Natural England Research Report NERR020

Validation Network Project Saltmarshes

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Published on 25 September 2008

ISSN 1754-1956

Project details

This report results from research commissioned by Natural England. The work was undertaken under Natural England contract SST 01\01\035 by the following team: Erica Kemp, Tom Stephenson (ECUS) & Clive Bealey (Natural England).

A summary of the findings covered by this report, as well as Natural England's views on this research, can be found within Natural England Research Information Note RIN020 - Validation Network Project Saltmarshes.

This report should be cited as:

KEMP. E, STEPHENSON. T & BEALEY. C (Natural England) 2008. Validation Network Project Saltmarshes. Natural England Research Reports, Number 020.

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Acknowledgments

The authors would like to thank the following: Ian Evans, Simon Cooter, Ben McCarthy, Nicola Evans, Graham Weaver, Deborah Russell, Sue Rees, Simon Brockington (Natural England), Zoe James (formerly English Nature); Samantha Cope (Channel Coast Observatory); Anne de Poitier (Chichester Harbour Conservancy); Doug McCutcheon; all owner/occupiers and others who facilitated the project.

Summary

In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as A Statement on Common Standards in Monitoring. The aim for each site is to maintain it in favourable condition, and condition is assessed on a set of key features of interest for the broad habitats within each site. New guidance on Common Standards Monitoring has been published (Joint Nature Conservation Committee 2004) which now forms the standard approach to monitoring statutorily designated sites.

The results of this regular monitoring against set targets enables management practices on these sites to be appraised and revised if required. Monitoring across a range of sites with similar habitats also allows some determination of the condition of the habitat resource as a whole, feeding into regional and national targets such as those identified within the UK Biodiversity Action Plan. This strategic monitoring forms the Validation Network Project, the aims of which are to validate condition monitoring, to establish control sites against which changes in interest features can be assessed, and to contribute to understanding the drivers of change in individual habitat types.

This report presents the results and conclusions of the analyses of data collected for saltmarsh sites within England, undertaken as part of the Validation Network Project.

Four saltmarsh sites within England were selected for the monitoring. These were: the Humber Estuary, Morecambe Bay, Chichester Harbour and The Wash. The first three are enclosed estuarine systems while the Wash is a more open intertidal system.

Datasets collected for each area included the standard Condition Assessment field survey for saltmarsh vegetation, quadrat-based data on composition and cover, and a range of measured variables also at the quadrat scale (For example - vegetation height, bare mud, height +/- mean high water level). In addition, a range of variables were assessed at the plot scale (For example - evidence of erosion and disturbance).

Analyses of these data took four approaches: comparison of qualitative and quantitative datasets; assessment of botanical communities in saltmarsh zones using NVC classification; assessment of the significance of measured variables in differentiating favourable and unfavourable plots; multivariate analysis of vegetation community data.

The comparison of qualitative and quantitative methodologies indicated that in general the rapid (qualitative) assessment was more likely to record attributes as favourable than the detailed (quantitative) assessment, within all estuary systems, with the majority of plots experiencing some disagreement between conditions utilising the two approaches.

The relatively quantitative approach to vegetation assessment facilitated accurate and detailed recording of botanical information which enables an objective assessment of botanical composition and community types to be made. Disagreements in condition in respect of this attribute occurred with abundances of indicator species often being recorded as favourable using the qualitative and unfavourable using the quantitative method.

Determining zonation was often difficult on the basis of quantitative assessment as the botanical composition of a quadrat did not necessarily reflect the zone in which it was deemed to occur for example, where accretional ramps with pioneer communities are present higher up the saltmarsh. In particular the presence of such features is not always apparent where the physical structure of the saltmarsh is complicated, for example incorporating spits, creeks or pans.

Analysis of botanical data revealed discrepancies between the perceived botanical communities recorded during qualitative survey, and the actual communities recorded from quadrat recording. Disagreement between condition assessment of the two methods was particularly pronounced in

respect of botanical composition, and this is considered likely to be influenced by unintentional recording bias using the qualitative method, which relies on surveyor-selected rather than random selection of recording points.

Analysis of whole plot and whole site environmental data produced very few meaningful correlations. However the sample sizes for analysis were small and restricted robust analysis of data and the outputs of data analysis may not reflect the true relationships within the data. Consideration of a larger data set to include information from other saltmarsh sites would enable a more comprehensive assessment to be made.

Multivariate analysis revealed that favourable and unfavourable plots were not readily separated by DCA, with sites usually overlapping to an extent. Equally no consistent trends in the ordination diagrams could be observed between favourable and unfavourable sites, with some unfavourable sites exhibiting greater spread than favourable sites and vice versa. On interrogation of the data, particularly in combination with the aerial photographs, there appear to be two mechanisms at work. Some unfavourable plots exhibited greater variability in species composition than favourable plots, for example due to the presence of a higher proportion of ruderal or agricultural species. This effect tended to be most pronounced in pairs with a limited range of saltmarsh zones recorded within the transect. Conversely, some favourable sites exhibited greater variation than unfavourable sites, due to improved zonation in the favourable site leading to a wider range of saltmarsh community types being present.

CCA outputs were often unclear due to number of factors acting alone or in combination. The range of botanical communities present within a single transect, and the differing management regimes that may apply to these communities or saltmarsh zones often complicated the CCA graphs. There was often poor separation between pairs of recorded favourable and unfavourable plots, suggesting that the plots were broadly similar and the classification of sites as favourable or unfavourable in the qualitative assessment may have been representative of only marginal differences between the plots. This is supported by the classification of greater numbers of plots as unfavourable in the quantitative assessment.

The CSM methodology requires saltmarsh zones to be determined as a pre-requisite to monitoring. However, determining zonation was often difficult on the basis of quantitative assessment as the grid references provided to indicate zonation often did not provide sufficient information to enable the zones in which individual quadrats were located to be determined, as the botanical composition of a quadrat does not necessarily reflect the zone in which it occurs, for example where accretional ramps with pioneer communities are present higher up the saltmarsh. In particular, the presence of such features is not always apparent where the physical structure of the saltmarsh is complicated, for example incorporating spits, creeks or pans.

Some attributes which are negative indicators include physical drivers of change other than the height of substrate +/- mean high-water level. Locally, these may be the indicators of severe pressure and causes of change due to, for example overgrazing and coastal squeeze. Currently, these are only noted during the field visit or from other sources but should be considered under a more quantitative recording exercise.

The current CSM guidance, when applied to saltmarsh habitats is of value in defining the status of individual SSSI units in respect of the variables recorded. However, the overall functional unit of the saltmarsh system is typically at the broader estuary level. Saltmarsh systems are dynamically locally unstable and are likely to be naturally more prone to variations in their extent, structure and function than terrestrial habitats such as broad-leaved woodland. Therefore it is particularly important when considering condition assessment that assessment is made of the overall functionality of the saltmarsh system at an estuary level. In particular an overall assessment of attributes such as extent, physical structure and vegetation structure across all units within each SSSI should form an intrinsic part of the condition assessment process.

Contents

Appendices

List of tables

List of figures

List of plates

Appendix 2:

1 Introduction

Background

1.1 In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as A Statement on Common Standards Monitoring (Joint Nature Conservation Committee 1998) and there is an introductory text on Common Standards Monitoring on the JNCC website at URL: www.jncc.gov.uk/page-2201 and summarised at URL: www.jncc.gov.uk/page-2219.

1.2 The sites covered by this framework are Special Protection Areas (SPAs), candidate Special Areas of Conservation (cSACs), Ramsar Sites, Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific Interest (ASSIs).

1.3 The aim for each site is to maintain it in favourable condition, and condition is assessed on a set of key features of interest for the broad habitats within each site as outlined in the Joint Nature Conservation Committee (1998) report.

1.4 The monitoring of key features allows each site to be categorized as favourable maintained, favourable recovered, favourable recovering, unfavourable no change, unfavourable declining, partially destroyed or destroyed.

1.5 The results of regular monitoring enable management practices on these sites to be appraised and changed if appropriate. Monitoring across a range of sites with similar habitats also allows some determination of the condition of the habitat resource as a whole, feeding into regional and national targets, including those identified within the UK Biodiversity Action Plan.

1.6 This document comprises an assessment of the findings of condition monitoring and its validation by quantitative assessment at four saltmarsh SSSI sites, the Humber Estuary, Morecambe Bay, Chichester Harbour and The Wash. The project covers notified SSSI saltmarsh habitat features as set out in the Coastal section of the SSSI guidelines.

Overall aims

1.7 The overall aims of the Validation Network project are to ensure that data on the condition of individual features on SSSIs are accurate, consistent and scientifically robust. The means to achieve this outcome are through a sample of sites on which quantitative monitoring is undertaken on a regular basis. This project operates in parallel with similar monitoring on other SSSIs.

1.8 The specific aims of the Validation Network project are as follows:

- to validate the condition assessment methodology in England through testing the suitability of attributes and associated targets in assessing quality and trends in condition;
- to establish a set of control sites to ensure that individual site assessments match regional or national changes in feature conditions over time; and
- to contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change.

2 Methodology

2.1 Methods for habitat monitoring have been derived from a combination of traditional quantitative methodologies, results of the Pilot Programme (Bealey & Cox 2004) and specialist advice. The basic strategy is to compare sets of quantitative data on attributes from plots which have been assessed as either favourable or unfavourable according to English Nature's condition monitoring criteria under Common Standards (JNCC 1998; Robertson & Jefferson 2000).

Selection of sample plots

2.2 Monitoring plots were selected by English Nature from a combination of ENSIS data (Level 1 and 2 and condition assessment information), site files (For example - NVC surveys) and visits to sites prior to Validation Network monitoring. For most sites, ENSIS data refer to large heterogeneous units or compartments and are therefore of limited use as the initial aim of Validation Network monitoring is to test the methodologies targeted at particular NVC types or Priority Habitats. Monitoring plots were therefore delineated within target vegetation types within the survey/management unit.

2.3 A sketch map of each monitoring plot was produced detailing observed zonation and any notable features (For example - turf cutting). Locations of key features such as quadrat locations and observed community boundaries were recorded using GPS. Locations of quadrats were not recorded on sketch maps.

2.4 At most sites, monitoring plots were paired (favourable and unfavourable) and represented the target NVC type within each site. Plots were also selected from within site condition monitoring units where vegetation was reasonably homogeneous (in terms of community and structure).

Botanical composition and associated measures

2.5 Within each plot a total of 30 x 4m2 botanical quadrats were recorded. Quadrats were set within each plot on a stratified random basis, being located proportionately to the relative amount of area in each saltmarsh vegetation zone. At each quadrat, presence of all vascular plants, filamentous algae and seaweeds, at six `nest' scales were recorded plus an overall percentage cover assessment of each species in the whole quadrat. The percentage cover of dead/dying *Spartina* was also recorded.

Environmental and structural variables

2.6 In addition to botanical recording, recording of environmental variables was undertaken at both an individual quadrat and whole plot levels.

2.7 Environmental parameters assessed at the quadrat level were:

- **Litter** - visually assessed for each quadrat.
- **Vegetation height** - assessed using a drop disk and metre rule.
- **Bare ground/mud** - visual assessment during botanical recording.
- **Height above or below mean high water level** - assessed using the GPS (accurate to a metre).

- **Evidence of erosion or accretion** - presence/absence of rotational sliding, toppled cliff blocks, overhanging or cantilever blocks and accretional ramp and pioneer species on an expanded 5 by 5 m quadrat for each plot.
- **Presence/absence of grazing** - frequency in an expanded 5 by 5 m quadrat for each plot.

2.8 Indicative features such as erosion, disturbance, pollution and other damage were also assessed on a whole plot basis. This assessment was made quantitatively in the field.

Other data

2.9 Climate summaries (based on monthly means 1971-2000) for the Humber Estuary, Morecambe Bay, Chichester Harbour and the Wash were obtained from the Meteorological Office.

Data availability

2.10 Quantitative data were supplied for all sites along with current aerial photographs. Data were supplied in digital format by English Nature, Peterborough.

2.11 Condition data was supplied for the Humber Estuary, Morecambe Bay, Chichester Harbour by English Nature local or national teams and were supplied as raw assessment sheets from the Project Officer. No condition assessment information was supplied by The Wash local team.

2.12 Historic aerial photographs were supplied in hard copy for Morecambe Bay plots only (none of the wider catchment), The Wash (whole catchment) and some plots on the Humber.

Data analysis

Comparison of qualitative condition data with quantitative data

2.13 Assessment of attribute ‘value’ from the condition monitoring exercise has been compared with the average value calculated from quantitative assessments.

2.14 To standardise analysis between plots and sites, site-specific attributes and targets were not considered as part of the comparison of qualitative data. This may have led to some sites being considered as in unfavourable condition in the context of this assessment when they could be judged as being in favourable condition in relation to site-specific conservation objectives. For example, where a site does not support pioneer communities with characteristic species assemblages it has been judged as being in unfavourable condition, whereas the distribution of such communities within the entire monitoring unit or SSSI may mean the absence of these communities within a specific transect does not place the unit in favourable condition overall. Judgement of favourable condition was undertaken on the basis of the following criteria:

Extent of feature

2.15 No estimation of condition of ‘extent of feature’ was made in many of the assessments, with the surveyor often referring to the need to establish this through interrogation of aerial photographs. Where this judgement has been made reference has been made to historic aerial photographs (where these are available) and the feature recorded as being in agreement with quantitative assessment (which also requires assessment of aerial photographs).

Physical structure - creeks and pans

2.16 Judgements must be made on day of survey.

Vegetation structure - zonation of vegetation

2.17 For the purposes of determining favourable condition this has been considered to require presence of pioneer, low-mid saltmarsh, mid-upper saltmarsh and transition zones, except where the presence of transition zones is prohibited by the presence of natural limiting features such as cliffs. As one or more zones may be naturally absent in some sites the key element in comparing qualitative and quantitative assessment has been agreement in respect of zones present rather than overall condition.

Vegetation structure - transition zones

2.18 These are defined by site-specific targets which are not considered within this assessment, except where the presence of an artificial barrier prevents their existence, which has been judged as unfavourable.

Vegetation structure - sward structure

2.19 The Common Standards Monitoring methodology specifies that grazing should be recorded as light to heavy (and abandoned) defined by the standing crop. In the majority of condition assessment no attempt has been made to quantify grazing in this manner other than to note whether grazing occurs (and sometimes the type of grazing). Where no note has been made stating that the plot is in unfavourable condition in respect of this attribute this has been taken as representing unfavourable condition. Assessment of condition based on quantitative survey has been made on the basis of average sward height in grazed plots.

Vegetation composition - Characteristic species

2.20 Assessment of favourable condition has been made on the basis of vegetation communities present (regardless of whether some communities are lacking) and is as specified in the Common Standards Methodology for pioneer, low-mid saltmarsh and mid-upper saltmarsh communities for both qualitative and quantitative recording methods.

Vegetation composition - Negative indicator species, *Spartina anglica*

2.21 The Common Standards Monitoring methodology specifies an indicative target of less than 10% expansion of *Spartina anglica* to pioneer saltmarsh in the last 10 years. This study has considered botanical information gathered over the course of a single year only and as such favourable condition cannot be judged against this target for the purposes of this assessment. In this study a plot has been considered to be in unfavourable condition in respect of qualitative assessment if this is specified on the condition assessment form, and in unfavourable condition on the basis of quantitative assessment if *Spartina anglica* forms an abundant component of the pioneer zone quadrats.

Other negative indicators

2.22 For this attribute unfavourable condition in qualitative assessment is judged to be where note has been made on the condition assessment. In terms of quantitative assessment this attribute has been considered as being in unfavourable condition where one or more of the following have been recorded or are discernable from recent aerial photographs:

- artificial drains;
- obvious visual pollution;
- turf cutting; and
- vehicle trampling or damage at vulnerable locations.

2.23 Final comparisons of qualitative and quantitative assessments have been made by comparing membership of favourable or unfavourable categories where these were recorded.

Assessment of botanical composition

2.24 Assessment of botanical composition has been undertaken to ensure ‘membership' of the correct zonal community by species associated with specific areas of stable saltmarsh. If saltmarshes are stable, then species will be associated with the zone according to height in relation to mean high water line and saltmarsh structure. However, if rapid changes are occurring, pioneer species may appear in the wrong zone. Consideration must be given to accretional ramps colonised by pioneer species as these may mislead data interpretation. Also, the recent die back of *Spartina* is having an effect on the dynamics of saltmarshes where the species was dominant.

2.25 Information on zones and NVC communities can be found in The English Nature/JNCC Saltmarsh Common Standards guidance and the book British Plant Communities Vol. 5: Maritime Communities and Vegetation of Open Habitats (Rodwell and others 2000), were referenced for ensuring accurate assessment of zones and NVC communities. Survey data was imported into the software MAVIS, developed by CEH, in order to classify the NVC community.

Assessment of influence of environmental variables

2.26 Environmental variables for each plot were collected over expanded 5 x 5 m quadrats (centred on the 2 x 2 m quadrat) for each botanical quadrat.

2.27 At each site environmental variables recorded at a quadrat scale included presence of litter; bare ground; toppled blocks; overhanging blocks; rotational sliding; accretional ramps and grazing. Environmental data recorded were compared between favourable and unfavourable paired plots for each site using two sample t-tests and Spearman’s rank correlation.

Multivariate analysis

2.28 The statistical package CANOCO (Leps & Smilauer 2003) was used to compare quadrat and plot data. Detrended Correspondence Analysis (DCA) was used to analyse community data for paired plots (favourable and unfavourable). Rare species were down weighted in the analysis to reduce their influence on community ordinations.

2.29 Canonical Correspondence Analysis (CCA) was used to relate the environmental variables recorded within quadrats directly to botanical composition.

2.30 Median axis 1 and 2 scores were calculated from the DCA using the median of the scores for quadrats taken from the pooled sites DCA. The medians were then assessed against whole plot environmental variables including temperatures, rainfall, northing and easting using a Spearman rank correlation to identify correlations between these data.

Aerial photographs

2.31 Where these were available analysis of aerial photographs at the plot level was undertaken to inform a determination of condition.

3 Results and discussion

Vegetation condition assessment

3.1 Plot names used in qualitative and quantitative assessment were often different within plots. For consistency nomenclature adopted during quantitative assessment has been followed in this study.

Humber Estuary

3.2 The Humber Estuary validation network comprised six plots. No indication was given in the data supplied of pairing of plots. However, on the basis of vegetation analysis the following pairs were identified:

- Barton and Barrow (Favourable) and Ellerker (Unfavourable).
- Pyewipe (Favourable) and East Halton (Unfavourable).
- Stone Creek (Favourable) and Welwick (Unfavourable).

3.3 Condition judgements presented within this report reflect retrospective judgements supplied in March 2006.

Morecambe Bay

3.4 Condition assessment of six Morecambe Bay plots were paired through the condition assessment process as follows:

- Foulshaw (Favourable) and Milnthorpe (Unfavourable).
- Sandside North (Favourable) and Sandside South (Unfavourable).
- Warton North (Favourable) and Warton South (Unfavourable).

Chichester Harbour

3.5 Chichester Harbour comprised the following plots, all of which were judged to be in unfavourable condition by the qualitative survey. However, in order to undertake the analysis required for this project the pairs of plots have been considered as relatively favourable and unfavourable as detailed below:

- Horse Point (Favourable) and Verner Common (Unfavourable).
- Ellanore (Favourable) and Mengham Salterns (Unfavourable).
- Fishbourne (Favourable) and Langstone (Unfavourable).

The Wash

3.6 The Wash plots comprised the following sites. No overall assessment of condition was made by the qualitative surveyor and relative favourable status has been determined on the basis of overall condition of units (Frampton and The Haven) and vegetation communities, including zonation and abundance of *Spartina anglica*:

- Wainfleet (Favourable) and Wrangle (Unfavourable).
- Frampton (Favourable) and The Haven (Unfavourable).
- Snettisham (Favourable) and Terrington (Unfavourable).

Comparison of qualitative and quantitative condition data

Humber Estuary

3.7 Comparisons of recorded condition for each Humber plot are presented in Tables 1-6 below. In general features noted within individual plots were comparable between recording methods. However, overall estimation of plot condition did not accord with the characteristics for many sites, with none of the Humber plots being recorded as in favourable condition based on stringent application of the condition assessment methodology. The most favourable site was Pyewipe, which failed on only a single criterion - the presence of a vehicular access track along the upper limit of the upper saltmarsh, which is considered to be preventing establishment of transition vegetation communities.

3.8 The most commonly failed criterion was presence of a seawall preventing future landward colonisation by saltmarsh communities as may be expected to otherwise occur if sea levels rise as a result of global warming. Seawalls also inhibit the development of transitional vegetation communities.

3.9 Botanical composition was generally comparable between the two methodologies, although recording of zonation was different at both Welwick and Pyewipe. The botanical communities present within the recorded zones generally reflect the zonation recorded in the condition assessment.

3.10 *Spartina anglica* was present within all plots and often formed an abundant or dominant component of the pioneer vegetation community. In the context of this assessment this has been taken to represent a failure of affected plots to meet the ‘negative indicators’ criterion. However it is noted in the Humber Condition Assessments that the surveyor considers that higher abundances of *Spartina anglica* may be more acceptable at Humber sites than elsewhere.

Table 1 Barton and Barrow: data comparison

Barton and Barrow (Humber Bridge)	Condition assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Favourable	n/a		
Extent of habitat	Prograding and small area of erosion noted but could be a typo from East Halton as phrasing identical	Aerial photographs not sufficiently clear	n/a	n/a
Physical structure: creeks and pans	Natural creek patterns (P)	Aerial photographs not sufficiently clear	n/a	n/a
Vegetation structure: zonation of vegetation	No mid saltmarsh present (F)	No mid-marsh present (F)	Y	Y
Vegetation structure: sward structure	No comment made (P)	No grazing. Mean height 33.5 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	None present (F)	*Aster tripolium* R (F)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	n/a		
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 2A, 1F (P)	None recorded		
Vegetation composition: *Spartina anglica*	Co-dominant (F)	Co-dominant (F)	Y	Y
Other negative indicators	Seawall present (F)	Seawall present (F)	N	Y
Number of failed attributes	4	4		

Table 2 Ellerker: data comparison

Ellerker	Condition assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable	n/a		
Extent of habitat	Aerial photographs needed	No aerial photographs available	n/a	n/a
Physical structure: creeks and pans	Possible modified creek (F)	n/a	n/a	n/a
Vegetation structure: zonation of vegetation	Only brackish swamp transition present (F)	Mid-low/mid-upper communities with SM16 (F)	Y	Y
Vegetation structure: sward structure	Short-grazed grassland (F)	Mean vegetation height 29 cm but reflects presence of *Bolboschoenus maritimus* and some quadrats <10 (F)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	None present (F)	None present (F)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	None present (F)	*Aster tripolium* and *T. maritima* O (F)		
Mid-upper saltmarsh. At least 1 sp A and 3 F	1 D (F)	3 O (F)	Y	N
Vegetation composition: *Spartina anglica*	None present (P)	Locally abundant in low saltmarsh quadrats (?)	Y	Y
Other negative indicators	None noted	None apparent	N	Y
Number of failed attributes	6	5/6		

Table 3 Pyewipe: data comparison

Pyewipe	Condition assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Favourable	n/a		
Extent of habitat	Accretion noted, presumed natural change (P)	No aerial photographs available	n/a	n/a
Physical structure: creeks and pans	Natural change only (P)	No aerial photographs available	n/a	n/a
Vegetation structure: zonation of vegetation	No upper saltmarsh present - young saltmarsh (P)	All zones recorded during quantitative transects (P)	Y	N
Vegetation structure: sward structure	Not grazed, no specific comment made (P)	Not grazed, mean vegetation height 10.5, (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1A, 1D, 1F (P)	1A, 1D, 1F (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 5 present abundance not noted (P)	No quadrats within reported lower saltmarsh zone	?	Disagreement with zonation
Mid-upper saltmarsh. At least 1 sp A and 3 F	Not present	Lower saltmarsh targets met in this area	Y	Disagreement with zonation
Vegetation composition: *Spartina anglica*	Frequent in some areas, not dominant (P)	Present in all pioneer quadrats typically low percentage cover but up to 50 % (P, marginal)	Y	Y
Other negative indicators	Track along upper end of saltmarsh preventing development of transitional communities (F)	Track visible in current aerial photographs (F)	Y	Y
Number of failed attributes	1	1		

Table 4 East Halton: data comparison

East Halton	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable	n/a		
Extent of habitat	Prograding with small area of erosion and stone tipping noted	Evidence of erosion noted. No historic aerial photographs available	n/a	n/a
Physical structure: creeks and pans	No comment made (P)	No aerial photographs available	n/a	n/a
Vegetation structure: zonation of vegetation	All zones present (P)	No low-mid saltmarsh recorded (F)	N	N
Vegetation structure: sward structure	Not grazed, no specific comment made (P)	Not grazed, mean vegetation height 20 cm (P)	Y	Y
Vegetation composition: Characteristic species				
Pioneer. At least 1 sp F and 1 O	2A, 1F (P)	2A, 1F (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A, 1F (P)	1D, 2A, 1F (P)	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	3F (F)	3F (F)	Y	Y
Vegetation composition: *Spartina anglica*	Frequent in some areas, not dominant (P)	Present in 2 quadrats at 2 & 90% (P)	Y	
Other negative indicators	Seawall present (F)	Seawall present (F)	Y	Y
Number of failed attributes	2	3		

Table 5 Welwick: data comparison

Welwick	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Favourable	n/a		
Extent of habitat	Aerial photographs needed	Aerial photographs needed	n/a	n/a
Physical structure: creeks and pans	A few creeks - apparently natural (P)	A few creeks - look natural from current aerials(P)	n/a	n/a
Vegetation structure: zonation of vegetation	No transition habitats (F)	Transition habitats recorded on transects, but see below (F)	N	N
Vegetation structure: sward structure	Not grazed vegetation tall and dense (P)	Not grazed, mean vegetation height 21 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	4A (P)	2A, 1F (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 1A, 2F (P)	1D, 1A, 2F (P)	?	?
Mid-upper saltmarsh. At least 1 sp A and 3 F	4 present, abundance not noted (presumed P)	Only 1O in recorded mid-upper saltmarsh zone, but 3 O in 'habitats above upper saltmarsh' (F)	Y	Disagreement with zonation
Vegetation composition: *Spartina anglica*	Frequent sometimes abundant throughout plot (P)	5-70% cover in pioneer quadrats (F)	N	N
Other negative indicators	Seawall present (F)	Seawall present (F)	Y	Y
Number of failed attributes	2	4		

Table 6 Stonecreek: data comparison

Stone Creek	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable	n/a		
Extent of habitat	Aerial photographs needed	Aerial photographs needed	n/a	n/a
Physical structure: creeks and pans	Some creeks appear unnaturally straight (F)	Straightened creeks apparent on current aerials (F)	n/a	n/a
Vegetation structure: zonation of vegetation	No mid-upper saltmarsh or transition communities present (F)	No transition communities present (F)	Y	N
Vegetation structure: sward structure	Not grazed vegetation tall and dense (P)	Not grazed, mean vegetation height 17 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1A 1F (P)	1A, 1F (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	4A 2F (F)	1D, 1A, 2F (P)	N	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	None present (F)	1O, 4R (F)	Y	N
Vegetation composition: *Spartina anglica*	Frequent in pioneer zone but not dominating community (P)	Dominant in pioneer quadrats (F)	N	N
Other negative indicators	Seawall present (F)	Seawall present (F)	Y	Y
Number of failed attributes	5	5		

Morecambe Bay

3.11 None of the plots sampled at Morecambe were found to be in favourable condition when considered against the Common Standards Monitoring Guidance. Foulshaw was found to be relatively more favourable than Milnthorpe as identified by the Condition Assessment, but other pairs of sites were found to fail the same number of attributes in favourable and unfavourable stands.

3.12 Sites that were recorded as being in favourable condition on the basis of prior knowledge were without exception found to be in unfavourable condition on the basis of not only quantitative data, but also the condition assessment undertaken when specific attributes were considered against the CSM guidance.

Table 7 Milnthorpe: data comparison

Milnthorpe	**Condition Assessment**		**Agreement**	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Favourable	n/a		
Extent of habitat	Natural change only (P)		Y	Y
Physical structure: creeks and pans	Natural change only (P)		Y	Y
Vegetation structure: zonation of vegetation	No pioneer or transition communities (F)	No pioneer or transition communities (F)	Y	Y
Vegetation structure: sward structure	Considered good (P)	Mean sward height 4 cm in grazed quadrats (F)	N	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A (P)	1D, 1A, 1F (P)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	No overall judgement made but 1D, 1A, 1F, 2 O/F (P)	1D, 1A, 2F (P)	Y	Y
Vegetation composition: *Spartina anglica*	Very rare along leading edge (P)	Rare (P)	Y	Y
Other negative indicators	Seawall present (F)	Seawall present (F)	Y	Y
Number of failed attributes	2	3		

Table 8 Foulshaw: data comparison

Foulshaw	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Conditions**	**Details**
Overall condition recorded	Favourable	n/a		
Extent of habitat	Rapidly eroding edge but considered natural change (P)			
Physical structure: creeks and pans	No recent modification (P)			
Vegetation structure: zonation of vegetation	Only mid-upper saltmarsh present (F)	Mid-upper saltmarsh and transition zones recorded in transects (F)	Y	Y
Vegetation structure: sward structure	Over-grazed - 2 cm sward and limited sp. diversity (F)	Most quadrats grazed. Mean sward height 3.3 cm in grazed quadrats (F)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	n/a		
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 1A, 3F (P)	1A, 3F (P)	Y	N
Vegetation composition: *Spartina anglica*	None	None	Y	Y
Other negative indicators	Limited sheep trampling (P)	Sheep trampling 2% (P)	Y	Y
Number of failed attributes	2	2		

Table 9 Warton North: data comparison

Warton North	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Favourable recovered			
Extent of habitat	Front edge eroding - natural change (P)			
Physical structure: creeks and pans	Active natural change (P)			
Vegetation structure: zonation of vegetation	Only mid-upper zone present (F)	Low-mid and mid-upper zones recorded (F)	Y	N
Vegetation structure: sward structure	Sheep and cattle grazing - stocking halved 5 years ago (P)	Mean sward height 6.7 cm (F)	N	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	1F, 2R - sp. More indicative of upper saltmarsh community (F)	N	Query re. Zonation
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 3A, 2F (P)	4A, 2F (P)	Y	N
Vegetation composition: *Spartina anglica*	None present (P)	None present (P)	Y	Y
Other negative indicators	None noted	Obvious visual pollution <1% (P)		
Number of failed attributes	1	3		

Table 10 Warton South: data comparison

Warton South	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable no change	N/A		
Extent of habitat	No change (P)			
Physical structure: creeks and pans	No alterations apparent (P)			
Vegetation structure: zonation of vegetation	Mid-upper and brackish swamp transition zones only (F)	No pioneer zone present (F)	Y	N
Vegetation structure: sward structure	Over-grazed, sheep, too short (F)	Mean sward height in grazed quadrats 6.7 (F)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	1F, 2R - sp. More indicative of upper saltmarsh community (F)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 2A, 3F (P)	2A, 3F (P)	Y	N
Vegetation composition: *Spartina anglica*	None present (P)	None present (P)	Y	Y
Other negative indicators	Small amount of compaction (P)	None noted (P)	Y	N
Number of failed attributes	2	3		

Table 11 Sandside North: data comparison

Sandside North	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable no change			
Extent of habitat	No change (P)			
Physical structure: creeks and pans	No alterations apparent (P)			
Vegetation structure: zonation of vegetation	Only mid-upper zone present (F)	Only mid-upper zone present (F)	Y	Y
Vegetation structure: sward structure	Over-grazed, sheep, too short (F)	Mean sward height in grazed quadrats 5.7 (F)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	n/a		
Mid-upper saltmarsh. At least 1 sp A and 3 F	2D, 1O (F)	2A, 1F (F)	Y	N
Vegetation composition: *Spartina anglica*	None present (P)	None present (P)	Y	Y
Other negative indicators	Turf cutting present (F)	Turf cutting present (F)	Y	Y
Number of failed attributes	4	4		

Table 12 Sandside South: data comparison

Sandside South	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Unfavourable no change			
Extent of habitat	No change (P)			
Physical structure: creeks and pans	No alterations apparent (P)			
Vegetation structure: zonation of vegetation	Only mid-upper zone present (F)	Only mid-upper zone present (F)	Y	Y
Vegetation structure: sward structure	Over-grazed, sheep, too short (F)	Mean sward height in grazed quadrats 6.7 (F)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	n/a	n/a		
Mid-upper saltmarsh. At least 1 sp A and 3 F	2D, 1A (F)	2A, 2F (P)	N	N
Vegetation composition: *Spartina anglica*	None present (P)	None present (P)	Y	Y
Other negative indicators	Turf cutting present (F)	Turf cutting present (F)	Y	Y
Number of failed attributes	3	3		

Chichester Harbour

3.13 All recorded plots at Chichester Harbour were noted as being in unfavourable condition in the qualitative survey on the basis of one or more mandatory attributes, although no overall judgement of condition was made on the condition assessment form. Erosion and coastal squeeze were noted as failing attributes in a number of plots, and analysis of botanical data (Sections 3.17 - 3.54) indicates that mid-upper saltmarsh zones are dominated by vegetation assemblages typical of pioneer or low-mid saltmarsh communities at all plots with the exception of Verner Common.

3.14 The main areas of disagreement between qualitative and quantitative assessment for the Chichester Harbour plots relate to either 'Vegetation composition' or 'Other negative indicators'. Both presence and abundance of key indicator species often varied between methods and this resulted in differences in condition of at least one attribute being recorded from all but one plot (Horse Point). Eutrophication and trampling were also noted during the qualitative assessment for a number of plots but were not identified as significant factors during quantitative assessment. It is possible that judgements about eutrophication were made on the basis of personal local knowledge rather than being directly related to conditions recorded on site.

Table 13 Horse Point: data comparison

Horse Point	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	n/a		
Extent of habitat	Upper saltmarsh being 'squeezed' (F)	No aerials supplied		
Physical structure: creeks and pans	No major pans (P)	No aerials supplied		
Vegetation structure: zonation of vegetation	No transition habitats no comment made (presumed P)	No transition habitats, but plot represents 'finger' extending between saltmarsh area and therefore may naturally not occur within the transect (P)	Y	Y
Vegetation structure: sward structure	No comment made (P)	No grazing, mean sward height 13 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1A, 2F (P)	1A, 2F (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A, 1F (P)	1D, 3A (P)	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	1O, (F)	None present in quadrats. Communities tending towards pioneer (F)	Y	Y
Vegetation composition: *Spartina anglica*	Dominant in pioneer zoned (F)	Up to 100% cover in pioneer zone quadrats (F)	Y	Y
Other negative indicators	None noted (P)	None noted (P)	Y	Y
Number of failed attributes	3	2		

Table 14 Ellanore: data comparison

Ellanore	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	No aerials supplied		
Extent of habitat	Not specified (P)	Some erosion, but whether natural change unclear, no historic aerial photographs supplied		
Physical structure: creeks and pans	Few pans, some creeks, no evidence of erosion (P)	No aerials supplied		
Vegetation structure: zonation of vegetation	No transition habitats present (F)	No transition habitats present (F)	Y	Y
Vegetation structure: sward structure	No comment made (P)	Ungrazed, mean sward height 13 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1D (F)	1A, 1F (P)	N	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A, 2F (P)	1D, 1A, 2F (P)	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	3O, 1R, (F)	None present in quadrats - mid-marsh communities only (F)	Y	Y
Vegetation composition: *Spartina anglica*	Recorded as F, but not failed (P)	Generally low abundance in pioneer zone quadrats (<10%) (P)	Y	Y
Other negative indicators	Bare mud along path (F)	2% bare mud along path (F)	Y	Y
Number of failed attributes	4	3		

Table 15 Verner Common: data comparison

Verner Common	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	n/a	n/a	n/a
Extent of habitat	Not specified			
Physical structure: creeks and pans	Cliff erosion (F)			
Vegetation structure: zonation of vegetation	All zones present, but transitions outside plot (P)	All zones present, but transitions outside plot (P)	Y	Y
Vegetation structure: sward structure	No comment made (P)	Sward height rather short, but ungrazed except in most landward quadrat (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1F (F)	1F, 1R (F)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	No D, 4A (F)	No D, 3A, 1F (F) high proportion of pioneer (P) in sward	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	2A, 2F (P)	2A, 2F (P)	Y	Y
Vegetation composition: *Spartina anglica*	Abundant in pioneer zone (F)	Dominant in pioneer quadrats (F)	Y	N
Other negative indicators	Upper saltmarsh may be 'squeezed' by seawall, horse poaching, seawall present (F)	Seawall present, some trampling from horse riding (1%) (F)	Y	Y
Number of failed attributes	5	4		

Table 16 West Fishbourne: data comparison

West Fishbourne	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	n/a	n/a	n/a
Extent of habitat	Not specified			
Physical structure: creeks and pans	Vegetated creek with little open mud (P)			
Vegetation structure: zonation of vegetation	Pioneer, low-mid, mid-upper, strandline and other habitats above mid-marsh present (P)	Pioneer, low-mid, mid-upper and strandline present (P)	Y	Y
Vegetation structure: sward structure	No comment made (P)	No grazing (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	3F, 2O (P)	3O, 2R (F)	N	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A, 1F (P)	1D, 1F, 1O (F)	N	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	1O, other sp. More characteristic of mid-low saltmarsh - problems with zonation noted (F)	4O, other sp. Typical of lower saltmarsh (F)	Y	Y
Vegetation composition: *Spartina anglica*	Dominant in pioneer zone (F)	Dominant in pioneer zone (F)	Y	Y
Other negative indicators	Eutrophication from adjacent fields and harbour considered likely (F)	10% cover green algae (F)	Y	Y
Number of failed attributes	3	5		

Table 17 Langstone: data comparison

Langstone	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	n/a	n/a	n/a
Extent of habitat	No comment made (P)			
Physical structure: creeks and pans	Cliffing along creeks indicate high erosion (F)	Some erosion noted (F)	Y	Y
Vegetation structure: zonation of vegetation	Pioneer, low-mid saltmarsh, mid-upper saltmarsh and strandline present (P)	No mid-upper saltmarsh recorded (F)	N	N
Vegetation structure: sward structure	No comment made(P)	Ungrazed. Mean sward height 9 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1D, (F)	1F, 1O, (F)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1A, 2F - possibly attributable to poor sampling (F)	1A, 1F, 2O (F)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 1A, 3O (F)	Not recorded	Y	N
Vegetation composition: *Spartina anglica*	Abundant in pioneer zone (F)	Locally abundant in some pioneer quadrats, but incidence less than 50%. Occasional in mid-marsh communities (F)	Y	Y
Other negative indicators	Eutrophication (high levels of Enteromorpha) and trampling (F)	None noted (P)	N	N
Number of failed attributes	6	5		

Table 18 Mengham Salterns: data comparison

Mengham Salterns	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not specified	n/a	n/a	n/a
Extent of habitat	No comment made (P)	No anthropogenic changes apparent (P)	Y	Y
Physical structure: creeks and pans	No evidence of realignment (P)	No evidence of realignment (P)	Y	Y
Vegetation structure: zonation of vegetation	Pioneer, low-mid saltmarsh and mid-upper saltmarsh present, but little upper-marsh vegetation recorded (F)	All zones recorded as present (P)	N	N
Vegetation structure: sward structure	No comment made (P)	No grazing. Mean sward height 11 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	2F, 1R, (P)	1O (F)	N	N
Low-mid saltmarsh. At least 1 sp D and 2 F	3A, (F)	3O (F)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	1O, 3R, other vegetation more typical of mid-marsh (F)	No sp. Present. low-mid saltmarsh and pioneer communities only (F)	Y	Y
Vegetation composition: *Spartina anglica*	Dominant in pioneer zone (F)	Dominant in nearly 50% of quadrats (F)	Y	Y
Other negative indicators	Trampling (F)	None noted (P)	N	N
Number of failed attributes	5	4		

The Wash

3.15 No assessment of overall condition of The Wash plots was made by the qualitative assessor, and only attributes relating to botanical structure were assessed. Assessment of other attributes was considered by the English Nature local team to be inappropriate due to the restricted areas of the quantitative plot transects, which do not necessarily give an overview of condition in the unit overall.

Table 19 Frampton: data comparison

Frampton	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	Only low-mid saltmarsh zones recorded (F)	Only mid-upper zone present (F)	Y	Y
Vegetation structure: sward structure	Sward height 10-30 cm (P?)	Mean sward height in grazed quadrats 9.86 (F)	?	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	n/a	n/a		
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2F, 4 O/R (P)	1D, 2F, 4 O/R (P)	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	n/a	n/a		
Vegetation composition: *Spartina anglica*	Not recorded (P)	Present occasionally, not dominating communities (P)	Y	N
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	1/2	2		

Table 20 The Haven: data comparison

The Haven	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	Only low-mid saltmarsh and pioneer zones recorded (F)	Only low-mid zone present (F)	Y	N
Vegetation structure: sward structure	Sward height <5 cm (F)	Mean sward height in grazed quadrats 7cm (F)	Y	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1D, 1O, 1R (P)	None recorded	N	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2F, 2O, 2R (P)	1D, 2F, 2O, 2R (P)	Y	Y
Mid-upper saltmarsh. At least 1 sp A and 3 F	n/a	n/a	Y	
Vegetation composition: *Spartina anglica*	Recorded as rare (P)	Single quadrat only (P)	Y	Y
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	2	2		

Table 21 Wainfleet: data comparison

Wainfleet	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	Only low-mid saltmarsh and pioneer zones recorded (F)	Pioneer, low-mid and mid-upper saltmarsh communities recorded (F)	Y	N
Vegetation structure: sward structure	Not noted	Mean sward height in grazed quadrats 13.25 cm (P)	N	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	2A (F)	1F, 1O, 2R (P)	N	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 3A, 5R (P)	2D, 2A, 1O, 2R (P)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	n/a	2R (F)	N	N
Vegetation composition: *Spartina anglica*	Occasional in low-mid saltmarsh (P)	Frequent in both pioneer and low-mid saltmarsh (F)	N	N
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	2	3		

Table 22 Wrangle: data comparison

Wrangle	Condition Assessment		Agreement	
Attribute	**Condition Assessment**	**Agreement**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	Only low-mid saltmarsh and pioneer zones recorded (F)	Pioneer, mid-low and mid-upper communities recorded (F)	Y	N
Vegetation structure: sward structure	Only recorded for low-mid saltmarsh communities, mean sward height 14 cm (P)	Mean sward height in grazed quadrats 5 cm (F)	N	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1D, 2A, 1F, 1O, 2R (P)	1F, 2O (P)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	2D, 3A, 3F, 2R (P)	2D, 1A, 3O, 2R (P)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	n/a	1A, 2F, 1O, 1R (F)	N	N
Vegetation composition: *Spartina anglica*	Abundant in pioneer zone (F)	Dominant in pioneer, frequent in low-mid saltmarsh (F)	Y	N
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	2	4		

Table 23 Snettisham: data comparison

Snettisham	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	No transitional habitats sampled (F)	Saltmarsh strand, mid-upper, low-mid and pioneer present (F)	Y	Y
Vegetation structure: sward structure	Only recorded for pioneer and low-mid saltmarsh communities, mean sward height 12.7 cm (P)	Mean sward height in grazed quadrats 13.5 cm (P)	Y	Y
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1A, 1O, 3R (P)	2A, 2F (P)	Y	N
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 5A, 3O, 2R (P)	1D, 1A, 1F, 1O, 1R (P)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	1D, 3O, 9R (F)	1O, 1R (F)	Y	N
Vegetation composition: *Spartina anglica*	Rare (P)	Abundant throughout (F)	N	N
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	2	2		

Table 24 Terrington: data comparison

Terrington	Condition Assessment		Agreement	
Attribute	**Qualitative**	**Quantitative**	**Condition**	**Details**
Overall condition recorded	Not noted			
Extent of habitat	Not noted			
Physical structure: creeks and pans	Not noted			
Vegetation structure: zonation of vegetation	Only low-mid saltmarsh and pioneer zones recorded (F)	Pioneer, low-mid, and mid-upper present (F)	Y	N
Vegetation structure: sward structure	Not noted	Not grazed (P)	N	N
Vegetation composition: characteristic species				
Pioneer. At least 1 sp F and 1 O	1D, 3A (P)	1D, 3A (P)	Y	Y
Low-mid saltmarsh. At least 1 sp D and 2 F	1D, 2A, 1O (P)	2D, 1F, 1R (P)	Y	N
Mid-upper saltmarsh. At least 1 sp A and 3 F	n/a	0 (F)	N	N
Vegetation composition: *Spartina anglica*	Abundant in pioneer and frequent in low-mid saltmarsh communities (F)	Non present (P)	N	N
Other negative indicators	Not noted	None noted	Y	Y
Number of failed attributes	2	2		

Assessment of botanical composition

3.16 Assessment of vegetation communities and zonation was undertaken based on recorded locations of zones (from qualitative and/or quantitative data as available) and assessment of botanical communities recorded within each of the identified zones during quantitative assessment using MAVIS software.

Assessment of NVC community types

Humber estuary

Ellerker

3.17 Condition assessment noted NVC communities S4 *Phragmites australis* swamp and reedbeds, S21 *Bolboschoenus maritimus* swamp and MG6 *Lolium perenne* - *Cynosurus cristatus* grassland as occurring within the Ellerker plot.

3.18 Quadrats recorded as part of the quantitative survey support the qualitative assessment that no pioneer communities are present within the transect, with the lowest reaches of the saltmarsh being dominated by *Bolboschoenus maritimus* with *Agrostis stolonifera* and having closest affinity with S21. However, the lowest saltmarsh areas supporting true saltmarsh communities occur as a triangular area bounded on two sides by *Bolboschoenus maritimus* and comprise SM16 *Festuca rubra* saltmarsh community. The sward is not completely closed with between 10 and 30% bare ground being recorded from low saltmarsh quadrats. SM 16 communities are usually found on grazed saltmarshes, as is the case at Ellerker and typically have a short sward, although the vegetation heights recorded within relevant quadrats at Ellerker are not particularly short with heights between 15 and 32 cm being recorded from quadrats. The mid-upper saltmarsh communities also comprise SM16 saltmarsh, although no clear sub-community distinction can be made on the basis of the MAVIS analysis. The sward in the mid-upper saltmarsh has the general character of an agriculturally re-sown sward with selective saltmarsh species re-establishing themselves.

3.19 The vegetation communities recorded from quadrats at Ellerker bear little apparent similarity to the vegetation recorded during qualitative assessment. It seems likely that recording of vegetation during qualitative assessments was undertaken at slightly different locations to the area covered by quantitative survey and the condition assessment commented that the plot was located between areas of *Phragmites* reedbed (presumably explaining the presence of S4 as a community type in the qualitative data), but this cannot be confirmed as the ordnance survey grid references supplied for the site were incorrect, relating to the Barton and Barrow plot.

Barton and Barrow

3.20 The pioneer zone at Barton Barrow is dominated by *Bolboschoenus maritimus*, and as such comprises S21 swamp. Low and mid saltmarsh communities are absent from this site and the upper saltmarsh/brackish swamp areas correspond well to SM16c community type.

Pyewipe

3.21 Condition assessment at Pyewipe noted NVC communities SM10 transitional low saltmarsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*, SM11 *Aster tripolium* var. *discoides* saltmarsh communities, and SM13 *Puccinellia maritima* saltmarsh community as occurring within the plot.

3.22 Quadrats sampled as part of the quantitative survey show the seaward edge of the pioneer saltmarsh to comprise *Puccinellia maritima*, *Spartina anglica* and *Salicornia* agg. with no definitive NVC associations. Approximately halfway along the pioneer zone *Aster tripolium*

var. *discoides* begins to appear within the sward indicating possible transitions towards SM10 and SM11 communities due to the prominence of *A. tripolium* var. *discoides*. Stands of *Bolboschoenus maritimus* were recorded from the base of sand dunes that mark the upper limit of the saltmarsh at this site.

East Halton

3.23 Condition assessment noted NVC communities SM6, *Spartina anglica* saltmarsh community, SM8 Annual *Salicornia* saltmarsh community, SM10, SM11, SM13 *Puccinellia maritima* saltmarsh, SM16, SM24 *Elymus pycnanthus* saltmarsh community, and S21 as occurring within the East Halton plot.

3.24 *Spartina anglica* was recorded from the quadrats 1 and 2 within the pioneer zone during the quantitative survey, although NVC analysis using MAVIS does not identify SM6 as a potential community fit due to the presence of other species including *Spergularia marinum*, *Puccinellia maritima* and *Aster tripolium* and these quadrats have no definitive fit with any particular saltmarsh community. Low-mid saltmarsh communities comprise SM24 saltmarsh as identified during condition assessment and upper saltmarsh communities comprise S21. SM16 communities are present as middle saltmarsh communities adjacent to the lake.

Stone Creek

3.25 Condition assessment noted NVC communities SM6, SM8, SM10, SM13, SM14 *Atriploides portaculoides* saltmarsh, and SM24 as occurring within the Stone Creek plot.

3.26 These community assessments are broadly well supported by quantitative survey which identifies SM6, SM8 and SM14a as potential fits for the pioneer zone quadrats, although all at low match coefficients. The low-middle saltmarsh quadrats have most affinity with SM13 and SM14, and are better fitted than the pioneer communities. The low-mid saltmarsh zone includes four quadrats, the lower of which (7 and 8) have slightly higher affinity to SM14 with the upper two quadrats having slightly better affinity to SM13. The mid-upper saltmarsh zone comprises SM24 saltmarsh.

3.27 The zonation at Stone Creek is well defined and can be readily determined from aerial photographs of the site facilitating community analysis. The vegetation types present are representative of the zonation and are located as would be expected within the saltmarsh communities.

Welwick

3.28 Condition assessment noted the same NVC communities at Welwick as recorded at Stone Creek (SM6, SM8, SM10, SM13, SM14, (SM16), SM24).

3.29 The pioneer zone at Welwick fits most closely into the SM10 community type, although it is similarly matched to NVC community type SM11 *Aster tripolium* var. *discoideus* saltmarsh. The low saltmarsh vegetation is better matched with NVC SM14a and the mid-upper saltmarsh communities exhibit good matches with both SM24 and SM26.

Morecambe Bay

3.30 No record of the NVC community types present was supplied for Morecambe Bay plots. Locations of stopping points of the structured walk were not supplied making comparison of observed and expected communities impractical.

Milnthorpe

3.31 No pioneer saltmarsh communities are present at Milnthorpe. The low-mid saltmarsh communities have the closest affinity with SM16a, typically a community of upper saltmarsh habitats, although it is known to extend seaward in western sites such as Morecambe Bay. This community extends into the recorded upper saltmarsh zone, but closer associations with

SM23 *Spergularia maritima - Puccinellia distans* saltmarsh occur towards the centre of this zone. SM23 is typically an ephemeral community indicative of continuous disturbance. The quadrats recorded at Milnthorpe lack the characteristic species *Puccinellia distans*, but this species is not constant within the community. Quadrats 19-24 are grazed, and the condition assessment notes some cattle poaching within the plot which may have led to the development of vegetation communities typically associated with disturbance.

Foulshaw

3.32 No pioneer or low-mid saltmarsh communities are present within the Foulshaw plot. Upper saltmarsh communities exhibit a best fit with SM16c *Festuca rubra* saltmarsh: *Festuca rubra - Glaux maritima* sub-community. This sub-community is typically associated with sheep-grazed upper saltmarsh habitats as is the case at Foulshaw and has been widely recorded in Morecambe Bay.

3.33 Other habitats are recorded as being present above the upper saltmarsh and it is noted in the quantitative survey that these include *Lolium perenne*, although this was recorded from a single quadrat in the upper saltmarsh and not in the 'above upper saltmarsh' location. Based on quadrat recording these habitats are a good match with SM18 *Juncus maritimus* saltmarsh community, an upper saltmarsh community that commonly occurs on grazed sites. The unpalatability of *Juncus maritimus* to grazing livestock reduces the value of the site as grazing land and may help promote invasion of the species into upper saltmarsh areas at overgrazed sites such as Foulshaw.

Warton North

3.34 No pioneer zone was recorded from within the Warton North plot. Transect locations indicate a band of low-mid saltmarsh extending approximately half the width of the plot, although vegetation present represents SM16 saltmarsh, an upper saltmarsh community. Quadrats recorded within the specified upper saltmarsh zone comprise SM16 communities.

Warton South

3.35 As at Warton North, no pioneer zone was recorded from within the Warton South plot. Transect locations indicate a band of low-mid saltmarsh extending approximately half the width of the plot, although the vegetation present represents SM16 saltmarsh, an upper saltmarsh community. Quadrats recorded within the specified upper saltmarsh zone comprise SM18 communities as recorded at Foulshaw and may have expanded within the upper saltmarsh due to over-grazing. Transition habitats are recorded as present above the upper saltmarsh, but no clear distinction in vegetation type can be determined on the basis of quadrat analysis as these also comprise SM18 communities.

Sandside North

3.36 Sandside North comprises predominantly mid-upper saltmarsh habitat, which is characterised by SM16 saltmarsh communities. A narrow pioneer zone dominated by *Puccinellia maritima* accounts for two of the quadrats recorded.

Sandside South

3.37 Sandside North comprises mid-upper saltmarsh only, which is characterised by SM16 saltmarsh communities.

Chichester Harbour

Horse Point

3.38 Quadrats 14, 17 and 20 were discounted from vegetation analysis as the co-ordinates supplied recorded these quadrats as not being within the transect, and it was not possible to confirm the locations of these quadrats on site.

3.39 Within the marked pioneer zone vegetation communities are intermediate between the pioneer saltmarsh community SM6 *Spartina anglica* saltmarsh community in the southwestern corner of the transect and SM13, which is typically a low-saltmarsh or pioneer community, tending to establish in this zone on sandy substrates from vegetative fragments uprooted as a result of grazing elsewhere within the catchment and washed ashore. At Horse Point the community has some affinity with the SM13e turf fucoid sub-community.

3.40 The low-mid saltmarsh communities at Horse Point exhibit 'best fit' with SM14a *Atriplex portulacoides* saltmarsh, *Atriplex portulacoides* sub-community. This is the most species-poor of the SM14 sub-communities and can occur in different zones depending on the site.

3.41 The mid-upper saltmarsh communities show a strong affinity to SM26 *Inula crithmoides* on saltmarshes. In Britain this community type is restricted to the southern coasts potentially due to climatic conditions, although it has also been reported as being associated with base-rich freshwater inputs.

West Fishbourne

3.42 The pioneer zone of West Fishbourne sample site comprises a 'leading edge' of *Spartina anglica* with SM14a *Atriplex portulacoides*: *Atriplex portulacoides* sub-community in the upper pioneer and low saltmarsh zones. This community persists in the middle and upper saltmarsh zones with SM25 *Suaeda vera* driftline community towards the top of the upper saltmarsh. Above this area the vegetation is dominated by *Elymus pycnanthus*, which occurs as virtually monospecific stands with some affinity towards SM24, although the lack of a supporting community in the quadrats sampled means that the match coefficient is relatively low.

Ellanore

3.43 The pioneer saltmarsh communities at Ellanore show some affinity with the *Suaeda maritima* salt-marsh community SM9, which typically occur on areas subject to disturbance, tending to be replaced by locally appropriate saltmarsh communities with increased stabilisation. At Ellanor the pioneer sub-community has affinities with that of SM14a, which is present in the low-mid saltmarsh zones. Upper saltmarsh areas comprise SM26 *Inula crithmoides* communities as found at Horse Point.

Mengham Salterns

3.44 Zonation at Mengham Salterns is relatively complex to determine on the basis of desk study due to the presence of a creek to the northeast of the site and the poor quality of the overhead photographs for this site, which hinders visual identification of vegetation communities. The upper saltmarsh communities to the northwest of the site show most affinity with SM14 *Halimione portulacoides* community, whilst the pioneer and low saltmarsh communities are characterised by *Spartina anglica, Salicornia* agg. and *Frankenia laevis*, with no great affinity for any particular NVC type. *Frankenia laevis* is nationally scarce and occurs within only two NVC community types in the UK SM21 *Suaeda vera - Limonium binervosum* saltmarsh community and SM22 *Halimione portaculodes - Frankenia laevis* saltmarsh community (restricted in Britain to the north Norfolk coast). Variants of S22 lacking *H. portulacoides* may occur at the interface of saltmarsh and shingle communities and at Mengham Salterns may be indicative of such substrates.

Langstone

3.45 Pioneer communities at Langstone are characterised by *Suaeda maritima*, *Salicornia* agg. and *Spartina anglica*, giving it affinities with both SM9 *Suaeda maritima* saltmarsh community and SM8 Annual *Salicornia* saltmarsh community. Low-mid saltmarsh communities comprise SM13c *Puccinellia maritima* saltmarsh: *Limonium vulgare - Armeria maritima* sub-community. Above the saltmarsh bank the community comprises SM26 *Inula crithmoides* community as found at Horse Point and Ellanore.

Verner Common

3.46 At Verner Common the lower edge of the pioneer zone is vegetated solely with *Spartina anglica* with *Salicornia* agg. and *Suaeda vera* (closest NVC match SM8) occurring nearer the lower saltmarsh (upper) boundary. The low and middle saltmarsh communities exhibit best match with SM13c *Puccinellia maritima* saltmarsh: *Limonium vulgare - Armeria maritima* sub-community.

The Wash

Wrangle

3.47 The pioneer zone at Wrangle comprises bare mud with occasional *Saliconia* species. Only two quadrats were taken within this zone, one of which had 50% cover of *Spartina anglica* indicating that this species may be invasive at the site either currently or in future. The low mid-marsh communities have affinities with both SM14/14a communities and SM 11 communities. Quadrats recorded as forming the upper saltmarsh have closest affinity with SM17 communities.

Wainfleet

3.48 The pioneer zone at Wainfleet comprises four quadrats supporting *Salicornia* species., *Suaeda maritima* and *Puccinellia maritima* and, has affinities with SM14a (sub-community *Atriplex portulacoides* dominant) and SM10. *Spartina anglica* is present in all but the most seaward quadrat, but is generally at fairly low abundance (between 2 and 20%), and does not seem to currently dominate the community. However, it was the most abundant species recorded in quadrat 2, which may be indicative of potential invasion by the species in future.

3.49 Low mid-marsh communities exhibit a generally good fit with SM14a. This community occurs extensively in the south east and has been reported as forming up to 30% of the saltmarsh communities of the Wash. Mid-upper saltmarsh vegetation is not particularly well distinguished from that of the low-mid saltmarsh, also tending towards SM14.

Frampton

3.50 The pioneer zone within the Frampton plot is represented by 5 quadrats comprising saltmarsh vegetation community type SM14a. The low-mid saltmarsh communities also comprise SM 14 communities, but are more similar to SM14c (*Puccinellia maritima* sub-community) or b (*J. maritimus* sub-community).

3.51 Mid-upper saltmarsh communities are represented by quadrats 7-9 and NVC type SM23. Along the strandline at the northern edge of the transect botanical communities are typically dominated by *Elymus pycnanthus* and is not very well fitted to any NVC community type, exhibiting ‘best fit’ with SM24 *Elymus pycnanthus* saltmarsh community.

The Haven

3.52 No indication of zonation changes is given in the quantitative assessment and the vegetation communities are homogenous throughout the transect, typically being dominated by *Puccinellia maritima*, with *Aster tripolium* var. *discoides*, *Spergularia marina* and *Suaeda maritima* occurring frequently throughout the transect. The floristic composition of the plot places it as being intermediate between SM10 and SM11, both of which are typical of low-marsh communities, which occur frequently throughout the Wash.

Terrington

3.53 The pioneer saltmarsh communities at Terrington are typified by *Salicornia* sp., *Suaeda maritima, Spartina anglica* with *Aster tripolium* and *Puccinellia maritima* present at low density. *Atriplex portulacoides* is dominant in the low-mid saltmarsh placing the vegetation type within SM14a. Community change in the upper-marsh zone is relatively indistinct, with the vegetation present being most closely matched to SM14a. However, the presence of

Elymus pycnanthus in two of the three mid-upper saltmarsh quadrats indicates a transition towards SM24 communities.

Snettisham

3.54 Botanical recording undertaken within the pioneer zone at Snettisham places the vegetation community as intermediate between SM10 and SM11. The low-mid saltmarsh communities retain some affinity with SM10, but as in the majority of plots on the Wash are better fitted to SM14a communities. NVC analysis indicates that the mid-upper saltmarsh communities have most affinity with SM25 *Suaeda vera* driftline community, although this classification is heavily influenced by a single quadrat record for *Suaeda vera* close to the transect strandline. If the influence of this single quadrat is removed communities recorded represent a closer fit with SM14a.

Assessment of vegetation and environmental variables

Quadrat scale variables

3.55 Environmental data recorded at each site are discussed below. The results of this analysis are presented in Tables 25 and 26 below.

Morecambe Bay

3.56 At Morecambe Bay all plots were subject to grazing, with grazing being recorded from the majority of quadrats at all sites except Milnthorpe, where only 12 out of 30 quadrats showed evidence of grazing. No significant differences between vegetation heights recorded from favourable and unfavourable paired plots are evident from the data (see Table 25). Signs of erosion were recorded from all Morecambe Bay plots, and no accretional ramps were recorded from the estuary system. The most commonly occurring sign of erosion was presence of overhanging blocks, which were recorded from eight quadrats at Sandside North and seven at Sandside South along with single quadrats from Foulshaw and Milnthorpe. Toppled blocks were recorded from eight quadrats overall, comprising one record from each plot except Sandside North and South which had two records each.

Table 25 Results of the two sample t-test for significant differences between vegetation heights of favourable and unfavourable plots

Data used	DF	t-value	p-value
All sites pooled data	643	2.75	0.006
Humber Estuary pooled data	178	0.62	0.539
Barton and Barrow and Ellerker paired plots	58	3.54	0.001
Pywipe and East Halton paired plots	58	-4.51	0.000
Stone Creek and Welwick paired plots	58	-1.72	0.091
Morecambe Bay pooled data	175	-0.56	0.574
Foulshaw and Milnthorpe paired plots	56	2.58	0.013
Sandside North and Sandside South paired plots	58	0.76	0.449
Warton North and Warton South paired plots	57	-2.99	0.004
Chichester Harbour pooled data	178	7.01	0.000
Horse Point and Verner Common paired plots	58	4.08	0.000
Ellanore and Mengham Salterns paired plots	58	1.50	0.138
Fishbourne and Langstone paired plots	58	8.41	0.000
The Wash pooled data	106	0.90	0.372
Wainfleet and Wrangle paired plots	26	0.02	0.983
Frampton and The Haven paired plots	34	1.23	0.229
Snettisham and Terrington paired plots	42	-0.68	0.501

3.57 Paired sites transects were located in relatively similar locations in relation to the mean high water level, with no significant differences observed between paired plots Foulshaw and Milnthorp and Sandside North and Sandside South. A significant difference was detected between the height in relation to mean high water line between Warton North and Warton South, which was reflected in the t-test for pooled Morcambe Bay data. (see Table 26). In this instance the mean height of the quadrats in relation to mean high water line was significantly greater in the unfavourable plot Warton South than at the favourable condition plot Warton North. At Foulshaw and Milnthorpe plots were typically located between 7 and 9 m above mean high water level. No low-mid saltmarsh communities were recorded at Foulshaw and mid-upper saltmarsh plots were generally well vegetated, with bare ground being recorded at low percentage cover (1 and 5%) from only two of the 30 quadrats.

Table 26 Results of the two sample t-test for significant differences between height above or below mean high water line for favourable and unfavourable plots

Data used	DF	t-value	p-value
All sites pooled data	716	-1.01	0.314
Humber Estuary pooled data	178	-4.37	0.000
Barton and Barrow and Ellerker paired plots	58	0.80	0.425
Pywipe and East Halton paired plots	58	-6.47	0.000
Stone Creek and Welwick paired plots	58	-2.64	0.011
Morecambe Bay pooled data	178	-2.39	0.018
Foulshaw and Milnthorpe paired plots	58	1.16	0.252
Sandside North and Sandside South paired plots	58	-1.14	0.258
Warton North and Warton South paired plots	58	-3.46	0.001
Chichester Harbour pooled data	176	0.34	0.737
Horse Point and Verner Common paired plots	57	-2.81	0.007
Ellanore and Mengham Salterns paired plots	57	3.09	0.003
Fishbourne and Langstone paired plots	58	1.75	0.086
The Wash pooled data	178	1.52	0.131
Wainfleet and Wrangle paired plots	58	4.48	0.000
Frampton and The Haven paired plots	58	2.79	0.007
Snettisham and Terrington paired plots	58	-4.88	0.000

3.58 Grazing was recorded from all Foulshaw plots with a mean sward height of 3.7cm in mid saltmarsh communities, which were noted as being subject to excessive sheep-grazing in the qualitative assessment. Based on the condition assessment criteria given for grazing this would equate to ‘heavy grazing’. The mid-upper saltmarsh communities at Milnthorpe are cattle-grazed and cattle trampling is noted as a concern in the qualitative assessment. Vegetation height in quadrats recorded in these communities ranges from 5-7 cm, again indicative of heavy grazing.

3.59 The low-mid saltmarsh quadrats at Milnthorpe are recorded as ungrazed, but this is not reflected in the vegetation height, with quadrats within these communities having a mean vegetation height of 6.5 cm. Bare ground is prevalent in parts of the low-mid saltmarsh communities, with some quadrats recording up to 80% bare ground.

3.60 Toppled blocks, rotational sliding and overhanging blocks were recorded from a single quadrat on the seaward edge of the Milnthorpe plot, indicative of erosion in this area. Toppled and overhanging blocks were also recorded as present in the seaward most quadrat at Foulshaw.

3.61 Sandside North (favourable) and Sandside South (unfavourable) range between 3 m and 13 m above mean high water level. Both sites comprise predominantly mid-upper saltmarsh habitats, although two pioneer quadrats comprising *Puccinellia maritima* and bare ground were recorded from Sandside North. Grazing was recorded from all quadrats in both plots, with the exception of the single pioneer quadrat at Sandside North. No significant differences between vegetation heights were recorded from the two plots, both of which had mean vegetation heights well below 10 cm, indicative of heavy grazing. Toppled and overhanging blocks were recorded from the seaward edge quadrats at both Sandside North and South, as well as higher up the saltmarsh, where they are typically associated with pans and creeks. Turf cutting was noted at both Sandside North and Sandside South in both the quantitative and qualitative assessments.

3.62 Warton North (favourable) and Warton South (unfavourable) are also subject to grazing. Sward height was significantly higher at Warton South than at Warton North, attributable mainly to the transition habitats at Warton South, which contained high proportions of *Juncus maritimus*, which is unpalatable to livestock. As with other Morecambe Bay plots, toppled and overhanging blocks were recorded in seaward quadrats at both sites.

Humber Estuary

3.63 At the Humber estuary the majority of plots were ungrazed, with the exception of Ellerker, where grazing was recorded from all quadrats. Vegetation height at Ellerker was significantly shorter than at its paired plot Barton Barrow (see Table 25), which is ungrazed. Both Barton Barrow and Ellerker plots are sited close to the mean high water level (between 0 and 6 m). No signs of erosion or accretional ramps were recorded from either of the two plots. Condition assessment for Barton Barrow notes the presence of a newly developed band of pioneer saltmarsh dominated by *Spartina anglica*.

3.64 Neither Stonecreek (unfavourable) nor Welwick (favourable) are subject to grazing and no significant differences are present between the sward heights of the two plots (see Table 25). Pioneer quadrats at both sites recorded high proportions of bare ground, with overhanging blocks being recorded from both sites along the transition between pioneer and low-mid saltmarsh communities.

3.65 The mean vegetation heights were significantly different between East Halton (unfavourable) and Pyewipe (favourable), where the mean vegetation height was higher at the unfavourable East Halton plot. Pyewipe was the only plot within the Humber Estuary where accretional ramps were recorded, along with toppled blocks, which occurred adjacent to a track towards the estuary side of the plot 3 m below mean high water level. This may be indicative of localised erosion and subsequent accretion related to storm events and/or high tides. High proportions of bare ground were recorded from many of the Pyewipe quadrats, which follow the contours of a large pan in the centre of the plot.

Chichester Harbour

3.66 All Chichester Harbour plots are ungrazed, although vegetation at Horse Point was significantly taller than that at Verner Common and significantly taller at Fishbourne than at Langstone (see Table 25).

3.67 The Verner Common plot is located on a point of land and many of the quadrats are sparsely vegetated, particularly in the pioneer zone, where quadrats comprised up to 90% bare ground. 10 pioneer community quadrats were recorded from Verner common, compared to seven from Horse Point. Vegetation heights for pioneer communities were typically higher at Verner Common than Horse Point, probably due to the presence of *Spartina anglica* within the sward at Verner Common. The low to upper saltmarsh communities at Horse Point are significantly taller than those at Verner Common, probably due to the prominence of *Aster tripolium* in the sward at Horse Point. Signs of erosion were evident at both plots, but were recorded most frequently from the Verner Common quadrats, where toppled blocks were

recorded from 6 quadrats in the low-mid saltmarsh and overhanging blocks were recorded from 11 quadrats, mostly in the low-mid saltmarsh, compared to in three pioneer community quadrats and a single low-mid saltmarsh quadrat respectively at Verner Common. Rotational sliding was recorded from 2 quadrats at Horse Point and three quadrats at Verner Common.

3.68 Both Langstone and Fishbourne are located at and around the mean high water level (-3 to 3 m) and no significant difference exists between the mean height in relation to mean high water line of the two plots(see Table 26). Vegetation height at Fishbourne is significantly greater than that at Langstone throughout all zones (see Table 25). As neither site is recorded as being subject to grazing it is likely that these differences arise as a result of variation in botanical composition between the two sites. No signs of erosion or accretion were recorded from expanded 5 m quadrats at Fishbourne, although overhanging blocks were noted in the whole plot assessment at less than 2% cover. Signs of erosion were recorded frequently throughout the Langstone quadrats, with both toppled blocks, rotational sliding and overhanging blocks being recorded from both pioneer and low-mid saltmarsh quadrats. Further signs of erosion are evidenced by mud mound topography, which was recorded over 40 % of the Langstone plot in plot level recording.

3.69 All Mengham Salterns quadrats and the majority of the Ellanore plot quadrats are located below mean high water level. There are no significant differences in vegetation height between the two plots (see Table 25). Signs of erosion were recorded from both plots, but were recorded from more quadrats at Ellanore, which recorded rotational sliding and overhanging blocks in seven and eight of the pioneer and low-mid saltmarsh quadrats respectively, particularly along the seaward edge of the pioneer communities, where toppled blocks were also recorded.

The Wash

3.70 Both Frampton and The Haven are grazed in the majority of quadrats, and no significant differences occur between the vegetation heights of the two plots (see Table 25). Both qualify as ‘heavily grazed’ in grazed plots, with mean sward heights of around 10 cm. Toppled blocks were recorded from a single seaward plot at Frampton and from two plots at The Haven, one of which was located along the estuarine edge of the plot, the other of which was associated with the banks of a creek. No signs of accretion were recorded from either plot.

3.71 Grazing was recorded from around half of the Snettisham plots, but was not recorded at Terrington. This difference in management regime was not evident in the vegetation heights recorded at the two sites, as no significant differences were recorded between the plots (see Table 25). However, vegetation heights were not recorded for some Terrington plots. Toppled blocks were recorded from only the estuarine-most quadrat at Snettisham, although overhanging blocks were recorded from four of the Terrington quadrats. Accretional ramps were recorded from Terrington.

3.72 Both Wrangle and Wainfleet are subject to some level of grazing, with grazing being recorded in quadrats 27-30 at Wrangle, which equate to mid-upper saltmarsh communities and other habitats above the upper saltmarsh bank. Grazing was recorded more frequently at Wainfleet than at Wrangle, where quadrats within both the low-mid and mid-upper saltmarsh communities were grazed. There were no significant differences between vegetation heights in the two plots (see Table 25). Toppled and overhanging blocks were recorded from a single quadrat at Wrangle, where they were associated with a creek in the low-mid saltmarsh. Toppled blocks were recorded from a single quadrat at Wainfleet towards the lower limit of the low-mid saltmarsh, and rotational sliding was noted from a single quadrat, also in the low-mid saltmarsh. Accretional ramps were recorded from all three pioneer quadrats at Wainfleet and two pioneer quadrats at Wrangle, one of which also recorded overhanging blocks.

Assessment using multivariate analysis

Detrended Correspondence Analysis (DCA)

3.73 DCA analysis exhibited a variable degree of separation between favourable and unfavourable plots. DCA outputs for paired and grouped plots are included below.

Humber Estuary

3.74 The DCA of pooled species data for Humber estuary is shown as Figure 1. Of the paired Humber Estuary plots only Pyewipe and East Halton were well separated with Pyewipe quadrats aggregating around *Salicornia* sp. and *Puccinellia maritima* (Figure 3), as would be expected on the basis of the communities present. The absence of *Salicornia* sp. at East Halton would appear to be the main influencing factor in the segregation of the two plots. At Barton and Barrow and Ellerker species characteristic of separate zones showed no clear signs of segregation within the DCA (Figure 2). In general, the DCA showed more aggregation of quadrats within Barton and Barrow than within Ellerker, indicating more variability in species composition at the unfavourable site. The majority of quadrats from Barton and Barrow are aggregated close to *Scirpus maritimus* and *Elytrigia repens*. Stonecreek and Welwick were poorly separated in the DCA (Figure 4) with each plot exhibiting a high degree of spreading, indicative of a high variability in species composition at each site.

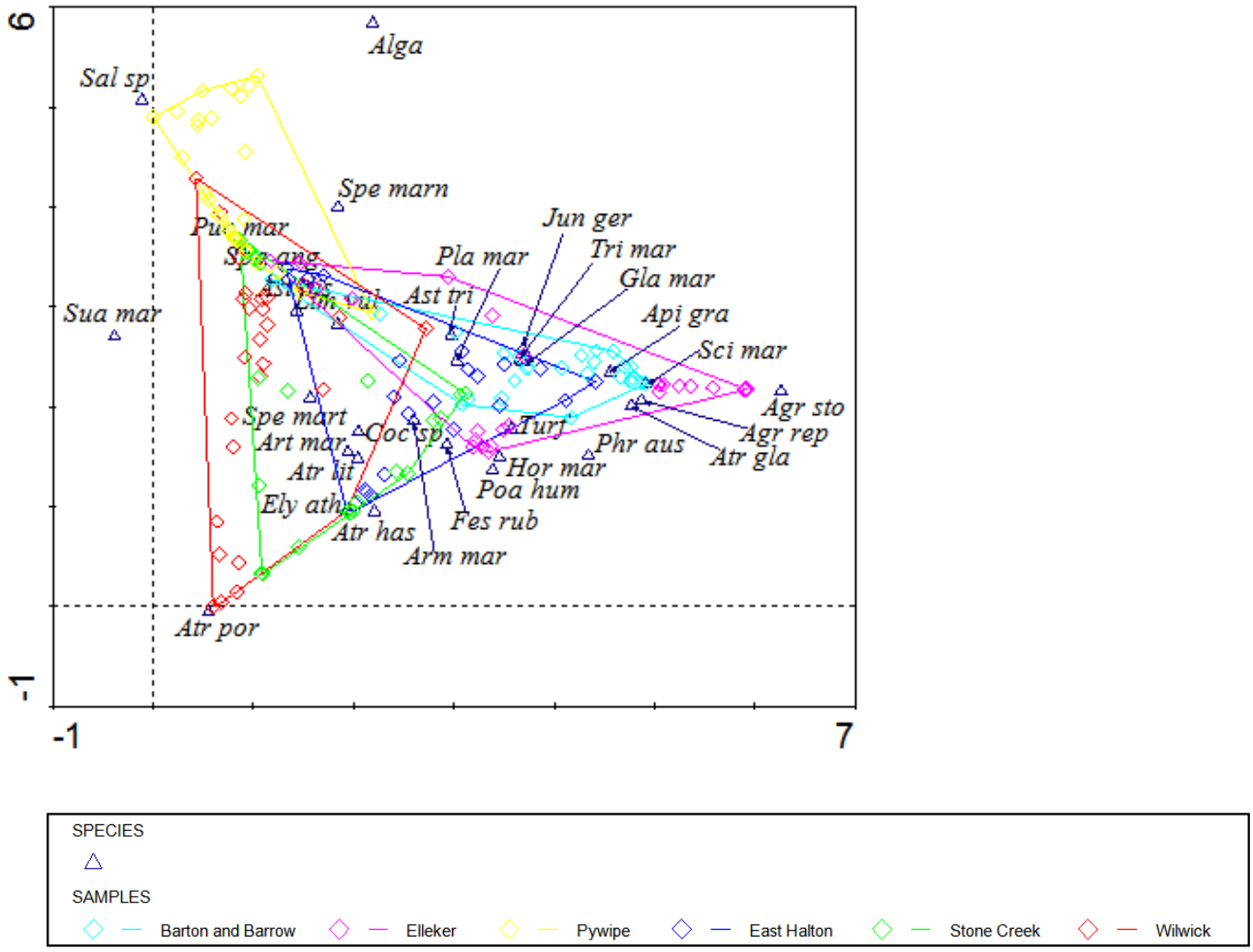

Figure 1 DCA graph of pooled species data for all sample plots within the Humber Estuary site

3.75 Plots classified as favourable for the purpose of this analysis are Barton and Barrows, Pywipe and Stone Creek. Those plots classified as unfavourable for the purpose of the analysis are Ellerker, East Halton and Welwick.

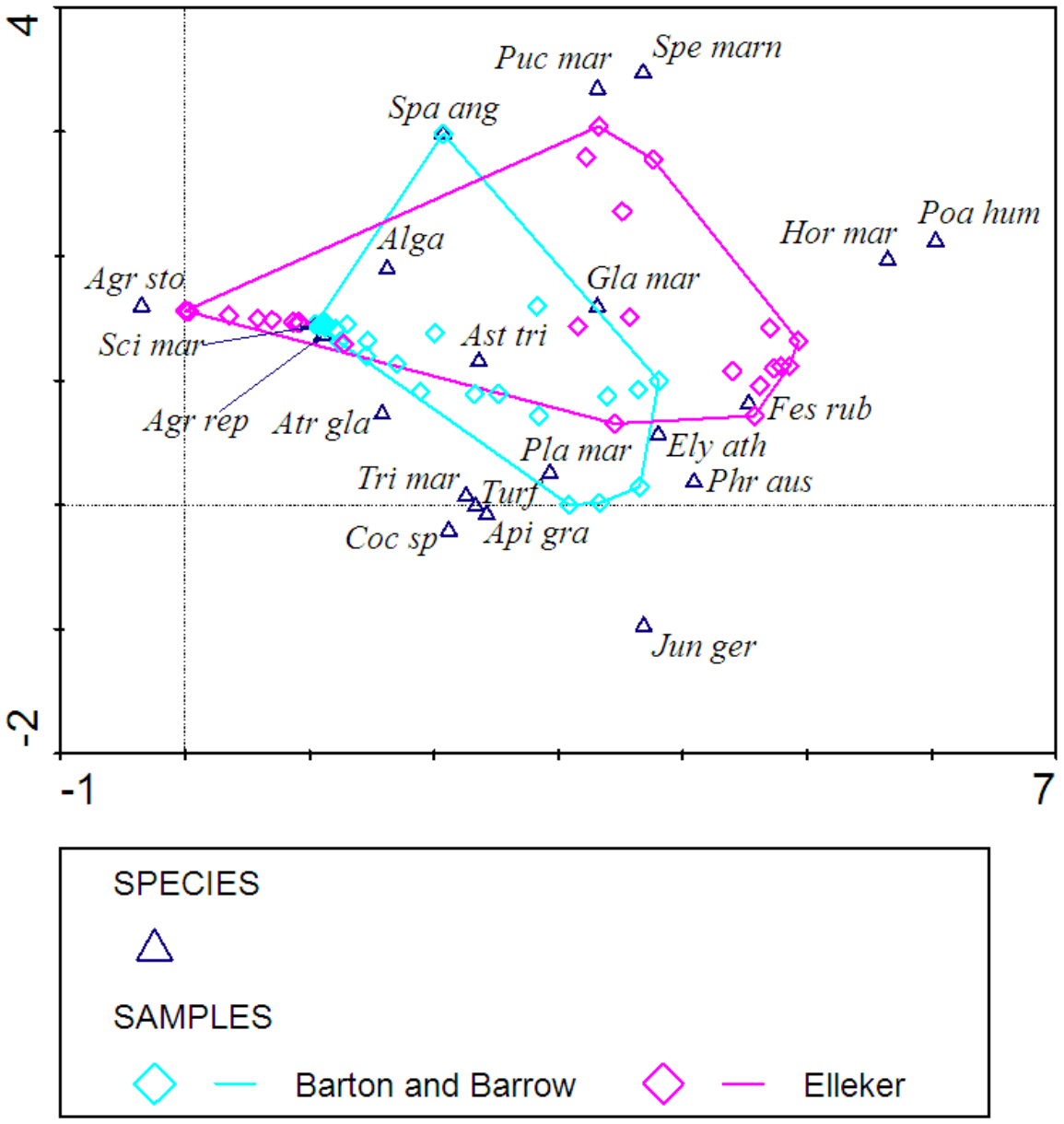

Figure 2 DCA graph of species data for the paired plots Barton and Barrow and Ellerker

3.76 Within the analysis Barton and Barrow is classified as favourable and Ellerker is classified as unfavourable.

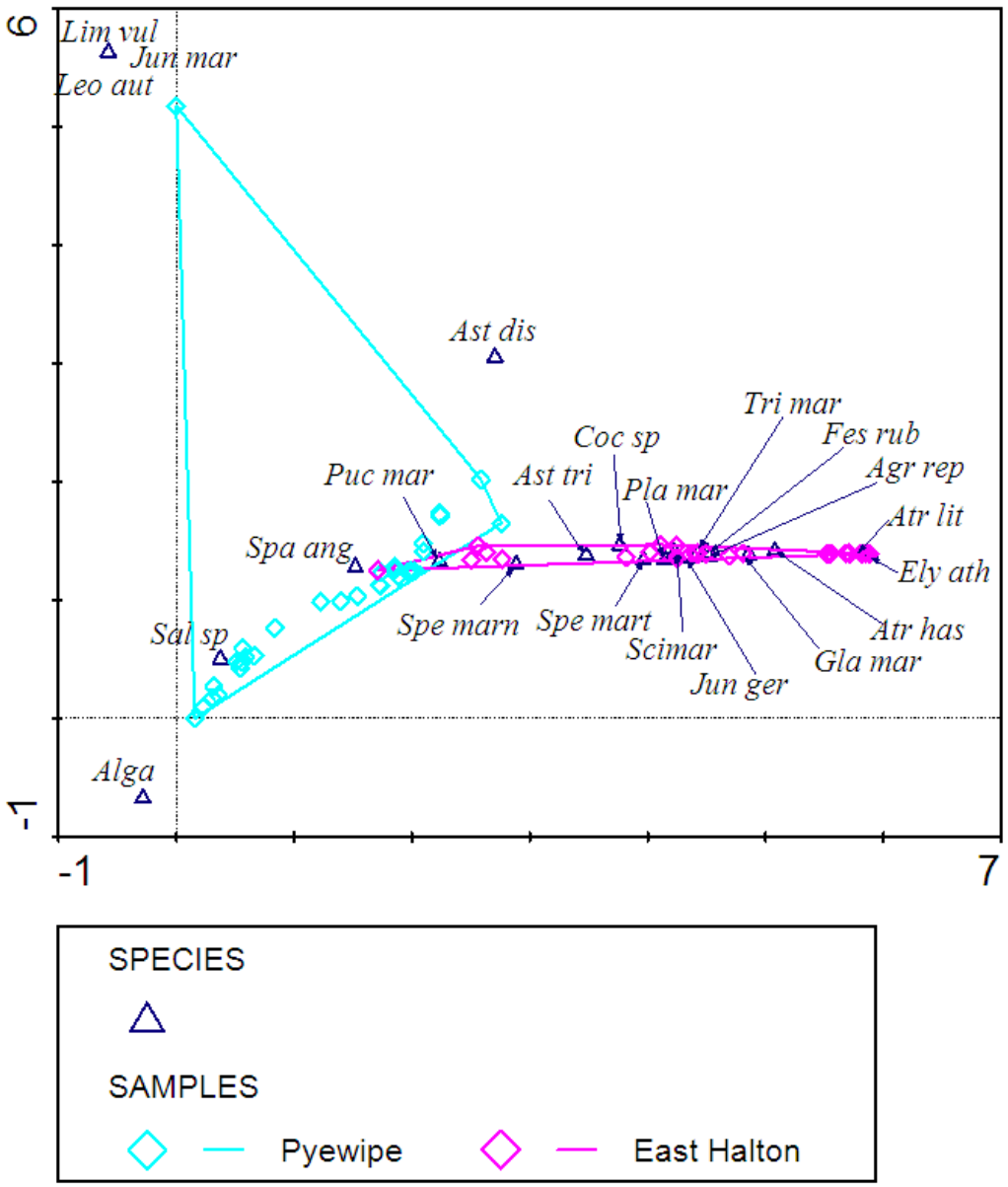

Figure 3 DCA graph of species data for the paired plots Pyewipe and East Halton

3.77 Within the analysis Pyewipe is classified as favourable and East Halton is classified as unfavourable.

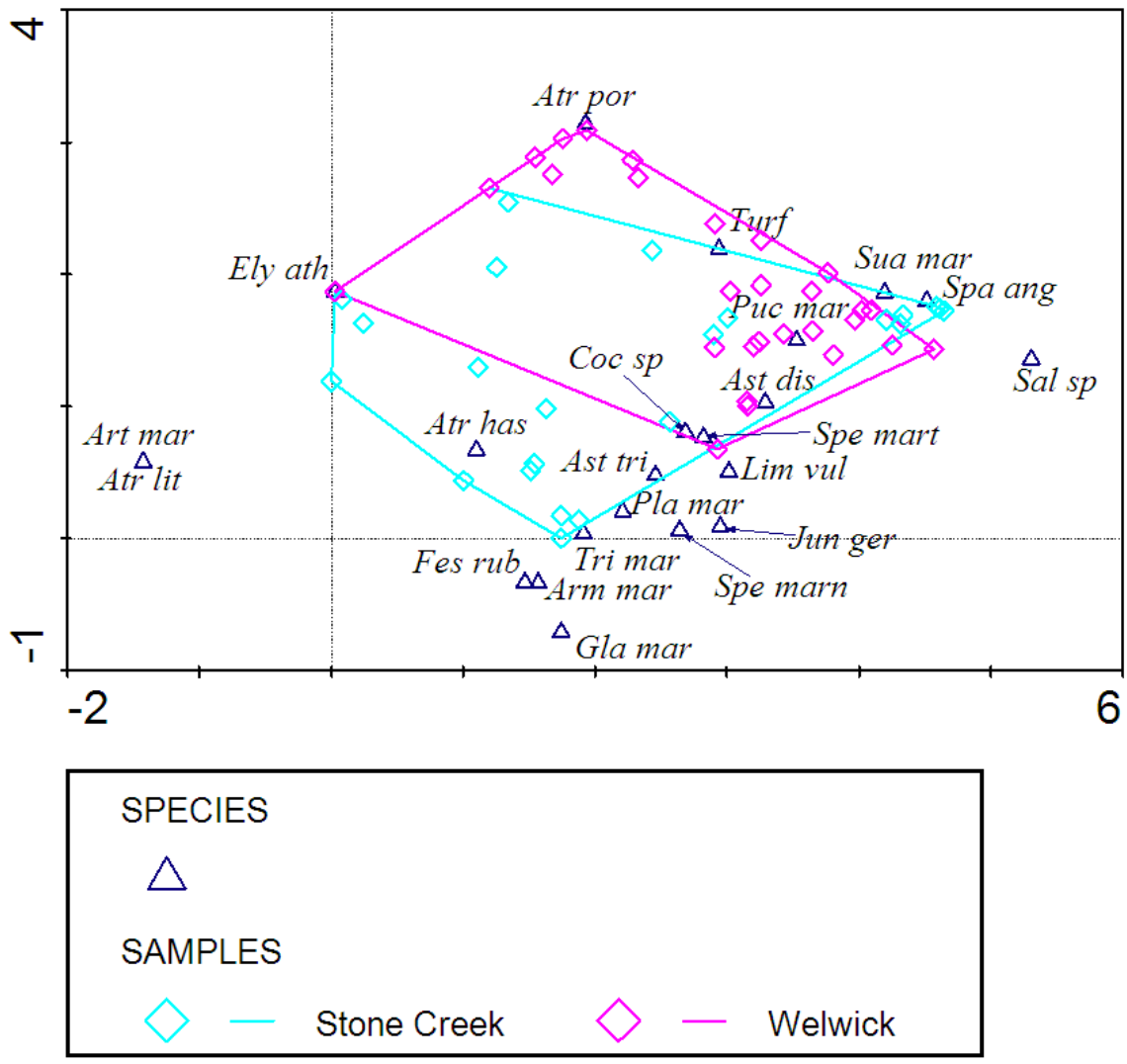

Figure 4 DCA graph of species data for the paired plots Stone Creek and Welwick

3.78 Within the analysis Stone Creek is classified as favourable and Welwick is classified as unfavourable.

Morecambe Bay

3.79 The Morecambe Bay paired plots were also separated to varying degrees in the DCA graphs (Figures 5-8). Foulshaw and Milnthorpe were clearly separated (Figure 6), with Foulshaw plots (favourable) aggregating in two broad groups corresponding with mid-upper saltmarsh quadrats and 'other habitats above mid-marsh' as recorded during quantitative assessment. The Milnthorpe plot exhibited a slightly lower degree of spreading, with mid-upper and low-mid saltmarsh communities aggregating into fairly distinct groups.

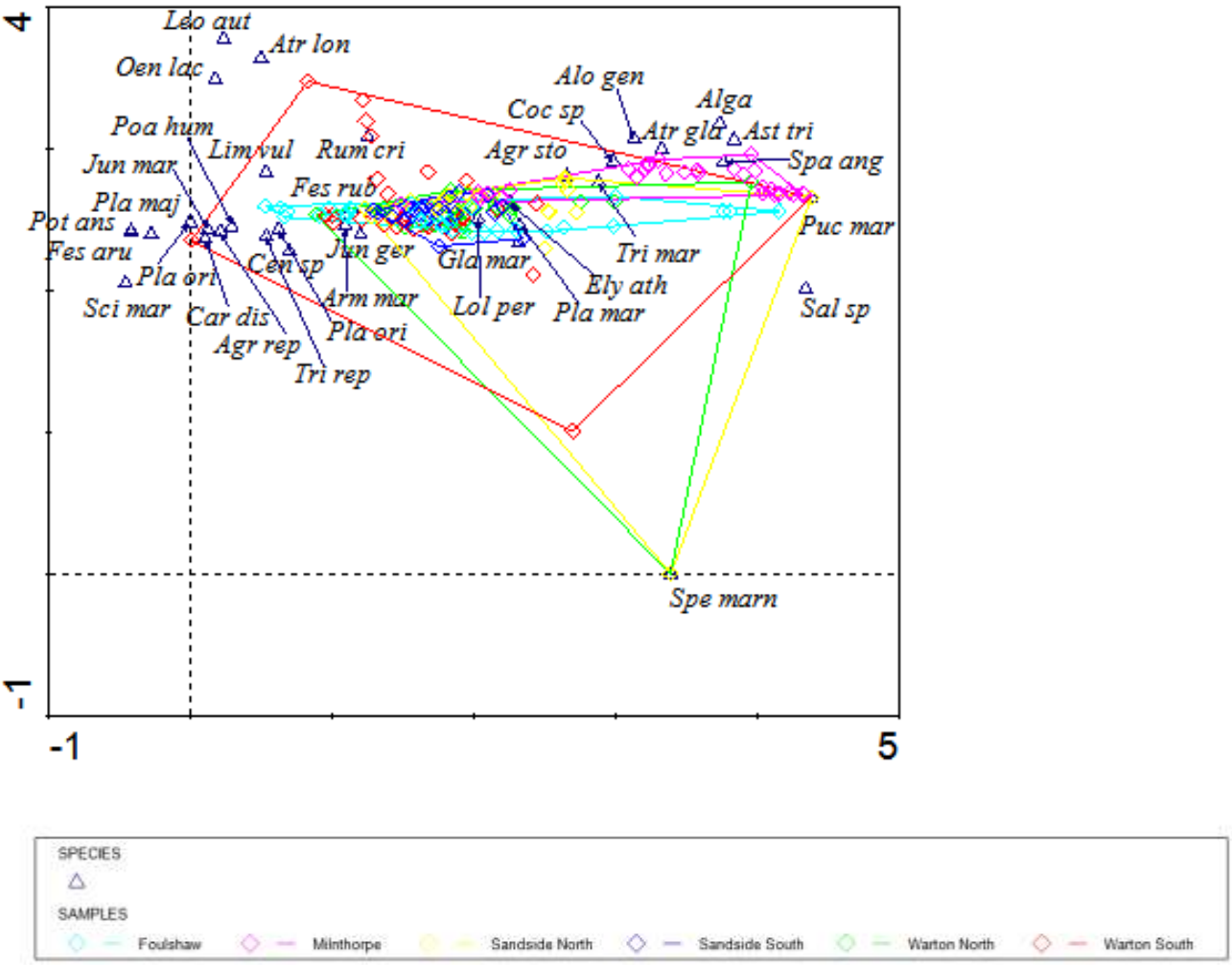

Figure 5 DCA graph of pooled species data for all sample plots within the Morecambe Bay site

3.80 Plots classified as favourable for the purpose of this analysis are Foulshaw, Sandside North and Warton North. Those plots classified as unfavourable for the purpose of the analysis are Milnthorpe, Sandside South and Warton South.

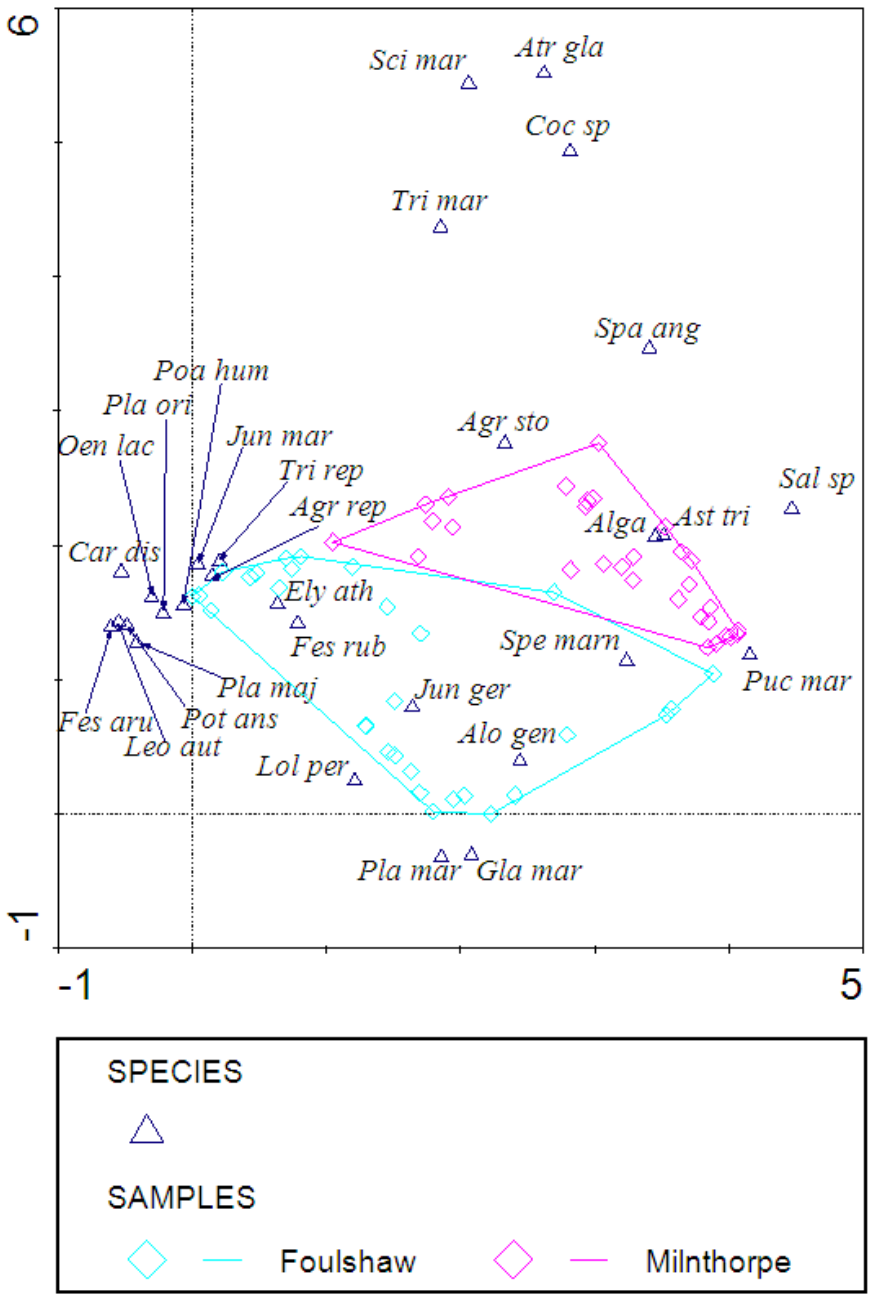

Figure 6 DCA graph of species data for the paired plots Foulshaw and Milnthorpe

3.81 Within the analysis Foulshaw is classified as favourable and Milnthorpe is classified as unfavourable.

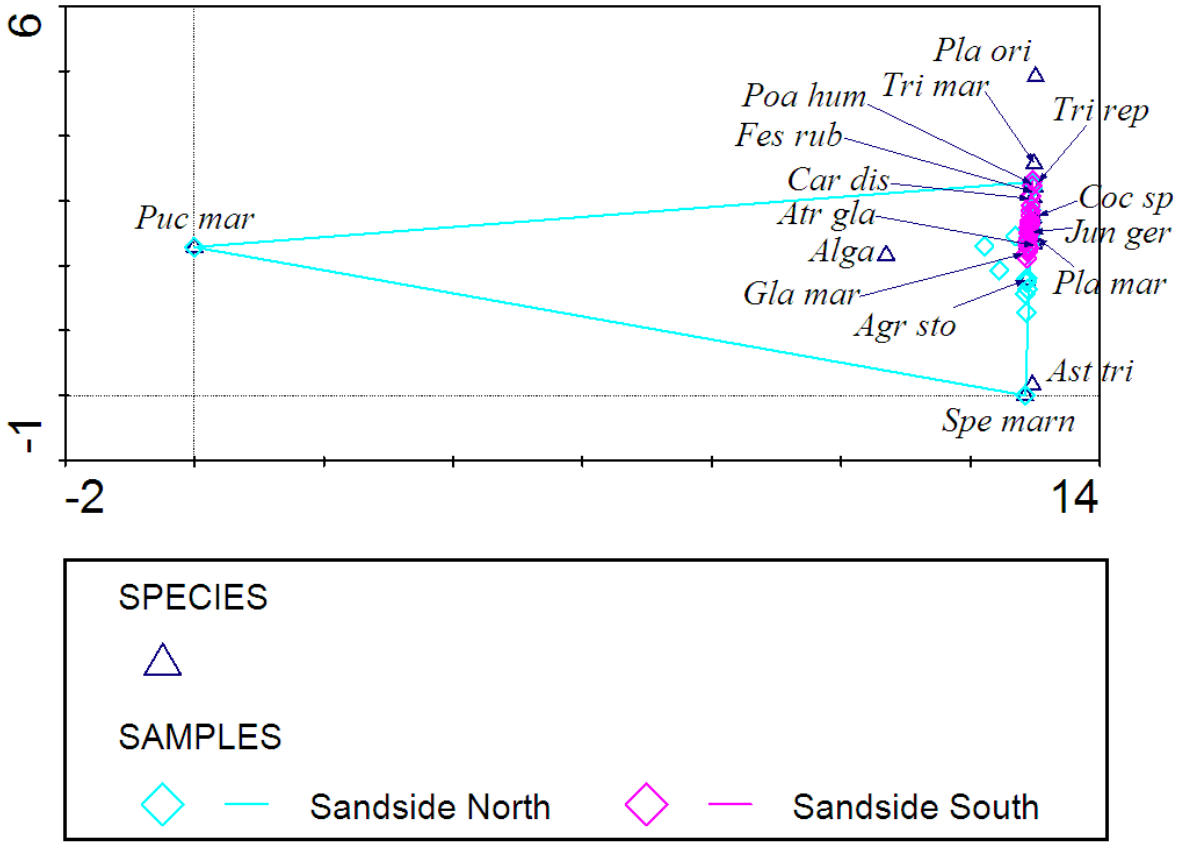

Figure 7 DCA graph of species data for the paired plots Sandside North and Sandside South

3.82 Within the analysis Sandside North is classified as favourable and Sandside South is classified as unfavourable.

3.83 Sandside North (favourable) and Sandside South (unfavourable) generally have a high degree of overlap (Figure 7). However, the two pioneer quadrats at Sandside North are clearly separated from the remainder of quadrats from both plots in the DCA. The Sandside South plot shows little spread, indicative of low variability between the species data, as would be expected on the basis of botanical analysis, which reported only SM16 saltmarsh communities throughout the plot.

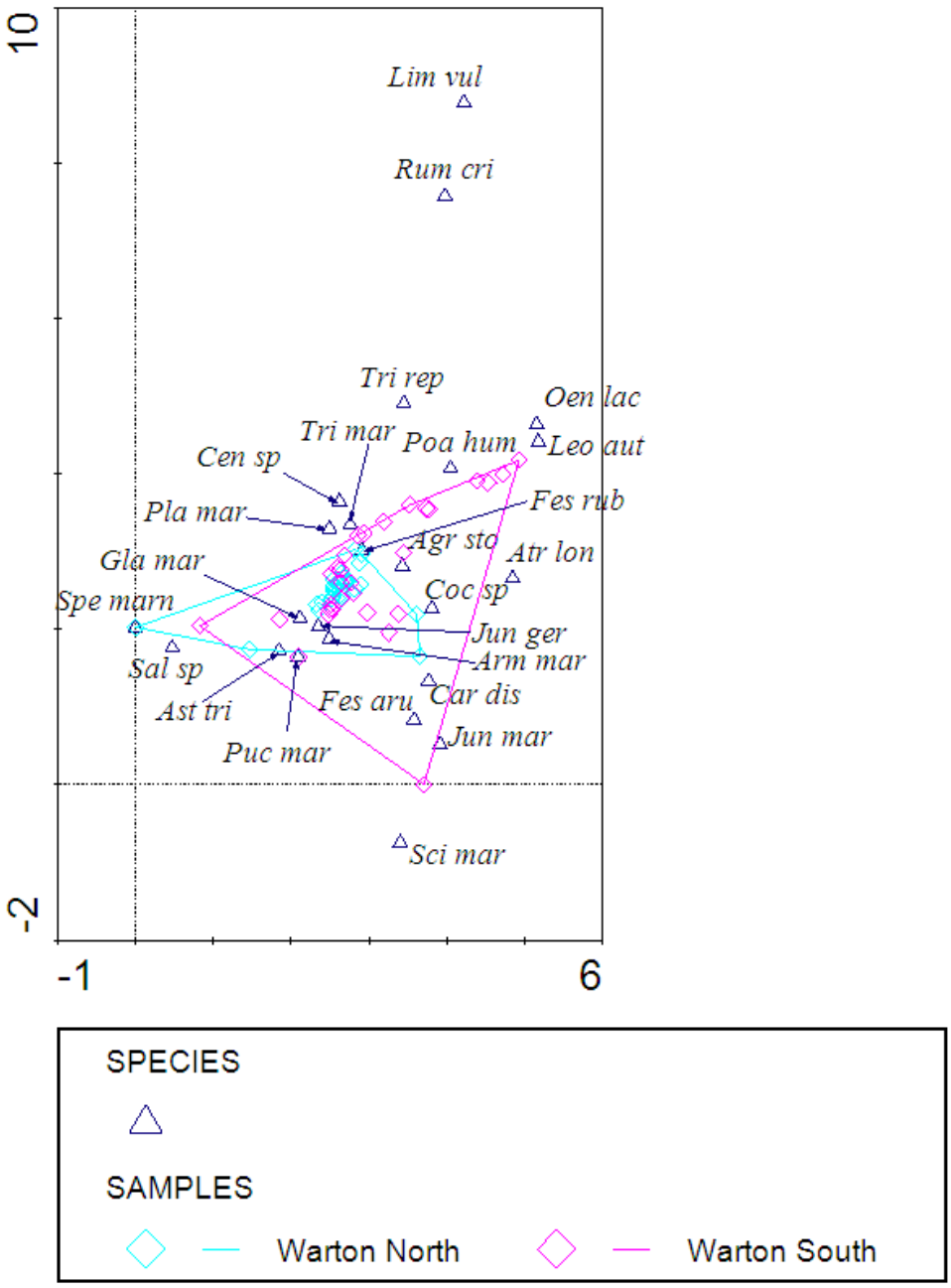

Figure 8 DCA graph of species data for the paired plots Warton North and Warton South

3.84 Within the analysis Warton North is classified as favourable and Warton South is classified as unfavourable.

3.85 Warton North (favourable) and Warton South (unfavourable) showed little separation between the two plots in the DCA (Figure 8). A higher degree of spread is evident for Warton South, indicating greater variability of species composition at the unfavourable site. The vast majority of the Warton North quadrats are aggregated towards the centre of the diagram, with no clear distinctions evident between the different saltmarsh zones. The clearest cluster from the Warton South plots comprises the aggregation of some mid-upper saltmarsh quadrats towards *Leontodon autumnalis* and *Poa humilis*, species more typical of disturbed ground or roadside verge communities than true saltmarsh assemblages.

The Wash

3.86 At The Wash, as with the majority of other sites, paired plots exhibit some degree of separation, but no consistent patterns can be inferred between the pairings (Figures 9-12). The Haven and Frampton are generally well separated with the exception of a single quadrat from The Haven, which occurs along the saltmarsh strand (Figure 10). Other quadrats from The Haven are aggregated close to *Puccinellia maritima, Aster tripolium and Salicornia* sp., supporting the findings of field survey and botanical analysis, which recorded only low-mid saltmarsh communities from this plot. In contrast, quadrats from Frampton exhibit a wider degree of spread, with samples from the individual plots being more strongly aggregated together. Wrangle and Wainfleet and Snettisham and Terrington both show a similar degree of spread and a limited degree of separation, indicating similar conditions within each of the plot pairings. Wrangle and Wainfleet (Figure 12) appear to be more species-rich than Snettisham and Terrington (Figure 11).

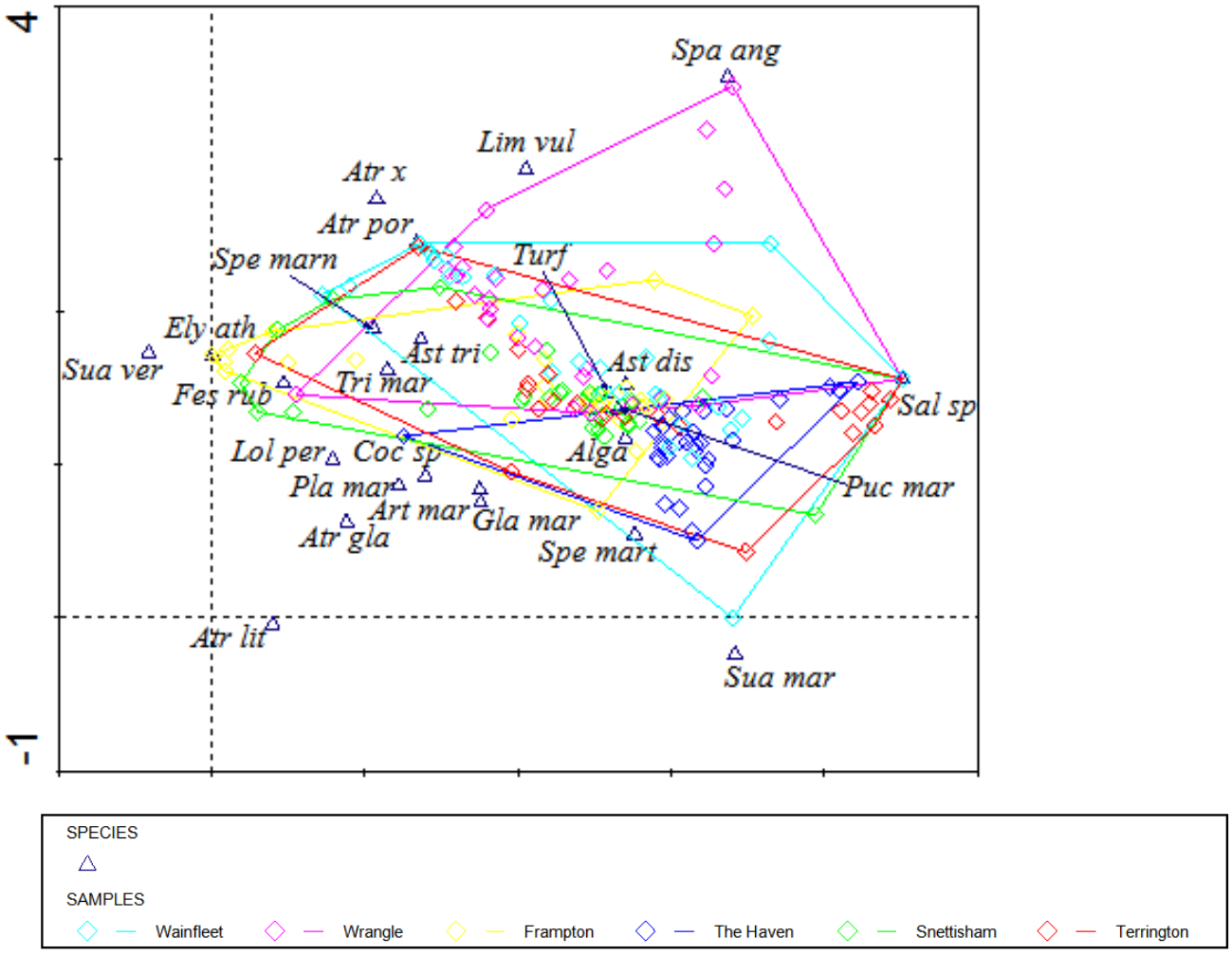

Figure 9 DCA graph of pooled species data for all sample plots within The Wash site

3.87 Plots classified as favourable for the purpose of this analysis are Wainfleet, Frampton and Snettisham. Those plots classified as unfavourable for the purpose of the analysis are Wrangle, The Haven and Terrington.

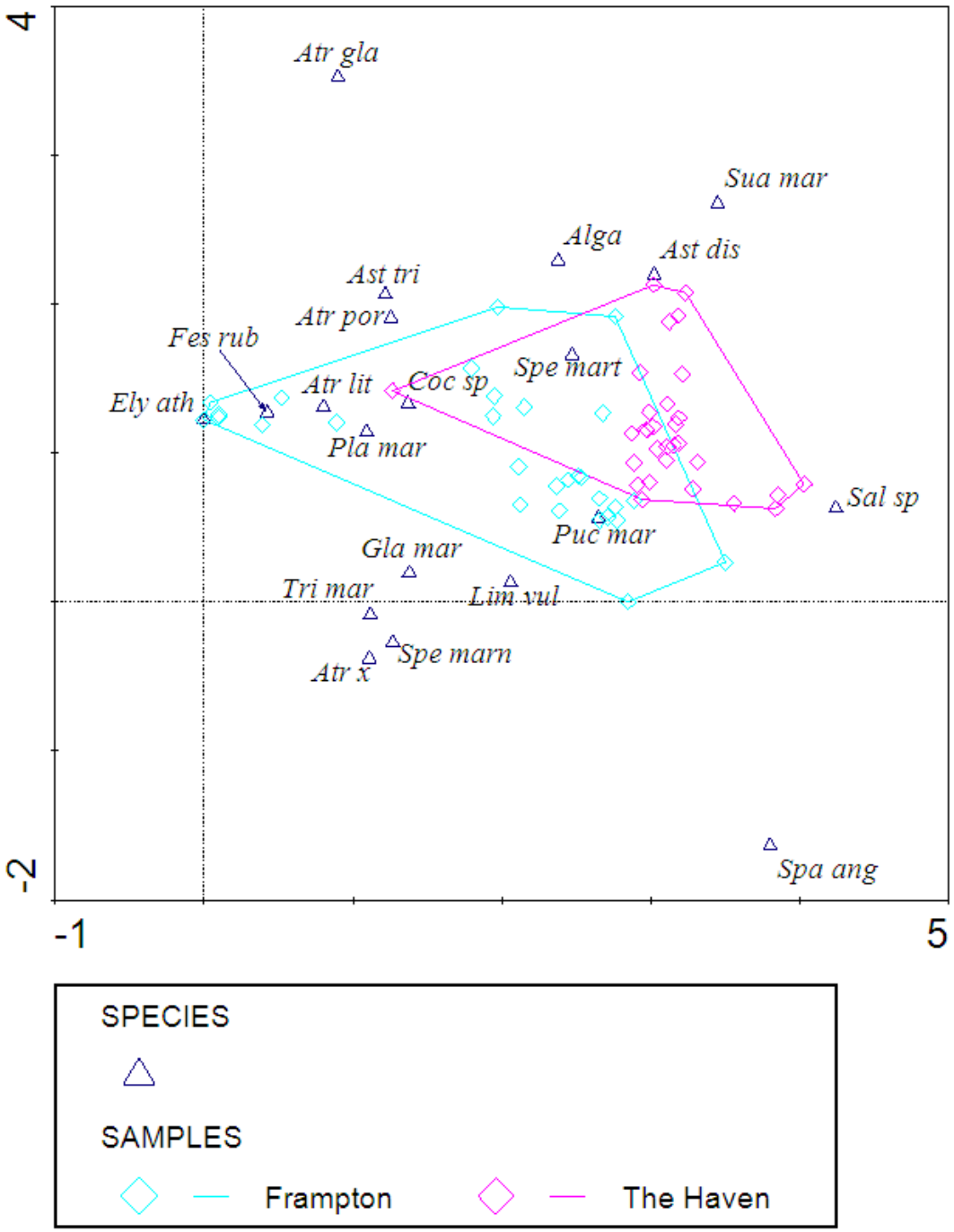

Figure 10 DCA graph of species data for the paired plots Frampton and The Haven

3.88 Within the analysis Frampton is classified as favourable and The Haven is classified as unfavourable.

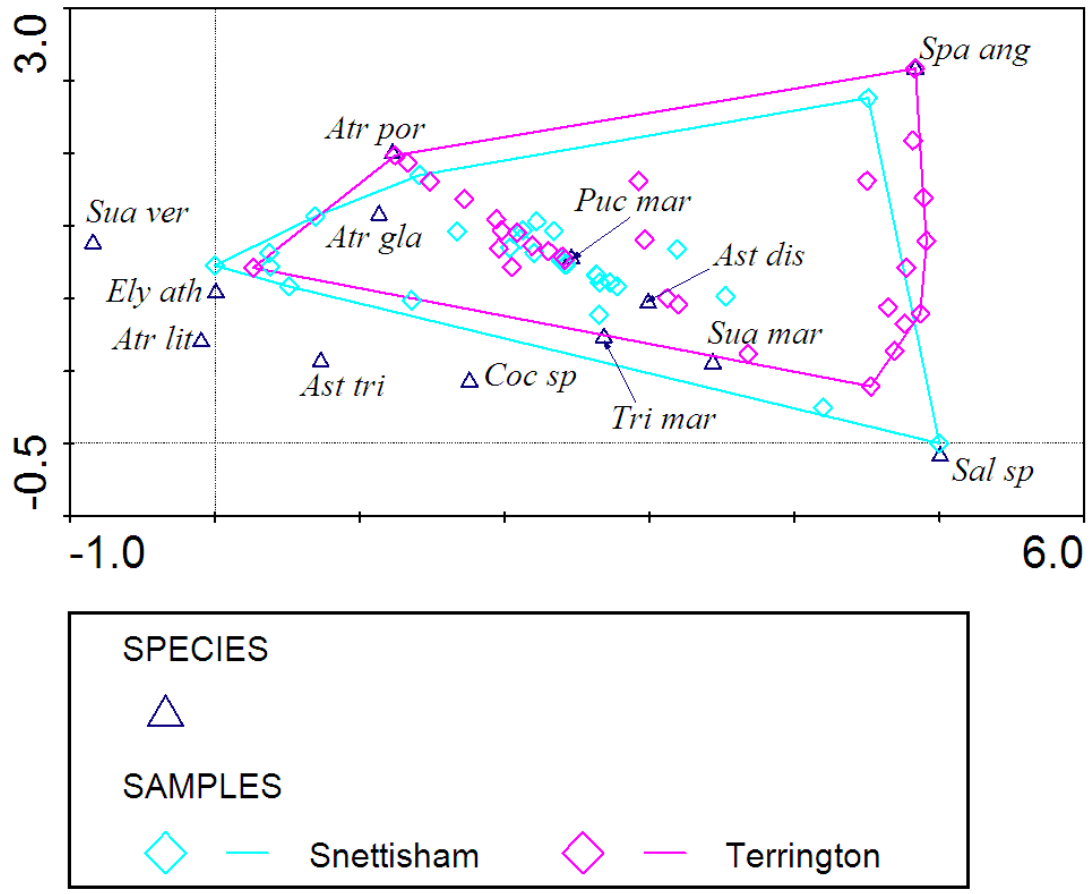

Figure 11 DCA graph of species data for the paired plots Snettisham and Terrington

3.89 Within the analysis Snettisham is classified as favourable and Terrington is classified as unfavourable.

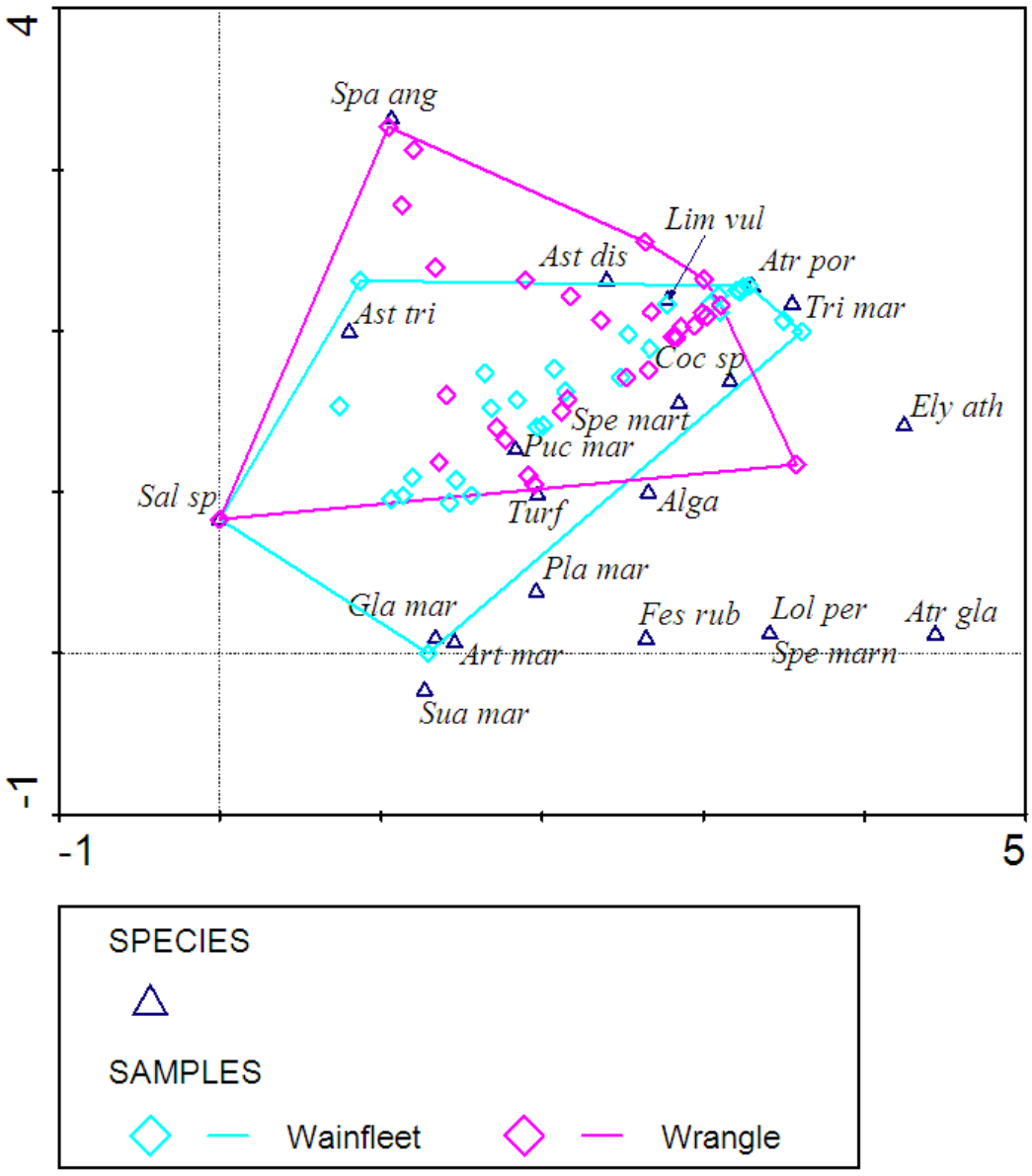

Figure 12 DCA graph of species data for the paired plots Wainfleet and Wrangle

3.90 Within the analysis Wainfleet is classified as favourable and Wrangle is classified as unfavourable.

Chichester Harbour

3.91 Whilst Chichester Harbour plots have been paired as relatively favourable or unfavourable for the purpose of this analysis, all were rated as unfavourable by the qualitative surveyor and this is reflected in the DCA outputs, which generally show poor segregation between favourable and unfavourable sites (Figures 13-16). Some differentiation is evident between Langstone (favourable) and Fishbourne (unfavourable), with seaward quadrats aggregating towards either *Spartina anglica* (Fishbourne) or *Salicornia* sp./*Suaeda maritima* (Langstone) (Figure 14). With the exception of these pioneer quadrats, other communities do not clearly separate between the two sites, being aggregated towards the centre of the ordination. Mengham Salterns (unfavourable) and Ellanore (favourable) are not clearly differentiated in the DCA, with the unfavourable site exhibiting less spread and hence less species variability (Figure 15). In general the low-mid saltmarsh quadrats at Mengham Salterns are aggregated towards *Spartina anglica*, a failing attribute for this plot in both the quantitative assessment

and condition assessment. A proportion of the observed spread in samples at Ellanore is associated with the saltmarsh strand quadrats, which are separated both from each other and the remaining quadrats in the ordination. Pioneer quadrats at Ellanore occur fairly close together, but are not clearly aggregated. An additional loose cluster is formed by some mid-upper quadrats, which aggregate towards *Inula crithmoides*. The DCA output for Horse Point (favourable) and Verner Common (unfavourable) also shows greater spread at the favourable site (Figure 16). Zonation at Horse Point is difficult to determine on the basis of plotted quadrats and the aerial photograph, partly due to the presence of anomalous grid references for some quadrats. A clear aggregation towards the right hand side of the ordination diagram is evident in Horse Point samples, which appears to correspond most readily to strandline quadrats, although some inconsistencies remain. Pioneer quadrats at Verner Common are strongly aggregated towards *Spartina anglica*, a failing criteria in both quantitative and qualitative assessment. The majority of other quadrats at Verner Common are poorly separated, indicating that there is likely to be little vegetative distinction between low-mid and mid-upper saltmarsh communities on the basis of the quadrats recorded. This is broadly supported by the findings of quantitative and qualitative assessment.

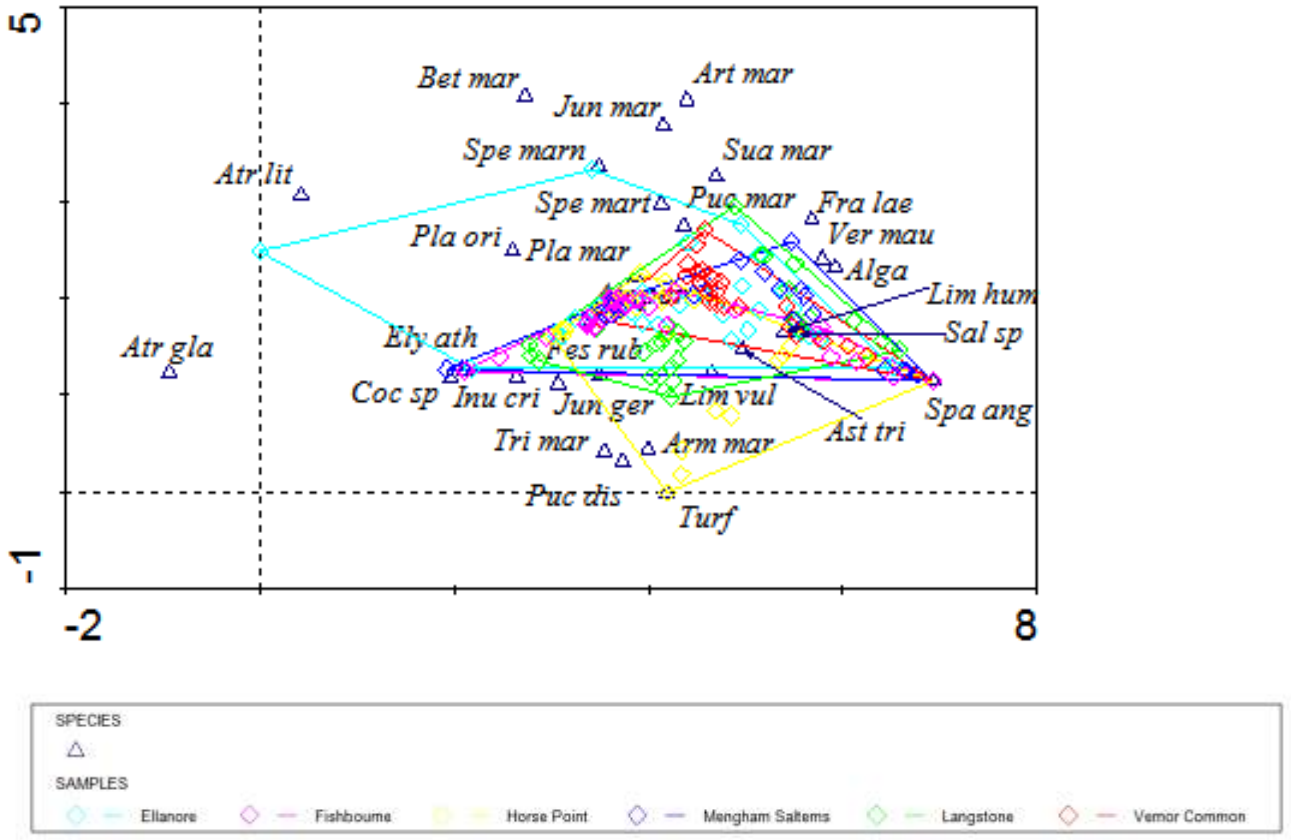

Figure 13 DCA graph of pooled species data for all sample plots within the Chichester Harbour site

3.92 Plots classified as favourable for the purpose of this analysis are Horse Point, Ellanore and Fishbourne. Those plots classified as unfavourable for the purpose of the analysis are Vernor Common, Mengham Salterns and Langstone.

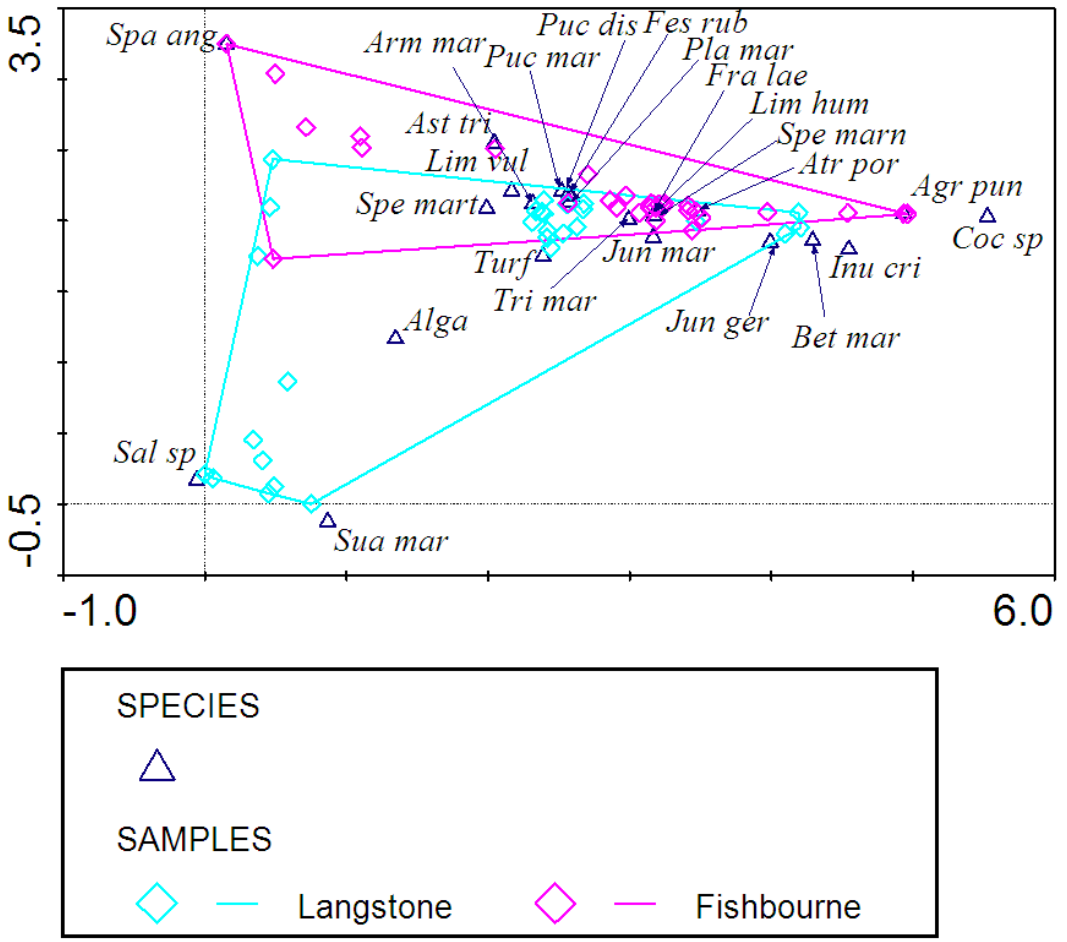

Figure 14 DCA graph of species data for the paired plots Langstone and Fishbourne

3.93 Within the analysis Fishbourne is classified as favourable and Langstone is classified as unfavourable.

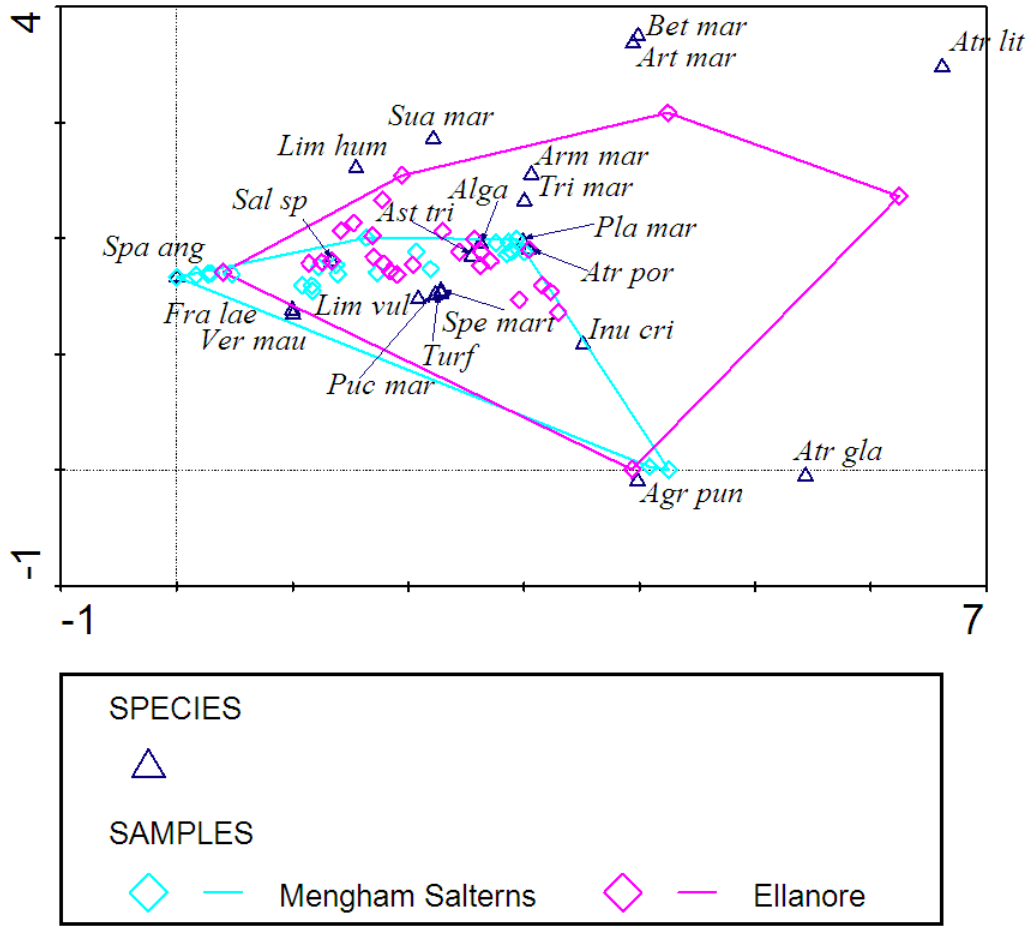

Figure 15 DCA graph of species data for the paired plots Mengham Salterns and Ellanore

3.94 Within the analysis Ellanore is classified as favourable and Mengham Salterns is classified as unfavourable.

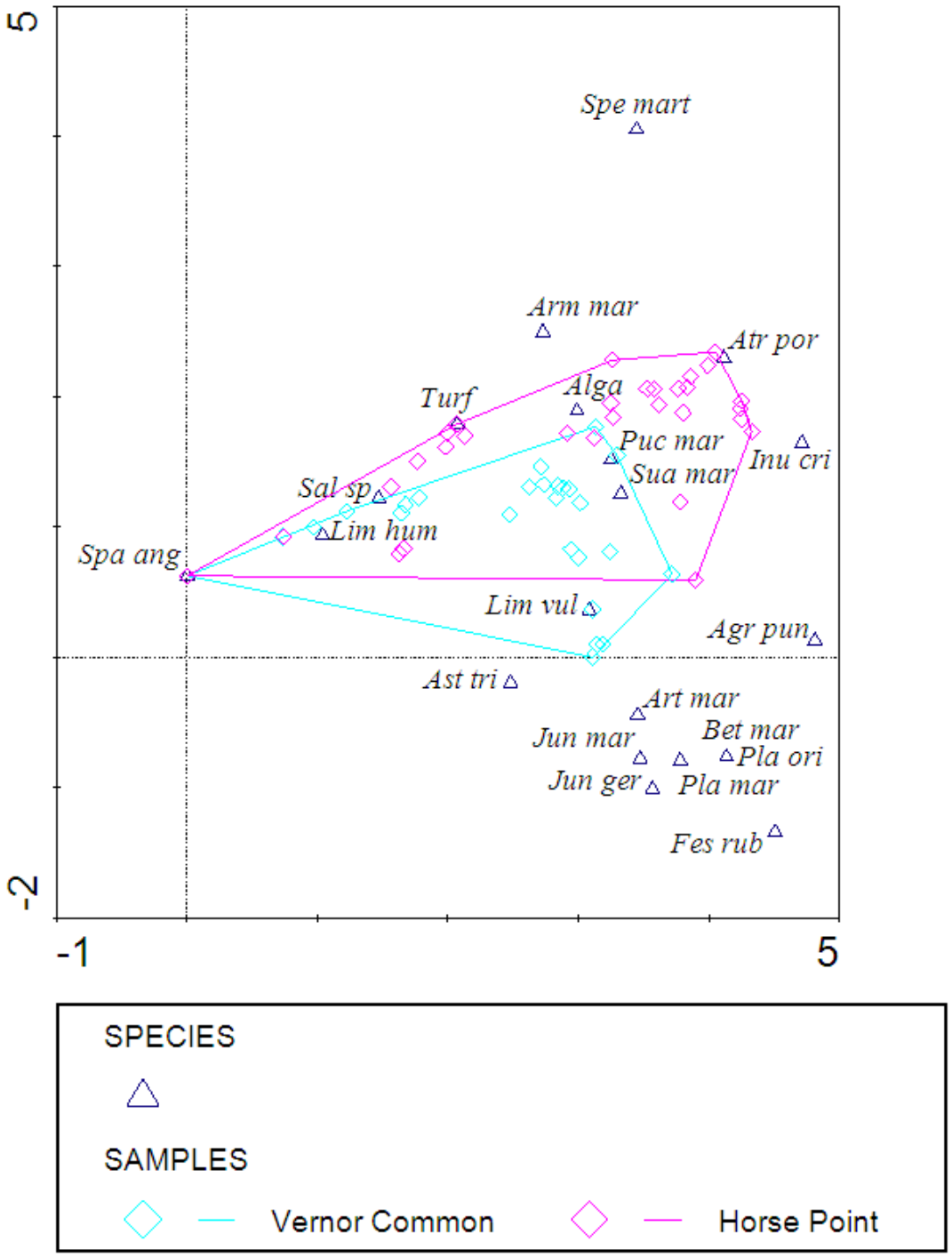

Figure 16 DCA graph of species data for the paired plots Vernor Common and Horse Point

3.95 Within the analysis Horse Point is classified as favourable and Vernor Common is classified as unfavourable.

Plot scale variables

3.96 Using Spearman's rank correlation coefficient to assess the level of agreement between median axis 1 and 2 scores for the individual plots, taken from the pooled sites DCA, and the corresponding assessment of the extent of the individual structural attributes, the following correlations were observed. Axis 1 scores exhibited a negative correlation with occurrence of rotational sliding, and a positive correlation with area of turf cutting. In addition area of turf cutting is positively correlated with vehicle damage or trampling at vulnerable areas of the

saltmarsh, which is in turn negatively correlated with occurrence of mud-mound topography (see Table 27).

Table 27 Spearman's rank correlations for variables at the plot and site scale

Correlation	Scale	N	Correlation coefficient	Significance
Axis 1 & Rotational sliding	Plot	24	-0.510	0.011
Axis 1 & Turf cutting	Plot	24	0.464	0.022
Turf cutting & Vehicle damage/trampling	Plot	24	0.456	0.025
Vehicle damage/trampling & Mud-mound topography	Plot	24	-0.495	0.014
Axis 2 & Rainfall	Site	4	-1.000	0.000
Temperature & Northing	Site	4	-1.000	0.000

3.97 Median axis 2 scores at the site scale were found to be negatively correlated with rainfall. In addition temperature was found to be negatively correlated with northing, indicating the average temperature decreased at more northerly sites. Due to the small sample sizes for the site scale variables there is a greater likelihood of the correlation coefficient exaggerating the level of correlation or failing to detect a correlation at all. This may explain the perfect negative correlations indicated for both of the site scale correlations (see Table 27).

Canonical Correspondence Analysis

3.98 CCA outputs are discussed and presented below.

Humber Estuary

3.99 Humber Estuary Pooled CCA shows a separation of Ellerker samples along gradients of litter, grazing and height in relation to mean high water line (Figure 17). This group of samples is also associated with species characteristic of transitional zones and those of the upper reaches of saltmarsh. Vegetation height also increases in the same direction as grazing pressure, although to a lesser extent. As this variable was measured using a drop disk it is possible that the taller species are unpalatable to herbivores, for example *Juncus* spp. Ellerker samples also appear to be associated with a number of grass species. This and the association with a gradient of increased grazing pressure suggest that over grazing in this plot has favoured these grazing tolerant grass species. A gradient of morphological change is apparent and is associated with a separation of predominantly Pyewipe samples, but including samples from East Halton, Stone Creek and Welwick. This may be indicative of the zonation at Pyewipe which comprises predominantly pioneer saltmarsh.

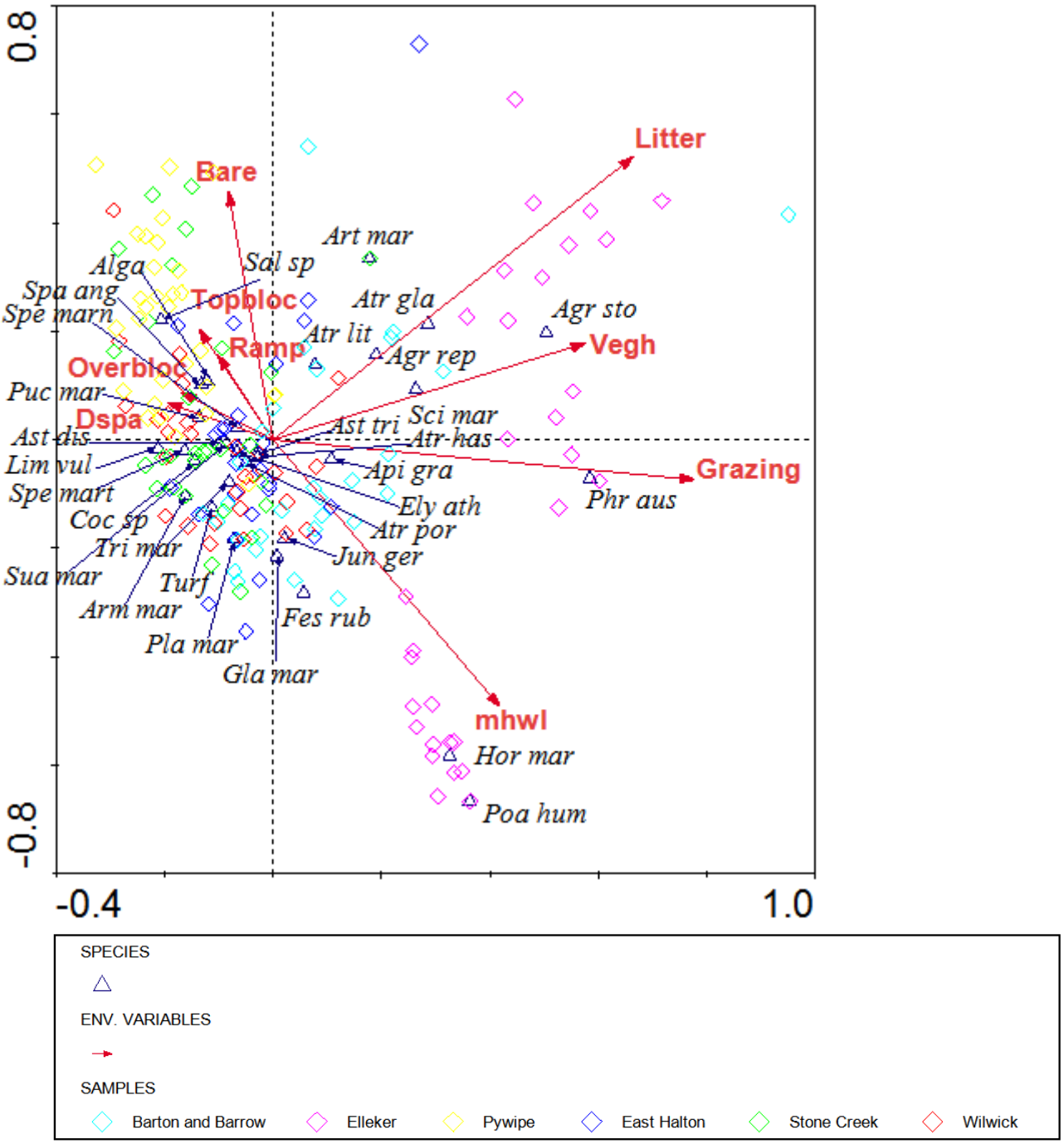

Figure 17 CCA graph of pooled environmental and species data for all sample plots within the Humber Estuary site

3.100 Plots classified as favourable for the purpose of this analysis are Barton and Barrows, Pywipe and Stone Creek. Those plots classified as unfavourable for the purpose of the analysis are Ellerker, East Halton and Welwick.

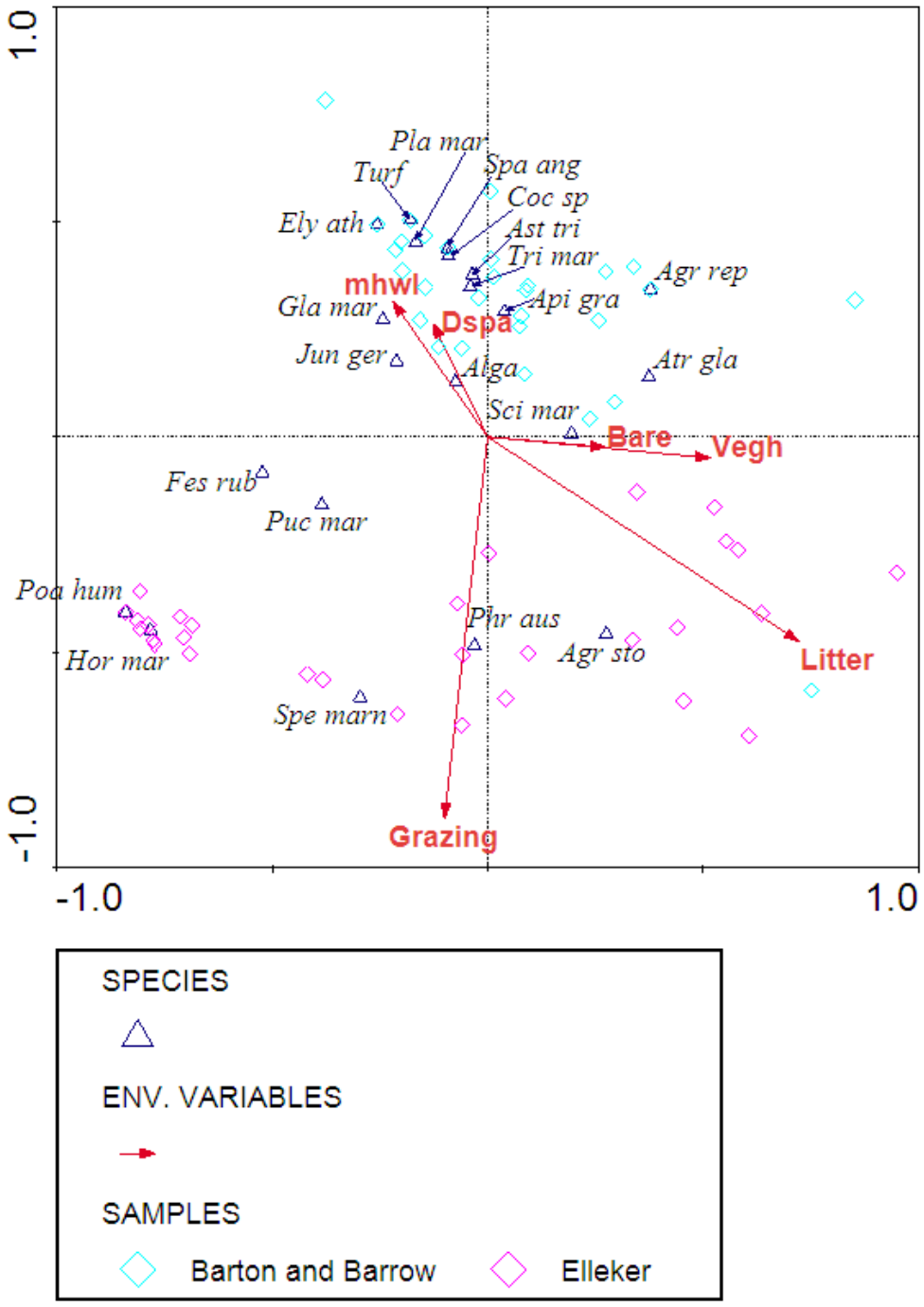

Figure 18 CCA graph of environmental and species data for the paired plots Barton and Barrow and Ellerker

3.101 Within the analysis Barton and Barrow is classified as favourable and Ellerker is classified as unfavourable.

3.102 This relationship is supported by the paired plot CCA for Barton and Barrow and Ellerker (Figure 18). The majority of samples and species are tightly aggregated in the middle of the graph. However, samples from Barton and Barrow show a lesser degree of separation along the same gradients as Ellerker samples; indicating some similarity in species composition and a lesser influence from grazing. Environmental variables relating to the physical structure appear to be more important at this plot. In addition Pyewipe samples and the environmental variables relating to physical structure appear to show a negative association with

increasingly higher position within the saltmarsh system. This is supported by the paired plot CCA for Pyewipe and East Halton (Figure 19).

3.103 In the CCA analysis for Barton Barrow and Ellerker, the gradients relating to increased grazing pressure and litter cover are apparently of high importance (Figure 18). The CCA also shows obvious separation between plots; with Ellerker quadrats showing a positive association with increased grazing pressure, as would be expected as grazing was recorded in all quadrats at this site and none from Barton Barrow, where quadrats are associated with absence of grazing. A high proportion of the grass species at the plots are positively associated with grazing to varying degrees. While Barton and Barrow sites are strongly aggregated and associated with sea weeds (shown as Turf in the graph) and *Spartina* sp.

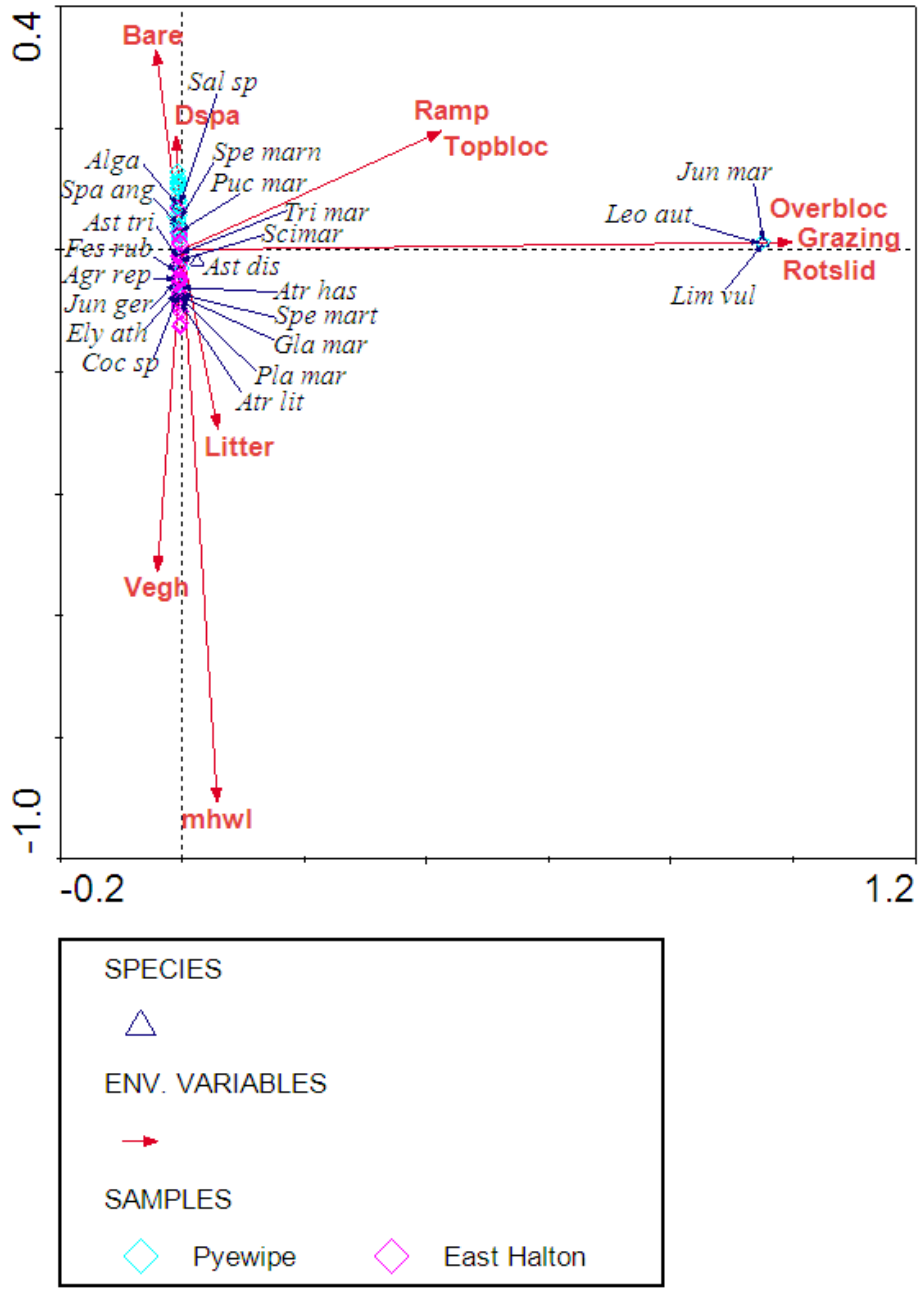

Figure 19 CCA graph of environmental and species data for the paired plots Pyewipe and East Halton

3.104 Within the analysis Pyewipe is classified as favourable and East Halton is classified as unfavourable.

3.105 At Pyewipe and East Halton the sites are also separated with Pyewipe, the favourable condition plot, being associated with presence of dead *Spartina anglica* and East Halton samples showing a positive association with increasing height in relation to mean high water line, vegetation height and litter cover (Figure 19). However this graph is otherwise unhelpful in determining the effect of environmental variables on species composition, as a small number of samples appear to have had a pronounced effect upon the spread of samples and species, creating a restricted spread for the bulk of these. Grazing appears to have an important effect however this is likely to be as a result of being recorded at a single sample location, as the remainder of the samples are spread in a vertical distribution only, at right angles to the grazing gradient. A gradient of morphological change exists in same direction and is associated with species characteristic of mid-upper saltmarsh and transitional zones.

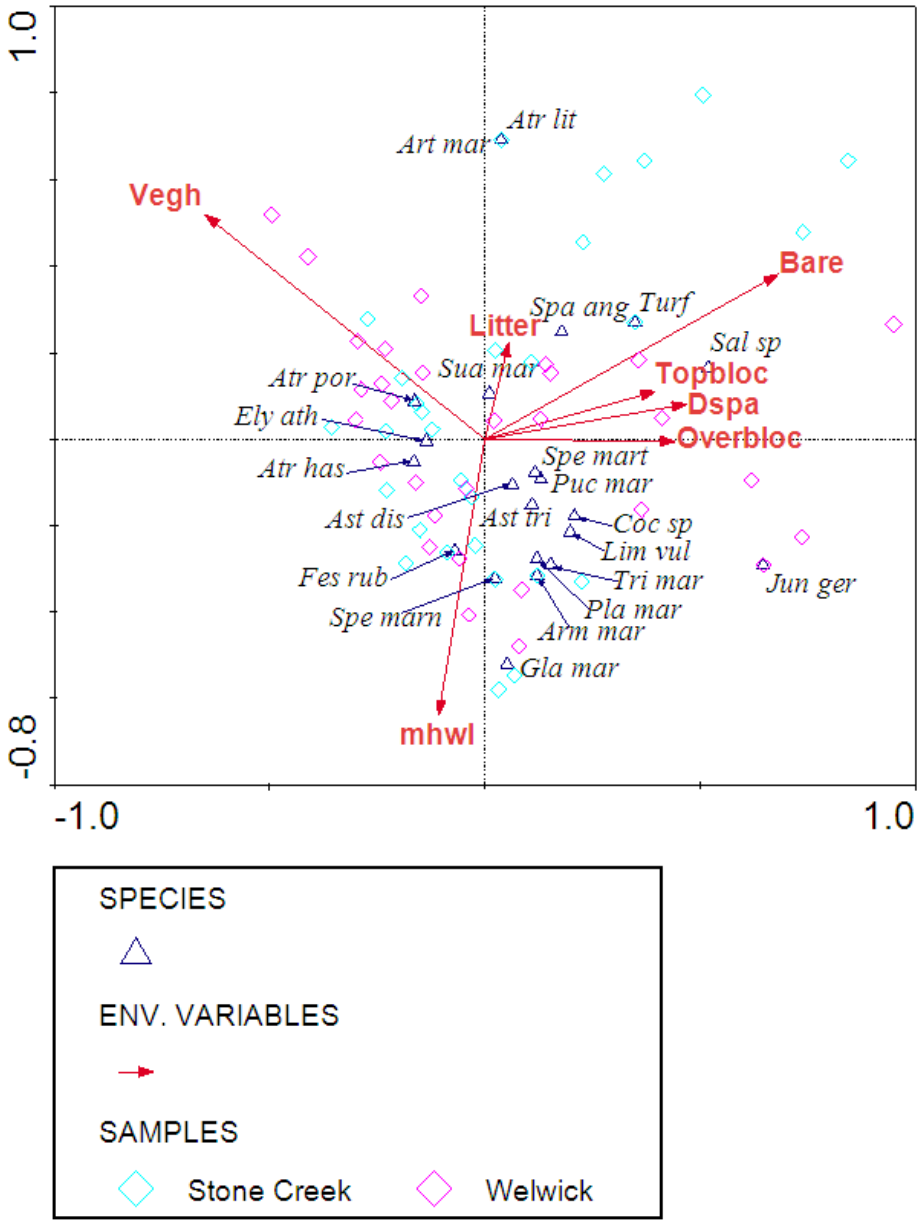

Figure 20 CCA graph of environmental and species data for the paired plots Stone Creek and Welwick

3.106 Within the analysis Stone Creek is classified as favourable and Welwick is classified as unfavourable.

3.107 The CCA for the paired plots of Stone Creek and Welwick appears to show a relatively high degree of variability between the species composition of the various samples and no clear differences between the two plots, indicated by a lack of separation between samples from different plots (Figure 20). There is a slight separation of unfavourable plot samples in association with a gradient of erosion as exemplified by presence of toppled blocks and overhanging blocks. The three most influential environmental variables are vegetation height, amount of bare ground and height in relation to mean high water line. These are arranged roughly 120° apart, indicating negative associations between all three parameters. Dead Spartina anglica and environmental variables relating to structural features of the saltmarsh are positively associated with amount of bare ground and negatively associated with position in relation to mean high water line and vegetation height. These relationships are very much as would be expected of a saltmarsh system and indicate no unusual ecological interactions that might influence condition assessment.

Morecambe Bay

3.108 The Morecambe Bay pooled CCA shows a very strong aggregation of samples around the centre of the graph, which is combined with limited separation of individual plots (Figure 21). The most obvious separation occurs with some samples from Foulshaw and Warton South. These samples show a positive association with amount of litter cover and increasing vegetation height. There is a separation of species from the main group which is also associated with this gradient. These species are typical of drier saltmarsh, transition between saltmarsh and terrestrial habitats and other maritime habitats that are not part of the saltmarsh system. This suggests that the samples in this region of the graph were taken from the upper reaches of the respective plots. A further separation occurs with an aggregation of Milnthorpe samples strongly associated with a gradient of increasing cover of dead Spartina anglica. There is a broad gradient of morphological change formed by the individual gradients of erosion indicators. Individually these gradients appear to have a limited effect but when combined into a gradient of ‘morphological change’ they are associated with a large number of samples. Due to the complex environmental factors influencing the saltmarsh system, the ecology and species assemblages of the separate zones differs greatly. For this reason the pooled CCA graphs, and in particular the Morecambe Bay CCA, are more useful in identifying samples taken from separate zones rather than individual plots or relative condition in the majority of cases. Where an obvious separation occurs it is often possible to identify influential variables that may be deterministic in the condition assessment.

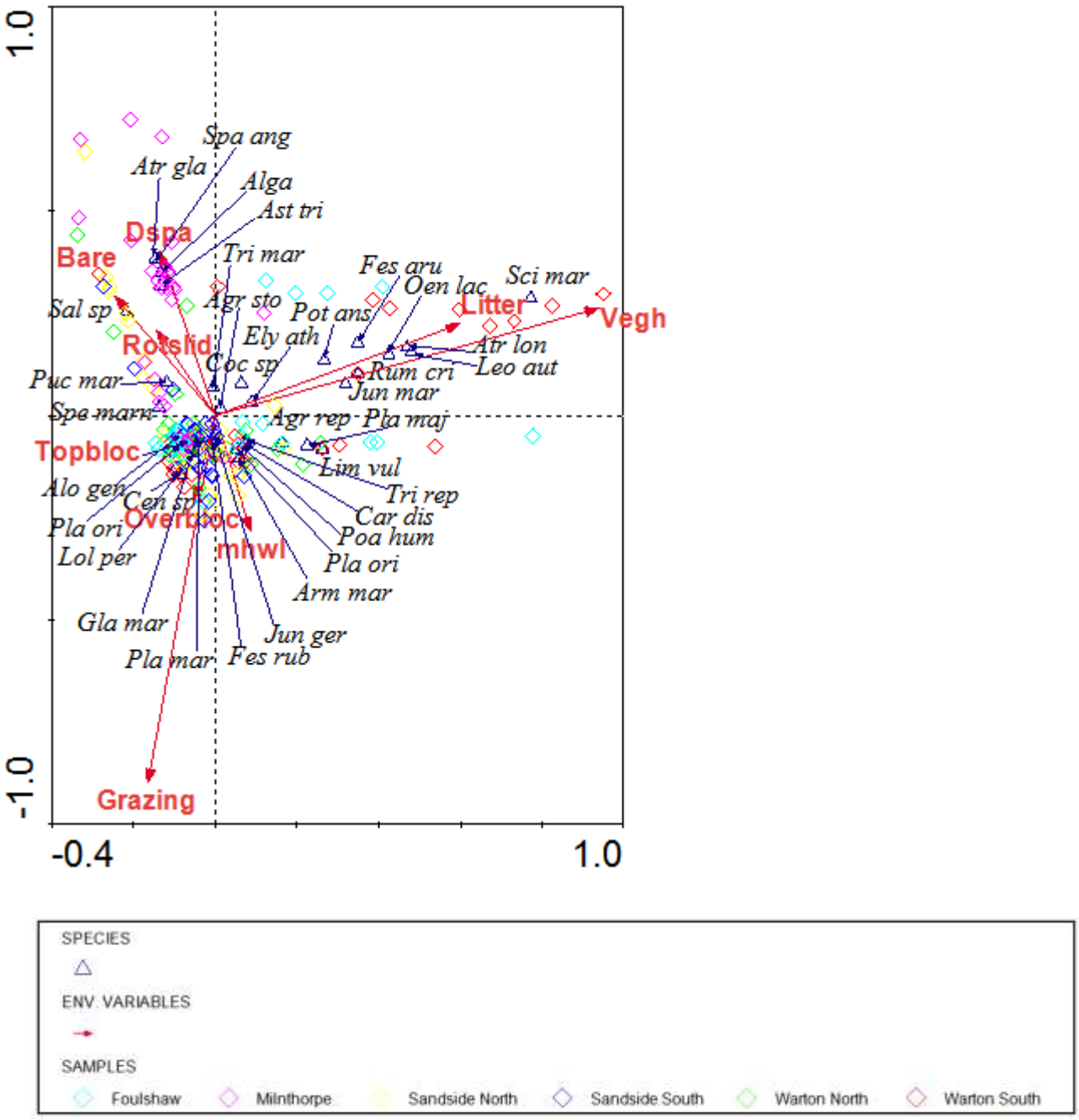

Figure 21 CCA graph of pooled environmental and species data for all sample plots within the Morecambe Bay site

3.109 Plots classified as favourable for the purpose of this analysis are Foulshaw, Sandside North and Warton North. Those plots classified as unfavourable for the purpose of the analysis are Milnthorpe, Sandside South and Warton South.

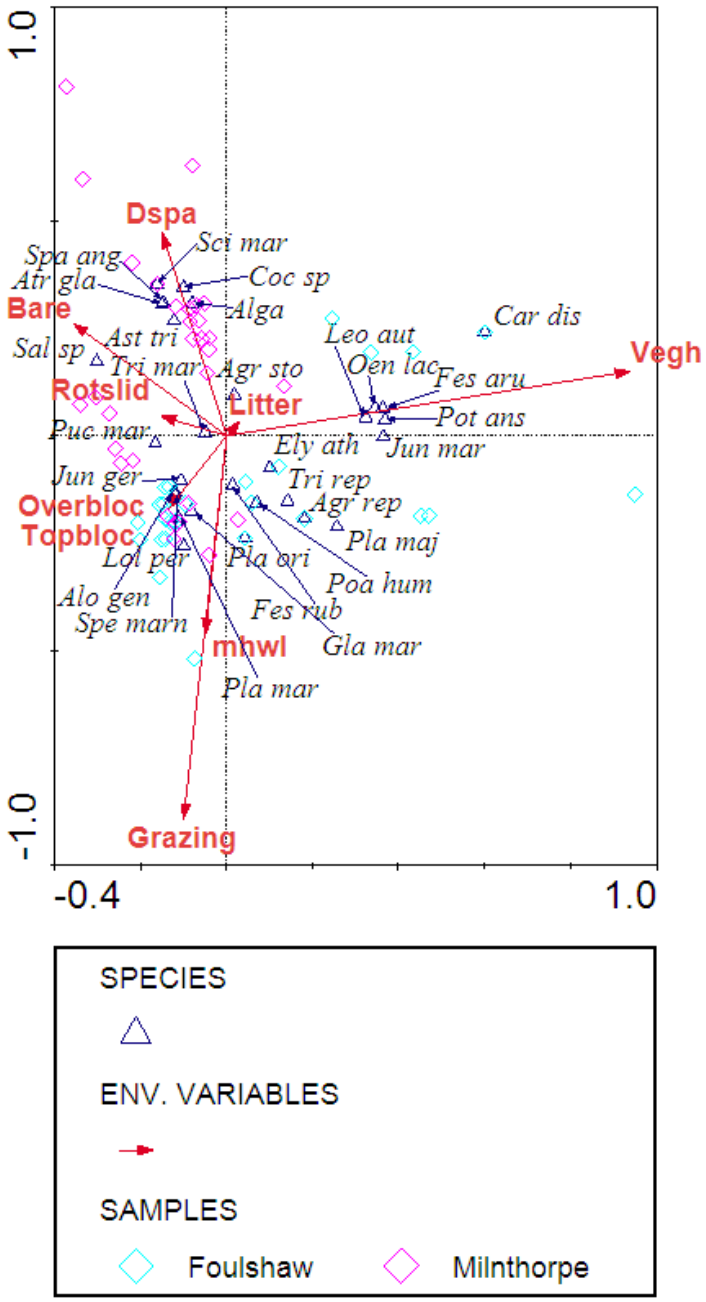

Figure 22 CCA graph of environmental and species data for the paired plots Foulshaw and Milnthorpe

3.110 Within the analysis Foulshaw is classified as favourable and Milnthorpe is classified as unfavourable.

3.111 The Foulshaw Milnthorpe paired CCA shows a relatively high degree of separation between the two plots (Figure 22). In addition to this there are some interesting aggregations and gradients. There are a number of species groups that appear to represent communities from all zones of the saltmarsh. The prominence of dead *Spartina anglica* in the pioneer zone at Milnthorpe is evidenced by the aggregation of these quadrats along this environmental variable. This aggregation is also associated with a lower position in relation to mean high water line and negatively associated with the influential gradient of grazing pressure. Grazing pressure and vegetation height appear to be the most influential variables with this plot pairing. The distribution of Foulshaw samples in relation to vegetation height gradient suggests that the vegetation at this plot is more developed than at Milnthorpe. In addition grazing appears to be more prevalent at Foulshaw. A degree of separation and aggregation is evidenced by two apparently separate gradients of erosion within the Foulshaw and

Milnthorpe pair (Figure 22). Foulshaw samples are associated with an erosion gradient indicated by overhanging blocks and toppled blocks. Samples from Milnthorpe are associated with a gradient of morphological change indicated by bare mud and rotational sliding.

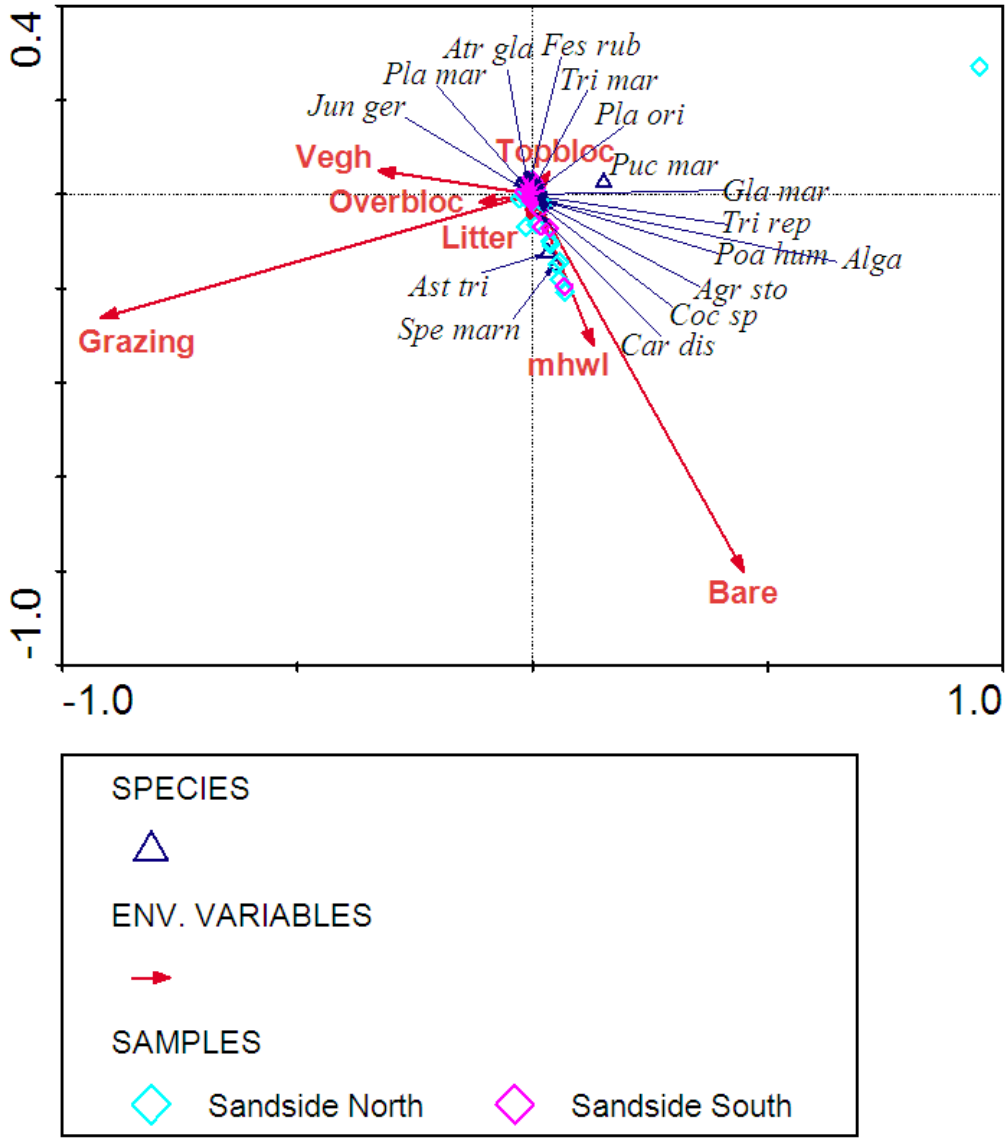

Figure 23 CCA graph of environmental and species data for the paired plots Sandside North and Sandside South

3.112 Within the analysis Sandside North is classified as favourable and Sandside South is classified as unfavourable.

3.113 The species contained within the graph of the CCA for Sandside North and Sandside South contain a high proportion of species typically found in transitional zones of a saltmarsh (Figure 23). These species are very strongly aggregated along with the majority of the samples, making it impossible to disseminate any fine scale groupings or associations between the environmental variables and the majority of samples and species. Grazing and amount of bare ground are the two most influential variables in this pairing, and both show some level of either positive or negative association with species and samples. *Puccinellia maritima* is negatively associated with increasing grazing pressure, however this does not necessarily indicate an intolerance of grazing as this species favours wetter areas of saltmarsh which would ordinarily be avoided by herbivores. A separation of samples, mainly from the favourable Sandside North plot, is positively associated with amount of bare ground

and increasing height in relation to mean high water line. The species associated with this separation are typically found in saltmarsh, indicating that this grouping of samples represents a more typical saltmarsh community and consistent with the favourable condition assessment. Other than occurrence of bare mud, indicators of morphological change appear to have only a minimal effect upon the data taken from Sandside South and North.

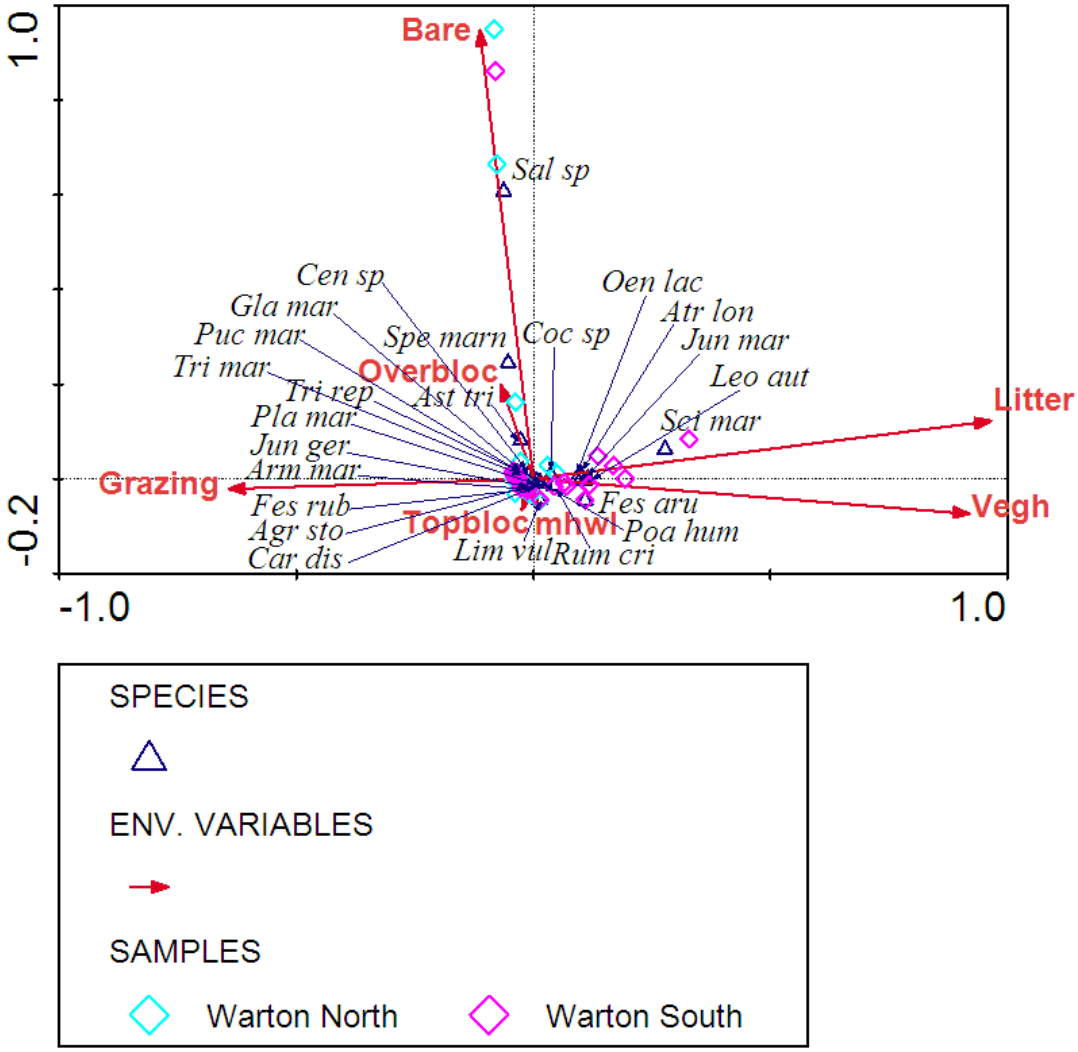

Figure 24 CCA graph of environmental and species data for the paired plots Warton North and Warton South

3.114 Within the analysis Warton North is classified as favourable and Warton South is classified as unfavourable.

3.115 Again the Warton North and Warton South paired CCA shows a very strong aggregation of samples and species, creating a graph with few clear relationships (Figure 24). What is apparent is that amount of bare ground, amount of litter, height of vegetation and grazing pressure are important variables within the graph. There is some separation of species closely associated with a gradient of increasing bare ground, which is also associated with *Salicornia* species which tend to be found in middle and upper saltmarsh communities. These species are also typically associated with increased occurrence of bare mud, which can be seen throughout the set of CCA analyses. There is also a slight spatial separation from the main group of samples from the unfavourable plot Warton South. This group is positively associated with increasing litter and vegetation height, and negatively associated with increasing grazing pressure. The species assemblage in this region of the graph appears to be one that would occur in a drier region of the saltmarsh with tall vegetation such as might

develop near to the transition between saltmarsh and fully terrestrial habitats. The environmental variable of height in relation to mean high water line gives little information on the variation in species data. This and the association of a number of Warton South samples with the above mentioned community suggests that the unfavourable condition assessment is due to a non-typical saltmarsh species assemblage, possibly resulting from the effects of unmeasured environmental variables.

The Wash

3.116 The CCA graph for the pooled Wash plots consists of a large tightly aggregated cluster of species and samples from all sites, from which there is relatively little separation (Figure 25). Those samples that are separated from this group originate from a mixture of plots and show no pattern with regards to favourable or unfavourable condition. These samples are generally associated with the more influential environmental variables; amount of bare ground, presence of accretional ramps, vegetation height and grazing pressure. The majority of species are clustered around the centre; however those that are separated tend to be found in association with increasing vegetation height and litter accumulation. These species are typical of upper reaches of the system, with one occurring only above the high water line, suggesting that taller communities occur higher in the system. There are separate gradients of both accretion and erosion. The accretion gradient, ie increased occurrence of accretional ramps, appears to have an important effect in terms of explaining variation within the data. The erosion gradient, which is indicated by occurrence of toppled blocks and rotational sliding have a lesser effect but are associated with a greater number of samples.

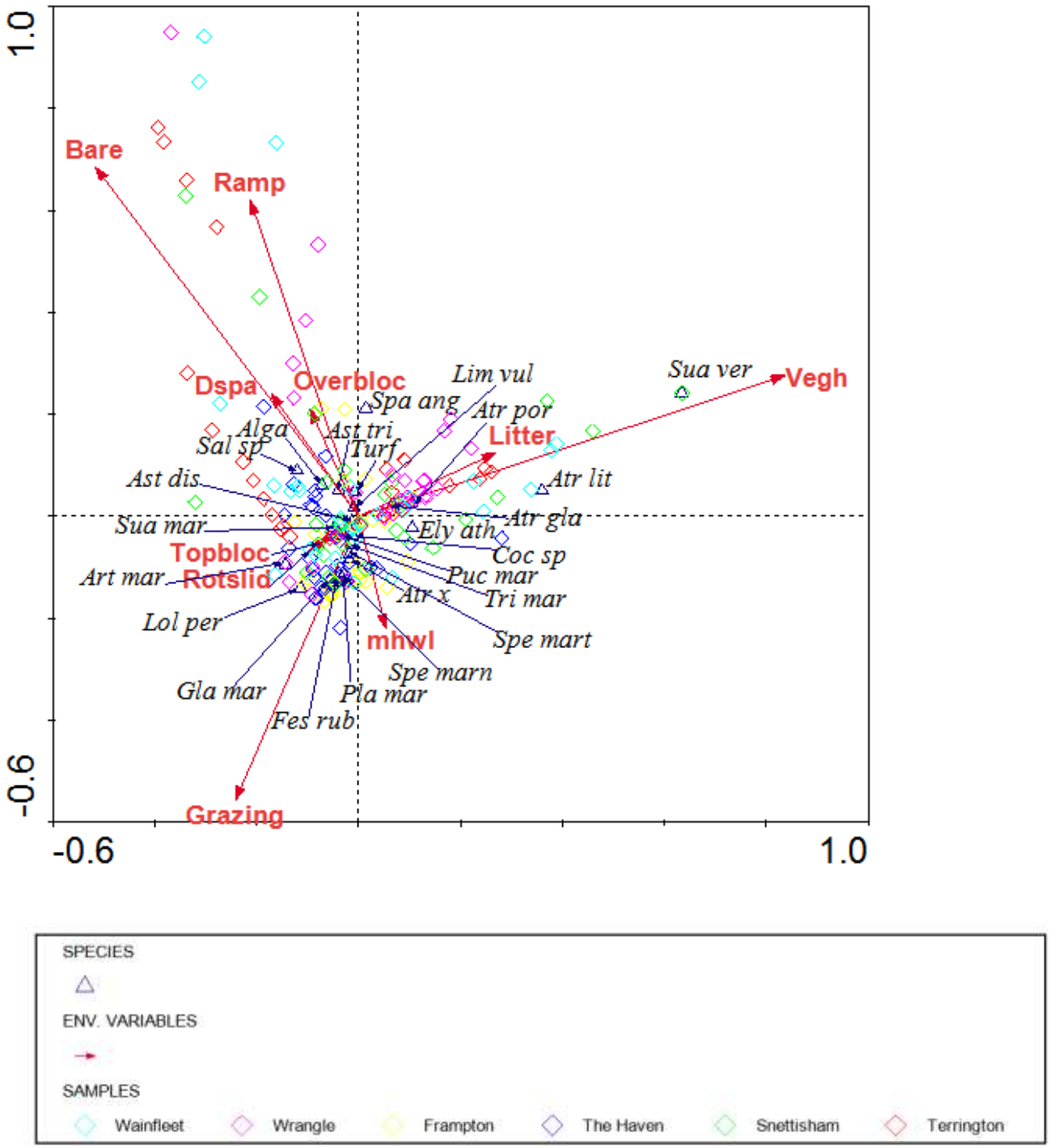

Figure 25 CCA graph of pooled environmental and species data for all sample plots within The Wash site

3.117 Plots classified as favourable for the purpose of this analysis are Wainfleet, Frampton and Snettisham. Those plots classified as unfavourable for the purpose of the analysis are Wrangle, The Haven and Terrington.

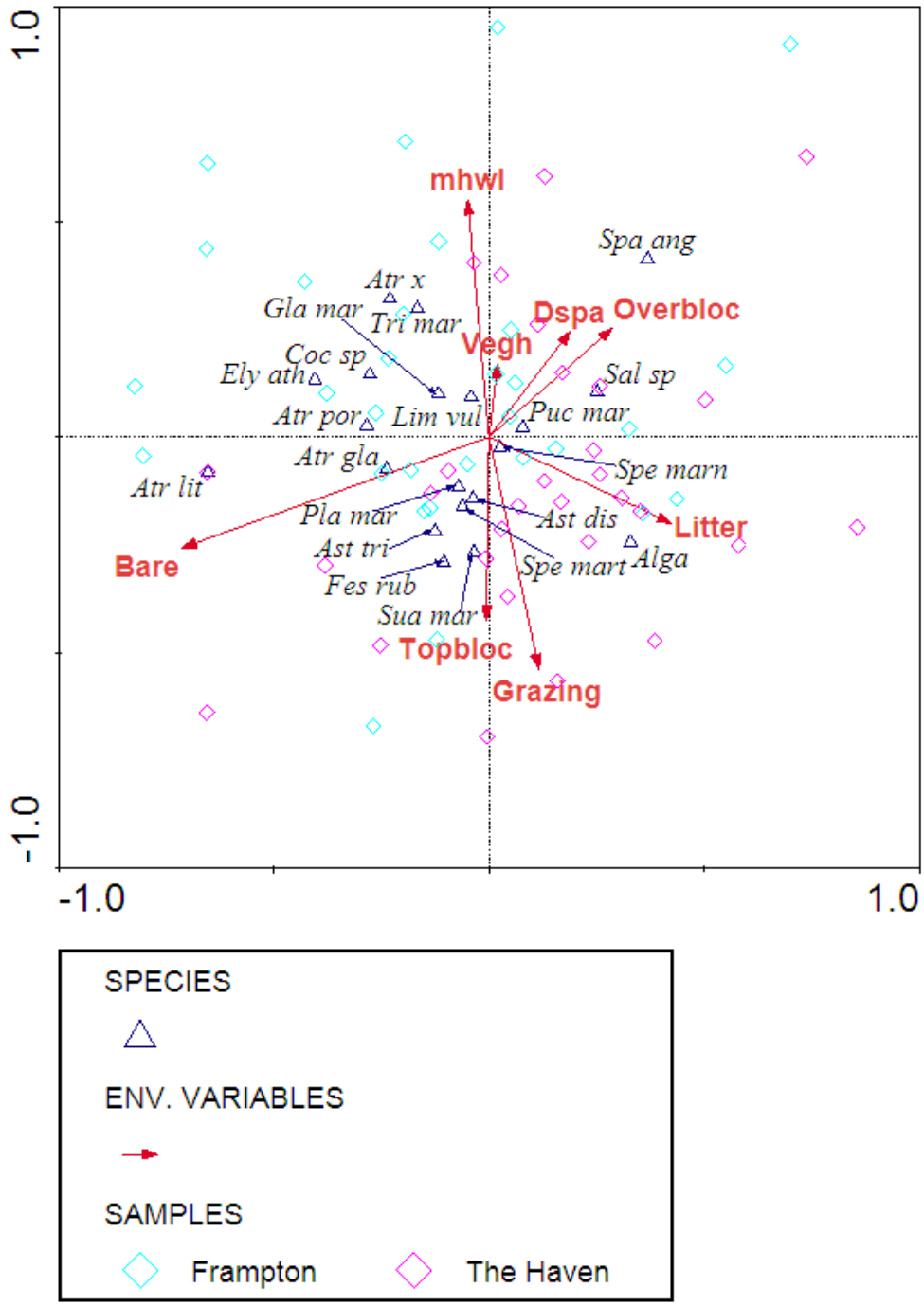

Figure 26 CCA graph of environmental and species data for the paired plots Frampton and The Haven

3.118 Within the analysis Frampton is classified as favourable and The Haven is classified as unfavourable.

3.119 The paired plot CCA for Frampton and The Haven shows a broad distribution of samples, with samples from individual plots tending towards opposite corners of the graph (Figure 26). Some mixing of samples occurs, however a clear division does exist as samples near the centre of the graph originate from both plots. The broad distribution and lack of environmental variables with a highly dominating influence suggests a high degree of variation between the vegetation sampled at the various sites and no defining effect of individual environmental variables. In the case of plots from The Wash, the condition assessment was not made by the assessor. Therefore the plots have been classified as relatively favourable or unfavourable for the purpose of this study. This may explain the lack of clear separation of samples. The

division that does occur is most likely to be due to subtle changes in the species composition at the two plots. There is no clear gradient of morphological change despite the appearance of indicators of erosion or accretion within the CCA. Such features are more suited to explaining variation between samples rather than plots.

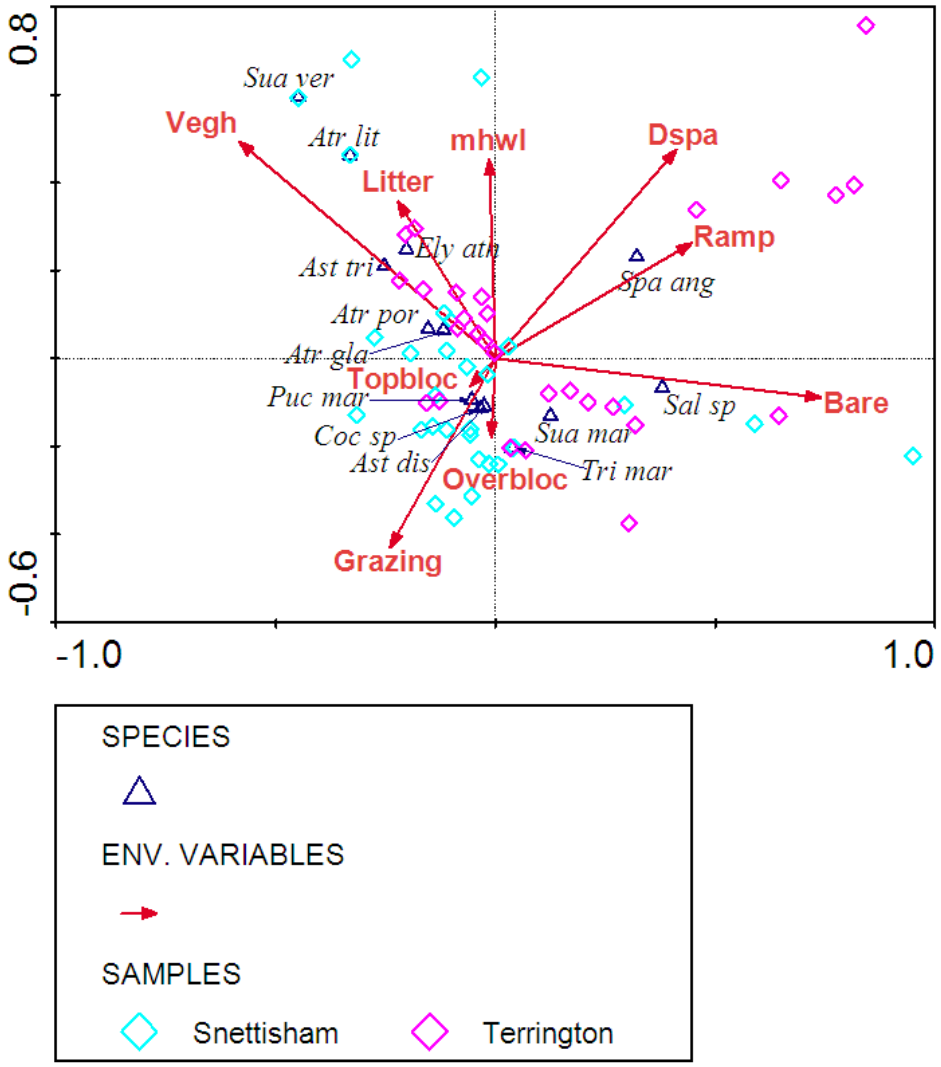

Figure 27 CCA graph of environmental and species data for the paired plots Snettisham and Terrington

3.120 Within the analysis Snettisham is classified as favourable and Terrington is classified as unfavourable.

3.121 The paired plot CCA for Snettisham and Terrington shares similarities with the above graph, in that there are no dominating environmental variables (Figure 27). However there are some more meaningful associations which can be observed. A group of Snettisham samples exhibit a positive association with the grazing gradient suggesting that grazing has altered the species composition of the plot. There is also a gradient of vegetation height that increases in association with increasingly higher position with in the saltmarsh, and is supported by the position of individual species within the graph. The Snettisham and Terrington pair shows a gradient of accretion, indicated by accretional ramps and possibly occurrence of bare ground, associated with samples from Terrington. There is also a gradient of erosion that is associated with samples from Snettisham.

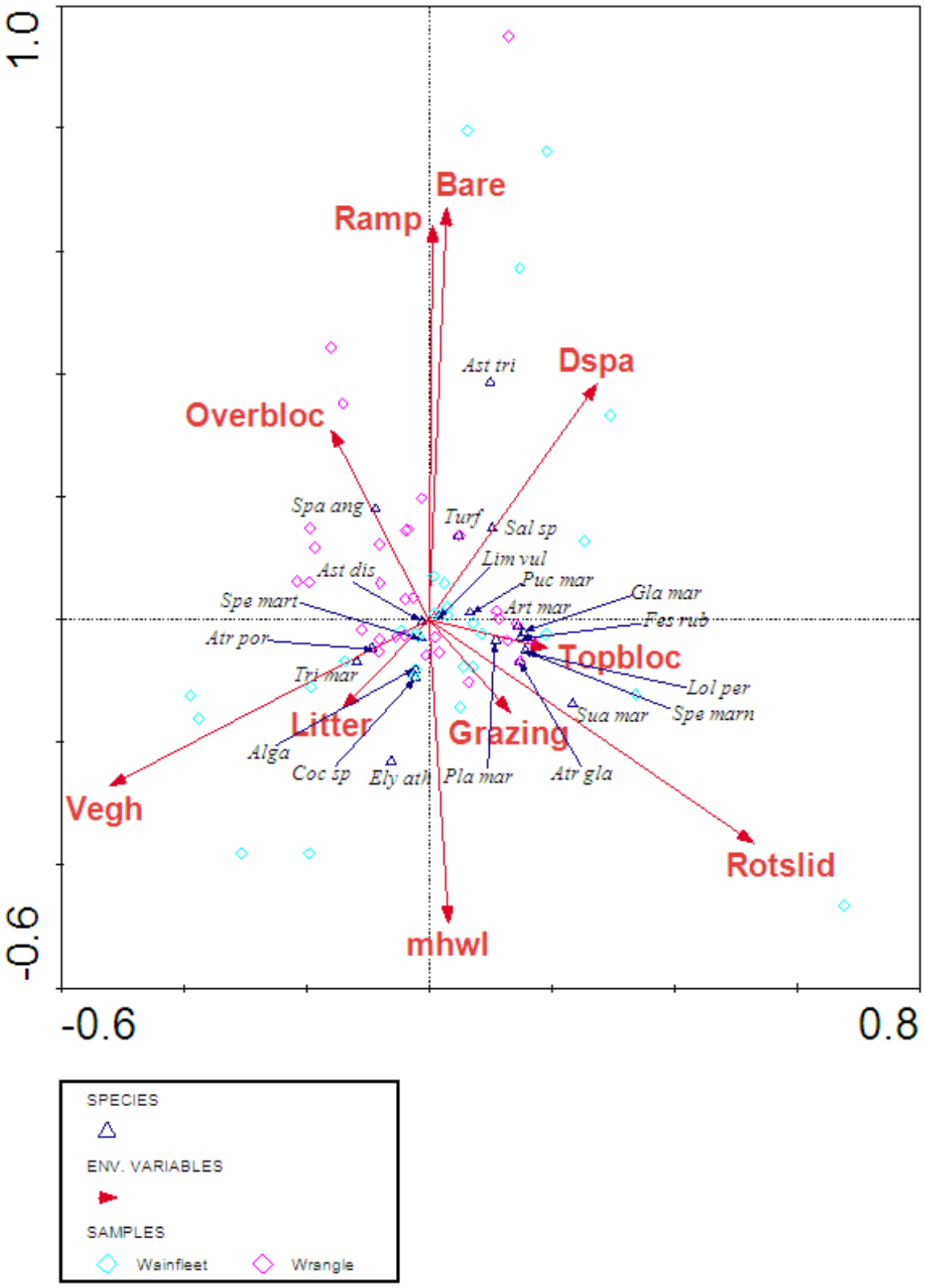

Figure 28 CCA graph of environmental and species data for the paired plots Wainfleet and Wrangle

3.122 Within the analysis Wainfleet is classified as favourable and Wrangle is classified as unfavourable.

3.123 The Wainfleet and Wrangle CCA graph consists of small groups of tightly aggregated samples with some outlying samples (Figure 28). In addition the gradients of increasing litter cover, grazing and cover of dead *Spartina anglica* exhibit a dominating influence. The

groupings of samples that do occur consist of a mixture of both plots. No overall pattern can be observed to distinguish the ecological interactions at the separate plots, although it is clear that grazing is important in influencing species composition in a number of samples. There is no obvious gradient of morphological change, with individual indicators acting in different directions, suggesting an effect upon samples rather than plots.

Chichester Harbour

3.124 The pooled plot CCA for Chichester Harbour consists in general of a mixed aggregation from all sites (Figure 29). Despite this the samples are fairly well separated when compared to other CCA graphs for the saltmarsh sites and there are some apparent groupings of samples from the same plots, and also some degree of grouping of plots with the same condition assessment. The aggregation becomes less pronounced towards the right hand side of the graph, in association with the most influential environmental gradients: bare ground, amount of letter cover, cover of dead *Spartina anglica* and increasing vegetation height. In addition to this the majority of species appear to be separated in to two distinct groups, although no patterns exist relating to the various habitat types in which these groups of species typically develop. It is notable that a relatively large proportion of the species within the graph occur in drier saltmarsh habitats. As the condition assessment for all plots at this site resulted in a condition of unfavourable, the plots have been classified as relatively favourable and unfavourable for the purpose of this study. This is reflected in the CCA diagrams for the paired plots where there is generally a high degree of overlapping between the two plots for each pairing. In addition, samples from the unfavourable plots are frequently associated with a gradient of morphological change. This occurrence can also be seen within the CCA for individual plot pairings for Chichester Harbour (Figures 30 to 32).

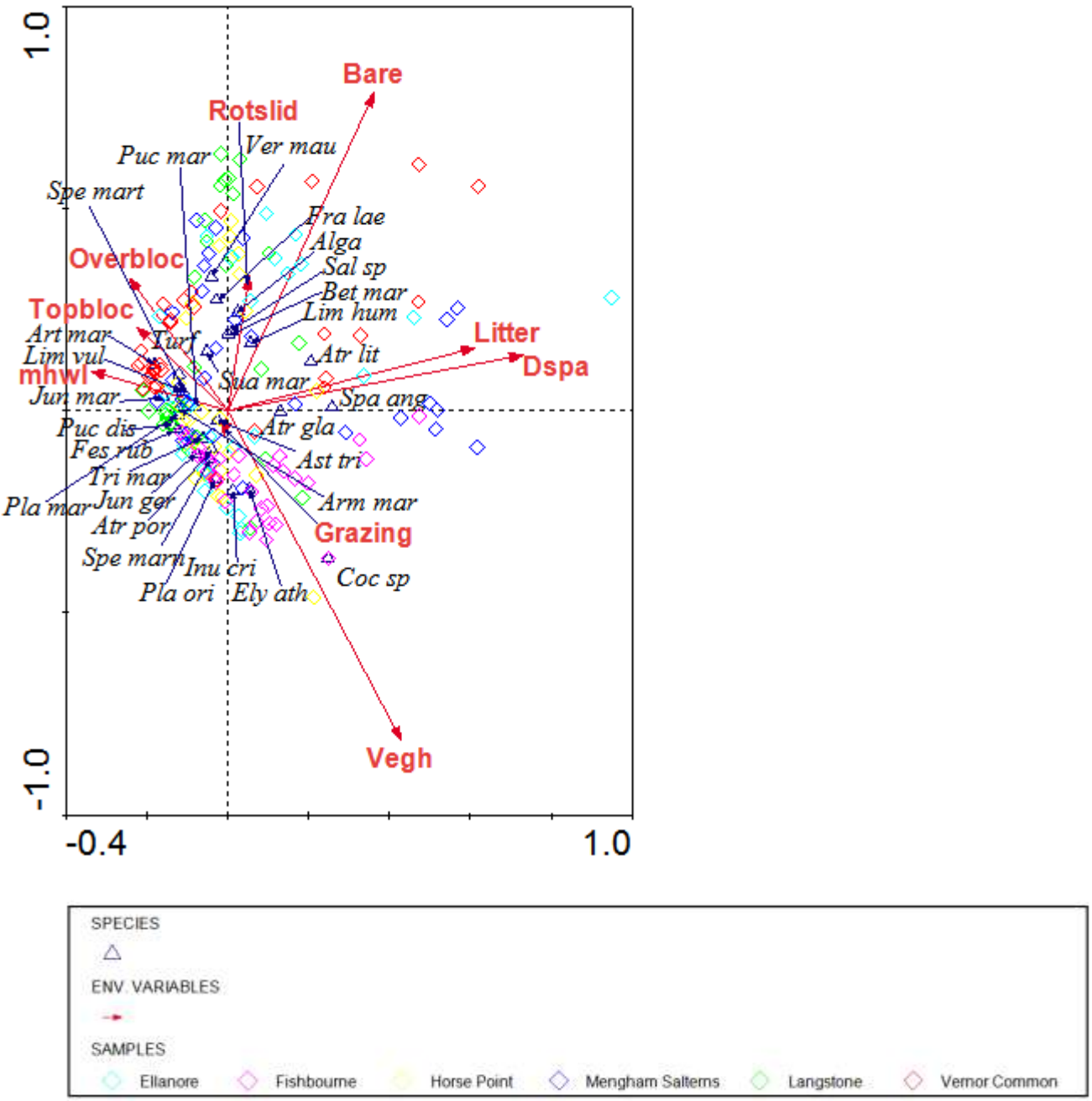

Figure 29 CCA graph of pooled environmental and species data for all sample plots within the Chichester Harbour site

3.125 Plots classified as favourable for the purpose of this analysis are Horse Point, Ellanore and Fishbourne. Those plots classified as unfavourable for the purpose of the analysis are Vernor Common, Mengham Salterns and Langstone.

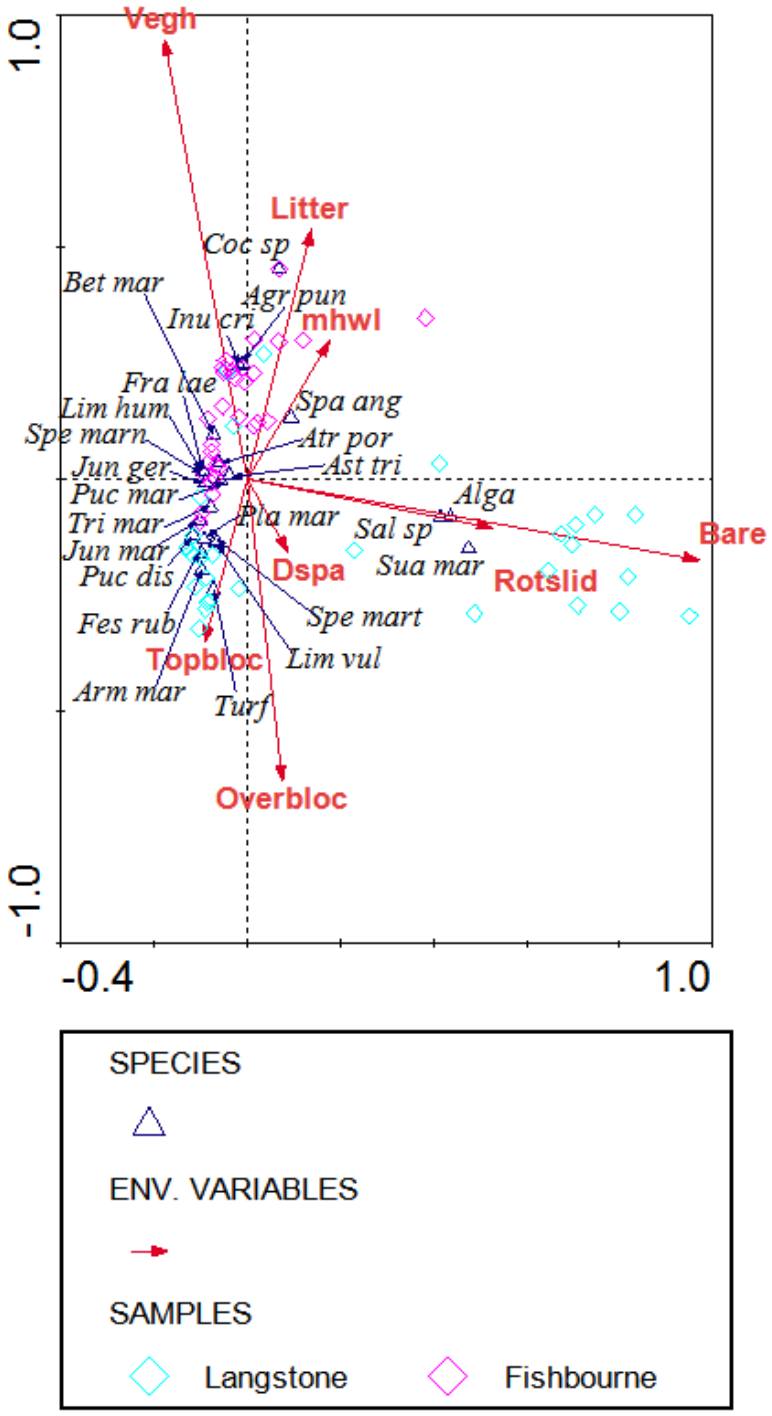

Figure 30 CCA graph of environmental and species data for the paired plots Langstone and Fishbourne

3.126 Within the analysis Fishbourne is classified as favourable and Langstone is classified as unfavourable.

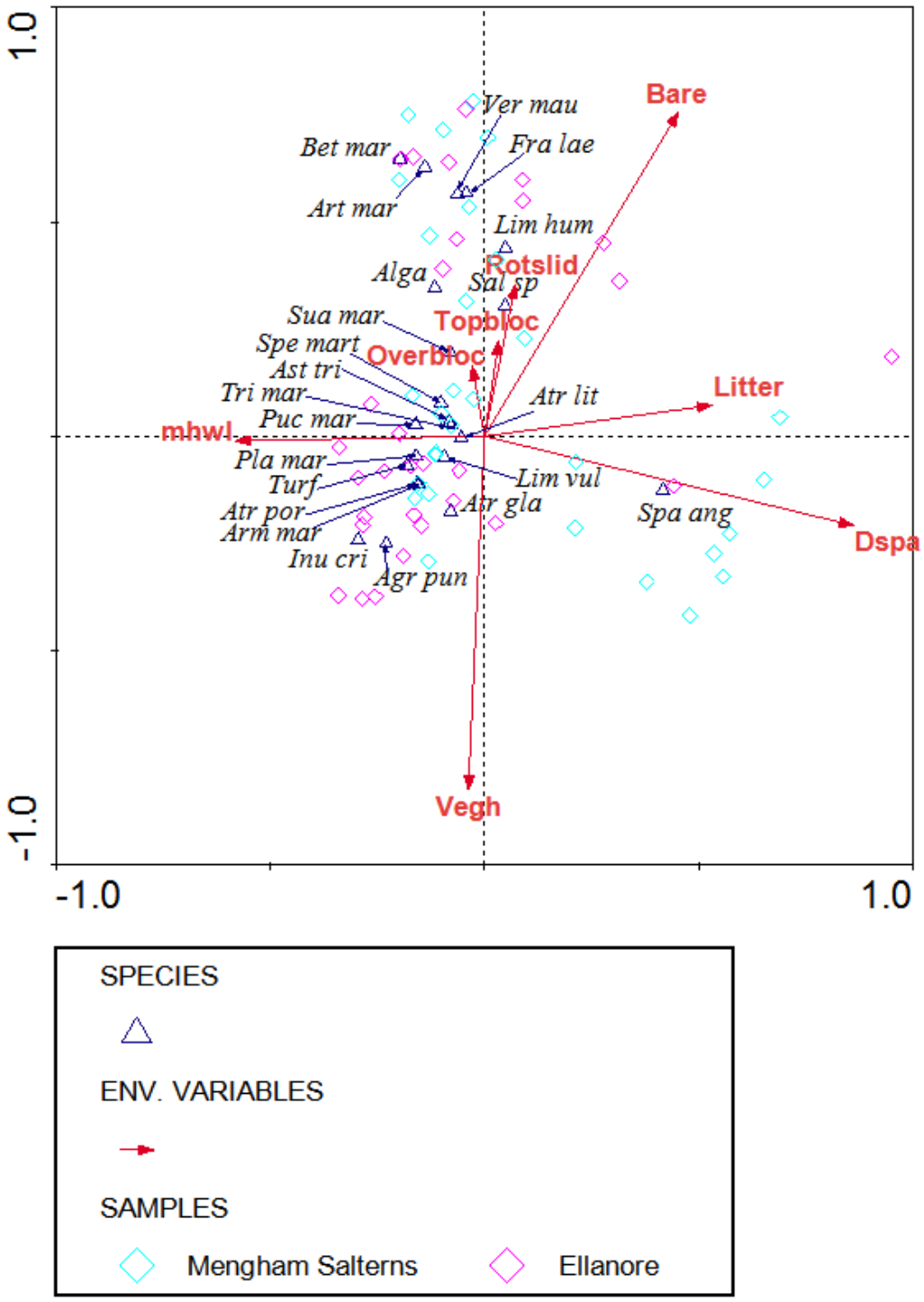

Figure 31 CCA graph of environmental and species data for the paired plots Mengham Salterns and Ellanore

3.127 Within the analysis Ellanore is classified as favourable and Mengham Salterns is classified as unfavourable.

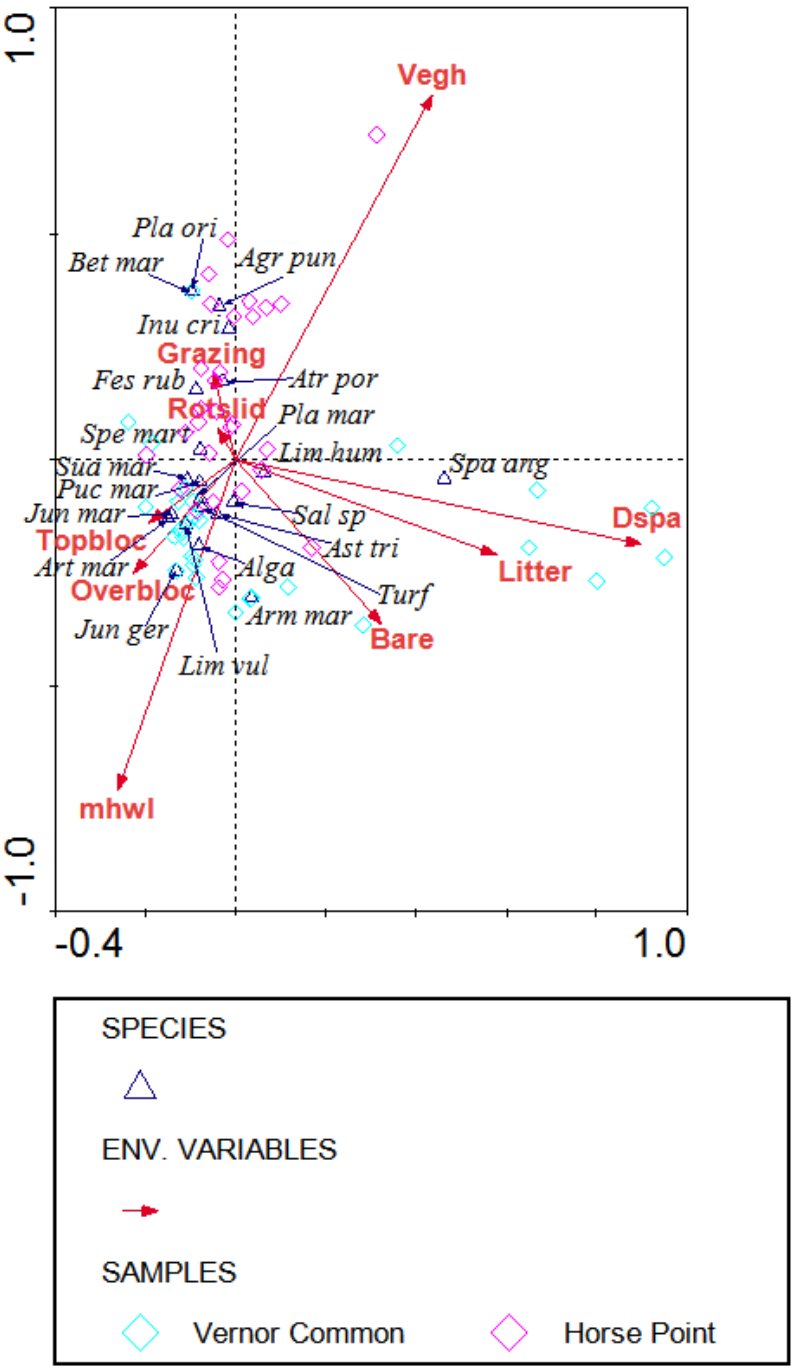

Figure 32 CCA graph of environmental and species data for the paired plots Vernor Common and Horse Point

3.128 Within the analysis Horse Point is classified as favourable and Vernor Common is classified as unfavourable.

3.129 The CCA graphs for paired Langstone and Fishbourne and paired Mengham Salterns and Ellanore share some similarities (Figures 30 & 31). Both show mixing between the two plot sample sets and in both graphs vegetation height and amount of bare ground are important variables in explaining variation in the species data. Notably, as all plots were classified as unfavourable, grazing does not feature on these graphs. This suggests under-grazing may be a factor contributing to the unfavourable condition assessment. There is a separation of samples from Langstone along a gradient of increasing bare ground and occurrence of rotational sliding. The species found in this region of the graph are all typical of saltmarsh communities. In the Mengham Salterns and Ellanore CCA graph, a separation of samples

from Mengham Salterns exists in relation to a gradient of increasing cover of dead *Spartina anglica* and association with the species variable of *Spartina anglica*. This explains the categorization of this plot as relatively unfavourable. The CCA graph for Verner Common and Horse Point is influenced by a number of environmental variables including vegetation height, dead *Spartina anglica*, mean high water level, litter and bare ground (Figure 32). Again there is a separation of samples from the plot classified as relatively unfavourable in association with a gradient of increasing cover of *Spartina anglica* and the individual species variable of *Spartina anglica*.

All sites

3.130 Figure 33 shows the CCA output for all pooled species and environmental data for all saltmarsh sites included within this study. The samples are classified in line with the site condition assessment according to the common standards methodology in an attempt to identify any associations between site condition assessment and the environmental variables measured. No such relationship appears to exist. The most useful information that can be extrapolated from the graph is that of those environmental variables measured the most important in terms of explaining variation in species composition are grazing pressure, height in relation to mean high water line, vegetation height and litter cover.

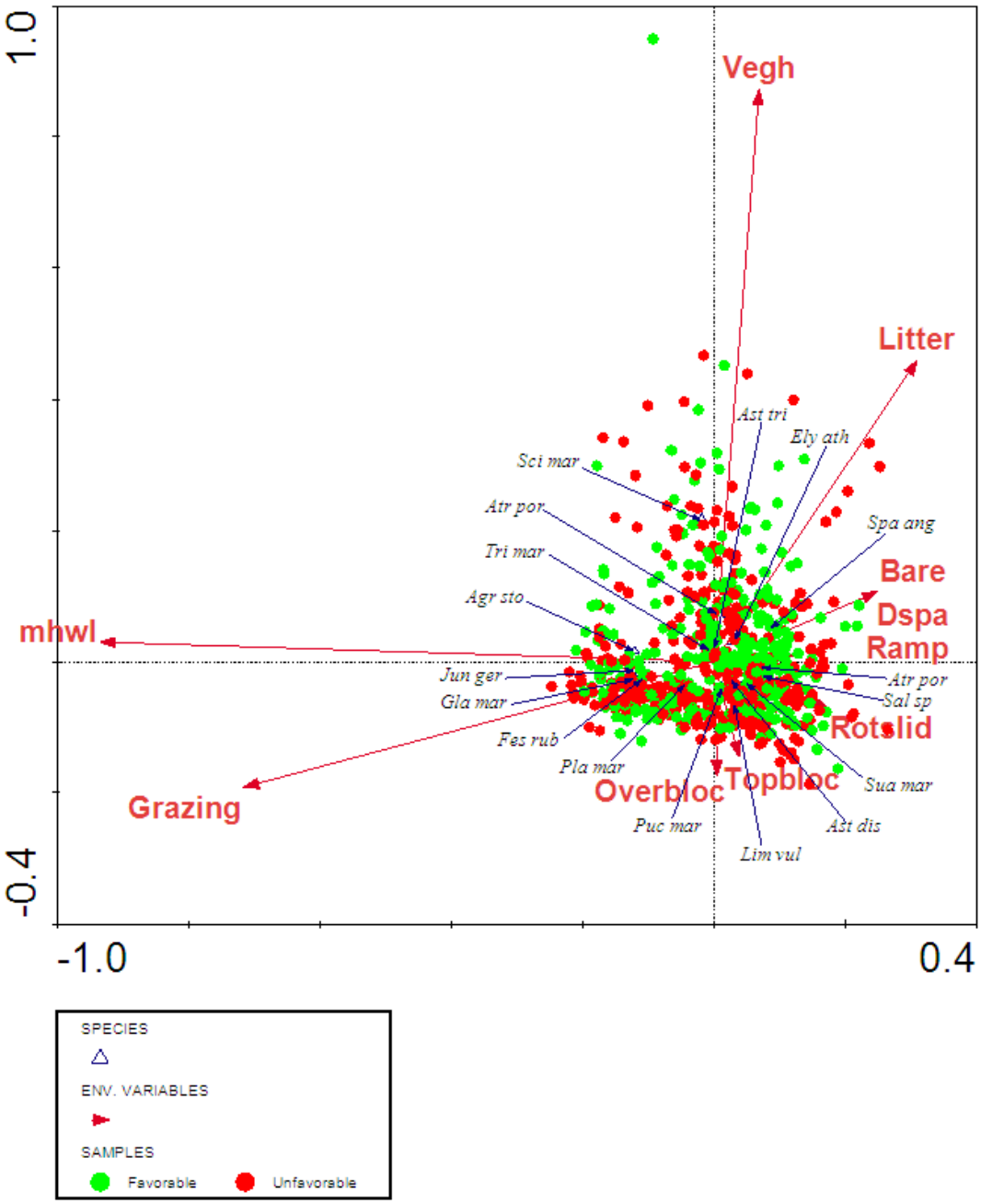

Figure 33 CCA diagram of all pooled species and environmental saltmarsh data with a 5% to 100% inclusion rule applied to limit the number of species appearing on the graph

3.131 Those environmental variables that relate to saltmarsh morphology appear to have a less pronounced effect upon the distribution of samples, when observed individually, than grazing pressure, height in relation to mean high water line, vegetation height and litter cover. However each of the variables relating to accretion and erosion have an effect on the distribution of samples in the same broad direction. This is indicative of a combined environmental gradient of morphological change, indicated by amount of bare mud, presence of accretional ramps, rotational sliding, toppled blocks and overhanging blocks.

3.132 Figure 34 shows that samples from Humber Estuary, Chichester Harbour and The Wash are frequently associated with this gradient of morphological change. Morecambe Bay samples, in contrast, are poorly associated with these variables. There is no clear separation of samples between favourable and unfavourable plots within the sites evident in Figure 34; suggesting that coastal squeeze is not in its self a deterministic factor leading to an unfavourable condition, more likely it is a contributing factor towards habitat degradation.

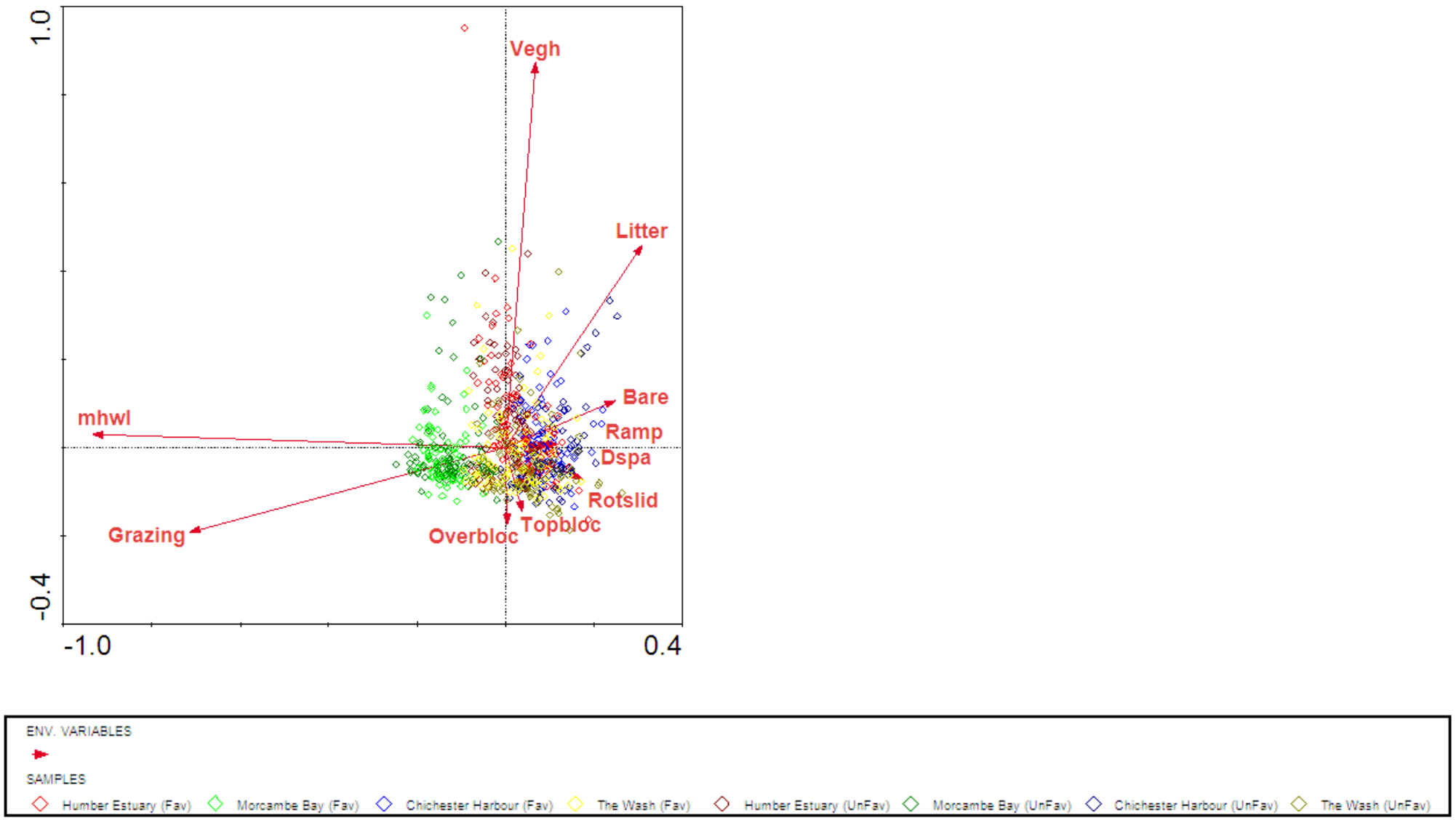

Figure 34 CCA diagram of all pooled species and environmental saltmarsh data with species suppressed to prevent appearance within the graph. Samples are classified by site and condition assessment

4 Conclusions

4.1 This project has been undertaken as four distinct elements of work comprising comparison of qualitative and quantitative recording; botanical analysis of quantitative data; analysis of environmental variables, and multivariate analysis of botanical and environmental quantitative data.

Comparison of qualitative and quantitative recording

4.2 In general qualitative assessment was more likely to record attributes as favourable than quantitative assessment, with all estuary systems, and the majority of plots experiencing some disagreement between conditions utilising the two approaches.

4.3 It is important to note that although plots were described as relatively favourable and unfavourable for the purpose of this analysis, all sites surveyed failed condition assessment on at least one criterion with at least one recording method.

4.4 Both the qualitative and quantitative approaches to recording of botanical and environmental information had advantages and disadvantages.

4.5 The quantitative approach to assessment facilitates accurate and detailed recording of botanical information which enables a non-subjective assessment of botanical composition and community types to be made. Disagreements in condition in respect of this attribute often occurred in the information presented in the qualitative and quantitative assessments, with abundances of indicator species often being recorded as favourable using the qualitative and unfavourable using the quantitative method.

4.6 However, determining zonation was often difficult on the basis of quantitative assessment as the grid references provided to indicate zonation often did not provide sufficient information to enable the zones in which individual quadrats were located to be determined, as the botanical composition of a quadrat does not necessarily reflect the zone in which it occurs, for example where accretional ramps with pioneer communities are present higher up the saltmarsh. In particular the presence of such features is not always apparent where the physical structure of the saltmarsh is complicated, for example incorporating spits, creeks or pans.

Analysis of botanical data

4.7 Analysis of botanical data revealed discrepancies between the perceived botanical communities recorded during qualitative survey, and the actual communities recorded from quadrat recording. Disagreement between condition assessment of the two methods was particularly pronounced in respect of botanical composition, and this is considered likely to be influenced by unintentional recording bias using the qualitative method, which relies on surveyor selected rather than random selection of recording points.

Analysis of environmental data

4.8 Analysis of quadrat scale environmental variables between favourable and unfavourable plots revealed relatively few statistically significant differences between the environmental variables recorded from each plot. In particular differences in vegetation heights between grazed and ungrazed quadrat and/or plots were not always statistically significant, and required

interpretation in conjunction with the botanical data; for example dominance of plant species unpalatable to herbivores resulted in increased sward heights in some quadrats compared to ungrazed sections. This may be offset by the use of a more robust method of assessing vegetation height that takes into account the species comprising the sward and highlights the need for appropriate judgement to be applied when assessing condition. The attribute for grazing specifies indicative sward heights for assessment of grazing pressure, but these measurements must be used in conjunction with species data if a realistic assessment of such pressure is to be achieved. It may be possible to use dung counts as a more reliable method of quantifying herbivore activity and therefore grazing pressure, particularly in the mid and upper marsh.

4.9 Analysis of whole plot and whole site environmental data produced very few meaningful correlations. However the sample sizes for analysis were too small to enable robust analysis of data, and the outputs of data analysis may not reflect the true relationships within the data. Consideration of a larger data set to include information from other saltmarsh sites would enable a more comprehensive assessment to be made.

Multivariate analysis

4.10 Favourable and unfavourable plots were not necessarily readily separated by DCA, with sites usually overlapping to a greater or lesser extent. Equally no consistent trends in the ordination diagrams could be observed between favourable and unfavourable sites, with some unfavourable sites exhibiting greater spread than favourable sites and vice versa. On interrogation of the data, particularly in combination with the aerial photographs, there appear to be two mechanisms at work. On some occasions unfavourable plots exhibit greater variability in species composition than favourable plots, for example due to the presence of a higher proportion of ruderal or agricultural species such as *Lolium perenne*, *Poa humilis* or *Leontodon autumnalis*. This effect tends to be most pronounced from pairs with a limited range of saltmarsh zones recorded within the transect. Conversely, some favourable sites exhibited greater spread than unfavourable sites, due to improved zonation in the favourable site leading to a wider range of saltmarsh community types being present.

4.11 CCA outputs were often unclear due to number of factors acting alone or in combination. The range of botanical communities present within a single transect, and the differing management regimes that may apply to these communities or saltmarsh zones often complicates the CCA graphs, which then require dissection on a quadrat by quadrat basis to enable interpretation. There was often poor separation between pairs of recorded favourable and unfavourable plots, suggesting that the plots were broadly similar and the classification of sites as favourable or unfavourable in the qualitative assessment may have been representative of only marginal differences between the plots. This is supported by the classification of greater numbers of plots as unfavourable in the quantitative assessment.

4.12 Where the main separating criteria in the favourable condition assessment comprised environmental parameters that had specifically been recorded during quantitative assessment such as presence of *Spartina anglica*, the paired plots generally separated well in the CCA, and often also, at least in terms of their pioneer communities in the DCA. However, in many cases there was no clear deterministic environmental variable, which may mean that key influencing factors were not recorded as part of the quantitative assessment, or that the interactions affecting the composition of saltmarsh habitats are more complex than can easily be displayed visually. The use of yes/no recording for the majority of environmental parameters can also lead to an over prominence of a particular variable recorded at only a single quadrat, particularly if that quadrat is the sole representative of a particular zone or community type.

4.13 Within Figure 34 there is a gradation from left to right of samples from Morecambe Bay, through The Wash, Humber Estuary and ending with Chichester Harbour. It should be noted

that where costal squeeze is a primary concern, ie the Humber Estuary and Chichester Harbour samples are commonly located in association with a gradient of increased accretion and erosion. In contrast, samples from Morecambe Bay and The Wash, are found at the left of the graph in association with a gradient of increased grazing pressure and height in relation to mean high-water line.

4.14 Saltmarshes are part of a dynamic, high energy system that is characterised by frequent inundation by saline water and relatively unstable substrate in comparison to less disturbed habitats. These physical processes govern the botanical communities that characterise saltmarsh habitats and the designation of the sites relates to both the unique physical and biological attributes of this habitat type.

4.15 Within a pristine saltmarsh the dominant environmental factor in determining species composition is time for which the ground is inundated. This is determined by the height in relation to mean high-water line. Height in relation to mean high-water line is a relatively stable attribute which is not typically subject to rapid short-term change, although the height of an individual point within a saltmarsh may change over time depending whether the marsh is in an overall eroding or accreting phase, and in the longer term due to rising sea levels associated with climate change.

4.16 Where a saltmarsh is able to function normally in terms of its abiotic processes, other biotic processes become important in determining community type. In combination with the proximity of source populations for colonising species, which was not quantified within this study, grazing is important in determining the relative species composition and relative abundance within the community. This effect is clearly visible in many of the CCA analyses described in Sections 3.82 to 3.109. CCA analysis is not suitable for precise quantification of the optimum level of grazing, but is able to demonstrate its importance as a determining factor in community change. As in other habitats either under or over-grazing can result in loss of condition on site-specific basis.

4.17 Where costal squeeze occurs, the lateral tidal range is restricted by physical barriers altering the relative importance of the various environmental factors. Duration of inundation becomes uniform across the saltmarsh system, which results in dominance of species tolerant of these physical conditions, most typically those characteristic of the pioneer zone.

4.18 This has had the effect of confusing the established zonation patterns characteristic of saltmarsh habitats. The effect of substrate instability has been quantified by measuring the frequency with which features of erosion and accretion occur. This gradient of ‘morphological change’ appears within the CCA analysis described in Section 3.82 to 3,109 where it is frequently associated with unfavourable condition. Unlike grazing pressure, causes of costal squeeze are not easily manipulated from a management point of view.

4.19 Categorisation of saltmarsh habitats into favourable and unfavourable condition is complicated by the need to consider the different physical habitat parameters and botanical communities supported by the different zones individually prior to assessment of the condition of the plot overall. This is demonstrated by both the lack of agreement on condition between the qualitative and quantitative analyses and the lack of a clear separation of favourable and unfavourable plots within the analysis.

4.20 In summary the use of CCA for saltmarsh habitats is more complicated and often less effective than for habitats comprising fewer and more similar communities. The outputs of any analysis must be considered on a zone by zone basis if meaningful interpretation is to be made. Environmental factors, particularly height of the substrate compared to mean high-water level, are clearly of huge importance in driving differences in saltmarsh communities. Other factors associated with grazing pressure and erosion appear to be locally important at a number of sites, although secondary to the main driver.

5 Recommendations

5.1 The most efficient and accurate approach to botanical recording would combine the quantitative approach to quadrat recording as included in the quantitative methodology, but would assign individual quadrats to specific zones at the time of monitoring as currently occurs with the CSM approach. This would have the benefit of ensuring that recorded communities are verifiable on return from site.

5.2 The current CSM guidance, when applied to saltmarsh habitats is of value in defining the status of individual SSSI units in respect of the variables recorded. However, the overall functional unit of the saltmarsh system is typically at the broader estuary level. Saltmarsh systems are dynamically locally unstable and are likely to be naturally more prone to variations in their extent, structure and function than terrestrial habitats such as broad-leaved woodland. Therefore it is particularly important when considering condition assessment that assessment is made of the overall functionality of the saltmarsh system at an estuary level. In particular an overall assessment of attributes such as extent, physical structure and vegetation structure across all units within each SSSI should form an intrinsic part of the condition assessment process.

5.3 The implications of one failed attribute are that the feature is unfavourable-even if different assessments come up with different failed attributes. This has implications for deciding on a remedy but should be seen as a trigger for checking that the feature is in unfavourable condition by re-visiting the assessment overall and supplementing with other information. Zonation seems to be an issue and there is a need to identify and record this. This will be critical if the same areas are being revisited in future to look for change. It is possible that using remote sensing applications such as CASI can help with this.

5.4 Environmental factors, particularly height of the substrate compared to mean high-water level, are clearly of huge importance in driving differences in saltmarsh communities. Other factors associated with grazing pressure and erosion appear to be locally important at a number of sites, although secondary to the main driver. Currently, evidence of these negative attributes are recorded non-quantitatively during a monitoring visit. A more quantitative assessment under CSM should be considered.

5.5 CSM should be able to be applied at a system level-there is merit in looking into this and developing some additional guidance using the Estuary guidance. URL: www.jncc.gov.uk/PDF/CSM_marine_estuaries.pdf.

6 References

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Appendix 1 Summary of multivariate statistical analyses

Table A Summary of the DCA ordination results

All sites pooled				
Axes	1	2	3	4
Eigenvalues	0.871	0.534	0.360	0.303
Length of gradients	6.075	4.168	4.130	4.263
Cumulative percentage variance of species data	10.0	16.1	20.2	23.7
Humber Estuary pooled				
Axes	1	2	3	4
Eigenvalues	0.872	0.614	0.359	0.299
Length of gradients	5.925	5.315	2.948	3.429
Cumulative percentage variance of species data	12.7	21.7	26.9	31.3
Morecambe Bay pooled				
Axes	1	2	3	4
Eigenvalues	0.701	0.416	0.191	0.153
Length of gradients	4.379	3.475	2.853	1.949
Cumulative percentage variance of species data	19.7	31.3	36.7	41.0
Chichester Harbour pooled				
Axes	1	2	3	4
Eigenvalues	0.757	0.356	0.256	0.222
Length of gradients	6.923	3.315	2.924	2.595
Cumulative percentage variance of species data	15.4	22.6	27.8	32.3
The Wash pooled				
Axes	1	2	3	4
Eigenvalues	0.717	0.401	0.148	0.114
Length of gradients	4.509	3.476	2.062	2.471
Cumulative percentage variance of species data	22.9	35.7	40.5	44.1

Table continued…

Barton and Barrow and Ellerker paired plots				
Axes	1	2	3	4
Eigenvalues	0.843	0.528	0.341	0.125
Length of gradients	4.929	3.040	6.798	2.743
Cumulative percentage variance of species data	21.1	34.3	42.9	46.0
Pyewipe and East Halton paired plots				
Axes	1	2	3	4
Eigenvalues	0.908	0.772	0.420	0.231
Length of gradients	5.886	5.179	3.897	2.635
Cumulative percentage variance of species data	18.0	33.4	41.7	46.3
Stone Creek and Welwick paired plots				
Axes	1	2	3	4
Eigenvalues	0.807	0.508	0.242	0.192
Length of gradients	4.645	3.091	1.984	1.738
Cumulative percentage variance of species data	21.4	34.9	41.3	46.4
Foulshaw and Milnthorpe paired plots				
Axes	1	2	3	4
Eigenvalues	0.729	0.286	0.104	0.082
Length of gradients	4.070	2.761	1.896	1.778
Cumulative percentage variance of species data	27.5	38.3	42.2	45.3
Sandside North and Sandside South paired plots				
Axes	1	2	3	4
Eigenvalues	0.809	0.233	0.179	0.103
Length of gradients	12.963	3.315	2.394	1.655
Cumulative percentage variance of species data	44.4	57.1	66.9	72.6
Warton North and Warton South paired plots				
Axes	1	2	3	4
Eigenvalues	0.646	0.421	0.238	0.098
Length of gradients	4.933	4.173	4.110	3.576
Cumulative percentage variance of species data	18.4	30.4	37.2	40.0

Table continued…

Horse Point and Verner Common paired plots				
Axes	1	2	3	4
Eigenvalues	0.850	0.327	0.145	0.069
Length of gradients	4.332	2.342	2.318	1.941
Cumulative percentage variance of species data	25.4	35.2	39.5	41.6
Ellanore and Mengham Salterns paired plots				
Axes	1	2	3	4
Eigenvalues	0.835	0.459	0.243	0.097
Length of gradients	6.244	3.086	2.043	1.589
Cumulative percentage variance of species data	19.2	29.7	35.3	37.5
Fishbourne and Langstone paired plots				
Axes	1	2	3	4
Eigenvalues	0.759	0.435	0.283	0.104
Length of gradients	4.962	3.249	2.077	1.875
Cumulative percentage variance of species data	20.0	31.4	38.9	41.6
Wainfleet and Wrangle paired plots				
Axes	1	2	3	4
Eigenvalues	0.564	0.394	0.178	0.135
Length of gradients	3.605	3.264	2.627	1.889
Cumulative percentage variance of species data	22.5	38.2	45.3	50.6
Frampton and The Haven paired plots				
Axes	1	2	3	4
Eigenvalues	0.829	0.193	0.134	0.061
Length of gradients	4.030	2.127	1.762	1.333
Cumulative percentage variance of species data	32.6	40.2	45.5	47.9
Snettisham and Terrington paired plots				
Axes	1	2	3	4
Eigenvalues	0.761	0.277	0.155	0.100
Length of gradients	5.001	2.583	2.600	1.625
Cumulative percentage variance of species data	26.7	36.4	41.8	45.3

Appendix 2 Arial photographs of plots showing locations of quantitative survey transects and sample points

Plate A Humber Estuary: Barton and Barrow

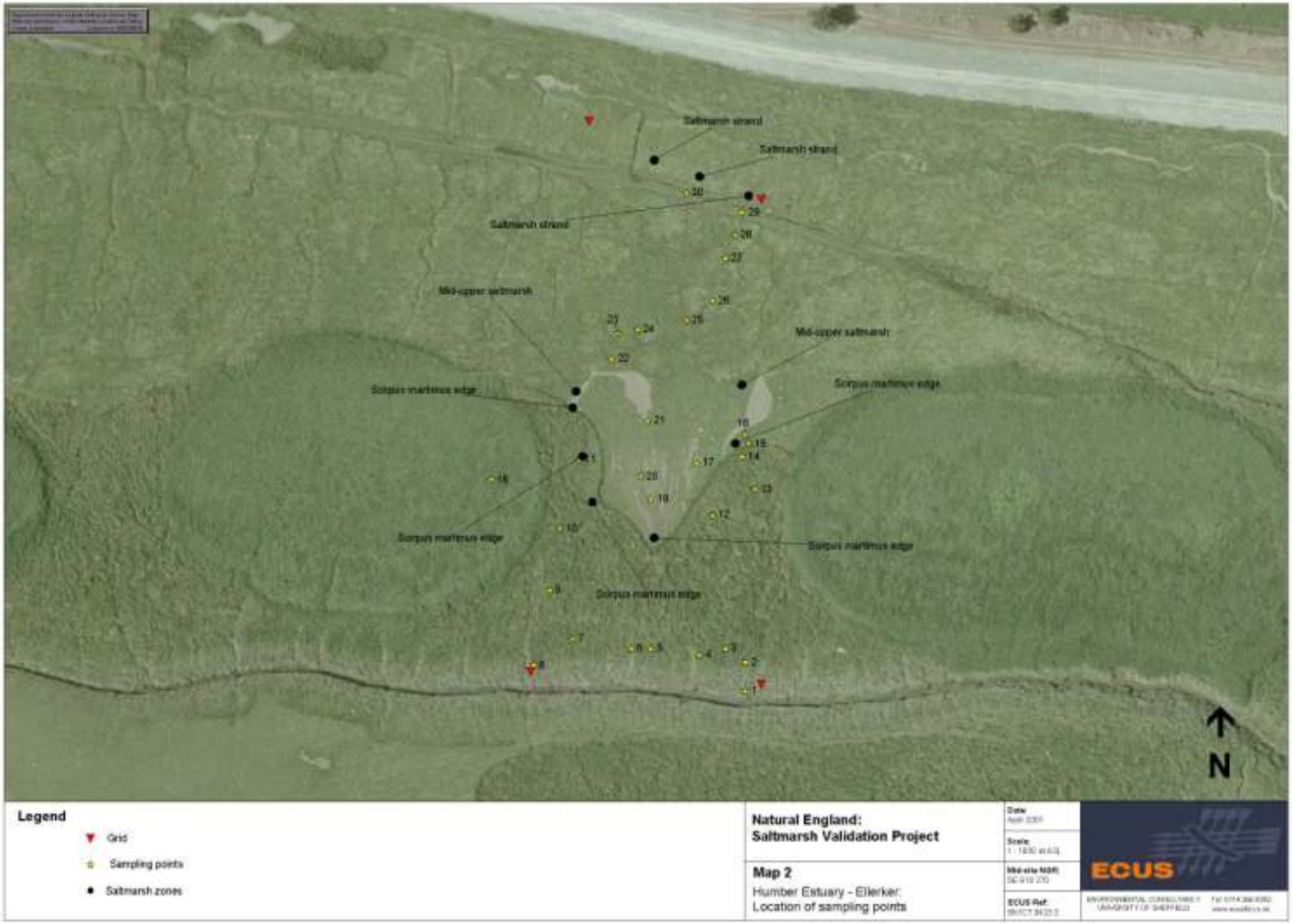

Plate B Humber Estuary: Ellerker

Plate C Humber Estuary: Pyewipe

Plate D Humber Estuary: East Halton

Plate E Humber Estuary: Stone Creek

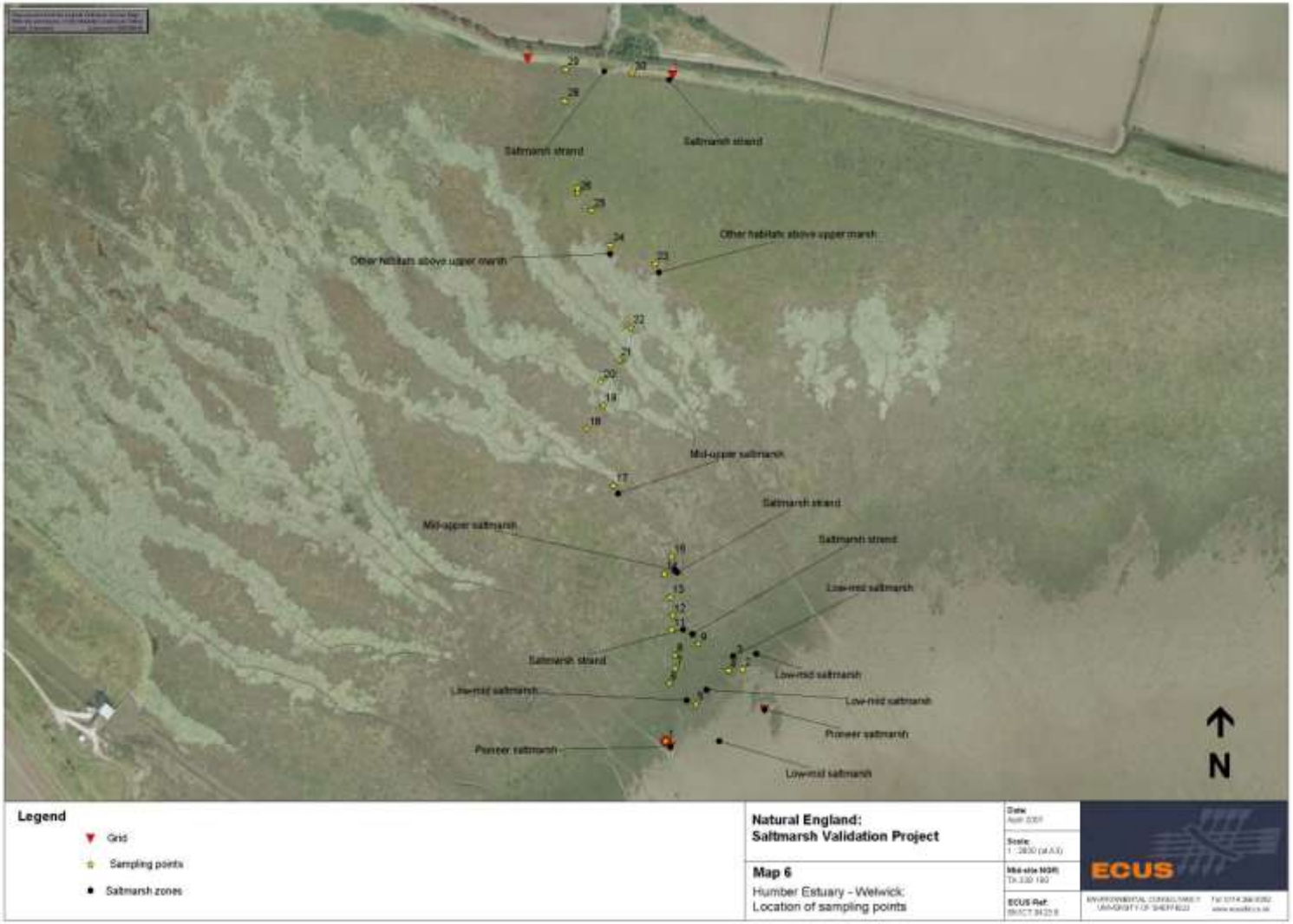

Plate F Humber Estuary: Welwick

Plate G Morecombe Bay: Foulshaw

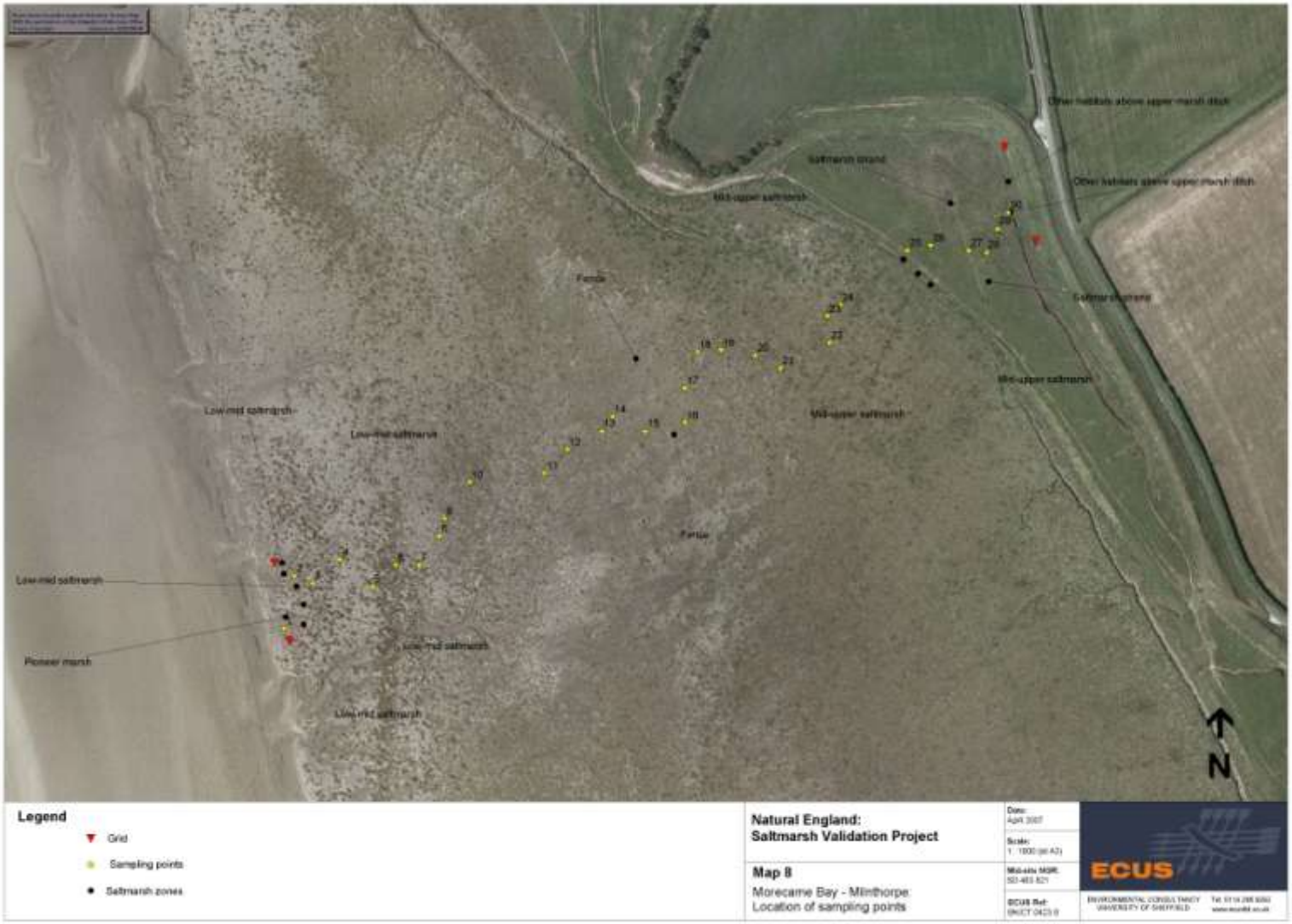

Plate H Morecambe Bay: Milnthorpe

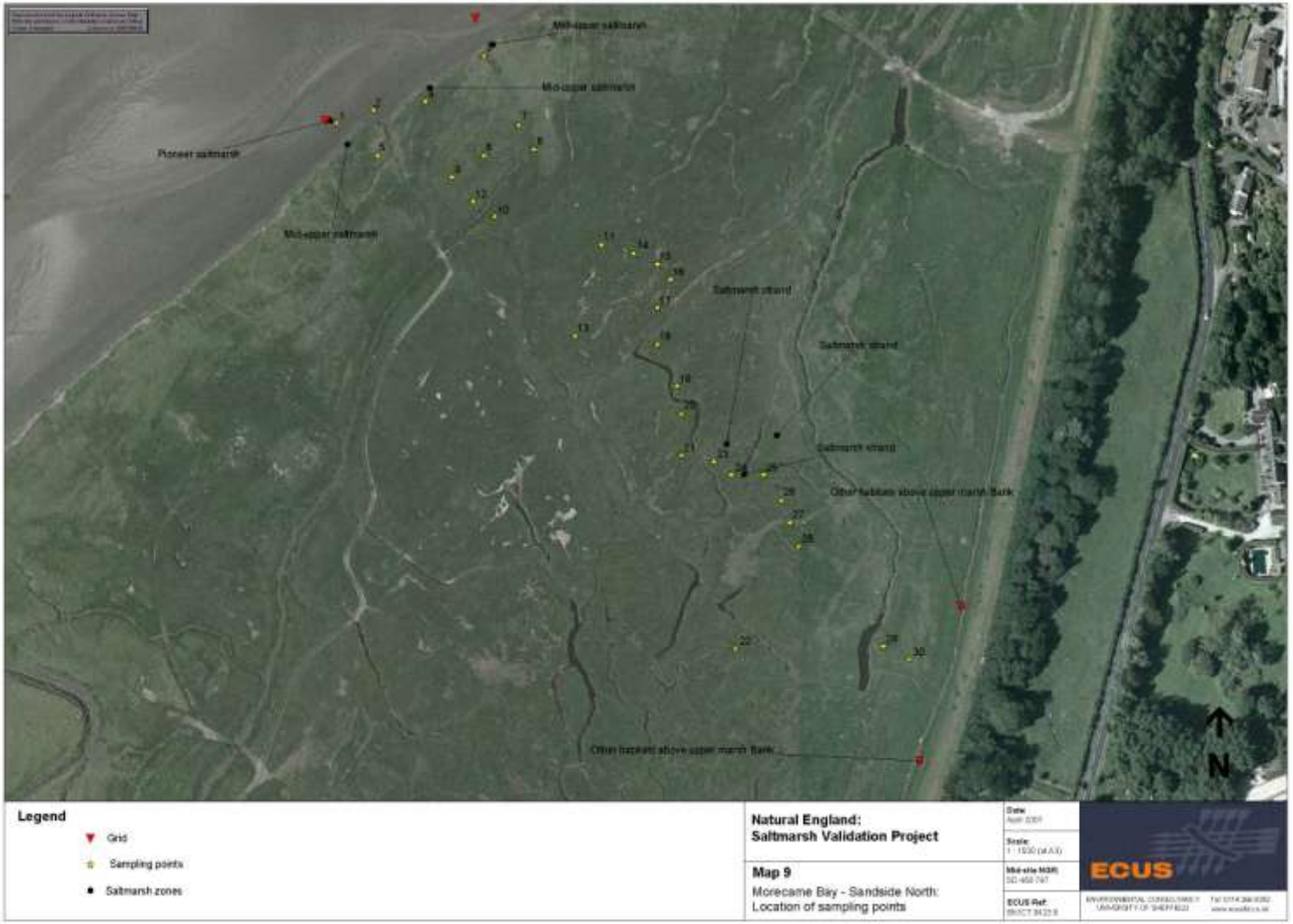

Plate I Morecambe Bay: Sandside North

Plate J Morecambe Bay: Sandside South

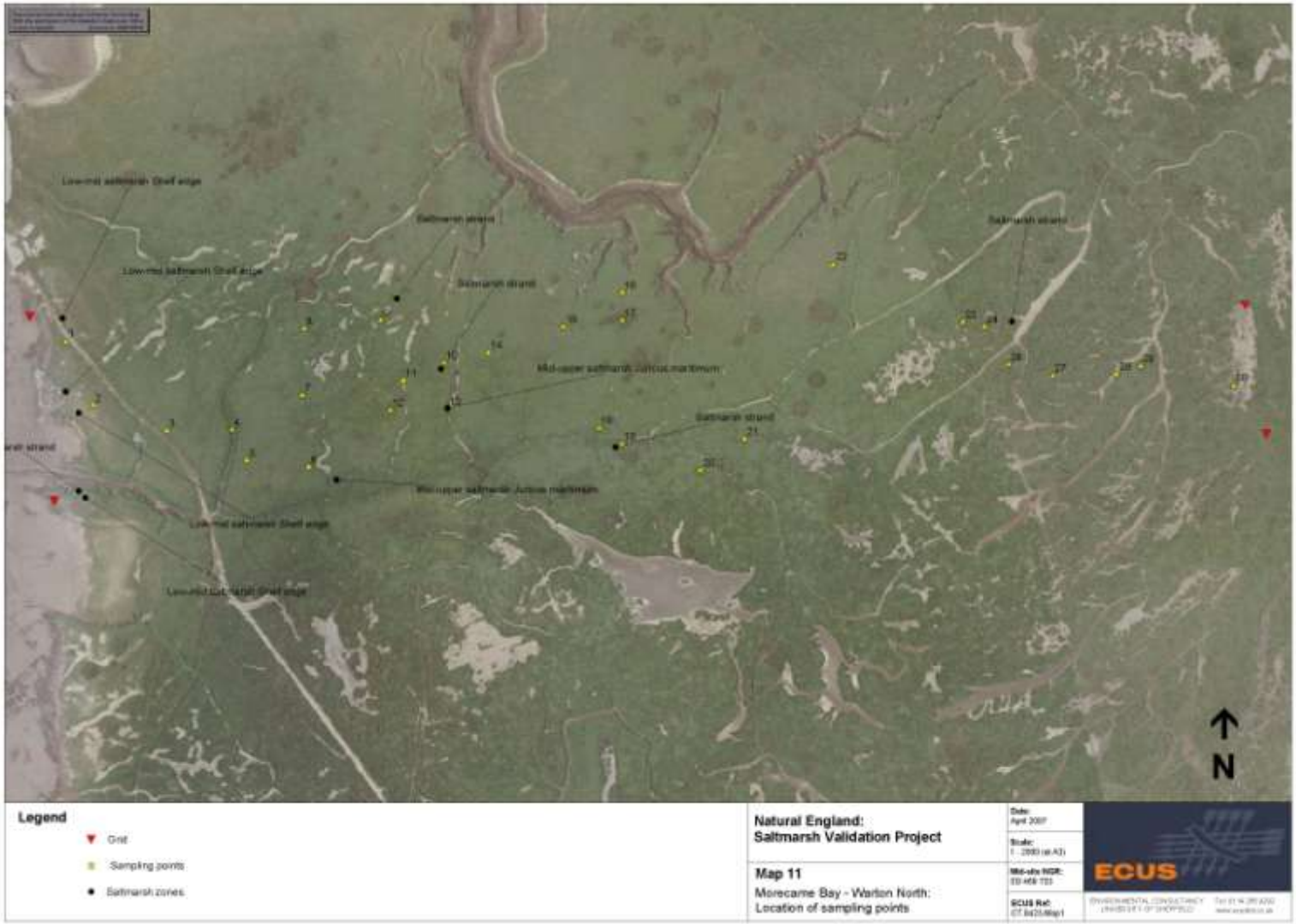

Plate K Morecambe Bay: Warton North

Plate L Morecambe Bay: Warton South

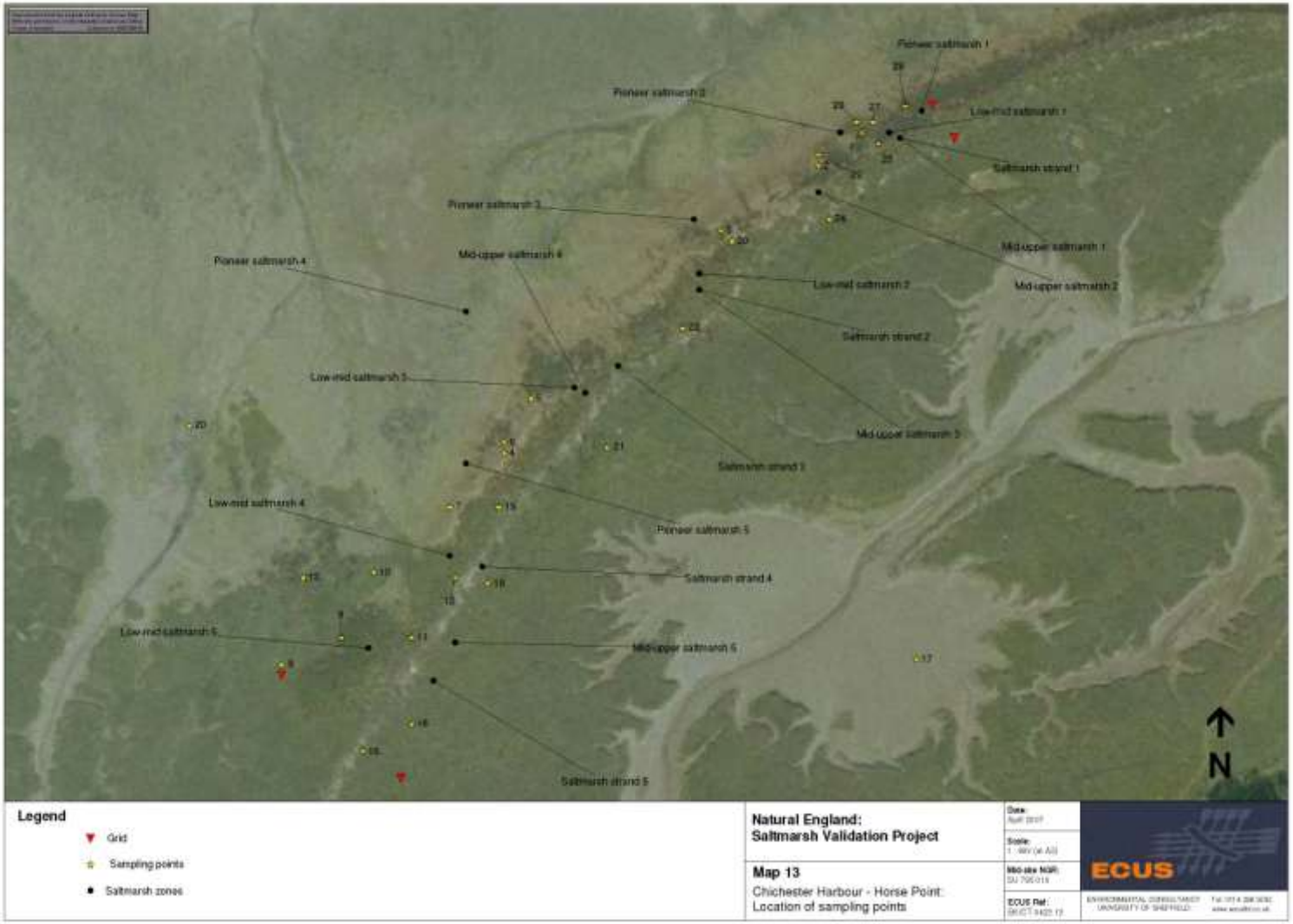

Plate M Chichester Harbour: Horse Point

Plate N Chichester Harbour: Verner Common

Plate O Chichester Harbour: Ellanore

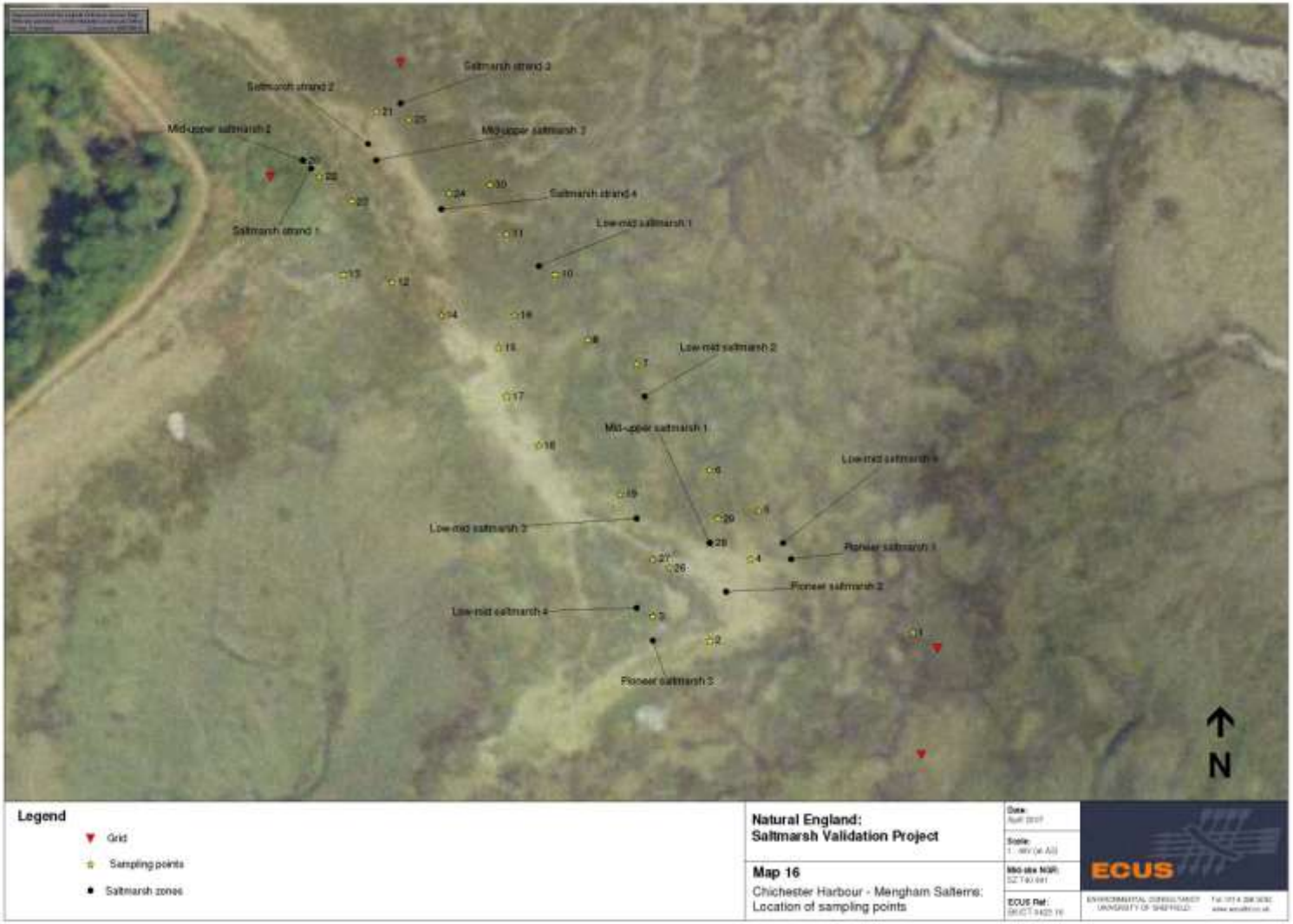

Plate P Chichester Harbour: Mengham Salterns

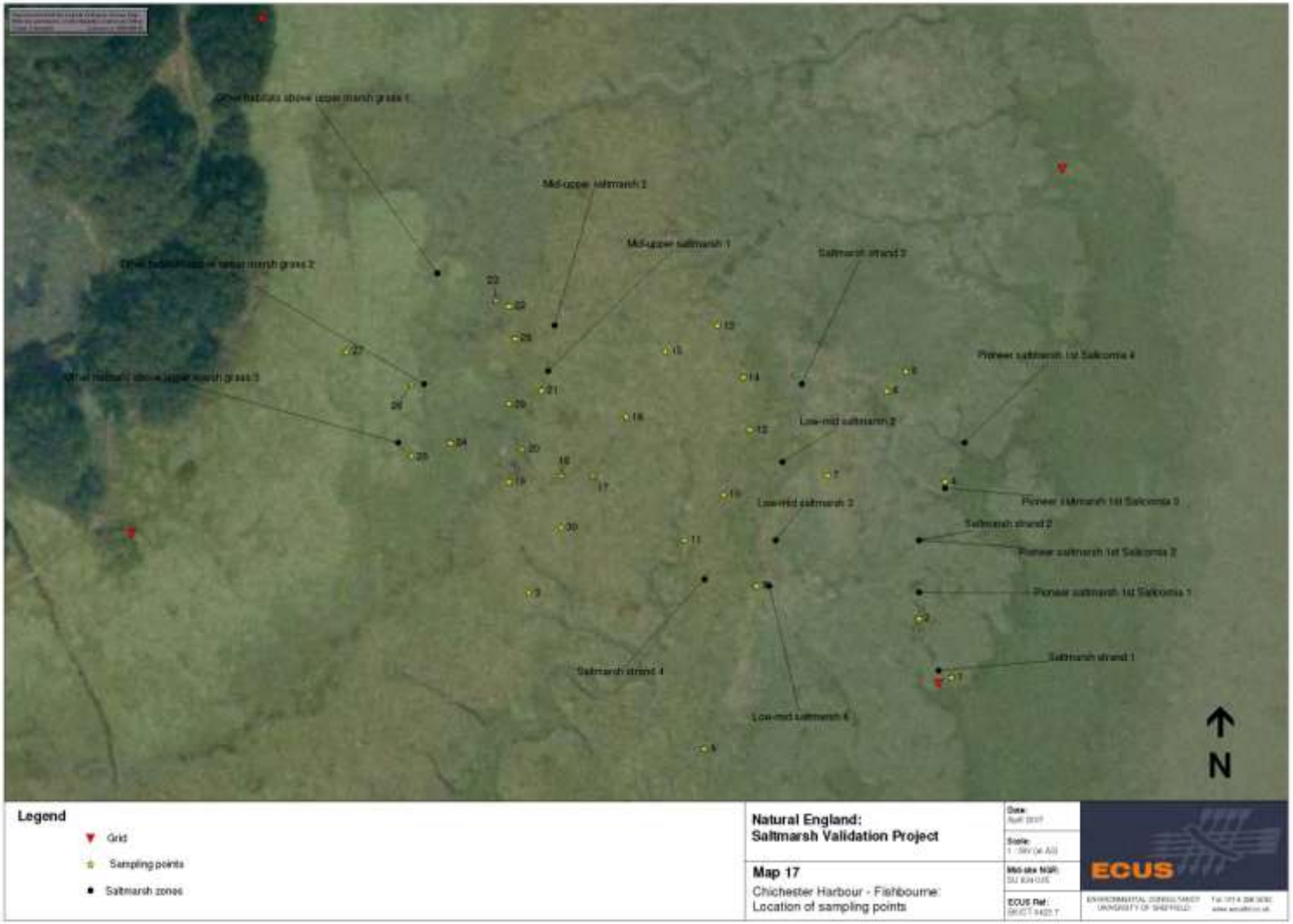

Plate Q Chichester Harbour: Fishbourne

Plate R Chichester Harbour: Langstone

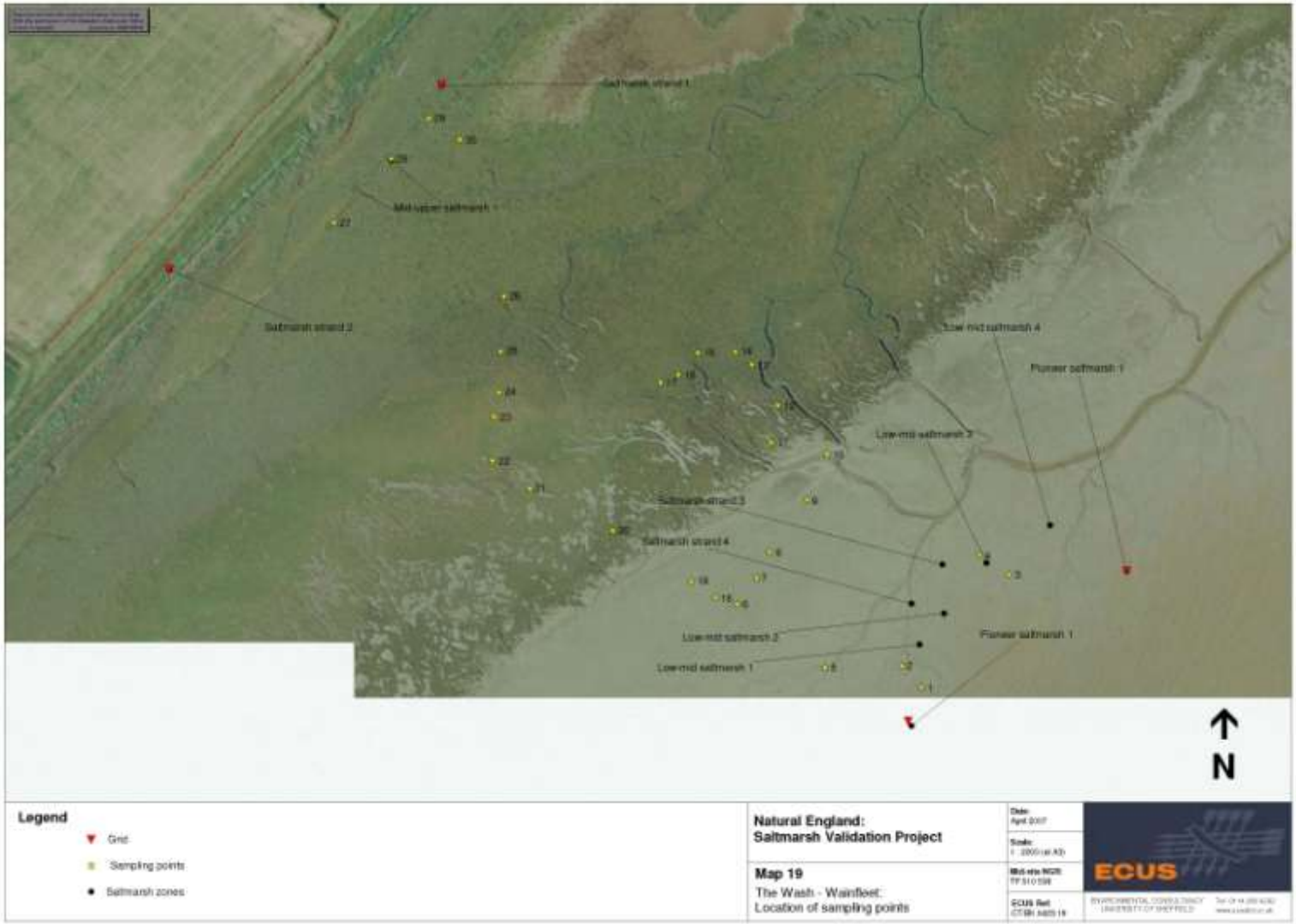

Plate S The Wash: Wainfleet

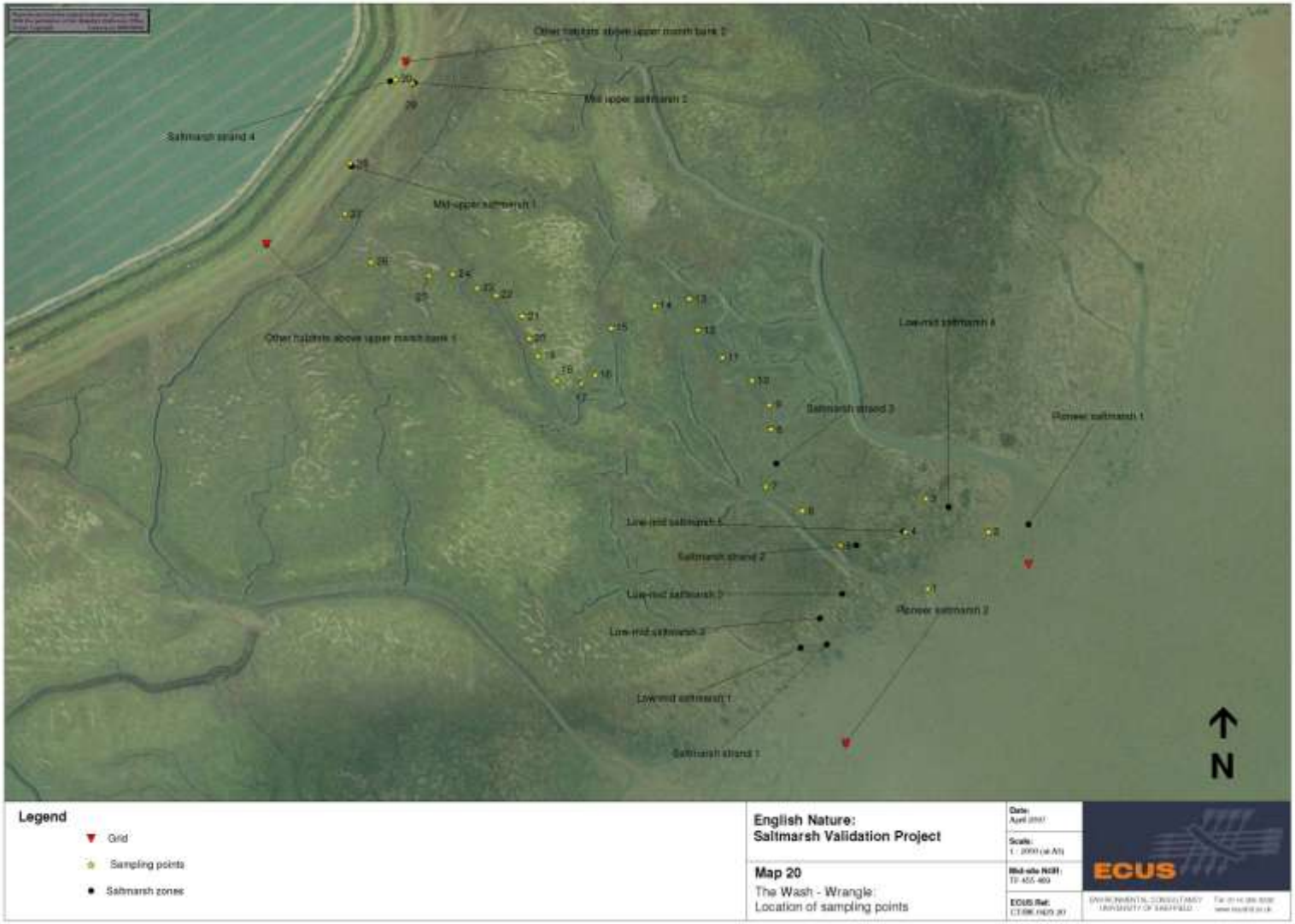

Plate T The Wash: Wrangle

Plate U The Wash: Frampton

Plate V The Wash: The Haven

Plate W The Wash: Snettisham

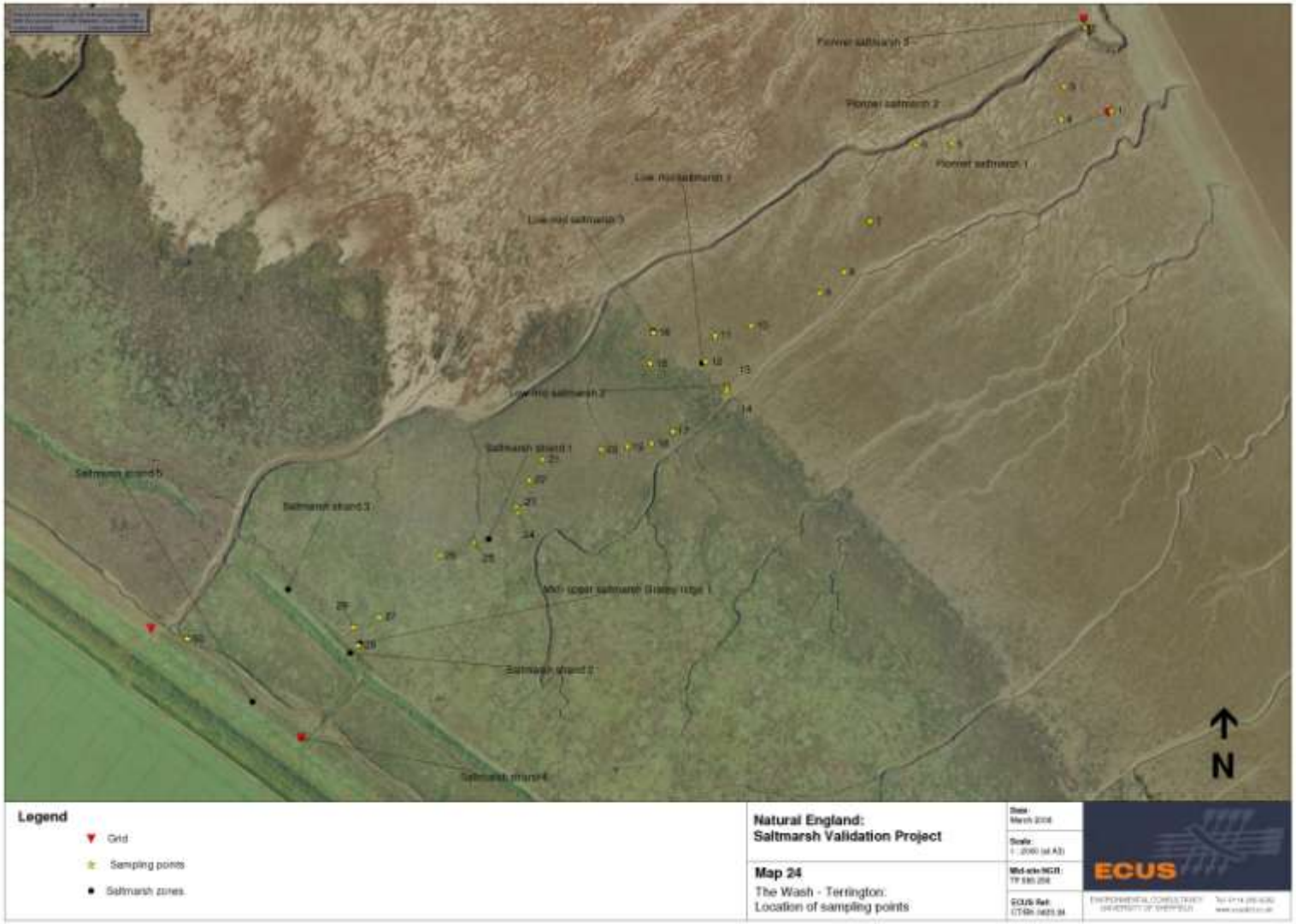

Plate X The Wash: Terrington

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