can be used as an alternative to aid accurate reporting. Previous studies carried out by Cooper & Cooper (2000), 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 four Suffolk estuarine SSSIs between 1999/2000 and 2006/07. Two key saltmarsh attributes within the 63 management units will be assessed including:

¹ Annex I - Glossary of terms used in Common Standards Monitoring and Reporting <http://www.jncc.gov.uk/page-2325>

Saltmarsh extent - The Suffolk 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, 2004²).

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 1999/2000 and 2006/2007
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
3. to present the data in a format that will allow site assessment of changes in these attributes
4. to report on the current assessment of changes in saltmarsh extent (1999/2000 and 2006/2007) and compare with the previous study carried out by Cooper et al 2000 (1971 to 1998)
5. to report on the change in creek network from 1999/2000 and 2006/2007

² JNCC, 2004. Common Standards Monitoring Guidance for Saltmarsh Habitats. Version August 2004 Updated from (February 2004)

2. METHODS

2.1 Study Area / Management Units

Figure 1 shows the geographical area of the Suffolk estuarine SSSIs which has been covered by this report. The Management Units chosen for the assessment by Natural England within the four estuaries include:

- Alde-Ore Estuary SSSI – Units 1-12, 19, 23-25, 28, 29, 31, 41 & 43
- Deben Estuary SSSI – Units 1 to 22
- Minsmere-Walberswick Heaths & Marshes SSSI – Units 8, 60, 62-65
- Orwell Estuary SSSI – Units 1-9, 11-13, 15 & 21

A total of 63 units.

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 1999 or 2000 to be used as the baseline for all management units
- 2006 or 2007 for the comparative year for all management units

2.3 GIS Techniques

2.3.1 MAPPING

True colour aerial photographs for 1999, 2000 and 2007 were provided by Natural England for this study through their agreement with Geostore / Infoterra Ltd. These were captured at a scale of 1:10,000 and a resolution of 25cm and were provided to IECS fully rectified and in Mapinfo format. Additional photographs for 2006 were sourced for the Minsmere-Walberswick Heaths and Marshes SSSI from the Environment Agency. Full details of the aerial photographs used can be found in Appendix 1. GIS files of the SSSI boundaries and Management Units were downloaded from the Natural England website. All data used was projected in British National Grid.

In MapInfo (v9.0) the management units were overlaid onto the aerials and the saltmarsh was digitised as enclosed polygons within each of the prescribed units. Digitising was generally undertaken at a scale of 1:700 to maintain consistency throughout unless the resolution or clarity of the photo at this scale compromised feature identification. Where the saltmarsh extended to the landward 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, and that all shared boundaries were clipped ensuring no slithers or gaps.

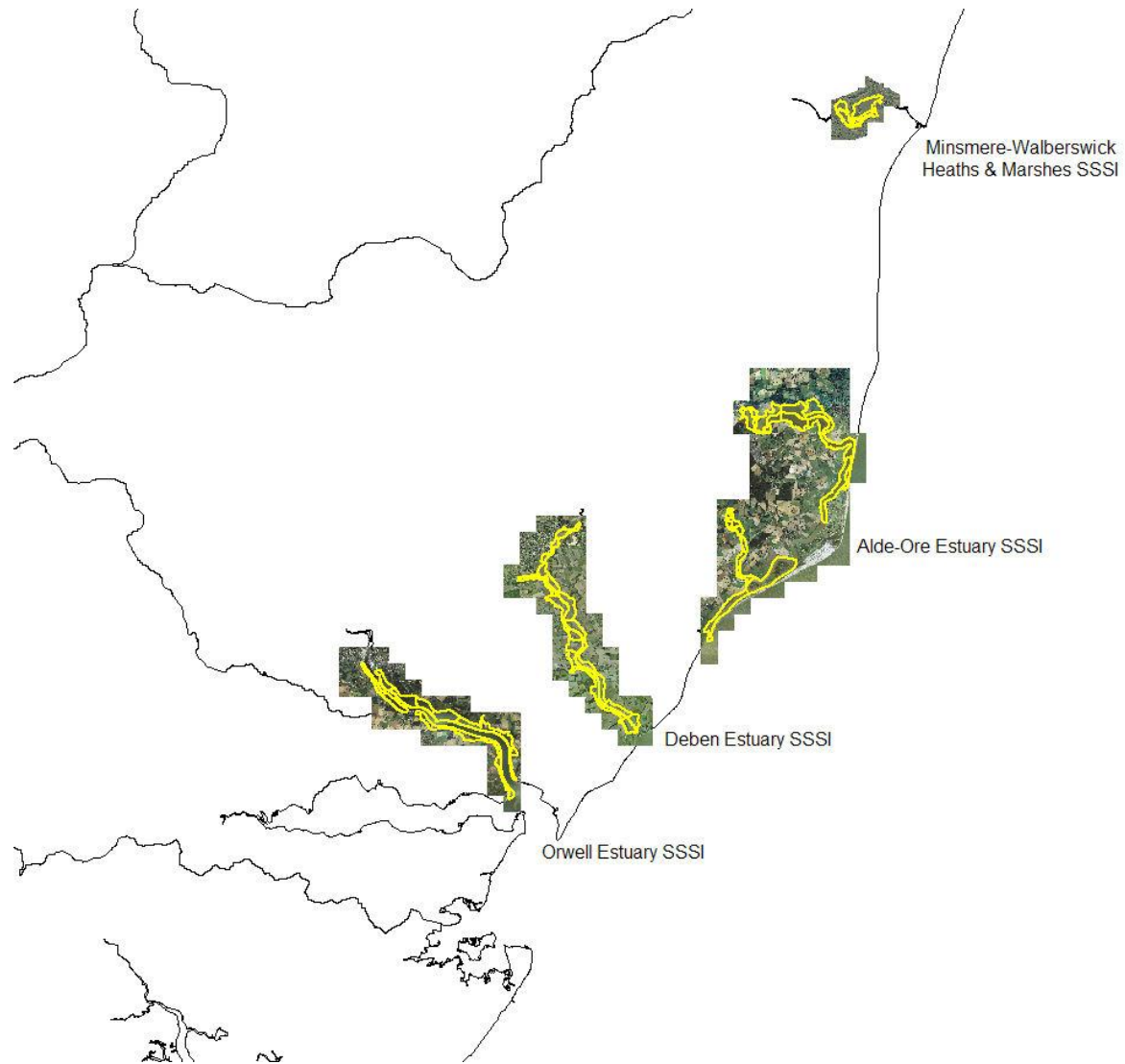


Figure 1 Location of the four Suffolk Estuarine SSSIs

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. No saltmarsh area less than 5m² was mapped.

Distinctions had to be made between saltmarsh, reedbed, grassland, algae and other mudflat characteristics based on shades of green and relief of saltmarsh from only the aerial photographs provided. No additional height relief maps, LiDAR data or interpolative software was used in this study. Transition zones at the front and back 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 aerial photographs available, have been discussed in Appendix 2.

2.3.2 SPATIAL ANALYSIS

Once the saltmarsh within each Management Unit was digitised, the spatial analysis tool in MapInfo allowed the comparison of polygons 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 only present in the baseline year (representing eroded saltmarsh);
2. Saltmarsh only present in the comparison year (representing accreted saltmarsh);
3. 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 change in each Management Unit within each SSSI are tabulated presenting:

- Area of saltmarsh gained in each unit (hectares)
- Area of saltmarsh lost in each unit (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 four Suffolk estuarine SSSIs. Again, losses are shown in red and gains in green and

stable saltmarsh in yellow. A table shows the following mapped attributes for each of the 4 SSSIs:

- Saltmarsh gains (hectares)
- Saltmarsh losses (hectares)
- Net saltmarsh losses (hectares)
- Net saltmarsh gains (hectares)
- Stable saltmarsh (hectares)

From the digitised maps, some assessment has been made in text to changes to creek morphology, planform and density between the baseline and comparative aerial photographs. Any changes in the creek network will be 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.

3. RESULTS

This section presents the results from the saltmarsh mapping and spatial analysis for each Management Unit within each SSSI. All maps can be found in Volume 2 – Maps, with the GIS files on the accompanying DVD.

3.1 Alde-Ore Estuary SSSI

This SSSI consists of three tidal river reaches comprising of the rivers Alde, Butley and Ore, including Havergate Island and Orfordness, however this report only deals with Management Units within the Alde and Ore. The estuary is bounded on the seaward side by the large barrier spit and ness complex of Orfordness. On the landward side, extensive areas of saltmarsh have been reclaimed, possibly since Roman times, to provide areas for cattle grazing (Pye, 2005). Saltmarsh is recorded in all reaches of the Alde with a large total area of saltmarsh in the River Butley. The RSPBs nature reserve at Havergate Island is also bounded by saltmarsh, as is the lower reach of the Ore.

Prior to reclamation there were extensive active saltmarshes adjoining the Alde and Ore Rivers. Estimates for the total area of reclaimed saltmarsh and mudflat in the Alde, and Ore estuaries are 1450ha and 2515ha respectively (Beardall *et al.* 1991). Estimated areas of remaining active marsh in the early 1990s were 163ha for the Alde and 275ha in the Ore (Pye & French, 1993). The marshes generally show morphological and sedimentological evidence of healthy vertical accretion, although most of the marsh edges are cliffed and are either stable or slowly eroding. The saltmarsh is restricted to a narrow fringe fronting the river banks with more extensive areas of marsh restricted to areas outside the embankments, mainly in the inner Alde estuary, and in those areas where marsh reactivation has occurred following breaching of the river banks (Pye, 2005).

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 Alde-Ore Estuary SSSI. By digitising and comparing the extent of saltmarsh in 2000 and 2007, Table 1 shows the overall calculations for the Alde-Ore Estuary, breaking down the total extents, gains and losses and net and average rate of change within each Unit.

Management Unit 1

Map 2 shows that some saltmarsh accretion has occurred along the seaward boundary throughout this unit, particularly at The Maltings and to the northeast of Iken Wood. Saltmarsh loss has occurred at the seaward boundary of Iken Cliff and to the north of Iken Wood. Of the 2.98ha of saltmarsh present in 2000, a total of 0.40ha was lost to erosion, but an additional 0.31ha was gained elsewhere through natural accretion resulting in a net loss of -0.09ha by 2007. This gave an overall extent of 2.89ha in 2007 with a rate of change averaging -0.01ha/yr^{-1} over the study period.

Management Unit 2

The saltmarsh in Unit 2 has remained relatively stable over the seven year period (13.69ha in 2000 to 13.67ha 2007) with only minimal erosion occurring along the seaward boundary along the majority of the length. Some accretion can be seen at the northern edge of this unit south of Snape Warren with changes to the creek system and the fronting edge. 0.24ha of saltmarsh was gained over the seven years, with erosion accounting for 0.27ha (see Map

2). The saltmarsh change over the seven year period has been calculated at a loss of -0.02ha.

Management Unit 3

Of the 6.23ha of saltmarsh present in 2000, a total of 0.69ha was lost to erosion, but 0.39ha was gained elsewhere through natural accretion resulting in a net loss of -0.31ha by 2007. Erosion has occurred along the seaward length of this unit, particularly at Troublesome Reach and to the north of The Anchorage where the main channel is close to the bank. Some accretion has occurred at Iken Cliff and within the saltmarsh body with the narrowing of creek systems (see Map 2). The saltmarsh change over the seven year period has been calculated averaging -0.04ha/yr^{-1} .

Management Unit 4

This management unit has again remained relatively stable over the seven years with its extent calculated at 23.17ha in 2000 increasing slightly by +0.33ha to 23.50ha in 2007 ($+0.33\text{ha/yr}^{-1}$). Although Map 2 shows some signs of erosion along the fronting marsh edge, accretion of the saltmarsh has occurred in the south western half, particularly to the west of Church Reach. 22.66ha of saltmarsh has remained stable throughout the seven years.

Management Unit 5

The saltmarsh within Unit 5 shows a very stable area in the centre adjacent to Yarn Hill, with changes in extent mapped at the eastern and western ends of this unit (see Map 3). Saltmarsh erosion has occurred along the floodbank south of Long Reach and also at the seaward margin of the extent north of Iken Marshes since 2000. However, saltmarsh accretion has been mapped along the majority of the seaward boundary of this unit with accretion occurring along the landward marsh edge since 2000 to the north of Iken Marshes. Of the 3.45ha of saltmarsh present in 2000, a total of 0.38ha was lost to erosion, but 0.67ha was gained elsewhere through natural accretion resulting in a net gain of +0.29ha by 2007. The saltmarsh extent in 2007 was mapped at 3.74ha.

Management Units 6 & 7

Map 3 shows the saltmarsh extents mapped in Units 6 and 7. Because of a 40m shift to the right in the aerial photographs at Barber's Point between 2000 and 2007, the saltmarsh extent for these two units have been reported together as one total to avoid reporting a false loss and gain within the two units.

Of the 3.42ha of saltmarsh present in 2000, a total of 0.67ha was lost to erosion, but 0.85ha was gained elsewhere through natural accretion resulting in a net gain of +0.18ha by 2007. The most stable area of saltmarsh lies within Ham Creek, with an increase of saltmarsh at the seaward edge along the majority of the central extent of Unit 6. A notable area of erosion since 2000 has occurred to the west of Unit 6 south of Black Heath. 3.60ha of saltmarsh was mapped in 2007 giving an average rate of change of $+0.03\text{ha/yr}^{-1}$.

Management Unit 8

Unit 8 has shown a slight increase in erosion within the seven year comparison (13.63ha in 2000 to 13.54ha in 2007), most noticeably at the western end of this unit northwest of Stanny Farm. 1.03ha of erosion has been recorded along the seaward edge. Erosion has also occurred around the fragmented saltmarsh areas to the west of Cob Island. However

this has been balanced by the accretion/recolonisation of internal areas within the saltmarsh extent within the overall management unit giving an overall change of -0.09ha (-0.01ha/yr^{-1}).

Management Unit 9

Map 3 shows the saltmarsh extent mapped in Unit 9. Of the 1.47ha of saltmarsh present in 2000, a total of 0.31ha was lost to erosion, with only 0.18ha gained elsewhere through natural accretion, resulting in a net loss of -0.13ha by 2007. The largest area of stable saltmarsh is adjacent to Aldeburgh Marshes with some accretionary areas mapped to the north and south of this block. Erosion has occurred along the majority of the marsh frontage, particularly to the south of the Unit at West Row Point. The saltmarsh extent within Unit 9 was mapped at 1.35ha in 2007, giving a rate of change of -0.02ha/yr^{-1} .

Management Unit 10

Large areas of saltmarsh exists on both banks of the Alde within this Unit as shown on Map 4. Minimal erosion has been mapped between the seven years along the full extent of the unit on both the south and north banks of the River Alde (1.32ha loss), but in the main the extent has remained stable (22.83ha). Most of this erosion has been balanced by the accretion/recolonisation of mud pans within the main saltmarsh body and to the northern end of the south bank area opposite West Row Point ($+1.27\text{ha}$ throughout the unit). The saltmarsh extent in Unit 10 was calculated at 24.15ha in 2000 decreasing by -0.04ha to 24.11ha in 2007, giving an average loss of only -0.01ha/yr^{-1} .

Management Unit 11

The majority of saltmarsh on both the east and west banks of the River Alde within this extensive unit have remained stable over the seven years (19.07ha) (see Map 5). Saltmarsh loss was mapped along the east bank to the south and north of the extent at Pig Pail Bridge and on the west bank near Orford jetty. Natural accretionary areas were mapped to the west of Blackstakes Reach and within the stable saltmarsh extents by the narrowing of creek systems and infilling/recolonisation of mud pans. This unit was mapped as having 20.39ha of saltmarsh in 2000 increasing to 21.11ha in 2007 giving an overall net gain of $+0.72\text{ha}$ (averaging 0.10ha/yr^{-1}).

Management Unit 12

Map 5 shows over a 3ha increase in saltmarsh within this unit due to the increase of saltmarsh through a managed realignment scheme. The 2000 aerial photographs show mudflat and channels within the breached area south of Slaughden colonised by algae. However by 2007, the aerial photographs show definite saltmarsh formations accounting for the large increase in extent within this unit from 1.94ha in 2000 to 5.14ha in 2007 (a net gain of $+3.19\text{ha}$). This gives a rate of change of $+0.46\text{ha/yr}^{-1}$ over the seven years.

Management Unit 19

The saltmarsh extent at Kings Marshes and Orfordness was mapped at 22.80ha in 2000 with a slight decrease of -0.21ha throughout the unit by 2007 to 22.60ha (Map 6). This can mainly be accounted for by the erosion of vegetation within the stable areas creating extended mud pans and the slight erosion along the seaward edge of the saltmarsh extents.

Management Unit 23

Of the 20.31ha of saltmarsh present in 2000, a total of 1.24ha was lost throughout the unit to erosion, with 0.82ha gained elsewhere through natural accretion, resulting in a net loss of -0.42ha by 2007. The majority of saltmarsh has remained stable within this management unit (19.07ha) particularly around Stoney Ditch and Stoney Ditch Point (Map 6). Slight erosion has occurred on the seaward margins particularly around The Crouch with some widening of internal creek systems. Some erosion of fringing saltmarsh has also occurred along the southern bank of Stoney Ditch in the middle section of this unit. The extent decreased to 19.90ha in 2007 (averaging -0.06ha/yr^{-1}).

Management Unit 24

Unit 24 along the length of the River Ore has seen erosion of the saltmarsh along the fronting margin, particularly along the east bank stretches at Kings Marshes, at the Chinese Wall Bridge and to the north of Stoney Ditch Point (Map 6). Some natural succession has been mapped at the landward boundary of these saltmarsh areas from saltmarsh to grass/scrub. On the west bank of the River Ore, the saltmarsh frontage has experienced some accretion, particularly to the east of Town Marshes on the northern bank of the River Ore. The overall extent in 2000 was mapped at 14.71ha, decreasing to 13.73ha in 2007, with a loss of nearly a hectare of saltmarsh (-0.99ha). 13.30ha remained stable throughout the seven years, with 1.42ha lost throughout the unit to erosion both along the frontage and within the stable areas, with a gain of 0.43ha.

Management Unit 25

Management Unit 25 holds the second largest extent of saltmarsh on the Alde-Ore complex due to saltmarsh recreation within the managed realignment site to the northeast end of Havergate Island (Map 7). Some advancing saltmarsh has been mapped at Chantry Point and the area known as Dovey's at the southwest tip on Havergate Island. Both created saltmarsh and areas of natural accretion within the unit amounts to 3.28ha of additional saltmarsh mapped over the seven years. This Unit also experienced the highest loss of saltmarsh over the assessment period with 2.14ha lost throughout the unit. Changes in the widths of creek systems has led to some internal erosion of the stable saltmarsh, with also loss of the marsh edge to the east of the area known as Dovey's on Havergate Island. Some natural vegetation change has been mapped at the landward boundary of the marsh area from saltmarsh to grass/scrub. The overall extent in 2000 was mapped at 26.77ha increasing to 27.91ha in 2007, giving a net gain of +1.14ha, averaging $+0.16\text{ha/yr}^{-1}$.

Management Unit 28

Unit 28 covering the lower Butley River has near continuous saltmarsh on both the east and west banks (Map 7). Of the 24.10ha of saltmarsh present in 2000, a total of 1.14ha was lost throughout the unit to erosion, with 2.27ha gained elsewhere through natural accretion, resulting in a net gain of +1.12ha by 2007. Saltmarsh has been lost along the seaward fronting margins mainly around Boyton Marshes and along the majority of the east bank. Saltmarsh gains have been mapped along the majority of the seaward margin on the west bank, north of Boyton Dock to the Ferry Bridge. Large mud pans have also recolonised by the later year accounting for the majority of increase in extent within this Unit.

Management Unit 29

The saltmarsh within Unit 29 has remained relatively stable over the seven years (11.86ha) with slight recessions along the seaward edge of the marsh in the main River Butley channel (Map 9). Of the 12.27ha of saltmarsh present in 2000, a total of 0.41ha was lost throughout the unit to erosion, with 0.68ha gained elsewhere through natural accretion, resulting in a net gain of +0.27ha by 2007. Losses have occurred on the outer boundary of the marsh particularly on the extent east of Carmen's Wood to the north of this Unit, and on the saltmarsh extent on the east bank near The Cliff, Gedgrave. Some natural vegetation change has been mapped at the landward boundary of the marsh area from saltmarsh to grass/scrub.

Management Unit 31

Of the saltmarsh mapped within the Alde-Ore Estuary SSSI, Unit 31 holds the greatest extent (Map 8). Some accretion has taken place along the stretch of saltmarsh southeast of the sewage works and to the northern end of the unit. Some erosion has taken place at the marsh edge, within the internal creeks and mud pans and also changes through natural succession of vegetation at the landward boundary of saltmarsh to grass/scrub. However, there has still been an overall increase in extent between 2000 (29.71ha) and 2007 (30.54ha) by +0.83ha (+0.12ha/yr⁻¹).

Management Unit 42

The saltmarsh in Unit 42 in the upper Butley River is more fragmented than in the rest of the SSSI (see Map 9), but has remained stable over the seven years. The saltmarsh extent was mapped at 21.12ha in both 2000 and 2007 with erosion and accretion balancing each other out at 1.03ha throughout the unit. Erosion was experienced along the landward boundary through natural succession of vegetation from saltmarsh to grass/scrub and with changes in the internal creek system. Accretion was noted mainly around the fragmented saltmarsh areas and within the internal marsh extent.

Management Unit 43

The extent of saltmarsh in Unit 43 has remained stable over the seven years (Map 9). Of the 17.61ha of saltmarsh present in 2000, a total of 0.42ha was lost throughout the unit to erosion, with 0.42ha gained elsewhere through natural accretion, resulting in no net change by 2007. Some natural vegetation change has been mapped at the landward boundary of the marsh area from saltmarsh to grass/scrub.

Summary

Table 1 Summary statistics for the Alde-Ore 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
1	2.98	2.89	-0.09	0.40	0.31	2.58	-0.01
2	13.69	13.67	-0.02	0.27	0.24	13.42	0.00
3	6.23	5.92	-0.31	0.69	0.39	5.53	-0.04
4	23.17	23.50	+0.33	0.51	0.84	22.66	+0.05
5	3.45	3.74	+0.29	0.38	0.67	3.08	+0.04
6 & 7	3.42	3.60	+0.18	0.67	0.85	2.76	+0.03
6	2.87	3.03	+0.15	0.45	0.60	2.43	+0.02
7	0.55	0.57	+0.03	0.22	0.25	0.33	0.00
8	13.63	13.54	-0.09	1.03	0.94	12.61	-0.01
9	1.47	1.35	-0.13	0.31	0.18	1.16	-0.02
10	24.15	24.11	-0.04	1.32	1.27	22.83	-0.01
11	20.39	21.11	+0.72	1.32	2.04	19.07	+0.10
12	1.94	5.14	+3.19	0.53	3.73	1.41	+0.46
19	22.80	22.60	-0.21	1.11	0.90	21.69	-0.03
23	20.31	19.90	-0.42	1.24	0.82	19.07	-0.06
24	14.71	13.73	-0.99	1.42	0.43	13.30	-0.14
25	26.77	27.91	+1.14	2.14	3.28	24.63	+0.16
28	24.10	25.22	+1.12	1.14	2.27	22.95	+0.16
29	12.27	12.54	+0.27	0.41	0.68	11.86	+0.04
31	29.71	30.54	+0.83	1.18	2.02	28.52	+0.12
42	21.12	21.12	0.00	1.03	1.03	20.09	0.00
43	17.61	17.61	0.00	0.42	0.42	17.19	0.00

3.2 Deben Estuary SSSI

The Deben Estuary extends south-eastwards for over 12km from the town of Woodbridge to the sea just north of Felixstowe. It is relatively narrow and sheltered, and has limited amounts of freshwater input. The estuary mouth is the narrowest section and is protected by the presence of shifting sandbanks. The intertidal areas are constrained by sea walls but this estuary displays some of the most complete range of saltmarsh community types in Suffolk (JNCC, 2001). The upper Deben contains only small fringes of discontinuous marsh except near Sutton where the flood embankments have been allowed to breach leading to the recreation of mudflats and saltmarsh. The central reach contains the largest proportion of active marsh, attaining their greatest width to the north of Felixstowe Ferry, between Martlesham Creek and Waldringfield, and between Waldringfield and Hemley. The total area of active marsh was reported by Burd (1989) to be 461ha, although Beardall et al (1991) calculated a figure of 251ha.

Like all Suffolk estuaries, the Deben has had a long history of reclamation, with Beardall et al (1991) estimating the total amount of intertidal loss amounting to 2242ha. However a significant increase in saltmarsh extent occurred in the 20th century with 180ha present in 1840s increasing to 250ha by the 1990s. This was attributable to flood embankment failure at Hemley, Sutton and Bromeswell.

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 10 shows the location of the SSSI units within the Deben Estuary SSSI. By digitising and comparing the extent of saltmarsh in 2000 and 2007, Table 2 shows the overall calculations for the Deben Estuary, breaking down the total extents, gains and losses and net and average rate of change within each Unit.

Management Unit 1

Map 11 shows the small areas of saltmarsh within Unit 1 on the north bank on the Deben estuary have remained stable over the seven years with some small areas of accretion towards Wilford Bridge. A small area of saltmarsh mapped in 2000 fringing the reed bed habitat on the south bank had eroded by 2007. Of the 0.16ha of saltmarsh present in 2000, a total of 0.03ha was lost to erosion, but an additional 0.03ha was gained elsewhere through natural accretion resulting in a net gain of +0.01ha by 2007.

Management Unit 2

Map 11 shows the majority of saltmarsh in Unit 2 lies within a retaining wall structure opposite the marina on the east bank of the Deben adjacent to Brown's Planting and Home Wood. The extent of saltmarsh in 2000 was mapped at 7.56ha decreasing by 0.29ha to 7.27ha in 2007. Erosion mainly occurred along the seaward marsh edge and two creek systems within the main extent close to Brown's Planting have widened beyond 3m within the seven years.

Management Unit 3

Map 12 shows the extent of saltmarsh within Unit 3. Of the 1.55ha of saltmarsh present in 2000, a total of 0.29ha was lost to erosion, but an additional 0.05ha was gained elsewhere through natural accretion resulting in a net loss of -0.27ha by 2007. Erosion occurred along the marsh frontage particularly adjacent to the sewage works at Melton on the west bank

and to the south of the unit along the bank at Sutton Hoo Farm. 1.26ha of saltmarsh remained stable throughout the seven years.

Management Unit 4

Map 13 shows the extent of saltmarsh within Unit 4. The greatest extent of stable saltmarsh lies adjacent to the reservoirs near Ferry Cliff on the east bank of the Deben. 2.40ha of saltmarsh was present in 2000 of which 0.29ha was lost to erosion but 0.10ha was gained by natural accretion. This resulted in a net change of -0.19ha by 2007 to 2.20ha of saltmarsh. Some erosion occurred along the marsh edges with very little internal erosion of the saltmarsh body. Accretionary areas were mapped close to Mill Hills marina and to the south of the unit near the slipways on the west bank.

Management Unit 5

Unit 5 shown on Map 14 holds the third largest extent of saltmarsh in the Deben with 20.19ha mapped in 2000 reducing to 17.50ha in 2007 (a net loss of -2.69ha). Of this total, 3.25ha of saltmarsh was lost to erosion, particularly along the marsh frontage along the whole length of this unit and around the fragmented areas adjacent to the stretch of the main channel known as Troublesome Reach. Some successional change of vegetation from saltmarsh to grass/scrub has occurred along the landward edge to the north of this unit. The saltmarsh, although mapped as a continuous block in 2000, had by 2007 become further fragmented by erosion accounting for some loss in the overall extent. The rate of change within this unit was calculated at -0.38ha/yr^{-1} , the second largest average loss rate of the 22 management units on the Deben estuary.

Management Unit 6

In 2000, Unit 6 extended along Martlesham Creek had a saltmarsh extent of 2.64ha. However fragmentation of some areas which were previously mapped as one polygon in 2000 have led to the decrease in extent by the 2007 mapping to 1.92ha (-0.71ha which averages a loss of -0.10ha/yr^{-1}). An example of this mapping can be seen in Appendix 2. Erosion has particularly occurred along the north bank of the tributary around Kingston and Kyson Point and on the south boundary of the unit opposite Martlesham Rectory with 0.81ha lost (shown in Map 14).

Management Unit 7

The saltmarsh within Unit 7 on the south bank of this tributary was mapped at 0.17ha in 2000, however over half of this was lost by 2007, reducing to 0.08ha (see Map 14). The majority of saltmarsh lost in this unit has been replaced by reed bed habitat.

Management Unit 8

Saltmarsh within Unit 8 along the western bank of the middle Deben was mapped at 11.28ha in 2000 with a continuous stretch along the main estuary bank. However Map 14 shows extensive erosion along the seaward marsh edge along its entire length, particularly at the southern extent of this unit at Waldringfield. Fragmentation of the saltmarsh along the marsh front has led to erosion over the seven years decreasing the overall extent by 1.61ha to 9.69ha by 2007. This continued fragmentation will lead to a further reduction in extent of saltmarsh over future years. Some saltmarsh accretion has occurred to the north of this Unit, however this is marginal in comparison to the loss in the majority of the area.

Management Unit 9

Unit 9 (shown on Map 15) contains the second greatest extent of saltmarsh within the Deben Estuary mapped at 30.58ha in 2000. However by 2007, the extent had decreased to 26.96ha attributable to erosion along the marsh edge and internal widening of the creek systems. The saltmarsh becomes more stable at the southern end of the unit with some accretion at the landward boundary of these areas. The average loss of saltmarsh from this unit is -0.52ha/yr^{-1} , the greatest of the 22 units within the Deben estuary.

Management Unit 10

Unit 10 lies on the east bank of the central Deben and represents one of the areas where the saltmarsh has remained relatively stable over the assessment period. Map 15 shows 5.84ha of discontinuous saltmarsh mapped along the length of this unit with some erosion at the seaward margin. Erosion has also occurred along the northern edge of the island of saltmarsh north of Stonner Point. This Unit demonstrates some natural accretion along the estuary bank between The Hams and The Tips. Of the 5.84ha of saltmarsh present in 2000, a total of 0.82ha was lost to erosion, with 0.49ha gained elsewhere through natural accretion resulting in a net loss of -0.33ha by 2007.

Management Unit 11

Map 16 shows a continuous extent of saltmarsh within Unit 11 on the west bank of the Deben. The saltmarsh extent between Waldringfield sailing club and north of Early Creek was mapped at 16.00ha in 2000 with a slight decrease by 2007 to 15.29ha (-0.71ha which equates to a loss of -0.10ha/yr^{-1}). Although a lot of the saltmarsh extent remained stable (14.56ha), losses occurred on the outer marsh edge along the full extent of this Unit and along internal creek edges.

Management Unit 12

Of the 13.50ha of saltmarsh present in 2000, a total of 1.82ha was lost to erosion, but an additional 0.41ha was gained elsewhere through natural accretion resulting in a net loss of -1.41ha by 2007. The majority of erosion occurred along the fronting marsh edge and around the saltmarsh island at Stonner Point. Some creek widening occurred within the marsh body particularly to the north of the unit (see Map 16). The saltmarsh extent was mapped at 12.09ha in 2007 with a net loss averaging -0.20ha/yr^{-1} over this seven year period.

Management Unit 13

Unit 13 lies on the east bank of the central Deben adjacent to Hemley and represents the largest area of saltmarsh within the estuary, mapped at 31.53ha in 2000 with only minimal change in extent by 2007 to 30.87ha. Large areas of saltmarsh have remained stable (with only slight erosion mapped at the saltmarsh edge and within internal creek systems (see Map 16). As there has been a relatively good balance between erosion and accretion, this unit has lost only 0.66ha over the seven years averaging -0.09ha/yr^{-1} .

Management Unit 14

The continuous extent of saltmarsh in Unit 14 between Spinny Marsh and Kirton Creek can be seen on Map 17. Of the 16.68ha of saltmarsh present in 2000, a total of 0.93ha was lost to erosion or a transition in vegetation, but 0.76ha was gained elsewhere through natural

accretion resulting in a net loss of -0.17ha by 2007. This resulted in the extent in 2007 mapped as 16.51ha, averaging a -0.02ha/yr^{-1} over the seven years. Erosion was mapped along the leading marsh edge and some widening of creeks within the marsh structure. Encroachment from the scrub vegetation at the back of the site accounted for some loss along the landward boundary at Hemley. Areas of accretion were mainly mapped within the main saltmarsh body where creeks formerly mapped had accreted or salt pans had recolonised.

Management Unit 15

The continuous extent of saltmarsh on the east bank of the Deben within Unit 15 showed little change over the seven years. 9.68ha was mapped in 2000 reducing by -0.14ha to 9.54ha in 2007. Of this, 9.25ha remained stable throughout the seven year, with 0.43ha lost to erosion and 0.29ha gained throughout the unit by natural accretion. The majority of erosion occurred along the fronting marsh edge balanced by the narrowing of creeks in the main saltmarsh body and some accretion at the two ends of the saltmarsh body close to Lodge Plantation and Ramsholt (Map 17).

Management Unit 16

Two main areas of saltmarsh are present in Unit 16 (Map 17) located at the entrance to Kirton Creek and also at the Boat Hard. Of the 2.41ha of saltmarsh present in 2000, a total of 0.20ha was lost to erosion, but 0.10ha was gained elsewhere through natural accretion resulting in a net loss of only -0.10ha by 2007. This resulted in the extent in 2007 being mapped as 2.31ha, averaging only a -0.01ha/yr^{-1} loss over the seven years. Erosion was predominantly mapped along the fronting marsh edge and along the extent of saltmarsh at the mouth of Kirton Creek. The greatest accretion was also mapped here within the internal creek systems of this extent.

Management Unit 17

The saltmarsh within Unit 17 forms a continuous extent from Ramsholt Quay down to the bend of the river north of Ramsholt Marshes (see Map 18). The saltmarsh was mapped at 15.55ha in 2000 with a slight decrease by 2007 to 15.19ha (-0.36ha which equates to a loss of -0.05ha/yr^{-1}). Although a lot of the saltmarsh extent remained stable (14.65ha), losses occurred on the outer marsh edge along the full extent of this Unit and along internal creek edges. Some accretion occurred in an area opposite Falkenham Creek and within the established marsh with the narrowing of creeks and recolonisation of mud pans.

Management Unit 18

Map 18 also shows the saltmarsh within Unit 18 stretching from the Boat Hard at Kirton Marshes in the north to just north of Falkenham Marshes to the south of the unit. Of the 14.41ha of saltmarsh present in 2000, a total of 0.81ha was lost to erosion, but 0.71ha was gained elsewhere through natural accretion resulting in a net loss of only -0.10ha by 2007. This resulted in the extent in 2007 being mapped at 14.31ha, averaging only a -0.01ha/yr^{-1} loss over the seven years. Erosion was predominantly mapped along the whole of the fronting marsh edge, and within the main body of the marsh at Falkenham Creek. Saltmarsh gains were also accounted for within the main saltmarsh extent with the narrowing of internal creek systems, recolonisation of large mud pans and areas of fragmented saltmarsh unmapped in 2000 subsequently mapped in 2007.

Management Unit 19

Unit 19 on the east bank of the Deben contains a continuous stretch of saltmarsh shown on Map 19. Of the 15.94ha of saltmarsh present in 2000, a total of 0.50ha was lost to erosion, but an additional 0.28ha was gained elsewhere through natural accretion resulting in a net loss of -0.22ha by 2007. 15.45ha of saltmarsh remained stable throughout the seven years. This resulted in the extent mapped in 2007 at 15.72ha, averaging only a -0.03ha/yr^{-1} loss over the seven years. Erosion occurred along the entire marsh frontage, with some erosion of the internal marsh towards the northern end of the unit. The narrowing of creeks, both at the marsh front and within the internal body of the marsh accounts for the majority of saltmarsh gains within this unit. Changes along the landward boundary indicate a change in vegetation type.

Management Unit 20

Map 19 shows Unit 20 on the west bank of the Deben. The saltmarsh lies in two distinct blocks, one to the north adjacent to Red House Farm and the second to the south adjacent to Falkenham Marshes. The saltmarsh within these two areas has remained generally stable with a total of 3.06ha mapped in 2000, with only a 0.26ha loss resulting in 2.80ha in 2007. Of this, 2.70ha remained stable throughout the seven years, with 0.37ha lost and 0.10ha gained by natural accretion throughout the unit.

Management Unit 21

Of the 13.95ha of saltmarsh present in 2000, a total of 0.49ha was lost to erosion, but an additional 0.52ha was gained through natural accretion resulting in a net gain of +0.03ha by 2007. The majority of this saltmarsh gain was mapped at the south of the unit adjacent to the amenity area off Ferry Road (see Map 20). Some erosion of the fronting marsh has occurred along the whole length of the unit with losses and gains to the internal marsh. This resulted in the extent mapped in 2007 at 13.98ha, averaging a $+0.004\text{ha/yr}^{-1}$ gain over the seven years.

Management Unit 22

Map 20 shows the extent of saltmarsh within Unit 22 located on the west bank at the mouth of the estuary reaching from Kings Fleet to Felixstowe Ferry terminal. This continuous stretch of saltmarsh was mapped at 13.44ha in 2000, experiencing a loss of -0.18ha resulting in an extent of 13.27ha by 2007. Although a lot of the saltmarsh extent remained stable (12.70ha) between the seven years, losses occurred at the outer marsh edge along the full extent of this Unit and along the landward edge of the saltmarsh. Losses and gains were also mapped in the internal saltmarsh body mainly at the northern end of this unit with mudpans recolonising or areas experiencing erosion.

Additional Notes

It should be noted that where saltmarsh extended beyond the boundary of the SSSI unit, specifically to the landward side, the saltmarsh was not mapped. Examples of this include Units 3, 9, 12, 15, 16, 17, 19, 20 and 21 where saltmarsh exists landward of the SSSI boundary.

Summary

Table 2 Summary statistics for the Deben 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
1	0.16	0.17	+0.01	0.03	0.03	0.14	+0.001
2	7.56	7.27	-0.29	0.49	0.20	7.07	-0.04
3	1.55	1.28	-0.27	0.29	0.05	1.26	-0.04
4	2.40	2.20	-0.19	0.29	0.10	2.10	-0.03
5	20.19	17.50	-2.69	3.25	0.54	16.94	-0.38
6	2.64	1.92	-0.71	0.81	0.10	1.82	-0.10
7	0.17	0.08	-0.09	0.12	0.03	0.05	-0.01
8	11.28	9.67	-1.61	1.99	0.38	9.29	-0.23
9	30.58	26.96	-3.62	4.24	0.62	26.34	-0.52
10	5.84	5.50	-0.33	0.82	0.49	5.02	-0.05
11	16.00	15.29	-0.71	1.72	1.03	14.56	-0.10
12	13.50	12.09	-1.41	1.82	0.41	11.69	-0.20
13	31.53	30.87	-0.66	1.81	1.13	29.43	-0.09
14	16.68	16.51	-0.17	0.93	0.76	15.75	-0.02
15	9.68	9.54	-0.14	0.43	0.29	9.25	-0.02
16	2.41	2.31	-0.10	0.20	0.10	2.22	-0.01
17	15.55	15.19	-0.36	0.90	0.54	14.65	-0.05
18	14.41	14.31	-0.10	0.81	0.71	13.60	-0.01
19	15.94	15.72	-0.22	0.50	0.28	15.45	-0.03
20	3.06	2.80	-0.26	0.37	0.10	2.70	-0.04
21	13.95	13.98	+0.03	0.49	0.52	13.46	+0.004
22	13.44	13.27	-0.18	0.75	0.57	12.70	-0.03

3.3 Minsmere-Walberswick Heaths & Marshes SSSI

Almost the entirety of the saltmarsh extent within the Blyth is located within the central reach on the southern side of Angel Marshes and Bulcamp Marshes. Thirteen saltmarsh and two swamp communities have been identified (Suffolk Wildlife Trust, 1993) covering a total of 86ha. There has been very limited development of saltmarsh on the main bulk of the mudflats and northern side of these areas following breach of the estuary defences in the 1950-1960s. This suggests that the inundated land was at a low-level relative to mean high water and that, in addition, the overall rate of sediment accumulation is low. Pioneer saltmarsh accounts for approximately 13% of the total habitat, a relatively high component compared with the other estuaries.

Reclamation has occurred within the Blyth dating from Roman Times but occurred most significantly between the 16th and 17th centuries when much of the high marsh areas were enclosed. Beardall et al (1991) estimated that by 1842, some 1100ha of the intertidal zone had been reclaimed, with a further 178ha by the 1990s.

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 21 shows the location of the SSSI units within the Minsmere-Walberswick Heaths and Marshes SSSI. By digitising and comparing the extent of saltmarsh in 1999 and 2006, Table 3 shows the overall calculations for the SSSI, breaking down the total extents, gains and losses and net and average rate of change within each Unit. The following assessments have been made for each management unit, with the maps found at the back of this report.

Management Unit 8

There are two discreet bodies of saltmarsh in Unit 8, the first located to the north of the unit at Sandpit Covert Marshes, Bulcamp and the second to the south of the unit adjacent to Bulcamp House (Map 22). Of the 0.63ha of saltmarsh present in 1999, a total of 0.15ha was lost to erosion, with only 0.06ha gained through natural accretion resulting in a net loss of -0.09ha by 2006. 0.48ha remained stable throughout this period. Erosion occurred along the fronting marsh of both extents, with saltmarsh gain recorded at localised areas throughout the unit.

Management Unit 60

Saltmarsh occurs as a fringing marsh at both the west and east boundaries of this Unit (Map 23). The marsh hugging the west coast of Bulcamp Marshes has remained relatively stable but with losses along the fronting marsh edge particularly to the north. There has also been some gain of marsh along the marsh frontage to the south of this extent. The second saltmarsh area contours the west bank of the River Blyth. Erosion of the marsh has occurred particularly along the seaward edge with some internal erosion of the saltmarsh body. Some saltmarsh has accreted at the confluence of the River Blyth and Wolsey's Creek by 2006. In 1999 the saltmarsh was mapped at 6.91ha, reducing to 6.46ha in 2006. This has led to an overall net loss of -0.45ha between 1999 and 2006 over the entire unit.

Management Unit 62

Unit 62 covers the area known as Collin's Island which is entirely colonised by saltmarsh (Map 24). Of the 3.51ha of saltmarsh present in 1999, a total of 0.12ha was lost to erosion by 2006 predominantly along the fronting edge where the main channel of the River Blyth

(known as New Cut) runs parallel to the marsh edge. 3.39ha remained stable over the seven years. This resulted in the extent mapped in 2006 at 3.40ha, averaging a -0.02ha/yr^{-1} loss over the seven years.

Management Unit 63

Unit 63 extends over the remainder of the marsh south of Collin's Island (Map 24). Of the 6 units mapped within the Minsmere-Walberswick Heaths and Marshes SSSI, this unit contains the greatest extent of saltmarsh. Of the 11.76ha of saltmarsh present in 1999, 11.02ha remained stable throughout the seven year period, but a total of 0.74ha was lost to erosion and/or the transition of vegetation communities. A large area of reedbed exists within this unit expanding northwards from Deadman's Covert. Saltmarsh gain was mapped along the southern marsh edge of Collin's Island, with further natural accretion along the saltmarsh body adjacent to Hill Covert. However with only 0.29ha gained through natural accretion, this resulted in an overall net loss of -0.45ha by 2006, when the marsh extent was mapped at 11.31ha.

Management Unit 64

Unit 64 covers the area of saltmarsh within Angel Marshes (Map 24). Of the 5.51ha of saltmarsh present in 1999, only 4.29ha remained stable throughout the seven year period. A total of 1.22ha was lost to erosion and/or the transition of vegetation communities. Areas of poorly colonised marsh in 1999 were colonised by reedbed habitat by 2006, notable to the south east of the unit. Three mid channel islands also mapped as saltmarsh in 1999 were then mapped as reedbed habitat in the 2006 aeriels. Some natural accretion occurred within the Unit, particularly along the marsh edges east of Blythburgh. In 2006 the saltmarsh extent was mapped at 4.73ha, representing a net loss of -0.78ha throughout the unit at an average rate of change of -0.11ha/yr^{-1} , recording the greatest net loss within the units mapped.

Management Unit 65

Map 25 shows the saltmarsh extent in Unit 65 which stretches from Deadman's Covert in the south west to Tinker's Marsh in the north east. Of the 11.48ha of saltmarsh present in 1999, 10.64ha remained stable throughout the seven years, with 0.84ha lost to erosion and/or the transition of vegetation communities, with only 0.47ha gained through natural accretion. This resulted in an overall net loss of -0.37ha by 2006 (averaging -0.05ha/yr^{-1}). The saltmarsh to the north east of the unit has remained relatively stable throughout the mapping period with only slight changes to internal creek channels and mud pans. Reed habitat has again colonised areas of sparse saltmarsh southwest of Tinker's House by 2006 accounting for the net loss of marsh along this landward transition zone.

Additional Notes

Differentiating between saltmarsh extent and reedbed habitat within this unit was made particularly difficult due to the quality of the 1999 aerial photographs compared to those in 2006.

Summary

Table 3 Summary statistics for the Minsmere-Walberswick Heaths & Marshes SSSI Management Units

Management Unit	Total Saltmarsh area in 1999 (ha)	Total Saltmarsh area in 2006 (ha)	Net Change (ha)	Total saltmarsh losses (ha)	Total saltmarsh gains (ha)	Total stable saltmarsh (ha)	Rate of Change
8	0.63	0.54	-0.09	0.15	0.06	0.48	-0.01
60	6.91	6.46	-0.45	0.74	0.30	6.16	-0.06
62	3.51	3.40	-0.11	0.12	0.01	3.39	-0.02
63	11.76	11.31	-0.45	0.74	0.29	11.02	-0.06
64	5.51	4.73	-0.78	1.22	0.44	4.29	-0.11
65	11.48	11.11	-0.37	0.84	0.47	10.64	-0.05

3.4 Orwell Estuary SSSI

Beardall et al (1991) report that an estimated 980 ha of saltmarsh has been reclaimed in the Orwell since 1200 AD. It is reported by Pye & French (1993) that active saltmarsh were extensive along the western shore of the estuary in the early 19th century, but their width has greatly reduced by reclamation activities between 1800 and 1840 and by later erosion. Today, active saltmarsh occurs as a narrow and discontinuous fringe along both banks of the Orwell estuary between Shotley Point and Ipswich, with the best developed areas along the frontage of Trimley Marshes, Chelmondiston and at Levington. Burd (1992) reported that there was net erosion loss of 32.4ha between 1973 and 1985, representing 32.6% of the 1973 area.

The following assessments have been made for each management unit, with the maps found in Volume 2 - MAPS. Map 26 shows the location of the SSSI units within the Orwell Estuary SSSI. By digitising and comparing the extent of saltmarsh in 2000 and 2007, Table 4 shows the overall calculations for the Orwell Estuary, breaking down the total extents, gains and losses and net and average rate of change within each Unit.

Management Unit 1

The saltmarsh in Unit 1 extends along the west bank of the estuary, south of the Orwell Bridge to Freston Reach. Erosion of the seaward marsh frontage has occurred along the length, with small pockets of accretion (Map 27). The most notable loss is around Redgate Hard where the saltmarsh formed one extent in 2000 but has eroded back by 2007 to form two distinct extents. Of the 1.70ha of saltmarsh present in 2000, a total of 0.19ha was lost to erosion, with only 0.04ha gained through natural accretion resulting in a net loss of -0.15ha by 2007.

Management Unit 2

Unit 2 lies on the east bank of the Orwell and contains only small discreet patches of saltmarsh. None of these small areas were stable over the seven years and four of the fragmented patches in 2000 had eroded by 2007 leaving only one mappable area in this latter year (see Map 27). Of the 0.02ha of saltmarsh present in 2000, a total of 0.02ha was lost to erosion, but with a new discreet patch measuring 0.02ha gained through natural accretion by 2007, this resulted in zero net loss.

Management Unit 3

Of the 2.12ha of saltmarsh present in 2000, a total of 0.28ha was lost to erosion, with 0.42ha gained through natural accretion resulting in a net gain of 0.15ha by 2007. 1.84ha remained stable throughout this period. The largest saltmarsh extent stands adjacent to the golf course where in 2000, discreet patches of saltmarsh existed along the marsh frontage, however by 2007, pioneering saltmarsh had grown to merge these areas with the main marsh body (see Map 28). Saltmarsh loss was also recorded at the north of this Unit close to Mulberry Middle. Change recorded along the landward boundary is due to natural succession in vegetation. In 2007 the saltmarsh extent was mapped at 2.26ha.

Management Unit 4

Saltmarsh was mapped in two discreet blocks at the northern end of Unit 4 on the west bank of the Orwell (see Map 28). Erosion was mapped along the seaward marsh frontage of both

areas with some accretion noted at Freston Point and adjacent to Freston Tower. In 2000, the saltmarsh was mapped at 0.96ha reducing to 0.91ha by 2007.

Management Unit 5

Unit 5 on the east bank of the Orwell demonstrated an accretionary environment between 2000 and 2007 with an additional 0.36ha of saltmarsh gained (Map 29). The extent was mapped at 0.27ha in 2000 increasing to 0.63ha in 2007. Of this total 0.26ha remained stable, 0.37ha was gained through natural accretion and only 0.01ha lost to erosion.

Management Unit 6

The saltmarsh extent of Unit 6 was mapped at 5.36ha in 2000 decreasing to 5.19ha by 2007 giving an average rate of change of -0.02ha/yr^{-1} . Large areas of saltmarsh within this Unit remained stable throughout the seven years (4.95ha) with 0.41ha lost to erosion mainly along the marsh frontage (Map 29). Change recorded along the landward boundary is due to natural succession in vegetation. Of the 0.24ha gained, the most significant area was at Coastguard Cottages, Pinmill with the advancement south adjacent to the coast.

Management Unit 7

Unit 7 on the east bank of the Orwell contains one area of continuous saltmarsh shown on Map 29. Of the 1.89ha of saltmarsh present in 2000, a total of 0.16ha was lost to erosion, but an additional 0.80ha was gained through natural accretion resulting in a net gain of 0.64ha by 2007. This resulted in the extent mapped in 2007 at 2.53ha, averaging a 0.09ha/yr^{-1} gain over the seven years. Of all the units mapped on the Orwell, Unit 7 demonstrates the highest net gain through natural accretion. Accretion occurred along the majority of the marsh frontage, with the one creek breaking up the extent in 2000 colonised by saltmarsh by 2007.

Management Unit 8

Unit 8 on the west bank of the estuary contains the greatest extent of saltmarsh mapped within the Orwell Estuary. 18.10ha of marsh was mapped in 2000, decreasing by -1.52ha to 16.58ha in 2007. Map 30 shows the greatest losses occurred along the full extent of the marsh frontage, with further changes to the pattern of internal creek channels. Changes recorded along the landward boundary is due to natural succession in vegetation. 0.66ha of accretion occurred throughout the unit, mainly within the internal body of the saltmarsh and within the saltmarsh extent at The Cliff, Chelmondiston.

Management Unit 9

Of the 2.03ha of saltmarsh present in 2000, a total of 0.28ha was lost to erosion, with 0.13ha gained through natural accretion resulting in a net loss of -0.15ha by 2007. 1.75ha remained stable throughout this period. The largest saltmarsh extent lies to the east of Unit 9 along the Nacton Shore, where erosion has occurred along the marsh frontage (see Map 30). This resulted in an extent of 1.88ha mapped in 2007, averaging a -0.02ha/yr^{-1} loss over the seven years.

Management Unit 11

Unit 11 on Map 30 shows significant erosion of the marsh frontage on both sides of the marsh at the mouth of Levington Creek. However accretion has been recorded within the internal creek systems of the stable saltmarsh body and along the marsh on the upper east

and west banks of the creek. Of the 10.01ha of saltmarsh present in 2000, a total of 0.95ha was lost to erosion, with 1.28ha gained through natural accretion resulting in a net gain of +0.33ha by 2007. The total saltmarsh area mapped in 2007 was 10.34ha.

Management Unit 12

The largest saltmarsh extent within Unit 12 lies at Crane's Hill where the fragmented mosaic of saltmarsh experienced accretion on its seaward margins but erosion on the landward side (Map 31). Of the 4.26ha of saltmarsh present in 2000, a total of 0.48ha was lost to erosion, with 0.75ha gained through natural accretion resulting in a net gain of +0.27ha by 2007. 3.78ha remained stable throughout this period. Saltmarsh accretion has occurred along the landward boundary of this unit.

Management Unit 13

Unit 13 shows two distinct areas of saltmarsh, one southeast of Stratton Hall marina and the second lying on the seaward side of Trimley Marshes (Map 31). Of the 2.87ha of saltmarsh present in 2000, a total of 0.43ha was lost to erosion, with 0.17ha gained through natural accretion resulting in a net loss of 0.25ha by 2007. 2.44ha remained stable throughout this period. The main losses were experienced at the marsh extent close to the marina and along the fronting edge of the stable marsh near Trimley Marshes. The extent was mapped at 2.64ha in 2007.

Management Unit 15

Unit 15 lies on the west bank of the outer Orwell and contains three areas of saltmarsh (Map 32). There has been some erosion of the seaward marsh edge at Shotley marshes and at Shotley Point, but in the main, there has been a gain in marsh particularly in the area north of Shotley Marina. Of the 1.54ha of saltmarsh present in 2000, a total of 0.09ha was lost to erosion, with 0.70ha gained through natural accretion resulting in a net gain of 0.61ha by 2007 (a rate of change of +0.09ha/yr⁻¹).

Management Unit 16

Saltmarsh is present in Unit 16 on the lower reaches of the Orwell estuary from Trimley Marshes to Fagbury Point (Map 32). This stretch of saltmarsh was mapped at 1.52ha in 2000, experiencing a loss of -0.38ha resulting in an extent of 1.14ha by 2007. Erosion has occurred along the outer marsh edge along the full length of this marsh, with a narrow 150m stretch lost from the north and an additional 0.18ha from the south of the reach at Fagbury Point with the extension of the Container Park reclaiming the marsh. Saltmarsh has been lost at a rate of -0.05ha/yr⁻¹ since 2000.

Management Unit 21

In 2000, an area of land was being actively prepared for managed realignment at North Trimley Marshes (Map 31). At the time the aerial photography was taken, the area had not been breached. However by 2007, 8.88ha of saltmarsh had colonised the realignment area after breaching.

Points of note

Saltmarsh was not mapped beyond the SSSI unit boundary therefore marsh was excluded from Units 4, 6, 11, 12

Summary

Table 4 Summary statistics for the Orwell 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
1	1.70	1.55	-0.15	0.19	0.04	1.51	-0.02
2	0.02	0.02	0.00	0.02	0.02	0.00	0.00
3	2.12	2.26	+0.15	0.28	0.42	1.84	+0.02
4	0.96	0.91	-0.05	0.11	0.06	0.85	-0.01
5	0.27	0.63	+0.36	0.01	0.37	0.26	+0.05
6	5.36	5.19	-0.17	0.41	0.24	4.95	-0.02
7	1.89	2.53	+0.64	0.16	0.80	1.73	+0.09
8	18.10	16.58	-1.52	2.18	0.66	15.92	-0.22
9	2.03	1.88	-0.15	0.28	0.13	1.75	-0.02
11	10.01	10.34	+0.33	0.95	1.28	9.06	+0.05
12	4.26	4.53	+0.27	0.48	0.75	3.78	+0.04
13	2.87	2.62	-0.25	0.43	0.17	2.44	-0.04
15	1.54	2.15	+0.61	0.09	0.70	1.45	+0.09
16	1.52	1.14	-0.38	0.44	0.06	1.08	-0.05
21	0.00	8.88	+8.88	0.00	8.88	0.00	+1.27

4. DISCUSSION

When carrying out a mapping exercise such as this, it is useful to check with other recent and historical accounts of change reported for the area, both for management purposes and scientific review. This chapter reports on how other studies have calculated saltmarsh change within the four estuaries and makes some comparison to the results of this current study.

4.1 Previous Studies

In 2000, Cooper & Cooper investigated the erosion of saltmarsh within the Suffolk estuaries between 1971, 1986 and 1998. This study involved mapping and quantifying the area of saltmarsh present and calculating the extent of change between years. They mapped and compared 1:10000 scale aerial photographs flown in 1971 and 1986, and 1:5000 scale aerial photographs flown in 1998. The saltmarsh present on the aerial photographs was mapped onto tracing paper including areas of transitional saltmarsh species (e.g. Common reed – *Phragmites*), which were then subsequently digitised directly into GIS. From this, areas of stable, eroding and accreting saltmarsh were calculated. Within this study, the Rivers Blyth (incorporating the Minsmere-Walberswick Heaths and Marshes SSSI), the Alde-Ore and the River Deben were included. The Cooper and Cooper (2000) dataset is considered to provide the most comprehensive and consistent record of saltmarsh cover and has therefore been used by various studies (Royal Haskoning, 2006; Suffolk County Council, 2007).

Cooper et al (2000) also carried out a further study of Essex estuaries for the Environment Agency comparing saltmarsh between the years 1973, 1988 and 1998. This included the River Orwell which spans the counties of Essex and Suffolk. Cooper et al (2000) used baseline saltmarsh extents derived from a study carried out by the Institute of Terrestrial Ecology (ITE) in 1973. The saltmarsh was mapped using panchromatic vertical aerial photographs at a scale of 1:10560, traced directly onto ordnance survey base maps with no orthorectification applied. The 1988 data was derived from a study carried out by Burd (1992) who used 1:5000 scale aerial photographs flown in 1988 where saltmarsh extents were again traced then digitised into a GIS. A series of spatial analysis queries were undertaken to compare the 1988 coverage with previous 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 were included on the 1973 mapping, but excluded on the 1988 mapping;
- In order to overlay the 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 these two previous studies as baseline years, the saltmarsh extent within the Orwell estuary was digitised by Cooper et al (2000) for 1997 at a scale of 1:10000. The 1997 saltmarsh extents were again traced then digitised into a GIS. A series of spatial analysis queries were undertaken to compare the 1997 coverage with previous 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 SPAs, including the Deben and Orwell estuaries, comparing the change in area between the SPAs year of designation and the area in 2004. However, their assessment was based on previous bodies of work with no new mapping of saltmarsh.

4.2 Previous Results

The results of the Cooper & Cooper (2000); Cooper et al (2000) and Royal Haskoning (2006) studies are shown in Table 5.

Table 5 Results from previous studies

	Total saltmarsh area (ha)			Net change in saltmarsh (ha & %)	Rate of Change (ha/yr ⁻¹)
	1971	1986	1998	1971-1998 (ha & %)	Rate of Change (ha/yr ⁻¹)
Cooper & Cooper (2000)					
Alde-Ore (inc the Butley)	360.9 (264.6 Alde-Ore) (96.3 – Butley)	356 (266.7 Alde-Ore) (89.3 – Butley)	343.7 (256.6 Alde-Ore) (87.1 – Butley)	17.2 ha (4.8%) loss	-0.64
River Deben	311.7	265.9	240.7	71 ha (22.8%) loss ⁽¹⁾	-2.63
River Blyth ⁽²⁾	68.1	65.7	63.4	4.7 ha (6.9%) loss	-0.17
Cooper et al (2000)					
River Orwell	100	70	54	46 ha (46%) loss	-1.92
Royal Haskoning (2006)	Designated year	Area at designation (ha)	Area in 2004 (ha)	Designated year – 2004 (ha & %)	Rate of Change (ha/yr⁻¹)
Deben	1996	231.8	214.8	17 ha (7%) loss	-2.13
Stour & Orwell ⁽³⁾	1994	180	117.1	62.9 ha (35%) loss	-6.29

⁽¹⁾ Includes 18ha of reclamation which occurred within the River Deben between 1971 and 1986

⁽²⁾ The River Blyth calculation includes the whole of the river system and not just the Minsmere-Walberswick Heaths & Marshes SSSI

⁽³⁾ The Stour & Orwell calculation includes saltmarsh in the River Stour which is excluded from this current study

4.2.1 RIVER ALDE-ORE SSSI

In order to be comparative with the extent of this current study, Table 5 above combines the saltmarsh extents within the Rivers Alde, Ore and Butley calculated by Cooper & Cooper (2000). Of the 246.6ha of saltmarsh present in the Alde/Ore complex in 1971, Cooper & Cooper (2000) reported that a total of 40.5ha was lost due to erosion, but an additional 42.6ha was gained through natural accretion. This resulted in a net gain of 2.1ha by 1986

representing 2.1% of the total area in 1971. The accreting saltmarsh occurred along Orford beach and also on a large scale between Ikencliff and The Maltings suggesting that flood defences at this location may have breached with subsequent recolonisation. Erosion was particularly pronounced along the leading edge of the marsh through the lower reaches of the Alde. Between 1986 and 1998, a net loss was recorded of 10.1ha representing 3.8% of the total area in 1986. Saltmarsh erosion was mapped at the meander bend near Slaughden in the lower reach of the Alde and on Orford beach.

Of the 96.4ha of saltmarsh in the River Butley in 1971, a net loss of 7ha was recorded by 1986 representing 7.2% of the total area in 1971 (Cooper & Cooper, 2000). Of the 87.1ha of saltmarsh present in the River Butley in 1986, a total of 12.7ha was lost due to erosion, some of which was through internal dissection, but an additional 10.5ha was gained through natural accretion. By 1998, a further 2.5% net loss was experienced in the River Butley.

For the combined figures for this three rivers complex, 17.2ha of saltmarsh were calculated to have been lost over the 27 year period resulting in a -0.64ha/yr^{-1} rate of change.

4.2.2 RIVER DEBEN SSSI

Of the 311.7ha of saltmarsh present in 1971, a total of 72.9ha was lost to erosion and reclamation, but an additional 27.1ha were gained through natural accretion. This resulted in a net loss of 45.8ha by 1986. Saltmarsh extent was lost along the northern bank of Martlesham Creek and in two locations on the western side of the estuary opposite Metersgate Quay. Cooper & Cooper (2000) mapped a further loss of 25.2ha of saltmarsh in the Deben between 1986 and 1998 occurring at both the fronting marsh edge and through the process of creek widening with the marsh body, possibly due to sea level rise. Between 1971 and 1998, a net loss of 71ha of saltmarsh was recorded in the River Deben, representing 22.8% of the total area in 1971 and occurring at an average annual loss rate of 2.63ha per year (Cooper & Cooper, 2000). Of all the surveyed estuaries in Suffolk, the Deben had experienced the greatest absolute net loss of saltmarsh between 1971 and 1998, and the greatest percentage loss in terms of its original area.

4.2.3 MINSMERE-WALBERSWICK HEATHS & MARSHES SSSI

Minsmere-Walberswick Heaths and Marshes SSSI forms part of the River Blyth catchment. Cooper & Cooper (2000) studied the whole of the river system from the upper reach at Blyford Bridge down to the Walberswick Harbour. In contrast, this current study only covers those SSSI units within the upper and central reach between Blyford Bridge and Bulcamp Marshes. Of the 68.1ha of saltmarsh present in the River Blyth in 1971, Cooper & Cooper (2000) reported a total of 10.7ha was lost due to erosion, but an additional 8.3ha was gained through natural accretion. This represented a net loss of 2.4ha by 1986, representing 3.5% of the 1971 area (Cooper & Cooper, 2000). Of the 65.7ha present in 1986 an additional 2.3ha was again lost by 1998 representing 3.5% of the area. Of this total, 9.2ha was lost due to erosion but an additional 6.9ha was gained through natural accretion. Cooper & Cooper (2000) mapped saltmarsh erosion throughout all reaches of the River Blyth with erosion being prevalent along the front of the edge of the marsh and along internal creeks of the marsh surface. Between 1971 and 1998, they reported a net loss of 4.7ha of saltmarsh within the River Blyth occurring at an average annual rate of 0.17ha per year. The Suffolk Wildlife Trust (1993) estimated an annual loss of saltmarsh within the Blyth to be in the order of 0.5 – 1% of the total area.

4.2.4 RIVER ORWELL SSSI

Of the 100ha of saltmarsh in 1973 in the River Orwell, 30 hectares was lost by 1988, of which 7.5ha was lost to reclamation notably in the vicinity of Felixstowe Docks and Levington marina. The rest of this total was lost due to erosion, with the most significant areas being located at the seaward edge of the open stretches at Trimley Marshes and Shotley Point. Burd (1992) also reported large areas of pioneer marsh lost at Levington Creek and Woolverstone Park. The total amount of natural accretion in the River Orwell was relatively small (9.9ha) (Cooper et al, 2000). By 1997, a further 16ha of saltmarsh had been lost again due to reclamation at the docks, but also by natural erosion at the seaward edges of Trimley Marshes, Shotley Point, Chelmondiston, Levington, Woolverstone Park and Freston Park. Considerable erosion was also noted at Levington Creek, Church End and Chelmondiston. The total amount of natural accretion in the River Orwell between 1988 and 1997 was relatively small (9.2ha) (Cooper et al, 2000).

4.3 Comparison to Current Study

A direct comparison of saltmarsh extents within the four SSSIs cannot be compared between this current study and the Cooper and Royal Haskoning reports due to the different areas calculated. This current study focuses on specific SSSI management units within each estuary and not the water body as a whole. Similarly, different vegetation was mapped between the studies, with the Cooper assessments mapping reedbed as part of the saltmarsh classification whereas this study has excluded areas of transitional reedbed habitat. The extent of 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 reports and this current study.

However, the results of the studies can still be compared using the average yearly rates of change within the estuaries, and therefore the Cooper reports and the Royal Haskoning reports can be used to make a historic assessment of change for the four estuaries in the context of this research. The results of the current study can be seen in Table 6.

This study has reported a net gain of saltmarsh in both the Alde-Ore and Orwell SSSI management units mapped. A net loss was recorded in both the Deben and Minsmere-Walberswick Heaths and Marshes SSSIs.

Table 6 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	Rate of change in Cooper (*) & Royal Haskoning (**) reports
Alde-Ore	303.94	309.73	+5.79	17.52	23.32	286.41	+0.83	-0.64 (*)
Deben	248.53	234.45	-14.08	23.06	8.98	225.48	-2.01	-2.63 (*) -2.13 (**)
Minsmere-Walberswick H&M	39.80	37.55	-2.25	3.81	1.56	35.99	-0.32	-0.17 (*)
Orwell	52.63	61.20	+8.56	6.02	14.59	46.61	+1.22	-1.92 (*)

4.3.1 RIVER ALDE-ORE SSSI

Map 33 shows the saltmarsh changes mapped within the Alde/Ore SSSI management units. Of the 303.94ha of saltmarsh present in the Alde/Ore complex in 2000, a total of 17.52ha was lost due to natural erosion throughout the SSSI, but an additional 23.32ha was gained through natural accretion and two managed realignment schemes (Units 12 and 25) by 2007. This resulted in a net gain of +5.79ha by 2007 representing 1.9% of the total area in 2000 (Table 6). The rate of change in saltmarsh is reported at +0.83ha/yr⁻¹ in the Alde-Ore, in contrast to -0.64ha/yr⁻¹ reported by Cooper & Cooper (2000). The two realignment areas within this SSSI have had a positive outcome on the rate of change and overall saltmarsh extent.

4.3.2 RIVER DEBEN SSSI

The Deben SSSI has suffered the greatest net loss of saltmarsh within its management units over the seven year mapping period of the four estuaries mapped. Map 34 shows the saltmarsh changes mapped within the Deben SSSI management units. Table 6 shows that of the 248.53ha of saltmarsh present in the Deben estuary in 2000, a total of 23.06ha was lost due to natural erosion throughout the SSSI, with only 8.98ha gained through natural accretion by 2007. This resulted in a net loss of -14.08ha by 2007 which represents a 6% of the total area in 2000. The rate of change in saltmarsh in this current study has been calculated at -2.01ha/yr⁻¹ in the Deben, in contrast to -2.63ha/yr⁻¹ reported by Cooper & Cooper (2000) and -2.13ha/yr⁻¹ by Royal Haskoning (2006).

4.3.3 MINSMERE-WALBERSWICK HEATHS & MARSHES SSSI

The Minsmere-Walberswick Heaths and Marshes SSSI has also suffered a net loss of saltmarsh within its management units over the seven year mapping period. Map 35 shows the saltmarsh changes mapped within the management units considered. Of the 39.80ha of saltmarsh present in the SSSI in 1999, a total of 3.81ha was lost due to natural erosion and transitions in vegetation communities throughout the SSSI, with only 1.56ha gained through natural accretion by 2006. This resulted in a net loss of -2.25ha by 2006 which represented 5.6% of the total area in 1999 (see Table 6). The rate of change in saltmarsh within this current study has been calculated at a much higher rate of -0.32ha/yr⁻¹, in contrast to -0.17ha/yr⁻¹ reported by Cooper & Cooper (2000). However the higher loss has resulted not from direct erosion at the marsh channel interface, but of a change in habitat from saltmarsh to reedbed habitat at the landward transition zone either as a natural change over the seven years or as an artefact of the mapping exercise due to poor quality aerials.

4.3.4 RIVER ORWELL SSSI

Map 36 shows the saltmarsh changes mapped within the River Orwell SSSI management units. Table 6 shows that of the 52.63ha of saltmarsh present in the Orwell Estuary in 2000, a total of 6.02ha was lost due to natural erosion throughout the SSSI, but an additional 14.59ha was gained through natural accretion and a significant managed realignment scheme at North Trimley Marshes (Unit 21) creating in itself 8.88ha of saltmarsh by 2007. This resulted in a net gain of +8.56ha by 2007 representing 16% of the total area in 2000. The rate of change in saltmarsh is currently reported at +1.22ha/yr⁻¹ in the Orwell, in contrast to -1.92ha/yr⁻¹ reported by Cooper et al (2000). The realignment area within this SSSI has had a positive outcome on the rate of change and overall saltmarsh extent mapped within this SSSI.

5. CONCLUSION

The current assessment can be used to assess the effectiveness of existing conservation initiatives but can also be used to inform future conservation objectives and appropriate management strategies by 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 to be present in 2060 and 2110 respectively (Table 7).

Table 7 Predicted saltmarsh area within the Suffolk SSSIs over the next 50 to 100 years.

Estuary	Total saltmarsh area in latest year mapped calculated within the Management Units considered (ha)	Rate of change in current study (ha/yr ⁻¹)	Area of saltmarsh predicted for 2060 (ha)	Area of saltmarsh predicted for 2110 (ha)
Alde/Ore	309.73	+0.83	351.23ha	392.73ha
Deben	234.45	-2.01	133.95ha	33.45ha
Minsmere-Walberswick Heaths and Marshes	37.55	-0.32	21.55ha	5.55ha
Orwell	61.20	+1.22	122.2ha	183.2ha

However, this makes the broadest assumption that the rate of change in saltmarsh area over the last 10 years is linear and is to continue linearly at this 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, natural transition of plant communities eg. from saltmarsh to scrub/grassland, land claim, embankment construction and sea level change.

Many factors can be managed to some extent, and some are in fact intended changes as a result of management initiatives. However, in considering long term change, sea level rise and the associated increase in tidal velocities and tidal energy, is an important factor and its affect on saltmarsh communities is inevitable. The natural response to sea level rise would be a gradual creep of saltmarsh communities up the shore in line with the shifting tidal range. However, much of the coastline is altered in some way by sea defences, thereby physically restricting this upward shift. This restriction would lead 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, current best estimates of future relative sea level change in eastern England and calculated for four UKCIP02 scenarios using the Hadley Centre models. Table 8 shows the results:

Table 8 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 9, 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 9 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.

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APPENDIX 1

Aerial photographs used in this study

Location	Date	Scale	Details	No. Of Photos Used	Source & Comments
Alde-Ore	2000	1:10000	Colour	102	Geostore, Natural England
	2007	1:10000	Colour	102	
Deben	2000	1:10000	Colour	50	Geostore, Natural England
	2007	1:10000	Colour	50	
Minsmere- Walberswick Heaths & Marshes	1999	1:10000	Colour	10	Natural England 2007 aerials unusable due to cloud cover, therefore Environment Agency aerials used for 2006.
	2006	1:10000	Colour	10	
Orwell	2000	1:10000	Colour	40	Geostore, Natural England
	2007	1:10000	Colour	40	

APPENDIX 2 – LIMITATIONS OF DATA

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 in interpreting the aerial photographs.

Aerial photographs were available in digital format for 2000 and 2007 for all Suffolk estuaries except for the Minsmere Walberwick SSSI where significant cloud cover meant that alternatives of 1999 and 2006 were used. Although all aerials were confirmed as being orthorectified, orthorectification can vary in accuracy and problems were found for some of the areas leading to unjust net differences in saltmarsh between the baseline and comparison years.

For example, some of the aerial photographs for the Alde-Ore SSSI (yr 2000) displayed a shift of approximately 40m to the west of the Ordnance survey reference and the SSSI boundaries based upon it (see Plate 1).

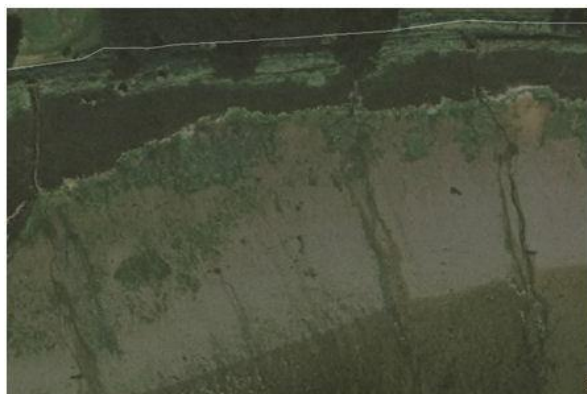


Plate 1 – Aerial photographs shifted 40m from OS reference

In these cases, as a consequence, saltmarsh which would correctly be recorded as being within a particular SSSI unit is recorded either as being inside an adjacent unit or outside the SSSI boundary and not recorded at all. Comparisons between the baseline and comparative years then incorrectly show a dramatic increase or decrease in net area of saltmarsh.

Due to the nature of orthorectification, these discrepancies are not uniform and therefore cannot be easily accounted for or corrected.

The brightness and colour balance varied slightly between some of the aerials – the boundaries between saltmarsh and other vegetation (such as *Enteromorpha*) were more difficult to differentiate in the darker photographs as subtle colour differences and textures were less evident (Plate 2). Aerials between years also varied in clarity due to either atmospheric haze or photograph resolution (Plate 3).



Orwell Unit 3 - 2000



Orwell Unit 3 - 2007

Plate 2 Colour differences between years



Minsmere Unit 65 - 1999



Minsmere Unit 65 - 2006

Plate 3 Differences in atmospheric haze or photograph resolution

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 aerials 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 *Enteromorpha*. 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.

All aerials supplied were taken during summer months (June to August) with the exception of the Orwell coverage where some were taken in October (see Plate 4).



Orwell Unit 2



Orwell Unit 2

Plate 4 Colour differentiation and shadows

Reedbed changes colour during the year and is therefore not always visibly different to saltmarsh when viewed from above. Reedbed does however have less defined creek systems and can sometimes be identified by the radial fashion by which it colonises. This was a problem when digitising the Minsmere-Walberswick Heaths and Marshes SSSI (Plate 5).



Minsmere-Walberswick Unit 63 - 1999



Minsmere-Walberswick Unit 63 - 2006

Plate 5 Quality of aerials making saltmarsh vs reedbed habitat difficult to map

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 6 where the area was digitised as one polygon in 2000, as the individual saltmarsh patches were too close together for individual polygons. However by 2007, the saltmarsh patches had further eroded, becoming more fragmented with wider creeks leading to their individual digitisation. In cases such as these, under this method, the losses calculated are often larger than are actually the case.



Deben Unit 6 - 2000



Deben Unit 6 - 2007

Plate 6 Fragmentation of saltmarsh between years leads to differences in mapping technique and subsequent area/extent calculated