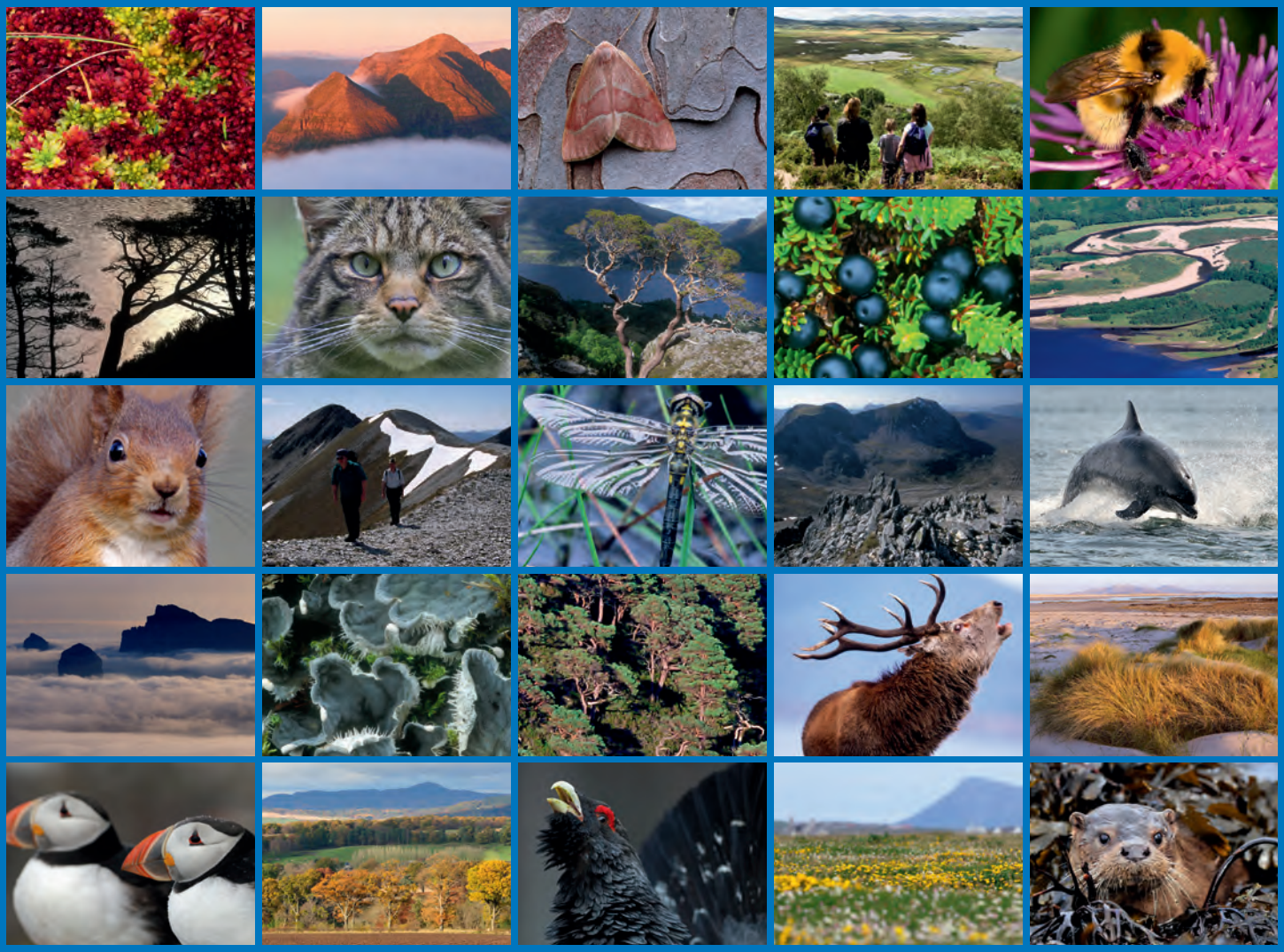
Scottish Natural Heritage
Commissioned Report No. 786

Scottish saltmarsh survey national report



Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

SEPA
Scottish Environment Protection Agency

COMMISSIONED REPORT

Commissioned Report No. 786

Scottish saltmarsh survey national report

For further information on this report please contact:

Stewart Angus
Scottish Natural Heritage
Great Glen House
INVERNESS
IV3 8NW
Telephone: 01463 725000
E-mail: stewart.angus@snh.gov.uk

This report should be quoted as:

Haynes, T.A. 2016. Scottish saltmarsh survey national report. *Scottish Natural Heritage Commissioned Report No. 786.*

COMMISSIONED REPORT

Summary

Scottish saltmarsh survey national report

Commissioned Report No. 786
Project No: 1384
Contractor: NatureBureau Ltd.
Year of publication: 2016

Background

From 2010-2012 all known saltmarshes larger than 3ha were surveyed across the Scottish mainland and offshore islands, to compile the first detailed comprehensive national survey of this habitat in Scotland. All saltmarsh and brackish swamp was mapped using the National Vegetation Classification. All mapped areas were digitised to a 1:4,000 scale GIS database. The condition of each saltmarsh site visited was assessed.

A total of 249 sites were visited and 7,704ha of saltmarsh were recorded and mapped. 5,840ha of the habitat was dominated by saltmarsh vegetation; 870ha of the habitat was dominated by swamp vegetation; and 994ha of other vegetation/land cover types were also present.

Main findings

- The surveyors assessed the condition of saltmarsh against UK targets, which have been set at a high level, beyond that needed to achieve Favourable Condition under the Habitats Directive. Based on these criteria, sixty-seven per cent of saltmarsh sites assessed were considered to have failed one or more condition targets.
- The main reasons for failure (especially in designated sites) related to the presence of built structures (like embankments) and the lack of natural landward transition habitats, which are issues that cannot be readily addressed through site management. Negative impacts of grazing were recorded more frequently from non-designated sites. Pollution impacts were recorded from both designated and non-designated sites.
- Some saltmarsh sub-communities show signs of being distinct from the published NVC descriptions such as SM13x, SM16x and SM16jb, which include species combinations not identified within the published classifications. Some of the published NVC sub-communities include a wide range of variation (e.g. SM16b and SM28), while some NVC sub-communities lack a clear floristic identity (SM16c).
- Recommendations for future research include: multivariate analysis of the extensive NVC dataset; integration of related coastal datasets; investigation into the vegetation of the saltmarsh transition zone; exploration of the observed changes in Salicornia spp.; and detailed assessment of erosion and accretion rates.

For further information on this project contact:
Stewart Angus, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or stewart.angus@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

Table of Contents **Page**

Acknowledgements

I would like to thank all the surveyors that worked on the project including Ian Strachan, Theo Loizou, Robin Payne and Stephen Beal who provided valuable information for this project and all of the NatureBureau team for supporting the project. I give a special thanks to Ian Strachan for reviewing and providing recommendations to this National Report. I give thanks to SNH and SEPA for all the supporting data, funds and time provided to make this project possible, with special thanks for the support and guidance of the core project team at SNH and SEPA: Stewart Angus, Clare Scanlan and Naveed Bhatti. I would also like to thank my wife, Ruth, for all her support through the course of this project.

1. INTRODUCTION

1.1 Layout of the National Report

This section provides details on the requirements, objectives and scope of the project. Section 2 provides full details on the project methodology including field surveys and analysis. Section 3 gives summary information on the ecology of Scottish saltmarshes and discusses the results of the saltmarsh condition assessment. Section 4 details the variety of saltmarsh vegetation communities encountered and their distribution. Section 5 concludes the report and provides recommendations for future studies.

1.2 Background

1.2.1 Why are saltmarshes important?

Saltmarshes are an important component of the UK coastal zone. They provide: filtration services; water regulation; flood defences; refuge and food for a variety of taxa; public amenity; agricultural services; and support a number of highly restricted and rare species. Saltmarshes are a valuable and understudied carbon sink (Cannell *et al*. 1999). Saltmarshes with a high structural and plant diversity, particularly marshes with freshwater seepages, provide a transition from fresh to brackish water conditions where a number of specialist species occur (Maddock 2011).

Saltmarsh is protected under EU legislation including the Habitats Directive (European Commission 1992) and the Water Framework Directive (European Commission 2000; WFD). The Habitats Directive Article 6 (2) requires member states to avoid the deterioration of natural habitats within SACs, Article 11 obliges states to undertake surveillance of conservation status and Article 17 obliges reporting in respect of Article 11. The Water Framework Directive identifies saltmarsh as an important component of the assessment of ecological status of associated water bodies. Enforcement of these directives and monitoring of the condition of the habitat is the duty of the Scottish Government and the competent authorities (Scottish Natural Heritage [SNH] and the Scottish Environment Protection Agency [SEPA] in Scotland).

1.2.2 Why is saltmarsh vegetation important?

Saltmarsh vegetation can provide detailed information about coastal processes and hydrological regimes across the coastline. Vegetation data can be used to assess changes in land use and management and to help understand how humans affect the coastal environment. Saltmarsh vegetation can also allow changes in climate and coastal biodiversity to be detected reliably into the future.

Figure 1-1 shows the global distribution of saltmarshes. Large areas of coastline are occupied by saltmarsh across most coastal European countries. They are replaced by mangrove swamps near the equator and into the southern hemisphere. Large areas of saltmarsh can also be found in South America, South Africa and Australia.

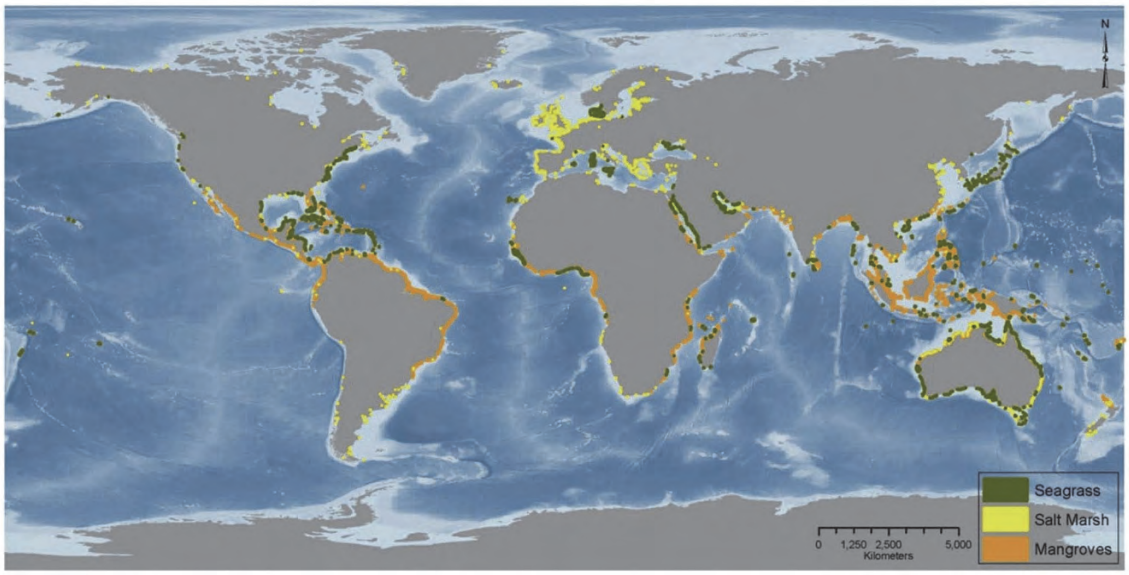


Figure 1-1: Global distribution of seagrasses, saltmarshes and mangroves (Pendleton et al. 2012)

The saltmarshes of the UK show considerable differentiation between the northern and southern limits of the UK. Southern areas of saltmarsh include more species and are found in large areas, while fewer species and smaller saltmarshes are found in northern areas (Boorman 2003).

1.2.3 NVC studies

Work on Great Britain's National Vegetation Classification (NVC) began in 1974, drawing on the phytosociological studies undertaken by a variety of researchers. The first book of classifications was published in 1991 (covering woodlands and scrub, Rodwell 1991a) and the final volume in the publication series (Volume 5) published in 2000 covered the saltmarsh vegetation of the UK (Rodwell 2000). However, it is recognised that it might not apply as well to Scotland as elsewhere in the UK and some re-assessment would be useful.

1.2.4 Previous reports

The most comprehensive previous survey was the Saltmarsh Survey of Great Britain (Burd 1989), which included distribution data and individual reports for most Scottish sites. The Saltmarsh Survey of Great Britain pre-dated the NVC so used its own saltmarsh classification system, and utilised hand-drawn maps which are drawn at too coarse a scale for application in current conservation schemes or for the purposes of the Water Framework Directive (WFD).

1.2.5 The requirements of the project

Collection of data on the vegetation found across Scottish saltmarshes allows a variety of analyses to be undertaken. Many habitat classification systems such as the UK BAP, Habitats Directive (HD) and WFD classifications vary in their interpretation of where different coastal habitat zones begin and end. The ability to map these coastal zones accurately is a key concern in monitoring the condition of the resource in UK conservation schemes and at EU level.

The WFD requires all water features above a certain size threshold to be defined as water bodies. For Scotland, this was carried out using a combination of typology data and data on ecosystem health (SEPA 2007). It should be noted that saltmarshes do not always fall within

discrete waterbodies, sometimes overlapping waterbody boundaries. However, there is a legal requirement for SEPA to report the status of WFD biological quality elements (of which marine angiosperms {saltmarsh} form one) at waterbody level.

To limit the cost of undertaking separate analyses for each conservation and legislative scheme, it was decided that a comprehensive approach to mapping saltmarsh would allow Scotland's saltmarsh resource to be classified in a variety of ways. It was decided that the saltmarsh vegetation communities would be assessed at the finest level possible (National Vegetation Classification sub-community level) to allow flexibility in data analysis.

Marine angiosperms (saltmarsh and seagrass) are used as one of the biological quality elements for assessing the ecological status of coastal and transitional waters under the WFD. Data required include vegetation samples, area estimates and vegetation classification.

A national condition assessment was also required to report on the status of Scotland's saltmarsh resource to the European Commission and as part of UK and Scottish conservation strategies.

1.2.6 The contract

The saltmarsh survey was tendered in 2009 and awarded to NatureBureau Ltd, who began work on the project in 2010.

1.3 Aims of the Scottish Saltmarsh Survey

The primary aims of the Scottish Saltmarsh Survey (SSS) were to obtain information on the morphology, vegetation community structure and species found on saltmarsh sites above 3ha in area. The project also provides information to further Water Framework Directive (WFD) tool development and allow WFD classification, while also identifying the pressures affecting saltmarshes, and identifying areas suitable for habitat enhancement as a secondary aim. The WFD recognises hydromorphological pressures as primary influences upon saltmarshes, with other anthropogenic influences such as nutrient enrichment as secondary pressures. Anthropogenic pressures on saltmarshes include enclosure, 'coastal squeeze', construction and development on marshes, grazing, ship and boat movements (e.g. return currents/waves/ water level draw down), dredging activities, localised mud digging, pollution, eutrophication, refuse disposal, and trampling.

Specific survey outputs include a GIS saltmarsh database mapped using the NVC and an image library for each site. Specific project objectives are listed in Table 1-1.

Table 1-1: Scottish Saltmarsh Survey objectives, taken from the original contract (2009)

Objective	Description
Obj. 1	Provide a GIS polygon dataset showing the distribution of all NVC sub-communities on all Scottish saltmarshes over 3ha in area or over 500m in linear extent.
Obj. 2	Provide geo-referenced photography and quadrat data representative of variation and geographic distribution.
Obj. 3	Comment on the validity of the published NVC for saltmarsh in Scotland, and make suggestions for improvements.
Obj. 4	Complete Site Condition Monitoring forms for notified saltmarsh features on the SSSIs included in the contract and on survey sites that are not notified for saltmarsh, each category to be summarised separately.
Obj. 5	Supply sufficient information on failures to meet targets to allow area staff to make an assessment of condition.
Obj. 6	Photograph representative features of all surveyed sites, and all failures to meet targets, in ways that provide maximum information and full geo-referencing.
Obj. 7	Provide GPS tracks of all transects and walks used in the forms.
Obj. 8	Provide a geo-referenced photographic record of all transects and walks.
Obj. 9	Provide sufficient information on any changes or issues to allow future changes to be measured against these (including changes in species distributions due to climate change and the presence of non-native species).
Obj.10	Provide a text report on each site describing general features, vegetation, site condition, land use, and any other subjects of interest.
Obj.11	Provide feedback on any aspect of the SCM forms or the survey process that allows these to be improved.
Obj.12	Provide any other information on the feature or site that might be regarded as valuable, such as the distribution of the most interesting part of the feature, or the recording of rare species seen during the visit.
Obj. 13	In general the format of Site Condition Monitoring work should follow that of Cycle 1 reporting for the National Contract by Hutcheon Bros (2002-2005).
Obj. 14	Provide statistics for each saltmarsh zone derived from the NVC maps using GIS, and lists of vascular plants for each zone, on all sites over 50ha in extent as listed in the appropriate appendices.

1.4 Outputs of the Scottish Saltmarsh Survey

The key outputs for the project are presented in Table 1-2.

Table 1-2: List of project outputs

ID	Output Type	Sub-output	Format	File name/naming convention	Location*
1	A GIS database of saltmarsh polygons classified to NVC sub-community level including associated NVC and land cover types	GIS Polygon dataset	tab and shape formats	SSS.Polygons.v61	GIS Database Folder
		Mosaic database	tab and shape formats	SSS.Polygon Type List database.v08	GIS Database Folder
		Length of flood defences	tab and shape formats	SSS.Sea Defence Lengths	GIS Database Folder
		Metadata and revision guidance documentation	.txt and .doc	Various	GIS Database Folder
2	Site reports for individual or grouped saltmarsh sites, discussing the ecology of the site(s) and describing the saltmarsh vegetation communities present (see appendix 2).	SSS Report	.doc or .docx	Area.Site Name.SSS Report	Area folders/Site Folder
		SSS Maps	.jpg	Site Name NVC Map 1	Area folders/Site Folder/Appendix
3	Site condition monitoring (SCM) assessment forms and reports for individual or grouped saltmarsh sites, discussing the quality of the saltmarsh and negative impacts and threats present (see appendix 2)	SCM Report	.doc or .docx	Area.Site Name.SCM Report	Area folders/Site Folder
		SCM Maps	.jpg	Site Name SCM Map 1	Area folders/Site Folder/Appendix
		SCM Forms	.doc or .docx	Site Name SCM Form 1	Area folders/Site Folder/Appendix
4	Vegetation samples of saltmarsh sub-community variation across the country.	Site Samples	.csv or .xls	Site name samples	Area folders/Site Folder/Appendix
5	Target Notes relating to condition and noteworthy features for each site.	TNs	.csv	Site name TNs	Area folders/Site Folder/Appendix
		Site track	.csv	Site name Track	Area folders/Site Folder/Appendix
6	Geo-referenced images for each site.	Image library	.jpg in camera model folders	Various	Area folders/Site Folder/Appendix/ Images
7	National report on the saltmarshes of Scotland (this document).	Scottish Saltmarsh Survey National Report	.doc	Scottish Saltmarsh Survey National Report	National Report

* The full set of project outputs including site-specific reports are held by SNH and SEPA.

1.5 Scope and purpose of the National Report

The national report is the closing output of the SSS project. It provides details on how the project was undertaken, and analyses the results and findings of all of the saltmarsh surveys undertaken across Scotland.

The report provides full details on the methodology used to collect, analyse and report information, and discusses the ecology of Scottish saltmarshes and brackish swamps.

This report also provides analyses and summary data on the condition of Scotland's saltmarsh resource and summary descriptions and distribution maps of the various saltmarsh and brackish swamp vegetation communities found.

The purpose of the report is to provide an overarching narrative to the project, to provide important information on how the project was undertaken, to highlight key results and identify site reports that provide valuable information on key findings (e.g. sub-community variation) and to provide future research recommendations.

2. METHODOLOGY

2.1 Introduction

This section details the methods applied to all aspects of the project including:

- Site selection
- Trial field surveys and mapping
- Taxonomy and species terminology
- Field survey planning
- Field surveys
- GIS mapping
- SSS site report development
- SCM report development
- National report data analysis

It should be noted that this methodology is the product of the survey design of the Project Leader, Thomas Haynes, and was outlined to surveyors in documented guidance and training sessions and regular discussions. There are instances where the detailed methodology outlined in this document differs from those applied by other surveyors. Where differences are known they will be discussed.

2.2 Site selection

2.2.1 Point dataset

The survey sites were identified from existing datasets held by SNH and SEPA. The most relevant datasets were the range of reports and maps available from the Saltmarsh Survey of Great Britain (Burd 1989); the Sand Dune Vegetation Survey of Scotland (Dargie 2000b); the SNH report on the distribution of coastal habitats (Posford Duvivier 1998); and the Cycle 1 Site Condition Monitoring reports (Hutcheon Brothers 2000).

From these data sources a database of potential saltmarsh sites across Scotland was created, which provided information on the location, size and type of saltmarshes present on each site. This database was provided to NatureBureau as part of the tendering process for the project in 2009. This dataset included 404 individual grid reference locations for saltmarsh habitat across Scotland (SNH 2009).

NatureBureau analysed the database, using the Mapinfo GIS platform (Pitney Bowes 2009) and created a map of the point locations of individual saltmarshes by area (see Figure 2-1).

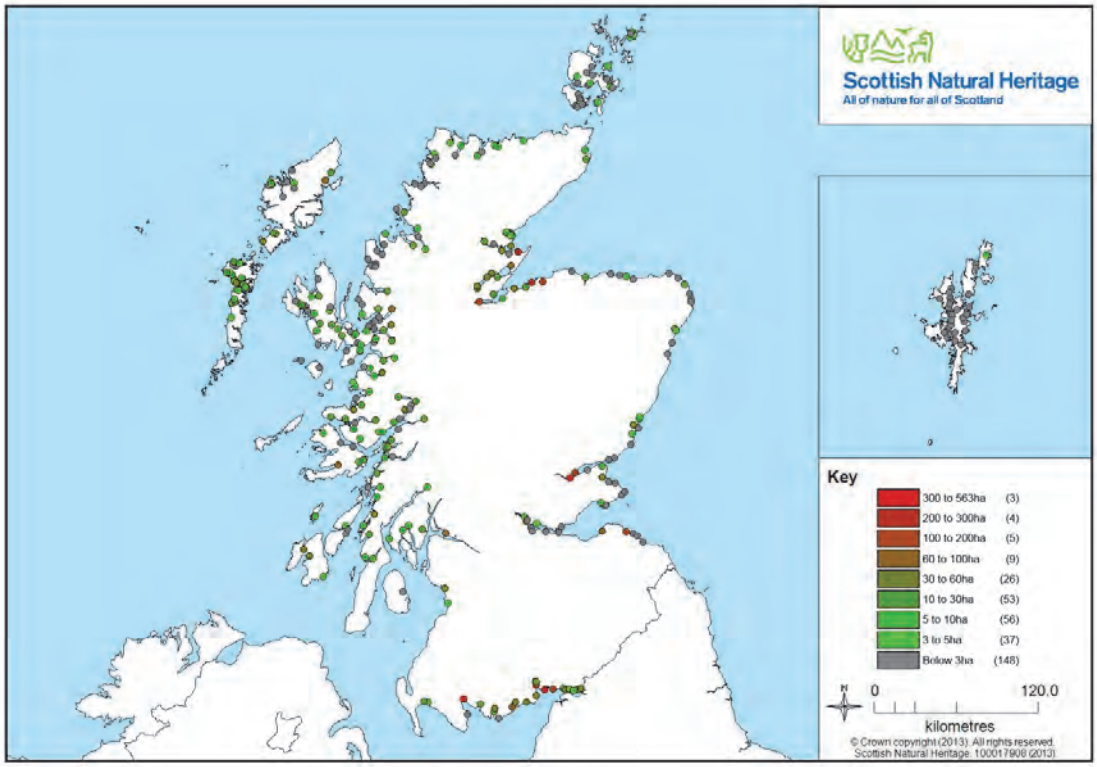


Figure 2-1: Initial point map of the saltmarsh sites identified in 2009 by SNH (by area).

The requirements of the survey indicated that all saltmarshes identified as being over 3ha (or 500m in linear extent) required surveying and it was clear that field surveying techniques would be quite different dependent on the region of Scotland under survey. The east coast and Solway Firth would require surveys of large areas of saltmarsh (mostly 30-100ha), while the islands and the west and north coastlines would require surveying of a high volume of small sites (3-5ha).

Survey region blocks were established to maximise survey outputs and to minimise transportation and accommodation costs. These survey blocks are detailed in Table 2-1 and presented in Figure 2-2.

Table 2-1: Survey block information.

Survey Block No.	Location	Surveyors	Year of Survey
1	North-East Coast	T.Haynes & R.Haynes	2011
2	South-East Coast	T.Haynes & R.Haynes	2010
3	Solway Firth	T.Haynes & S.Beal	2012
4	South-West Coast	I.Strachan	2011-2012
5	North-West Coast	I.Strachan	2011-2012
6	Outer Hebrides	T.Loizou & R.Payne	2012
7	North Coast	T.Haynes	2011
8	Orkney and Shetland	T.Loizou	2012

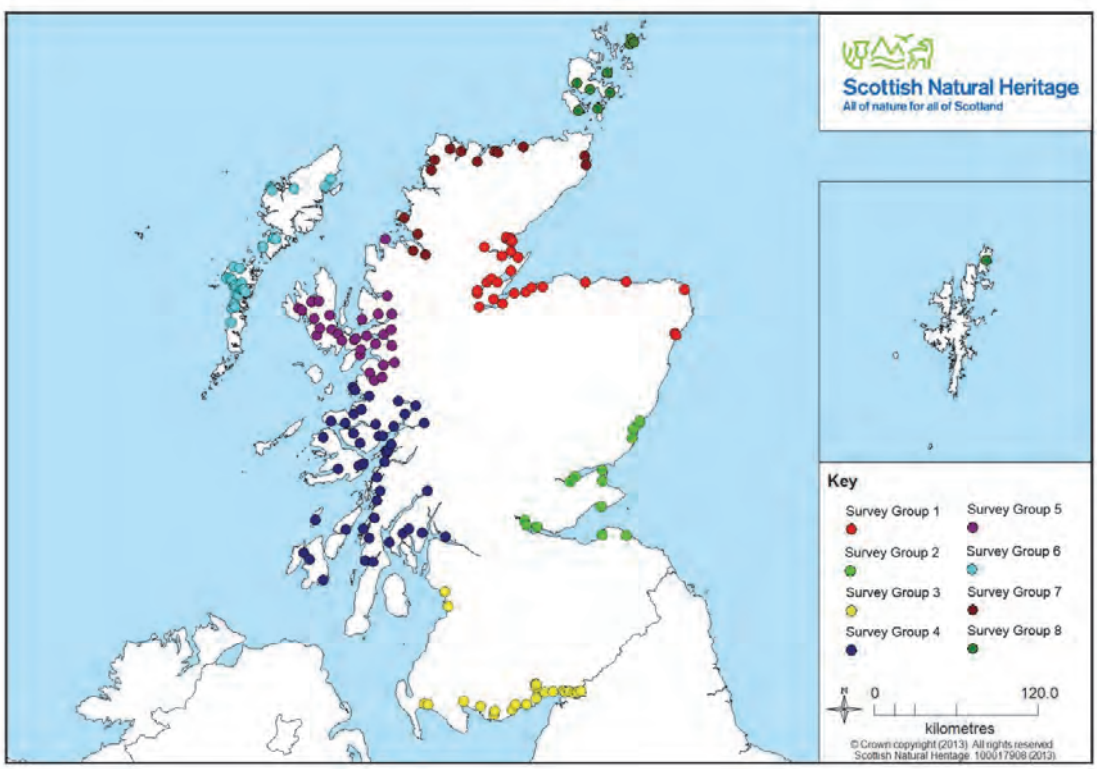


Figure 2-2: Map of survey regions.

2.2.2 Polygon site selection

One of the main outputs from the Posford Duvivier report (1998) was a collection of GIS polygon layers representing digitised habitat maps and approximations derived from the coastal habitat data available from the surveys discussed in 2.1 and from Ordnance Survey (OS) base maps.

The Posford's saltmarsh GIS layer provided more information about the size, extent and shape of the saltmarshes under investigation than the SNH point dataset (2009). This GIS polygon dataset does not include all areas mapped as part of the Saltmarsh Survey of Great Britain (Burd 1989) with very few polygons available for the west coast and the offshore islands. Most of the polygons overlapped with existing points requiring survey in the SNH point dataset, but there were a small number of polygons that were 3ha or larger that were identified as additional sites. These sites were also incorporated into the survey scheme.

2.2.3 Small and perched site selection

The project also required the surveying of:

- 10 perched saltmarsh sites
- 25 small sites (under 3ha)

It was required that a geographically representative sample of the above should be surveyed, including loch-head saltmarshes.

The point dataset identifies a total of:

- 226 saltmarsh sites under 3ha
- 16 perched saltmarsh sites (note that these 16 sites are also under 3ha)

The geographical representation of the smaller sites is presented in Figure 2-3.

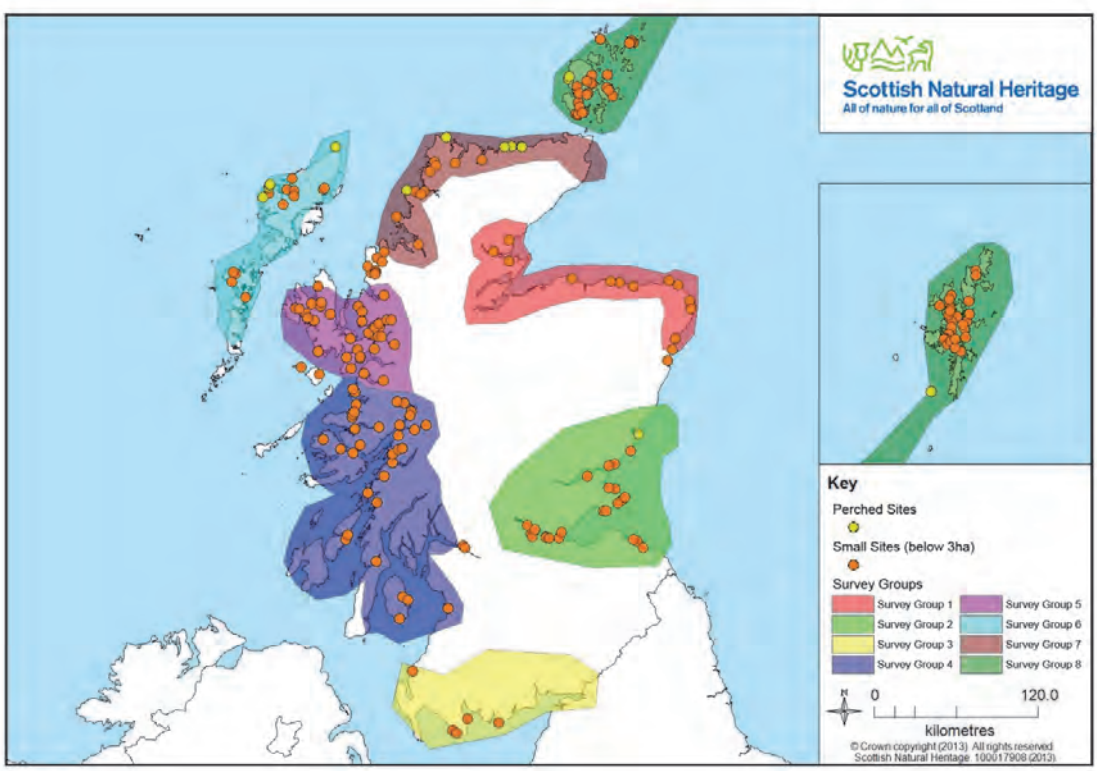


Figure 2-3: Small and perched saltmarsh sites (by survey block).

Small and perched sites were separated into the geographical regions identified in Figure 2-3. This allowed the proportion of small and perched sites to be identified (see Table 2-2 and) for each geographic area. The number of small and perched sites to be sampled was based on their representation in each region (see the percentages in each table).

Table 2-2: Small site sampling (by geographic area).

Geographic Region	**Number of Small Saltmarsh Sites**	**Percentage**	**Number of small sites to be sampled**
South Coast (Solway)	5	2.2%	0
South-West Coast	37	16.4%	4
North-West Coast	37	16.4%	4
North Coast	25	11.1%	3
North East Coast (Aberdeen - Inverness)	15	6.6%	2
East Coast (Angus - East Lothian)	26	11.5%	3
Outer Hebrides	17	7.5%	2
Shetland and Orkney Islands	64	28.3%	7
Total	**226**		**25**

Table 2-3: Perched site sampling (by geographic area).

Geographic Region	Number of Small Saltmarsh Sites	Percentage	Number of perched sites to be sampled
North Coast	6	37.5%	4
East Coast	1	6.3%	1
Shetland and Orkney Islands	4	25.0%	2
Outer Hebrides	5	31.3%	3
Total	**16**		**10**

2.2.4 Final Site Selection

The SSS identified a total of 255 sites requiring survey including all point data sites over 3ha in extent; all polygon sites over 3ha in extent; and a representative set of 25 sites less than 3ha in extent, and 10 perched saltmarsh sites.

Of these 255 sites, 249 were mapped and assessed as part of the project. One of the 255 sites was not visited (Kylemorar, Lochaber) which was due to difficulties accessing the site by boat; and five sites were visited but no saltmarsh was recorded. The six sites where saltmarsh was not recorded are:

- Rubh' an Dunain, Stoer (North Coast)
- Kintour (Islay) (Argyll)
- River Leven (Clyde)
- Rack Wick (Orkney)
- ‘Poly 08’ (Orkney)
- Westbrough (Orkney)

A full list of the 255 sites is provided in Table 2-4.

Table 2-4: List of all saltmarsh sites surveyed as part of the SSS. 'Site type' relates to which dataset the site was identified from. Blank entries relate to the point dataset (SNH 2009).

Site no.	Site name	Site Type	Location	Survey Year
001EDE	Eden Estuary		South East	2010
002TAY	Tayport		South East	2010
003TAY	Tay Estuary		South East	2010
004MON	Montrose Basin		South East	2010
005KIN	Kinnaber Links (St Cyrus)		South East	2010
006LUN	Lunan Bay		South East	2010
007CUL	Culross Shore		South East	2010
008GRA	Grangemouth		South East	2010
009SKI	Skinflats		South East	2010
010FOR	Forth (Alloa)		South East	2010
011COC	Cocklemill Bay		South East	2010
012ABE	Aberlady Bay		South East	2010
013TYN	Tyninghame Shore		South East	2010
014BLA	Blackness and Blackburn	Small	South East	2011
015BAL	Balmerino Shore	Small	South East	2011
016BAR	Barry Burn	Small	South East	2011
017BOD	Boddin Point	Perched	South East	2011
018SLE	Sleek of Tarty		North East	2011
019SAN	Sands of Forvie		North East	2011
020STA	Stakeness		North East	2011
021STR	Strathbeg		North East	2011
022SPE	Spey Bay		North East	2011
023FIN	Findhorn Bay		North East	2011
024LOS	Lossiemouth	Small	North East	2011
025CUL	Culbin		North East	2011
026WHI	Whiteness Head		North East	2011
027CAS	Castle Stuart Bay		North East	2011
028INV	Inverness	Polygon	North East	2011
029BEA	Beauly Firth		North East	2011
030MUN	Munlochy Bay		North East	2011
031UDA	Udale Bay		North East	2011
032CON	Conon Islands		North East	2011
033DIN	Dingwall		North East	2011
034BAL	Balconie Point		North East	2011
035DAL	Dalmore		North East	2011
036NIG	Nigg Bay		North East	2011
037MOR	Morrich More		North East	2011
038TAI	Tain	Small	North East	2011
039DOR	Dornoch Firth South		North East	2011
040BON	Bonar Bridge		North East	2011
041DOR	Dornoch Point		North East	2011
042COU	Coul Links (Loch Fleet)		North East	2011
043SKE	Skelbo (Loch Fleet)		North East	2011
044CAM	Cambusmore Lodge (Loch Fleet)		North East	2011
045BAL	Balbair (Loch Fleet)		North East	2011
046THE	The Mound (Loch Fleet)		North East	2011
047CRE	Creag Bheag (Loch Fleet)	Small	North East	2011
048LOC	Loch Duich		North West	2011
049LOC	Loch Broom		North West	2011
050LIT	Little Loch Broom		North West	2011
051OPI	Opinan		North West	2011
052AUL	Aultbea	Small	North	2011
053STR	Strathcanaird		North	2011
054ACH	Achnahaird Bay		North	2011
055RUB	Rubh' an Dunain, Stoer	Perched	North	2011
056LOC	Loch Laxford		North	2011
057LOC	Loch Sheigra		North	2011
058RHI	Rhiconich	Small	North	2011
059KYL	Kyle of Durness		North	2011
060EIL	Eilean Dubh (Loch Eriboll)		North	2011
061KYL	Kyle of Tongue		North	2011
062RHI	Rhian Burn	Small	North	2011

Site no.	Site name	Site Type	Location	Survey Year
065POR	Portskerra 1	Perched	North	2011
066POR	Portskerra 2	Perched	North	2011
067MEL	Melvich		North	2011
068RIV	River Wester		North	2011
069RIV	River Wick		North	2011
070LOC	Loch Fyne		Argyll	2011
071SAL	Sallachan Point	Small	Lochaber	2011
072CAM	Camas na Croise		Lochaber	2011
073LOC	Loch a' Choire		Lochaber	2011
074KIL	Kilchoan		Lochaber	2011
075THR	Three Mile Water	Small	Lochaber	2011
076CAO	Caol Spit		Lochaber	2011
077INV	Inversanda		Lochaber	2011
078DER	Dervaig		Argyll	2011
079LOC	Loch Sunart Head		Lochaber	2011
080CUI	Cuil Bay	Small	Lochaber	2011
081DUN	Dunstaffnage		Argyll	2011
082ARD	Ardentiny		Argyll	2011
083BAL	Balure of Shian (Loch Creran)		Argyll	2011
084LOC	Loch Sligachan		Skye & Lochalsh	2011
085LOC	Loch Slapin		Skye & Lochalsh	2011
086CAM	Camas na Sgianadin	Small	Skye & Lochalsh	2011
087ISL	Isleornsay		Skye & Lochalsh	2011
088LOC	Loch Ainort		Skye & Lochalsh	2011
089LOC	Loch na Dal		Skye & Lochalsh	2011
090BRO	Broadford Bay		Skye & Lochalsh	2011
091RUB	Rubha Ardnish		Skye & Lochalsh	2011
092LOC	Loch Portree		Skye & Lochalsh	2011
093LOC	Loch Eynort		Skye & Lochalsh	2011
094LOC	Loch Melfort		Argyll	2011
095BAR	Barrisdale Bay		Skye & Lochalsh	2011
096NON	Nonach		Skye & Lochalsh	2011
097LOC	Loch Harport		Skye & Lochalsh	2011
098LOC	Loch Craignish		Argyll	2011
099GLE	Glenmore		Lochaber	2011
100LOC	Loch Moidart		Lochaber	2011
101LOC	Loch Eil		Lochaber	2011
102ARI	Arisaig		Lochaber	2011
103LOC	Loch Leven		Lochaber	2011
104INV	Inverscaddle Bay		Lochaber	2011
105LOC	Lochailort		Lochaber	2011
106LOC	Loch an t-Sailein		Argyll	2011
107KIN	Kintour (Islay)	Polygon	Argyll	2011
108EIL	Eilean an Droighinn	Polygon	Argyll	2011
109GLE	Gleann Aoistail		Argyll	2011
110THE	The Strand		Argyll	2011
111GRU	Gruinart Flats		Argyll	2011
112AUC	Auchalick Bay		Argyll	2011
113WHI	Whitehouse Bay		Argyll	2011
114LOC	Loch Caolisport		Argyll	2011
115BRI	Bridgend Flats		Argyll	2011
116ARD	Ardpatrick	Polygon	Argyll	2011
117LOC	Loch Stornoway		Argyll	2011
118ULV	Ulva Islands & Loch na Cille	Polygon	Argyll	2011
119POW	Pow Burn		Ayrshire	2011
120GAR	Garnock Estuary		Ayrshire	2011
121INN	Inner Clyde		Clyde	2011
122RIV	River Leven (Inner Clyde)	Polygon	Clyde	2011
123HOL	Holy Loch		Argyll	2011
124LOC	Loch Striven		Argyll	2011
125RUE	Ruel Estuary/Loch Ridden		Argyll	2011
126LOC	Loch Feochan		Argyll	2011

063TOR	Torrisdale Bay		North	2011
064BRA	Brawl, Strathy	Perched	North	2011
129LOC	Loch Laich		Argyll	2012
130LIN	Linne Mhuirich		Argyll	2012
131SAI	Sailean na h-Airde	Polygon	Argyll	2012
132STR	Straad	Polygon	Argyll	2012
133BUN	Bunacaimb		Lochaber	2012
134DRU	Druimavuic		Lochaber	2012
135EIL	Eilean Uaine	Polygon	Lochaber	2012
136INV	Inverie Bay		Lochaber	2012
137KEN	Kentra Bay	Polygon	Lochaber	2012
138ARD	Ardelve (Loch Alsh)	Small	North West	2011
139KIN	Kinlochteacuis		Lochaber	2012
140KYL	Kylemorar		Lochaber	2012
141LOC	Loch Aline		Lochaber	2012
142LOC	Loch Nevis Head		Lochaber	2012
143AN	An Caolas	Polygon	Mull	2012
144ARD	Ardura		Mull	2012
145LOC	Loch Beg		Mull	2012
146LOC	Loch Don		Mull	2012
147LOC	Loch Beag		Skye (N)	2012
148LOC	Loch Dunvegan		Skye (N)	2012
149LOC	Loch Greshornish (Loch Snizort)		Skye (N)	2012
150LOC	Loch Eyre (Loch Snizort)		Skye (N)	2012
151POO	Pool Roag		Skye (N)	2012
152DUN	Dunvegan Bay (Loch Dunvegan)	Small	Skye (N)	2012
153ARD	Ardintoul (Loch Alsh)	Polygon	Skye (S)	2012
154GLA	Glas Eilean (Loch Alsh)	Polygon	Skye (S)	2012
155GLE	Glenelg		Skye (S)	2012
156KIN	Kinlochhourn		Skye (S)	2012
157KIS	Kishorn		Skye (S)	2012
158KYL	Kyle		Skye (S)	2012
159LOC	Loch Carron		Skye (S)	2012
160LOC	Loch Torridon		Skye (S)	2012
161TOS	Toscaig		Skye (S)	2012
162KIR	Kirkton (Loch Alsh)	Small	Skye (S)	2012
163CEA	Ceann a' Baigh	Small	Outer Hebrides	2012
164CRE	Creag Fiavig lochans	Perched	Outer Hebrides	2012
165GAL	Gallan Head	Perched	Outer Hebrides	2012
166LOC	Loch Grimersta	Small	Outer Hebrides	2012
167BUT	Butt of Lewis	Perched	Outer Hebrides	2012
168CRO	Crowlista		Outer Hebrides	2012
169TIM	Timsgarry		Outer Hebrides	2012
170LON	Lon Erista		Outer Hebrides	2012
171LOC	Loch Gealavat		Outer Hebrides	2012
172TON	Tong Saltings SSSI		Outer Hebrides	2012
173GRE	Gress Saltings SSSI		Outer Hebrides	2012
174LOC	Loch Paible 1		Outer Hebrides	2012
175BAY	Bayhead		Outer Hebrides	2012
176HOW	Howbeg		Outer Hebrides	2012
177ARD	Ardheisker-Horisary		Outer Hebrides	2012
178BAL	Balgarva		Outer Hebrides	2012
179LAG	Lag Gorm		Outer Hebrides	2012
180VAL	Vallay		Outer Hebrides	2012
181GUA	Gualan		Outer Hebrides	2012
182LIN	Liniclate		Outer Hebrides	2012
183EIL	Eilean Cuithe nam Fiadh		Outer Hebrides	2012
184ILL	Illeray 1		Outer Hebrides	2012
185TRA	Traigh Eachkamish		Outer Hebrides	2012
186BEN	Benbecula Airport - Gramsdale 1		Outer Hebrides	2012
187BEN	Benbecula Airport - Gramsdale 2		Outer Hebrides	2012
188GRE	Grenitote		Outer Hebrides	2012
189CAR	Carinish		Outer Hebrides	2012

127AN	An Seilean		Argyll	2012
128LOC	Loch Crinan	Polygon	Argyll	2012
195LUS	Luskentyre Banks and Saltings SSSI 1		Outer Hebrides	2012
196LUS	Luskentyre Banks and Saltings SSSI 2		Outer Hebrides	2012
197KIR	Kirkibost 1	Polygon	Outer Hebrides	2012
198KIR	Kirkibost 2	Polygon	Outer Hebrides	2012
199FAO	Faoghail Vallaquie	Polygon	Outer Hebrides	2012
200BER	Berneray	Polygon	Outer Hebrides	2012
201NOR	Northton Bay SSSI 2	Polygon	Outer Hebrides	2012
202ILL	Illeray 2	Polygon	Outer Hebrides	2012
203LOC	Loch Paible 2	Polygon	Outer Hebrides	2012
204BAL	Baltasound		Shetland	2012
205CUL	Cullivoe	Small	Shetland	2012
206GLU	Gluss Voe	Small	Shetland	2012
207WEI	Weisdale Voe	Small	Shetland	2012
208BRI	Bridge of Waithe and Cummi Ness		Orkney	2012
209WAU	Waulkmill Bay		Orkney	2012
210VEA	Veantrow Bay		Orkney	2012
211BAY	Bay of Suckquoy		Orkney	2012
212LIT	Little Sea		Orkney	2012
213LAM	Lama Ness Oyce		Orkney	2012
214CAT	Cata Sand		Orkney	2012
215QUO	Quoys		Orkney	2012
216OYC	Oyce of Quindry		Orkney	2012
217RAC	Rack Wick	Polygon	Orkney	2012
218TOY	Toy Ness	Polygon	Orkney	2012
219POL	Poly 08		Orkney	2012
220WES	Westbrough	Polygon	Orkney	2012
221LAM	Lamaness South (West)	Polygon	Orkney	2012
222LAM	Lamaness South (East)	Polygon	Orkney	2012
223STA	Start Point	Polygon	Orkney	2012
224LIT	Little Ayre	Polygon	Orkney	2012
225SKA	Skara Brae to Point of Qui Ayre 1	Perched	Orkney	2012
226SKA	Skara Brae to Point of Qui Ayre 2	Perched	Orkney	2012
227SAN	Sandi Sand	Small	Orkney	2012
228SWA	Swarsquoy	Small	Orkney	2012
229TOR	Torr Ness to Quivals Creek	Small	Orkney	2012
230WYN	Wyng Strand	Small	Orkney	2012
231CAR	Carse Bay		Solway (W)	2012
232SOU	Southerness	Polygon	Solway (W)	2012
233SOU	Southwick		Solway (W)	2012
234ROU	Rough Firth		Solway (W)	2012
235AUC	Auchencairn Bay		Solway (W)	2012
236ORC	Orchardton Bay		Solway (W)	2012
237MAN	Manxman's Lake		Solway (W)	2012
238RIV	River Dee		Solway (W)	2012
239FLE	Fleet Bay		Solway (W)	2012
240WIG	Wigtown		Solway (W)	2012
241GLE	Glen Luce		Solway (W)	2012
242LUC	Luce Bay		Solway (W)	2012
243LUC	Luce Sands	Polygon	Ayrshire	2012
244BAL	Ballantrae Bay		Solway (E)	2012
245GRE	Gretna to Redkirk		Solway (E)	2012
246BRO	Browhouses		Solway (E)	2012
247TOR	Torduff Point		Solway (E)	2012
248DOR	Dornock		Solway (E)	2012
248ANN	Annan		Solway (E)	2012
249MIL	Milnfield Merse		Solway (E)	2012
250PRI	Priestside Bank		Solway (E)	2012
252CAE	Caerlaverock		Solway (E)	2012
253GLE	Glencaple & Kelton		Solway (E)	2012
254GRE	Greenmerse		Solway (E)	2012
255KIR	Kirkconnell Merse		Solway (E)	2012

2.3 Trial field surveys and mapping

It was important to ensure that the methodologies used to collect field data were fit for purpose. SNH had also reported idiosyncrasies between Scottish saltmarsh communities and the published NVC tables (Rodwell 2000). A trial set of surveys was undertaken to test the designed methodology and to take account of the variation in size and type of saltmarshes that would be under assessment through 2010-2012.

Trial sites were visited June-July 2010 with Dr Theo Loizou supporting the development of the field data collection exercise. Table 2-5 includes all the sites visited as part of the trial surveys.

Table 2-5: List of the saltmarsh sites visited in June-July 2010 as part of the trial surveys.

Site no.	Site name	Surveyors	Purpose	Location	Trial Survey Date
004MON	Montrose Basin	T.Haynes & T.Loizou	NVC type assessment and H&S procedure trial	South East	29/06/2010
002TAY	Tayport	T.Haynes & T.Loizou	NVC mapping trials	South East	01/07/2010
003TAY	Tay Estuary	T.Haynes & T.Loizou	SCM survey trials	South East	30/06/2010
027CAS	Castle Stuart Bay	T.Haynes & A.Strange	NVC mapping trials	North East	03/07/2010
050LIT	Little Loch Broom	T.Haynes	Full survey trial	North West	04/07/2010
063TOR	Torrisdale Bay	T.Haynes	Full survey trial	North	06/07/2010
138ARD	Ardelve (Loch Alsh)	T.Haynes	SCM survey trials	North West	07/07/2010
048LOC	Loch Duich	T.Haynes	Full survey trial	North West	07-08/07/2010

2.3.1 Modifications to the survey methodology

Through the trial period it was apparent that the 1:10,000 scale maps of the Ordnance Survey were too coarse and inaccurate to map NVC communities to sub-community level. Instead, SNH's aerial photography collection was utilised to map saltmarsh polygons (see 2.7.2 for full details).

Many of the saltmarsh communities observed on the various sites formed mosaics. The method of mapping habitat mosaics is discussed in 2.6.4.

Carrying quadrats and other measurement equipment was impractical across most of the saltmarshes surveyed, thus samples were measured out using approximate distances and followed the NVC methodology (Rodwell 2006).

The collation of target notes using a GPS was also revised so that waypoint reference codes (downloaded from the GPS unit) were noted onto a field sheet.

2.4 Taxonomy and species terminology

All species information collected as part of the SSS follows the naming conventions identified below in Table 2-6.

Table 2-6: Taxonomic nomenclature references.

Taxa	Nomenclature reference
Flowering plants	Botanical Society of the British Isles species checklist (2007)
Mosses and Liverworts	British Bryological Society species checklist (2008)
Seaweeds	A Checklist and Atlas of the Seaweeds of Britain and Ireland. 2nd corr. ed. (Hardy and Guiry 2006)
Lichens	Checklist of Lichens of Great Britain and Ireland (Coppins 2002)

Where a species was not fully identified the abbreviation 'sp.' is used after the genus name (e.g. *Salicornia* sp.). Where more than one species is described, the abbreviation 'spp.' is used after the genus name. 'x' within a scientific name relates to a hybrid while sub-species are described using the abbreviation 'subsp'.

2.5 Field survey planning

Sites for survey were investigated using: Mapinfo GIS software; 1:25,000 Ordnance Survey maps; 1:10,000 Ordnance Survey maps; SNH's aerial photography collection and site reports from Burd (1989) and Dargie (2000a).

Access points onto saltmarsh sites were identified using the maps and aerial photography described above and the relevant SNH Area offices contacted to confirm the date and the areas requiring access. Any additional information regarding site risks and health & safety were also collated.

An estimation of the time required to complete each site survey was also determined with input from NatureBureau's field ecologists.

Aerial photography and Ordnance Survey maps were printed for each site covering the estimated area of saltmarsh. Aerial imagery for habitat mapping was printed at a scale of 1:4,000.

Large sites were segmented into areas that could be completed across a number of walks or days. For very large sites (such as the Tay Estuary and Caerlaverock) areas for site walks were prioritised where variation in vegetation or unique patterns were evident from the aerial photography.

Site condition monitoring reports and previous survey documents were reviewed before field surveys commenced.

2.6 Field surveys

2.6.1 Defining survey boundaries

The project required that all areas including halophytic vegetation should be surveyed as part of the project. This meant that the landward limits of the survey were dictated by surrounding development (e.g. agricultural fields at the rear of the marsh), field boundaries, or where there were limited signs of saline influence on the landward vegetation. Halophytic vegetation is not always the best measure of saline influence, particularly for swamp vegetation (see 4.10). The limits of saline influence are often found within transitional communities such as grassland or fen. It is important to note that inundation grassland and swamps are mapped as part of the project (as they include limited halophytic vegetation), but fen habitats (which often lack halophytic vegetation) are not always mapped. Transitional fen communities are described as the landward boundaries in individual site reports.

Pictures and target notes are included. Further study of the transitional communities is recommended (see 5.6.10).

Some sites also include long narrow belts of saltmarsh, which are found in larger bays, estuaries and sea lochs and can extend across the border of sea lochs and estuaries for a considerable distance. In these instances, the vegetation was target noted or sampled and the patterns of vegetation matched to aerial photography. Ian Strachan mapped long narrow belts of saltmarsh around sea lochs by surveying these areas to the first significant break in continuity. Most narrow belts of saltmarsh connected to larger saltmarsh sites are included within the GIS database.

Sites with fine and highly fragmented edges are difficult to map. Dependent on the amount of fragmented vegetation present, these areas are either included as part of a mosaic polygon or excluded from the GIS database (where the fragmentation is finer than the SSS mapping scale). These areas are normally target noted and described in individual site reports.

Each survey consisted of five separate data collection exercises:

- NVC classification (2.6.2)
- Habitat mapping (2.6.3)
- Vegetation sampling (2.6.7)
- Site condition monitoring (2.6.9)
- Target noting and photography (2.6.10 and 2.6.11)

2.6.2 NVC classification

All sites were assessed for vegetation communities matching those published in the five volumes of the British Plant Communities (Rodwell 1991a, 1991b, 1992, 1995, 2000).

Each surveyor was introduced to the survey programme and the scale and method of NVC classification (to enable uniformity in habitat mapping across Scotland).

Classification was undertaken by identifying homogeneous areas or repeating pattern in the field while undertaking walk-over surveys. Once the NVC community structure of each area became apparent then vegetation sampling took place (see 2.6.7).

Dargie's work on Scottish sand dunes (Dargie 2000a) indicated that further classification types beyond the existing NVC communities may be required. In these instances, Dargie added unpublished descriptions of additional NVC communities/sub-communities based on information gathered as part of his survey scheme (Dargie 2000a). The SSS surveys included Dargie's additional classifications along with the same system of establishing additional sub-communities.

The criteria that allowed an additional community or sub-community to be included within the SSS project required that such communities needed to show evidence of stable community formation on a number of separate sites. Such communities are mostly present at the northern and western limits of Scotland (including the Outer Hebrides, Orkney and Shetland). Additional sub-communities were added from the next available sub-community suffix (e.g. SM16g), while others were provided a suffix that summaries the species content (e.g. SM16jb - *Festuca rubra* and *Juncus balticus* sub-community).

As multiple surveyors undertook the survey work, it is difficult to confirm at the time of writing how much crossover there is between the extra sub-communities identified by each surveyor. It is beyond the scope of the current project to analyse the vegetation community variation between surveyors, although each additional community/sub-community is described in section 1 and possible similarities are discussed.

2.6.3 Habitat mapping

Habitat maps were drawn onto aerial photography at a standardised scale of 1:4,000. Various scales were tested in the trial surveys, but 1:4,000 provided the best compromise between detail and the time required to complete and digitise each site.

Vegetation patterning in the field was assessed on aerial photography to detect the observed variation. Such patterns then provided a guide to develop the habitat maps. Habitat maps were completed to sub-community level for all saltmarsh types and community level for associated habitats.

Coarser levels of community structure were sometimes used (e.g. 'MG' for mesotrophic grassland) where additional habitat information was provided (e.g. terrestrial communities landward of the saltmarsh).

It was noted as part of the trial surveys that an assessment of the accreting and eroding edge of saltmarshes can be difficult to assess without access to up to date aerial photography. A GPS was used to provide additional information in instances where significant expansions or declines in saltmarsh area were detectable in comparison with the aerial photography. Such methods of assessment were also important when assessing finer details and sparser vegetation types which were not visible or clear on the aerial photographs.

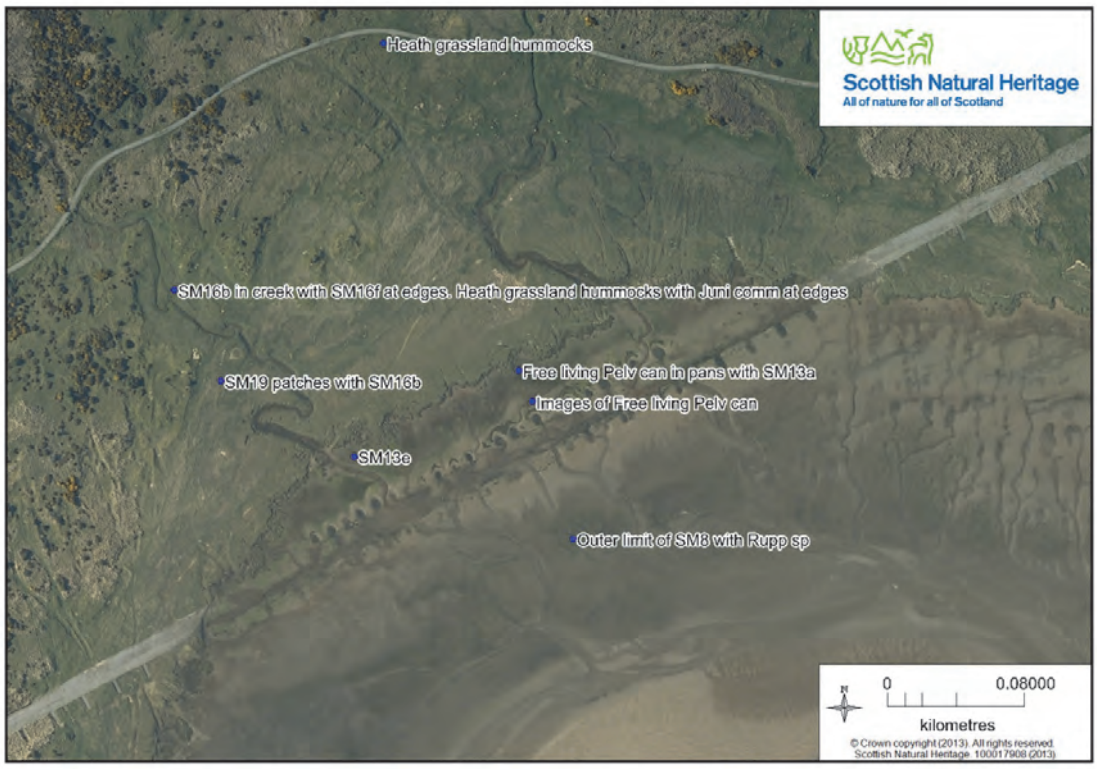


Figure 2-4: A map showing how the surveyor's GPS was used to ascertain additional information from sites where aerial photography appeared to be out of date.

Due to the wide variation of mapping units on different coastlines (e.g. large uniform areas of saltmarsh on the Solway Firth and small, but complex community structures on small sites in the west) it was concluded that there would be no set minimum mapping unit. Instead the scale of mapping was set to 1:4,000, thus the resolution of mapping was dictated by the resolution of the aerial photography.

2.6.4 Mosaic mapping

The trial surveys indicated that vegetation community types can often occur in mosaic formations and repeating patterns. Such linked vegetation community types can occur across large areas, showing little variation in pattern (see Figure 2-5). A robust method for the assessment of mosaics needed to be established early into the project.

Figure 2-5: A typical example of a large vegetation mosaic across the saltmarshes at Wigtown.

The method utilised was based on the mosaic mapping method developed by Dargie (2000a). Repeating patterns of individual NVC vegetation types were assessed in the field and then the area of the mosaic was mapped onto the 1:4,000 scale maps. An estimate of the cover of each component of the mosaic was then noted as a proportion out of ten. This means that for each mapped area of a mosaic, all the constituent components will total up to ten portions, being the total area of the mapped polygon. An example is presented below and in Figure 2-6:

Mosaic polygon : SM13d (6) + SM16b (4) = 10 portions

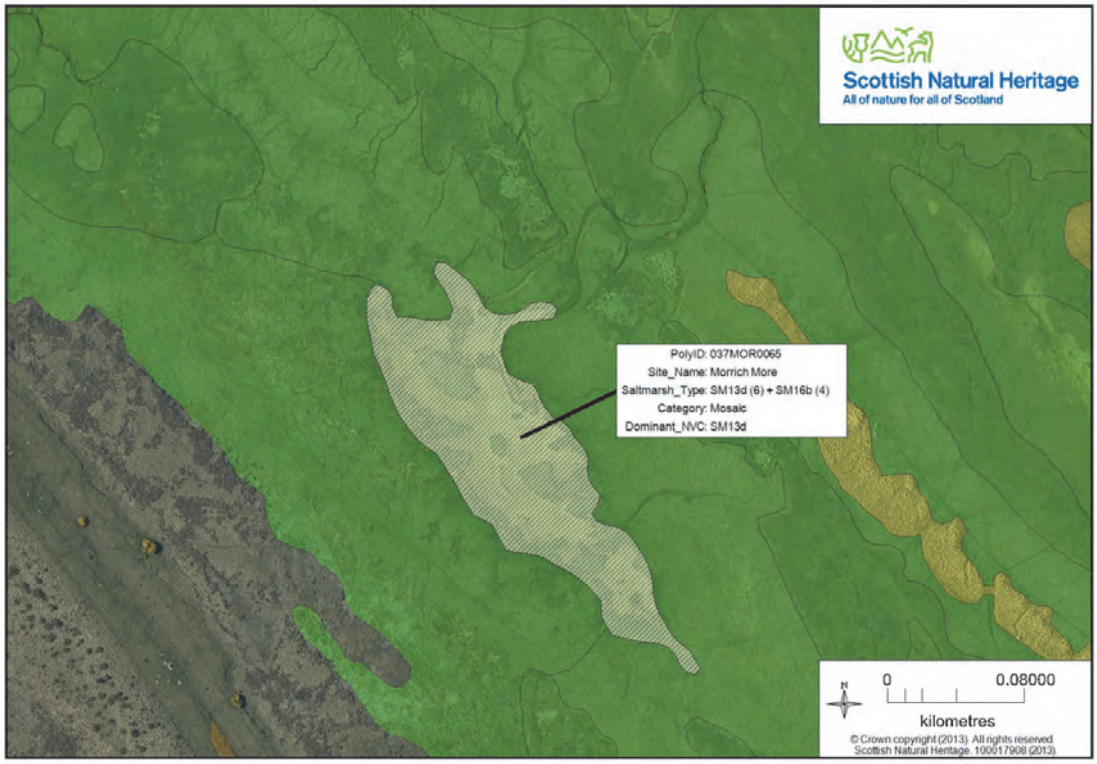


Figure 2-6: Map showing mosaic polygons and the underlying polygon descriptions.

Figure 2-6 provides an example of how polygons are displayed in the GIS system. By using this system it was possible to provide an estimate of area for each component of the mosaic, allowing full statistics for each NVC type to be collected (also see 2.7.6).

This mosaic mapping scheme is size-dependent and some elements of a mosaic are too small to be separated accurately i.e. covered much less than 10% of the polygon. In such instances the information was considered to be at too fine a level of detail for the mosaic mapping to detect and this information was target noted (see 2.6.10).

Any polygon with more than one NVC sub-community within it was considered a mosaic. Note that this included multiple types of saltmarsh sub-community. Mosaic mapping also included land cover types that take account of different substrates and structures. An example was the common occurrence of SM8 (Annual *Salicornia* saltmarsh) and bare sand (which is described as 'SM8 + BS' in the GIS database).

Mosaic information was provided in weighted order with the largest proportions beginning the mosaic description (e.g. 'SM16a (9) + SM13a (1)'). Where a mosaic was equally proportional, then the descriptions are provided in numerical/alphabetical order (e.g. 'SM13a (5) + SM13b (5)').

2.6.5 Land cover types and open/sparse vegetation

As discussed in the previous section, there are instances where further information was required regarding the substrate and associated land use of sites, which do not adequately fit with the NVC classification. In these instances an adaptation of Dargie's method of classifying land cover types was used (Dargie 2001). The core land cover types developed by Dargie, which are an adaptation from the JNCC Phase I classification (JNCC 2010), are indicated as abbreviations.

In areas where a single species stand dominates the vegetation and was not comparable to the NVC, such as large stands of invasive non-native species or highly localised species, an abbreviation of the species name was included (e.g. stands of *Aster novi-belgii* are abbreviated to 'Ast nov').

In some instances additional land cover types are included where a certain type of vegetation was observed on a number of sites. Examples include different types of sparsely vegetated shingle (BSHc and BSHx). A full key to the land cover classifications used is included in Table 2-7.

Table 2-7: Land cover types used within the SSS surveys and GIS database

Code	Description	Code Origin
All car	*Allium carinatum* community	New codes created for SSS
Ast nov	*Aster novi-belgii* community	New codes created for SSS
BBG	Buildings and Bare Ground	Dargie (2001)
BM	Bare Mud	Dargie (2001)
BR	Bare Rock	Dargie (2001)
BS	Bare Sand	Dargie (2001)
BSH	Bare Shingle	Dargie (2001)
BSHc	*Cochlearia officinalis* pioneer community (dense-sparse) on shingle	New codes for SSS
BSHx	*Armeria maritima* pioneer community (sparse) on shingle	New codes for SSS
Car rec	*Carex recta* community	New codes for SSS
Car rec x Car aqu	*Carex recta x Carex aquatilis* hybrid community	New codes for SSS
Car sal	*Carex salina* community	New codes for SSS
Fal jap	*Fallopia japonica* community	New codes for SSS
Her man	*Heracleum mantegazzianum* community	New codes for SSS
Imp gla	*Impatiens glandulifera* community	New codes for SSS
Iri pse	*Iris pseudacorus* community	New codes for SSS
Mim gut	*Mimulus guttatus* community	New codes for SSS
OW	Open Water	Dargie (2001)
Pans	Pans	New codes for SSS (2013)
RF	Rock with fucoids	New codes for SSS (2013)
Rud lac	*Rudbeckia laciniata* community	New codes for SSS (2013)
Sal Scr	Salix scrub	New codes for SSS (2013)
SF	Shingle with fucoids	New codes for SSS (2013)
Spe med	*Spergularia media* only	New codes for SSS (2013)

2.6.6 Creeks, pans and drainage ditches

The size, depth and shape of creeks were complicated to assess fully, mainly due to the sheer number and variation of creeks and pans on each site. Notes regarding the structure of creeks, pans and drainage ditches are included as target notes along with relevant photographs. Large pans, creeks and drainage ditches sometimes support distinct vegetation communities. Where such communities are distinct at a scale of 1:4,000, they are mapped (e.g. drainage ditches populated with S22 – *Glyceria fluitans* water-margin vegetation). Areas below the mapping resolution are target-noted.

2.6.7 Vegetation sampling

Vegetation sampling took place once the NVC types present in the survey area were understood (See 2.6.2). Vegetation sampling was undertaken using the NVC methodology (Rodwell 2006). At least one quadrat sample of each saltmarsh sub-community or brackish swamp community was collected from each site. Samples of other transitional vegetation types with halophytes present were also collected on a selective basis. There are some instances where each saltmarsh sub-community present was not sampled. Reasons for this include:

- Post-survey reclassification of the NVC types
- Inaccessible vegetation
- Vegetation initially identified on site but not observed again in sampling phase.
- Site conditions (e.g. weather and tide coming in)

2.6.8 Species identification

Training on species identification and saltmarsh community sampling was undertaken by Thomas Haynes and Theo Loizou and each surveyor's identification skills were assessed. Dr Theo Loizou is the British Bryological Society's VC90 recorder and Ian Strachan is the BSBI's Westerness recorder and supported the identification of complex species.

Any plants that were difficult to identify were first assessed by surveyors using the appropriate keys. The distributions of short-listed potential species were then assessed against the site where the record was taken. At this stage, if identification was still not clear, specimens or images were sent to a BSBI botanical referee.

2.6.9 Site Condition Monitoring

Saltmarsh condition was assessed using a target-based assessment form developed by SNH. This form identifies key attributes and features which allow overall condition assessment of the following Habitats Directive Annex I habitat types:

- H1310 - Salicornia and other annuals colonising mud and sand (Pioneer saltmarsh)
- H1330 - Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*) (Atlantic saltmarsh)

Atlantic saltmarsh was considered to be any of the saltmarsh NVC types SM10 and SM13 to SM28. Pioneer saltmarsh was considered to be SM8, SM9 and SM12a. Note that SM6 (*Spartina anglica* salt-marsh community) is excluded from this list due to its non-native invasive status (unless SM8 or SM9 were previously recorded).

All condition surveys are based on site walks, which were conducted as part of the NVC and habitat mapping survey. On larger sites more than one walk took place. In other instances a single walk covered multiple sites.

Any condition-related notes were collected throughout the walk, and the site assessed against the targets at the completion of the survey.

All vegetation composition data are based on the NVC samples collected and additional information gathered on the walk, and provide a general vegetation context to the samples. The NVC vegetation samples should be considered the primary source of vegetation data (see 2.6.7).

Although all targets are assessed within the form, it was important that surveyors used their professional judgement to guide the decision on whether each site (as a whole) failed specific condition targets. All surveyors were briefed to ensure that the format of the targets was used as a guide to determine whether or not each failed target impacted the site's overall condition (rather than an exhaustive appraisal of features). For example most sites suffer from breaks in the natural vegetation transition (particularly at the upper limits of each marsh). Some of these transition interruptions occurred over 100 years ago with the development of agricultural land. If this target was appraised solely on the target description, then almost all saltmarsh sites would fail this target. Instead transition integrity is only considered where the surveyor has used his professional judgement to conclude that the integrity of the natural transition on the site is having a negative impact on overall condition. The results of all condition monitoring surveys were assessed by NatureBureau and any inconsistencies were discussed and modified in conjunction with the field surveyors.

If targets fail the assessment then an SCM report or text within the SCM form is provided which details the reasons for the failure (see SCM report development 2.9 and appendix 2 for a full index of site reports).

2.6.10 Target notes and site walks

All data regarding target notes and site walks were collected using handheld GPS units. Targets notes were collected using the 'waypoint' feature of the GPS software. For the majority of surveys each waypoint was assigned an automatic, rolling number (by the GPS), which was noted on field sheets for cross referencing. The original reference number is included within the target note sheets for each site to retain a link with the raw data sources. All target note data sheets are appended to the individual site reports (see Table 1-2 and appendix 2).

Site walks were recorded using the GPS unit's automatic tracking capability, which records automatic points every 10-15 seconds.

GPS units were set to Longitude/Latitude using the WGS84 projection. Each unit is able to display projected coordinates using the British National Grid System, but the core units are provided in Longitude/Latitude format.

It should be noted that British National Grid references derived from the GPS in the extreme latitudes of Scotland (particularly Orkney and Shetland) and the west coast are not reliable and the Longitude/Latitude points are the most accurate data.

Many GPS units identify their precision up to 3m away from the original point. In practice such precision is not reliable and 5-10m precision should be considered a more cautious estimate. It is also important to remember that the layout of the surroundings (e.g. dense tree cover) and the triangulation of satellites at the time of survey can also affect the accuracy of target notes and tracks. Such information is displayed on the screen of some GPS models, but it is impractical to review on a regular basis (this is noteworthy regarding automatically generated site walk data). For target notes it was ensured that the GPS was indicating the finest accuracy possible (approx 3m) before each target note was recorded.

There was a small number of instances where site tracks were not recorded from sites due to GPS unit failures. In these instances coordinates were acquired from the H&S emergency GPS device, if available (see 2.6.12). Full details of the GPS units used by surveyors are included in Table 2-8.

Table 2-8: List of camera and GPS unit models used through the course of the fieldwork.

Camera Model	Resolution	Surveyor	Comment
Canon DSLR 450d	12.2 Megapixels	T.Haynes	Primarily used for vegetation sample images
Canon Ixus	12.1 Megapixels	T.Haynes	
Fuji FinePix HS10 HS11	10.3 Megapixels	S. Beal	
Olympus TG-310	14 Megapixels	T. Loizou	
Pentax Optio WG-1	14 Megapixels	I. Strachan	
Sony Cyber-shot DSC-S2000	10.1 Megapixels	I. Strachan	One site only
Sony DSC - U20	2 Megapixels	R. Payne	
GPS Model		**Surveyor**	**Comment**
Garmin 60CSx		T.Haynes	
Garmin eTrex		I. Strachan and T.Loizou	
Garmin eTrex 20		R. Payne	
Garmin Oregan 550		S. Beal	
Vista H		T.Loizou	

2.6.11 Photography

A selection of photographs is provided that illustrate the size and shape of the site, key features relating to site condition and photos of samples and other relevant information.

Standard practice for taking pictures of samples was for a series of shots to be taken from the same position including: close-up shots of the vegetation; pictures of the sample's position in its immediate surroundings; and pictures of the sample in the wider area. GPS marks were taken each time pictures were taken denoting relevant features or samples. This method was used as the original process of geo-referencing in 2010 and presented as a table in the site report appendices (see appendix 2 for a site report index).

The bulk of the mainland sites for 2011 and 2012 includes photos with time and geo-reference stamps created using RoboGEO software (Pretek 2013) from GPS tracking data (see Figure 2-5). Time and geo-referencing stamps were not included for the offshore island sites surveyed by Theo Loizou and Robin Payne and are instead included as tables of geo-referenced images in the site report appendices (see appendix 2 for a full report index). Images by Theo Loizou and Robin Payne are also directly labelled with the relevant sample or target note number.

Additional photos without geo-references are included in many reports and are indicated as such in the appendices or reports where they are illustrated.

2.6.12 Health & Safety

Saltmarsh surveying has a number of unique risks associated with it that required mitigation to ensure field surveyor safety was maintained. Noteworthy and unique risks discussed at the beginning of the project included:

- Quicksand and unstable mud
- Deep creeks
- Tidal fluctuations

NatureBureau operated a call-in system for all contracted surveyors, requiring them to phone in at pre-arranged times while undertaking field visits. Satellite phones were used for this purpose in areas where mobile phone reception was poor.

All contracted surveyors also carried an emergency Spot Satellite GPS Messenger (Spot LLC 2013), which allowed a surveyor's location to be monitored by NatureBureau and included an emergency button that would transmit an emergency location signal to the GEOS International Emergency Response Centre. Surveyors also carried a life jacket where appropriate. Tide times were also monitored by surveyors on a regular basis.

In practice, tidal fluctuation was only a risk when large creeks or ditches filled up with water, making it difficult to estimate the depth of the creek. There is a low likelihood of experienced field surveyors being washed off saltmarsh habitat, except in significant storms. The main precautions relating to the tide were to ensure that data were collected from the seaward edge of the marsh before the tide started to come in and to exercise extreme caution when crossing creeks and ditches towards an incoming tide.

Quicksand and mud can be hazardous, particularly when crossing larger creeks or drainage channels with an unstable substrate.

The main risk to surveyors relates to hidden and deep creeks, which can be very difficult to see through tall grass on many sites. A walking stick is a valuable aid in assessing saltmarshes for hidden creeks and it is often safer to manoeuvre across the mud and sand flats at the front of the marsh than negotiate the main saltmarsh on certain sites. Estuarine sites are often more hazardous in this regard. It is also safer to walk along the base of creeks than on the higher saltmarsh surface when sites are highly fragmented with fine-dendritic creeks.

2.7 GIS Mapping

The primary GIS software used was Mapinfo v10 and later v11 (Pitney Bowes 2009, 2011) and was used for GIS database development, mapping, data collation and analysis. Habitat mapping and map production were undertaken on separate GIS platforms by other surveyors. Ian Strachan used Map Maker Desktop Mapping v3.5 (Map Maker Ltd 2013) and Theo Loizou & Robin Payne used ArcGIS v10 (ESRI 2013).

2.7.1 Software settings

The core projection used while digitising maps and collating data sets was British National Grid (EPSG: 27700) using a Spherical Distance/Area measurement. Statistics and area/perimeter calculations were undertaken using the same projection profile.

2.7.2 Base mapping

The SSS surveys utilised the SNH base mapping library of the Scottish coastline with the following datasets used:

- 1:10,000 Scale Raster Ordnance Survey Maps - 5km x 5km tiles
- 1:25,000 Scale Raster Ordnance Survey Maps - 10km x 10km tiles
- 1:2,500 Scale Raster Getmapping Vertical Aerial Photography - 1km x 1km tiles (2003-2009)

The Getmapping aerial photography was the highest resolution dataset available for the project and was the focus of habitat mapping work. All available aerial photography for each saltmarsh site was printed and habitat polygons were directly traced onto the aerial images.

Any missing aerial photography was purchased to ensure that mapping could be undertaken accurately.

It should be noted that in some areas the coastline has changed since the aerial images (collected between 2003 and 2009) were taken (e.g. Morrich More, Spey Bay and Ballantrae Bay). Others sites indicated errors in the aerial photography, particularly where aerial images are merged together (e.g. Kilchoan Bay and An Sàilean). Some of these errors are caused by aerial images being taken at different times of the year and show different shadowing and vegetation formations (see Figure 2-7). Seasonal differences did not cause any problems when mapping the final polygons.

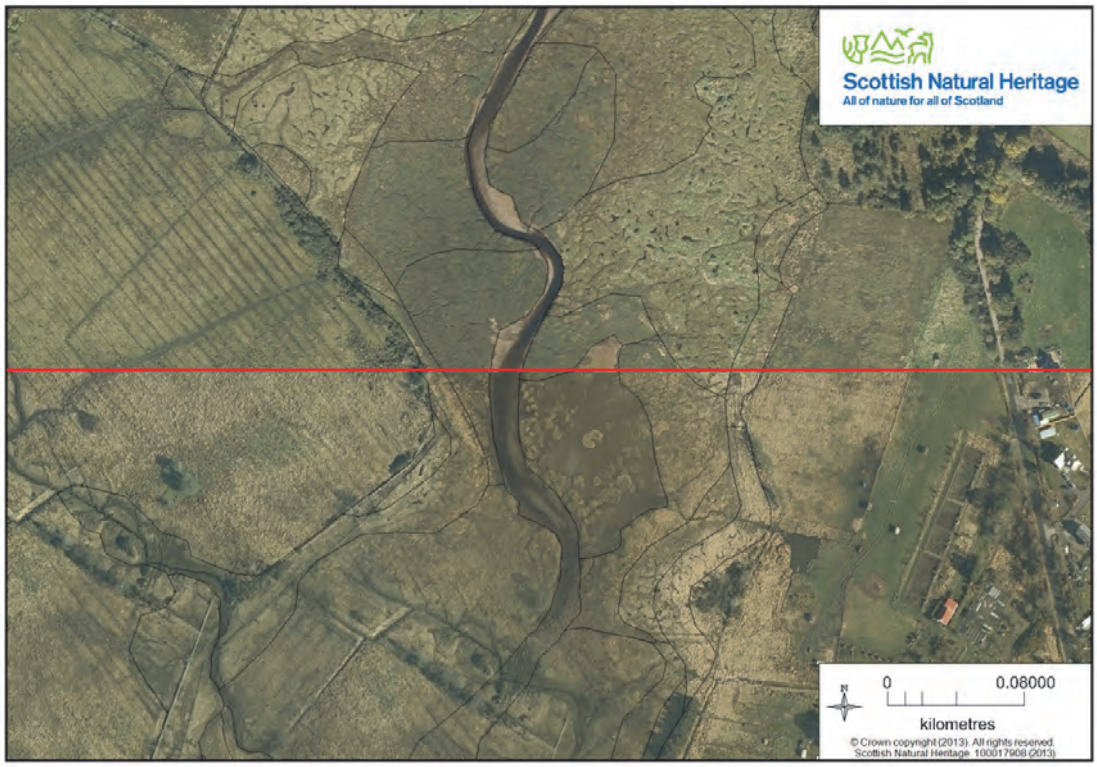


Figure 2-7: Aerial photo of An Sàilean showing two images taken at different times of the year. Note the difference in vegetation patterning either side of the red line.

In some areas of the Solway Firth and the west coast the aerial images were taken at high tide with lower and pioneer marsh zones underwater and not visible (see Figure 2-8).

Figure 2-8: Aerial photo of the Solway Firth showing the lower sections of saltmarsh covered by the high tide.

Ordnance Survey maps were mainly used for navigating access to sites. The low accuracy and detail on both Ordnance Survey datasets make them difficult to use for habitat mapping purposes.

2.7.3 Mapping scale

As previously discussed, all field mapping was undertaken on maps printed at a scale of 1:4,000. The same scale was used for digitising in the GIS system. There are many instances where mapping was undertaken at a finer level than 1:4,000 (particularly on creeks and edges with complex shapes). Graphic tablet mapping was also undertaken at a finer scale (normally 1:2,000).

2.7.4 Field map digitisation

Field map digitisation was overseen or undertaken by field surveyors to ensure the accuracy of the maps was maintained. The field maps from larger sites were reassessed from multiple survey walks to investigate patterning of vegetation across the site as a whole.

The technique used to digitise maps evolved and became faster as the project progressed. The preferred method used through 2011 to 2013 was to trace polylines onto the GIS platform with a matched back drop and scale to the original field map. The lines were then approved by the field surveyor who drew the original maps. Later maps also benefited from the use of a graphics tablet and Mapinfo's auto-node function (10 pixel draw distance), allowing the borders of vegetation to be mapped to the aerial photography more accurately. Note that this method is associated with Mapinfo and that each surveyor digitised using different GIS software and differing techniques. All of the final maps were checked by NatureBureau's QA team and there was no significant difference between mapping techniques.

The target notes and samples collected in the field (using GPS units) were also used to confirm community types and transitions in the GIS system. NVC community types and other land cover codes were added into the GIS attribute table once individual polygons were created.

2.7.5 Polygon creation

Polygons were created by tracing around the polylines created as described in the previous section. 'Holes' were cut out of polygons in instances where a polygon was located entirely within a larger polygon (see Figure 2-9). This ensured that no polygons overlapped in the dataset.

Figure 2-9: An example small polygons (white and green striped) located within a larger polygon (green) at Tyninghame Shore.

Polygon joins were created by tracing around the adjoining edge to ensure borders between polygons were shared. Users of ArcGIS also used a different tool allowing polygons to be created by segregating them out of a larger shape. A similar approach was generally adopted with Map Maker by using the 'cutter' tool. Although different methods of polygon creation were used, each polygon was checked by NatureBureau's quality assessor to ensure that polygons were of high quality and comparable with Tom Dargie's sand dune mapping (Dargie 2000a).

2.7.6 Mosaic polygons

Mosaic polygons were created as described above, but with additional information provided in the attribute table which included the mosaic description (see 2.6.4) and an indication that this polygon included mosaic data (also see 2.7.7 and 2.7.9).

2.7.7 Attribute table content

The attribute table was designed in the early stages of the project and provides valuable information about each saltmarsh polygon including:

- Site name and code
- A unique polygon code
- Site region information
- NVC and land cover types present
- Broad category NVC and land cover types (e.g. SM)
- Area and perimeter
- Coordinates of the centre of each polygon
- Date of survey
- Surveyor names

Most of the data included in the attribute table were added using SQL queries in Mapinfo. All NVC codes and land cover types were entered manually.

2.7.8 Quality control and error checking

Polygons for each site were created as individual files. This was performed so that any errors or modifications could be made on a site basis. An error checking function was used to analyse each set of site polygons for issues such as:

- Overlapping nodes
- Self-intersections
- Gaps between polygons

All of the individual sites were then combined and the polygons checked again for errors.

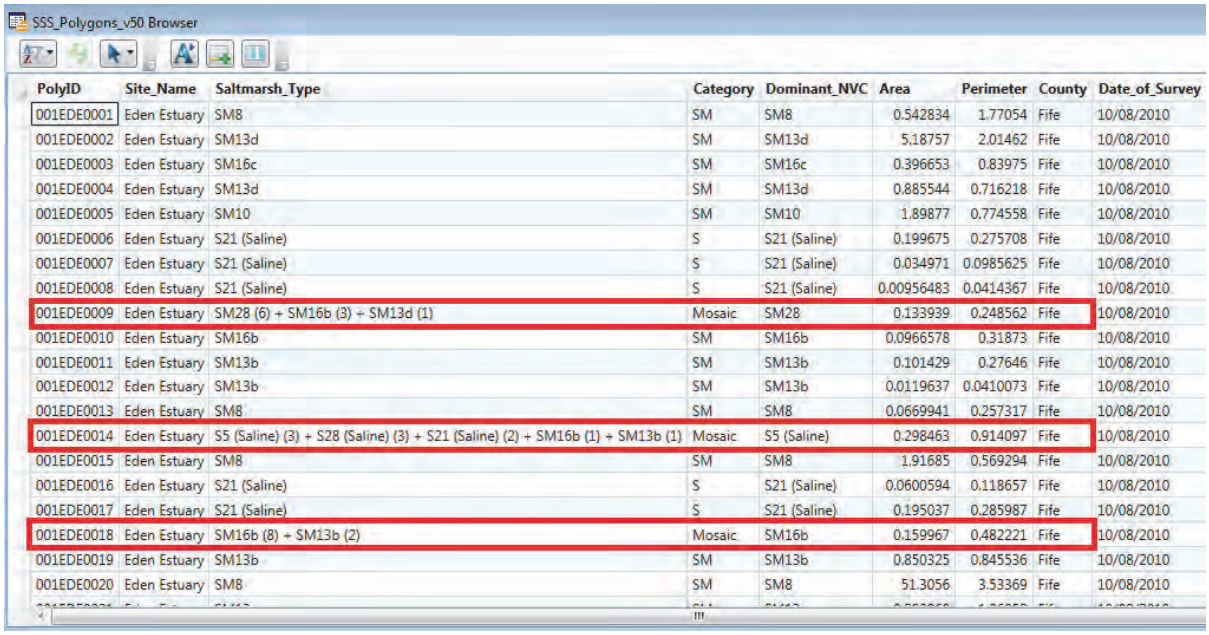
At this stage a thorough analysis of naming and formatting conventions was undertaken for the entire attribute table. Any NVC or land cover types which were new or did not conform to previous definitions were clarified with the respective surveyors.

A version history for the GIS database was also created and documents the major processes and modifications to the database including minor amendments.

2.7.9 Polygon type database

An important aspect of the GIS database is the ability to estimate the total area of NVC and land cover types, however, the existence of mosaic polygons can make such area estimates difficult to assess. The method of mosaic estimation applied in the field fits well with the development of an area estimate for each individual component of a mosaic, but such information is difficult to display in a succinct single database.

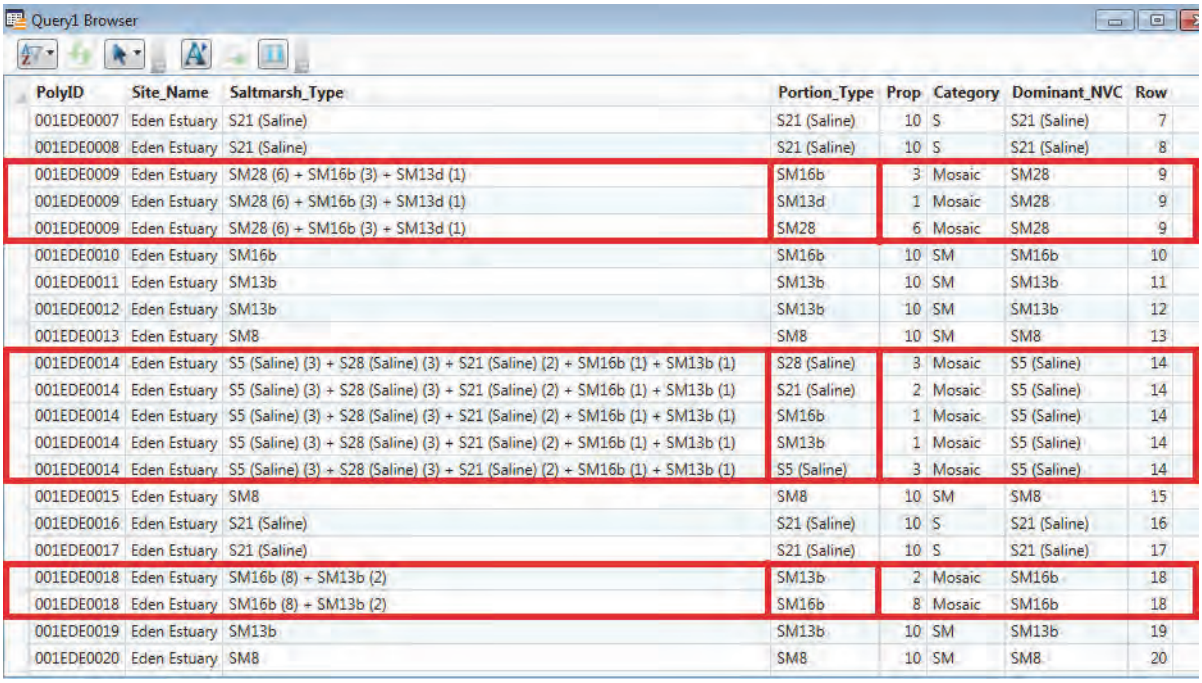
A sister database was created to ensure mosaic polygon data could be analysed accurately within estimations of area, perimeter and related statistics. The Polygon Type Database contains no geo-referenced shapes, but details the individual NVC and land cover types and their proportions within each polygon. Statistics can be created using these two tables to calculate the area of each mosaic component into an accurate measure of the whole resource (see Figure 2-10 and Figure 2-11).



SSS_Polygons_v50 Browser

PolyID	Site_Name	Saltmarsh_Type	Category	Dominant_NVC	Area	Perimeter	County	Date_of_Survey
001EDE0001	Eden Estuary	SM8	SM	SM8	0.542834	1.77054	Fife	10/08/2010
001EDE0002	Eden Estuary	SM13d	SM	SM13d	5.18757	2.01462	Fife	10/08/2010
001EDE0003	Eden Estuary	SM16c	SM	SM16c	0.396653	0.83975	Fife	10/08/2010
001EDE0004	Eden Estuary	SM13d	SM	SM13d	0.885544	0.716218	Fife	10/08/2010
001EDE0005	Eden Estuary	SM10	SM	SM10	1.89877	0.774558	Fife	10/08/2010
001EDE0006	Eden Estuary	S21 (Saline)	S	S21 (Saline)	0.199675	0.275708	Fife	10/08/2010
001EDE0007	Eden Estuary	S21 (Saline)	S	S21 (Saline)	0.034971	0.0985625	Fife	10/08/2010
001EDE0008	Eden Estuary	S21 (Saline)	S	S21 (Saline)	0.00956483	0.0414367	Fife	10/08/2010
001EDE0009	Eden Estuary	SM28 (6) + SM16b (3) + SM13d (1)	Mosaic	SM28	0.133939	0.248562	Fife	10/08/2010
001EDE0010	Eden Estuary	SM16b	SM	SM16b	0.0966578	0.31873	Fife	10/08/2010
001EDE0011	Eden Estuary	SM13b	SM	SM13b	0.101429	0.27646	Fife	10/08/2010
001EDE0012	Eden Estuary	SM13b	SM	SM13b	0.0119637	0.0410073	Fife	10/08/2010
001EDE0013	Eden Estuary	SM8	SM	SM8	0.0669941	0.257317	Fife	10/08/2010
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	Mosaic	S5 (Saline)	0.298463	0.914097	Fife	10/08/2010
001EDE0015	Eden Estuary	SM8	SM	SM8	1.91685	0.569294	Fife	10/08/2010
001EDE0016	Eden Estuary	S21 (Saline)	S	S21 (Saline)	0.0600594	0.118657	Fife	10/08/2010
001EDE0017	Eden Estuary	S21 (Saline)	S	S21 (Saline)	0.195037	0.285987	Fife	10/08/2010
001EDE0018	Eden Estuary	SM16b (8) + SM13b (2)	Mosaic	SM16b	0.159967	0.482221	Fife	10/08/2010
001EDE0019	Eden Estuary	SM13b	SM	SM13b	0.850325	0.845536	Fife	10/08/2010
001EDE0020	Eden Estuary	SM8	SM	SM8	51.3056	3.53369	Fife	10/08/2010

Figure 2-10: Part of the GIS Database, showing that each row relates to a single polygon. Note that mosaic polygons (highlighted in red) are included in a single row, making estimates of mosaic component areas difficult to assess.



Query1 Browser

PolyID	Site_Name	Saltmarsh_Type	Portion_Type	Prop	Category	Dominant_NVC	Row
001EDE0007	Eden Estuary	S21 (Saline)	S21 (Saline)	10	S	S21 (Saline)	7
001EDE0008	Eden Estuary	S21 (Saline)	S21 (Saline)	10	S	S21 (Saline)	8
001EDE0009	Eden Estuary	SM28 (6) + SM16b (3) + SM13d (1)	SM16b	3	Mosaic	SM28	9
001EDE0009	Eden Estuary	SM28 (6) + SM16b (3) + SM13d (1)	SM13d	1	Mosaic	SM28	9
001EDE0009	Eden Estuary	SM28 (6) + SM16b (3) + SM13d (1)	SM28	6	Mosaic	SM28	9
001EDE0010	Eden Estuary	SM16b	SM16b	10	SM	SM16b	10
001EDE0011	Eden Estuary	SM13b	SM13b	10	SM	SM13b	11
001EDE0012	Eden Estuary	SM13b	SM13b	10	SM	SM13b	12
001EDE0013	Eden Estuary	SM8	SM8	10	SM	SM8	13
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	S28 (Saline)	3	Mosaic	S5 (Saline)	14
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	S21 (Saline)	2	Mosaic	S5 (Saline)	14
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	SM16b	1	Mosaic	S5 (Saline)	14
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	SM13b	1	Mosaic	S5 (Saline)	14
001EDE0014	Eden Estuary	S5 (Saline) (3) + S28 (Saline) (3) + S21 (Saline) (2) + SM16b (1) + SM13b (1)	S5 (Saline)	3	Mosaic	S5 (Saline)	14
001EDE0015	Eden Estuary	SM8	SM8	10	SM	SM8	15
001EDE0016	Eden Estuary	S21 (Saline)	S21 (Saline)	10	S	S21 (Saline)	16
001EDE0017	Eden Estuary	S21 (Saline)	S21 (Saline)	10	S	S21 (Saline)	17
001EDE0018	Eden Estuary	SM16b (8) + SM13b (2)	SM13b	2	Mosaic	SM16b	18
001EDE0018	Eden Estuary	SM16b (8) + SM13b (2)	SM16b	8	Mosaic	SM16b	18
001EDE0019	Eden Estuary	SM13b	SM13b	10	SM	SM13b	19
001EDE0020	Eden Estuary	SM8	SM8	10	SM	SM8	20

Figure 2-11: Part of the Polygon Type Database showing how the same polygons highlighted in Figure 2-10 are displayed. Note that rows are divided by NVC or land cover components, thus, there can be more than one row referring to a single Polygon ID.

The Polygon Type Database was created by exporting the completed GIS attribute table into Microsoft Excel and dividing each of the mosaic descriptions into separate columns and multiplying the results by the number of individual components (e.g. a mosaic polygon with 'SM16b (8) + SM13b (2)' would be included twice). Errors were assessed using the same methods applied in 2.7.8.

2.7.10 Mapping legend

The attribute table for the GIS database includes a column for keying out colours in a map legend. Colour-coding is based on a modification of the JNCC Phase I methodology (JNCC 2010) in the map images presented in reports. The GIS database does not hold any colour-coding information.

2.7.11 Map images

The map image templates are produced in jpeg format at a resolution of 150 dpi. Map images were produced using Mapinfo (Pitney Bowes 2011), while others were produced using Mapmaker (Map Maker Ltd 2013) and ArcGIS (ESRI 2013). All surveyors were required to follow the map template as closely as possible.

2.7.12 Samples, target notes and tracks

Latitude and longitude data were extracted from the GPS source files for each GPS unit and modified so that they were in a suitable format for entry into the GIS system. Each target note and track point was then loaded into the GIS system as point data. Track maps were created by converting point data into polylines in chronological order within the GIS system. GPS Tracks and maps are found within the appendices of individual site reports (see Table 1-2 and appendix 2).

2.8 SSSI Site report development

A standard template for each report was created early into the project and was improved over the course of the project in conjunction with SNH and SEPA. Tenses and fonts were included within the template and each surveyor was briefed on the completion of the reports. These reports focus on the ecology of the site and the vegetation communities recorded. An index for all of the site reports is included in appendix 2.

2.9 SCM report development

SCM report templates were completed as per the SSS reports and include relevant information from the SSS report. These reports focus on failures to meet condition targets and any other relevant information on site condition. An index for all of the site reports is included in appendix 2.

2.10 Habitats Directive Article 17 Reporting

As part of an extension to the project, NatureBureau was contracted by SNH to appraise the overall condition of saltmarsh habitats identified under Annex I of the Habitats Directive. This appraisal was undertaken by reviewing the results of the condition monitoring surveys (see 2.6.9). This review was conducted by developing a Site Condition Monitoring Database file for each relevant Annex 1 habitat. Statistics for habitat extent and distribution were also compiled using GIS software. The two following Annex 1 habitats were considered as part of this reporting:

2.10.1 H1310 - Salicornia *and other annuals colonising mud and sand* (Pioneer marsh)

The following NVC types are represented by pioneer marsh (JNCC 2012):

- SM7 *Arthrocnemum perenne* stands
- SM8 Annual *Salicornia* salt-marsh community
- SM9 *Suaeda maritima* salt-marsh community
- SM27 Ephemeral salt-marsh vegetation with *Sagina maritima*

SM8 is the commonest of these communities in Scotland with SM9 also present to a limited extent.

Areas of annual *Salicornia* are also described as 'Pioneer saltmarsh' for WFD purposes.

2.10.2 H1330 - Atlantic salt meadows (Glauco-Puccinellietalia maritimae) (Atlantic saltmarsh)

The following NVC types are represented within H1330 (JNCC 2013):

- SM10 Transitional low-marsh vegetation
- SM11 *Aster tripolium* var. *discoideus* salt-marsh community
- SM12 Rayed *Aster tripolium* salt-marsh community
- SM13 *Puccinellia maritima* salt-marsh community
- SM14 *Halimione portulacoides* salt-marsh community
- SM15 *Juncus maritimus – Triglochin maritima* salt-marsh community
- SM16 *Festuca rubra* salt-marsh community (coastal examples only)
- SM17 *Artemisia maritima* salt-marsh community
- SM18 *Juncus maritimus* salt-marsh community
- SM19 *Blysmus rufus* salt-marsh community
- SM20 *Eleocharis uniglumis* salt-marsh community

Atlantic salt meadows correspond with 'middle' and 'upper' saltmarsh communities within the WFD.

2.11 National report data analysis

All data analyses in the national report were undertaken using the GIS databases and a collated database of SCM information.

2.11.1 SSSI and SAC analysis

All analyses of sites that are found within SSSI and SAC designated areas were assessed using up-to-date GIS layers for SACs and SSSIs provided by SNH.

2.11.2 NVC type analysis

All analyses of NVC types were assessed using the combined GIS polygon database and the Polygon Type database.

2.11.3 Distribution maps

All distribution maps were created on a 5km^2 grid to allow simple demonstration of the mapped data at coarser scales. An estimate of abundance for Figure 3-1 and Figure 3-27 was developed using a thematic layer with estimates of polygon occupancy (per square).

It should be noted that all distribution maps created in section 4 are based on mapped NVC communities and do not represent the distribution of individual species or include NVC communities that were below the 1:4,000 mapping scale (unless otherwise indicated).

2.11.4 Condition analysis

All condition data are collated from the completed SCM site forms. Estimates of earth banks and sea defences were developed from field records, discussions with surveyors and SCM data. These estimates were created by mapping polylines at a scale of 1:8,000.

3. SALTMARSHES OF SCOTLAND

3.1 Introduction

This section provides further information on the saltmarshes of Scotland, including their distribution, morphology and structure. The results of the saltmarsh condition monitoring surveys are also discussed.

3.2 The extent and distribution of saltmarshes in Scotland

3.2.1 Extent results

A total of 7,704ha of saltmarsh and associated habitat were surveyed in Scotland as part of the SSS project. Most of the vegetation types and land cover types shown in Table 3-1 were recorded from across saltmarsh habitat and their borders. The largest proportion of vegetation present was saltmarsh with 5,840ha (seeTable 3-2).

A total of 870ha of swamp vegetation was also recorded. Other vegetation and land cover types are also present on saltmarshes for example: 126ha of sand were mapped as part of the project, but much of this sand was recorded in mosaic with pioneer saltmarsh. Note that a range of vegetation communities can be found across saltmarsh habitat including grassland, fen and sand dune communities. These communities are present due to surrounding ecological factors, management and modifications. Over 50% of the total area of saltmarsh in Scotland is SM16 (*Festuca rubra* saltmarsh*)* with 27% SM13 (*Puccinellia maritima* saltmarsh). Further details are provided in Table 3-3.

Table 3-1: Full list of NVC and land cover codes from the SSS surveys.

Code	Description	Code Origin
A11	*Potamogeton pectinatus-Myriophyllum spicatum* community	NVC
A16	*Callitriche stagnalis* community	NVC
All car	*Allium carinatum* community	New codes for SSS
Ast nov	*Aster novi-belgii* community	New codes for SSS
BBG	Buildings and Bare Ground	Dargie (2000a)
BM	Bare Mud	Dargie (2001)
BR	Bare Rock	Dargie (2001)
BS	Bare Sand	Dargie (2001)
BSH	Bare Shingle	Dargie (2001)
BSHc	*Cochlearia officinalis* pioneer community (dense-sparse) on shingle	New codes for SSS
BSHx	*Armeria maritima* pioneer community (sparse) on shingle	New codes for SSS
Car rec	*Carex recta* community	New codes for SSS
Car rec x Car aqu	*Carex recta* x *Carex aquatilis* hybrid community	New codes for SSS
Car sal	*Carex salina* community	New codes for SSS
CG10	*Festuca ovina-Agrostis capillaris-Thymus praecox* grassland	NVC
Fal jap	*Fallopia japonica* community	New codes for SSS
H7	*Calluna vulgaris-Scilla verna* heath	NVC
H10	*Calluna vulgaris-Erica cinerea* heath	NVC
Her man	*Heracleum mantegazzianum* community	New codes for SSS
Imp gla	*Impatiens glandulifera* community	New codes for SSS
Iri pse	*Iris pseudacorus* community	New codes for SSS

M	NVC Mire grouping	NVC
M6	*Carex echinata-Sphagnum recurvum/auriculatum* mire	NVC
M13	*Schoenus nigricans-Juncus subnodulosus* mire	NVC
M15	*Scirpus cespitosus-Erica tetralix* wet heath	NVC
M16	*Erica tetralix-Sphagnum compactum* wet heath	NVC
M17	*Scirpus cespitosus-Eriophorum vaginatum* blanket mire	NVC
M23	*Juncus effusus*/*acutiflorus-Galium palustre* rush-pasture	NVC
M23b	*Juncus effusus*/*acutiflorus-Galium palustre* rush-pasture, *Juncus effusus* sub-community	NVC
M25	*Molinia caerulea-Potentilla erecta* mire	NVC
M25x	*Molinia caerulea-Potentilla erecta* mire - *Iris pseudacorus-Filipendula ulmaria* mire. *Poa trivialis* sub-community	Dargie (2000a)
M27	*Filipendula ulmaria-Angelica sylvestris* mire	NVC
M28	*Iris pseudacorus-Filipendula ulmaria* mire	NVC
MC	NVC Maritime Cliff grouping	NVC
MC2	*Armeria maritima-Ligusticum scoticum* maritime rock-crevice community	NVC
MC5	*Armeria maritima-Cerastium diffusum* ssp. *diffusum* maritime therophyte community	NVC
MC8	*Festuca rubra-Armeria maritima* maritime grassland	NVC
MC8g	*Festuca rubra-Armeria maritima* maritime grassland, *Armeria maritima*-dominated sub-community	NVC
MC9	*Festuca rubra-Holcus lanatus* maritime grassland	NVC
MC10	*Festuca rubra-Plantago* spp. maritime grassland	NVC
MC10b	*Festuca rubra-Plantago* spp. maritime grassland, *Carex panicea* sub-community	NVC
MC10c	*Festuca rubra-Plantago* spp. maritime grassland, *Schoenus nigricans* sub-community	NVC
MG	NVC Mesotrophic grassland grouping	NVC
MG1	*Arrhenatherum elatius* grassland	NVC
MG1a	*Arrhenatherum elatius* grassland, *Festuca rubra* sub-community	NVC
MG5	*Cynosurus cristatus-Centaurea nigra* grassland	NVC
MG6	*Lolium perenne-Cynosurus cristatus* grassland	NVC
MG9	*Holcus lanatus-Deschampsia cespitosa* grassland	NVC
MG10	*Holcus lanatus-Juncus effusus* rush-pasture	NVC
MG11	*Festuca rubra-Agrostis stolonifera-Potentilla anserina* grassland	NVC
MG12	*Festuca arundinacea* grassland	NVC
MG13	*Agrostis stolonifera-Alopecurus geniculatus* grassland	NVC
Mim gut	*Mimulus guttatus* community	New codes for SSS
Mx	*Carex nigra* rich fen (Machair fens)	Dargie (2000a)
OV	NVC Open vegetation community	NVC
OW	Open Water	Dargie (2001)
Pans	Pans	New codes for SSS
RF	Rock with fucoids	New codes for SSS
Rud lac	*Rudbeckia laciniata* community	New codes for SSS
S	NVC Swamp community	NVC
S3 (Saline)	*Carex paniculata* swamp	Adapted from NVC

S4	*Phragmites australis* swamp and reed-beds	NVC
S4 (Saline)	Brackish *Phragmites australis* swamp and reed-beds	Adapted from NVC
S5	*Glyceria maxima* swamp	NVC
S6	*Carex riparia* swamp	NVC
S7	*Carex acutiformis* swamp	NVC
S12	*Typha latifolia* swamp	NVC
S12 (Saline)	Brackish *Typha latifolia* swamp	Adapted from NVC
S14	*Sparganium erectum* swamp	NVC
S18	*Carex otrubae* swamp	NVC
S19	*Eleocharis palustris* swamp	NVC
S19 (Saline)	Brackish *Eleocharis palustris* swamp	Adapted from NVC
S20	*Scirpus lacustris* ssp. *tabernaemontani* swamp	NVC
S20 (Saline)	Brackish *Scirpus lacustris* ssp. *tabernaemontani* swamp	Adapted from NVC
S21	*Scirpus maritimus* swamp	NVC
S21 (Saline)	Brackish *Scirpus maritimus* swamp	Adapted from NVC
S22	*Glyceria fluitans* water-margin vegetation	NVC
S28	*Phalaris arundinacea* tall-herb fen	NVC
S28 (Saline)	Brackish *Phalaris arundinacea* tall-herb fen	Adapted from NVC
Sal Scr	Salix scrub	New codes for SSS
SD	NVC Sand dune vegetation	NVC
SD2	*Honkenya peploides-Cakile maritima* strandline community	NVC
SD3	*Matricaria maritima-Galium aparine* strandline community	NVC
SD4	*Elymus farctus* ssp. *boreali-atlanticus* foredune community	NVC
SD5	*Leymus arenarius* mobile dune community	NVC
SD5a	*Leymus arenarius* mobile dune community, species-poor sub-community	NVC
SD5c	*Leymus arenarius* mobile dune community, *Festuca rubra* sub-community	NVC
SD6	*Ammophila arenaria* mobile dune community	NVC
SD7	*Ammophila arenaria-Festuca rubra* semi-fixed dune community	NVC
SD8	*Festuca rubra-Galium verum* fixed dune grassland	NVC
SD9	*Ammophila arenaria-Arrhenatherum elatius* dune grassland	NVC
SD10	*Carex arenaria* dune community	NVC
SD12	*Carex arenaria-Festuca ovina-Agrostis capillaris* dune grassland	NVC
SF	Shingle with fucoids	New codes for SSS
SM1	*Zostera* communities	NVC
SM2	*Ruppia maritima* salt-marsh community	NVC
SM5	*Spartina alterniflora* saltmarsh	NVC
SM6	*Spartina anglica* saltmarsh	NVC
SM8	*Annual Salicornia* saltmarsh	NVC
SM9	*Suaeda maritima* saltmarsh	NVC
SM10	Transitional low-marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*	NVC
SM12a	Coastal stands of rayed *Aster tripolium*	NVC
SM13a	*Puccinellia maritima* saltmarsh - *Puccinellia maritima* dominated sub-community	NVC
SM13b	*Puccinellia maritima* saltmarsh - *Glaux maritima* sub-community	NVC

SM13c	*Puccinellia maritima* saltmarsh - *Limonium vulgare-Armeria maritima* sub-community	NVC
SM13d	*Puccinellia maritima* saltmarsh - *Plantago maritima-Armeria maritima* sub-community	NVC
SM13e	*Puccinellia maritima* saltmarsh - *Puccinellia maritima*-turf fucoid sub-community	NVC
SM13x	*Puccinellia maritima* saltmarsh - *Puccinellia maritima-Spartina anglica* sub-community	New codes for SSS
SM14a	*Halimione portulacoides* saltmarsh - *Halimione portulacoides* dominated sub-community	NVC
SM14c	*Halimione portulacoides* saltmarsh - *Puccinellia maritima* sub-community	NVC
SM15	*Juncus maritimus-Triglochin maritima* saltmarsh	NVC
SM16a	*Festuca rubra* saltmarsh - *Puccinellia maritima* sub-community	NVC
SM16b	*Festuca rubra* saltmarsh - *Juncus gerardii* dominated sub-community	NVC
SM16c	*Festuca rubra* saltmarsh - *Festuca rubra-Glaux maritima* sub-community	NVC
SM16cx	*Festuca rubra* saltmarsh - *Agrostis stolonifera*/*Festuca rubra-Glaux maritima* sub-community	New codes for SSS
SM16d	*Festuca rubra* saltmarsh - Tall *Festuca rubra* dominated sub-community	NVC
SM16e	*Festuca rubra* saltmarsh - *Leontodon autumnalis* sub-community	NVC
SM16f	*Festuca rubra* saltmarsh - *Carex flacca* sub-community	NVC
SM16g	*Festuca rubra* saltmarsh - *Juncus gerardii*, *Agrostis stolonifera*, *Glaux maritima* & *Triglochin maritimum* pioneer sub-community	New codes for SSS
SM16i	*Festuca rubra* saltmarsh - *Agrostis stolonifera*/*Triglochin maritimum* dominated sub-community	New codes for SSS
SM16jb	*Festuca rubra* saltmarsh - *Festuca rubra* and *Juncus balticus* sub-community	New codes for SSS
SM16p	*Festuca rubra* saltmarsh - *Eleocharis palustris* variant	New codes for SSS
SM16t	*Festuca rubra* saltmarsh - Transitional saltmarsh sub-community	New codes for SSS
SM16x	*Festuca rubra* saltmarsh - *Festuca rubra* and *Molinia caerulea* sub-community	New codes for SSS
SM17	*Artemisia maritima* saltmarsh	NVC
SM18a	*Juncus maritimus* saltmarsh community - *Plantago maritima* sub-community	NVC
SM18b	*Juncus maritimus* saltmarsh community - *Oenanthe lachenalii* sub-community	NVC
SM18x	*Juncus maritimus* saltmarsh community - proposed *Molinia caerulea* sub-community	New codes for SSS
SM19	*Blysmus rufus* saltmarsh	NVC
SM20	*Eleocharis uniglumis* saltmarsh community	NVC
SM23	*Spergularia marina-Puccinellia distans* saltmarsh community	NVC
SM27	Ephemeral saltmarsh vegetation with *Sagina maritima*	NVC
SM28	*Elymus repens* saltmarsh	NVC
SM28x	*Festuca rubra* dominated variant	New codes for SSS
Spe med	*Spergularia media* only	New codes for SSS
U	NVC Acid grassland grouping	NVC
U4	*Festuca ovina-Agrostis capillaris-Galium saxatile* grassland	NVC
U4b	*Festuca ovina-Agrostis capillaris*-Galium saxatile grassland, *Holcus lanatus-Trifolium repens* sub-community	NVC
U5	*Nardus stricta-Galium saxatile* grassland	NVC
W	NVC Woodland grouping	NVC
W2	*Salix cinerea-Betula pubescens-Phragmites australis* woodland	NVC

W3	*Salix pentandra-Carex rostrata* woodland	NVC
W4	*Betula pubescens-Molinia caerulea* woodland	NVC
W5	*Alnus glutinosa-Carex paniculata* woodland	NVC
W7	*Alnus glutinosa-Fraxinus excelsior-Lysimachia nemorum* woodland	NVC
W10	*Quercus robur-Pteridium aquilinum-Rubus fruticosus* woodland	NVC
W21	*Crataegus monogyna-Hedera helix* scrub	NVC
W23	*Ulex europaeus-Rubus fruticosus* scrub	NVC
W25	*Pteridium aquilinum-Rubus fruticosus* underscrub	NVC

Table 3-2: Habitat Area Summary.

Vegetation/Land Cover	**Area (Ha)**
Saltmarsh	5,840
Swamp	870
Grassland	424
Sand Dune	130
Bare Sand	126
Mire	95
Woodland	46
Aquatic Vegetation	39
Cliff	33
Shingle	31
Bare Mud	28
Water	16
Bare Rock	13
Heath	7
Buildings/Roads	3
Invasive Species	2
Open Vegetation	<1
Bare Rock	<1
Total	**7,704**

Table 3-3: Summary of the extent of saltmarsh communities in Scotland.

Saltmarsh Community	**Area (Ha)**
SM1	8
SM2	<1
SM6	83
SM8	279
SM9	12
SM10	51
SM12	92
SM13	1,610
SM14	18
SM15	<1

SM16	3,197
SM17	4
SM18	50
SM19	18
SM20	35
SM23	1
SM27	7
SM28	351
Other Vegetation and Cover	24
Total	**5,840**

3.2.2 Extent comparison

Table 3-4 provides a comparison with the previously estimated saltmarsh extents for Scotland. It should be noted that the present survey demonstrates the first detailed analysis of saltmarsh habitat in Scotland using GIS software. The methodology developed for the SSS project is very different to the methods used by Burd (1989) for assessing area, which used dot maps to assess hand-drawn maps on Ordnance Survey maps, while the present survey utilised aerial photography and area statistics assessed by GIS. The vegetation and habitats assessed were similar in both surveys, with many of the habitat maps within Burd's regional reports providing valuable information about the historical condition of each site. These maps provided useful information on the distribution and patterning of vegetation communities and the range of species present, but they are insufficient for providing a robust estimate for changes in extent (due to the low resolution of the mapping undertaken). The SSS survey provides more data on bordering transitional communities than Burd (1989), but further work on the extent and dynamics of transitional communities is required (see 5.6.10). It is not clear from the Saltmarsh Survey of Great Britain whether Burd's totals include transitions and swamp communities (see Table 3-4).

The polygon dataset produced by Posford Duvivier (1998) does not include as many sites as the SSS project, but takes account of the majority of larger saltmarsh sites. The polygons are of a coarser scale and are often significant over or under estimates.

The SNH Point Dataset (2009) is based on the area estimates from Burd (1989) with additional sites added, thus the comments above apply equally to this dataset.

It should be noted that the SSS extent figures account for sites over 3ha in area, thus the total amount of saltmarsh in Scotland will be higher.

Table 3-4: Comparison of overall saltmarsh extent from Burd (1989), Posford Duvivier (1998) and SNH (2009).

Extent estimate (Ha) from previous surveys	Extent estimate (Ha) from current survey	Difference
Burd		
6,089	7,704	+27%
Posford Duvivier		
5,747	7,704	+34%
SNH Point Dataset		
6,248	7,704	+23%

3.2.3 Extent of Annex I habitat types

The current extent of Pioneer Saltmarsh (H1310) surveyed is 291ha. Based on the results of the SSS field surveys, it would appear that H1310 is declining on the west coast, but with minimal impacts on overall extent (due to the small areas of H1310 present on the west coast). H1310 is only present in sparse formations on the Solway Firth, where denser and larger areas were indicated in previous reports. The reasons for such a change are unclear at the present time, but natural succession is a possible factor on the Solway Firth (with former H1310 habitat now better representing H1330). See 4.3.3 and the Solway series of SSS site reports for further information.

H1310 on the east coast is stable, with some area losses due to site modifications (e.g. Whiteness Head). Conversely, some saltmarsh modifications (such as sediment digging in the upper levels of saltmarshes) have increased the area of H1310 on certain sites (see the SSS reports for Skinflats and Eden Estuary).

The current extent of Atlantic Saltmarsh (H1330) surveyed is 5,075 ha. Of the 249 sites reviewed, 46 sites were noted to fail targets for maintained extent. Evidence for such a decline relates to observations on eroding coastal edges, land use change, human modifications, changes in hydrology and salinity, and misinterpretation within previous surveys (see 3.8).

Some of the largest losses are due to sites formerly identified as H1330 habitat being recorded in the SSS surveys as more terrestrial in nature than previous surveys; with coastal grasslands MG11-13 recorded frequently. This could be due to differences in the classification of communities across different surveys or genuine change (see the SSS East Coast site reports for Beauly Firth, Bonar Bridge, Conon Islands, Spey Bay and Udale Bay).

Some larger areas of H1330 appear to have decreased in extent on the Solway Firth, with Priestside Bank and Caerlaverock showing losses. However, Caerlaverock has shown a net gain in saltmarsh area, mainly due to the saltmarsh habitat expanding onto the sand/mud flats (see the SSS site report for Caerlaverock). Aerial imagery for the Solway Firth (particularly in the east) was taken at high tide which has led to saltmarsh extent being under-recorded in the past (e.g. see the SSS report for Gretna to Redkirk).

Site specific statistics regarding NVC sub-communities and comparisons of the SSS survey findings with previous surveys are found in the individual SSS site reports (see Table 1-2).

3.2.4 Distribution results

Figure 3-1 shows the distribution of Scottish saltmarshes covered by the SSS project. The largest saltmarshes are found on the Solway Firth, which includes all three of Scotland's largest saltmarshes (Caerlaverock, Kirkconnell Merse and Wigtown). In between these large complexes are narrow borders of marsh, which are present across most of the northern border of the Solway Firth.

The remainder of the west coast is occupied by a high number of small to medium sized saltmarshes. Most of these marshes are associated with sea lochs. Larger marshes include Gruinart Flats on Islay; Loch Crinan in Argyll; and Loch Carron in West Ross.

A high number of small-medium size saltmarshes are also found in the Outer Hebrides, particularly on North Uist, where the largest saltmarshes are found on Baleshare (e.g. Illeray).

A small number of isolated small-medium sized sites are found on the north coast mainland, Orkney and Shetland, which include perched and loch-head sites.

Large saltmarshes are present on the east coast (associated with the Forth, Tay, Moray, Cromarty and Dornoch firths), with the Tay Estuary, Culbin and Morrich More being the largest saltmarsh complexes found in these areas. The northern mainland limit of saltmarsh is Melvich on the north coast and the southern limit is Manxman's Lake on the Solway Firth. Only a small number of saltmarshes are found in Aberdeenshire, which is related to the rocky coastline.

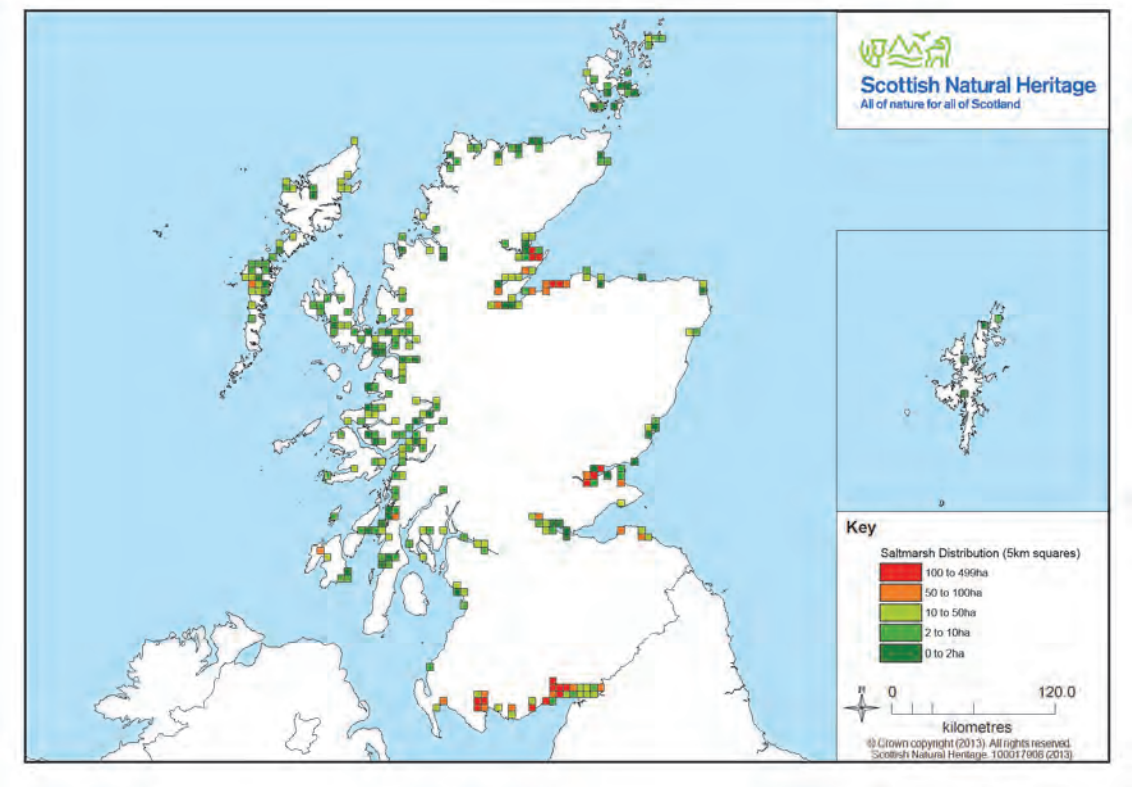


Figure 3-1: Distribution of saltmarsh across Scotland (5km grid).

3.2.5 Distribution of Annex I habitat types

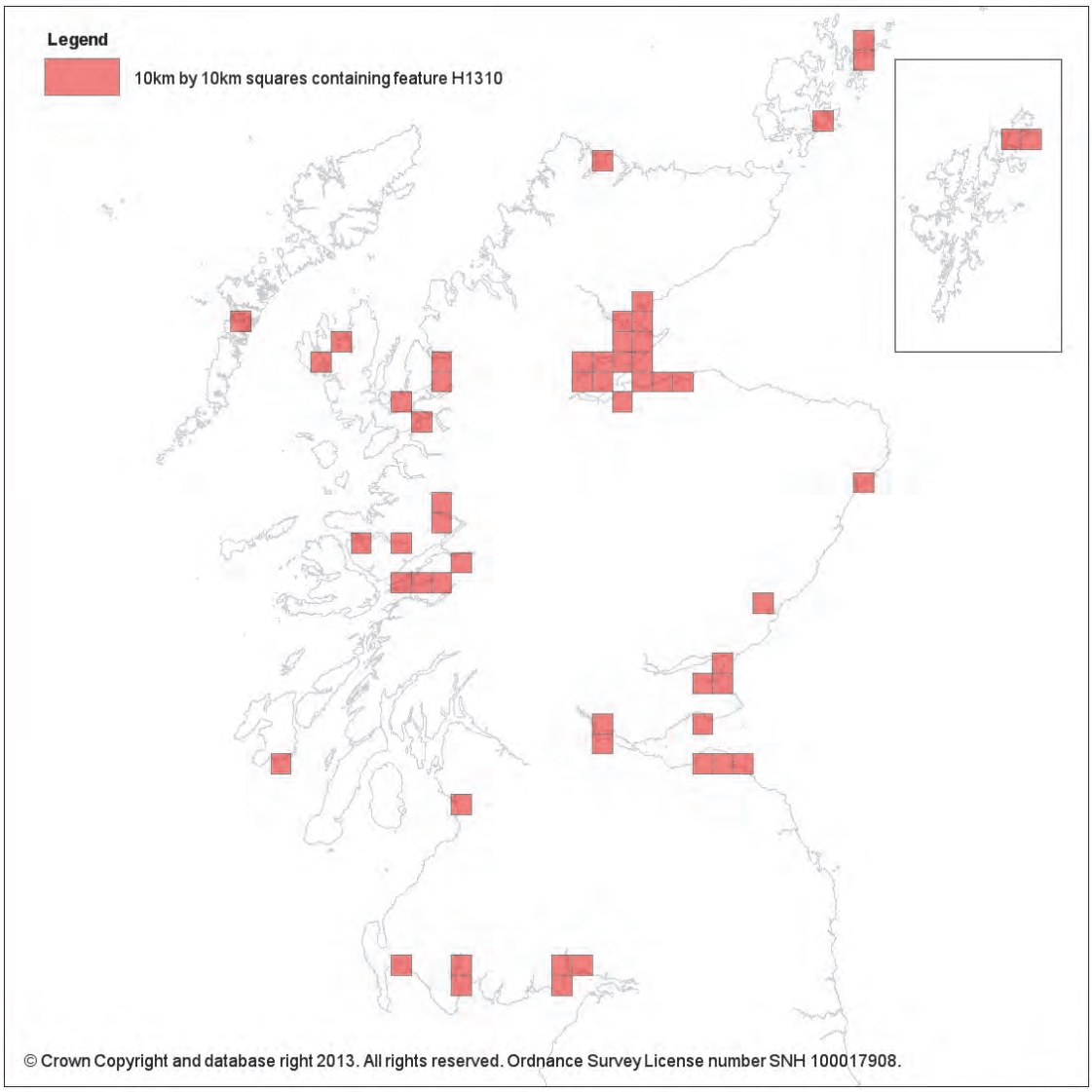


Figure 3-2: Distribution of H1310 (10km grid)

The distribution of H1310 shows that the habitat is strongly associated with the east coast of Scotland (see Figure 3-2). Large areas are found at Tyninghame Shore and Aberlady Bay (East Lothian). Smaller areas are found further into the Firth of Forth, associated with the front of the Grangemouth industrial complex and also at Skinflats.

On the south-east coast, the Eden Estuary (Fife) hosts one of the largest recorded areas of H1310 in Scotland; growing on sand flats on the south shore of the estuary (54 ha). The habitat is found only in small areas at the outer edges of the Tay Estuary and in Montrose Basin (Angus).

On the north-east coast, the habitat is found in large areas in Moray and the Cromarty and Dornoch Firths. The largest areas recorded are from Culbin (Moray), Morrich More (Dornoch Firth), Dingwall (Cromarty Firth) and Munlochy Bay (Moray Firth).

On the Solway (Dumfries and Galloway) only limited amounts of H1310 were recorded. Bands of H1310 were noted at Wigtown, Caerlaverock and Luce Bay. Although the area of

polygons can be extensive (88 ha at Wigtown and 64 ha at Caerlaverock), the constituent species only contribute a small amount of the area, which is mostly open mud or sand.

H1310 is restricted on the west coast with localised areas present, the largest being at the Garnock Estuary (North Ayrshire) with 1.82 ha. The habitat is also found along the edges of Loch Creran (Argyll) and Loch Eil (Lochaber), Loch Carron and Loch Torridon (West Ross). Small areas were also recorded from Loch an-t sailein (Lochaber).

The distribution of H1310 becomes restricted further north with only small areas found at Loch Fleet (east coast) and the most northerly mainland record of H1310 taken from Loch Eriboll.

Only one site for H1310 is recorded from the Outer Hebrides at Grimsay (North Uist).

On Orkney Mainland only one site for H1310 is recorded (Bay of Suckqouy). H1310 is present from a number of small saltmarsh sites on Sanday including Little Sea, Torr Ness to Quivals Creek, Cata Sand and Lamaness South (West).

The northern limit of the habitat is Baltasound (Unst) with 0.56ha on Shetland.

It should be noted that the constituent species of H1310 are also found within other saltmarsh communities, and the information provided only details situations where the species in question have formed a geographical area large enough to be classified as a mappable saltmarsh community (NVC classes SM8 and SM9).

It would appear from the SSS data that the distribution of H1310 is more restricted than previously reported. Only limited areas of H1310 were recorded on the Solway Firth, where more extensive areas were previously recorded. The Firth of Clyde; Firth of Forth; and the Tay Estuary are potential areas where H1310 should be capable of occurring more frequently. It is noted that brackish swamp often borders the pioneer zone of the saltmarsh (particularly *Bolboschoenus maritimus*) in these areas.

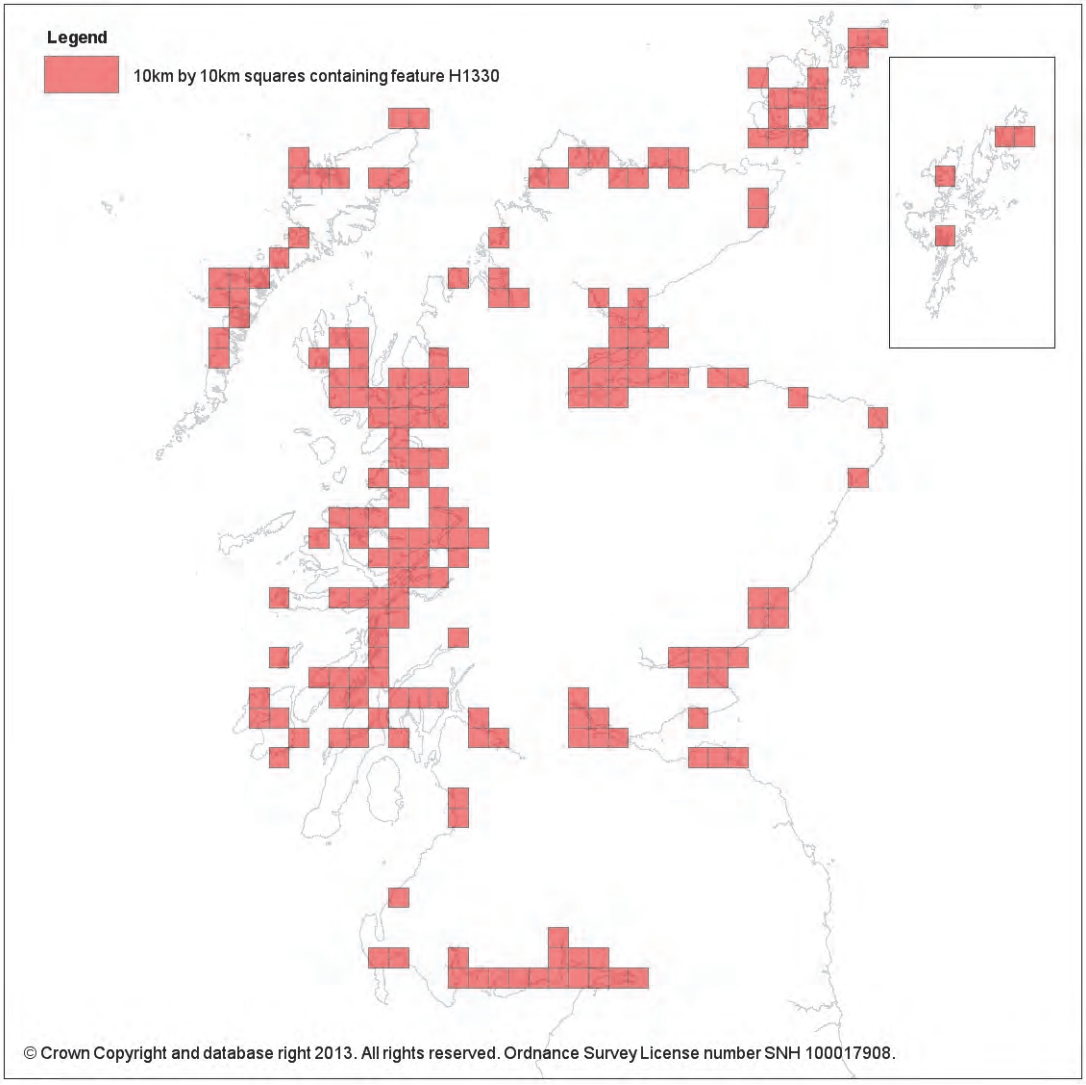


Figure 3-3: Distribution of H1330 (10km grid)

Figure 3-3 shows the distribution of H1330. It can be seen that the distribution of H1330 is widespread across Scotland.

3.2.6 Range of Annex I habitat types

The range of H1310 indicates that it is capable of occupying the majority of sand and mud-based bays and estuaries present in Scotland. It is unlikely that the habitat will colonise cliff-lined coast. H1310 is recorded from coarse shingle on the west coast and offshore islands, but is localised. It is unlikely that H1310 will occupy stony sea lochs, due to the substrate being unsuitable for H1310 to colonise.

Figure 3-3 presents the range of H1330. This habitat is capable of occupying the majority of sand and mud-based bays and estuaries in Scotland. In addition H1330 is capable of developing in north and west coast loch-heads (with stone, shingle, mud or sand substrates). Small areas of H1330 are able to develop on thicker sediments on top of (and behind) sea cliffs.

3.3 Saltmarsh types

There are a variety of different saltmarsh types found in Scotland. Some of these types have unique vegetation communities associated with them and others have unique pressures and locations. Note that the figures following site names are the total area of saltmarsh in hectares taken from the NVC sub-communities recorded in the GIS Polygon dataset.

3.3.1 Estuarine saltmarshes

Estuarine saltmarshes are found in the transitional area between mudflats and terrestrial habitats. They often form in the wider mouth of estuaries, normally behind a sheltered headland. The movement of sediment and regular influxes of saline water allow expansive saltmarshes to form. Estuarine marsh can include a number of other types (discussed below), with the most common being embayment and river fringing types and should be considered as an overarching group of saltmarshes.

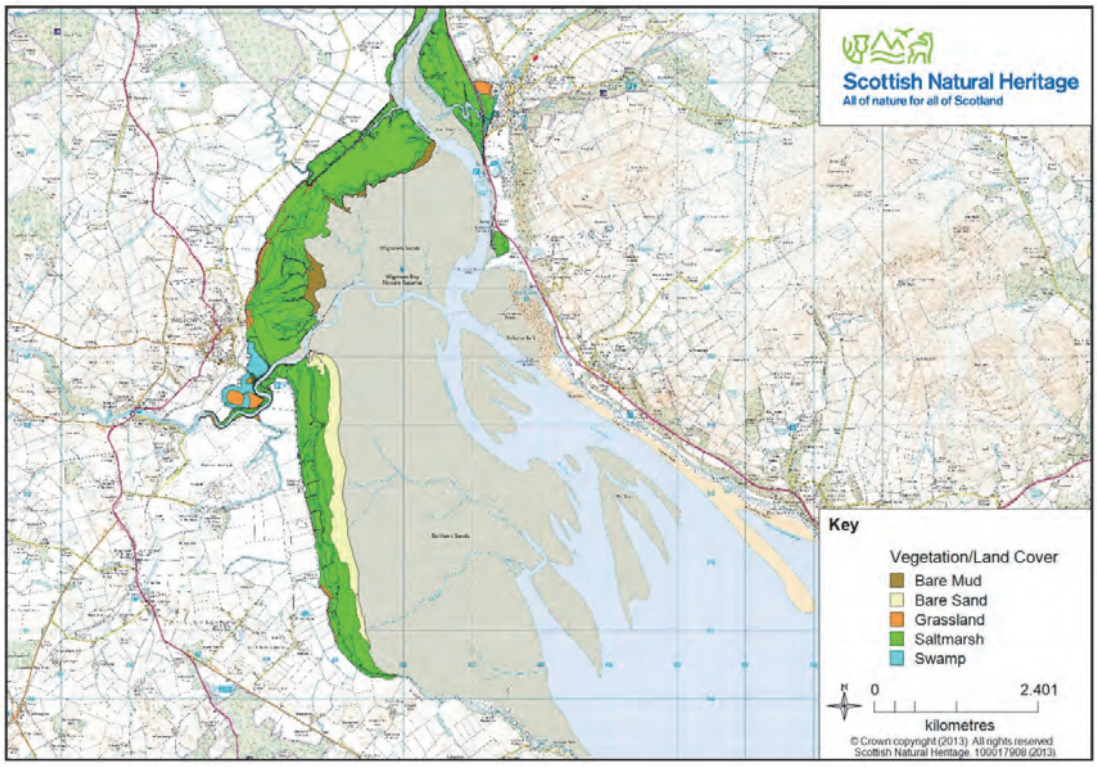


Figure 3-4: Estuarine saltmarsh at Wigtown. Note that the saltmarsh occurs on both sides of the estuarine channel.

All of the largest saltmarshes in Scotland are estuarine in nature. Kirkconnell Merse (213ha) is associated with the Nith Estuary, while Caerlaverock (716ha) is found between the Nith Estuary and Lochar Water and is part of the wider Solway Firth. Wigtown's saltmarshes (676ha) are associated with the Cree Estuary (see Figure 3-4).

Other noteworthy saltmarshes in estuaries include the Forth (119ha); Beauly Firth (45ha); Cromarty Firth (200ha); and the Garnock Estuary (45ha).

Brackish swamp is a key component of estuarine systems with S21 (*Scirpus maritimus* swamp) and S4 (*Phragmites australis* swamp and reed-beds) abundant on many of the systems discussed above. The Tay Estuary is mostly brackish S4, with very little saltmarsh present (11ha of saltmarsh and 310ha of brackish swamp). Large stands are also present on

the Clyde (23ha of saltmarsh and 18ha of brackish swamp) and the Solway Firth (2,324ha of saltmarsh and 103ha of brackish swamp).

Some unusual vegetation types also occur in the pioneer zone of estuarine systems with S21 and SM16b (*Juncus gerardii* dominated sub-community) occurring at the seaward fringe of the marsh (see section 1 for further details).

Creeks on estuarine systems are abundant quite far into the saltmarsh zone. They can also be quite deep.

Estuarine systems are dynamic and the longevity of these saltmarshes is dependent on the complex interplay of geomorphological and tidal processes, which can cause drastic and significant changes to saltmarsh, such as the drifting of deep river channels and the re-depositing of soils, shingle and sand. For these reasons, the surveys of estuarine systems often indicate large losses but also large gains in habitat area.

3.3.2 Embayment saltmarshes

Embayment marshes are saltmarshes developing in a bay where surrounding headlands protect the saltmarsh from wave action. This is a very common type of saltmarsh in Scotland. Embayment marshes are often crescent-shaped formations and often include a full range of saltmarsh zones. Embayment marshes are similar to estuarine saltmarshes but embayment saltmarshes are generally smaller. Embayment marsh is often present in estuarine saltmarshes (where bays are present on the shore of larger estuaries such as the Tay and the Solway) and larger sea lochs. The shape of a bay allows a wide saltmarsh to develop near the centre of the crescent, which gradually narrows towards the outer limits of the bay (see Figure 3-5).

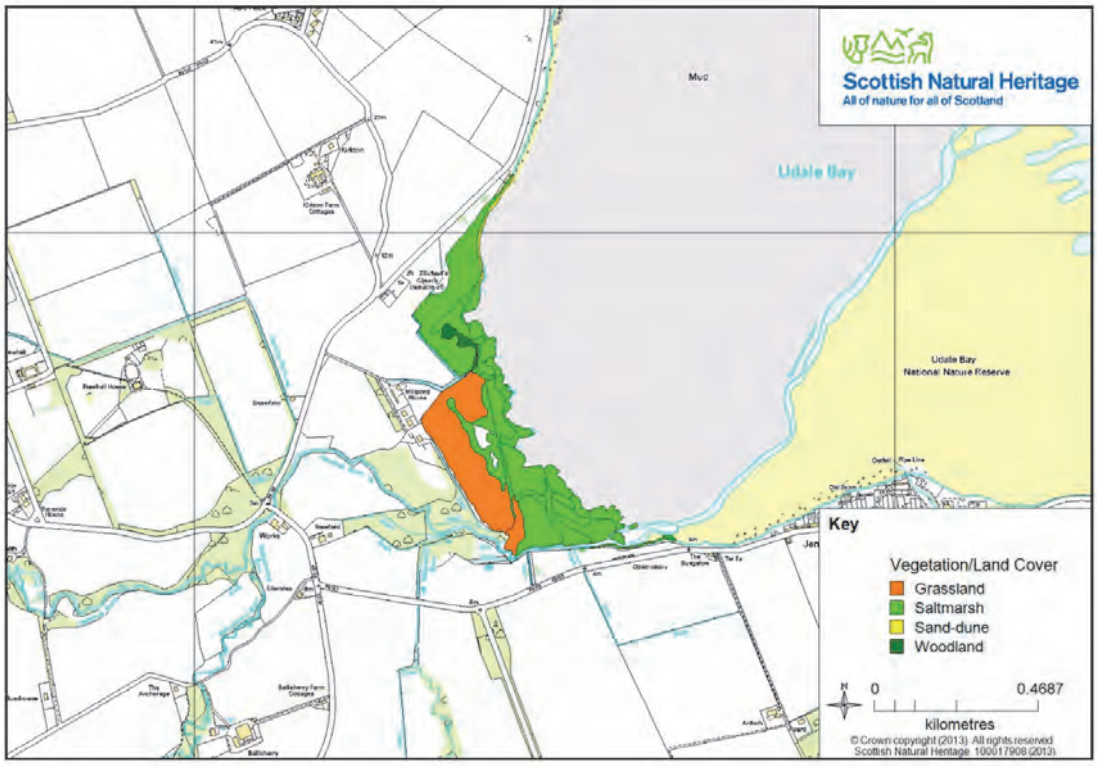


Figure 3-5: Typical embayment saltmarsh at Udale Bay, Cromarty Firth. Note the much larger scale of map when compared to Figure 3-4.

The largest embayment marsh is Findhorn Bay where large areas of saltmarsh (196ha) are found around the entirety of the bay. The width of many of the embayment marshes allows a range of transitional communities to develop at the landward boundaries of the habitat. These include mesotrophic grasslands, swamps, heathland and mire. Embayment marshes are strongly associated with the east coast and the Solway Firth and the Outer Hebrides. North Uist and Lewis have a high number of embayment marshes in the open sandy coasts of Vallay and Tong Saltings.

If the surrounding areas of an embayment marsh are converted to agricultural land or adapted with flood defences, the saltmarshes can narrow and become thin marsh belts (such as Sandi Sand on Orkney and sections of Nigg Bay on the Cromarty Firth).

Embayment marshes are more stable than other types as their dependence on the surrounding geography to deposit sediment allows these marshes to continue to build. Pressure from surrounding developments such as road embankments, flood defence schemes and grazing are the main factors that can cause erosion and losses on embayment systems.

3.3.3 Back-barrier saltmarshes

Back-barrier saltmarsh forms in the shelter of sand dune and shingle structures, which shelter the marsh from direct wave action. They are also found behind shingle spits and bars on the west coast. On the east coast and Solway Firth, back-barrier marshes normally develop parallel to the coastline, between two sets of tall sand dunes or shingle ridges (see Figure 3-6). This parallel formation is created by regular tidal intrusion into the dunes, which causes erosion. What remains is a flat plateau of short vegetation developing over mud, sand and shingle, which is regularly inundated. This character creates a very different type of saltmarsh with many stunted variants of saltmarsh plants intermingled with sand dune vegetation of embryo dunes.

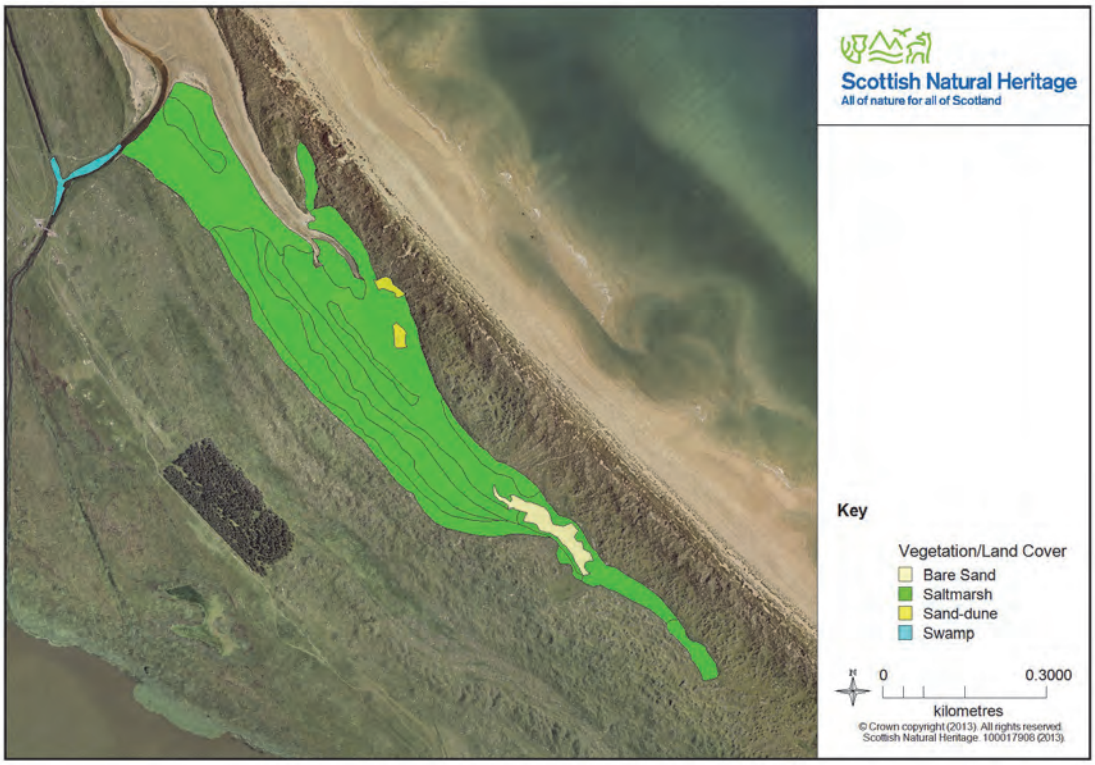


Figure 3-6: Typical back-barrier marsh at Strathbeg, Aberdeenshire.

Back-barrier saltmarshes in Scotland are rare, with only a few examples present on the west, east coast and the Outer Hebrides. They show a high species and vegetation community diversity compared to all other saltmarsh types, which is due, in part, to sand dune vegetation being a key component of the typology. It should be noted that west coast back-barrier marshes do not include sand dune vegetation as they are normally associated with shingle structures.

As back-barrier marshes form in the shelter of sand dune and shingle habitat, they are normally free of surrounding sea defences and land claim, allowing some of the widest habitat transition zones to develop. Some of these marshes are bordered by stable dunes as part of golf courses, but these marshes can still present a very wide and diverse transitional zone.

There is also a number of saltmarsh sub-community types which have a strong association with back-barrier marsh, including SM9 (*Suaeda maritima* saltmarsh), SM10 (Transitional low-marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*) and SM17 (*Artemisia maritima* saltmarsh). Back barrier marsh is also host to a

variant form of SM13d (*Plantago maritima-Armeria maritima* sub-community), which is heavily stunted and dominated by *Plantago maritima* and *Armeria maritima*. Sedges normally found in diverse upper marsh habitat are also found in this SM13d variant.

Unlike the other saltmarsh types, creeks and pans are infrequent, with pans (if present) being very shallow and more akin to wind blow-outs in sand dunes.

The largest and most important back barrier marshes are all found on the east coast with Tyninghame Shore, Morrich More, Whiteness Head, Dornoch Point and Strathbeg being good examples of this type.

Back-barrier marshes are highly dynamic and very sensitive systems. Winter storms that modify or breach the seaward barrier of sand dunes and shingle can significantly change the vegetation communities present and equally destroy all of the saltmarsh present. Seaward accretion of sand dunes can also cause back-barrier marsh to develop into dune slack.

Trampling and vehicular damage can quickly cause significant damage to the short and waterlogged saltmarsh swards on back-barrier marshes.

3.3.4 Fringing saltmarshes

Fringing marshes can be found in most regions of Scotland and are often associated with rivers and channels with mud or sand banks (see Figure 3-7). They are often narrow in width with larger areas developing in kinks or bays. Fringing marsh is often found where estuarine systems narrow into rivers. They can also be found at the edges of larger drainage ditches and channels.

Figure 3-7: Typical fringing marsh along the River Wick, Caithness.

Fringing marshes are often species and vegetation community poor with many dominated by SM16a (*Festuca rubra* and *Puccinellia maritima* sub-community), which has a rank, uneven sward. It is likely that the lack of species associated with such marsh is related to surrounding land modification. Most sites include earth banks or flood defences and surrounding developments which limit the marshes ability to develop landward. Brackish swamp communities are also an important component of fringing marsh.

Long fringing marshes are associated with the larger estuaries and bays and extending out of loch-head marshes. Beauly Firth, the inner Forth, Linne Mhuirich and Spey Bay all include good examples of this type.

3.3.5 Loch-head saltmarshes

Loch-head saltmarshes are the main type found on the west and north coasts of Scotland. These are similar to embayment marshes but tend to be found at the landward terminus of lochs or in bays, river mouths and sheltered areas (see Figure 3-8). Gravel and shingle are more prominent on these systems than on other saltmarshes with SM13e (*Puccinellia maritima*-turf fucoid sub-community) found almost exclusively on loch-head marshes. Sand and mud substrates are also common. Exposed gravel and shingle substrates often host sparsely vegetated areas with one or two species in abundance, bare shingle and *Armeria maritima* being one such example (see 4.8.2).

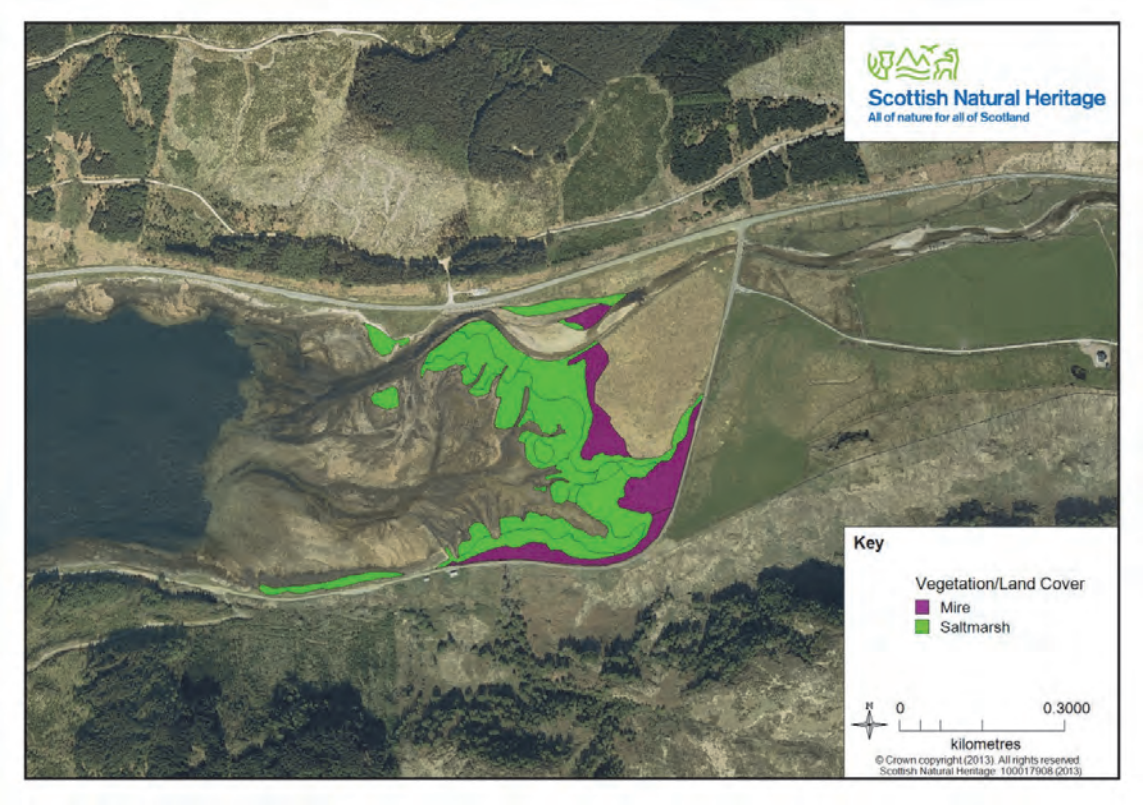


Figure 3-8: Typical loch-head saltmarsh at Loch Sunart Head on the west coast.

Loch-head marshes host very interesting transitional communities, particularly transitions to mire and heath with *Molinia caerulea* forming a distinct sub-community of the *Festuca rubra* dominated swards (see 4.6.13).

Macroalgae are also more abundant on loch-head marshes, with a number of different species found in the lower and pioneer marsh zones, including a dense understorey of turf fucoids (see 4.5.4).

The SM16e (*Leontodon autumnalis* sub-community) and SM16f (*Carex flacca* sub-community) upper marsh sub-communities are also very common, due to the intensity of grazing on many of the sites. Stock grazing is the main human pressure on these systems.

3.3.6 Perched saltmarshes

Perched saltmarsh is a rare (and likely under-recorded) type in Scotland and across the UK. Perched saltmarshes form on sea cliffs and in the shelter of raised rocky outcrops, where shallow sediment develops in the wave splash-zone (see Figure 3-9).

Figure 3-9: An example of perched saltmarsh at Portskerra on the north coast.

These marshes are often very small or present as short saltmarsh turf on cliff tops, which makes them difficult to map. These marshes are likely recorded more frequently as part of cliff vegetation surveys and may be interpreted as being closely associated with maritime cliff vegetation, rather than saltmarsh. The presence of species such as *Juncus gerardii* and *Triglochin maritimum* and in some cases *Puccinellia maritima* indicate the presence of this type.

Perched saltmarsh can be diverse in vegetation communities (such as Boddin Point in Angus) or species poor (such as Rubh' an Dunain in Stoer) depending on the type of perched site involved.

The main human pressure on these sites is stock grazing, but this is often limited by the exposed nature of these locations. The natural dynamism of these areas is the main factor governing perched saltmarshes' persistence.

3.4 Saltmarsh ecology and formation

3.4.1 Geomorphology

The force of direct wave action across exposed coastlines is one of the main limiting factors to the development of saltmarsh. Most saltmarshes develop in sheltered bays and in the lee of headlands, often with mudflats, sand flats or shingle/gravel banks softening any secondary wave action.

A regular supply of sediment is also important to allow saltmarsh to develop. Sediment sources can be sparse in isolated or smaller bays with only a limited number of sand flats and mud flats available for sediment transfer. These types of saltmarsh are often smaller and are unlikely to expand significantly. Larger marshes are strongly associated with systems with a high turnover of sediment (such as estuaries). The sediment resource in estuarine systems is much more extensive than in bay systems, with large marshes able to develop over deep mud and sand deposits. However, exposure to higher rates of wave and tidal power on estuaries limits the occurrence of saltmarsh, with very few saltmarshes found at the widened seaward mouth of each estuary.

Saltmarsh is present in more exposed situations in Scotland, but there are usually factors limiting the tidal movements that interact with the marsh. Saltmarshes present in more exposed situations are often protected from direct tidal action by shingle barriers and sand dune systems (see 3.3.3) and they also provide an ample supply of sediment. The most exposed sites are perched saltmarsh (see 3.3.6).

The development of Scottish saltmarshes is not simple and a number of important factors interplay including:

- Vegetation colonisation rates
- Sediment development and depth
- Tidal flooding rate and frequency
- Saline exposure
- Surrounding land uses and land management
- Coastal modifications
- Coastal erosion and accretion
- Sea-level rise

The development of saltmarshes will be discussed below in order of the various vegetation 'zones' that form across a saltmarsh.

3.4.2 Saltmarsh zones

Saltmarsh zones are defined to identify the various stages of saltmarsh development (in terms of vegetation succession). A number of classifications exist, but Table 3-5 provides further information on how the SSS project interprets each saltmarsh zone in with the NVC classification.

Table 3-5: Saltmarsh zones and corresponding NVC classifications including types not present in Scotland (SNH 2010).

NVC community	Community name
	Pioneer marsh zone
SM3	*Eleocharis parvula* saltmarsh
SM4	*Spartina maritima*
SM5	*Spartina alterniflora*
SM6	*Spartina anglica* saltmarsh
SM7	*Sarcocornia perennis*
SM8	Annual *Salicornia* saltmarsh
SM9	*Suaeda maritima* saltmarsh
SM11	*Aster tripolium* var. *discoides* saltmarsh
SM12	Rayed *Aster tripolium* on saltmarsh
	Lower marsh zone
SM10	Transitional low marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*.
SM13a	*Puccinellia maritima* saltmarsh, *Puccinellia maritima* dominant sub-community
	Middle marsh zone
SM14	*Atriplex portulacoides* saltmarsh
SM13b	*Puccinellia maritima* saltmarsh, *Glaux maritima* sub-community
SM13c	*Puccinellia maritima* saltmarsh, *Limonium vulgare-Armeria maritima* sub-community
SM13d	*Puccinellia maritima* saltmarsh, *Plantago maritima-Armeria maritima* sub-community
SM13e	*Puccinellia maritima* saltmarsh, turf fucoid sub-community
SM13f	*Puccinellia maritima – Spartina maritima* sub-community
SM15	*Juncus maritimus – Triglochin maritima* saltmarsh
	Upper marsh zone
SM16a	*Festuca rubra* saltmarsh *Puccinellia maritima* sub-community
SM16b	*Festuca rubra* saltmarsh *Juncus gerardii* sub-community
SM16c	*Festuca rubra* saltmarsh *Festuca rubra-Glaux maritima* sub-community
SM16d	*Festuca rubra* saltmarsh tall *Festuca rubra* sub-community
SM16e	*Festuca rubra* saltmarsh *Leontodon autumnalis* sub-community
SM16f	*Festuca rubra* saltmarsh *Carex flacca* sub-community
SM17	*Artemisia maritima* saltmarsh
SM18	*Juncus maritimus* saltmarsh
SM19	*Blysmus rufus* saltmarsh
SM20	*Eleocharis uniglumis* saltmarsh
SM21	*Suaeda vera - Limonium binervosum* saltmarsh
SM22	*Atriplex portulacoides - Frankenia laevis* saltmarsh
SM23	*Spergularia marina – Puccinellia distans* saltmarsh
SM26	*Inula crithmoides* stands
SM27	Ephemeral saltmarsh vegetation with *Sagina maritima*
	Driftline zone
SM24	*Elytrigia atherica* saltmarsh
SM25	*Suaeda vera* drift-line
SM28	*Elytrigia repens* saltmarsh

Pioneer marsh is found on sand and mud flats; and across shingle and gravel substrates, seaward of the main vegetated saltmarsh (Figure 3-10). Pioneer communities are also found in pans and depressions across the saltmarsh. These areas are very different to the other four saltmarsh zones found landward, which are more heavily vegetated. Pioneer marsh is often very sparse and dominated by one or two species. Pioneer marsh can be found as a bordering edge to the main saltmarsh sediment and isolated on mud flats and sand flats. Pioneer marsh is found on 27% of Scottish saltmarshes. The largest areas of pioneer marsh are associated with the larger estuaries. The west coast is relatively poor in pioneer marsh, which may be due to the incidence of coarser gravel and shingle substrates. Pioneer marsh was lacking from a number of sites where the habitat was previously recorded (see 4.3.3). The pioneer marshes of the Solway Firth were also not as extensive or as strongly vegetated as previously recorded. Field observations indicate a correlation between signs of accretion and the presence of pioneer marsh. The replacement of pioneer marsh by the more stable saltmarsh zones landward was rarely observed, but it was noted from Caerlaverock on the Solway Firth succeeding to SM13a.

Figure 3-10: Typical pioneer saltmarsh with scattered plants of Salicornia *developing across a mud flat at Nigg Bay (Cromarty Firth).*

Lower marsh is a zone often noted in the past as being absent in Scotland, but it is present on most sites. It is often found as a very narrow border at the seaward edge of the main saltmarsh sediment, which is often eroded and fragmented (a very common feature of Scottish saltmarsh). Lower marsh vegetation is denser than pioneer marsh and is normally dominated by *Puccinellia maritima*. *Aster tripolium* is also a key feature of the lower marsh zone. Lower marsh develops on eroded saltmarsh material and at the edges of creeks and on steeper sand and mud flats (Figure 3-11). Creeks and pans are not a prominent component of lower marsh, however, narrow and fine creeks can be a feature of lower marsh on eroding systems.

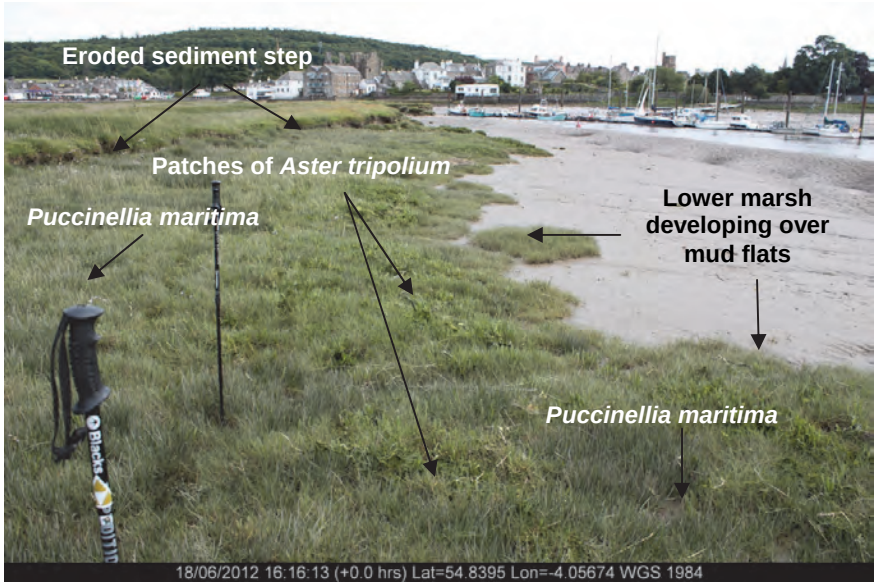


Figure 3-11: Typical lower saltmarsh with Puccinellia maritima *dominating the sward and rough patches of* Aster tripolium *on the River Dee (Kirkcudbright).*

Middle marsh is not always present on Scottish saltmarshes with the zone missing on many of the marshes surveyed. The key identifying feature of middle marsh is the presence of pans across a relatively flat area of the marsh (see Figure 3-12). The most characteristic middle marsh community is SM13d (*Plantago maritima-Armeria maritima* sub-community), and is visible from a distance in summer as a pale pink mat of *Armeria maritima* with *Plantago maritima* also forming a key component of the sward. Middle marsh communities often appear to be botanically diverse compared to other saltmarsh zones. Middle marsh sediment is also much firmer than pioneer and lower marsh.

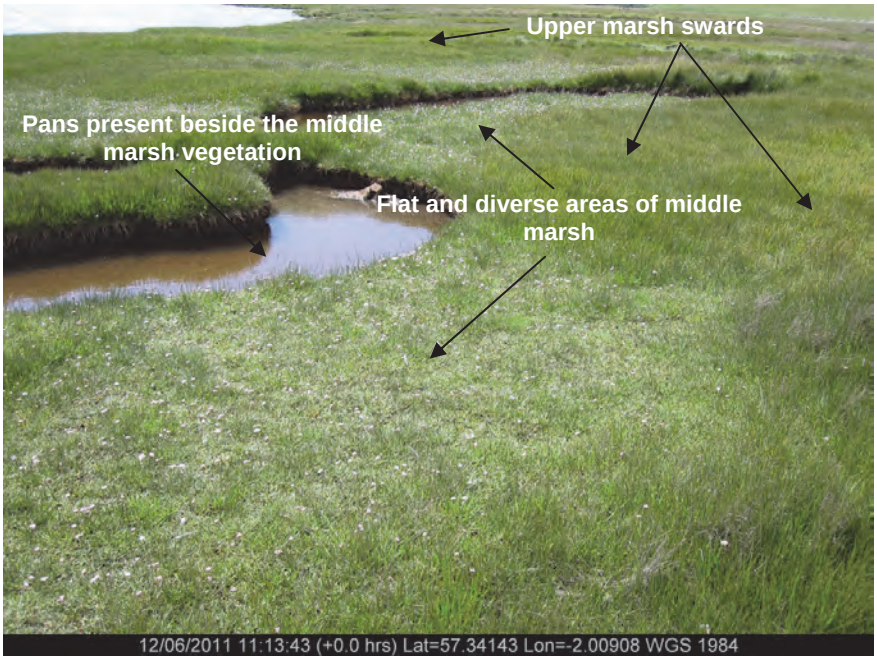


Figure 3-12: Typical middle saltmarsh with flat areas of diverse middle marsh with Armeria maritima *flowering next to pans at Sleek of Tarty.*

The upper marsh zone is the type covering the largest area in Scotland. Upper marsh is often dominated by tall *Festuca rubra* swards (Figure 3-13). These areas grade into transitional communities such as coastal grassland, swamp, mire and sometimes heath. They are notably species poor when found on disturbed sites and can be structurally very different under grazing management. On the west coast and offshore islands *Festuca* swards under grazing management can be species rich. Unlike typical saltmarsh zones, upper marsh can follow lower marsh and lack the middle marsh zone completely.

Figure 3-13: Typical upper saltmarsh with Festuca rubra *dominating the sward at Dingwall Bay (Cromarty Firth).*

The driftline zone is often found at the high water mark, where sea debris creates ridges and banks (see Figure 3-14). These areas are often dominated by vegetation indicative of disturbance. Communities such as SM28 (*Elymus repens* saltmarsh) and occasionally SD2 (*Honkenya peploides-Cakile maritima* strandline community) and SD5 (*Leymus arenarius* mobile dune community) can also occur. *Elytrigia repens* dominated strandline is often found on earth banks at the landward limit of larger saltmarshes. Driftline vegetation can occur across large areas of the upper marsh zone, normally where disturbance is apparent. These areas can be co-dominated by *Festuca rubra* and *Elytrigia repens* (see 4.7.2). Sites under grazing management often include SM16e and SM16f in areas which would normally be classified as the driftline zone. If grazing ceases for a period of time, then SM28 can recolonise. In these instances upper marsh and the driftline zone can be difficult to separate, but are better represented as upper marsh.

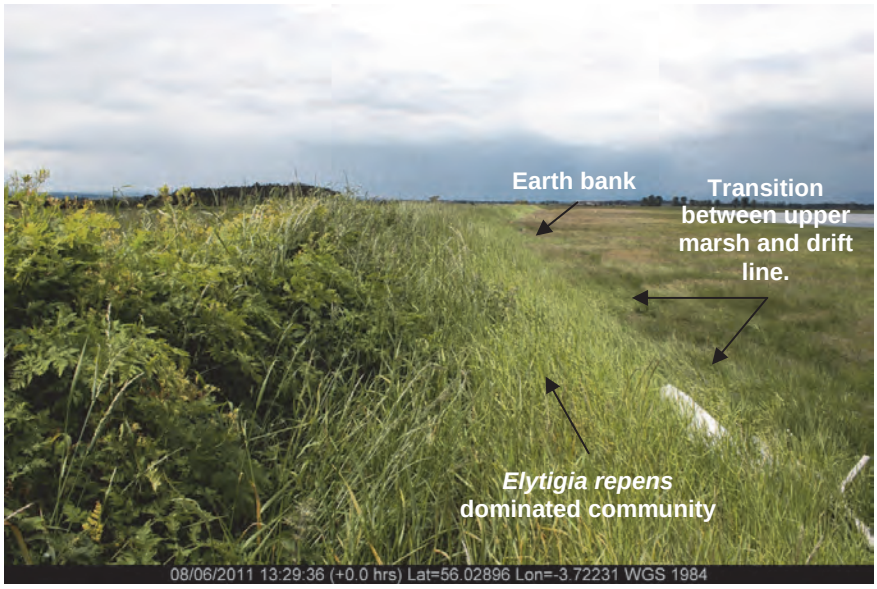


Figure 3-14: Typical driftline saltmarsh with Elytrigia repens *on an earth bank at the rear of Skinflats saltmarshes (Firth of Forth).*

As discussed in 2.6.9, the saltmarsh zones were initially investigated by assigning corresponding NVC types (see Table 3-5). This correspondence was based on three sources of information (Environment Agency 2007; Bhatti 2010; SNH 2010). There are many instances where the corresponding NVC types are found in different saltmarsh zones. One example is upper marsh vegetation (SM16b) present within pioneer marsh. There is also a high incidence of complex 'staged' mosaics (i.e. different sub-communities growing on different elevations of sediment), where both middle and upper marsh vegetation are integrated (Figure 3-12 includes both upper and middle marsh vegetation types).

3.4.3 Salinity

Many of the plant species found across saltmarshes have adaptations to support continued growth in saline conditions. Both *Puccinellia maritima* and *Festuca rubra* show a strong ability to survive in saline conditions. *Puccinellia maritima* can be found in areas frequently inundated by the tide, while *Festuca rubra* is associated with vegetation that is less regularly inundated. *Festuca rubra*, however, can survive near the seaward edge of the marsh (often associated with *Puccinellia maritima*), but the species is usually positioned on raised hummocks, which limit inundation.

Although *Festuca rubra* has a wide tolerance of saline conditions, it is not a strong indicator of them, as the species can be found in transitional and terrestrial vegetation at the landward limits of the marsh. *Festuca rubra* associates such as *Triglochin maritimum* and *Juncus gerardii* are better indicators of saline influence, as both species are mostly restricted to saltmarsh in Scotland. It is these two saltmarsh indicators that are often found across perched saltmarshes on tall sea cliffs.

The pioneer zone is regularly submerged (twice daily) with lower and middle marsh communities also submerged at the higher point of the tide. The upper marsh is rarely submerged, but creeks and pans often fill up with water. Creeks filling up with saline water at high tide often causes middle and lower marsh communities to develop on the banks of creeks.

3.4.4 Sediment depth

The depth of saltmarsh sediment is related to the typology of saltmarshes discussed in 3.3, with estuarine systems often associated with deeper sediments. The Solway Firth, Cromarty Firth and Beauly Firth are all developed over deep mud and sand sediments. Mud shelves are present on parts of these systems where deep mud deposits have built up at the edges of narrowing estuary mouths. Saltmarsh develops on the higher mud shelves (see Figure 3-15). In such systems creeks can be very deep. Field observations indicate that most saltmarsh sediments range from approx 20cm to 1-3m deep, while saltmarshes with an eroded edge have a depth of approx 50cm-1m. The sediment gets deeper towards the landward limit of the marsh and also becomes more stable.

Figure 3-15: Mud shelf at Beauly Firth.

Some marshes show signs of erosion and rebuilding, such as Annan on the Solway Firth (see Figure 3-16). On this marsh an inner shelf is present in the middle/upper saltmarsh zone.

Figure 3-16: Eroded shelf in the middle of the saltmarsh at Annan.

3.4.5 Tidal fluctuations

As discussed in 3.4.3, tidal exposure varies across saltmarsh zones. Pioneer marsh is submerged on a daily basis, but there are rare instances when none of the marsh is submerged by the tide (e.g. on some neap tides on marshes with a deep channel fronting the seaward edge such as at Beauly Firth in Figure 3-15). Tidal fluctuations can cause considerable amounts of debris to collect across the lower and upper marsh fringes. An abundance of macroalgae can also be found on the seaward edges of saltmarshes after high tide. The water retention of saltmarsh sediment can also be high when higher tides move across the site. This subsequently makes marsh vegetation more susceptible to damage under foot or hoof. Overflowing creeks also allow the flooding of undulations and depressions.

3.4.6 Competition and facilitation

Plant competition is related to vertical staging (elevation) on saltmarshes. Grass and rush species of the upper marshes are able to compete successfully for ground on elevations above the submergence zone. Below this elevation upper marsh grasses (like *Festuca rubra*) have difficulty competing against more salt-tolerant species. In these instances mosaics of upper and middle marsh vegetation form, or SM16c (*Festuca rubra-Glaux maritima* sub-community) becomes more prominent. In contrast species such as *Juncus gerardii* and *Eleocharis uniglumis* have a competitive advantage in depressions and water logged areas. *Blysmus rufus* has a competitive advantage on free draining gravels and rocks where few other plant species are able to persist.

The most obvious signs of competition relate to disturbed areas of saltmarsh and the infiltration of *Elytrigia repens* into *Festuca rubra* swards. *Salicornia* sp. and *Spartina anglica* have an interesting relationship, as they can both occur in the same locations in the pioneer zone. *Spartina anglica* is able to colonise large areas of mud flat, where *Salicornia* sp. would normally be found. *Spartina anglica* is discussed further in 3.8.8.

3.4.7 Dynamics

When the SSS maps were compared with the maps from Burd (1989) within the SSS site reports it was clear that many of the saltmarshes have not changed significantly in vegetation community structure. On some sites vegetation associated with coastal grassland was recorded where saltmarsh vegetation was indicated previously (see Beauly Firth and Conon Islands SSS site reports). Other differences between the two surveys are due to genuine site change since the circa 1989 surveys. A good example is Spey Bay, where the shingle ridge at the mouth of the bay has adjusted considerably, which has altered the movement of water through the bay and adjusted the frequency of tidal inundation of the saltmarsh swards leading them to succeed to *Festuca* dominated swards with terrestrial associates (see Spey Bay SSS site report).

The main area of dynamism is the seaward edge of the main marsh vegetation. These areas can be heavily eroded and include new creeks and bays since previous surveys were undertaken. Areas of *Salicornia* sp. are dynamic and are rarely found in the same locations as on previous surveys. Large and dense areas of *Salicornia* sp. were mostly absent from SSS surveys of the Solway Firth, despite previous reports of some of the largest areas of the community in Scotland. Large areas of accretion and erosion were noted from Caerlaverock (see 4.3.3).

3.4.8 Elevation

Elevation is one of the most important factors that influences the vegetation found on Scottish saltmarshes and links strongly to vegetation zones and the distribution of NVC

communities. As discussed in 3.4.2., there are difficulties in assigning saltmarsh zones based on vegetation community structure. Many Scottish saltmarshes are fronted by an eroded sediment edge followed by a narrow lower marsh belt, upper or middle marsh. In many instances a mosaic of both middle and upper marsh is present, which complicates the mapping of the saltmarsh zone. This mosaic is characterised by vertical staging, with upper marsh communities found on hummocks while middle marsh is present in depressions. The fine level of elevation variation found across many sites made it impractical to separate these communities at a scale of 1:4,000. The middle marsh component of the mosaic declines with distance from the seaward edge of the marsh (replaced with upper marsh vegetation).

It is clear that sediment accumulation and sediment height have a direct influence on the succession of saltmarsh vegetation. Erosion or modification of the saltmarsh surface, such as the digging of ditches in the upper marsh can create conditions for pioneer saltmarsh to develop; dependent on their exposure to regular saline water, these areas can persist as pioneer marsh or return to upper marsh vegetation stands and swamp. The saltmarsh zones essentially operate as separate habitats, which may expand or move dependent on surrounding conditions and their elevation.

There is evidence across many sites of upper marsh vegetation (normally found at higher elevations on the saltmarsh) being found at the seaward edge of saltmarsh habitat. There are also indications of coastal grasslands and brackish & freshwater swamps replacing saltmarsh vegetation (see 4.9 and 4.10).

3.4.9 Other taxa

Although the SSS project was primarily a vegetation and condition-based survey, a range of animal taxa was recorded across Scottish saltmarshes. Invertebrates are strongly associated with pans in the middle and upper marshes. Saltmarshes with foul water recorded from pans showed no signs of such invertebrates being present. The rarest invertebrate found on Scottish saltmarshes is the tadpole shrimp (*Triops cancriformis*) which is recorded from Caerlaverock. A possible new location for the species was noted from a sandy pan on the lower marsh with the distinctive tracks of the shrimp's tail and husks present.

Bird species are often found on saltmarshes with oystercatcher (*Haematopus ostralegus*) being one of the commonest observed. Curlew (*Numenius arquata*) are also quite common and often found feeding on invertebrates in pans. Large numbers of shoveler (*Anas clypeata*) were recorded from the north-west corner of Montrose Basin in Angus. Evidence of goose grazing was common on west coast sites, possibly contributing to erosion of lower and middle marsh locally.

Caerlaverock is regarded as holding one of the most important populations of natterjack toad (*Epidalea calamita*), but after searches of areas formerly known for the species, no toads were found. Local people discussed the recent decline of the natterjack toad, indicating that local people have seen significantly less of the species in recent years. An adder (*Vipera berus*) was recorded from driftline and upper marsh vegetation in Luce Bay (Solway Firth).

The normal grazing stock present on saltmarshes include cattle and sheep, but on Caerlaverock deer were also recorded grazing on the lower and middle marsh. Other animals grazing on saltmarshes include rabbits and hares.

3.5 Pans

Pans are found on most of the Scottish saltmarshes and are normally found in the middle and upper marsh zones. Pans can be various sizes, depths and shapes. Their ability to retain water is also variable. The hydrology of pans can be complex and unclear without investigation into the water channels flowing within the sediment layer. Some pans were observed to retain water at low tide, while neighbouring pans were dry. Pans can erode to the point where they create tunnels and channels to neighbouring pans where water is shared. Some pans also have a clear 'pipe-hole' which allows drainage and water flow beneath the sediment.

Pans are often wider inside with overhanging sediment surrounding the edges of the pan. Standing on these overhanging areas can cause the pans to subside. When pans are dry the sediment often cracks into crazy paving-like patterns. Similar patterns were also observed from mudflats.

Figure 3-17: Dried pan with cracked sediment.

Pans are rare in the pioneer and lower marsh zones and if they are present they are often very shallow and unvegetated. Similar shallow pans also form on middle and upper saltmarsh zones on back-barrier marshes on sandier systems. Pans that are apparently beginning to form are sometimes observed where a depression or undulation in a saltmarsh is occupied by lower or pioneer marsh vegetation communities such as SM8 (Annual *Salicornia* saltmarsh) or SM13a (*Puccinellia maritima* dominated sub-community).

SM13a is quite common in middle marsh pans, but is often species-poor with *Puccinellia maritima* being the only species present. In the upper marsh zone, pan vegetation can be more diverse with SM16b (*Juncus gerardii* dominated sub-community) being strongly associated with pans, often occupied by single species stands of *Juncus gerardii*. Pans occupied by SM16b can also be found in the middle marsh zone (Figure 3-18). SM20 (*Eleocharis uniglumis* saltmarsh community) and S19 (*Eleocharis palustris* swamp) are also found densely colonising pans on saltmarshes, normally in the upper marsh. *Bolboschoenus maritimus* is regularly found in pans in the upper marsh. It is noteworthy that *Phragmites australis* is not normally found in pans.

Plants found locally in pans include *Ranunculus baudotii* on Caerlaverock and the Nith Estuary (see Figure 3-19). The non-native *Cotula coronopifolia* was also recorded from

middle and upper marsh pans at Dornoch Point on the Dornoch Firth (see Figure 3-20). *Spergularia marina* can be abundant in shallow, upper marsh pans subject to stock trampling (see 4.6.20).

Figure 3-18: Pan colonised by SM16b at Skinflats.

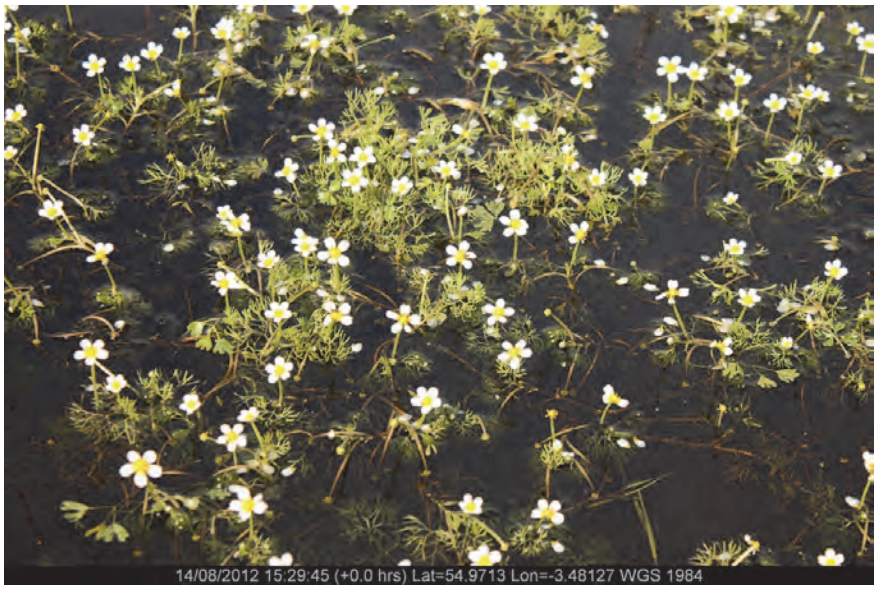


Figure 3-19: Pans colonised by Ranunculus baudotii*. Caerlaverock.*

Figure 3-20: Pans colonised by Cotula coronopifolia *at Dornoch Point.*

Ruppia maritima is also present in upper marsh pans on sites such as Caerlaverock and on many west coast sites (notably in Argyll).

3.6 Creeks

Creeks are found across most saltmarshes (apart from degraded and perched marshes) and are more often present than pans. Some marshes have a number of large creeks that run from the seaward edge landward. These larger creeks have secondary branching creeks that run parallel to the marsh edge. This is a typical creek formation and the incidence of such creeks depends on the specific saltmarsh. Tyninghame Shore has many branching and primary creeks spread across the middle marsh, which are also linked to pans (Figure 3-21).

Figure 3-21: Abundant creeks at Tyninghame Shore (East Lothian).

Another type of creek system is the very fine dendritic creeks that form on highly fragmented saltmarshes. These marshes include vegetation that forms clumps at the seaward edge of the marsh. These clumps are surrounded by a network of narrow dendritic creeks that can be difficult to cross. This type of creek system is often found on estuarine marsh systems and can be present into the upper marsh zone. As the sediment deepens landward the creeks often retain their original sea-level depth, thus making the upper marsh very difficult to cross without falling down the narrow creeks. This form of creek could be considered as an indicator of eroding or declining saltmarsh as these systems are often observed from narrow belts of marsh such as those recorded from the Tay and the Clyde estuaries. Pans are uncommon and SM16a (*Puccinellia maritima* sub-community) often makes up the surrounding vegetation.

Creeks are rarely vegetated, but can sometimes be colonised by swamp vegetation such as *Bolboschoenus maritimus* and *Phragmites australis*. *Phragmites australis* is normally found colonising creeks at the landward limits of the saltmarsh.

The banks of creeks are often dominated by SM13a and a variant of SM16a with abundant *Aster tripolium* and *Triglochin maritimum*. Larger creeks have an inner shelf where vegetation such as SM13a and SM16a can colonise. These shelves are often submerged at high tide. SM20 and S19 are found in vegetated creeks in the upper saltmarsh.

Larger creeks have often been straightened artificially on larger estuarine systems. Straightened creeks tend to be prone to significant silting in their inner banks with little vegetation present in the creek. SM28 and MG1 (*Arrhenatherum elatius* grassland) often grow on the sediment bank created from the straightening operation.

On English and Welsh saltmarshes, *Atriplex portulacoides* is commonly found on the banks of creeks in the middle marsh zone; the glaucous and shrubby appearance of the plant making it simple for surveyors to detect nearby creeks. This species is absent from most of Scotland apart from a limited number of sites on the Solway Firth. The species is most abundant at Southwick and Luce Bay. On these sandier sites the species is found forming raised hummocks beside creeks. *Atriplex portulacoides* is predicted to expand under certain climate change scenarios (Berry *et al*. 2001) and may a suitable candidate for use as a climate change indicator.

Creeks generally become narrower and branch more the further into the saltmarsh they reach, which may explain why more pans are associated with the middle and upper marshes (as surface water can be regularly distributed across the middle and upper marsh zones via a network of shallow creeks that flood frequently at high tide).

3.7 Accretion and erosion

Many of Scotland's saltmarshes show signs of erosion. Erosion is particularly evident at the seaward edge of the marsh where upper marsh subsides and slides down onto the mud/sand flats. Some saltmarshes had completely eroded away. Southerness on the Solway Firth was recorded as no longer having saltmarsh, with only a few clumps of former saltmarsh sediment with dead plants found on the sandy beach (see Figure 3-22 and the Southerness SSS site report). At Blackness and Black Burn on the Firth of Forth a similar set of saltmarsh clumps was also observed (see Blackness and Black Burn SSS site report). On the west coast there are many examples of heavily dissected middle marsh forming tall haggs up to a metre tall (see Figure 3-23).

Figure 3-22: Clumps of dead saltmarsh at Southerness (Solway Firth).

Figure 3-23: Heavily eroding middle marsh at Loch Eynort (Skye).

Much of the saltmarsh erosion appears to be linked to surrounding sea defences and land claim. Stewart Angus (pers. comm.) suggested that intensive grazing on the west coast could be causing vascular plants to be replaced with turf fucoids (e.g. at Kentra Bay). This situation may exacerbate the erosion of marshes as the root systems of the vascular plants will no longer be able to help bind the saltmarsh sediment together. There is anecdotal evidence to suggest that extensive areas of middle and lower marsh were once present across the larger Scottish saltmarshes. As much of the erosion pre-dates the last set of surveys (Burd 1989), a thorough analysis of historical imagery and information is required to ascertain the reasons for the comparative lack of low and middle marsh in Scotland. Such a project could easily be undertaken by researching a small selection of saltmarsh systems taking into account geographical variation (see 5.6.2).

Some erosion events are due to changes in water current and coastal storms, possibly associated with changing weather patterns. This is due to the gradual movement of estuarine channels or the erosion and movement of shingle and sand dune barriers, spits and bars. The Tay Estuary's river channel has gradually moved to the south bank of the estuary, which has allowed much of the north bank to silt up with mud, allowing conditions ideal for brackish swamp to develop. Brackish swamp has subsequently expanded and invaded areas formerly associated with saltmarsh. The dynamic shingle bar at Spey Bay has caused significant changes to the Spey Bay saltmarshes, which are now more strongly associated with terrestrial grassland.

It is noteworthy that the sites suffering the most significant levels of saltmarsh erosion are also the sites with the most significant signs of saltmarsh accretion. The surveys of Caerlaverock indicate heavy losses from the east side of the site, while there is a significant increase across most of the seaward edge of the marsh. Most of the accretion observed at Caerlaverock involved the colonisation of sandflats. SM13a and SM13d are starting to form across the sand flats seaward of the main marsh (south, into the Solway estuary) and it is possible that these lower and middle marsh communities are replacing pioneer stands of SM8 (see 4.3.3). Caerlaverock is unusual in having a very long and gradual pioneer-middle marsh transition zone, with only limited stepping present (when compared to other marshes). Another site showing significant saltmarsh accretion is Morrich More, due to the development of two sets of sand dune barriers on the headland. In the lee of the north-west barrier, a large area of sand flats is now protected from direct wave action; allowing lower and middle marsh to develop. Other than these two extreme examples, most marshes appear to show a mixture of erosion and accretion across different areas of each site, but without further quantification of the historical width of many of these marshes it is difficult to assess any rates of erosion.

3.8 Saltmarsh condition

In this section the results of the condition assessment surveys are discussed and analysed along with recommendations to improve the site condition assessment. The results are summarised in Tables 3-6 and 3-7. A full list of sites and condition monitoring results are found in the SCM Database (see appendix 1).

3.8.1 Saltmarsh condition assessment results

Two hundred and forty-nine sites where saltmarsh is present were assessed using the Site Condition Monitoring protocol produced by SNH (Hutcheon Brothers 2000). In total 67% of saltmarsh sites were considered to fail one or more targets for condition. Of the 392 assessment walks undertaken throughout the project 40% failed one or more identified condition targets.

Both designated and non-designated sites were assessed and 69% of SSSI sites were considered to fail targets while 72% of SAC sites failed targets. Sixty-five per cent of non-designated sites were considered to fail SCM targets. These figures are summarised in Table 3-7.

Table 3-6: SCM Results for each site. The full list of results is found in appendix 1 including the specific targets that failed on each site.

Site ID	Site Name	Location	Assessed	SCM failed	SSSI	SAC	Number of SCM walks	Atlantic saltmarsh present?	Pioneer saltmarsh present?
001EDE	Eden Estuary	South East	Y	Y	Y	Y	3	Y	Y
002TAY	Tayport	South East	Y	N	Y	Y	1	Y	Y
003TAY	Tay Estuary	South East	Y	N	Y	Y	2	Y	N
004MON	Montrose Basin	South East	Y	N	Y	N	1	Y	Y
005KIN	Kinnaber Links (St Cyrus)	South East	Y	Y	Y	N	1	Y	N
006LUN	Lunan Bay	South East	Y	Y	N	N	1	Y	N
007CUL	Culross Shore	South East	Y	Y	N	N	2	Y	N
008GRA	Grangemouth	South East	Y	Y	Y	N	1	Y	Y
009SKI	Skinflats	South East	Y	Y	Y	N	5	Y	Y
010FOR	Forth (Alloa)	South East	Y	Y	Y	N	4	Y	N
011COC	Cocklemill Bay	South East	Y	N	Y	N	1	Y	Y
012ABE	Aberlady Bay	South East	Y	N	Y	N	3	Y	Y
013TYN	Tyninghame Shore	South East	Y	Y	Y	N	3	Y	Y
014BLA	Blackness and Blackburn	South East	Y	Y	Y	N	1	Y	N
015BAL	Balmarino Shore	South East	Y	Y	Y	Y	1	Y	N
016BAR	Barry Burn	South East	Y	Y	N	N	1	Y	N
017BOD	Boddin Point	South East	Y	Y	Y	N	1	Y	N
018SLE	Sleek of Tarty	North East	Y	N	Y	N	1	Y	N
019SAN	Sands of Forvie	North East	Y	N	Y	N	1	Y	Y
020STA	Stakeness	North East	Y	N	Y	N	1	Y	N
021STR	Strathbeg	North East	Y	N	Y	N	1	Y	N
022SPE	Spey Bay	North East	Y	Y	Y	Y	1	Y	N
023FIN	Findhorn Bay	North East	Y	Y	Y	N	7	Y	Y
024LOS	Lossiemouth	North East	Y	Y	N	N	1	Y	N
025CUL	Culbin	North East	Y	N	Y	Y	4	Y	Y
026WHI	Whiteness Head	North East	Y	Y	Y	N	1	Y	Y
027CAS	Castle Stuart Bay	North East	Y	N	Y	N	2	Y	Y
028INV	Inverness	North East	Y	Y	N	N	1	Y	N
029BEA	Beauly Firth	North East	Y	Y	Y	N	8	Y	N
030MUN	Munlochy Bay	North East	Y	Y	Y	N	2	Y	Y
031UDA	Udale Bay	North East	Y	Y	Y	N	1	Y	N
032CON	Conon Islands	North East	Y	Y	Y	N	1	Y	N
033DIN	Dingwall	North East	Y	Y	Y	N	1	Y	Y
034BAL	Balconie Point	North East	Y	Y	Y	N	1	Y	Y
035DAL	Dalmore	North East	Y	Y	Y	N	1	Y	N

036NIG	Nigg Bay	North East	Y	Y	Y	N	3	Y	Y
037MOR	Morrich More	North East	Y	Y	Y	Y	8	Y	Y
038TAI	Tain	North East	Y	Y	Y	Y	1	Y	Y
039DOR	Dornoch Firth South	North East	Y	Y	Y	Y	2	Y	Y
040BON	Bonar Bridge	North East	Y	Y	N	Y	2	Y	N
041DOR	Dornoch Point	North East	Y	Y	Y	Y	1	Y	Y
042COU	Coul Links (Loch Fleet)	North East	Y	Y	Y	N	1	Y	N
043SKE	Skelbo (Loch Fleet)	North East	Y	N	Y	N	1	Y	Y
044CAM	Cambusmore Lodge (Loch Fleet)	North East	Y	Y	Y	Y	1	Y	N
045BAL	Balbair (Loch Fleet)	North East	Y	N	Y	N	1	Y	N
046THE	The Mound (Loch Fleet)	North East	Y	Y	N	N	1	Y	N
047CRE	Creag Bheag (Loch Fleet)	North East	Y	Y	Y	N	1	Y	Y
048LOC	Loch Duich	North West	Y	N	N	N	3	Y	N
049LOC	Loch Broom	North West	Y	Y	N	N	2	Y	N
050LIT	Little Loch Broom	North West	Y	Y	N	N	1	Y	N
051OPI	Opinan	North West	Y	Y	N	N	1	Y	N
052AUL	Aultbea	North	Y	Y	N	N	1	Y	N
053STR	Strathkanaird	North	Y	Y	N	N	1	Y	N
054ACH	Achnahaird Bay	North	Y	N	Y	Y	1	Y	N
055RUB	Rubh' an Dunain, Stoer	North	Y	N	N	N	1	Y	N
056LOC	Loch Laxford	North	Y	Y	N	Y	1	Y	N
057LOC	Loch Sheigra	North	Y	Y	N	N	1	Y	N
058RHI	Rhiconich	North	Y	N	N	N	1	Y	N
059KYL	Kyle of Durness	North	Y	N	Y	Y	1	Y	N
060EIL	Eilean Dubh (Loch Eriboll)	North	Y	Y	N	N	1	Y	Y
061KYL	Kyle of Tongue	North	Y	Y	N	N	1	Y	N
062RHI	Rhian Burn	North	Y	N	N	N	1	Y	N
063TOR	Torrisdale Bay	North	Y	Y	Y	Y	5	Y	N
064BRA	Brawl, Strathy	North	Y	N	Y	Y	1	Y	N
065POR	Portskerra 1	North	Y	N	Y	N	1	Y	N
066POR	Portskerra 2	North	Y	N	Y	N	1	Y	N
067MEL	Melvich	North	Y	Y	Y	N	1	Y	N
068RIV	River Wester	North	Y	Y	N	N	1	Y	N
069RIV	River Wick	North	Y	Y	Y	N	1	Y	N
070LOC	Loch Fyne	Argyll	Y	Y	N	N	1	Y	N
071SAL	Sallachan Point	Lochaber	Y	N	N	N	1	Y	N
072CAM	Camas na Croise	Lochaber	Y	N	N	N	2	Y	N
073LOC	Loch a' Choire	Lochaber	Y	Y	N	N	1	Y	N
074KIL	Kilchoan	Lochaber	Y	N	Y	N	1	Y	N
075THR	Three Mile Water	Lochaber	Y	N	N	N	1	Y	N

076CAO	Caol Spit	Lochaber	Y	Y	N	N	2	Y	N
077INV	Inversanda	Lochaber	Y	Y	N	N	1	Y	N
078DER	Dervaig (Mull)	Argyll	Y	Y	N	N	1	Y	N
079LOC	Loch Sunart Head	Lochaber	Y	Y	Y	Y	2	Y	Y
080CUI	Cuil Bay	Lochaber	Y	N	N	N	1	Y	N
081DUN	Dunstaffnage	Argyll	Y	Y	N	N	3	Y	N
082ARD	Ardentiny	Argyll	Y	Y	N	N	1	Y	Y
083BAL	Balure of Shian (Loch Creran)	Argyll	Y	Y	N	Y	1	Y	Y
084LOC	Loch Sligachan	Skye & Lochalsh	Y	N	N	N	3	Y	N
085LOC	Loch Slapin	Skye & Lochalsh	Y	Y	N	N	1	Y	N
086CAM	Camas na Sgianadin	Skye & Lochalsh	Y	Y	N	N	1	Y	N
087ISL	Isleornsay	Skye & Lochalsh	Y	Y	N	N	1	Y	N
088LOC	Loch Ainort	Skye & Lochalsh	Y	Y	N	N	2	Y	N
089LOC	Loch na Dal	Skye & Lochalsh	Y	N	Y	Y	1	Y	N
090BRO	Broadford Bay	Skye & Lochalsh	Y	Y	N	N	1	Y	N
091RUB	Rubha Ardnish	Skye & Lochalsh	Y	N	Y	N	1	Y	N
092LOC	Loch Portree	Skye & Lochalsh	Y	N	N	N	1	Y	N
093LOC	Loch Eynort	Skye & Lochalsh	Y	Y	N	N	1	Y	N
094LOC	Loch Melfort	Argyll	Y	Y	N	N	1	Y	N
095BAR	Barrisdale Bay	Skye & Lochalsh	Y	N	N	N	1	Y	N
096NON	Nonach	Skye & Lochalsh	Y	Y	N	N	1	Y	N
097LOC	Loch Harport	Skye & Lochalsh	Y	N	N	N	1	Y	N
098LOC	Loch Craignish	Argyll	Y	Y	N	N	1	Y	N
099GLE	Glenmore	Lochaber	Y	Y	Y	Y	1	Y	Y
100LOC	Loch Moidart	Lochaber	Y	N	Y	Y	2	Y	N
101LOC	Loch Eil	Lochaber	Y	Y	N	N	2	Y	Y
102ARI	Arisaig	Lochaber	Y	Y	N	N	2	Y	N
103LOC	Loch Leven	Lochaber	Y	Y	N	N	5	Y	Y
104INV	Inverscaddle Bay	Lochaber	Y	Y	N	N	3	Y	N
105LOC	Lochailort	Lochaber	Y	Y	N	N	3	Y	N
106LOC	Loch an t-Sailein	Argyll	Y	N	Y	Y	1	Y	Y
107KIN	Kintour (Islay) NO SALTMARSH	Argyll	N	N	N	N	0	N	N
108EIL	Eilean an Droighinn (Islay)	Argyll	N	Y	Y	Y	1	Y	N
109GLE	Gleann Aoistail	Argyll	Y	N	N	N	1	Y	N
110THE	The Strand	Argyll	Y	Y	Y	N	1	Y	N
111GRU	Gruinart Flats	Argyll	Y	Y	Y	N	2	Y	N
112AUC	Auchalick Bay	Argyll	Y	Y	N	N	1	Y	N

113WHI	Whitehouse Bay	Argyll	Y	Y	N	N	1	Y	N
114LOC	Loch Caolisport	Argyll	Y	Y	Y	N	2	Y	N
115BRI	Bridgend Flats	Argyll	Y	N	Y	N	3	Y	N
116ARD	Ardpatrick	Argyll	Y	N	Y	Y	2	Y	N
117LOC	Loch Stornoway	Argyll	Y	Y	N	N	1	Y	N
118ULV	Ulva Islands & Loch na Cille	Argyll	Y	Y	Y	Y	3	Y	N
119POW	Pow Burn	Ayrshire	Y	Y	Y	N	1	Y	Y
120GAR	Garnock Estuary	Ayrshire	Y	Y	Y	N	3	Y	Y
121INN	Inner Clyde	Clyde	Y	Y	Y	N	7	Y	Y
122RIV	River Leven (Inner Clyde)	Clyde	Y	N	N	N	0	N	N
123HOL	Holy Loch	Argyll	Y	Y	N	N	1	Y	N
124LOC	Loch Striven	Argyll	Y	Y	N	N	1	Y	N
125RUE	Ruel Estuary/Loch Ridden (Firth of Clyde)	Argyll	Y	Y	Y	N	2	Y	N
126LOC	Loch Feochan	Argyll	Y	Y	N	N	4	Y	N
127AN	An Seilean (Firth of Lorn)	Argyll	Y	Y	N	N	1	Y	N
128LOC	Loch Crinan	Argyll	Y	Y	Y	Y	3	Y	Y
129LOC	Loch Laich (Firth of Lorn)	Argyll	Y	Y	N	N	1	Y	Y
130LOC	Loch Mhuirich (Jura Sound)	Argyll	Y	Y	Y	Y	2	Y	N
131SAI	Sailean na h-Airde	Argyll	Y	Y	Y	N	1	Y	N
132STR	Straad	Argyll	Y	Y	N	N	1	Y	N
133BUN	Bunacaimb	Lochaber	Y	Y	N	N	1	Y	N
134DRU	Druimavuic (Loch Creran)	Lochaber	Y	Y	Y	Y	1	Y	Y
135EIL	Eilean Uaine	Lochaber	Y	N	N	N	1	Y	N
136INV	Inverie Bay	Lochaber	Y	N	N	N	1	Y	N
137KEN	Kentra Bay	Lochaber	Y	Y	Y	Y	2	Y	N
138ARD	Ardelve (Loch Alsh)	Skye & Lochalsh	Y	Y	N	N	1	Y	Y
139KIN	Kinlochteacuis	Lochaber	Y	Y	Y	Y	1	N	Y
140KYL	Kylemorar	Lochaber	N	N	N	N	0	N	N
141LOC	Loch Aline	Lochaber	Y	N	N	N	1	Y	N
142LOC	Loch Nevis Head	Lochaber	Y	Y	N	N	1	Y	N
143AN	An Caolas	Mull	Y	Y	N	N	1	Y	N
144ARD	Ardura (Mull)	Mull	Y	N	Y	Y	1	Y	N
145LOC	Loch Beg (Mull)	Mull	Y	N	N	N	1	Y	N
146LOC	Loch Don (Mull)	Mull	Y	Y	Y	N	1	Y	N
147LOC	Loch Beag	Skye (N)	Y	Y	N	N	1	Y	N
148LOC	Loch Dunvegan	Skye (N)	Y	Y	N	N	2	Y	Y
149LOC	Loch Greshornish	Skye (N)	Y	Y	N	N	1	Y	Y
150LOC	Loch Eyre	Skye (N)	Y	N	N	N	1	Y	Y
151POO	Pool Roag	Skye (N)	Y	N	N	N	1	Y	N
152DUN	Dunvegan Bay	Skye (N)	Y	Y	N	N	0	N	N

153ARD	Ardintoul (Loch Alsh)	Skye (S) & Borders	Y	N	N	N	1	Y	Y
154GLA	Glas Eilean (Loch Alsh)	Skye (S) & Borders	Y	N	N	Y	1	Y	Y
155GLE	Glenelg	Skye (S) & Borders	Y	Y	N	N	1	Y	N
156KIN	Kinlochhourn	Skye (S) & Borders	Y	Y	N	N	1	Y	N
157KIS	Kishorn	Skye (S) & Borders	Y	Y	Y	Y	1	Y	N
158KYL	Kyle	Skye (S) & Borders	Y	Y	N	N	1	Y	Y
159LOC	Loch Carron	Skye (S) & Borders	Y	Y	N	N	2	Y	Y
160LOC	Loch Torridon	Skye (S) & Borders	Y	Y	N	N	2	Y	Y
161TOS	Toscaig	Skye (S) & Borders	Y	Y	N	N	1	Y	N
162KIR	Kirkton (Loch Alsh)	Skye (S) & Borders	Y	Y	N	N	1	Y	Y
163CEA	Ceann a' Baigh	Outer Hebrides	Y	N	N	N	1	Y	N
164CRE	Creag Fiavig lochans	Outer Hebrides	Y	N	N	N	1	Y	N
165GAL	Gallan Head	Outer Hebrides	Y	N	N	N	1	Y	N
166LOC	Loch Grimersta	Outer Hebrides	Y	N	N	N	1	Y	N
167BUT	Butt of Lewis	Outer Hebrides	Y	N	N	N	1	Y	N
168CRO	Crowlista	Outer Hebrides	Y	N	N	N	1	Y	N
169TIM	Timsgarry	Outer Hebrides	Y	N	N	N	1	Y	N
170LON	Lon Erista	Outer Hebrides	Y	Y	N	N	1	Y	N
171LOC	Loch Gealavat	Outer Hebrides	Y	Y	N	N	1	Y	N
172TON	Tong Saltings SSSI	Outer Hebrides	Y	N	Y	N	1	Y	Y
173GRE	Gress Saltings SSSI	Outer Hebrides	Y	N	Y	N	1	Y	N
174LOC	Loch Paible	Outer Hebrides	Y	Y	Y	Y	2	Y	N
175BAY	Bayhead	Outer Hebrides	Y	N	N	N	1	Y	N
176HOW	Howbeg	Outer Hebrides	Y	Y	Y	Y	1	Y	N
177ARD	Ardheisker-Horisary	Outer Hebrides	Y	N	N	N	1	Y	N
178BAL	Balgarva	Outer Hebrides	Y	N	N	N	1	Y	N
179LAG	Lag Gorm	Outer Hebrides	Y	Y	Y	Y	0	N	N
180VAL	Vallay	Outer Hebrides	Y	N	Y	Y	1	Y	N
181GUA	Gualan	Outer Hebrides	Y	N	N	N	1	Y	N
182LIN	Liniclate	Outer Hebrides	Y	N	N	N	1	Y	N

183EIL	Eilean Cuithe nam Fiadh	Outer Hebrides	Y	N	N	N	1	Y	N
184ILL	Illeray	Outer Hebrides	Y	Y	Y	Y	3	Y	N
185TRA	Traigh Eachkamish	Outer Hebrides	Y	Y	Y	Y	1	Y	N
186BEN	Benbecula Airport - Gramsdale	Outer Hebrides	Y	N	N	N	1	Y	Y
187BEN	Benbecula Airport - Gramsdale	Outer Hebrides	Y	N	N	N	0	N	N
188GRE	Grenitote	Outer Hebrides	Y	Y	N	N	1	Y	N
189CAR	Carinish	Outer Hebrides	Y	Y	N	N	1	Y	N
190LAN	Langass	Outer Hebrides	Y	Y	N	N	1	Y	N
191CLE	Clett-Feora	Outer Hebrides	Y	Y	N	N	1	Y	N
192CNO	Cnoc Cuidhein	Outer Hebrides	Y	Y	N	N	1	Y	N
193GRI	Grimsay	Outer Hebrides	Y	Y	N	N	1	Y	N
194NOR	Northton Bay SSSI	Outer Hebrides	Y	Y	N	N	1	Y	Y
195LUS	Luskentyre Banks and Saltings SSSI	Outer Hebrides	Y	N	Y	N	1	Y	N
196LUS	Luskentyre Banks and Saltings SSSI	Outer Hebrides	Y	N	Y	N	0	N	N
197KIR	Kirkibost	Outer Hebrides	Y	N	Y	Y	1	Y	N
198KIR	Kirkibost	Outer Hebrides	Y	N	Y	Y	0	N	N
199FAO	Faoghail Vallaquie	Outer Hebrides	Y	N	Y	Y	1	Y	N
200BER	Berneray	Outer Hebrides	Y	N	Y	N	1	Y	Y
201NOR	Northton Bay SSSI	Outer Hebrides	Y	Y	Y	N	0	N	N
202ILL	Illeray	Outer Hebrides	Y	Y	Y	Y	0	N	N
203LOC	Loch Paible	Outer Hebrides	Y	Y	Y	Y	0	N	N
204BAL	Baltasound	Shetland	Y	Y	N	N	1	Y	Y
205CUL	Cullivoe	Shetland	Y	N	N	N	1	Y	N
206GLU	Gluss Voe	Shetland	Y	N	N	Y	1	Y	N
207WEI	Weisdale Voe	Shetland	Y	N	N	N	1	Y	N
208BRI	Bridge of Waithe and Cummi Ness	Orkney	Y	N	Y	Y	1	Y	N
209WAU	Waulkmill Bay	Orkney	Y	Y	Y	N	1	Y	N
210VEA	Veantrow Bay	Orkney	Y	Y	N	N	1	Y	N
211BAY	Bay of Suckquoy	Orkney	Y	N	N	N	1	Y	Y
212LIT	Little Sea	Orkney	Y	Y	Y	N	1	Y	Y
213LAM	Lama Ness Oyce	Orkney	Y	Y	N	N	1	Y	N
214CAT	Cata Sand	Orkney	Y	N	Y	N	1	Y	Y
215QUO	Quoys	Orkney	Y	N	N	N	1	Y	N
216OYC	Oyce of Quindry	Orkney	Y	Y	N	N	1	Y	N

217RAC	Rack Wick	Orkney	N	N	N	N	0	N	N
218TOY	Toy Ness	Orkney	Y	Y	N	N	1	Y	N
219POL	Poly 08	Orkney	N	N	N	N	0	N	N
220WES	Westbrough	Orkney	N	N	N	N	0	N	N
221LAM	Lamaness South (West)	Orkney	Y	Y	Y	Y	1	Y	Y
222LAM	Lamaness South (East)	Orkney	Y	Y	Y	Y	1	Y	N
223STA	Start Point	Orkney	Y	N	Y	Y	1	Y	N
224LIT	Little Ayre	Orkney	Y	Y	N	N	1	Y	N
225POI	Point of Qui Ayre	Orkney	Y	Y	Y	Y	1	Y	N
226SKA	Skara Brae to Point of Qui Ayre	Orkney	Y	Y	Y	Y	0	N	N
227SAN	Sandi Sand	Orkney	Y	N	N	N	1	Y	Y
228SWA	Swarsquoy	Orkney	Y	Y	N	N	1	Y	N
229TOR	Torr Ness to Quivals Creek	Orkney	Y	N	Y	Y	1	Y	Y
230WYN	Wyng Strand	Orkney	Y	N	N	N	1	Y	N
231CAR	Carse Bay	Solway (W)	Y	Y	Y	Y	1	Y	Y
232SOU	Southerness	Solway (W)	Y	Y	N	N	1	Y	N
233SOU	Southwick	Solway (W)	Y	Y	Y	Y	1	Y	N
234ROU	Rough Firth	Solway (W)	Y	Y	N	N	1	Y	Y
235AUC	Auchencairn Bay	Solway (W)	Y	Y	Y	N	1	Y	Y
236ORC	Orchardton Bay	Solway (W)	Y	Y	Y	N	0	N	N
237MAN	Manxman's Lake	Solway (W)	Y	N	N	N	1	Y	Y
238RIV	River Dee	Solway (W)	Y	Y	N	N	5	Y	N
239FLE	Fleet Bay	Solway (W)	Y	Y	N	N	3	Y	N
240WIG	Wigtown	Solway (W)	Y	Y	Y	Y	17	Y	Y
241GLE	Glen Luce	Solway (W)	Y	Y	Y	Y	1	Y	N
242LUC	Luce Bay	Solway (W)	Y	Y	Y	Y	1	Y	Y
243LUC	Luce Sands	Ayrshire	Y	Y	Y	Y	2	Y	N
244BAL	Ballantrae Bay	Solway (E)	Y	Y	Y	N	1	Y	N
245GRE	Gretna-Redkirk	Solway (E)	Y	Y	Y	Y	3	Y	Y
246BRO	Browhouses	Solway (E)	Y	Y	Y	Y	2	Y	N
247TOR	Torduff Point	Solway (E)	Y	Y	Y	Y	1	Y	N
248ANN	Annan	Solway (E)	Y	Y	Y	Y	1	Y	Y
248DOR	Dornock	Solway (E)	Y	Y	Y	Y	1	Y	N
249MIL	Milnfield Merse	Solway (E)	Y	Y	Y	Y	3	Y	N
250PRI	Priestside Bank	Solway (E)	Y	Y	Y	Y	9	Y	N
252CAE	Caerlaverock	Solway (E)	Y	Y	Y	Y	10	Y	Y
253GLE	Glencaple & Kelton	Solway (E)	Y	Y	Y	Y	12	Y	Y
254GRE	Greenmerse	Solway (E)	Y	Y	Y	Y	0	N	N
255KIR	Kirkconnell Merse	Solway (E)	Y	Y	Y	Y	0	N	N
		Total	**249**	**166**	**122**	**70**	**392**	**236**	**69**

Table 3-7: Summary of SCM Assessments.

	Total number of assessments	Total number of failed assessments	% of failed assessments
All saltmarsh sites assessed	249	166	67
Number of assessment walks	392	157	40
SSSI Sites	121	83	69
SAC Sites	69	50	72
Non-designated Sites	123	80	65

Figure 3-24 provides a summary of the failed targets for SSSI, SAC and non-designated sites, while Figure 3-25 provides a summary of failed targets across all sites (see 2.6.9 to find out more about how targets were assessed). Note that target failures across multiple walks are weighted proportionally for each site (to take account of high numbers of target failures for larger sites with many site walks).

It is clear from Figre 3-25 that built structures and transition integrity are the two targets most frequently failed. Targets for stock grazing intensity; the maintenance of saltmarsh extent; and poaching damage also fail frequently. A similar pattern of target failure is seen across SSSI, SAC and non-designated sites. A number of targets fail more frequently on non-designated sites including: overgrazing, vehicle damage and the presence of invasive species. In contrast there targets that fail more often on designated sites including the realignment of creeks; the presence of built structures; pollution; the presence of a complete set of saltmarsh zones; and the presence of pans and creeks.

Only 69 of the 249 sites assessed included pioneer marsh, but most pioneer marsh vegetation met the condition targets. Table 3-8 provides a summary of the impacts on pioneer saltmarsh. Note that the figures in Table 3-8 were not weighted proportionally in the same way as those for the Atlantic saltmarsh targets, due to the sporadic and localised nature of pioneer marsh in Scotland. *Spartina anglica* invasion was the target that failed most frequently, but overall failures were much less frequent than on sites assessed for Atlantic saltmarsh.

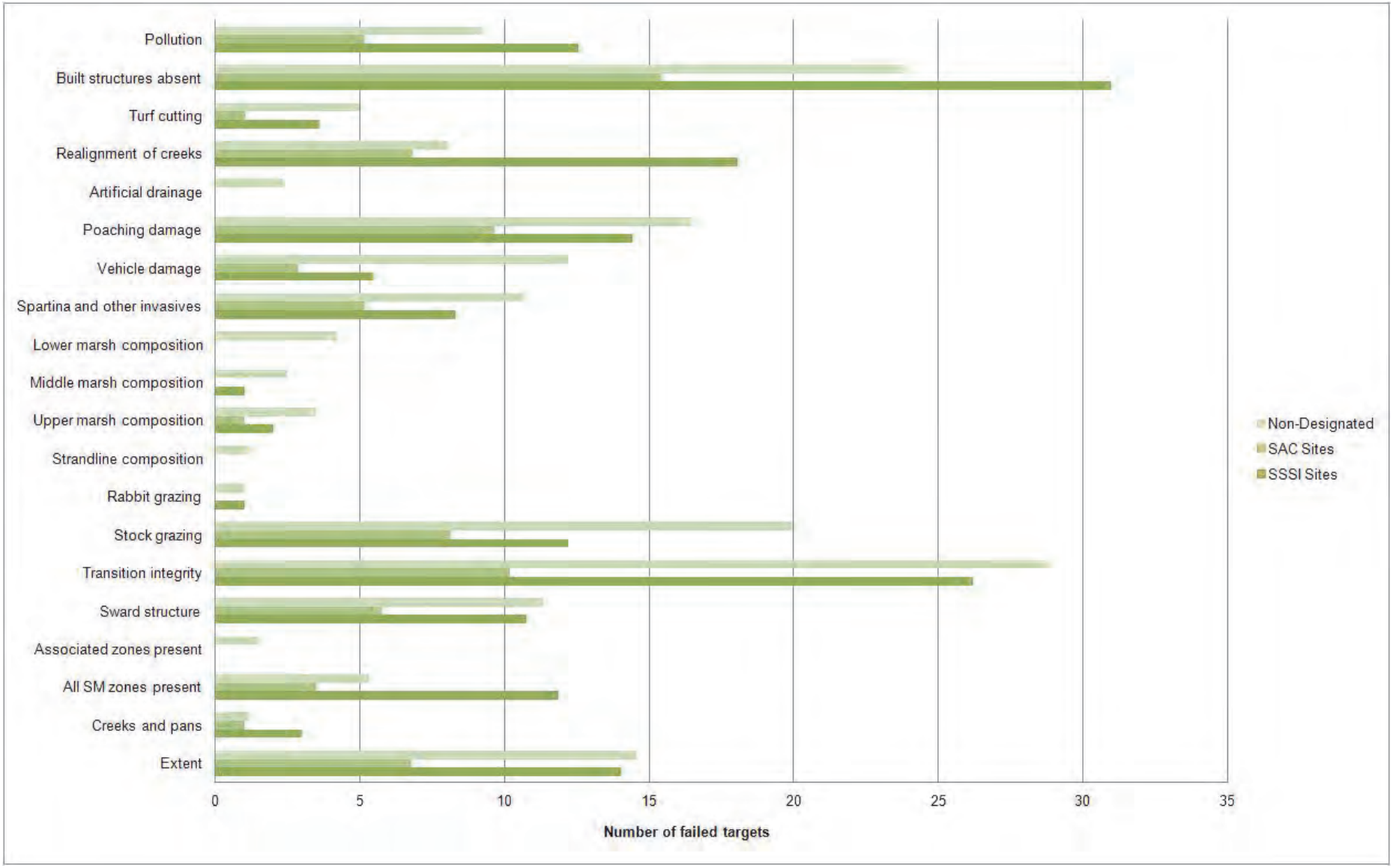


Figure 3-24: Summary chart of Atlantic Saltmarsh SCM target failures on SSSI, SAC and non-designated sites.

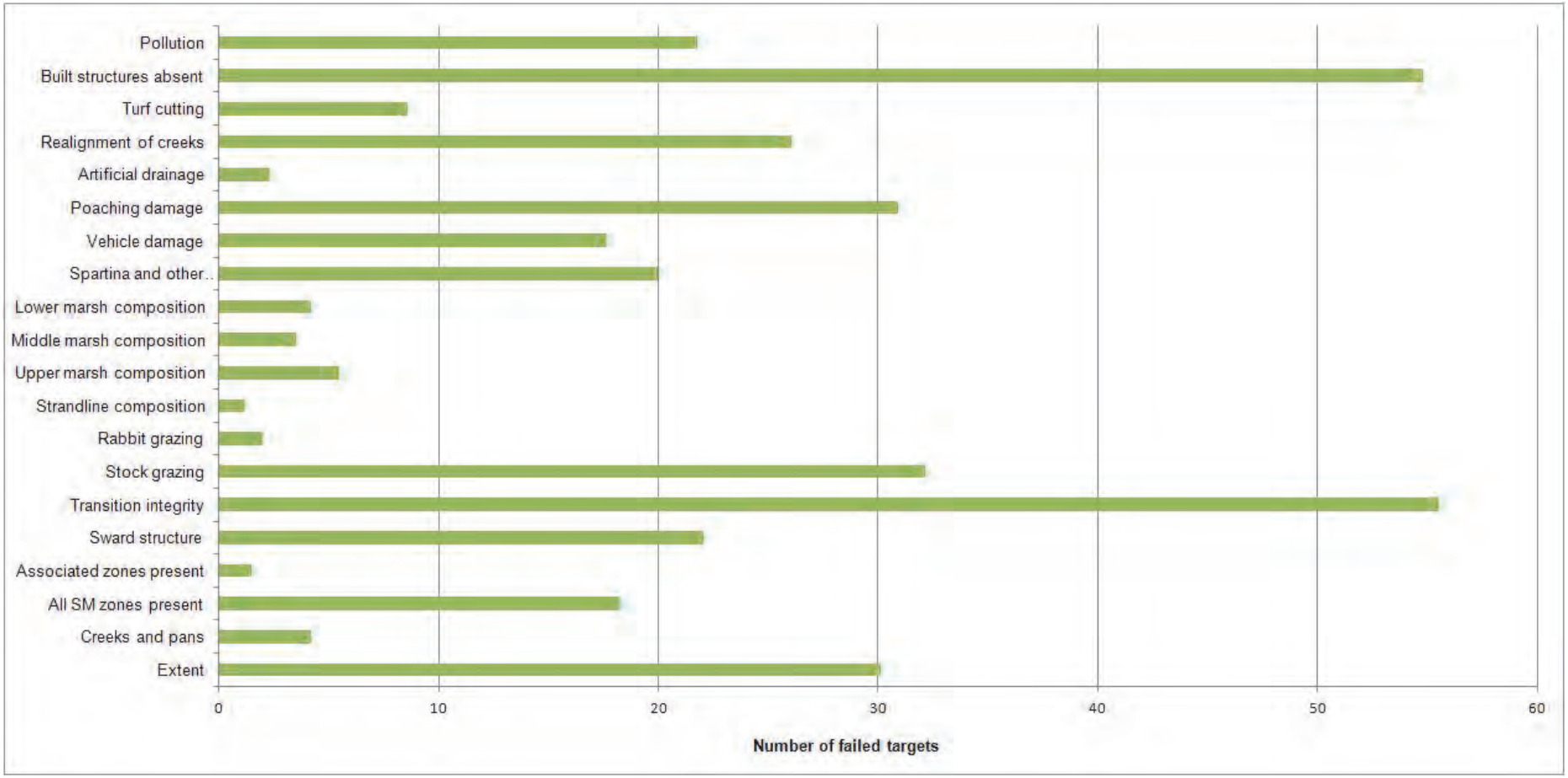


Figure 3-25: Chart of total Atlantic Saltmarsh SCM target failures across all sites.

Table 3-8: Summary of Pioneer Saltmarsh SCM condition target failures.

	All Sites	SSSI Sites	SAC Sites	Non-Designated
Extent	3	3	1	0
Physical structure, creeks and pans	0	0	0	0
Vegetation zonation	1	1	0	0
Vegetation composition	0	0	0	0
Coastal defences	4	4	2	0
Salicornia harvesting	0	0	0	0
Pollution	2	2	0	0
Bait digging	0	0	0	0
Spartina	6	3	2	2
Transitions	0	0	0	0
Total	**16**	**13**	**5**	**2**

3.8.2 Transition integrity, built structures and creek modifications

Targets for transition integrity (to terrestrial/other coastal habitats) were not met on a high number of sites (see Table 3-9). Most failures of transition integrity relate to modifications made to the saltmarsh, such as drainage channels and earth banks, which cause changes in vegetation communities. The presence of built structures (including earth banks) was the second most frequently failed target (see Table 3-10).

Table 3-9: Sites which failed transition integrity targets.

Site ID	Site Name	Location	SSSI	SAC	Number of Walks	Number of transition integrity fails
029BEA	Beauly Firth	North East	1	0	8	7
037MOR	Morrich More	North East	1	1	8	4
121INN	Inner Clyde	Clyde	1	0	7	4
023FIN	Findhorn Bay	North East	1	0	7	3
120GAR	Garnock Estuary	Ayrshire	1	0	3	3
126LOC	Loch Feochan	Argyll	0	0	4	3
240WIG	Wigtown	Solway (W)	1	1	17	3
245GRE	Gretna-Redkirk	Solway (E)	1	1	3	3
030MUN	Munlochy Bay	North East	1	0	2	2
036NIG	Nigg Bay	North East	1	0	3	2
076CAO	Caol Spit	Lochaber	0	0	2	2
103LOC	Loch Leven	Lochaber	0	0	5	2
239FLE	Fleet Bay	Solway (W)	0	0	3	2
246BRO	Browhouses	Solway (E)	1	1	2	2
007CUL	Culross Shore	South East	0	0	2	1
008GRA	Grangemouth	South East	1	0	1	1
014BLA	Blackness and Blackburn	South East	1	0	1	1
016BAR	Barry Burn	South East	0	0	1	1
024LOS	Lossiemouth	North East	0	0	1	1
028INV	Inverness	North East	0	0	1	1
031UDA	Udale Bay	North East	1	0	1	1
033DIN	Dingwall	North East	1	0	1	1

034BAL	Balconie Point	North East	1	0	1	1
035DAL	Dalmore	North East	1	0	1	1
038TAI	Tain	North East	1	1	1	1
039DOR	Dornoch Firth South	North East	1	1	2	1
040BON	Bonar Bridge	North East	0	1	2	1
046THE	The Mound (Loch Fleet)	North East	0	0	1	1
047CRE	Creag Bheag (Loch Fleet)	North East	1	0	1	1
050LIT	Little Loch Broom	North West	0	0	1	1
052AUL	Aultbea	North	0	0	1	1
069RIV	River Wick	North	1	0	1	1
070LOC	Loch Fyne	Argyll	0	0	1	1
073LOC	Loch a' Choire	Lochaber	0	0	1	1
078DER	Dervaig (Mull)	Argyll	0	0	1	1
082ARD	Ardentiny	Argyll	0	0	1	1
086CAM	Camas na Sgianadin	Skye & Lochalsh	0	0	1	1
090BRO	Broadford Bay	Skye & Lochalsh	0	0	1	1
098LOC	Loch Craignish	Argyll	0	0	1	1
102ARI	Arisaig	Lochaber	0	0	2	1
108EIL	Eilean an Droighinn (Islay)	Argyll	1	1	1	1
111GRU	Gruinart Flats	Argyll	1	0	2	1
119POW	Pow Burn	Ayrshire	1	0	1	1
123HOL	Holy Loch	Argyll	0	0	1	1
124LOC	Loch Striven	Argyll	0	0	1	1
125RUE	Ruel Estuary/Loch Ridden (Firth of Clyde)	Argyll	1	0	2	1
127AN	An Seilean (Firth of Lorn)	Argyll	0	0	1	1
129LOC	Loch Laich (Firth of Lorn)	Argyll	0	0	1	1
133BUN	Bunacaimb	Lochaber	0	0	1	1
134DRU	Druimavuic (Loch Creran)	Lochaber	1	1	1	1
137KEN	Kentra Bay	Lochaber	1	1	2	1
138ARD	Ardelve (Loch Alsh)	Skye & Lochalsh	0	0	1	1
139KIN	Kinlochteacuis	Lochaber	1	1	1	1
146LOC	Loch Don (Mull)	Mull	1	0	1	1
148LOC	Loch Dunvegan	Skye (N)	0	0	2	1
149LOC	Loch Greshornish	Skye (N)	0	0	1	1
156KIN	Kinlochhourn	Skye (S) & Borders	0	0	1	1
157KIS	Kishorn	Skye (S) & Borders	1	1	1	1
158KYL	Kyle	Skye (S) & Borders	0	0	1	1
159LOC	Loch Carron	Skye (S) & Borders	0	0	2	1
161TOS	Toscaig	Skye (S) & Borders	0	0	1	1
162KIR	Kirkton (Loch Alsh)	Skye (S) & Borders	0	0	1	1
235AUC	Auchencairn Bay	Solway (W)	1	0	1	1
242LUC	Luce Bay	Solway (W)	1	1	1	1

Table 3-10: Sites which failed targets due to the presence of built structures.

Site ID	Site Name	Location	SSSI	SAC	Number of Walks	Built structures absent
029BEA	Beauly Firth	North East	1	0	8	7
037MOR	Morrich More	North East	1	1	8	5
010FOR	Forth (Alloa)	South East	1	0	4	4
121INN	Inner Clyde	Clyde	1	0	7	4
120GAR	Garnock Estuary	Ayrshire	1	0	3	3
126LOC	Loch Feochan	Argyll	0	0	4	3
245GRE	Gretna-Redkirk	Solway (E)	1	1	3	3
249MIL	Milnfield Merse	Solway (E)	1	1	3	3
007CUL	Culross Shore	South East	0	0	2	2
076CAO	Caol Spit	Lochaber	0	0	2	2
103LOC	Loch Leven	Lochaber	0	0	5	2
128LOC	Loch Crinan	Argyll	1	1	3	2
239FLE	Fleet Bay	Solway (W)	0	0	3	2
240WIG	Wigtown	Solway (W)	1	1	17	2
246BRO	Browhouses	Solway (E)	1	1	2	2
253GLE	Glencaple & Kelton	Solway (E)	1	1	12	2
008GRA	Grangemouth	South East	1	0	1	1
014BLA	Blackness and Blackburn	South East	1	0	1	1
015BAL	Balmarino Shore	South East	1	1	1	1
016BAR	Barry Burn	South East	0	0	1	1
023FIN	Findhorn Bay	North East	1	0	7	1
026WHI	Whiteness Head	North East	1	0	1	1
030MUN	Munlochy Bay	North East	1	0	2	1
031UDA	Udale Bay	North East	1	0	1	1
033DIN	Dingwall	North East	1	0	1	1
034BAL	Balconie Point	North East	1	0	1	1
035DAL	Dalmore	North East	1	0	1	1
038TAI	Tain	North East	1	1	1	1
044CAM	Cambusmore Lodge (Loch Fleet)	North East	1	1	1	1
047CRE	Creag Bheag (Loch Fleet)	North East	1	0	1	1
052AUL	Aultbea	North	0	0	1	1
073LOC	Loch a' Choire	Lochaber	0	0	1	1
090BRO	Broadford Bay	Skye & Lochalsh	0	0	1	1
096NON	Nonach	Skye & Lochalsh	0	0	1	1
102ARI	Arisaig	Lochaber	0	0	2	1
108EIL	Eilean an Droighinn (Islay)	Argyll	1	1	1	1
111GRU	Gruinart Flats	Argyll	1	0	2	1
112AUC	Auchalick Bay	Argyll	0	0	1	1
113WHI	Whitehouse Bay	Argyll	0	0	1	1
118ULV	Ulva Islands & Loch na Cille	Argyll	1	1	3	1
123HOL	Holy Loch	Argyll	0	0	1	1
124LOC	Loch Striven	Argyll	0	0	1	1
129LOC	Loch Laich (Firth of Lorn)	Argyll	0	0	1	1
130LOC	Loch Mhuirich (Jura Sound)	Argyll	1	1	2	1
131SAI	Sailean na h-Airde	Argyll	1	0	1	1
133BUN	Bunacaimb	Lochaber	0	0	1	1
137KEN	Kentra Bay	Lochaber	1	1	2	1

142LOC	Loch Nevis Head	Lochaber	0	0	1	1
146LOC	Loch Don (Mull)	Mull	1	0	1	1
148LOC	Loch Dunvegan	Skye (N)	0	0	2	1
156KIN	Kinlochhourn	Skye (S) & Borders	0	0	1	1
157KIS	Kishorn	Skye (S) & Borders	1	1	1	1
158KYL	Kyle	Skye (S) & Borders	0	0	1	1
159LOC	Loch Carron	Skye (S) & Borders	0	0	2	1
160LOC	Loch Torridon	Skye (S) & Borders	0	0	2	1
162KIR	Kirkton (Loch Alsh)	Skye (S) & Borders	0	0	1	1
204BAL	Baltasound	Shetland	0	0	1	1
212LIT	Little Sea	Orkney	1	0	1	1
213LAM	Lama Ness Oyce	Orkney	0	0	1	1
218TOY	Toy Ness	Orkney	0	0	1	1
221LAM	Lamaness South (West)	Orkney	1	1	1	1
222LAM	Lamaness South (East)	Orkney	1	1	1	1
242LUC	Luce Bay	Solway (W)	1	1	1	1
243LUC	Luce Sands	Ayrshire	1	1	2	1
248ANN	Annan	Solway (E)	1	1	1	1

Many of the modifications to saltmarsh habitat are related to flood defence and agricultural improvement. These often take the form of earth banks which are normally found in the upper regions of the saltmarsh, but can also be found much closer to the front of the marsh. Earth banks can vary in height and width, but sites with larger earth banks also show signs of saltmarsh erosion. Most of Skinflats and the inner areas of the Firth of Forth are bordered with earth banks and considerable losses to saltmarsh extent are estimated across these saltmarshes since the earth banks were installed. Many of these structures were erected 50+ years ago. Only continued impacts on saltmarshes relating to earthbanks were recorded from the SCM surveys (e.g. continued declines since the surveys of Burd 1989 or Hutcheons Brothers 2000). If every site is failed based on the presence of earth banks it would make it difficult for many of the larger saltmarsh sites to pass the SCM assessment. It should be noted that earth banks may have hydrogeomorphological effects reportable under WFD condition monitoring. Table 3-11 provides a summary of the linear distance of sea defences recorded across Scottish saltmarshes by region. For more information on how these figures were estimated see 2.11.4. The east coast has the most earth bank and sea defences which are found across the larger saltmarsh systems on the Firth of Forth, Cromarty Firth and Tay Estuary. The Solway Firth also has a considerable amount of sea defence modifications.

Table 3-11: Sea defence linear distance summary across saltmarshes.

Region	**Linear distance of earth banks and sea defences**
East Coast	157.86km
Solway Firth	80.78km
West Coast	34.02km
Outer Hebrides	12.32km
Orkney	7.77km
North Coast	4.59km
Shetland	1.43km
Total	**298.77km**

Drainage ditches and straightened creeks are also installed on a high number of sites (particularly the larger saltmarshes). Earth banks are normally developed to improve the agricultural yield of neighbouring land and to improve saltmarshes for grazing. Such modifications alter saltmarsh vegetation communities, which includes changing the natural sediment deposition dynamics and the elevation of sediment on saltmarshes; leading to saltmarsh zones being found out of sequence. These modifications have significance to the ecological status of hydromorphological quality elements under the WFD, which require that channels correspond with undisturbed conditions to reach high ecological status (European Commission 2000). Furthermore, it is required that water bodies do not decrease in environmental status. New structural developments, such as sea defences, pose a considerable risk of disturbing saltmarsh vegetation and natural hydromorphological dynamism.

Many of the sites that show these modifications also have a greater range of saltmarsh vegetation communities types, particularly where marshy conditions are found in drainage ditches and scrapes in the upper marsh zone. Pioneer and lower marsh also colonise scrapes and disturbed areas (Skinflats and Montrose Basin are good examples of this). In contrast, significant modifications cause the merging of vegetation communities, particularly upper marsh vegetation infiltrating the middle and lower marsh zone. This pattern is also observed on sites under stock grazing management. These benefits and impacts relate to species and community diversity and do not consider the deeper ecological impacts of modifications to the natural transition zones, which can have wider impacts on the coastal habitat network and ecosystem functioning (Jones *et al.* 2011). The abundance of angiosperms and macroalgae is required to be maintained in conditions associated with minimal disturbance, in order for water bodies to reach high ecological status under the WFD (European Commission 2000). Although disturbed conditions provide a more diverse range of community types, under the WFD water bodies exhibiting such changes cannot reach high ecological status for this biological quality element.

It is logical that a higher incidence of transition integrity and built structure impacts are evident on designated sites, due to these developments being strongly associated with the larger saltmarshes, which were designated after many of these modifications were carried out. It is important that future condition monitoring work take into account continued impacts to the designated marshes relating to built structure and modifications, and not simply failing targets based on their presence.

3.8.3 Overgrazing, poaching and vehicle damage

Figure 3-24 and Table 3-12 shows the negative impacts that are more frequently observed on non-designated sites, which include overgrazing and vehicle damage. Overgrazing is reported from many saltmarsh sites, but appears to be less of an issue on SSSI and SAC sites generally, perhaps due to the introduction of agri-environment plans. However, many of the west-coast and offshore island sites are undesignated and are intensively grazed, as are SSSIs such as Kentra Bay. Intensive grazing can negatively affect the diversity of vegetation swards and could be linked to erosion rates. It is important that grazing controls are put in place on undesignated saltmarsh sites. Vehicle damage is also reported more frequently from non-designated sites, which is often related to grazing management, but on other sites it can be related to sport activities. Vehicular damage to back-barrier saltmarsh is particularly damaging and can destroy saltmarsh in a few years. Bikes and cars have caused considerable damage to the back-barrier marsh at Loch Fleet (Sutherland).

Table 3-12: Site which failed targets for grazing, poaching and vehicle damage.

Site ID	Site Name	Location	SSSI	SAC	Number of Walks	Over Grazing?	Vehicle damage?	Poaching damage?
010FOR	Forth (Alloa)	South East	1	0	4	2	1	2
013TYN	Tyninghame Shore	South East	1	0	3	1	1	0
023FIN	Findhorn Bay	North East	1	0	7	2	0	2
024LOS	Lossiemouth	North East	0	0	1	0	0	1
026WHI	Whiteness Head	North East	1	0	1	1	1	1
035DAL	Dalmore	North East	1	0	1	1	0	0
037MOR	Morrich More	North East	1	1	8	3	4	0
038TAI	Tain	North East	1	1	1	1	0	0
039DOR	Dornoch Firth South	North East	1	1	2	1	0	1
042COU	Coul Links (Loch Fleet)	North East	1	0	1	0	1	0
049LOC	Loch Broom	North West	0	0	2	0	0	1
050LIT	Little Loch Broom	North West	0	0	1	1	0	1
051OPI	Opinan	North West	0	0	1	1	0	0
060EIL	Eilean Dubh (Loch Eriboll)	North	0	0	1	0	1	0
063TOR	Torrisdale Bay	North	1	1	5	0	0	1
073LOC	Loch a' Choire	Lochaber	0	0	1	1	1	0
077INV	Inversanda	Lochaber	0	0	1	0	1	0
081DUN	Dunstaffnage	Argyll	0	0	3	0	1	0
082ARD	Ardentiny	Argyll	0	0	1	0	0	1
085LOC	Loch Slapin	Skye & Lochalsh	0	0	1	1	0	0
088LOC	Loch Ainort	Skye & Lochalsh	0	0	2	2	0	0
093LOC	Loch Eynort	Skye & Lochalsh	0	0	1	1	0	0
099GLE	Glenmore	Lochaber	1	1	1	0	0	1
101LOC	Loch Eil	Lochaber	0	0	2	0	1	0
102ARI	Arisaig	Lochaber	0	0	2	0	1	0
104INV	Inverscaddle Bay	Lochaber	0	0	3	1	0	0
105LOC	Lochailort	Lochaber	0	0	3	1	1	0
108EIL	Eilean an Droighinn (Islay)	Argyll	1	1	1	0	0	1
110THE	The Strand	Argyll	1	0	1	1	0	1
113WHI	Whitehouse Bay	Argyll	0	0	1	0	0	1
118ULV	Ulva Islands & Loch na Cille	Argyll	1	1	3	0	0	1
126LOC	Loch Feochan	Argyll	0	0	4	1	0	0
127AN	An Seilean (Firth of Lorn)	Argyll	0	0	1	0	0	1
128LOC	Loch Crinan	Argyll	1	1	3	0	0	1
129LOC	Loch Laich (Firth of Lorn)	Argyll	0	0	1	0	0	1
130LOC	Loch Mhuirich (Jura Sound)	Argyll	1	1	2	0	0	1
131SAI	Sailean na h-Airde	Argyll	1	0	1	0	0	1
132STR	Straad	Argyll	0	0	1	0	0	1
133BUN	Bunacaimb	Lochaber	0	0	1	1	1	1
137KEN	Kentra Bay	Lochaber	1	1	2	2	0	2
143AN	An Caolas	Mull	0	0	1	0	0	1
147LOC	Loch Beag	Skye (N)	0	0	1	1	0	0
148LOC	Loch Dunvegan	Skye (N)	0	0	2	2	2	2
155GLE	Glenelg	Skye (S) & Borders	0	0	1	1	0	0
156KIN	Kinlochhourn	Skye (S) & Borders	0	0	1	0	1	0
160LOC	Loch Torridon	Skye (S) & Borders	0	0	2	0	1	0
161TOS	Toscaig	Skye (S) & Borders	0	0	1	1	1	1

170LON	Lon Erista	Outer Hebrides	0	0	1	1	0	0
171LOC	Loch Gealavat	Outer Hebrides	0	0	1	1	0	1
174LOC	Loch Paible	Outer Hebrides	1	1	2	0	0	1
176HOW	Howbeg	Outer Hebrides	1	1	1	1	0	0
184ILL	Illeray	Outer Hebrides	1	1	3	3	0	0
185TRA	Traigh Eachkamish	Outer Hebrides	1	1	1	1	1	0
188GRE	Grenitote	Outer Hebrides	0	0	1	0	1	1
189CAR	Carinish	Outer Hebrides	0	0	1	1	1	0
190LAN	Langass	Outer Hebrides	0	0	1	1	0	0
191CLE	Clett-Feora	Outer Hebrides	0	0	1	1	1	0
192CNO	Cnoc Cuidhein	Outer Hebrides	0	0	1	1	0	0
193GRI	Grimsay	Outer Hebrides	0	0	1	1	0	0
194NOR	Northton Bay SSSI	Outer Hebrides	0	0	1	1	0	1
212LIT	Little Sea	Orkney	1	0	1	0	0	1
221LAM	Lamaness South (West)	Orkney	1	1	1	1	1	1
225POI	Point of Qui Ayre	Orkney	1	1	1	1	0	0
228SWA	Swarsquoy	Orkney	0	0	1	0	0	1
231CAR	Carse Bay	Solway (W)	1	1	1	0	0	1
234ROU	Rough Firth	Solway (W)	0	0	1	0	0	1
240WIG	Wigtown	Solway (W)	1	1	17	2	1	4
245GRE	Gretna-Redkirk	Solway (E)	1	1	3	0	0	1
248ANN	Annan	Solway (E)	1	1	1	0	1	1
249MIL	Milnfield Merse	Solway (E)	1	1	3	0	1	0
250PRI	Priestside Bank	Solway (E)	1	1	9	1	0	4
253GLE	Glencaple & Kelton	Solway (E)	1	1	12	0	0	3

3.8.4 Pollution

The sites that failed targets for the presence of various types of pollution are equally spread across both designated and non-designated sites, which indicates that designation does not regulate polluting activities per se. Pollution was recorded in a variety of forms, but was normally associated with foul water in pans; at the seaward edge of the marsh; and in creeks. Many sites include outflow pipes with foul water leaking out into the marsh (often in straightened creeks). Most of the observed outflow pipes are target-noted within individual site reports. On many sites water was observed that was a rusty brown colour. On other sites there was oil-like film on the water in pans and depressions. It is possible that both mineral staining and the oil-like film residues could relate to natural processes, but some sites (such as Skinflats and Udale Bay) require further investigation (see Table 3-13).

On the east coast there was a high incidence of sites with sanitary waste (mostly sanitary towels) washed up onto the shore line. Sites included Blackness and Black Burn (Firth of Forth) and Udale Bay (Cromarty Firth). Further information on sanitary waste is provided in the Site Condition Monitoring reports for these sites. Other pollutants found on saltmarshes include garden waste, scrap metal and manure. Table 3-13 includes a list of all the sites identified for failing pollution targets.

Table 3-13: Sites which failed pollution targets.

Site ID	Site Name	Location	SSSI	SAC	Number of Walks	Pollution Targets Failed
009SKI	Skinflats	South East	1	0	5	5
121INN	Inner Clyde	Clyde	1	0	7	2
010FOR	Forth (Alloa)	South East	1	0	4	1
014BLA	Blackness and Blackburn	South East	1	0	1	1
024LOS	Lossiemouth	North East	0	0	1	1
026WHI	Whiteness Head	North East	1	0	1	1
031UDA	Udale Bay	North East	1	0	1	1
034BAL	Balconie Point	North East	1	0	1	1
036NIG	Nigg Bay	North East	1	0	3	1
053STR	Strathkanaird	North	0	0	1	1
057LOC	Loch Sheigra	North	0	0	1	1
070LOC	Loch Fyne	Argyll	0	0	1	1
103LOC	Loch Leven	Lochaber	0	0	5	1
105LOC	Lochailort	Lochaber	0	0	3	1
111GRU	Gruinart Flats	Argyll	1	0	2	1
129LOC	Loch Laich (Firth of Lorn)	Argyll	0	0	1	1
148LOC	Loch Dunvegan	Skye (N)	0	0	2	1
189CAR	Carinish	Outer Hebrides	0	0	1	1
231CAR	Carse Bay	Solway (W)	1	1	1	1
232SOU	Southerness	Solway (W)	0	0	1	1
234ROU	Rough Firth	Solway (W)	0	0	1	1
235AUC	Auchencairn Bay	Solway (W)	1	0	1	1
238RIV	River Dee	Solway (W)	0	0	5	1
240WIG	Wigtown	Solway (W)	1	1	17	1
243LUC	Luce Sands	Ayrshire	1	1	2	1
246BRO	Browhouses	Solway (E)	1	1	2	1
247TOR	Torduff Point	Solway (E)	1	1	1	1
248ANN	Annan	Solway (E)	1	1	1	1
248DOR	Dornock	Solway (E)	1	1	1	1
250PRI	Priestside Bank	Solway (E)	1	1	9	1

3.8.5 Sward structure and saltmarsh zone representation

Targets for sward structure fail for a number of reasons, which usually relate to previously recorded swards no longer being present on the site. Changes in sward structure are normally the outcome of other failed targets (e.g. vehicle damage to saltmarsh at Loch Fleet causing a decline in sward structure). In other instances changes to sward structure are related to natural or climate-related change. Vegetation at Spey Bay now has less of an association with saltmarsh habitat due to the changing nature of the shingle spit that protects the bay. At Conon Islands much of the vegetation is considered to be brackish or coastal grassland and not saltmarsh. Changes in the vegetation at Conon Islands may also be due to differences in survey methodology, but it would appear that some sites now better represent coastal grassland vegetation rather than saltmarsh communities. For more information see 4.9.

A related issue is the lack of a full range of saltmarsh communities on Scottish saltmarshes. Due to many sites lacking a full range of communities, this section of the SCM form often identifies which communities are present. As discussed above, failed targets relate to damage to the saltmarsh or a cause of under-representation. Beauly Firth includes the

highest number of failures for this target, which is due to the poor association that this area has with saltmarsh vegetation, which is mostly coastal grassland and brackish swamp. Other sites are heavily affected by significant sea defences (which include seaward-fronting stone sea defences) which cause saltmarsh communities to erode. The information relating to saltmarsh community/sub-community representation is also of relevance to WFD monitoring. A small number of sites also fail composition targets for saltmarsh zones. Such sites normally fail due to degradation and damage from other impacts (built structures, straightened creeks, etc.). Such modifications can lead to impoverished swards of limited species. The highest number of failures is from upper marsh vegetation, which is due to the presence of species-poor stands of SM16a found on river and drainage ditch banks on developed sites.

3.8.6 Nutrient enrichment

Nutrient enrichment is not directly assessed within the current site condition monitoring regime, but it is an important consideration under various other European Directives and OSPAR. Under the WFD nutrients are part of the physico-chemical quality elements, and a number of biological quality elements monitoring tools respond to the pressure of nutrient enrichment. While this is not a primary pressure under WFD for saltmarsh, it is for macroalgal blooming. Excess blooms can in some circumstances have deleterious effects on saltmarsh if rafts of algae are deposited on the marsh and cause smothering.

Puccinellia dominated swards show no or little evidence of nutrient enrichment, but *Festuca* swards show signs of nutrient enrichment, particularly in SM16e areas.

Nutrient enrichment usually decreases the incidence and abundance of key upper-marsh species, such as *Juncus gerardii* and *Triglochin maritimum* that are replaced by *Trifolium repens* and *Leontodon autumnalis.* Most of the SM16b areas mapped at Caerlaverock appear to be in the early stages of converting to a more enriched variant, where abundant *Trifolium repens* (see 4.6.2) was recorded within the sward.

Most of the nutrient enrichment observed across Scottish saltmarshes is linked to stock-grazing through dunging, supplementary feeding, or modifications to the land (to make it suitable for grazing). Nutrient enrichment by stock-grazing is known to have significant effects on terrestrial grassland swards (Kirkham 2006). The level of stock grazing on saltmarshes across Scotland and the abundance of SM16 *Festuca* swards are likely connected. The absence of stock-grazing from the saltmarshes of the North Norfolk coast and the greater range of *Puccinellia* communities present are notable (Haynes & Beal 2014).

Also of note are areas of water enrichment in drainage channels and creeks. *Glyceria fluitans* is a strong indicator of these conditions (S22 - *Glyceria fluitans* water-margin vegetation, see Table 3-1).

3.8.7 Species of biogeographical importance

SNH provided the project team with a list of species that are restricted in saltmarsh habitat or at the limits of their southern or northern range. Any records of noteworthy species are discussed in individual SSS site reports and are target-noted/included within vegetation samples. This section discusses important notes regarding the list of biogeographical indicators and other noteworthy species (also see 3.8.8).

The restricted species *Carex maritima* was re-found at Boddin Point on perched saltmarsh (see Figure 3.26 and the Boddin Point SSS report). A number of smaller sedges were recorded in embryo dunes integrated into the saltmarsh mosaic at Morrich More, but further analysis is required to ascertain whether *Carex maritima* was among them.

Figure 3-26: Carex maritima *at Boddin Point.*

Carex recta and its hybrid are discussed in 4.10.9 (also see the River Wick and Bonar Bridge SSS site reports). One of the most significant achievements of the SSS project was locating three new sites for *Carex salina. Carex salina* is a highly restricted species that was only previously recorded from a single site (Strath Croe on Loch Duich). More details on this species are provided in 4.10.10 (also see the Loch Duich, Loch Sunart Head, Loch Nevis, and Torrisdale Bay SSS site reports).

Ligusticum scoticum was found on a number of sites across both coasts and was found in fen vegetation and in the borders of SM28 vegetation. The distribution records for the species do not indicate any significant expansion of its range.

Seriphidium maritimum was recorded from two sites as part of the SM17 NVC community, which is discussed in more detail in 4.6.14 (also see the River Dee & Manxman's Lake and Tyninghame Shore SSS site reports).

Atriplex portulacoides was found on two sites in the Solway Firth and is discussed in more detail in 4.5.6. and 4.5.7 (also see the Southwick, and Luce Bay SSS site reports).

Eleocharis parvula has been recorded from Conon Islands, but the only species recorded in the SSS surveys were the related *Eleocharis uniglumis* and *Eleocharis palustris*. Large stands of *Eleocharis uniglumis* lacked flowering heads making identification more difficult, but it is suggested that the much finer flowering heads of *Eleocharis parvula* would have been conspicuous if found at the site (see the Conon Islands SSS site report).

Elytrigia atherica was recorded from Spey Bay and suggested from a small number of other sites, but all records appear consistent with the known distribution of the species (also see 4.7.2).

Festuca arundinacea was found across many saltmarsh sites in Scotland as part of coastal grassland swards, which appear to be generally more common than reported previously for Scotland (Burd 1989), however, the records of the species are consistent with the species' known distribution. This species is discussed in more detail in 4.9.2.

Limonium spp. were only recorded from the Solway Firth and all plants found were *Limonium vulgare*. These records are discussed in more detail in 4.5.2., 4.5.6. and 4.5.7.

It should be noted that the SSS project focused on mapping the vegetation communities found on Scottish saltmarshes and assessing their condition. Rare and restricted species were recorded where seen, but were not given a priority in the project's objectives and this should not be considered an exhaustive record of their distribution.

3.8.8 Invasive species

A number of invasive non-native species were recorded on saltmarshes across Scotland. The most significant invasive species is *Spartina anglica* which covers large areas of the Solway Firth, but on a limited number of sites (see 4.3.2 and 4.4.2 for further information). *Spartina* sp. (thought to be the hybrid *Spartina x townsendii*) is present and expanding at several sites in northern Argyll, notably An Sàilean and Loch Creran.

Spartina anglica often grows on mudflats and acts as a pioneer community type. The root systems of this large plant give it the ability to stabilise mud substrates and allow saltmarsh to develop. This trait is why the species was planted in many areas in the first place. There was clear evidence that larger areas of *Spartina anglica* were allowing saltmarsh to develop further seaward into estuaries and for more typical saltmarsh to develop landward. The presence of other pioneer species such as *Salicornia* sp. in swards with *Spartina anglica* also raises the question of whether *Spartina anglica* is actively competing with other pioneer vegetation or facilitating the expansion of these communities. Sites with more expansive areas of *Spartina anglica* do appear to be less diverse with Auchencairn Bay and Fleet Bay including populations that have infiltrated the lower and middle marshes.

It would be valuable to undertake a historical assessment of the introduction of *Spartina* spp. onto these sites and also assess the saltmarsh habitat present before the species was introduced. *Spartina anglica* is only found in large areas on the Solway Firth, with the remaining areas of Scotland with small areas of the species that show little sign of expansion. *Spartina x townsendii* appears to be actively expanding in north Argyll and was discovered at several new sites.

Aster novi-belgii is found on a number of west-coast saltmarsh sites and is found in large areas at Caol Spit (Lochaber). *Cotula coronopifolia* was recorded filling pans at Dornoch Point (Dornoch Firth). Large areas of *Rudbeckia laciniata* and *Impatiens glandulifera* were found growing along the banks of the inner Tay and were present along the river towards Perth. *Mimulus guttatus* was also found in the same vegetation and is also present growing on shingle and gravels on some sites (Spey Bay). *Heracleum mantegazzianum* and *Impatiens glandulifera* are found in the landward transitions of saltmarshes (rarely on saltmarsh) and occupy large areas of the river bank. Large areas of *Heracleum mantegazzianum* were mapped at Montrose Basin (Angus), Spey Bay (Moray) and Cocklemill Bay (Firth of Forth). *Allium carinatum* was recorded on coastal grassland and saltmarsh at Kinnaber Links (Angus). *Fallopia japonica* was recorded from woodland borders on a number of sites with a particularly large belt of the species found at Manxman's Lake (Solway Firth) and at Loch Fyne. *Crocosmia x crocosmiflora* is locally abundant on the saltmarsh fringe at several sites on Skye.

3.8.9 Pressures and threats to the H1310 Annex 1 habitat

A set of pressures and threats was defined for use with reporting on the condition of Annex 1 habitats. These threats and pressures were compiled by the European Environment Agency and follow the classification developed by Salafsky *et al.* (2008). Pressures are considered to be factors that are acting now or have been acting during the article 17 reporting period, while threats are factors expected to be acting on the habitats in the future (Evans & Arvela 2011).

Table 3-14 presents the main pressures and threats considered to be facing Pioneer Marsh (H1310). Pressures include *Bolboschoenus maritimus*, a brackish swamp species often present at the seaward edge of saltmarsh habitat in estuaries, putting *Bolboschoenus maritimus* in competition for the small belt of exposed mud and sand where *Salicornia* spp. and *Suaeda maritima* are normally recorded.

Table 3-14: Pressures and threats facing H1310

Pressure	**Ranking** H = High importance M = Medium importance L = Low importance
G01.03.02 - off-road motorized driving	H
G05.01 - trampling, overuse	H
I01 - invasive non-native species	H
I02 - problematic native species	H
J02.05 - modification of hydrographic functioning	H
K04.01 - competition (flora)	H
D01.02 - roads, motorways	M
D01.05 - bridge, viaduct	M
D02.02 - pipe lines	M
G01.02 - walking, horse riding and non-motorised vehicles	M
J02.05.06 - wave exposure changes	M
J02.12.01 - sea defence or coast protection works, tidal barrages	M
J02.12.02 - dykes and flooding defence in inland water systems	M
M01.05 - water flow changes (limnic, tidal and oceanic)	M
M01.06 - wave exposure changes	M
M01.07 - sea-level changes	M
M02.01 - habitat shifting and alteration	M
C01.01 - Sand and gravel extraction	L
F04.02 - collection (fungi, lichen, berries etc.)	L
H03 - marine water pollution	L
H03.01 - oil spills in the sea	L
Threats	**Ranking** H = High importance M = Medium importance L = Low importance
A06.03 - biofuel-production	H
I01 - invasive non-native species	H
I02 - problematic native species	H
M01.07 - sea-level changes	H
M02.01 - habitat shifting and alteration	H
C01.01 - sand and gravel extraction	M
C01.01.02 - removal of beach materials	M
F04.02 - collection (fungi, lichen, berries etc.)	M
H03.01 - oil spills in the sea	M
H03.02 - toxic chemical discharge from material dumped at sea	M
J02.02 - removal of sediments (mud...)	M
J02.02.02 - estuarine and coastal dredging	M
J02.05.01 - modification of water flow (tidal & marine currents)	M
J02.12.01 - sea defence or coast protection works, tidal barrages	M
K01.02 - silting up	M
K04.01 - competition (flora)	M

M01.05 - water flow changes (limnic, tidal and oceanic)	M
M01.06 - wave exposure changes	M
H03 - marine water pollution	L

There were very few situations where *Bolboschoenus maritimus* was present at the front of a marsh where *Salicornia* sp. and *Suaeda maritima* were also present. There is little evidence to support the case that *B. maritimus* is actively outcompeting *Salicornia* sp. and *Suaeda maritima*. It is possible that the brackish *B. maritimus* is an indicator of changing conditions (possibly decreasing salinity) on Scottish estuaries.

The expansion of *Spartina* sp. indicates that it can actively compete with the species that make up H1310. *Spartina* sp. expansion is present on a limited number of sites on the Solway Firth, but with significant expansions recorded in these areas. In these areas *Spartina* sp. has already replaced H1310 (see the Rough Firth and Auchencairn Bay SSS site reports). *Spartina* expansion is limited to a small number of sites on the east and west coasts. Other significant pressures currently facing extant H1310 include trampling by visitors on high profile sites (such as Tyninghame Shore) and also vehicular damage on sites where vehicles have access to the foreshore (Fleet Bay).

Hydromorphological change is a key pressure influencing H1310 and is identified within the WFD with hydromorphological quality considered as an indicator of good ecological status. Nutrient levels are also are considered within the WFD.

The main threats facing H1310 in the future include changes in tidal current, wave exposure and the creation of sea defences. It is important that seed is able to spread across exposed mud and sand. If conditions restrict such movement then seeds will not be able to germinate and large areas of H1310 will decline.

Popular cooking programmes and literature also refer to *Salicornia* sp. (often referred to as ‘Samphire’) as a high quality ‘free food’. Members of the public often query surveyors about the location of ‘Samphire’. The removal of the species from sites for consumption is difficult to monitor and assess, due to the sporadic nature of H1310, but such media influence could play a part in the removal of the species from high profile sites.

Various websites reference the biofuel potential of *Salicornia* spp. Most of the experimentation has been completed *ex situ*, but there is a minor risk that such a scheme could be recommended in the UK.

3.8.10 Pressures and threats to the H1330 Annex 1 habitat

Table 3-15 presents the key pressures and threats facing Atlantic Saltmarsh (H1330). The pressures that cause the most condition targets to fail relate to built structures being present on the saltmarsh and habitat transition integrity. Many sites have been significantly altered landward (particularly where land rights are more clear), which alters the natural transition of H1330 to terrestrial habitat.

Table 3-15: Pressures and threats facing H1330

Pressures	**Ranking** H = High importance M = Medium importance L = Low importance
A04.02.02 - non intensive sheep grazing	H
E04 - structures, buildings in the landscape	H
J02.01.02 - reclamation of land from sea, estuary or marsh	H
J02.05 - modification of hydrographic functioning	H
J02.12.01 - sea defence or coast protection works, tidal barrages	H
J03.02 - anthropogenic reduction of habitat connectivity	H
A04.02.01 - non intensive cattle grazing	M
E04.01 - agricultural structures, buildings in the landscape	M
E04.02 - military constructions and buildings in the landscape	M
G02.01 - golf course	M
H01.05 - diffuse pollution to surface waters due to agricultural and forestry activities	M
I01 - invasive non-native species	M
J02.05 - modification of hydrographic functioning, general	M
J02.05.01 - modification of water flow (tidal & marine currents)	M
J03.03 - reduction, lack or prevention of erosion	M
K01.01 - erosion	M
K02.01 - species composition change (succession)	M
M01.05 - water flow changes (limnic, tidal and oceanic)	M
Threats	**Ranking** H = High importance M = Medium importance L = Low importance
H01.05 - diffuse pollution to surface waters due to agricultural and forestry activities	H
J02.12.01 - sea defence or coast protection works, tidal barrages	H
J03.02 - anthropogenic reduction of habitat connectivity	H
J03.03 - reduction, lack or prevention of erosion	H
M01.07 - sea-level changes	H
A04.02.01 - non intensive cattle grazing	M
A04.02.02 - non intensive sheep grazing	M
C01.01 - sand and gravel extraction	M
C01.01.01 - sand and gravel quarries	M
C01.01.02 - removal of beach materials	M
C03.04 - tidal energy production	M
E04 - structures, buildings in the landscape	M
G02.01 - golf course	M
G04.02 - abandonment of military use	M
H03.01 - oil spills in the sea	M
J02.05.01 - modification of water flow (tidal & marine currents)	M
K02.01 - species composition change (succession)	M
M01.05 - water flow changes (limnic, tidal and oceanic)	M
M02.01 - habitat shifting and alteration	M

Many sites also include an earth bank constructed at the rear of the marsh to protect agricultural land and residential areas from tidal flooding. Such structures also impact the natural transition of H1330. Realignment of creeks is also an important negative impact. Such modifications alter the natural flow of water across the surface of H1330. Roads, bridges and drainage systems are also constructed across H1330, which degrades or limits the saltmarsh. Other negative impacts include erosion; water level change; changes to wave exposure and river and tidal currents; stock grazing; and the presence of invasive species.

A key threat in the future of H1330 relates to climate change. Changes in tidal flow and volume could have significant impacts on H1330; changing the structure, extent, transition, and range of the habitat.

There are possible signs of such change within some Scottish estuaries including the Tay Estuary and Beauly Firth, where brackish swamp and coastal grassland are becoming more prominent components of the coastal habitat network.

Surface water run-off into pans and creeks in the upper regions of H1330 can also have negative impacts on specialist invertebrates and aquatic vegetation. It is likely that such impacts will continue into the future unless action is taken.

Hydromorphological change is a key pressure influencing H1330 and is identified within the WFD with hydromorphological quality considered as an indicator of good ecological status. Nutrient levels are also are considered within the WFD.

Changes in tidal flow and range may increase the need for sea defences that have the potential to damage H1330. Recent years have shown an increase in projects aimed at conserving such areas as natural sea defence. If these methods are applied widely then there may be reductions in damage caused by such projects.

Habitat interconnectivity is predicted to decrease over time. This is due to H1330 outside of protected areas being afforded less protection. The ability of H1330 to expand into new areas is restricted by the development of the coastline in heavily populated and industrial areas, where artificial and modified banks will not be suitable for H1330.

3.9 Brackish swamps of Scotland

3.9.1 The extent and distribution of brackish swamps in Scotland

Figure 3-27 shows the distribution of brackish swamp across Scotland. There is less brackish swamp present than saltmarsh and the largest areas are found on the Tay Estuary, Firth of Forth, Beauly Firth, Cromarty Firth, Dornoch Firth, Solway Firth, and the Firth of Clyde.

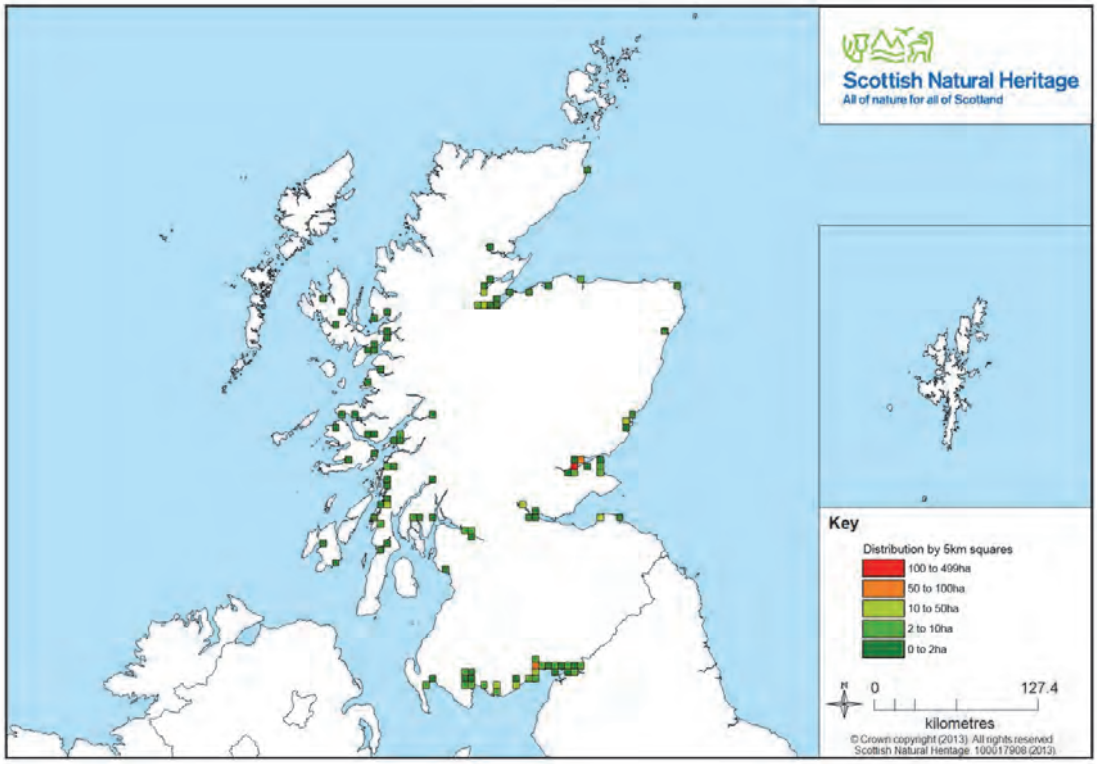


Figure 3-27: Distribution of brackish swamp in Scotland.

The key brackish swamp communities are S4, S21 and S20. The presence of S5 and S28 often indicates the limit of saline influence. More information on brackish swamp communities is provided in 4.10.

3.10 Brackish swamp ecology and formation

Brackish swamps are found on deeper mud deposits in estuarine systems and can form expansive areas across the banks of rivers and wider estuaries. Brackish swamp is also able to colonise inundated areas in the upper limits of marshes, such as pools, scrapes and ditches. The tall and densely compact nature of some of these communities makes them aggressive competitors with saltmarsh of shorter and more open swards in similar niches.

There is evidence that brackish swamp is expanding across some saltmarsh systems and the reasons are unclear, but grazing management, eutrophication and climate change could be possible causes (see 3.2.3). Coastal squeeze could also be a possible explanation with increased sediment depositing across areas already restricted for space, which would allow deeper silts to deposit at the front of saltmarshes. Heavy silting events are also reported to have a negative impact on pioneer species (Houwing *et al*. 1999). Assessment of previous maps also shows brackish swamp (particularly *Bolboschoenus maritimus*) is able to expand quickly. Landowners have also discussed the expansion of *Bolboschoenus maritimus* with surveyors.

Bolboschoenus maritimus's ability to colonise mudflats in the pioneer zone puts the species in direct competition with pioneer and lower marsh species, which was observed on many estuarine sites.

For more details about brackish swamp vegetation communities see 4.10.

3.11 Brackish swamp condition

Brackish swamp was not assessed individually as part of the SSS project, but most areas seem to be healthy and vigorous with minimal impacts. A few stands were badly poached by cattle e.g. Loch Crinan. The general scarcity of brackish swamp in the west may be due in part to grazing pressure. The impact that brackish swamp has on surrounding saltmarsh vegetation is discussed within the reports for sites including the Tay Estuary, Tayport (Fife), the Eden Estuary (Fife) and on the Solway Firth.

4. VEGETATION AND OTHER COVER TYPES

4.1 Introduction

This section of the report details the vegetation communities found on Scottish saltmarshes. The information provided in this section holds considerable value to the monitoring of biological elements under the WFD, particularly the composition and abundance of marine angiosperms (European Commission 2000). Each of the main saltmarsh sub-communities and brackish swamp communities includes a distribution map. Note that that these maps only include the locations of NVC communities mapped within the GIS database (see 2.11.3 for further details).

4.2 Littoral vegetation

Seagrass communities SM1 (*Zostera* communities) and SM2 (*Ruppia maritima* salt-marsh community) were excluded from the requirements of the SSS Project, but small areas of both SM1 and SM2 were recorded as part of the project. In most instances these communities were target noted, but areas of SM1 were mapped at the Eden Estuary and Montrose Basin on the east coast.

Any mapped areas of SM1 and SM2 within the SSS project should not be considered an accurate representation of the distribution of SM1 and SM2 in Scotland.

SM2 is often found in pans retaining water in the upper marsh zone on many sites on the Solway Firth and on the west coast. On the Solway Firth, *Ruppia maritima* is also found with *Ranunculus baudotii* in pans. A variant of the SM2 community is also present on the Cromarty Firth where *Ruppia maritima* develops a similar community to SM1 on the mudflats. Fragments of this variant were also found at a few west coast sites.

Stands of the unattached alga *Ascophyllum nodosum* ecad *mackayi* (a BAP Priority) are a notable feature of many west coast sea lochs. Where stands were observed beside saltmarshes they were recorded as target notes in individual site reports. At some sites they extended into saltmarsh creeks and pans e.g. Loch Leven.

4.3 Pioneer saltmarsh

4.3.1 SM5 (Spartina alterniflora saltmarsh)

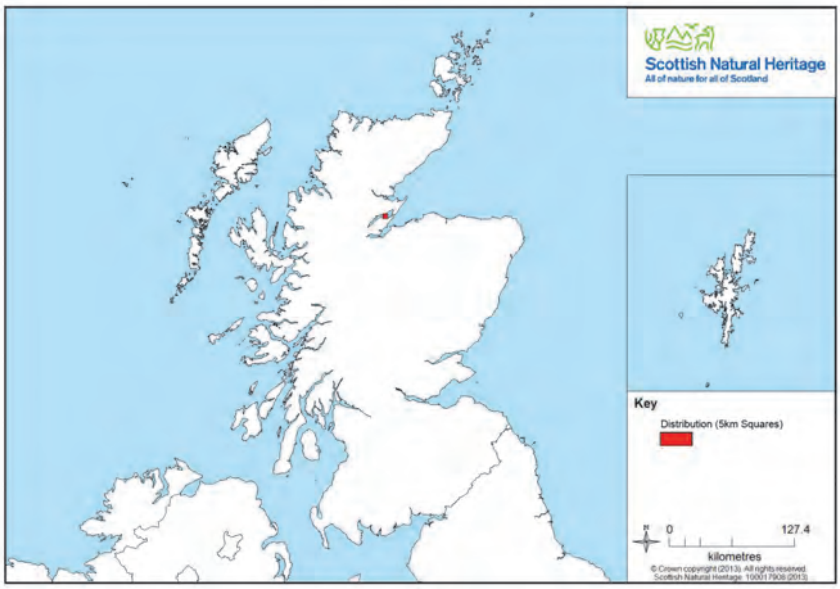


Figure 4-1: Distribution of SM5.

This community was noted from Udale Bay as part of a well-recorded population that was planted in the area to stabilise the saltmarsh sediment. The community is very similar to SM6 (see 4.3.3), but with Spartina alterniflora being the dominant species instead of Spartina anglica. The population itself is healthy and found across the mudflats close to the main saltmarsh sediment. *Spartina alterniflora* plants are regularly spaced leaving 5-20cm of space between individual plants. Puccinellia maritima is occasional within the community (see Figure 4-2Figure 4-2).

Figure 4-2: SM5 at Udale Bay.

4.3.2 SM6 (*Spartina anglica* saltmarsh)

Figure 4-3: Distribution of SM6.

SM6 is the community dominated by the invasive *Spartina anglica* and *Spartina x townsendii*. There is only a limited number of sites for this community in Scotland, in contrast to heavily *Spartina*-populated areas of England. Small areas of SM6 are found on the Eden Estuary in the shelter of a barrier island (too small to map). Small patches were also found on Nigg Bay on the Cromarty Firth. Previous reports also indicate a population at Dingwall, but this area was not re-found.

On the west coast, SM6 is found in large areas at An Sàilean (Argyll) and also on the nearby Ardentiny and Balure of Shian (Loch Creran); where it appears to be expanding. It has also spread to new sites including Dunstaffnage and Loch Laich. A small community is also recorded from Luskentyre (Isle of Harris), which is reported to have shown little or no expansion since it was first recorded (Law & Gilbert 1986; Payne 2013).

The largest areas of SM6 are located on the Solway Firth at: Rough Firth; Auchencairn & Orchardton Bays; Fleet Bay; and Wigtown.

The plant is easily recognisable when found as part of this virtually homogenous community with broad, browning leaves dying-back. The general size and appearance of the plant looks like a slim corn-cob from a distance. The community often gives mudflats a stubble-like appearance. The community looks untidy and unattractive, with exposed mud often evident around the plants. Algae are often prominent around the roots of *Spartina anglica*.

SM6 is able to form seaward of SM8 and the patterning of *Spartina* stands can appear similar to the structure of SM8 *Salicornia* communities, thus caution should be used if mapping from a distance. SM6 was strongly associated with areas where SM8 was previously present on the Solway Firth. As discussed previously (see 3.8.8), it is possible that *Spartina anglica* is in direct competition with *Salicornia* or that the community is facilitating the development of SM8. It seems to have displaced SM8 at Balure of Shian.

SM6 is able to survive much further seaward onto the mudflats than most of the other pioneer communities and can also be found in isolated islands of vegetation. *Spartina*

anglica is able to develop into the lower and middle marsh, but this variation is classified as SM13x (see 4.4.2).

As is the nature of *Spartina anglica,* the mud flats are stable and easy to manoeuvre across where SM6 is present and it is possible that the community may be beneficial in halting erosion on some sites.

There was no evidence of *Spartina* die-back, as observed in England, but equally there was little evidence to suggest aggressive expansion (except in Argyll). Many of the areas previously identified for the community in Burd (1989) still have similar sized areas.

The larger populations on the Solway Firth do pose some risks to neighbouring un-infested bays. The areas of SM6 on Rough Firth appeared to be recently established, particularly in the river mouth. *Puccinellia maritima* and *Salicornia* sp. are associated species (see Figure 4-4).

It should also be noted that small areas of *Spartina* are recorded from many sites and are not included on the distribution map. These areas are target noted in individual site reports.

Figure 4-4: SM6 at Rough Firth (Solway Firth).

4.3.3 SM8 (Annual Salicornia saltmarsh)

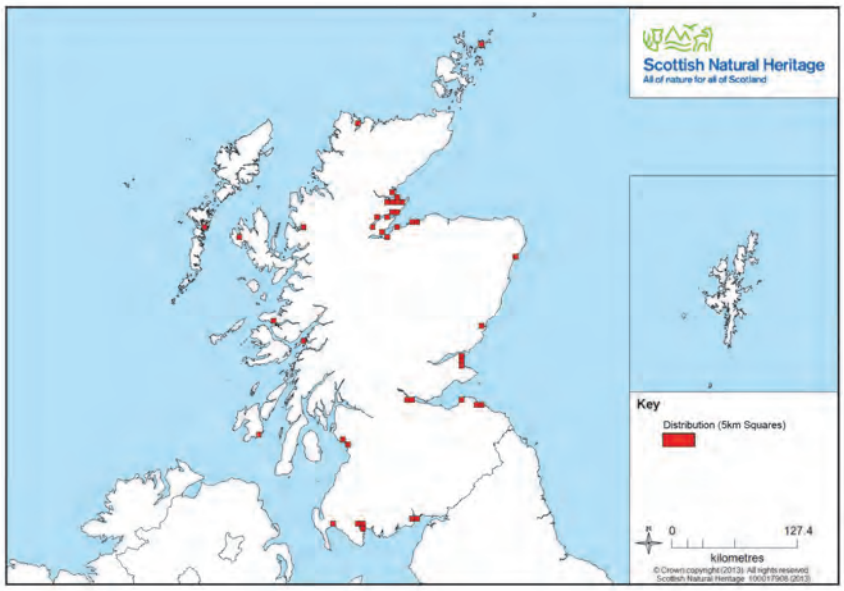


Figure 4-5: Distribution of SM8.

SM8 is a localised community often found on the saltmarshes surrounding the Solway Firth, the outer regions of the Firth of Forth and the Moray, Dornoch and Cromarty Firths. Outlying populations are present at Loch Torridon on the west coast and the most northern mainland record is from Eilean Dubh (Loch Eriboll), but small areas of SM8 were also recorded from Lamaness South on Sanday in Orkney. Stands too small to map occur more widely on the west coast. These are included in the SSS site reports as target notes (see appendix 2 for a full site report index).

The community is strongly associated with sandy substrates. There are only limited occurrences of the community forming on isolated sites, with most records found across clusters of associated sites. It is possible that populations are maintained by the movement of seed between neighbouring communities, particularly in Scotland's larger estuaries. Further analysis of all sites recorded for the presence of *Salicornia* would provide further detail about the community's distribution.

SM8 is typically found as sparse and open swards of *Salicornia* on sand flats. Small stands occur occasionally in pans and disturbed areas higher up the saltmarsh, which were recorded on the west coast, but were rarely recorded across the north and east coasts and Solway Firth. Early in the field season (e.g. June) SM8 can be difficult to find due to its short stature at this time of year. As the year progresses the plants become larger and branch frequently along the stem. SM8 can be found on gravelly and shingly substrates, but it is often stunted and small. It is possible that these stunted communities found on the limits of its northern range could be a different species of *Salicornia* from the ones found on mud-flats and sand-flats. Multiple species of *Salicornia* appear to be present at Tyninghame Shore in the shelter of a shingle spit. Most specimens examined on the west coast appeared to be *Salicornia europaea* agg. but *Salicornia procumbens* agg. was found at Kyle (Lochalsh).

Suaeda maritima and *Puccinellia maritima* can be occasional to frequent within the sward. Mats of filamentous algae (described as 'Algal mat' in SSS samples) and larger seaweeds can also be present (see Figure 4-8). *Aster tripolium* and *Spergularia media* are occasional.

SM8 is often found as a narrow border seaward of the main saltmarsh sediment. The community is often separate from the lower marsh and is found as isolated islands on mud and sand. On sandier systems the community integrates more into the lower marsh zone, forming SM10. Where a gradual transition between SM8 and the lower marsh zone is present, SM8 grades into SM13 (with *Puccinellia maritima* becoming more prominent).

SM8 appears to vary considerably in density and location from year to year, which may be due to its ephemeral nature. Much more extensive and dense areas were previously recorded from the Solway Firth.

Although areas of pioneer SM8 saltmarsh show signs of expansion, *Salicornia* spp. do not form dense stands (see Figure 4-6). There is a notable difference in *Salicornia* coverage when compared with previous imagery taken from 1999 by Stewart Angus (see Figure 4-7). The areas observed in 1999 were much denser and more extensive. The areas observed in 2013 were much sparser and more open. It is most likely that the areas indicated in Figure 4-7 have now developed into SM13a habitat (as *Salicornia* was frequently found within the SM13a sward). This change indicates that there is now less SM8 than previously recorded in 1999. Although Caerlaverock is showing significant signs of accretion and erosion, it should be noted that there were no dense areas (such as those pictured in Figure 4-7) recorded across any of the Solway Firth sites visited in 2012. It is possible that some of these areas of dense SM8 were buried by sand deposition events (reference to old maps and aerial photography indicates considerable change in the sediment deposition regime at Caerlaverock).

Figure 4-6: Open stands of SM8 on the mud-flats at Caerlaverock from 15/08/13.

Figure 4-7: Extensive and dense SM8 at Caerlaverock from 11/08/99, taken by Stewart Angus

Despite the polygons on the Solway being larger than most other SM8 polygons, *Salicornia* was often observed to be very sparse, when compared to older photography, and are not comparable (in density) to those recorded from sites such as the Eden Estuary (Fife). It is recommended that further investigation be undertaken on the observed changes in SM8 area and density on the Solway.

No signs of *Salicornia* harvesting were recorded from any of the SSS surveys, but such harvesting would show little evidence of occurrence. Sea defence developments and any works involving disturbance to sand and mud-deposits could affect these communities. Although self-pollination is reported for *Salicornia europaea* (Jefferies *et al*. 1981), consideration should be given to local and long distance seed dispersal. Populations of *Salicornia* may rely on recruitment from nearby populations and a lack of surrounding *Salicornia* populations may cause declines at local scales. Suitable substrate and environmental conditions for colonisation by *Salicornia* are also important considerations for the continued presence of SM8 in Scotland. If seeds are dispersed through estuaries (and larger coastal water bodies) and there is limited substrate available for colonisation, then it is likely that these seeds will not set.

Figure 4-8: SM8 at Tyninghame Shore.

4.3.4 SM9 (Suaeda maritima saltmarsh)

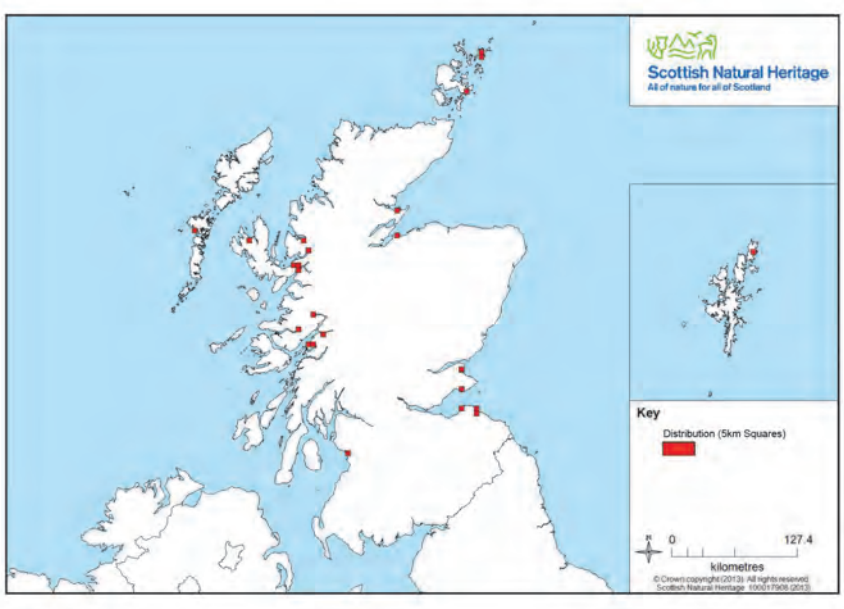


Figure 4-9: Distribution of SM9.

SM9 is a rare vegetation community in Scotland and has a broadly similar range and distribution to SM8, but is found across fewer sites. SM9 is found on sand and shingle sites and can colonise coarser gravels than *Salicornia*. The community is floristically very similar to SM8 with *Suaeda maritima* mostly replacing *Salicornia*. Unlike SM8, SM9 does not grow in expansive areas with all (except one) polygons being 1ha or less in area. The largest polygon of SM9 was recorded from Tyninghame Shore, where the community was found in abundance.

SM9 is often found in the same locations as SM8 and can form mosaics of the two communities. It should be noted that that patterning of mosaics and the dominance of each community may change from year to year due to the ephemeral nature of both communities.

SM9 has a wider distribution across the northern limits of its range than SM8 with populations found on the offshore islands including: Baltasound (Unst), Bay of Suckquoy (Orkney Mainland), Little Sea, Cata Sand, Lamaness South and Tor Ness to Quivals Creek (Sanday). It is possible that this distribution is due to SM9's ability to develop over shingle substrates (see Figure 4-10 and Figure 4-11). On the west coast it is locally frequent on patches of shingle, notably at sites in Loch Alsh.

Like SM8, SM9 is transitional to SM13a, where plants of *Suaeda maritima* can be abundant with a *Puccinellia maritima* sward. A micro-mosaic of SM9, SM8 and SM13a can form on some sites, which is more adequately classified as SM10.

Figure 4-10: Close up view of SM9 at Cocklemill Bay (Firth of Forth).

Figure 4-11: SM9 community structure at Cocklemill Bay (Firth of Forth).

4.3.5 *SM10 (Transitional low-marsh vegetation with Puccinellia maritima, annual Salicornia species and Suaeda maritima)*

Figure 4-12: Distribution of SM10.

SM10 is also a rare community in Scotland, which is due to both *Salicornia* and *Suaeda* needing to be present. SM10 is restricted to sandy sites and is recorded from all of the larger saltmarsh sites where sand substrates are prominent. The community is strongly associated with the east coast with a very limited presence on the Solway Firth (at Luce Bay) and on the west coast (Garnock Estuary, Loch Sunart Head and Loch Alsh). The community is also found on Benbecula (Benbecula Airport); Cata Sand on Sanday; and Sandi Sand on Orkney Mainland.

SM10 forms where there is a gradual and continuous linkage between the pioneer saltmarsh zone and the lower marsh zone. These transitions are often present on larger saltmarshes (on sandy substrates) where large, open areas of SM13a expand seaward on the sand flats. In such instances, SM13a is often homogenous with *Puccinellia maritima* being the only species present. *Puccinellia maritima* transitions through pioneer communities of both SM8 and SM9 and at this point *Puccinellia maritima*, *Salicornia* spp. and *Suaeda maritima* can often be found in abundance, but none of the three species clearly become the dominant component. Aberlady Bay includes very typical formations of SM10 (see Figure 4-13).

Figure 4-13: SM10 at Aberlady Bay.

4.3.6 SM11 (Aster tripolium var. discoideus saltmarsh community)

SM11 was not recorded as part of the SSS project, but was previously reported from Skinflats. SM11 is an unusual community as there is very little information within the published NVC documentation (Rodwell 2000), other than its similarity to SM12 (see below) but with a rayless form of *Aster tripolium* (var. *discoideus*). This variant is no longer recognised taxonomically and despite extensive searches of Skinflats none of this variety of *Aster* was found. It is concluded that SM11 is now a redundant NVC type in Scotland and that SM12a should be the preferred NVC type used for sub-communities dominated by *Aster tripolium* in the lower and pioneer regions of Scottish saltmarshes.

4.3.7 SM12a (Coastal stands of rayed Aster tripolium)

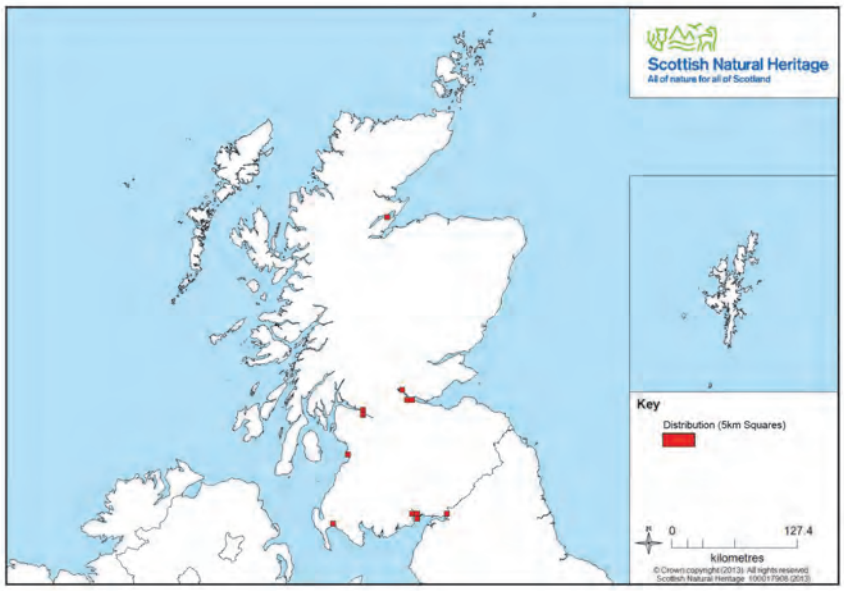


Figure 4-14: Distribution of SM12a.

This sub-community is rare in Scotland and is found in limited areas on the east coast (Firth of Forth and Cromarty Firth), west coast (Firth of Clyde and Pow Burn) and on a number of sites on the Solway Firth.

Aster tripolium is the dominant species present in this sub-community with *Puccinellia maritima* and *Triglochin maritimum* also prominent in the sward. *Salicornia* and *Suaeda maritima* were found in the swards at Udale Bay (see Figure 4-15). SM12a is found on areas of pioneer and lower marsh where the saltmarsh has been modified or recently disturbed. Most records are from sites with notable human modifications, such as the disturbed areas at the front of Grangemouth oil refinery and sites with earth bank modifications (Udale Bay and Luce Bay).

Aster tripolium can grow very tall in SM12a and can be approximately 1m in height (see Figure 4-16). *Aster tripolium* is found in a number of other communities but rarely gains the height or dominance it does within SM12a.

SM12a also seems capable of colonising shingle and gravel, which was observed (in small populations) on a number of east coast sites. On the Solway Firth, large areas of SM12a were recorded from accreting saltmarsh, particularly where the saltmarsh is frequently submerged. One large area of SM12a was found at Gretna to Redkirk on an isolated island separated from the main marsh by a wide drainage channel. At high tide this area was fully submerged and not visible on aerial photography (see Figure 2-8). This sub-community was found on a very similar situation on the inner Forth, near Alloa, where SM12a was dominating a large river island which was surrounded by a drainage system and banks. Small stands of SM12a were also found in undisturbed mid-marsh pans in Loch Crinan, on a sandy substrate.

Figure 4-15: SM12a at Udale Bay.

Figure 4-16: SM12a at Grangemouth.

4.4 Lower saltmarsh

4.4.1 SM13a (Puccinellia maritima dominated sub-community)

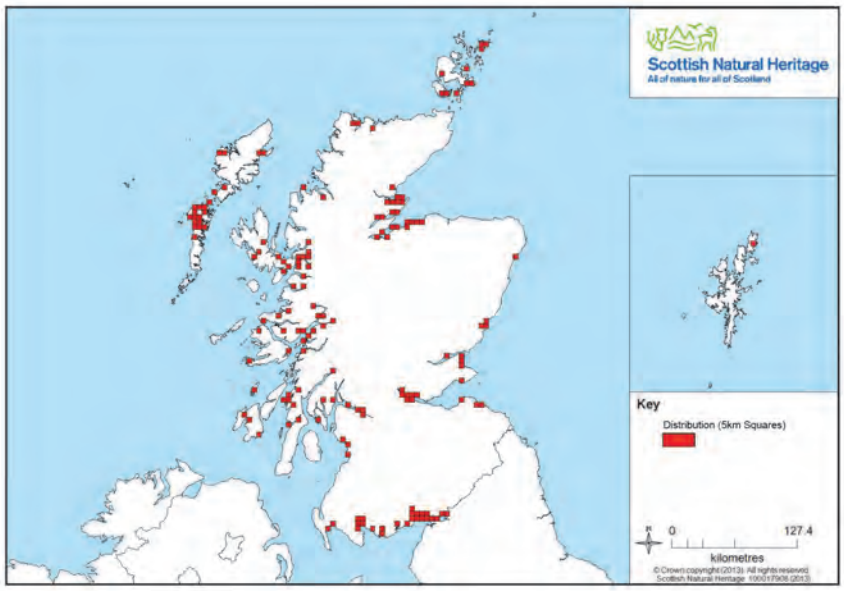


Figure 4-17: Distribution of SM13a.

SM13a was previously considered to be uncommon in Scotland, but this sub-community is found across the majority of saltmarshes and throughout their entire range.

The most typical form of SM13a is found in the lower marsh zone and is dominated by *Puccinellia maritima* and is found across large areas at the seaward edge of the marsh. The typical form of SM13a can be found on a number of different substrates but larger areas develop over mud and sand flats (see Figure 4-18 and Figure 4-19). This type of SM13a can form continuous mats or isolated hummocks. A distinctive feature of hummock forming SM13a is when the flowering heads spread out beyond the hummock and fall flat to the substrate. SM13a can also be quite diverse with *Aster tripolium, Salicornia* sp., *Suaeda maritima*, *Spergularia media*, *Spartina anglica, Glaux maritima* and other species found in abundance. SM13a is distinguished from closely associated middle marsh sub-communities by *Puccinellia maritima* maintaining a prominence within the sward. If *Glaux maritima* begins to become the dominant species then the sub-community would be better assigned to SM13b, or if *Plantago maritima* and *Armeria maritima* begin to co-dominate or equal the area occupied by *Puccinellia maritima* then SM13d might be a better classification. Some stands on the west coast have a dense carpet of turf fucoids and have been mapped as SM13e although occupying the niche of SM13a (see 4.5.4).

Unlike SM13a found in England and Wales, Scottish SM13a is often recorded as a narrow seaward fringe (approx 30cm-2m wide) to the main saltmarsh sediment and is found straddling the area between the sediment step at the seaward edge of the marsh and the silting base (on the sand/mud flats). When SM13a is found as a narrow fringe, it is often one of the only representatives of the lower or middle marsh zone, and is easily overlooked when surrounded by upper marsh vegetation. The presence and abundance of *Puccinellia maritima* is the key defining character of the community. *Puccinellia maritima* is often found with *Aster tripolium*, *Triglochin maritimum* and *Plantago maritima*. *Festuca rubra* and *Agrostis stolonifera* may also be present at low abundance levels, and when these two species become more prominent than *Puccinellia maritima*, then the sub-community is better defined as SM16a (see 4.6.1).

SM13a can also be found within a range of saltmarsh zones, particularly where conditions have created localised open areas (allowing vegetation to colonise). Such open areas include: depressions formed by pans and creeks; the regularly submerged edges of creeks, drainage ditches and pans; turf cuttings and other dig-outs; and areas heavily grazed in previous years. The cessation of grazing on some sites has shown that SM13a is able to re-colonise bare open areas where frequent tidal flooding persists (such as Wigtown on the Solway Firth).

Figure 4-18: Close up of SM13a at Wigtown (Solway Firth).

Figure 4-19: Community structure of SM13a at Wigtown (Solway Firth).

4.4.2 SM13x (Puccinellia maritima-Spartina anglica sub-community)

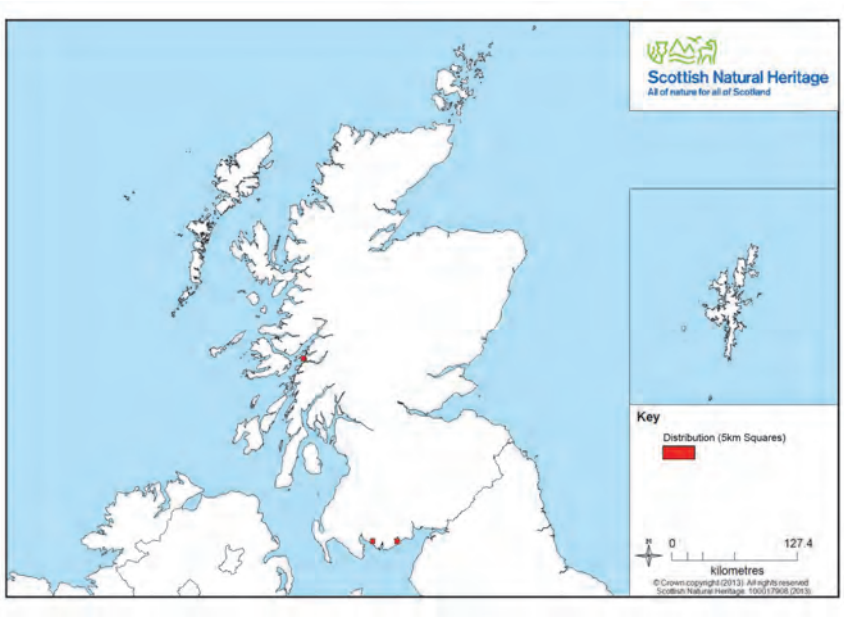


Figure 4-20: Distribution of SM13x.

SM13x is a sub-community that does not fit the published NVC classifications and is found on the Solway Firth and on one site on the west coast (An Sàilean). This sub-community was defined to take account of the transitional area between SM6 and the lower and middle marsh zones. SM6 is dominated by *Spartina anglica* or *Spartina x townsendii* and colonises bare mud, with few other associates. While undertaking the SSS project, it was clear that invasion of the *Puccinellietum* often occurs landward of SM6. In these areas *Puccinellia maritima* has more of a presence and often forms a continuous pattern of alternating patches of both species. SM13x can cover large areas of the lower and middle marsh zone, but is probably better described as lower marsh in many instances (see Figure 4-21 and Figure 4-22).

Figure 4-21: Close up of SM13x at Orchardton Bay.

Figure 4-22: Vegetation structure of SM13x at Orchardton Bay.

4.5 Middle saltmarsh

4.5.1 SM13b (Glaux maritima sub-community)

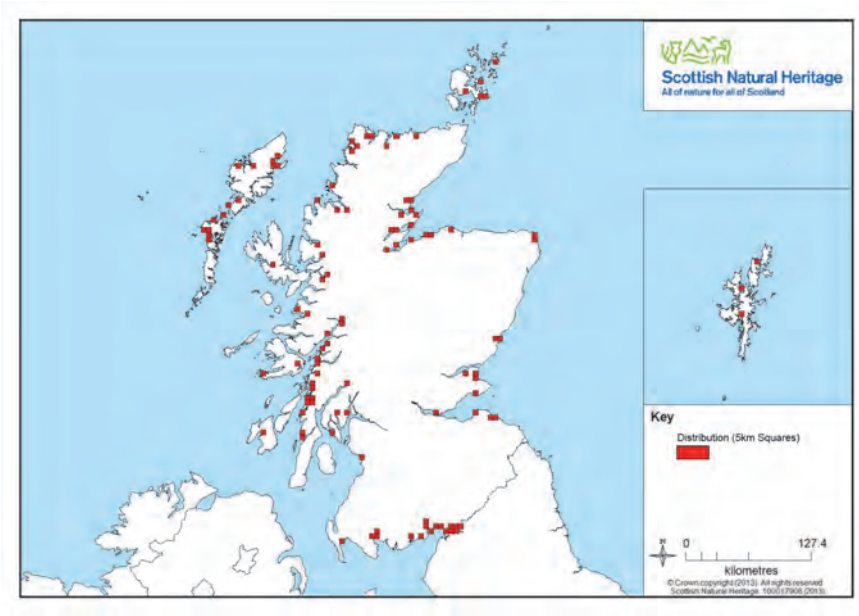


Figure 4-23: Distribution of SM13b.

SM13b is found in very similar situations to SM13a; its description as a 'middle marsh' community is tenuous and it would be better considered a form of lower marsh in Scotland. SM13b has a wide distribution and is normally found on shingle and gravel ridges and on muddy sand. The largest areas of the sub-community are found at Morrich More (Dornoch Firth) and in intensively grazed areas of Wigtown on the Solway Firth. The largest stands on the west coast occur on muddy sand at Caol Spit (Lochaber). The sub-community often forms as a response to grazing by geese.

SM13b can also become abundant across coarser sand substrates. Many of the associates of SM13a are present, but *Glaux maritima* is clearly dominant or co-dominant with

Puccinellia, but in these situations at the front of the marsh *Glaux maritima* is often stunted and close to the substrate (see Figure 4-24).

It is important to assess wider areas of the saltmarsh zone before classifying SM13b, as *Glaux maritima* is known to aggregate in local patches and in these situations may better fit a different classification such as SM13a.

SM13b is also found on sheep and rabbit grazed sites where the low growing habit of the sub-community appears to be a response to close grazing. In these instances, it is likely that SM13a was present before grazing was introduced. *Festuca rubra* can also be present in grazed SM13b stands. The boundaries between SM13b and SM16c can be difficult to ascertain in intensively grazed systems.

Figure 4-24: SM13b at Montrose Basin.

4.5.2 SM13c (*Limonium vulgare-Armeria maritima* sub-community)

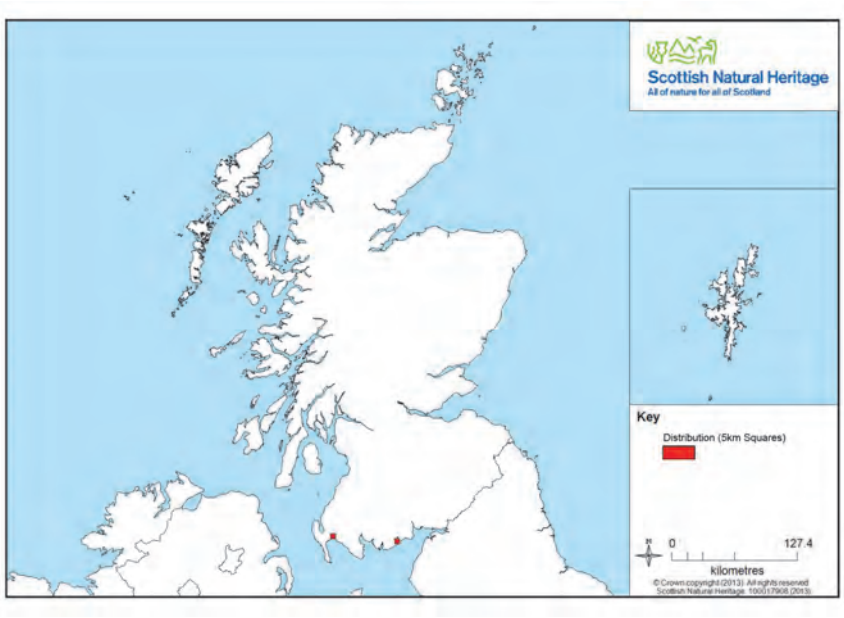


Figure 4-25: Distribution of SM13c.

SM13c is a very rare sub-community in Scotland due to the range limitations of two of the sub-community's key species (*Limonium vulgare* and *Atriplex portulacoides*). SM13c is found exclusively on the Solway Firth on two sites: Orchardton Bay and Luce Bay. SM13c has the same community structure as SM13d in Scotland, but with the addition of *Limonium vulgare* and *Atriplex portulacoides*. *Atriplex portulacoides* and *Limonium vulgare* do not gain dominance in this sub-community but are found occasionally throughout the sward. Areas are relatively open and are associated with SM14a.

Due to the highly restricted distribution of SM13c it is difficult to learn more of the sub-community's ecological niche in Scotland, but beyond the northern limits of the key species, all vegetation of this type is classified as SM13d.

Figure 4-26: SM13c at Orchardton Bay.

4.5.3 SM13d (Plantago maritima-Armeria maritima sub-community)

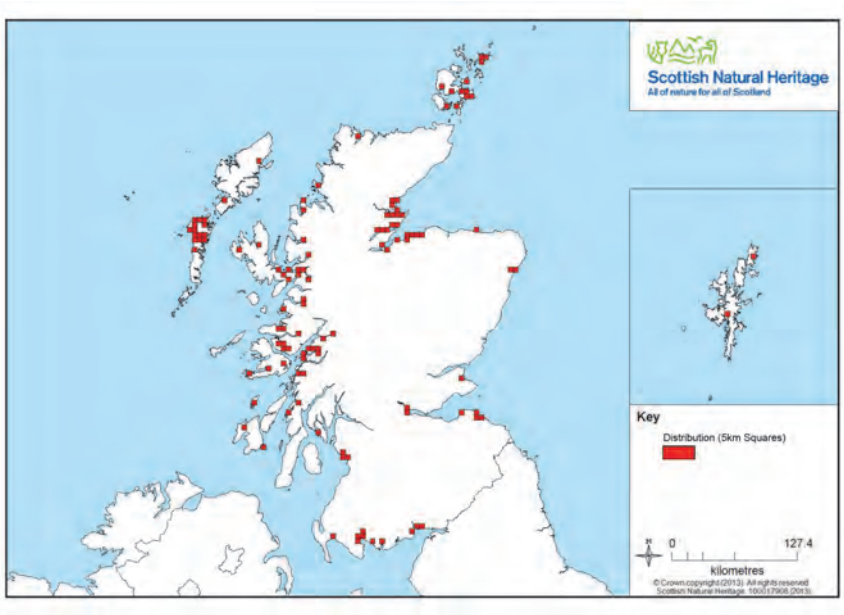


Figure 4-27: Distribution of SM13d.

SM13d is the key sub-community representing the middle marsh zone and is found across a wide range of sites. The presence of SM13d is a strong indicator of a full range of saltmarsh zones and a saltmarsh with a healthy hydrological system. There are two distinct variants of SM13d both of which are discussed in the published descriptions of the sub-community (Rodwell 2000).

The typical form is found across plateaux of sediment in the middle marsh zone. Pans and creeks are prominent and can also diversify the vegetation to include small areas of SM13a and SM13b. The continuous presence of both *Armeria maritima* and *Plantago maritima* are the key features that separate SM13d from the other *Puccinellietum* sub-communities. *Puccinellia maritima* is also much reduced in abundance when compared to SM13a. SM13d has a more diverse sward than SM13a and SM13b and can include all of the constituent species of the lower zone along with *Triglochin maritimum*, and low abundances of *Festuca rubra* and *Juncus gerardii*.

Figure 4-28: Typical form of SM13d with frequent pans.

SM13d can be simple to record from a distance when *Armeria maritima* is in flower as large areas have a white-pink hue (see Figure 4-28). It should be noted that on the west coast, SM13e can look almost identical. It is important to consider that assessment of the abundance of *Armeria maritima* can be complicated due to the difference in size between the leafy plant (barely visible outside of the flowering season) and the large flowering heads present through mid and late summer. In instances where assessment is undertaken outside of the *Armeria* flowering season, it is important to look for the fine whorled leaf shoots that look like small green rosettes growing on the substrate (see Figure 4-111). Other classification issues include stunted forms of *Plantago maritima* and *Triglochin maritimum*, which can look very similar. *Triglochin* has coriander-scented shoots which aid identification in these situations.

In grazed areas, SM13d often forms mosaics with SM16 sub-communities (see Figure 4-29). The mosaic components occur at different elevations, with SM13d usually claiming lower ground and depressions, while SM16 sub-communities cover hummocks and raised sediment. These mosaics can cover large areas and are usually too fine in scale to map at the SSS mapping scale of 1:4,000. On sandy sites the elevations that dictate the mosaic are very subtle and large areas of integrated SM13d and *Festuca* swards can form. In these instances SM16c is used as a classification, but there are issues with SM16c as a distinct sub-community type, which will be discussed in the upper marsh section (see 4.6.3).

Figure 4-29: SM13d in mosaic with SM16.

The second variant of SM13d is less common, but is exclusively found on sandy sites (normally back-barrier systems). This type can cover large areas of open sand in the lee of shingle spits and sand dune barriers, and is species-poor with *Plantago maritima* or *Armeria maritima* (or both) being the main components of the sward. The other species that are associated with the more widely distributed variant (discussed above) are often rare or absent. *Puccinellia maritima* is the most notable absent species from this sub-community. *Plantago maritima* and *Armeria maritima* plants found in these systems are often very stunted and rarely in flower (see Figure 4-30 and Figure 4-31). *Salicornia* sp. and *Suaeda maritima* can be present in localised areas, particularly where lower marsh is absent. *Glaux maritima* can also be abundant. It is possible that the reason this variant exists on back-barrier systems is due to the length of time that such areas are submerged by saltwater over the winter period, causing many of the plants present to decline or become heavily stunted due to stress. This variant of SM13d is highly sensitive to trampling and vehicle damage. Trampling and vehicle damage targets were failed within SM13d areas on a number of sites (see 3.8.3). This variant of SM13d gradually grades into short turf upper marsh communities such as SM16c and SM16b and sedge species such as *Carex distans* and *Carex flacca* may be present on the boundaries of the transition zone. Key sites for this variant include Culbin (Moray Firth), Tyninghame Shore (East Lothian) and Morrich More (Dornoch Firth).

Figure 4-30: Close up of the back-barrier marsh variant of SM13d.

Figure 4-31: Vegetation structure of the back-barrier marsh variant of SM13d.

Also see the habitat description for SM17 (4.6.14).

4.5.4 SM13e (Puccinellia maritima-turf fucoid sub-community)

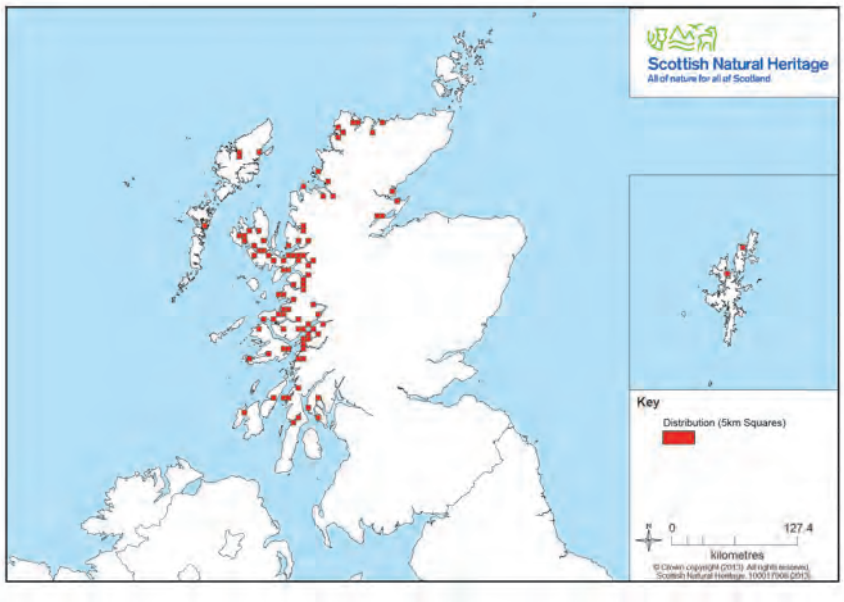


Figure 4-32: Distribution of SM13e.

SM13e is strongly associated with west coast loch-head marshes, but is also found on back-barrier marshes on the east coast. The southern limit of this sub-community is on Straad (Argyll) and it is absent from the north-east mainland (between Torrisdale Bay and Loch Fleet). SM13e was only found from one site on North Uist (Grimsay) and two sites on the Isle of Lewis (Loch Gimersta and Tong Saltings). No records of SM13e were noted for Orkney, and two sites were recorded for Shetland (Cullivoe and Gluss Voe).

This sub-community is the key indicator of middle marsh habitat on the west coast and mostly replaces SM13d, and to some extent SM13a in these areas. The vegetation is diverse and found with a dense understorey of stunted fucoid species, which is the identifying feature of the sub-community. Key associate species include *Puccinellia maritima*, *Armeria maritima* and *Plantago maritima* with all three found in abundance in most swards. *Plantago maritima* is often stunted and can appear very similar in structure to the type found on the SM13d variant found on back-barrier saltmarsh (see 4.5.3). Areas of turf fucoids heavily dominated by *Puccinellia maritima* at the lower margin of the saltmarsh zone may be better classified as SM13a. Associate species also include *Salicornia*, and *Aster tripolium*. *Spartina x townsendii* was recorded as invading the SM13e sward at Balure of Shian (Argyll North).

This sub-community often develops over shingle topped with saltmarsh sediment and can cover large areas of the saltmarsh. The often distinct yellow/brown colour of the turf fucoids can be distinguished from a distance (see Figure 4-33). Turf fucoids can also be found separate to the SM13e sub-community, growing on shingle in pans and at the edges of the marsh. Turf fucoids can also grow abundantly in SM16a and SM16c.

SM13e is frequently found in mosaic with a short sward version of SM16b, which is dominated by *Juncus gerardii.*

SM13e appears able to cope with intensive sheep grazing (unlike SM13a and SM13d), and may form as a response to such grazing on some sites. Grazed areas may form large rounded hummocks of saltmarsh sediment near the seaward edge of the saltmarsh on west coast loch-head marshes.

Figure 4-33: SM13e at Inversanda, Lochaber.

4.5.5 SM13f (Puccinellia maritima-Spartina maritima sub-community)

This sub-community is not present in Scotland with *Spartina maritima* only found in parts of south-east England and one area near Liverpool. It is strange that a sub-community to take account of the restricted *Spartina maritima* exists within the published datasets (Rodwell 2000), but an analogous sub-community taking account of *Spartina anglica* in similar situations is not accounted for (see 4.4.2).

4.5.6 SM14a (Halimione portulacoides dominated sub-community)

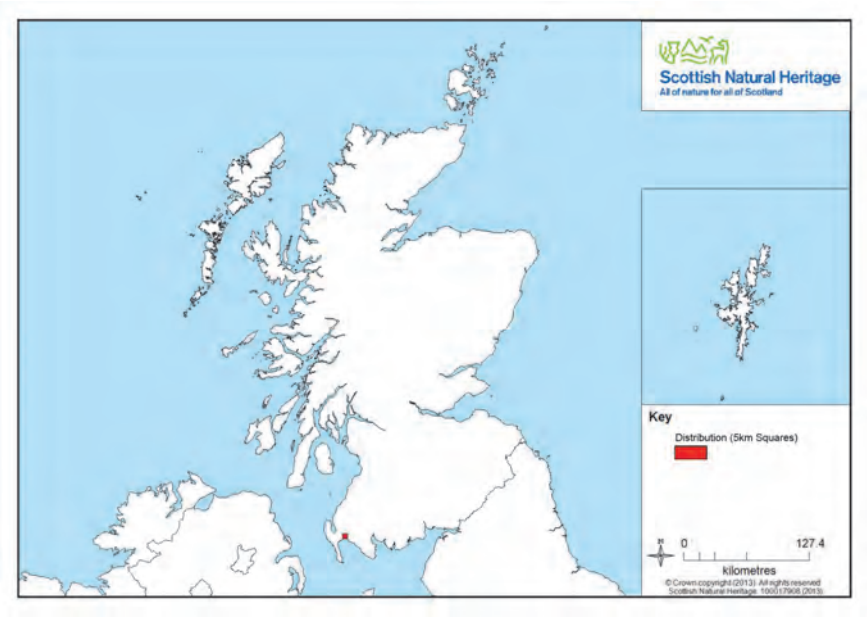


Figure 4-34: Distribution of SM14a.

SM14a is found across a wide range of sites in England and Wales, but restricted to one site in Scotland (Luce Bay on the Solway Firth) and is found in association with raised areas at the edges of creeks on a sandy saltmarsh system. *Atriplex portulacoides* is clearly the dominant species in these areas with this shrubby species topping many of the creeks. *Limonium vulgare* is also frequent. Other associate species include *Triglochin maritimum* and *Festuca rubra*. A characteristic feature of this sub-community is the undulating hummocks caused by the growth of *Atriplex portulacoides* (see Figure 4-35).

Figure 4-35: SM14a at Luce Bay.

4.5.7 SM14c (Puccinellia maritima sub-community)

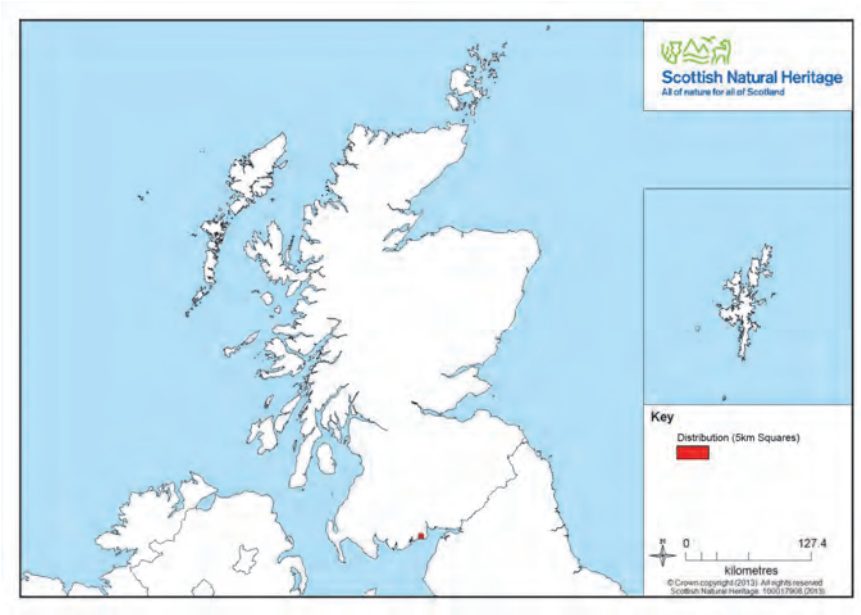


Figure 4-36: Distribution of SM14c.

SM14c is restricted to one site in Scotland (Southwick on the Solway Firth). This sub-community appears to be very different in structure to the SM14a sub-community discussed above. Both areas are found on sandy sites associated with creeks, but *Atriplex portulacoides* does not dominate the vegetation as it does in SM14a. *Puccinellia maritima* and *Festuca rubra* are abundant with *Triglochin maritimum* and *Limonium vulgare* also present (see Figure 4-37).

Figure 4-37: SM14c at Luce Bay.

4.5.8 SM15 (*Juncus maritimus-Triglochin maritima saltmarsh*)

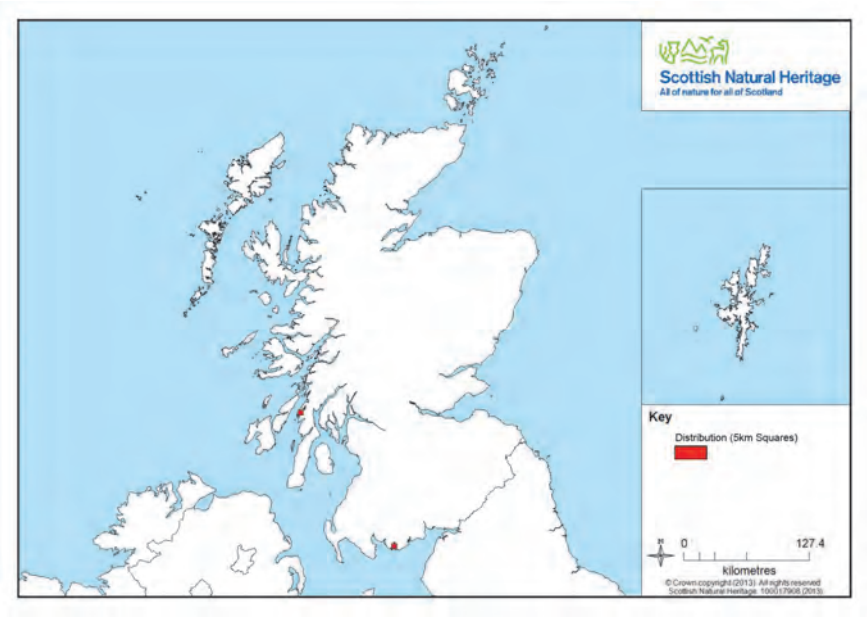


Figure 4-38: Distribution of SM15.

SM15 is highly localised in Scotland and is found on Manxman's Lake in the Dee estuary, on the Solway Firth (Figure 4-39) and at Linne Mhuirich in Argyll. Stands too small to map were found at Gruinart Flats (see Figure 4-40) and Balure of Shian (Argyll). A key identifying feature is the presence of *Juncus maritimus* which is found more often as part of the SM18 community. The community's most distinctive feature is its proximity to the seaward edge of the marsh sediment. *Juncus maritimus* is normally found in the upper limits of the marsh in SM18. It is possible that SM15 forms as a result of erosion at the saltmarsh edge, causing species of the middle marsh to develop in association with *Juncus maritimus*.

Figure 4-39: SM15 at Manxman's Lake, Kirkcudbright.

Figure 4-40: SM15 at Gruinart Flats, Islay.

4.6 Upper saltmarsh

4.6.1 SM16a (Puccinellia maritima sub-community)

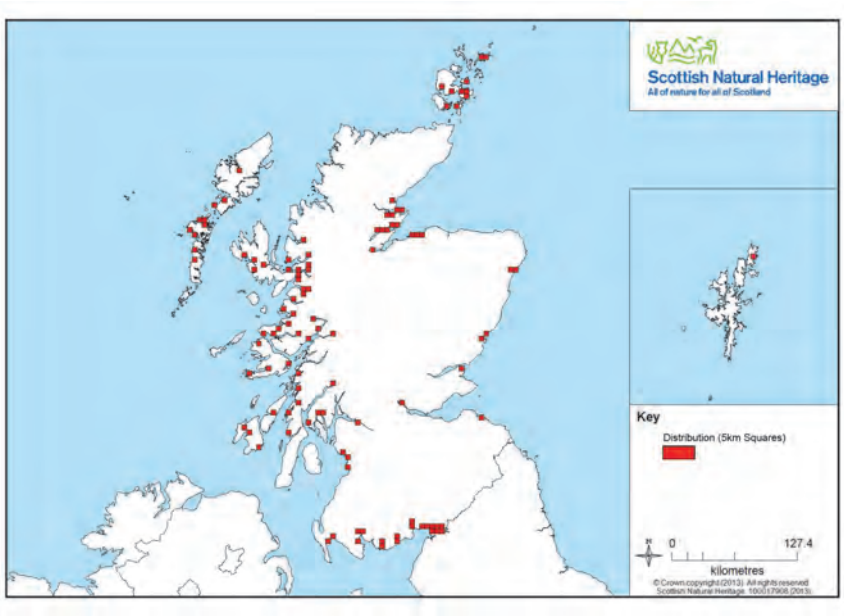


Figure 4-41: Distribution of SM16a.

SM16a is a very common sub-community and is found across the entire range of Scottish saltmarshes. SM16a is often found as the seaward fringing sub-community on many river-fringing and estuarine systems. SM16a has a close association with SM13a with many of the associate species present. In Scotland this sub-community differs from the published datasets (Rodwell 2000) in the abundance of *Puccinellia maritima*, which is often very localised or absent. It is likely that *Puccinellia maritima* is present within SM16a, but the species is difficult to locate due to the dominance of *Festuca rubra*. Although *Puccinellia maritima* can be difficult to detect, the associate species (normally found in the lower marsh) are simple to find. *Aster tripolium*, *Triglochin maritimum* and *Cochlearia officinalis* are strong indicators of SM16a. Other species include *Plantago maritima*, *Atriplex prostrata*, *Glaux maritima* and *Agrostis stolonifera*. Shoots of *Festuca rubra* can be between 3cm and 1m in length and often have yellowing stems (compared to the brown-red stems found in SM16d) which can be observed from a distance.

This sub-community classification differs from the published descriptions regarding *Agrostis stolonifera* and *Aster tripolium* being less frequent components of the sward (Rodwell 2000). *Aster tripolium* is in fact a key determinant of the sub-community.

The sub-community can be found in two different situations:

The first is as a narrow belt of saltmarsh on the seaward edge of river-fringing marsh, or at the edges of creeks and drainage channels (see Figure 4-42). In these areas the sub-community is only approx 50cm-1m wide and is found on the inner ledges of such areas (see Figure 4-43). This type of SM16a can be found in many zones of the saltmarsh, following creeks and channels.

Figure 4-42: SM16a belt on a river-fringing marsh.

Figure 4-43: SM16a on the inner ledge of a larger channel.

The second is when *Festuca rubra* maintains a prominent coverage into the lower and middle marsh zones. SM16a tends to cover larger areas in this situation and *Puccinellia maritima* may be more prominent (see Figure 4-44). The species are the same as those already discussed, but may include *Salicornia* sp. and *Suaeda maritima* on open soils near the seaward edge of the marsh. Fine dendritic creeks are often present across these areas. This sub-community is very similar to SM16c, but differs in there being less *Armeria maritima* and more *Aster tripolium*, but it is possible to interpret both SM16 types in some swards. It is important to note that the abundance of SM16a across Scotland makes it difficult to identify narrow belts of SM13a at the seaward edge of the marsh and may explain why SM13a has been under recorded in the past. The SSS surveys have allowed a rationalisation of both sub-communities and future surveyors should ensure that narrow belts of marsh are fully investigated for areas abundant-dominant in *Puccinellia maritima.*

Figure 4-44: SM16a in the lower and middle marsh.

4.6.2 SM16b (Juncus gerardii dominated sub-community)

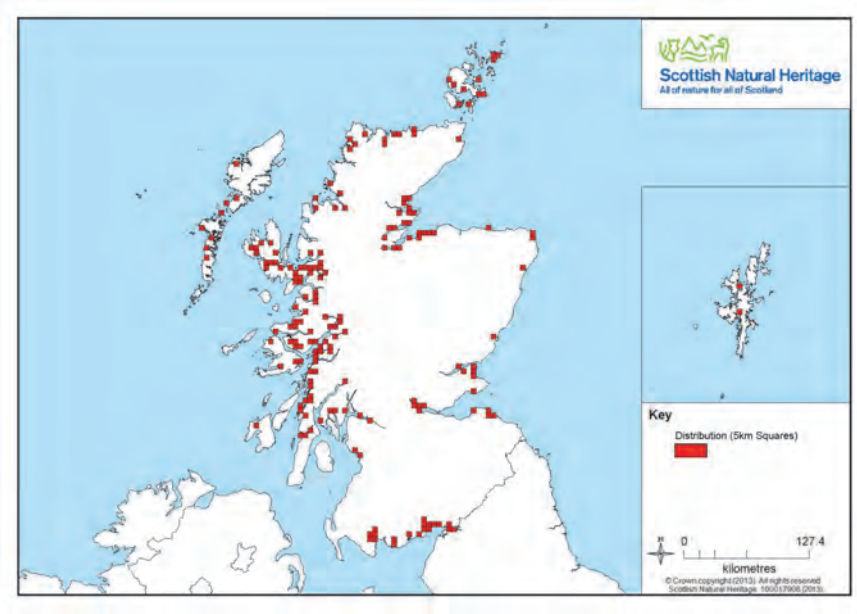


Figure 4-45: Distribution of SM16b

SM16b is a very common sub-community and is found in a variety of situations and across the entire range of Scottish saltmarshes. SM16b is indicative of wet depressions and areas of saline water run-off. The published description of SM16b suggests that the sub-community is found in small isolated patches (Rodwell 2000). As part of the SSS project SM16b was found in large areas on a number of sites including Wigtown, Caerlaverock and Morrich More. *Juncus gerardii* is the dominating vegetation type with *Festuca rubra* often present and in some instances is co-dominant. Other associates include *Triglochin maritimum*, *Glaux maritima* and *Agrostis stolonifera*. *Juncus gerardii's* brown-ginger shoots give the sub-community a distinctive colouring, which it is possible to see from a distance, and can only be confused with SM18. It is also possible to assess SM16b from aerial photography as it is often depicted as dark green or brown in aerial photography taken during summer.

Larger meadow-like areas of SM16b are restricted to Solway sites and the larger saltmarshes (such as Sleek of Tarty). In these areas the colouring can be either dark brown or bright green (see Figure 4-46). It is possible that grazing is responsible for the development of large areas of this sub-community. A notable variant of SM16b is found across Caerlaverock and the saltmarshes of the Nith Estuary, which includes *Trifolium repens* within the sward (see Figure 4-47). The presence of *Trifolium repens* is usually more indicative of SM16e, but the dominance of *Juncus gerardii* across large areas and the presence of SM16e further landward, concluded that SM16b was a better fit than SM16e.

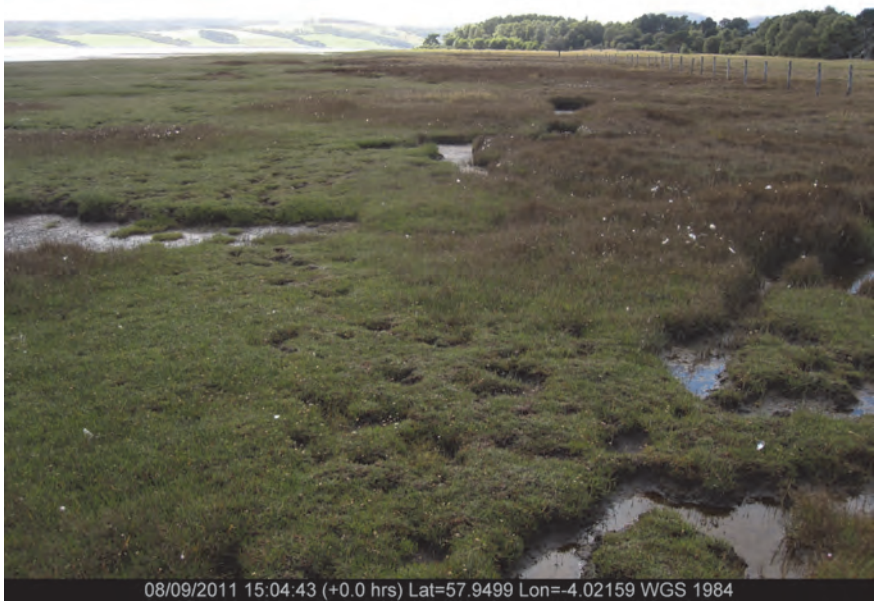


Figure 4-46: SM16b (to the right of the picture) in large meadow-like areas at Loch Fleet.

Figure 4-47: SM16b with Trifolium repens *at Wigtown.*

Another interesting form of SM16b is found acting as pioneer marsh. One of the best examples of this sub-community was found on the Firth of Clyde near Cardross, but is also recorded from a few other sites (see Figure 4-48).

Figure 4-48: SM16b acting as pioneer marsh vegetation at Conon Islands (Cromarty Firth).

On the west coast, SM16b can be found in association with SM13e middle marsh communities and can be located close to the seaward edge of the marsh. The sub-community can appear quite different to SM16b stands found in other areas of Scotland, being shorter and more akin to the larger meadow-like variant.

SM16b changes further at the northern limits of its range and is found in association with SM19 on shingle, gravel and rock outcrops. In these areas the sub-community is similar to the pure stands of *Juncus gerardii* acting as pioneer marsh, but *Agrostis stolonifera* and *Juncus articulatus* are also present. These additional species made it possible to classify them as a new sub-community (SM16g) by Thomas Haynes (see 4.6.8).

SM16b can also be found with *Carex extensa* and *Carex flacca.* A good example of this variant is found in a mosaic with SM13d on the back-barrier marshes at Whiteness Head. There is considerable cross with SM16f and SM19 in some variants of SM16b.

More typically SM16b is found in shallow pans and depressions. The circular shapes formed by the densely packed shoots of *Juncus gerardii* can be quite conspicuous (see Figure 4-49). The sub-community can also be found in waterlogged creeks, drainage ditches and ponds. Narrow belts of the SM16b can also be found at the base of sediment ledges and soil cliffs, presumably where water is more prone to collect. Good examples of this type of SM16b are found at Annan (see Figure 3-16).

Figure 4-49: SM16b in a pan at the edge of the Skinflats marshes.

A short turf variant is also found on sandy sites, such as Morrich More and is similar in composition to the exposed short-turf community found on the west coast.

Although *Festuca rubra* and *Juncus gerardii* are found in most of the SM16 sub-communities, it is relatively simple to identify SM16b based on: the abundance of *Juncus gerardii*; the presence of associate species; the absence/rarity of terrestrial species (such as *Trifolium repens*, *Leontodon autumnalis)*; and the niches that SM16b occupies.

SM16b is one of the sub-communities found on perched sites where thin layers of sediment develop in the splash zone. *Juncus gerardii*, *Triglochin maritimum*, *Agrostis stolonifera* and *Festuca rubra* are the species found in perched situations (see Figure 4-50).

Figure 4-50: SM16b on perched saltmarsh at Portskerra.

SM16b is one of a small number of sub-communities that are found in very small areas (such as pans), which were sometimes below the SSS project's mapping resolution of 1:4,000. Such instances are mapped as mosaics where possible (SM16b often forms a mosaic within middle and upper marsh vegetation). In some instances localised areas of SM16b are target noted when the areas were too small to map.

4.6.3 SM16c (Festuca rubra-Glaux maritima sub-community)

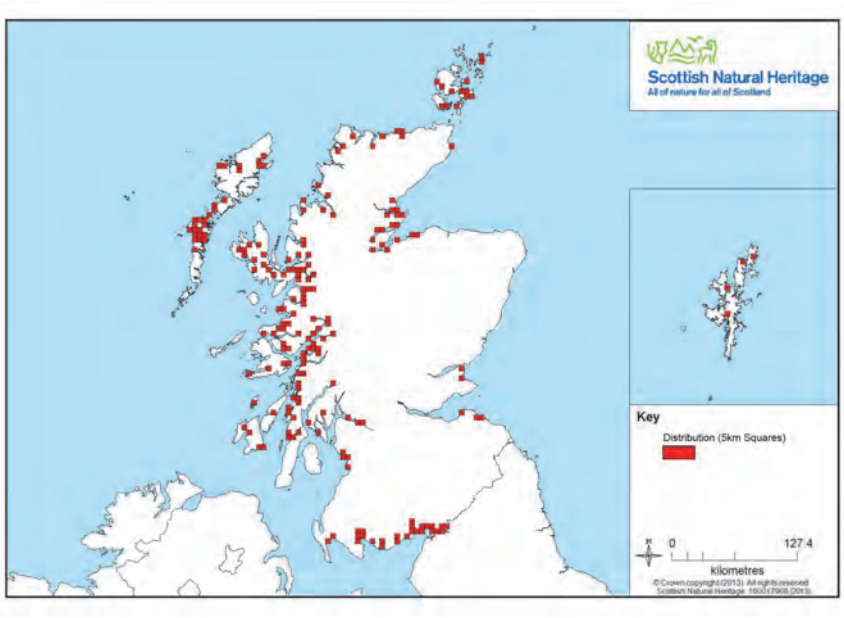


Figure 4-51: Distribution of SM16c.

SM16c is a very common sub-community in Scotland and is found across the entirety of the saltmarsh range. A key feature of the published description is the co-dominance of *Festuca rubra* and *Agrostis stolonifera*, but it is also emphasised that this co-dominating relationship may not be present or that one of the key species will be rarely found. The published data tables for SM16c take account of a considerable amount of variety which includes many middle and upper marsh species. Such an open approach to this upper marsh community allows interpretation in a variety of ways.

Surveyors on the SSS project considered SM16c as a category to assign swards of upper marsh vegetation which included typical upper marsh species, but lacked the defining features to support classification into more distinctive SM16 communities (e.g. SM16a, b, d, e and f). In practice, large areas of transitional middle and upper marsh are the best fit with the classification. These may include large areas of sandy or estuarine sites where *Festuca rubra*, *Agrostis stolonifera* and *Juncus gerardii* infiltrate into the middle marsh zone (where *Puccinellia maritima*, *Armeria maritima* and *Plantago maritima* are present). These transitional areas can also be classified as a mosaic of SM16b and SM13d (SM16b and SM13d mosaics are present on many Scottish saltmarshes). The classification of SM16c was used where SM16b and SM13d were found growing in close association. In such instances separating *Puccinellia maritima* and *Festuca rubra* can be difficult (particularly on heavily grazed sites). *Festuca rubra* has a less rigid and thinner leaf than *Puccinellia maritima* and is also a darker green, but the presence of a ligule on *Puccinellia maritima* is the distinguishing feature. A good example of SM16c is near the seaward edge of Southwick on the Solway Firth (see Figure 4-52).

Figure 4-52: SM16c at Southwick.

On many sites, particularly on the east coast and the Solway Firth, SM16c is a product of grazing on the middle marsh and shows a general trend away from the *Puccinellietum* group and succession to the *Juncetum gerardii* group. *Plantago coronopus* may be locally frequent in SM16c on west coast sites which are heavily grazed by sheep.

SM16c can also be found in large areas on sandy back-barrier saltmarsh sites. Morrich More is one of the best examples; and the sub-community's development is due to the irregular flow of saline water across the marsh and the very soft undulating pattern of the sand hummocks.

4.6.4 SM16cx (*Agrostis stolonifera/Festuca rubra-Glaux maritima* variant sub-community)

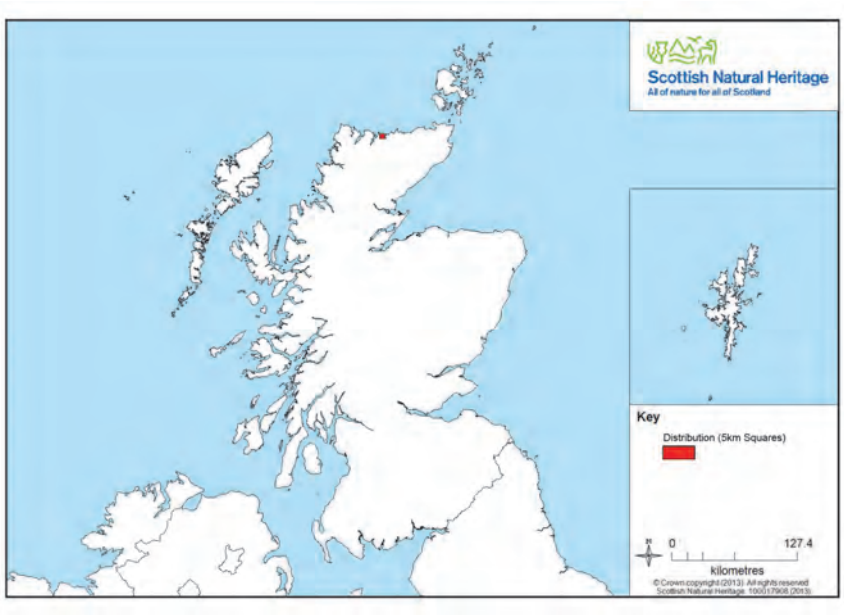


Figure 4-53: Distribution of SM16cx.

This variant of SM16c was identified on the shingle and sand substrate of Borgie Bay at Torrisdale Bay. This type included co-dominating stands of *Agrostis stolonifera* and *Festuca rubra* in the middle marsh zone along with middle marsh species such as *Armeria maritima* and *Plantago maritima* (see Figure 4-54). This variant was given the suffix SM16cx because the more typical form of SM16c (described above) was also present in the upper marsh zone, so this was utilised as a method of separating the two variants. Discussions with other surveyors on the SSS project and the wide variation of SM16c in general concludes that this variant is not a priority for inclusion in any proposals for reviews of the NVC classifications, but a more robust analysis of SM16c as a sub-community is required.

Figure 4-54: SM16cx at Borgie Bay.

4.6.5 SM16d (Tall Festuca rubra dominated sub-community)

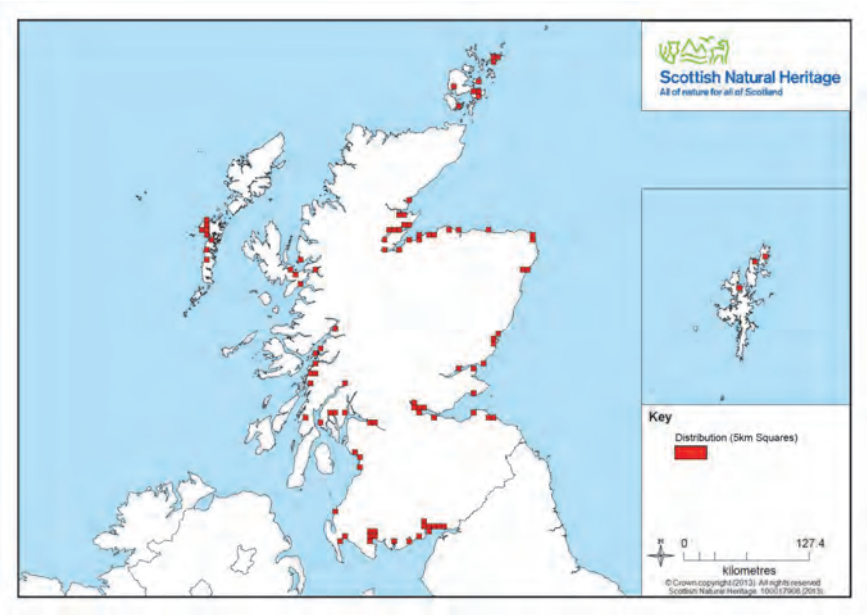


Figure 4-55: Distribution of SM16d.

SM16d is one of the most widespread and common saltmarsh sub-communities in Scotland, but interestingly SM16d shows a strong association with the larger saltmarshes of the Solway Firth and east coast. SM16d is found in smaller areas on the west coast.

SM16d is an unusual classification as it is described in the published classifications as being dominated by tall swards of *Festuca rubra* (Rodwell 2000). Such a classification does hold merit as the remaining species often found within SM16 swards are greatly reduced due to the tall habit of *Festuca rubra*. SM16d is strongly associated with infrequently grazed areas of saltmarsh. The marshes of the Cromarty Firth, Skinflats, Firth of Forth and the Beauly Firth include large areas of the sub-community. The long interwoven stems of *Festuca rubra* give the sub-community a springy feel underfoot. The stems also appear brown or red and can be approx 1m tall (see Figure 4-56), while the stems of *Festuca rubra* are yellow in SM16a.

Figure 4-56: SM16d at Castle Stuart Bay (Moray Firth).

The sub-community is species-poor with associates including *Agrostis stolonifera, Cochlearia officinalis*, *Triglochin maritimum* and *Atriplex prostrata*. *Juncus gerardii* and *Elytrigia repens* can also be present.

It is the height of the sward and lack of recent grazing that dictates the presence of the sub-community. This requirement may explain SM16d's restricted occurrence on the west coast and offshore islands, most of the sites surveyed in these areas are grazed regularly by sheep and not removed from grazing management for sufficient lengths of time to allow SM16d to form.

SM16d forms large homogeneous areas and pans are not a frequent feature (it is possible that pans are hidden beneath the taller swards). The sub-community is associated with SM16a at the edges of creeks (where the presence of abundant *Aster tripolium*, *Cochlearia officinalis* and *Triglochin maritimum* separate the sub-communities). SM28 is often associated with disturbed areas and the landward transition zones. There is also a variant that is co-dominated by *Festuca rubra* and *Elytrigia repens* (see 4.7.2).

4.6.6 SM16e (Leontodon autumnalis sub-community)

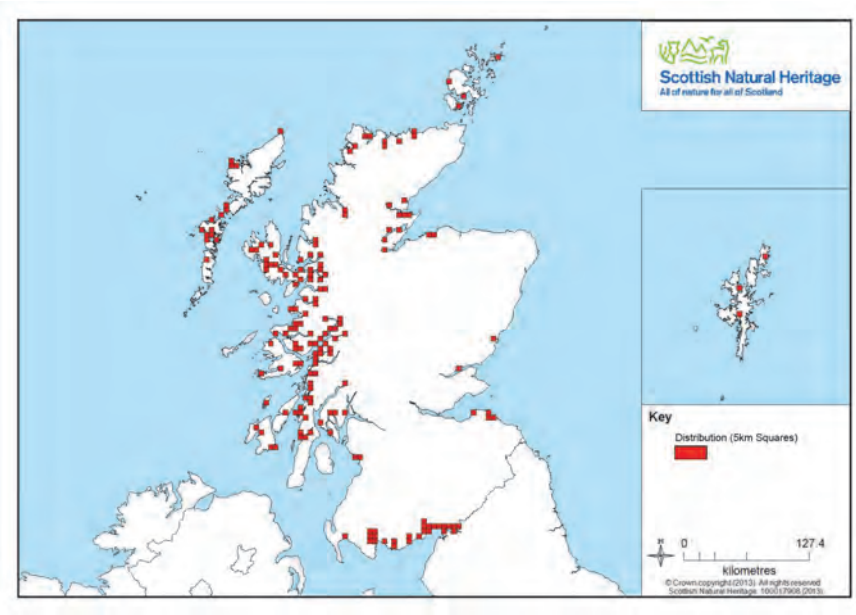


Figure 4-57: Distribution of SM16e.

SM16e is the sub-community found at the landward limits of many of Scotland's saltmarshes and is found across the entirety of the habitat's range. The published records for the sub-community indicated that it was poorly represented in Scotland (Rodwell 2000), but the results of the SSS project show otherwise. The largest areas are over 30ha and are found on the Solway Firth (see Figure 4-58).

Figure 4-58: Large areas of SM16e at Wigtown with regular field drains from the middle of the picture into the distance.

Figure 4-59: close up view of the SM16e sward.

SM16e is more solid under foot than the preceding sub-communities and appears more terrestrial in nature. This terrestrial transition is the key identifying feature of the sub-community with the leaves of *Leontodon autumnalis* being frequent to abundant in the sward. The late-flowering, yellow flowers of *Leontodon autumnalis* are not the best guide to identifying the sub-community through most of the season (see Figure 4-59). The abundant leaves of the species are a better identifying feature. *Festuca rubra* and *Juncus gerardii* still have an abundant presence, but other species such as *Trifolium repens* and *Plantago lanceolata* become frequent. Sedges such as *Carex distans, Carex otrubae* and *Carex flacca* can be found infrequently or in localised areas. Grasses of more improved and terrestrial swards can also be present such as *Lolium perenne* and *Poa pratensis*.

The published descriptions and data tables for SM16e and SM16f do not sufficiently distinguish the two sub-communities, with *Carex flacca* and *Leontodon autumnalis* often found in the same swards at varying abundances. It becomes apparent through further investigation of the two sub-communities that SM16e is more terrestrial and has a more grass dominated sward than SM16f, but it is still possible for different surveyors to identify these two sub-communities in various ways. On the west coast, Ian Strachan often recorded SM16f at higher elevations than SM16e. *Euphrasia* is often found in SM16e swards, which is not included in the published data sets, and neither is *Carex viridula* subsp. *viridula.* There can be a considerable amount of variation in the plant species present at the upper limits of the sub-community's geographical range with species such as *Lychnis flos-cuculi*, *Triglochin palustre* and *Potentilla anserina* present in many swards. *Agrostis stolonifera* also has more of a prominent presence in many swards than in preceding sub-communities.

SM16e is frequently found on cattle and sheep grazed sites with *Trifolium repens* and *Lolium perenne* indicating nutrient enrichment. Heavily grazed stands in the west have abundant *Plantago coronopus.* The larger areas of SM16e on the Solway Firth and on the east coast also include the most signs of human modification, as this more terrestrial sward is purposely modified to improve the saltmarsh's agricultural productivity. Such modifications include drainage ditches and runnels, fencing and the installation of water troughs (see Figure 4-58). These modifications decrease the association with more saline-tolerant plants.

SM16e can be found in mosaic with SM16b and SM16f and is also found landward of SM16d. The upper landward limits of SM16e are also associated with the coastal grassland communities MG11, MG12 and MG13.

4.6.7 SM16f (Carex flacca sub-community)

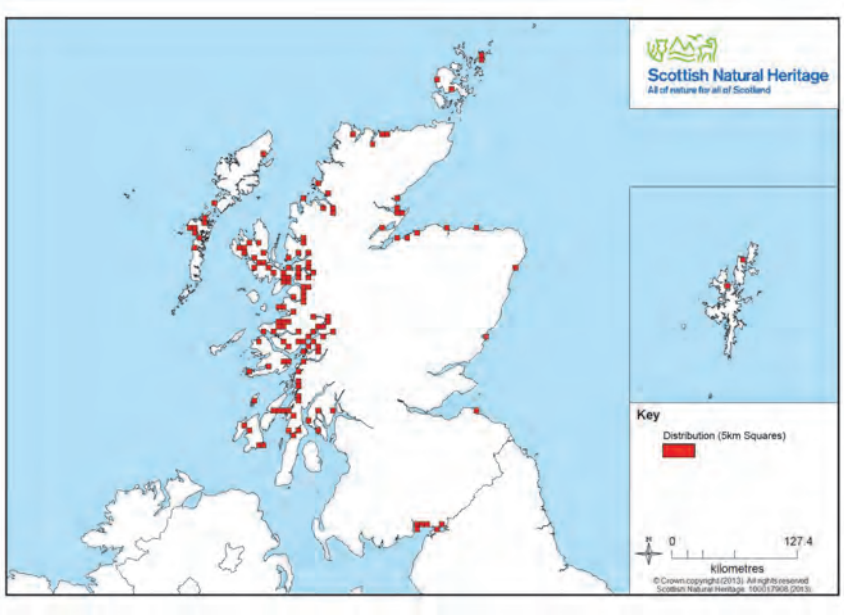


Figure 4-60: Distribution of SM16f.

As discussed in the SM16e section above, the published descriptions and data tables for SM16f and SM16e are very similar and can be difficult to separate. SM16f in the SSS surveys was considered as more sedge-rich than SM16e and has strong similarities with SM16b and SM19 in community structure.

SM16f is often found in smaller areas than SM16e, but exceptions to this include a very large area (over 50ha) at Caerlaverock. The sward is often quite short and the glaucous leaves of *Carex flacca* are obvious (see Figure 4-61). Short plants of *Juncus gerardii* are often present with *Festuca rubra* also present. *Carex extensa* and *Blysmus rufus* can also have an occasional presence. *Carex viridula* subsp. *viridula* is present on the west coast and back-barrier marshes (see Figure 4-62). *Carex distans* and the rare *Carex maritima* are also found in SM16f (see Figure 3-26). On the west coast *Juncus articulatus* is frequent in wetter stands, with *Eriophorum angustifolium* in transitions to mires.

Figure 4-61: Typical sward of SM16f.

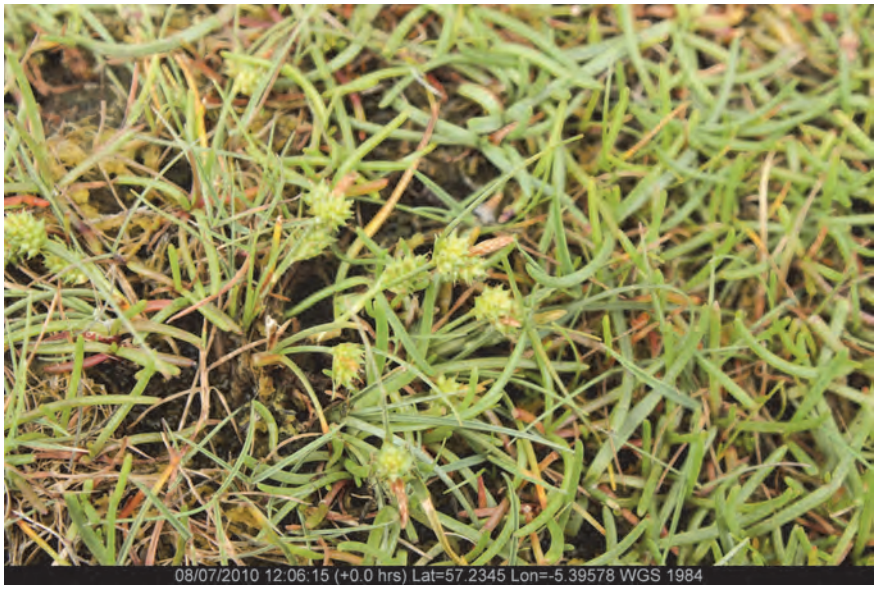


Figure 4-62: Carex viridula *subsp.* viridula *in SM16f.*

SM16f is one of a small number of sub-communities that can be found in small areas below the resolution of mapping for the SSS project. In these instances SM16f is found at the edges of well trodden and well-drained sheep tracks and footpaths. In this habitat there is significant cross with SM19 with many shared species associates.

The large areas of the sub-community found on Caerlaverock include *Trifolium repens* and *Oenanthe lachenalii*. Such areas could be re-classified as SM16e, but large areas of Caerlaverock were classified as SM16e which do not have a prominence of *Carex flacca*.

SM16f has a strong association with the west coast and is frequently found in the upper transitional zone and can include calcifugous species such as *Molinia caerulea* and *Nardus stricta*.

After extensive sampling of both SM16e and SM16f across the Scottish coast, it seems that drainage and substrate are important factors that separate the sub-communities. SM16f is often found in areas where fresh/brackish water flows across the substrate or slightly damp swards, while SM16e is often present where drainage systems are in place and the sediment is drier. SM16e seems to be more indicative of nutrient enrichment and agricultural improvement than SM16f.

It should also be noted that many of the species described above are not present in the published tables for SM16f (Rodwell 2000).

In conclusion, SM16f is the most diverse sub-community of the upper marsh and includes a number of noteworthy and rare species.

4.6.8 SM16g (*Juncus gerardii, Agrostis stolonifera, Glaux maritima & Triglochin maritimum pioneer sub-community)*

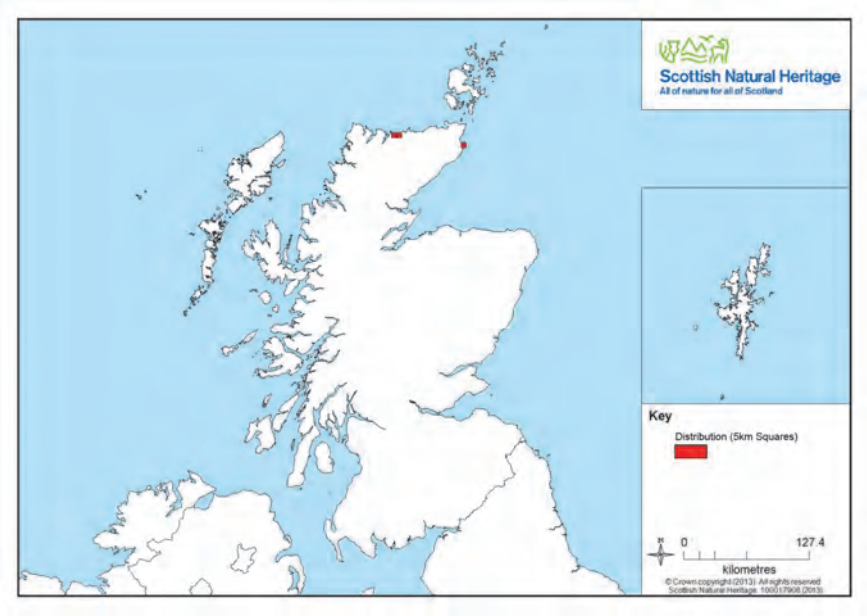


Figure 4-63: Distribution of SM16g.

SM16g was created to take account of variation in the SM16c and SM16b sub-communities at the northern limits of their range. On the north and north-east coast the four species can be found forming pioneer vegetation on shingle and on thin sediment among rocks and mud on narrow areas of river-fringing marshes (see Figure 4-64). *Juncus gerardii* is the dominant species with *Agrostis stolonifera* also gaining high levels of abundance. Such a pioneer community is unusual and appears to be the upper marsh adapting to a lack of species from the *Puccinellietum* being present. The sub-community seems to be derived from variants of SM16b found in free-draining areas, perched saltmarsh and developing across shingle. It is likely that SM16g shows a decline in species diversity as the sub-community approaches the northern limits of its range. Similar vegetation occurs on shingle and gravel in west coast sea lochs, with much exposed stone, where it was classed as SM16b. Further analysis of each surveyor's samples may add to this sub-community. Further analysis is required of SM16b to ascertain a robust grouping (also see SM16i below).

Figure 4-64: SM16g acting as pioneer vegetation on the north coast.

4.6.9 SM16i (Agrostis stolonifera/Triglochin maritimum dominated sub-community)

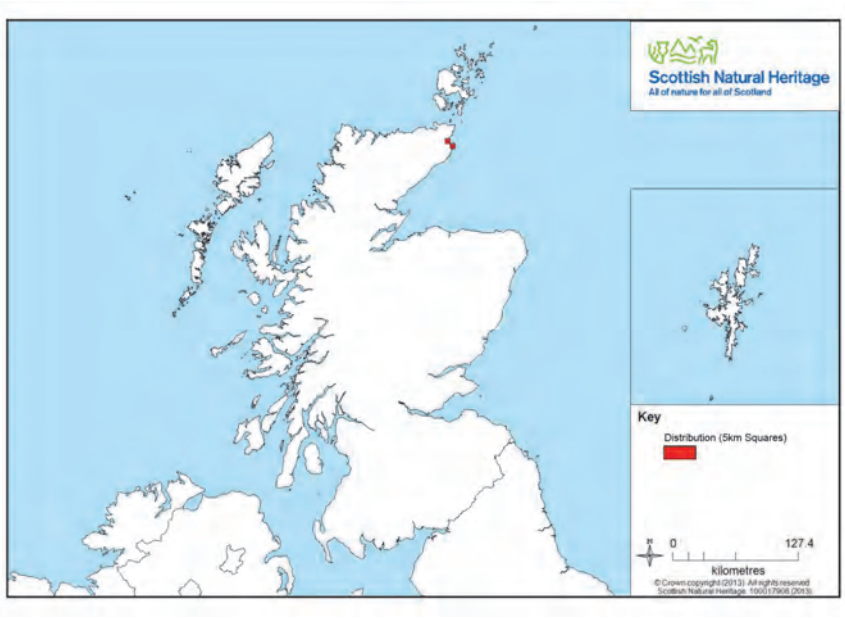


Figure 4-65: Distribution of SM16i.

SM16i was created to take account of variation in SM16c and SM16b sub-communities on the northern limits of their range. This sub-community is also very similar to a brackish variant of coastal grassland found at the limits of saline influence on muddy estuaries such as the Beauly Firth and Conon Islands (see MG13).

These areas are often dominated by *Agrostis stolonifera* with abundant *Triglochin maritimum*. *Cochlearia officinalis*, *Glaux maritima* and *Juncus gerardii* are also key components of this sub-community (see Figure 4-66). *Aster tripolium and Tripleurospermum maritimum* are sometimes present. Further analysis of SM16b and SM16c is required to create a robust grouping.

Figure 4-66: SM16i on the north coast.

4.6.10 SM16jb (Festuca rubra and Juncus balticus sub-community)

Figure 4-67: Distribution of SM16jb.

This sub-community was classified to take account of variation in the upper saltmarsh on North Uist (particularly the area of Baleshare). In this area the rare rush *Juncus balticus* is found within small localised areas of a sward similar to SM16b. In these areas *Juncus balticus* is clearly the dominant species (see Figure 4-68). *Juncus balticus* was also recorded from a limited number of sites on the north-east coast including Culbin (see Figure 4-69), but the species was often found in small areas and not possible to map. The plants of *Juncus balticus* in North Uist are much taller (75 cm) than those found on the mainland (30 cm).

Figure 4-68: SM16jb with the rare Juncus balticus *at Bayhead on North Uist.*

Figure 4-69: Juncus balticus *at Culbin (Moray).*

The sub-community is able to grow: near the seaward edge of the marsh; as part of surrounding upper marsh communities; and amongst exposed sand and shingle (see Figure 4-70).

Figure 4-70: SM16jb growing among shingle and rock at Vallay (North Uist).

4.6.11 SM16p (Eleocharis palustris variant)

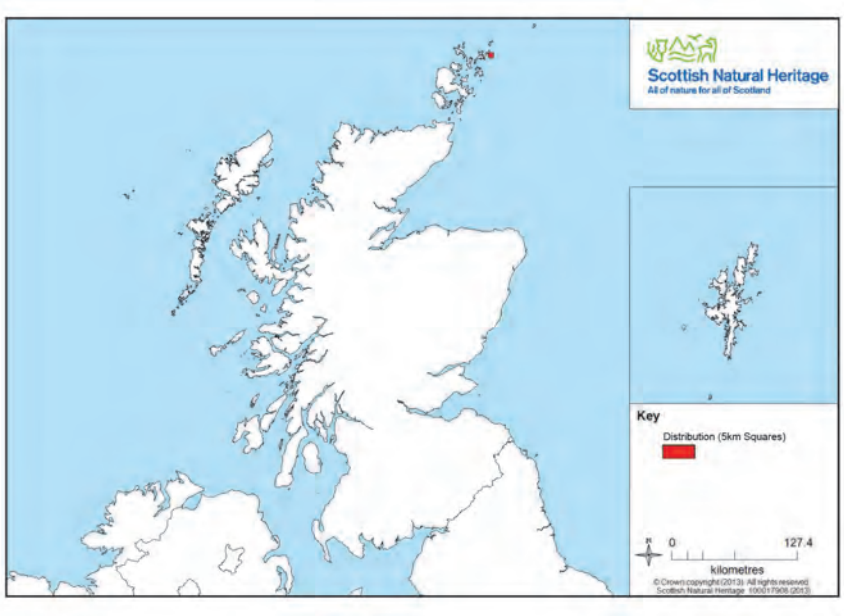


Figure 4-71: Distribution of SM16p.

This is a transitional sub-community classified to take account of variation on the island of Sanday (Orkney) at Start Point. The sub-community appears to be a transitional drift-line community. *Juncus gerardii* is the most abundant species found, but a range of species normally present in terrestrial systems are present including *Potentilla anserina*, *Rumex acetosa* and *Senecio jacobaea*. The species present are normally found as associates in SM28 or MG1, but the presence of occasional plants of *Eleocharis palustris* is unusual (see Figure 4-72). The habit of the sub-community does not fit well with the *Eleocharis palustris* community S19, which is often found in inundated areas. This sub-community would benefit from further study.

Figure 4-72: SM16p an unusual driftline transition sub-community found at Start Point on Sanday, Orkney.

4.6.12 SM16t (Transitional saltmarsh sub-community)

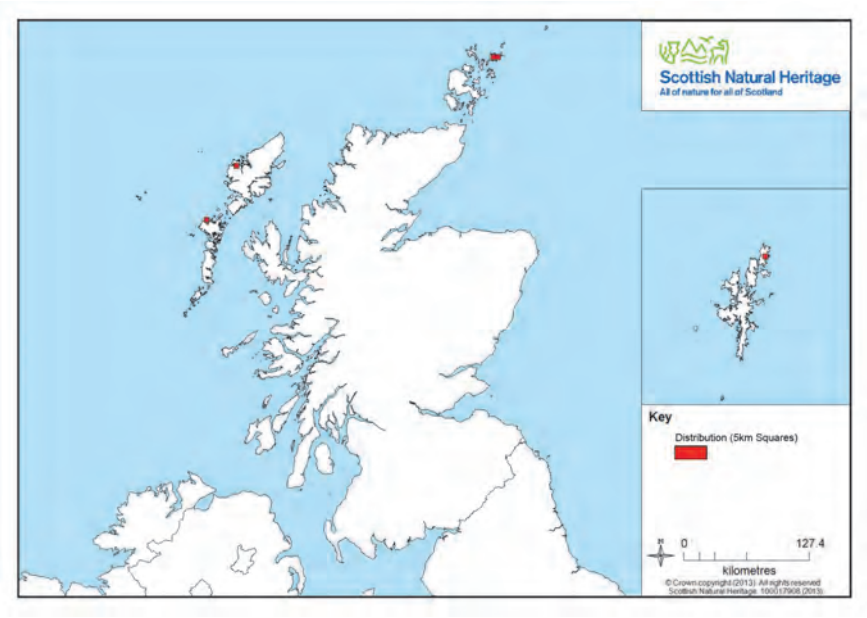


Figure 4-73: Distribution of SM16t.

This sub-community was created to take account of transitional variation present on the upper limits of saltmarshes on the Outer Hebrides and Orkney. This sub-community appears to originate in the SM16b sub-community but with an influx of terrestrial species including abundant *Potentilla anserina*, *Deschampsia cespitosa*, *Lychnis flos-cuculi* and *Anthoxanthum odoratum* (see Figure 4-74). This sub-community appears to be transitional between SM16b and MG5 and is found on a number of sites including Lon Erista, Vallay, Baltasound, Lama Ness Oyce and Lamaness South. This sub-community would benefit from further study.

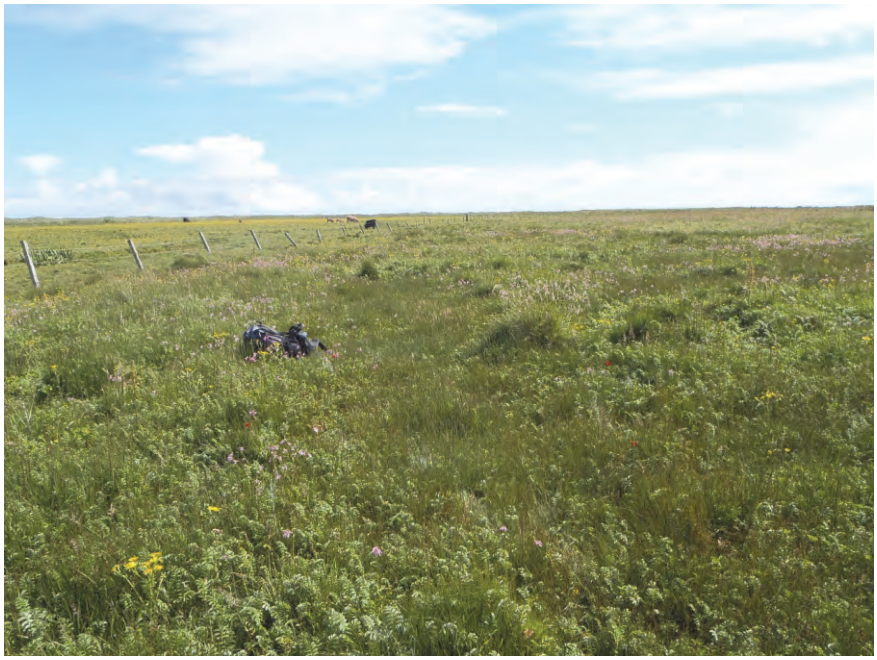


Figure 4-74: SM16t at Lama Ness Oyce.

4.6.13 SM16x (Festuca rubra and Molinia caerulea sub-community)

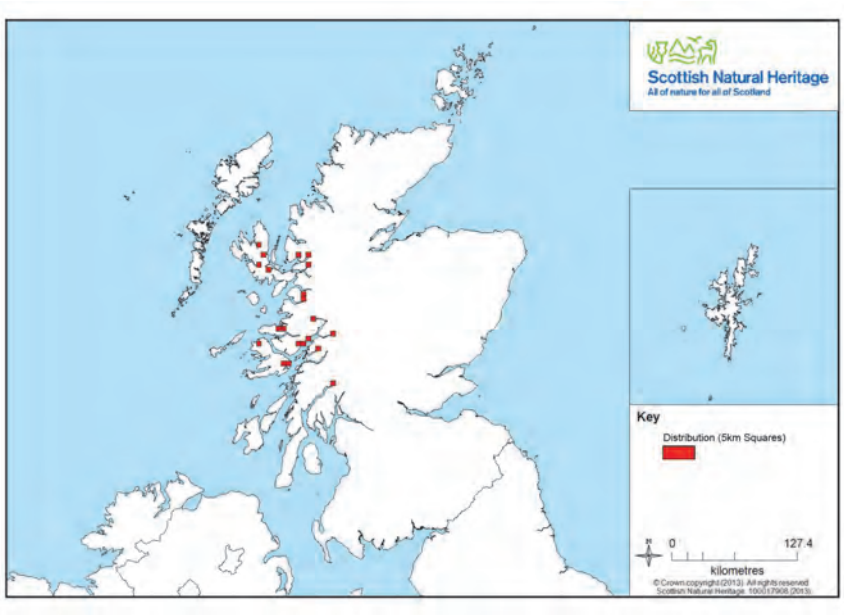


Figure 4-75: Distribution of SM16x.

SM16x was created to take account of transitional variation at the upper limits of saltmarshes on the west coast. Species normally associated with SM16f and SM16e are found with species present in mire vegetation. *Molinia caerulea* can be abundant to dominant in these areas (see Figure 4-76). Other associate species include *Carex viridula* subsp. *viridula*, *Lotus corniculatus*, *Schoenus nigricans* and the mosses *Kindbergia praelonga* and *Rhytidiadelphus squarrosus.* This transition rarely covers large areas, but is found across many west coast sites with good examples of the sub-community found on Loch Carron.

Figure 4-76: SM16x on Loch Eyre, Skye (front left).

4.6.14 SM17 (Artemisia maritima saltmarsh)

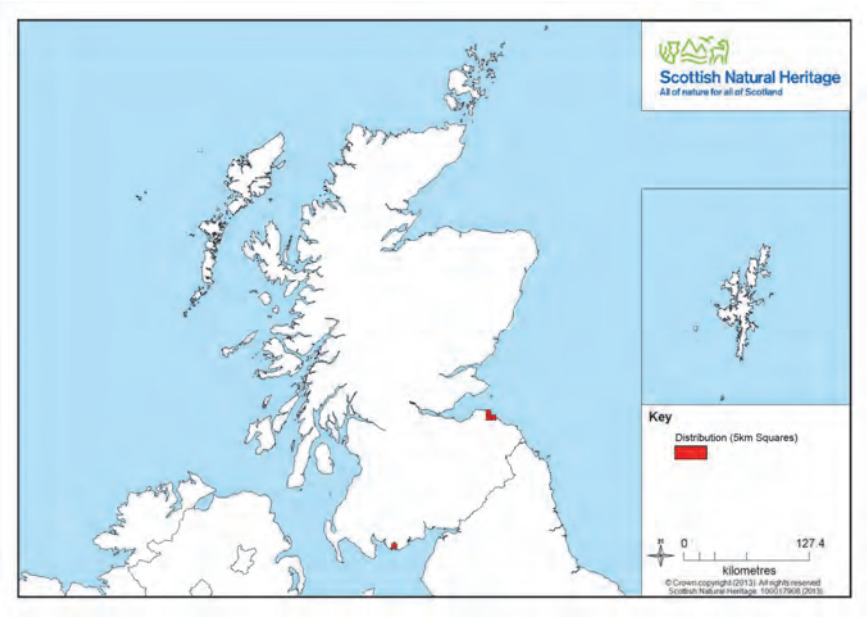


Figure 4-77: Distribution of SM17.

SM17 is a very rare community in Scotland and is found from two distinctly separate locations on the east coast (Tyninghame Shore) and on the Solway Firth (Manxman's Lake). Tyninghame Shore has the largest area of the community, which is similar in structure to SM16d, but with a constant presence of *Seriphidium maritimum*. At Tyninghame Shore the community is found in two separate locations and appears distinctly different. In the John Muir Country Park, *Seriphidium maritimum* is found in abundance on the drift line among driftwood and other debris where the abundance of the species' white-glaucous leaves is distinctive (see Figure 4-78). In this area the species associated are often found in SM16a, such as *Festuca rubra* and *Glaux maritima*. Behind this raised area the community is also found intermingled with the tall *Festuca rubra* sward.

Figure 4-78: SM17 on the driftline of Belhaven Bay (East Lothian).

At the western side of Tyninghame Shore (Heckies Hole) a turf-like variant of *Seriphidium maritimum* is present in the SM13d sward. It should be noted that although classified as SM13d, this is an important variation in the species' ecology (see Figure 4-79).

Figure 4-79: Turf version of Seriphidium maritimum *among SM13d.*

The community at Manxman's Lake is similar to the first described and is found on a raised area of saltmarsh among species associated with SM16a (see Figure 4-80). *Seriphidium maritimum* is restricted across Scotland and the areas found are small and highly localised.

Figure 4-80: SM17 at Manxman's Lake.

4.6.15 SM18a (Plantago maritima sub-community)

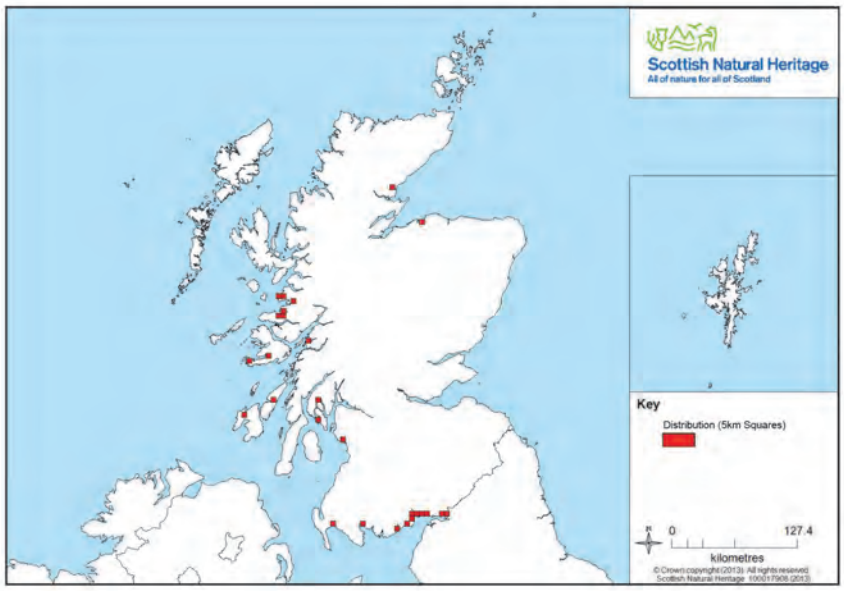


Figure 4-81: Distribution of SM18a.

SM18a is the most common variant of this restricted sub-community. The characteristic feature of this upper marsh grouping is the presence of the tall *Juncus maritimus*. *Juncus maritimus* can be quickly separated from related *Juncus* spp. by the sharp and pointed leaf tip and the abundance of tall brown and dead flowering heads from the previous year (*Juncus maritimus* is a late flowering species). *Juncus maritimus* can cover large areas, but few of the areas mapped as part of the SSS surveys were over 4ha. Significantly large stands are present at Findhorn Bay (Moray), Loch Beg (Argyll), Priestside Bank and Caerlaverock (Solway Firth).

Associate species include those often associated with SM16e and SM16f. *Festuca rubra* and *Agrostis stolonifera* have a constant presence (see Figure 4-82 and Figure 4-83). Other species include *Carex flacca*, *Leontodon autumnalis*, *Vicia cracca*, *Carex extensa* and *Euphrasia anglica*. *Ononis spinosa* is also present in the sub-community on the Solway Firth with *Festuca arundinacea* and *Oenanthe lachenalii* also present. It is possible to reclassify the Solway Firth areas as SM18b, but SM18a is recommended (see below).

Figure 4-82: Close up of SM18a at Findhorn Bay.

Figure 4-83: Vegetation structure of SM18a at Findhorn Bay.

4.6.16 SM18b (Oenanthe lachenalii sub-community)

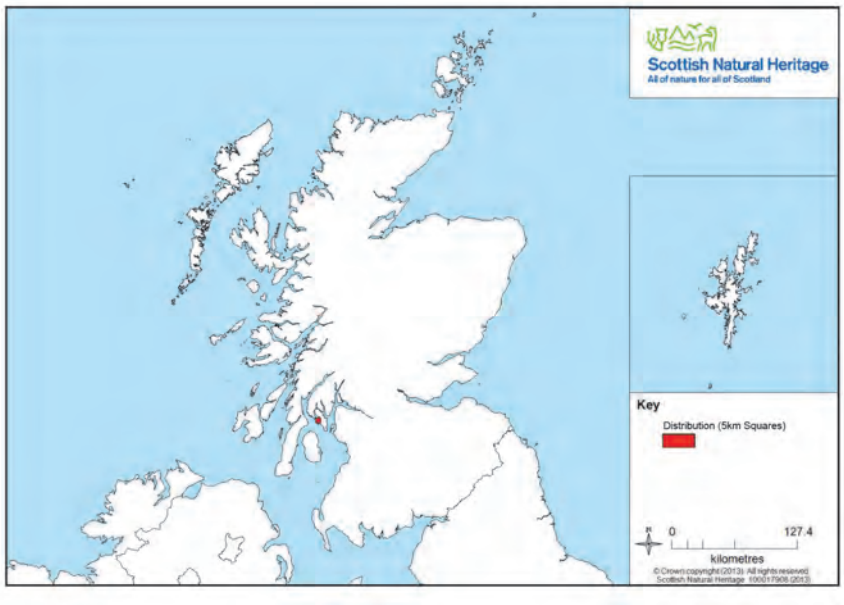


Figure 4-84: Distribution of SM18b.

Only one area of SM18b was recorded as part of the SSS project and this was found at Straad on Bute. SM18b is considered a more diverse sward than SM18a with a number of terrestrial associates included. This large area of the sub-community includes *Festuca rubra*, *Agrostis stolonifera*, *Juncus maritimus* and *Oenanthe lachenalii* (see Figure 4-85). It is possible to reclassify the areas of SM18a on the Solway Firth as SM18b, but SM18a is recommended.

Figure 4-85: SM18b at Straad.

4.6.17 SM18x (Molinia caerulea sub-community)

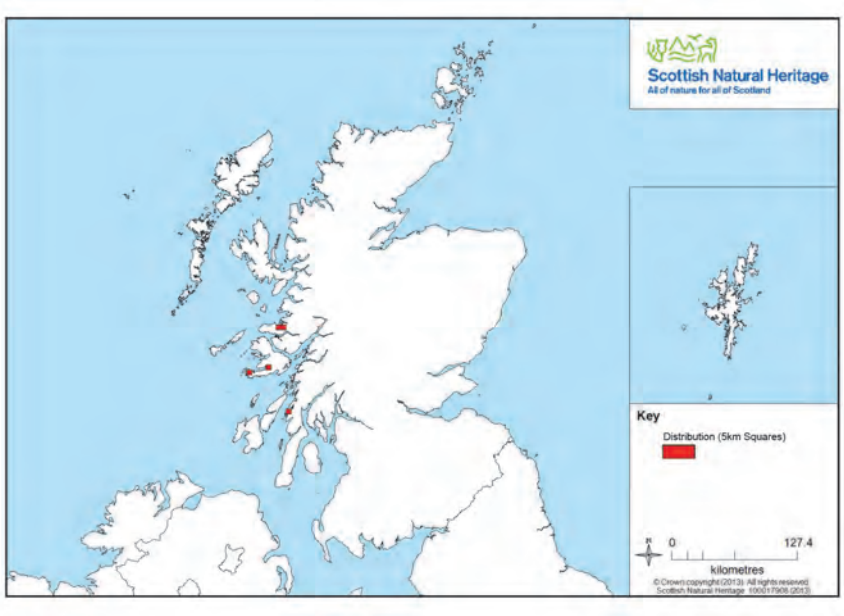


Figure 4-86: Distribution of SM18x.

SM18x was created to take account of stands of SM18 which include *Molinia caerulea* as a constant species (similar to SM16x). This sub-community is found exclusively on the west coast and includes: Linne Mhuirich (Argyll), Kentra Bay (Lochaber), An Caolas (Argyll) and Loch Beg (Argyll).

Juncus maritimus, Festuca rubra and *Molinia caerulea* are often abundant, with associates including *Lychnis flos-cuculi*, *Hydrocotyle vulgaris* and *Galium palustre* (see Figure 4-87). SM18x tends to be on slightly higher ground than SM18a, though both may occur together in mosaic.

Figure 4-87: SM18x on Linne Mhuirich.

4.6.18 SM19 (Blysmus rufus saltmarsh)

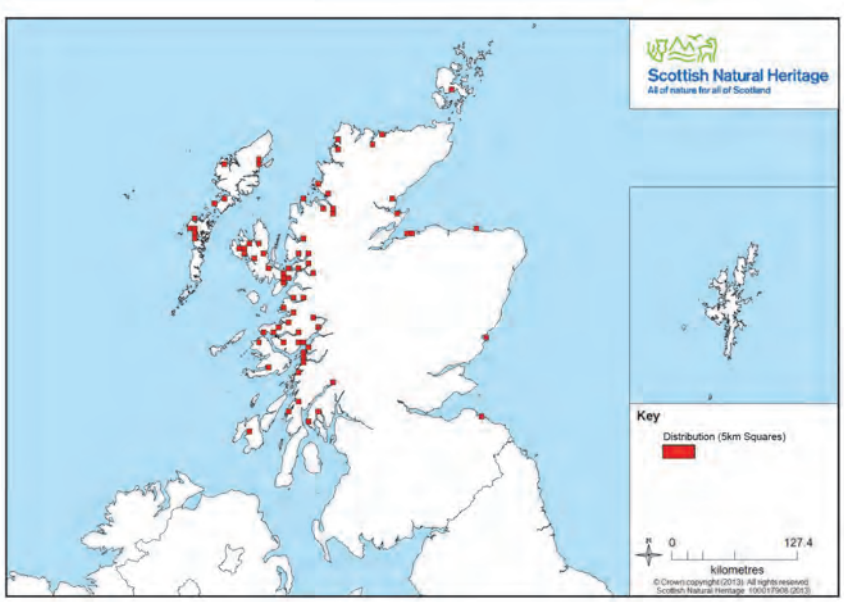


Figure 4-88: Distribution of SM19.

SM19 is a common community of north-west Scotland. The presence of *Blysmus rufus* is a key component with *Juncus gerardii*, *Triglochin maritimum*, *Carex flacca* and *Carex extensa* also present.

This is one of a small number of communities often found in small areas below the mapping scale utilised by the SSS project. SM19 is generally found in three situations. The most common occurrence of SM19 is a community of wet depressions and channels. It is unlikely that SM19 will be found in deeper creeks and pans (where SM16b and SM20 are likely to be present). SM19 is found beside well-worn sheep tracks and footpaths. In some instances the coverage can be extensive (such as in depressions on back-barrier marshes), but more often this type of SM19 is found in restricted areas (see Figure 4-89). There is an exceptionally large stand at Ardnish on Skye.

Figure 4-89: Typical form of SM19 in depressions and runnels.

The second type of SM19 is present on the west coast of Scotland where *Blysmus rufus* can be found topping saltmarsh banks and hummocks (see Figure 4-90). This is an unusual characteristic for this species, which normally prefers free-draining areas, but this pattern is found on a number of west coast sites including Strath Croe (Loch Duich).

Figure 4-90: West coast form of SM19 topping upper saltmarsh areas.

The third type is where SM19 is found developing over exposed shingle, gravel and rock. This type can be found in many saltmarsh zones including the pioneer zone. In these instances the community occupies areas where fresh water frequently flushes along runnels and channels. *Blysmus rufus* can be the only species present, but *Juncus gerardii* and *Triglochin maritimum* may also occur (Figure 4-91). This type of community has a number of crossovers with other identified communities including SM16b growing on similar substrates; SM16f; and the proposed north coast sub-communities of SM16cx, SM16g and SM16i. This version of SM19 can also be found on perched saltmarsh sites growing on similar substrates. Sites for perched SM19 include Boddin Point (Angus) and Stakeness (Aberdeenshire).

Figure 4-91: SM19 at the front of the saltmarsh among gravel.

4.6.19 SM20 (Eleocharis uniglumis saltmarsh community)

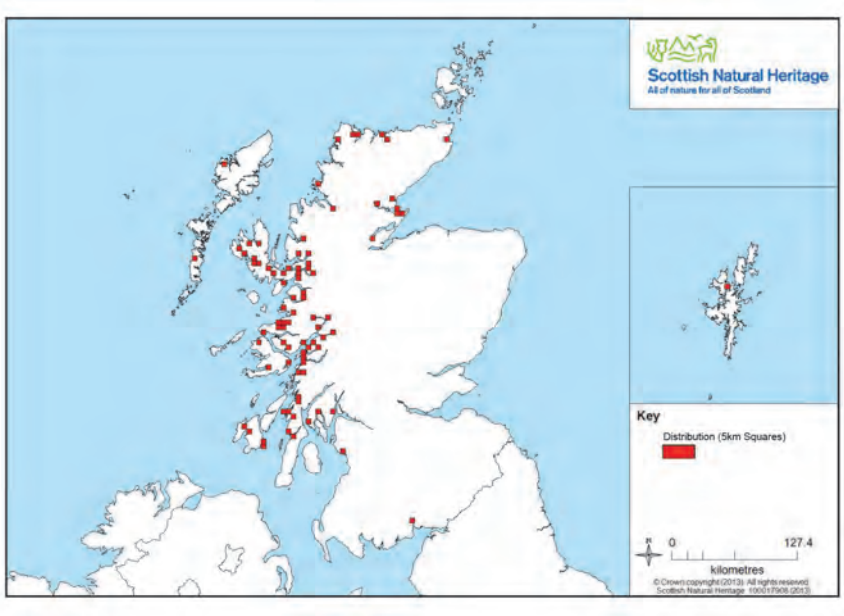


Figure 4-92: Distribution of SM20.

Like SM19 (see above) this community is mostly found in north-west Scotland where it is found in the upper marsh zone. SM20 grows in similar situations to SM16b, but is more often found in waterlogged areas, such as pools, and pans filled with water. Like SM19 and SM16b, the community is often found in small areas due to its preference for growing in water-filled pans, but large areas can occur in creeks on western loch-head marshes (see Figure 4-93). The largest areas of the community are found in waterlogged areas of Morrich More in the terrestrial transition zone (see Figure 4-94). It also commonly occurs in stony areas with freshwater seepage at west coast sites, often with SM19.

Figure 4-93: Typical form of SM20 in a large pan.

Figure 4-94: Expansive areas of SM20 and SM16b at Morrich More.

The community can be found mainly in the form of a single species stand of *Eleocharis uniglumis*. Other associates include species found in SM16b and SM19 vegetation such as *Juncus gerardii*, *Triglochin maritimum* and *Agrostis stolonifera*. It is possible that the species-poor form in pools could merit sub-community status as it does not fit with the published description. There is considerable overlap with the more freshwater grouping of S19 where the related *Eleocharis palustris* replaces *Eleocharis uniglumis*. Both species can be found in either community, which allows SM20 to be found inland of saltmarsh, sometimes where there is no saline influence. The differences between *Eleocharis palustris* and *Eleocharis uniglumis* are difficult to quantify from vegetation keys unless using a number of flower heads from each, but *Eleocharis palustris* is a more robust species with a wider and straighter stem. The minute *Eleocharis quinqueflora* can also be found on more open examples of SM20.

Like SM19, SM20 can also be found on perched saltmarsh (such as Boddin Point). Areas of SM20 were also found on the Nith Estuary (Solway Firth), particularly on Kirkconnell Merse along with areas of SM27 and pans with *Ruppia maritima* and *Ranunculus baudotii*.

At the northern limits of SM20's range and throughout the west coast, the community can be found as a form of pioneer vegetation on river-fringing marsh (much like the scenario discussed for SM16b, SM19 and SM16g, SM16i and SM16cx). A good example of this situation is found on the River Wester (Caithness) (see Figure 4-95).

Figure 4-95: SM20 growing at the front of the narrow saltmarsh in the River Wester.

4.6.20 SM23 (Spergularia marina-Puccinellia distans saltmarsh community)

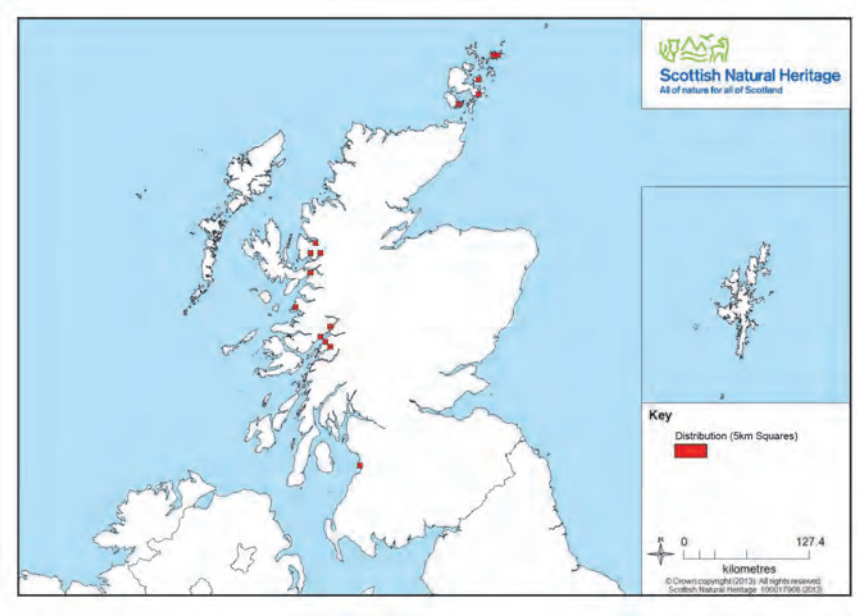


Figure 4-96: Distribution of SM23.

SM23 is a rare community found on a restricted number of sites on the west coast and across the islands of Orkney.

SM23 is found on open soils, gravels and shingle in the upper marsh zone; a particular niche of the community is irregularly inundated pans which are often heavily trampled by stock. In these situations the key species is *Spergularia marina* which is normally found with a different species of *Puccinellia* (*Puccinellia distans).*

This is a community that develops in small areas and is often below the mapping resolution of the SSS project.

On the west coast Ian Strachan noted this community on a number of sites, but with *Puccinellia maritima* in place of *Puccinellia distans* (see Figure 4-97). On Orkney, Theo Loizou noted SM23 on various sites with *Puccinellia distans* subsp. *borealis* (see Figure 4-98). Thomas Haynes target noted a small number of sites which included SM23 in pans, but these areas often included only *Spergularia*.

Figure 4-97: SM23 with Puccinellia maritima *at Inverscaddle Bay, Lochaber.*

Figure 4-98: SM23 with Puccinellia distans *subsp.* borealis *at Lama Ness Oyce, Sanday (Orkney).*

Species associated with SM23 include sparse coverings of *Plantago maritima*, *Salicornia europaea*, *Aster tripolium*, *Atriplex prostrata* and *Juncus bufonius*.

It is expected that the true distribution of this community is under-represented by the SSS project, due to the small and localised nature of the community.

4.7 Strandline and disturbance communities

4.7.1 SM27 (Ephemeral saltmarsh vegetation with Sagina maritima)

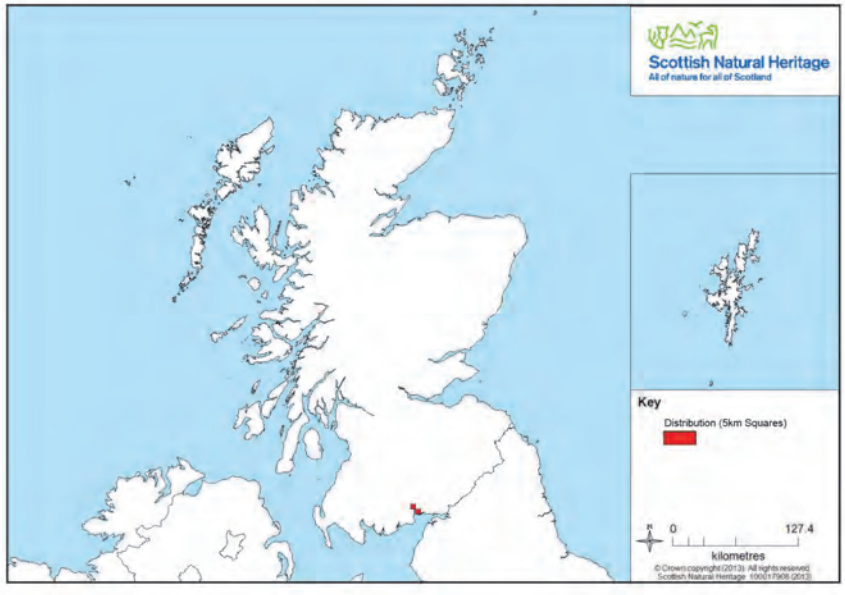


Figure 4-99: Distribution of SM27.

As discussed for SM23 above, SM27 is also a community that is typically found in small and localised areas. Dried out pans and areas of exposed soil caused by poaching are where this community is normally found.

This community is notably absent from most of the SSS project, but vegetation dominated by *Sagina* sp. was observed on exposed soils at two sites on the Solway Firth (Caerlaverock and Greenmerse). It is likely that further instances of the community are highlighted in target notes (due to the small scale of the community).

Sagina maritima was rarely encountered on Scottish saltmarshes as part of the SSS survey. SM27 areas found on the Solway Firth include *Sagina procumbens* (not *Sagina maritima*) and better fit OV20 (*Poa annua-Sagina procumbens* community).

4.7.2 SM28 (Elymus repens saltmarsh)

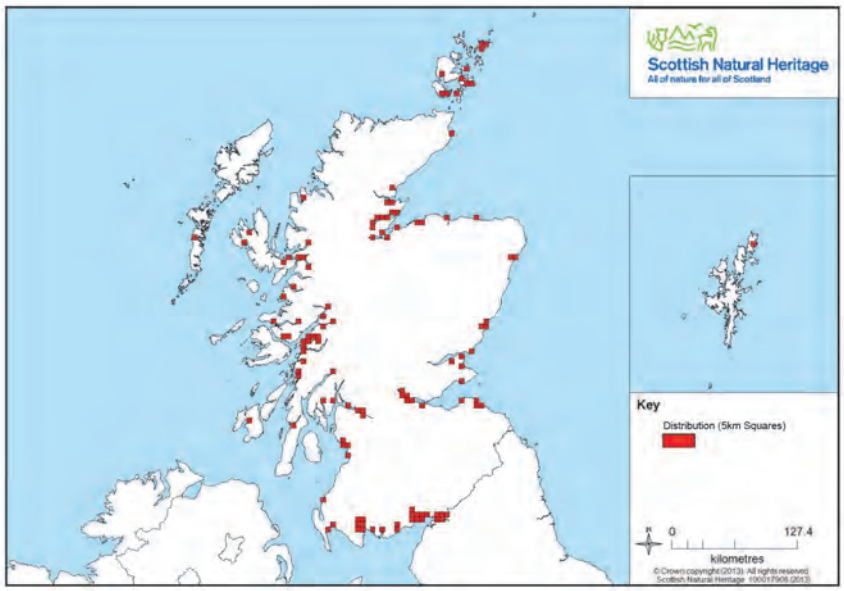


Figure 4-100: Distribution of SM28.

SM28 is a very common community found across the entire range of Scottish saltmarshes, but lacking from most of the Outer Hebrides and with larger areas found on the Solway Firth and the East Coast.

SM28 takes a wide range of forms compared to the published description and associated datasets (Rodwell 2000). SM28 appears to show a range of variants similar to the range of types identified in the upper marsh series, thus it is surprising that sub-communities were never assigned to SM28. As part of the SSS project there is no holistic analysis of the vegetation samples, but a statistical assessment of the SM28 samples would be a valuable exercise.

SM28 is a community found on saltmarsh that has experienced relatively recent disturbance (either natural or from human interference). The typical example of SM28 is when the community develops over earth banks at the landward edge of the saltmarsh (see Figure 4-101). *Elytrigia repens* is the constant species and is easy to identify in the sward due to its large flowering heads and broad leaves. Caution should be used in the early part of the survey season as the flowering heads of *Elytrigia repens* are absent and the flowering shoots are rolled up tight, which gives the community a very different and more open appearance.

Figure 4-101: Typical form of SM28 on earth banks, dominated by Elytrigia repens*.*

Elytrigia repens is not the only species of *Elytrigia* present in SM28. *Elytrigia atherica* can replace *Elytrigia repens* on some sandy drift line habitats. The two species can be difficult to separate due to the wide variation in distinguishing features for both species, but a definite record of *Elytrigia atherica* was made at Findhorn Bay (see Figure 4-102).

Figure 4-102: SM28 with Elytrigia atherica *at Findhorn Bay.*

The amount of *Elytrigia repens* within the sward can also vary widely, with more typical swards of drift-lines and earth banks mostly dominated by almost homogenous stands of *Elytrigia repens*, while others have many species present that are usually associated with MG1, such as *Arrhenatherum elatius*, *Sonchus arvensis, Rumex* spp. and *Dactylis glomerata*. SM28 with MG1 associates is one such variant that would be recommended for consideration as a sub-community (see Figure 4-103).

Figure 4-103: SM28 with MG1 associates, Nigg Bay (Cromarty Firth).

In other instances *Elytrigia repens* forms a co-dominating relationship with *Festuca rubra.* This type of SM28 can cover large areas. Again, these areas appear to have been disturbed in some form. This community is also present in areas of saltmarsh where grazing has ceased for a number of seasons. A good example of the *Festuca rubra/ Elytrigia repens* co-dominating community is found on the Sleek of Tarty (Aberdeenshire) (see Figure 4-104). There is also crossover here with the MG11 coastal grassland community which includes *Agrostis stolonifera* (see 4.9.1). *Agrostis stolonifera* can also be found in co-dominating situations in SM28 swards.

Figure 4-104: SM28 with Festuca rubra *and* Elytrigia repens *co-dominating with broadleaf tree planting occurring on site at Sleek of Tarty (Aberdeenshire).*

SM28 is found frequently on the banks of straightened creeks and drainage banks often growing parallel to the ditch/channel, where it grows on the disturbed spoil from the associated modifications. This type is normally the SM28/MG1 intermediate.

SM28 is often the community found at the landward limit of many saltmarshes and grades into mire and swamp communities and frequently agriculturally improved swards. SM28 can also be found in patches and large areas in the upper marsh, often forming mosaics with SM16d and SM16e.

SM28 is often found in drier situations and prefers raised sediments and banks. The community is also found on natural ridges developed from drift wood and other debris on a number of sites. Findhorn Bay has a number of natural and artificial ridges across most of the saltmarsh, which can often be difficult to separate.

The pale glaucous colour and uniform height of SM28 allows assessment from a distance and it is considered that the presence of SM28 has much value in the assessment of built structures and disturbance on Scottish saltmarshes as large areas of SM28 are usually an indication of considerable modification and disturbance to the area. A good example of this is Luce Bay on the Solway Firth, where significant modifications have been made to the river-fringing marshes with many earth banks present and drainage ditches and runnels. As a result many of the formerly upper marsh communities have been replaced by homogenous stands of SM28.

4.7.3 SM28x (Festuca rubra dominated variant)

Figure 4-105: Distribution of SM28x.

This variant was created to take account of variation in the SM28 sward (as discussed above) by Ian Strachan on the Garnock Estuary and Pow Burn in Ayshire (note that the Garnock Estuary is split across two grid squares in Figure 4-105). SM28x is identified as a variant where *Festuca rubra* is the dominant vegetation type with notably less *Elytrigia repens* and includes *Sonchus arvensis* and *Ammophila arenaria* (see Figure 4-106). This sub-community is likely present in others areas of Scotland. Further analysis of SM28 data is required to identify possible sub-community variation.

Figure 4-106: SM28x on Pow Burn.

4.8 Shingle Vegetation

There are a number of instances where shingle is encountered at the seaward edge of saltmarshes. Shingle can also be present in eroded areas, in pans, and at the banks of rivers. Where these substrates interact with saltmarsh vegetation, sparse vegetation can be found expanding across shingle areas, which act as a variation on the pioneer and lower marsh areas found on mud and sand substrates. The Bare Shingle 'BSH' classification was originally developed by Dargie in the SDVSS (Dargie 2000b) to identify areas of bare shingle. This same classification is used to identify areas of bare shingle in the SSS project. It should be noted that 'BSH' is often utilised to describe mosaics of bare shingle intermixed with saltmarsh vegetation. Figure 4-107 shows a distribution map of all the areas where bare shingle was recorded. These areas are strongly associated with the west coast and mosaics of various middle marsh, upper marsh and strandline vegetation can be found growing over shingle.

Shingle vegetation is poorly represented within the published NVC classification system and a revision of the communities would be beneficial. Such a revision is possible if the results of the SSS project are synthesised with the results of SNH's vegetated shingle project.

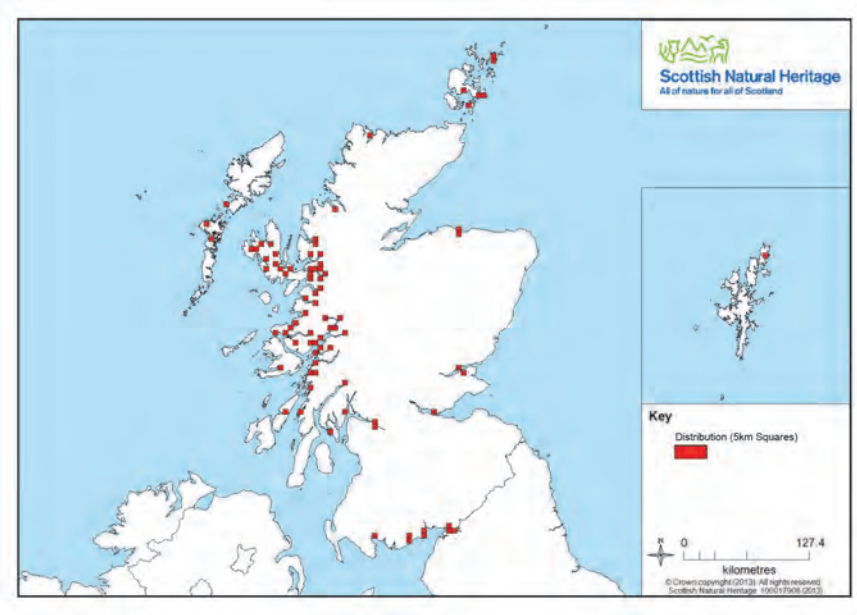


Figure 4-107: Distribution of BSH recorded as part of the SSS project.

The SSS project also includes two additional adaptations to the community to take account of sparse vegetation growing among bare shingle. These are discussed below.

4.8.1 BSHc (Cochlearia officinalis pioneer community on shingle)

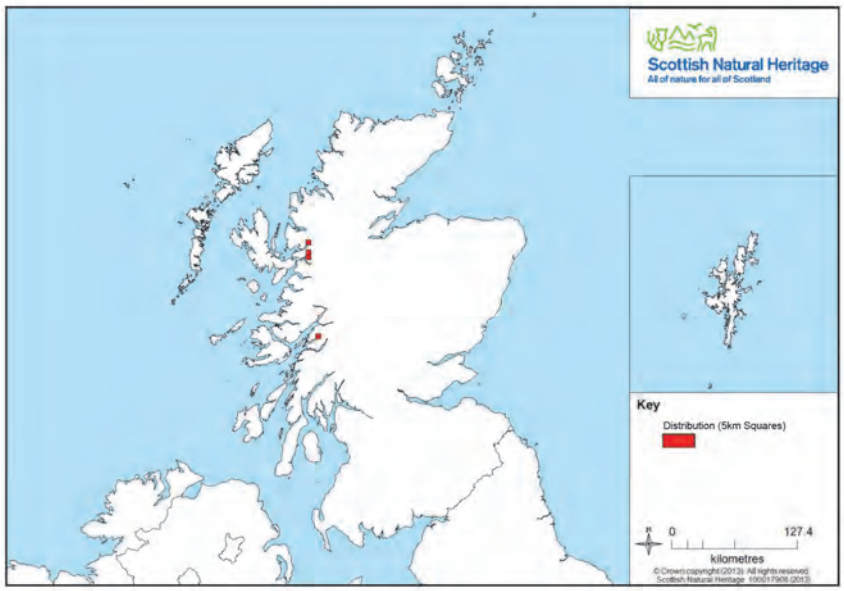


Figure 4-108: Distribution of BSHc.

This community was created to classify areas of dense to sparse *Cochlearia officinalis* growing over shingle at the seaward edge of loch-head saltmarshes on the west coast. This type was recorded from Nonach on Loch Alsh (see Figure 4-109), Druimavuic (Argyll) and Loch Carron (West Ross).

Figure 4-109: BSHc and seaweed on shingle in the pioneer zone at Nonach.

The community is below the low marsh zone on flats of sand and shingle, typically dominated by *Fucus spiralis* (attached to stones) with *Cochlearia officinalis* frequent to locally abundant. *Puccinellia maritima* and *Armeria maritima* are rare associates in some stands. Previous reports indicate that the *Cochlearia* sp. present could be *Cochlearia danica*,

but *Cochlearia officinalis* was considered a better fit for the species present at Nonach. In some site reports this community may also be referred to as 'Coc off'.

4.8.2 BSHx (Armeria maritima pioneer community on shingle)

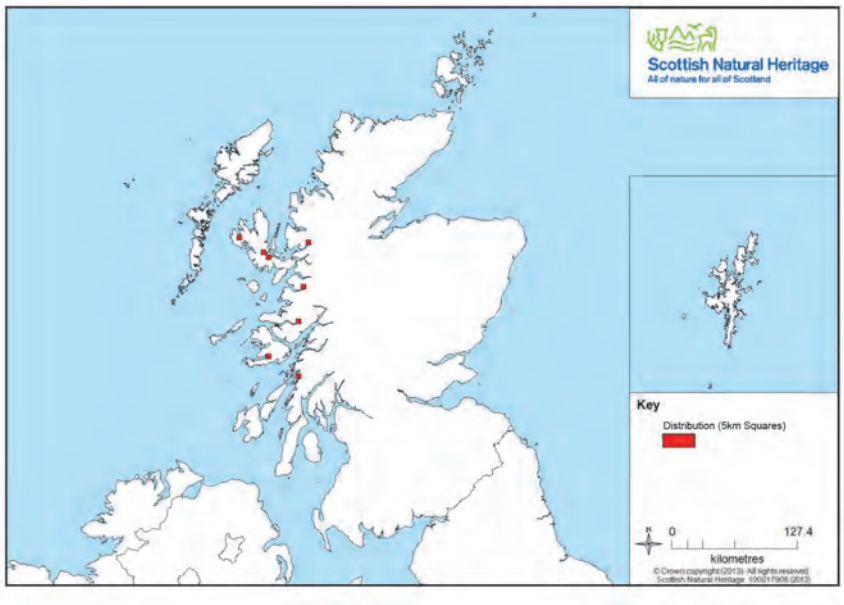


Figure 4-110: Distribution of BSHx.

Armeria maritima is able to expand across shingle at the seaward edge of loch-head saltmarshes on the west coast. *Armeria maritima* is the most frequent species and can be found as the sole species in some areas. Associates can include *Puccinellia maritima, Plantago maritima, Cochlearia officinalis* and *Suaeda maritima* (see Figure 4-111). Such areas are also classified as a mosaic of BSH and SM13b on some north-west sites by Thomas Haynes, where this community includes abundant *Armeria maritima* and associates including *Puccinellia maritima* and *Glaux maritima* (see Figure 4-112). In some SSS site reports this community may also be referred to as 'Arm mar' (see appendix 2 for a full index of the site reports).

Figure 4-111: BSHx showing rosettes of Armeria maritima *and* Plantago maritima *at Loch Sligachan, Skye.*

Figure 4-112: SM13b and BSH at Little Loch Broom.

4.9 Coastal grasslands

Three types of coastal grassland community are often present at the transitional limits of the upper marsh. These communities can also be found integrated into the upper saltmarsh in various situations. The three communities were often recorded previously as saltmarsh vegetation, but for reasons discussed in site reports are better classified as coastal grassland sites (see the site reports for: Loch Fleet, Beauly Firth, Bonar Bridge and Conon Islands). Justifications normally involve: reduced exposure to saline water; shingle spit dynamics; and changes in sediment movement.

4.9.1 MG11 (*Festuca rubra-Agrostis stolonifera-Potentilla anserina* grassland)

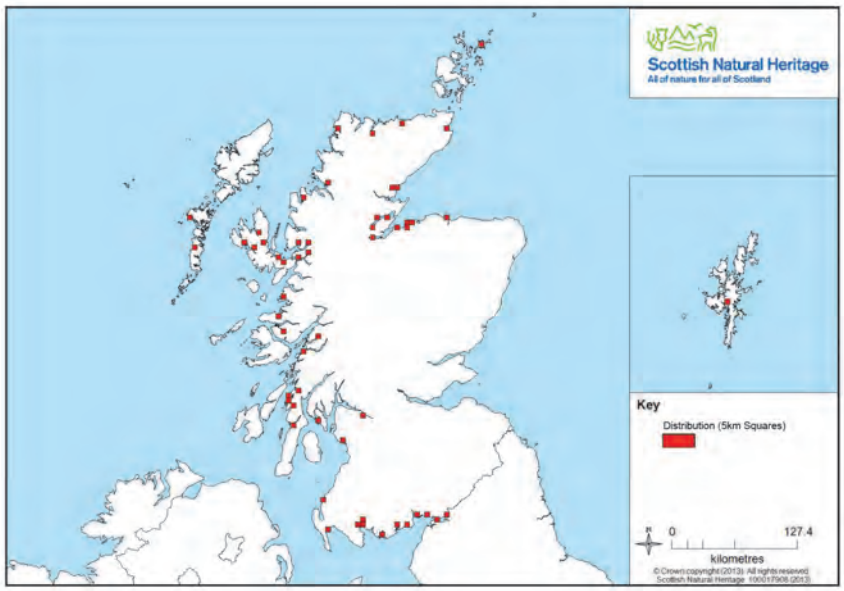


Figure 4-113: Distribution of MG11.

MG11 is well distributed across Scotland's saltmarshes, but is probably the least recorded coastal grassland type of the three. MG11 is closely aligned with SM28 and the SM16d communities. MG11 is often present landward of SM16d and can replace SM28 and can form across large homogeneous areas. Like SM28, MG11 is found in raised areas and a key characteristic is a co-dominance of *Festuca rubra* and *Agrostis stolonifera*. *Potentilla anserina* is often present (see Figure 4-114), but is absent from some swards. *Elytrigia repens* can play more of a prominent role in the community than identified in the published data sets (Rodwell 2000). The largest area of the community is recorded from the centre of the Culbin back-barrier marsh (where the saline influence is at its lowest limit). The community is also found at the landward limit of estuaries where saline flushing is greatly reduced.

Figure 4-114: Typical form of MG11.

4.9.2 MG12 (Festuca arundinacea grassland)

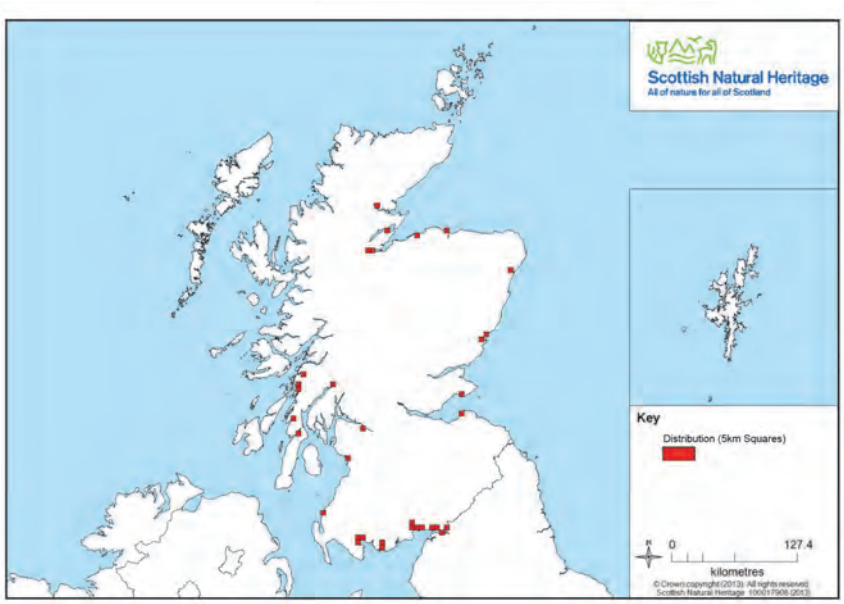


Figure 4-115: Distribution of MG12.

MG12 is also well distributed across the range of Scottish saltmarshes, but is absent from the north-west and the offshore islands. MG12 is very similar in species composition to MG11, but with tall tussocks of *Festuca arundinacea* having a constant presence (see Figure 4-116). This community is rarely found integrated into the upper marsh like MG11, but is usually found at the landward limit of the saltmarsh. This community can also develop large homogenous stands and is often found beside larger creeks in the upper marsh zone, which grades into surrounding habitat and agricultural land. MG12 can be found associated with MG11 and both brackish and non-brackish swamp communities (such as S4 and S28). The largest areas of the community are found at Greenmerse on the Solway Firth.

Figure 4-116: Typical form of MG12 (in the foreground).

4.9.3 MG13 (Agrostis stolonifera-Alopecurus geniculatus grassland)

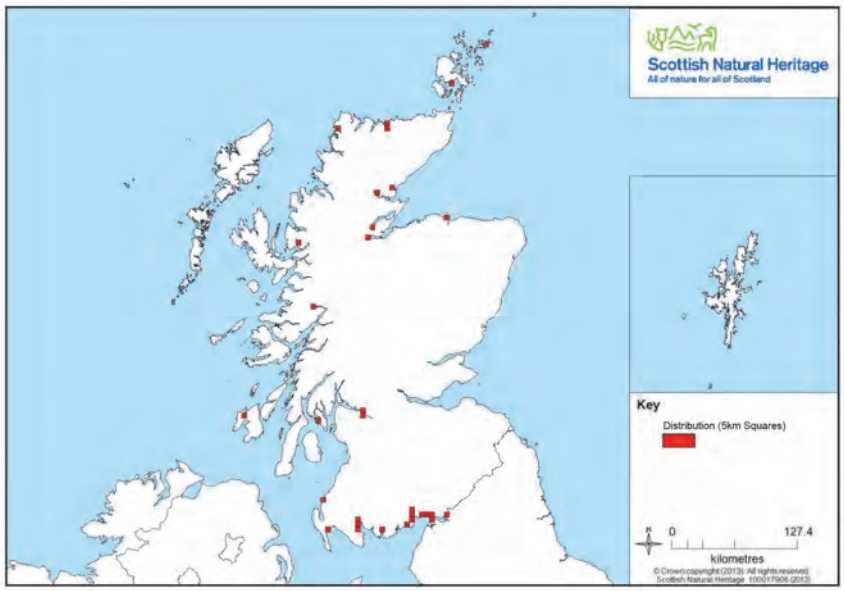


Figure 4-117: Distribution of MG13.

MG13 is a community that is found across many of Scotland's saltmarshes and at the landward limits of estuaries and sea lochs. It is rarely found on the west coast of Scotland except on a small number of sites including Loch Eil (Lochaber), Gruinart Flats (Argyll), Firth of Clyde (Renfrewshire) and Straad (Argyll). The community can form large areas with the largest found at Milnfield Merse (Solway Firth) and Conon Islands (Cromarty Firth).

There are two distinctive forms of MG13 on Scottish saltmarshes. The first is a typical form found in non-brackish conditions at the upper limits of saltmarshes. MG13 is found on waterlogged sediment, which is often very soft and feels unstable underfoot, but is held together by the stoloniferous roots of the core species. These areas can be widespread beside tracks and water troughs on grazed marshes and other areas prone to puddling. MG13 can also develop in low-lying depressions where saline input is limited, replacing SM16b and SM20 in similar locations. In these instances, MG13 is found in areas that show signs of agricultural improvement. Both *Agrostis stolonifera* and *Alopecurus geniculatus* are usually present, but sometimes only one is present. Both show a distinctive creeping habit in MG13 and create interwoven mats of vegetation. *Agrostis stolonifera* rarely flowers in MG13, but the flowers of *Alopecurus geniculatus* are often present (see Figure 4-118).

Figure 4-118: MG13 at the upper limits of the saltmarsh.

The second form is a distinctive brackish variety of MG13 that is dominated by *Agrostis stolonifera*. *Triglochin maritimum* is often present along with *Cochlearia officinalis*. Few other species occur, but *Atriplex prostrata*, *Juncus articulatus* and *Bolboschoenus maritimus* can also be present. This brackish form of MG13 is found at the seaward edge of swamps and coastal grassland communities at the landward limits of firths. Significant areas are found at the limits of the Cromarty Firth (Conon Islands) and on the muddy sediment of the Beauly Firth (see Figure 4-119). *Agrostis stolonifera* can cover wide areas in a creeping form similar to the more typical type of MG13. It would appear that this vegetation is a response to decreased saline conditions as the community is often found in brackish-fresh waters. This community also has strong similarities with forms of SM16b and SM16g, SM16h and SM16i that are found at the northern limits of their northern mainland range. Ian Strachan classified areas of MG13 on west coast sites as MG11 (due to the similar species content of the sample). Further analysis of these samples would prove valuable.

Figure 4-119: Brackish variant of MG13 found at the seaward edge of coastal grassland.

4.10 Brackish and freshwater swamps

Brackish swamp was found in association with saltmarsh on a number of sites and is strongly associated with estuarine systems. Floristically there is often very little difference between freshwater and brackish varieties, which is due to the dense homogenous form of the swamp communities observed. In this section the brackish varieties of swamp are described and any relevant important notes regarding the interaction with freshwater swamps and saltmarshes are also discussed. This section also includes restricted communities that are dominated by rare sedges.

Brackish forms of swamp communities are denoted by the word ‘saline’ in brackets after the NVC classification in the GIS polygon database (e.g. ‘S4 (Saline)’). Typical freshwater stands are recorded without any additional information.

4.10.1 S3 (Carex paniculata sedge-swamp)

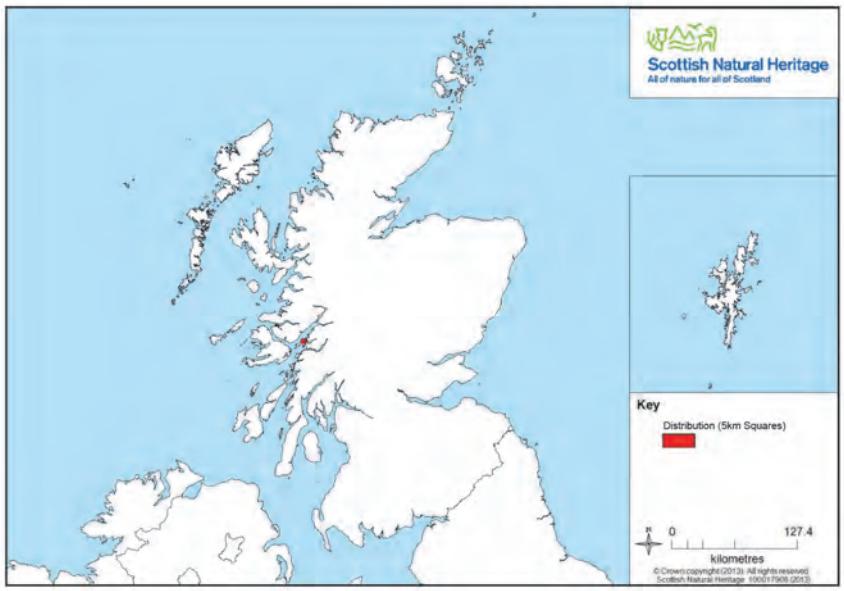


Figure 4-120: Distribution of Brackish S3.

Brackish S3 is a rare community only recorded on two saltmarsh sites on the west coast. This brackish form was recorded from An Sàilean (Argyll) with *Carex paniculata* dominant (see Figure 4-121). S3 merges into S4 reed swamp and SM20 saltmarsh. Associate species include *Cochlearia officinalis, Eleocharis uniglumis* and *Bolboschoenus maritimus.* Stands too small to map were recorded as target notes at Loch Crinan (Argyll).

Figure 4-121: S3 at An Sàilean.

4.10.2 S4 (Phragmites australis swamp and reed-beds)

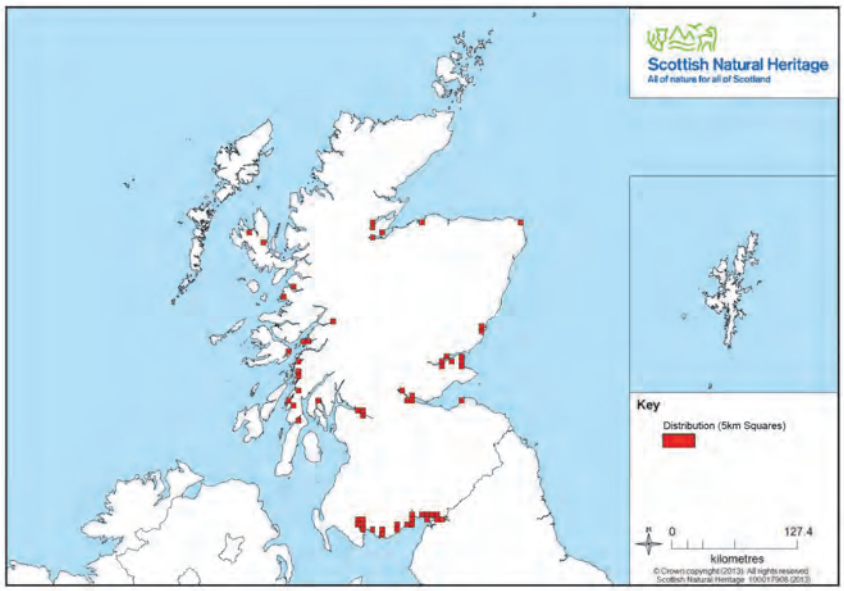


Figure 4-122: Distribution of brackish S4.

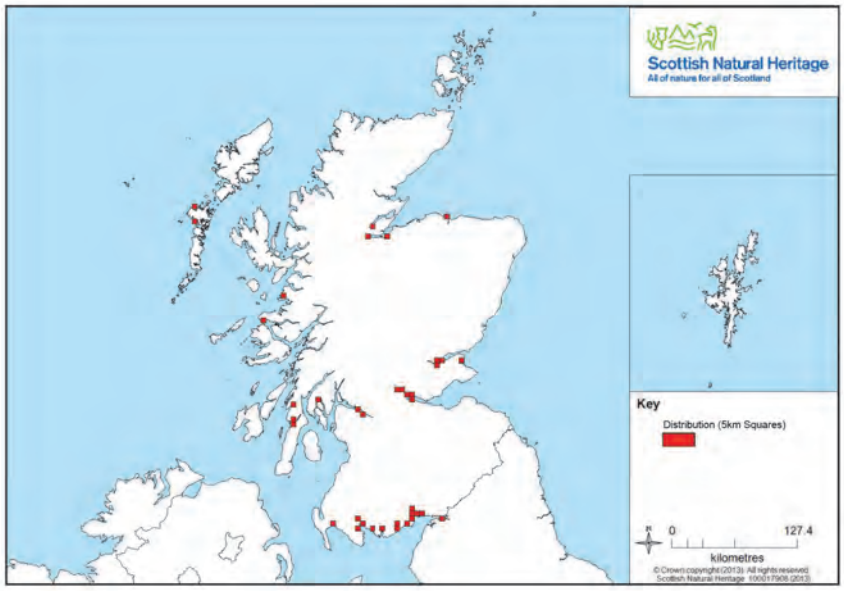


Figure 4-123: Distribution of freshwater S4.

Brackish S4 is mainly restricted to the larger estuarine systems with limited occurrences on the west coast and no presence on the offshore islands. The largest area of Brackish S4 is found on the Tay Estuary. It should be noted that only those areas of brackish S4 where saltmarsh have been recorded were visited. S4 can be found in large expansive stands where halophytes are only apparent in the first 2m of vegetation, with the remainder of the stands being composed of leaf litter and *Phragmites australis*. *Phragmites australis* is also a difficult species to assess in respec t of abundance inside the S4 canopy as much of the surface area is occupied by litter. Despite a lack of association with halophytes, the community is evidently brackish as shown by the surrounding vegetation stands (see Figure 4-124), which include S21 acting as a pioneer fringe to the community and areas of SM16e and SM16f sometimes located landward of S4 stands (e.g. Tay Estuary). Straightened creeks and drainage channels also increase the influx of saline water into larger areas of S4.

Figure 4-124: Brackish S4 at the Tay Estuary (in the middle of the picture).

Large stands of S4 can also be found at the upper limits of the saltmarsh, where saline input is minimal. In some instances the communities show no signs of halophytic vegetation and there is little evidence that the areas are regularly or irregularly flushed with brackish water. In these instances S4 is considered as freshwater-based, but the majority of S4 stands found linked to the upper marsh zone are brackish in nature (see Figure 4-125). Larger freshwater areas are normally found beyond the saltmarsh and further up river. Indicators of saline influence are usually the surrounding saltmarsh and grassland vegetation and other swamp types (such as S21, S20, S28 and S5) which have clear brackish and freshwater niches.

Figure 4-125: Brackish S4 at the upper limits of the saltmarsh.

On the west and north coasts, *Phragmites australis* can be found in stunted forms growing in creeks and as separate plants growing among upper marsh vegetation. Examples include Opinan and Kyle of Tongue (see Figure 4-126).

Figure 4-126: Stunted Phragmites australis *at Opinan.*

4.10.3 S5 (Glyceria maxima swamp)

S5 is not considered to have a brackish variant and is normally associated with freshwater stands at the limits of saline influence where saltmarsh vegetation and brackish stands of swamp vegetation are absent.

4.10.4 S12 (Typha latifolia swamp)

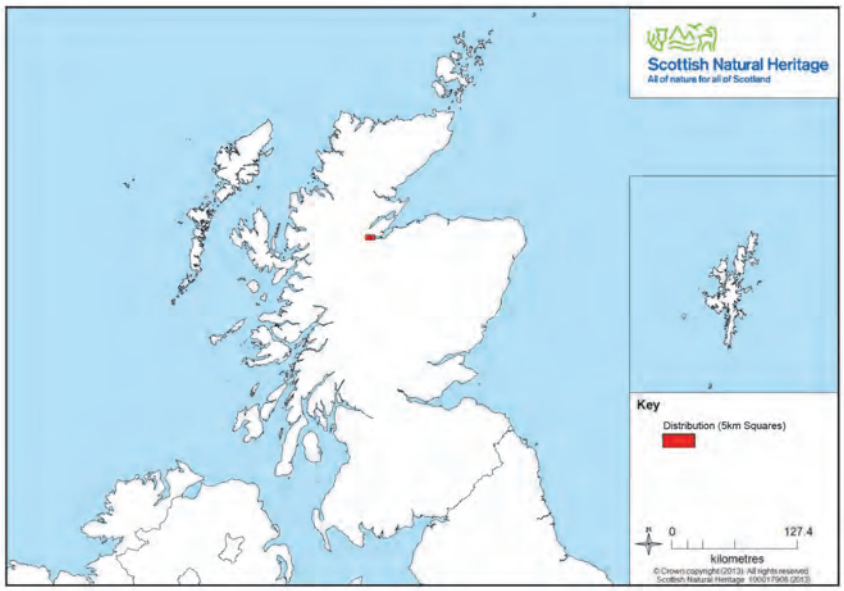


Figure 4-127: Distribution of brackish S12.

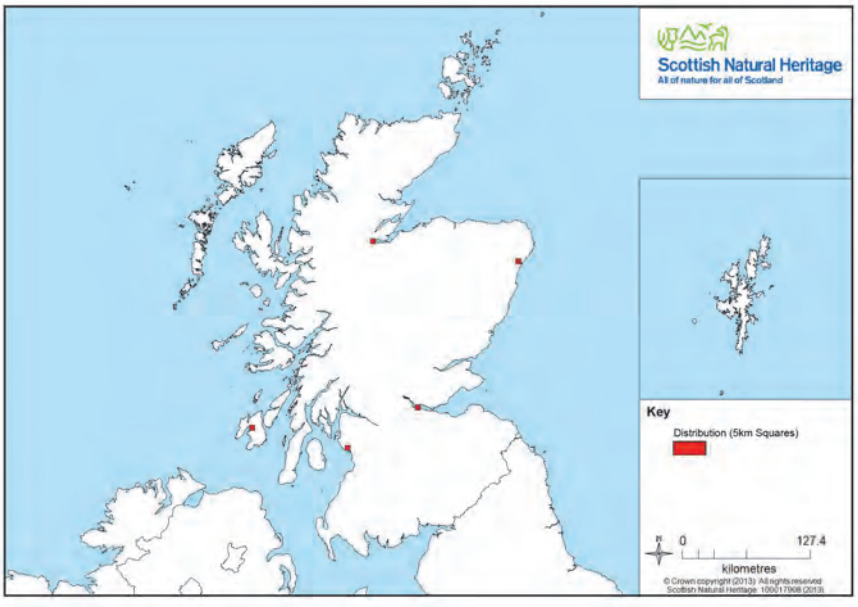


Figure 4-128: Distribution of freshwater S12.

Brackish swards of S12 were only recorded from the Beauly Firth and *Typha latifolia* is not normally found in brackish systems. The most conspicuous brackish version of the community is located on the south bank of the narrowing River Beauly. The other two areas of S12 indicated as saline are both found at the landward limits of the saltmarsh and are possible to interpret as saline or non-saline.

4.10.5 S19 (Eleocharis palustris swamp)

Figure 4-129: Distribution of brackish S19.

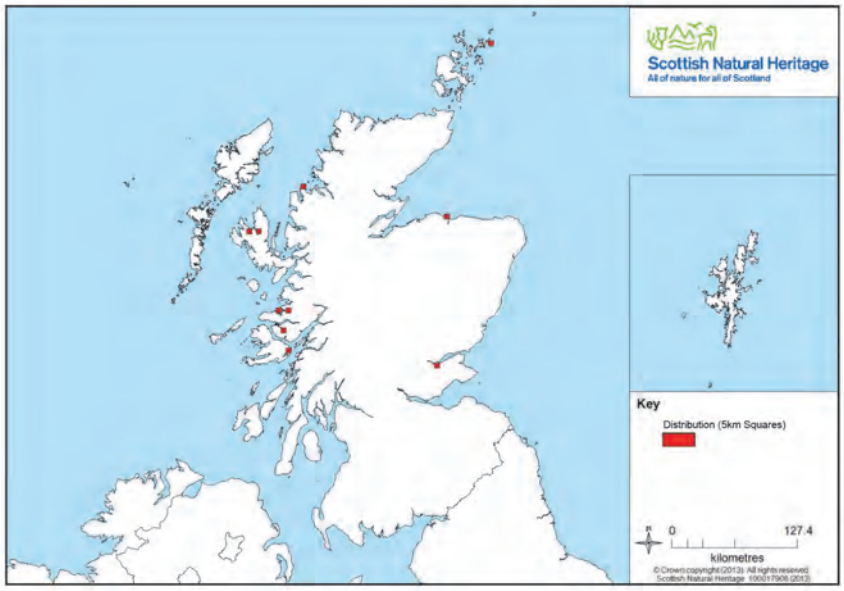


Figure 4-130: Distribution of freshwater S19.

Despite S19 being identified as having a stronger association with freshwater systems, there are instances where S19 is found in brackish conditions. S19 is found around a saline pool at Whiteness Head and a very small area of brackish S19 is found on Loch Fyne. For more information on the community see SM20 (4.6.19).

Figure 4-131: Freshwater S19 on the Tay Estuary.

4.10.6 S20 (Scirpus lacustris ssp. tabernaemontani swamp)

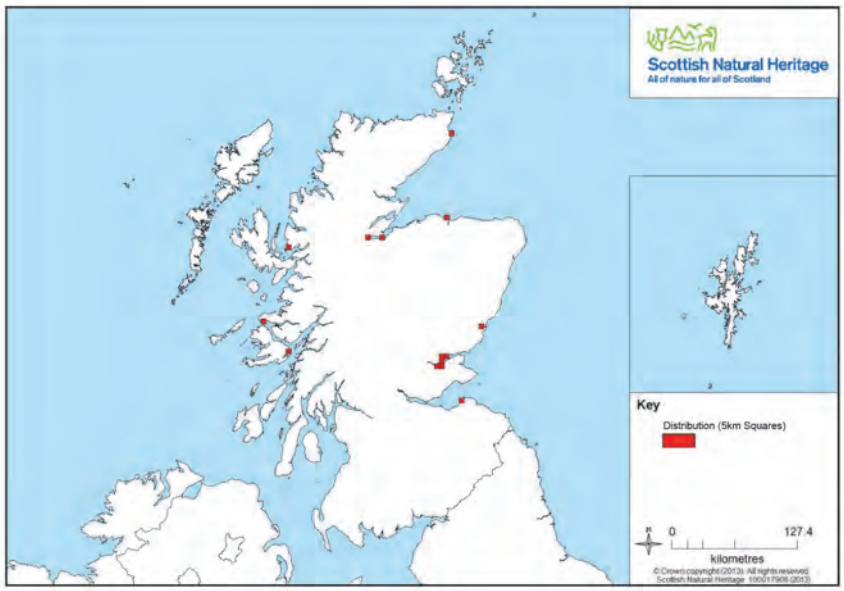


Figure 4-132: Distribution of brackish S20.

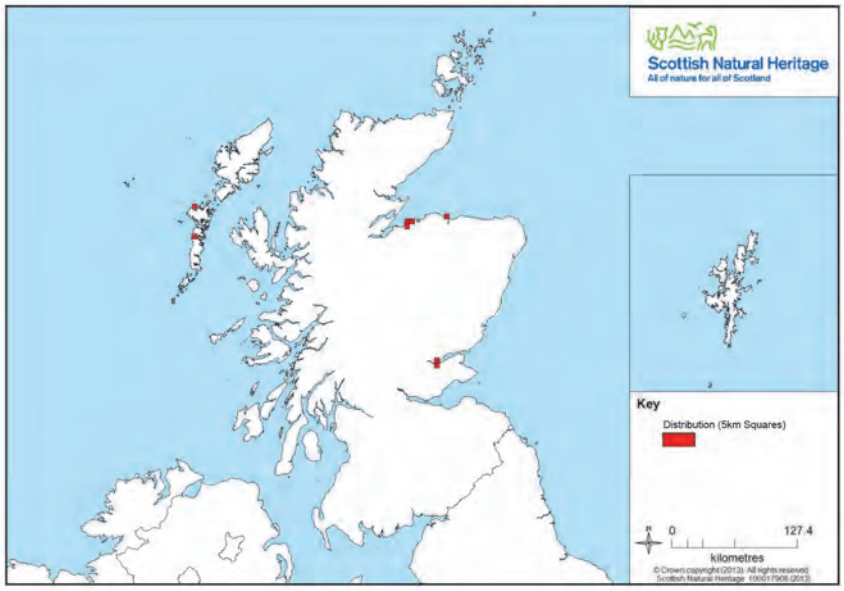


Figure 4-133: Distribution of freshwater S20.

S20 is a restricted community across Scotland and the brackish form is associated with estuarine systems and found in small areas on a limited number of west coast sites. The largest areas are recorded from the Tay Estuary. This community is dominated by *Schoenoplectus tabernaemontani* with few other associates present. The grey blue colour of the tall and erect plant shoots is quite conspicuous from a distance, and appear more rigid and colder in colour than areas of S21 (see Figure 4-134, Figure 4-135 and Figure 4-138).

Figure 4-134: Brackish S20 on the Tay Estuary (foreground).

Figure 4-135: Vegetation structure of S20.

S20 is found at the seaward edge of estuarine systems and rivers on the east and west coast and in small patches in the upper marsh transition zone on the west coast. The community is often replaced by S21 in similar situations in more saline waters, indicating that S20 is less tolerant of these conditions, or that the community is not able to compete with S21. S20 is a useful indicator of declining saline conditions and is found in a limited area of the Tay Estuary (near Newburgh). Both saline and non-saline swards are recorded with very few associates present. S20 is normally found in mosaic with other swamp communities such as S4 and S21.

4.10.7 S21 (Scirpus maritimus swamp)

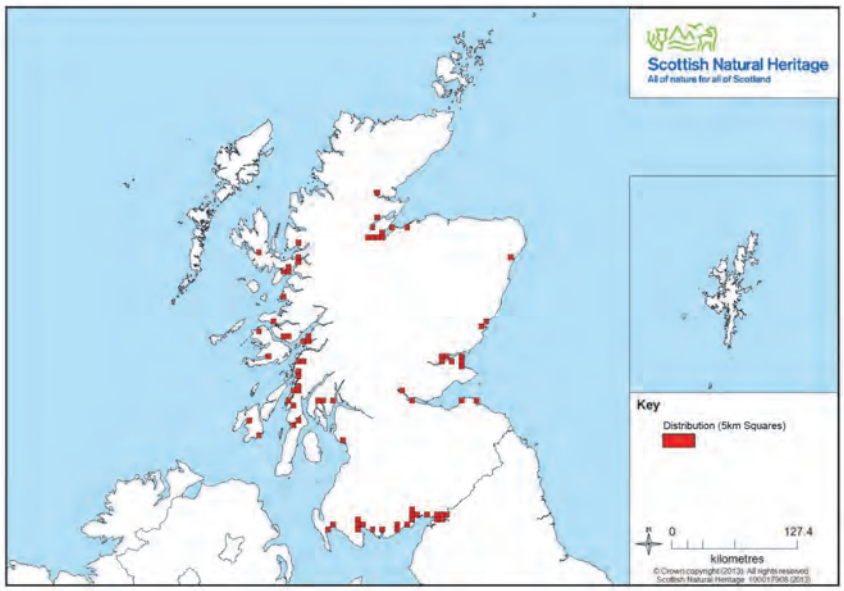


Figure 4-136: Distribution of brackish S21.

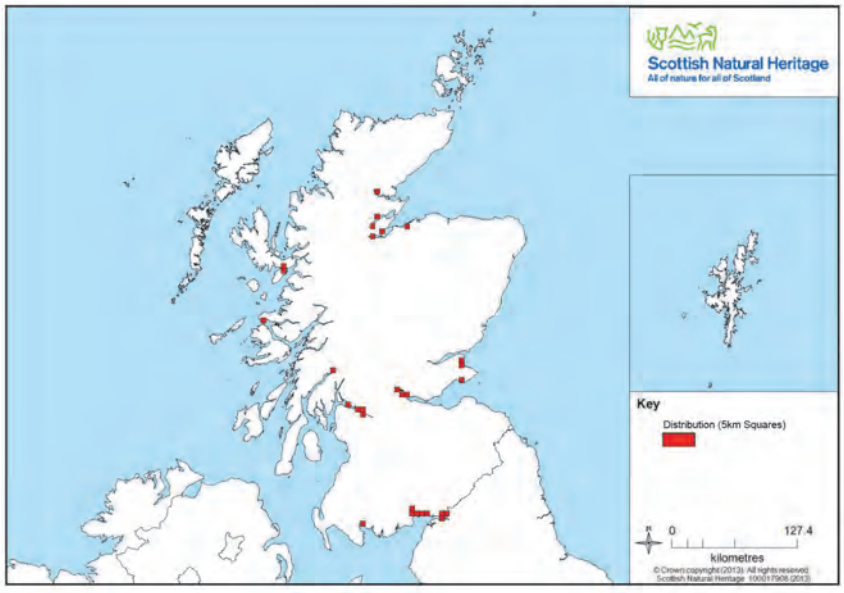


Figure 4-137: Distribution of freshwater S21.

S21 is a common and widespread swamp community on Scottish saltmarshes and is found through the majority of the saltmarsh range, but is lacking from the offshore islands.

S21 is often found in brackish situations but is also able to persist into more freshwater systems. The dominant species is *Bolboschoenus maritimus*, which is a vibrant green with a distinctive one sided flowering head. The straight-edged leaves spread equally in three directions often giving the community a distinctive look (see Figure 4-138), which is only easily mistaken from a distance for *Spartina* communities.

Figure 4-138: The distinctive formation of Bolboschoenus maritimus *in S21 vegetation.*

S21 rarely forms large and extensive areas like S4, but can form long narrow belts of marsh. S21 can also be found integrated into a complex mosaic in the upper saltmarsh zone, where the community can be regularly associated with SM16b, SM16c, SM16d and SM16e (see Figure 4-139). In other areas, S21 can also be associated with SM18 and can even be found in the middle marsh zone with SM13 sub-communities.

Figure 4-139: Mosaic forming areas of S21 in the upper marsh zone.

S21 is also found growing in pans, pools and creeks, normally in the upper limits of the saltmarsh, but has also been recorded from the seaward opening of creeks.

A variant of S21 is found in estuarine systems on deeper mud deposits where S21 forms a pioneer community and can be found fronting the main marsh sediment and also other brackish swamp vegetation (see Figure 4-140). Example sites include the Tay Estuary, Conon Islands and Tayport (Tay Estuary).

Figure 4-140: S21 acting as pioneer vegetation.

Associates are often very few with dense areas of *Bolboschoenus maritimus* present, but *Triglochin maritimum*, *Festuca rubra* and *Juncus gerardii* are sometimes present; these species are normally present due to their association with nearby communities.

As the saline content of the water decreases, S21 can be replaced at the seaward edge of river-fringing and estuarine marsh by S20. Other associates of S21 include S19 and SM20.

On some estuarine sites there are indications that S21 is actively competing with saltmarsh vegetation, with reduced saltmarsh reported from the Tay Estuary and an increase in the coverage of brackish swamp (Central Environmental Surveys 2003). The reasons for a change from saltmarsh habitat to brackish swamp in some areas is unknown but could be explained by changes in water current, sediment deposition, or the frequency of tidal inundation.

Areas of S21 are often simple to identify on aerial photography as they appear dark green through summer photography and a dark brown in winter.

4.10.8 S28 (Phalaris arundinacea tall-herb fen)

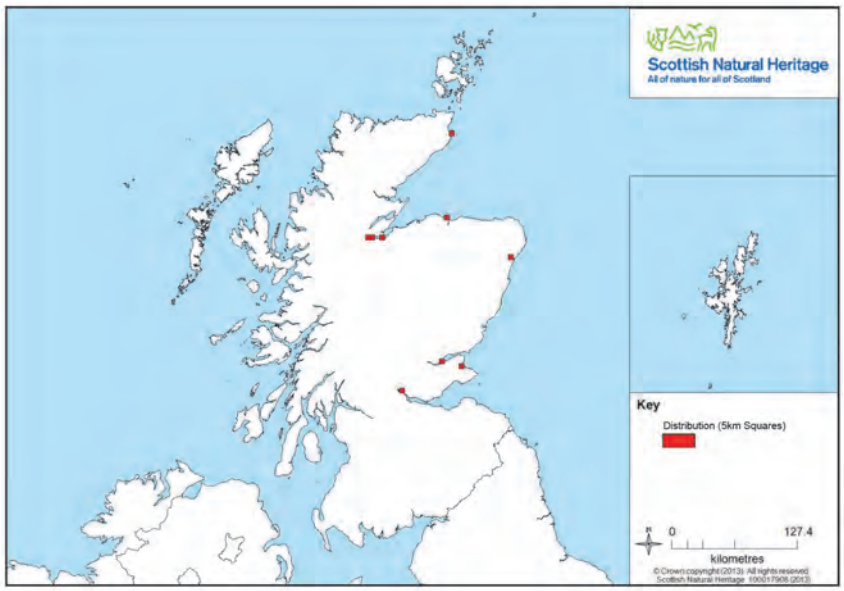


Figure 4-141: Distribution of brackish S28.

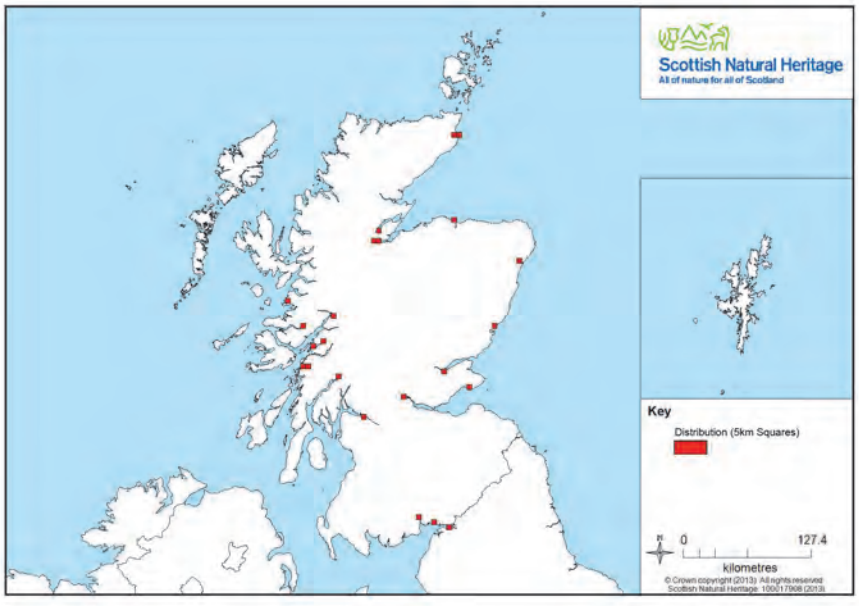


Figure 4-142: Distribution of freshwater S28.

S28 is not a community that is strongly associated with brackish conditions and is normally found at the limits of saline influence (along with S5). Areas of brackish S28 are usually identified by surrounding vegetation types (such as S21 and the brackish form of MG13). *Phalaris arundinacea* is the most abundant species but a variety of fen species can also be present.

4.10.9 Car rec (Carex recta dominated sedge community) and Car rec x Car aqu (Carex recta x aquatilis dominated sedge community)

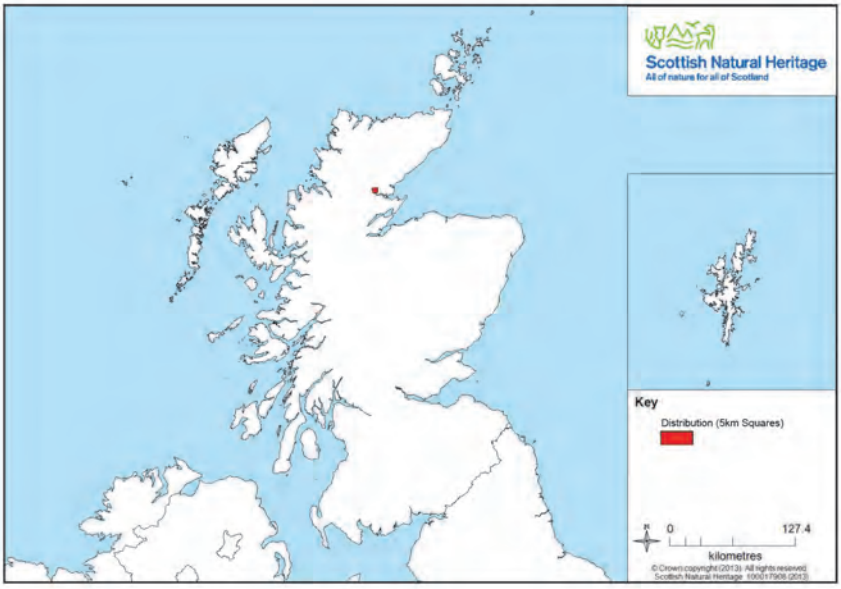


Figure 4-143: Distribution of Car rec.

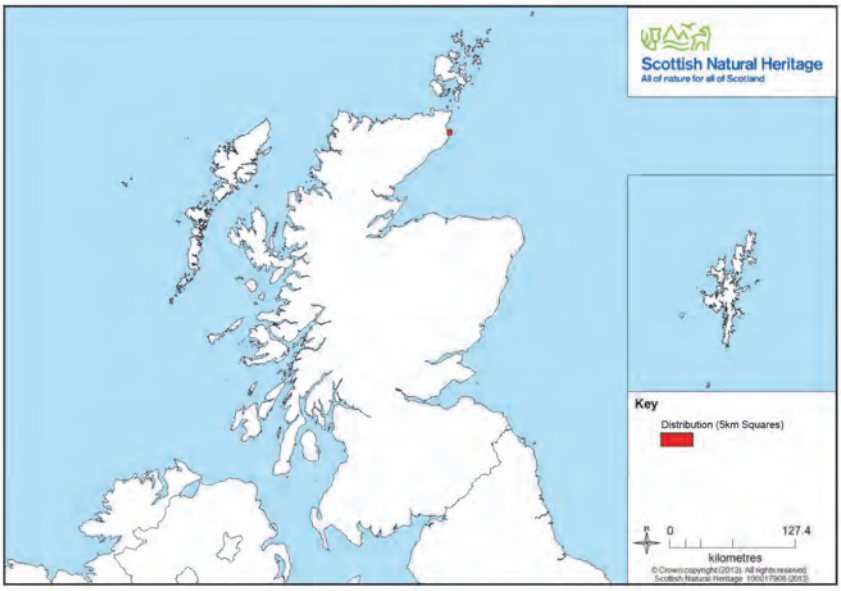


Figure 4-144: Distribution of Car rec x Car aqu.

These two rare and newly classified communities were created to take account of large stands of two rare sedges *Carex recta* and its hybrid *Carex recta* x *aquatilis*.

Car rec was recorded from Bonar Bridge (Dornoch Firth) where the community was found in mosaic with SM20. The community is easily overlooked as S21, but *Carex recta* is more slender and flowers less frequently. Associates include *Triglochin maritimum*, *Agrostis stolonifera* and *Bolboschoenus maritimus* (see Figure 4-145).

The hybrid community Car rec x Car aqu is found at the edges of the fringing marsh on the River Wick. This community includes pure stands of *Carex recta* x *aquatilis* which are found in association with brackish S20 (see Figure 4-146). Both of these hybrids are discussed in

detail by Dean & Ashton (2006) and their position within existing NVC classifications were detailed by the authors in 2010 (Dean & Ashton 2010). The authors cite complications with assigning community classifications at Wick and some of the species recorded from their samples of M27a fit the distinctive vegetation recorded from the SSS surveys nearby, which include SM16g (see 4.6.8) and SM16i (see 4.6.9). It should be noted that there are very few areas where these species are present to support the gathering of data on phytosociological trends.

Both of these communities are brackish in nature.

Figure 4-145: Carex recta *dominated sedge community at Bonar Bridge.*

Figure 4-146: Carex recta *x* aquatilis *dominated sedge community at River Wick.*

4.10.10 Car sal (Carex salina dominated sedge community)

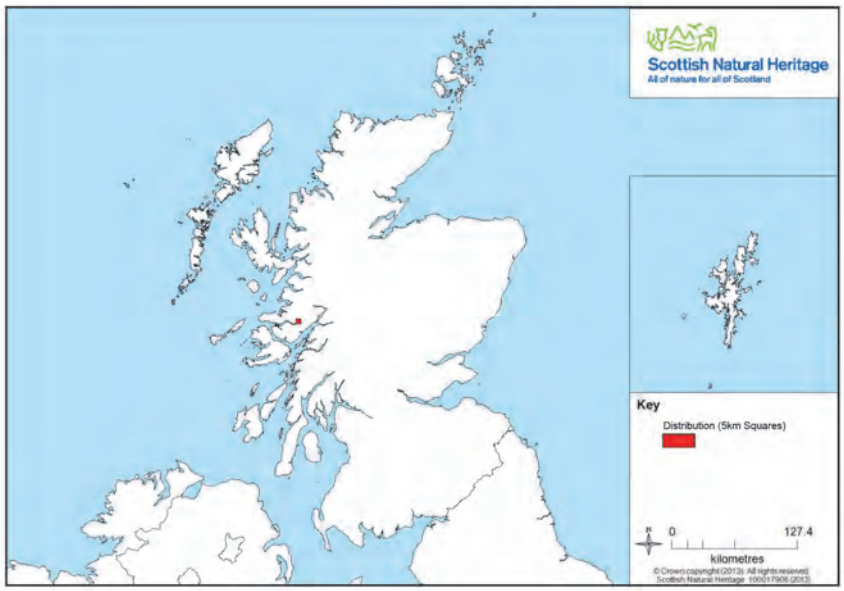


Figure 4-147: Distribution of Car sal.

This very restricted sedge species was previously recorded from only one site in the UK (Strath Croe at Loch Duich). As part of the SSS project the species has been found on further sites including Loch Sunart Head, Loch Nevis Head and Torrisdale Bay. Note that only one location is presented in Figure 4-147, as this was the only site where the species formed a mappable community type. Most stands of the species were too small to map and are instead target noted and discussed in the relevant site reports. Figure 4-148 includes a map of all records of the species from the SSS surveys.

Stands of Carex salina can occur in the mid-marsh zone, often in creeks and hollows; associated species include Puccinellia maritima, Glaux maritima, Plantago maritima, Triglochin maritimum and turf fucoids. Dense stands of the species were also recorded from Loch Sunart Head with few other associates present, which forms the community classified here (see Figure 4-149).

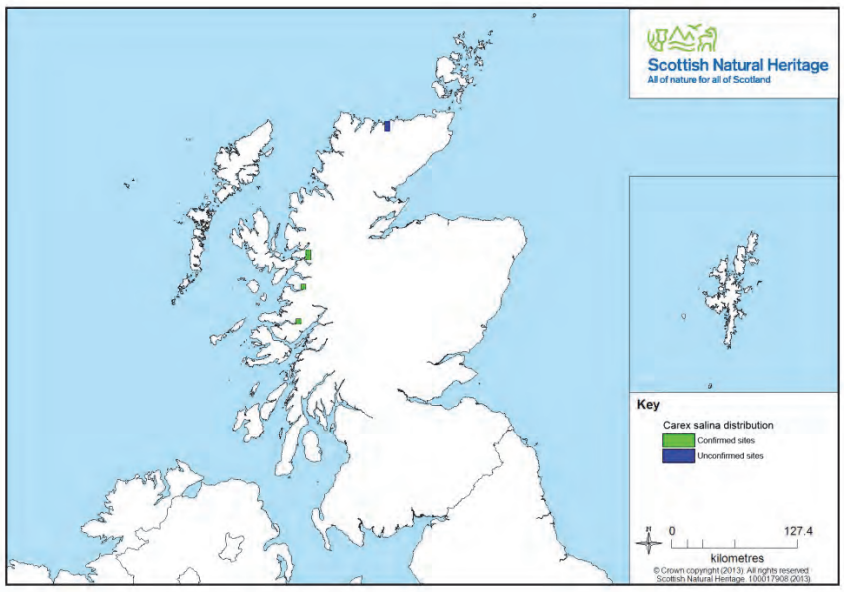


Figure 4-148: Distribution of Carex salina *records.*

Figure 4-149: Carex salina *community at Loch Sunart Head.*

Further swamp types were also mapped as part of the SSS Project and these are summarised in Table 3-1.

4.11 Other Habitat and land cover types

A range of other habitat types are also described at the boundaries and in association with saltmarsh habitat including mesotrophic grassland communities, various sand dune communities, swamp and mire communities. Table 3-1 provides a full list for the SSS which includes the remaining NVC types and land cover types detailed in site reports and in the GIS database. Further information on the invasive species communities found as part of the project is provided in 3.8.8.

5. CONCLUSION

All the project objectives outlined in 1.3 were met by the SSS Project with many of these outputs provided in the individual site reports and appendices.

5.1 Protecting Scottish saltmarshes

All of the saltmarsh sites that are over 100ha are under statutory protection which makes up the majority of the Scottish resource; equally all of the major back-barrier saltmarshes are under statutory protection. There is a disproportionate amount of larger saltmarshes under designation, even though the smaller marshes of the west coast and the offshore islands hold considerable biodiversity including restricted species and vegetation communities when compared to the larger saltmarshes of the Solway Firth and the east coast. In addition, the largest saltmarsh on the west coast, Loch Carron (82ha) but is undesignated. The SSSI series has some major gaps. For example, only 3 of the 34 saltmarshes surveyed in Skye & Lochalsh and Wester Ross have any statutory protection. Sea loch saltmarshes and saltmarshes that develop on shingle and stones are specialists of these parts of Scotland. In addition, many north-west coast saltmarshes include transitions to heath, mire and machair, which are valuable features to the SSSI series. It is recommended that the non-designated saltmarsh sites surveyed as part of this survey are appraised for statutory protection based on their nature conservation value.

5.2 Saltmarsh condition

The results of the saltmarsh condition assessment are discussed in 3.8.1. It is clear that there are a number of pressures on Scottish saltmarshes that can cause damage, and degradation. Links between the ability of saltmarshes to reduce wave action and the incidence of diverse and natural saltmarsh vegetation were identified in the UK National Ecosystem Assessment (Jones *et al.* 2011). Saltmarsh occupies a large area of the UK coastline (the second largest area of coastal habitat after sand dunes) with 13% of Great Britain's resource found in Scotland (Burd 1989).

Damage to saltmarshes from built structures and the modification of creeks and the creation of drainage ditches requires further investigation, as these structures are probably continuing to cause damage to saltmarsh habitat on many sites. Equally grazing and pollution need to be regulated and controlled across both designated and non-designated sites to ensure that these impacts are not causing saltmarsh to subside and erode. Invasive species also pose a serious threat in some areas e.g. *Spartina* in north Argyll. Grazing; pollution incidence; and the presence of invasive species are also important within Scotland's obligations under the WFD. Each of these pressures relates to the 'environmental status' of surface waters. The WFD requires that water bodies do not deteriorate in status and that each water body achieves at least 'good environmental status' by 2015 (SEPA 2007).

It is recommended that further controls be placed on the most significant pressures identified within the SCM surveys. The presence of built structures and the integrity of transitional areas require further management and policy controls. Grazing intensity also requires further management controls across many saltmarsh sites. The SCM surveys should also be further refined (see 5.5).

5.3 The validity of the published NVC for saltmarsh in Scotland

This was the requirement of Objective 3 and is discussed in detail in section 4. It is clear that the published saltmarsh NVC communities are a valuable tool for the identification of variability across saltmarshes. This variation is often consistent across regions and is found on many sites. There are instances where the NVC classification shows signs of being in need of revision. Recent expansions of non-native species alter the dynamics of vegetation

communities and are a significant issue for the whole NVC series. Outdated taxonomy is another issue for the entire series with a number of communities discussed within this report that no longer represent their current naming conventions. The key indicator of SM11 is no longer recognised taxonomically (*Aster tripolium* var. *discoideus,* a rayless form of the species*)* and is now considered as variant of the main species. This rayless form of *Aster tripolium* was not recorded as part of the SSS surveys (despite intensive surveys of locations where this form was previously recorded).

Some saltmarsh types recorded in the SSS show signs of being distinct from the published descriptions, such as SM13x, SM16x and SM16jb (all discussed in section 4). These include species combinations not identified within the published classifications. Proposals to refine the NVC types are identified in 5.6.5.

Some published sub-communities also lack a clear individual identity, with SM16c being the broadest sub-community, which was often used to classify transitional middle-upper marsh swards. Other types show a wide variability within a single sub-community, such as SM16b. SM28 also has a wide range of variants, and it is surprising that no sub-community structure exists for the community.

It is important to remember that the NVC classification system is used as a guide for assessing vegetation dynamics and should not be considered as a robust and rigid method of assessing changing conditions. Equally, NVC types should not be applied prescriptively to conservation management proposals. Such management proposals and policies should allow for natural variation between vegetation communities and sub-communities.

5.4 Saltmarsh Zones

The various saltmarsh zones were recorded in individual site reports and summary descriptions of each type are discussed in 3.4.2. The corresponding NVC types are also discussed in section 4. It is important to note that most saltmarshes in Scotland do include a lower, middle and upper marsh zone, but may have a variety of upper marsh vegetation integrated into each zone. When identifying saltmarsh zones it may be more appropriate to use saltmarsh morphology, informed by the presence of saltmarsh vegetation types, rather than an NVC correspondence approach for zone definition. It is possible to create a zone map with the data collected for this project, but a new set of criteria to define the zones would require development. Such a map would provide useful and simplified data compared to the NVC sub-community database, but is outside the scope of the current project.

5.5 Improvement to SCM surveys

The SCM process worked well throughout the course of the project, but only with detailed discussion about how best to approach the completion of the SCM forms. The forms were used as a means to guide professional judgement, and it is important that further guidance is provided with SCM documentation to ensure consistent assessments across monitoring cycles. SCM surveys should not be completed by inexperienced surveyors and it is important to consider the historical context of the changes observed on each site. If the forms are followed too rigidly, without consideration of historical changes, it is possible to fail most targets across most sites.

5.5.1 Atlantic Saltmarsh condition monitoring recommendations

The Atlantic saltmarsh condition monitoring forms were useful for cataloguing data throughout the SSS project, but it is important to separate historical impacts from those features that continue to have a negative impact on the site; for example, the emphasis on transition integrity could cause the majority of sites to fail this target, due to changes in land use landward of saltmarshes. The section regarding the presence of *Spartina* should be

changed to take account of any invasive species on the saltmarsh or to include a list of the most likely invasive species to be present.

There is duplication within the form regarding a target for transition integrity, which requires modification. It is also recommended to adjust how grazing is reported as some of the detail regarding grazing is indicated as 'non-mandatory', but provides very important information regarding the grazing regimes on many saltmarsh sites.

It is also recommended that a criterion be put in place for how many target failures are required before a site is concluded as in 'unfavourable condition'. A scored criterion approach could be weighted by the likely impact of each target attribute. It is important to note that a thorough process of final condition scoring is utilised by SNH Area teams and checked by habitat specialists and this recommendation would provide further information regarding the final scoring of each site.

5.5.2 Pioneer marsh condition monitoring recommendations

As discussed in 3.8.1, only a few sites failed targets for pioneer saltmarsh and most of these failures related to the presence of *Spartina* swards. Some failures were also related to changes in extent, which are often difficult to quantify due to the ephemeral nature of pioneer communities and because surveys use different mapping methodologies making comparisons between surveys statistically poor. A measure of extent is valuable and is more accurately assessed using aerial photography or a specific survey methodology for pioneer saltmarsh.

A larger extent of SM8 was previously recorded for the Solway Firth than found as part of the SSS survey. The few SM8 areas found also appeared much sparser than previously recorded (*Salicornia* plants were observed to be spread approx 50cm apart across the sand and mud flats). SM9 was also found less frequently on the Solway Firth than in previous surveys. Similar results are identified for the west coast where a number of sites previously recorded for SM8 showed no sign of the community. The offshore islands have a number of areas of pioneer marsh, which develop over rock and shingle.

Some of the targets identified for pioneer marsh are difficult to detect such as harvesting, and sites with sea defences often lack pioneer marsh, thus the pioneer section of the form is often not completed in these instances. It is recommended that the targets for pioneer marsh are reviewed to provide more robust data on the status of pioneer marsh. One recommendation is to provide information on the density of plants in such areas by using a set of scales or tick boxes (e.g. closely packed 0-1cm; Open, >1-10cm; or sparse >10-50cm), while also identifying some negative features (such as sea defences) and whether pioneer marsh is present or not. Another useful addition would be an assessment of the suitability of a site for pioneer marsh (e.g. are suitable mud/sand flats present for colonisation).

5.6 Further research recommendations

The project has highlighted a number of avenues for further investigation. These areas of further research have been discussed in this report and are summarised below:

5.6.1 Salicornia spp. *decline*

Pioneer saltmarsh is a key habitat type identified under the Habitats Directive, and may be considered as a zone for WFD monitoring. Indications of the zone's decline are significant, particularly across strongholds such as the Solway Firth. The variety of ecological processes that influence pioneer saltmarsh and where it can develop are complex and it would be a valuable exercise to investigate further rates of decline and the population dynamics of

pioneer communities across a number of years. There is a significant amount of data within individual site reports regarding pioneer marsh that is only summarised here and would be valuable to investigate further.

5.6.2 Saltmarsh erosion and accretion

The GIS aspect of the project was mapped over aerial photography from circa 2004. Significant data could be gathered about the rates of sediment accretion and erosion by analysing: historical photography; recent aerial photography; and remote sensing data. Such a project could provide valuable insights into sediment movement, which may have significant ecological influences over the wider saltmarsh including the abundance of upper marsh vegetation, increases in brackish swamp vegetation and the decline of pioneer marsh. Skinflats would be an interesting trial site due to the number of historical datasets and aerial imagery available.

5.6.3 Comprehensive mapping of saltmarshes using remote sensing data

The data collected as part of the SSS project could be used in conjunction with remote sensing data to ground-truth and survey areas of saltmarsh under the 3ha cap of the present survey and create a comprehensive map of all of Scotland's saltmarshes. Such an exercise may also be able to separate complicated saltmarsh mosaics at a scale finer than the 1:4,000 scale used in the SSS project. Lidar data could also provide additional information about erosion and accretion rates when used in conjunction with the SSS dataset.

5.6.4 Brackish swamp expansion and ecology

The expansion of brackish swamp merits further investigation, which could be performed using historical aerial photography and assessing previous photography of sites, while researching the ecology of the species. Methods of management also require further research.

5.6.5 Saltmarsh NVC Analysis

A large amount of vegetation quadrats were collected as part of the SSS project. A number of avenues of reclassification and review are suggested within section 4. It would be valuable to reassess the samples collected by all surveyors and compare them against the set of proposed sub-communities in section 4. Relationships with various sub-communities (particularly sub-communities of SM16) were noted through the course of the project and warrant further investigation. A thorough analysis of the vegetation samples collected and the construction of a revised set of NVC classification is possible using the SSS data in conjunction with the collected quadrat data.

5.6.6 Perched saltmarsh

It is likely that there is more perched saltmarsh present across Scotland than is currently recorded. The vegetation is strongly associated with the 'MC' classification and further research into the vegetation of maritime cliffs is required.

5.6.7 Integration of Coastal Shingle Project and SSS results

There is significant overlap between these two projects with shingle sites noted and mapped as part of the SSS project and saltmarsh vegetation recorded as part of the Coastal Shingle Project. A number of shingle forms of saltmarsh are also discussed in section 4. It is important that the results of both projects are integrated to gain further insight into these (often associated) habitats.

5.6.8 Assessment of the conservation value of the saltmarsh resource

A range of data and information is summarised within this report and discussed further in individual site reports. It is possible to undertake a study of the nature conservation value of saltmarshes in Scotland and how they contribute to the wider nature conservation value of Scotland.

5.6.9 Policy recommendations

The results of the saltmarsh SCM surveys need to inform management practices and policy across Scotland. A project focusing on policy options to improve the nature conservation and management of saltmarsh and brackish swamps including cost implications would prove valuable for SNH and SEPA.

5.6.10 Transitional vegetation

As discussed in 2.6.1, transitional vegetation, particularly fen vegetation was not mapped or assessed in the same detail as coastal grassland and swamp vegetation. It is clear that transitional vegetation is an important component of the upper limits of the saltmarsh and is often found in similar situations to driftline communities (i.e. in association with earth banks and saltmarsh borders). It is recommended that further research is undertaken on the transition zone. The SSS project results are a strong starting point for such a project as the target notes, image libraries and site reports provide a lot of information regarding transitional vegetation.

5.6.11 Saltmarsh Invertebrates

Saltmarshes are occupied by rare and restricted invertebrates groups. Records of sites with abundant invertebrates are target noted within individual site reports. It is recommended that further research be undertaken on saltmarsh invertebrate groups including identifying the distribution of protected species and investigating risks and negative impacts.

6. DATA SHARING

A significant amount of data was collected across Scotland within the SSS project. It is recommended that quadrat and target note data are shared with relevant recording organisations (such as the BSBI). It is also important that the GIS database is identified as a source of coastal mapping data in the various metadata schemes across the EU. Invasive species records should also be submitted to EU invasive species research groups such as DAISIE.

7. APPENDIX CONTENTS

Appendix 1 - SCM Database (2014): A full list of the sites where site condition monitoring was undertaken and the results of the SCM surveys including information about target failures. These figures were used to generate the results in 3.8.

Appendix 2 – Site Report Index (2014): This spreadsheet identifies all of the SSS and SCM reports referenced in this national report. Each site report includes appendices with GPS tracks, photos and NVC samples. These site files are too large to be included with this report and are available, on request, from SNH and SEPA.

8. REFERENCES

Berry, P. M., Harrison, P. A., Hossell, J. E., Riding, A. E., Viles, H. A., Brown, I., & Harford, C. 2001. Characterising the bioclimatic classification. In P. A. Harrison, P. M. Berry, & T. P. Dawson (Eds.), *Climate Change and Nature Conservation in Britain and Ireland* (pp. 23–41). Available at: http://www.eci.ox.ac.uk/research/biodiversity/downloads/MON1_Exec_Chapter1-3.pdf

Bhatti, N. 2010. *SEPA Salt-marsh Field Survey Method*, Stirling.

Boorman, L. 2003. *Saltmarsh Review: An overview of coastal saltmarshes, their dynamic and sensitivity characterstics for conservation and management. JNCC Report, No 334*, Peterborough.

Botanical Society of the British Isles. 2007. *Species Checklist*. BSBI. Available at: http://www.bsbi.org.uk/BSBI2007.xls

British Bryological Society. 2008. *Checklist of British and Irish bryophytes*. Available at: http://rbg-web2.rbge.org.uk/bbs/resources/downloads.htm

Burd, F. 1989. No.17: *The Saltmarsh Survey of Great Britain: An Inventory of British Saltmarshes*, Peterborough.

Cannell, M.G.R., Milne, R., Hargreaves, K.J., Brown, T.A.W., Cruickshank, M.M., Bradley, R.I., Spencer, T., Hope, D., Billett, M.F., Adger, W.N. & Subak, S. 1999. National Inventories of Terrestrial Carbon Sources and Sinks: The U.K. Experience. *Climatic Change*, 42(3), pp.505–530. Available at: http://dx.doi.org/10.1023/A:1005425807434.

Central Environmental Surveys. 2003. *Commissioned Report: Habitat Survey Inner Tay Estuary 2002*, Inverness.

Coppins, B. J. 2002. *Checklist of Lichens of Great Britain and Ireland*. London: British Lichen Society.

Dargie, T. 2000a. *Sand Dune Vegetation Survey of Scotland - National Report, Volume 1 (Main Report)*, Inverness.

Dargie, T. 2000b. *Sand Dune Vegetation Survey of Scotland - National Report, Volume 2 (An Atlas of Scottish Sand Dune Vegetation)*, Inverness.

Dargie, T. 2001. *Sand Dune Vegetation Survey of Scotland: East Coast. Volume 1: Main Report. Scottish Natural Heritage Research, Survey and Monitoring Report No.179 (Volume 1 of 3)*, Inverness.

Dean, M. & Ashton, P.A. 2006. A reassessment of the distribution of *Carex recta* Boott (Cyperaceae) in the British Isles. *Watsonia*, 39, 31–39.

Dean, M. & Ashton, P.A. 2010. Ecology, distribution and fertility of *Carex recta* Boott (Cyperaceae) in the British Isles. *Watsonia*, 42, 33–42.

Environment Agency. 2007. *Operational Instructions WFD Saltmarsh Monitoring*, London. ESRI. 2013. ArcGIS v10.

European Commission. 1992. *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora*, Brussels.

European Commission. 2000. *Directive 2000(60)EEC of the European Parliament and of the Council of 23 October 2000 establishing a framework form community action in the field of water policy*, Brussels.

Evans, D. & Arvela, M. 2011. *Assessment and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidlines for the period 2007-2012*, Brussels.

Hardy, G. & Guiry, M. D. 2006. *A Check-list and Atlas of the Seaweeds of Britain and Ireland* (2nd ed.). British Phycological Society.

Haynes, T. & Beal, S. 2014. *Condition monitoring of saltmarsh features in the Wash & North Norfolk Coast SAC: Volume 2 The North Norfolk Coast. Final Report*. Natural England.

Houwing, E-J., van Duin, W.E., Smit-van der Waaij, Y., Dijkema, K.S. & Terwindt, J.H.J. 1999. Biological and abiotic factors influencing the settlement and survival of Salicornia dolichostachya in the intertidal pioneer zone. *Mangroves and Salt Marshes*, 3(4),197–206. Available at: http://dx.doi.org/10.1023/A:1009919008313.

Hutcheon Brothers. 2000. *Coastal Site Conditon Monitoring (Cycle 1)*. Unpublished report to Scottish Natural Heritage, Inverness.

Jefferies, R.L., Davy, A.J. & Rudmik, T. 1981. Population biology of the salt marsh annual *Salicornia europaea* agg. *Journal of Ecology*, 69, 17–31.

JNCC. 2010. *Handbook for Phase 1 habitat survey - a technique for environmental audit*, JNCC.

JNCC. 2012. *1310* Salicornia *and other annuals colonising mud and sand*. Available at: http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H1310.

JNCC. 2013. *1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)*. Available at: http://jncc.defra.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=H1330.

Jones, L., Angus, S., Cooper, A., Doody, P., Everard, M., Garbutt, A., Gilchrist, P., Hansom, J., Nicholls, R., Pye, K., Ravenscroft, N., Rees, S., Rhind, P. & Whitehouse, P. 2011. *Coastal Margins: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment*, Cambridge.

Kirkham, F. 2006. *The potential effects of nutrient enrichment in semi-natural lowland grasslands through mixed grazing or supplementary feeding. Scottish Natural Heritage Commissioned Report No. 192 (ROAME No. F04AA101/2)*, Inverness.

Law, D. & Gilbert, D. 1986. *Saltmarsh survey - NW Scotland: the Western Isles*. Unpublished report to Nature Conservancy Council, Inverness.

Maddock, A. 2011. *UK Biodiversity Action Plan Priority Habitat Descriptions*, Available at: http://jncc.defra.gov.uk/_ukbap/UKBAP_BAPHabitats-49-SeagrassBeds.doc

Map Maker Ltd. 2013. Map Maker Desktop Mapping v3.5.

Payne, R. 2013. *Site Condition Monitoring Report: Luskentyre Banks and Saltings SSSI*, Inverness: Scottish Natural Heritage.

Pendleton, L., Donato, D. C., Murray, B. C., Crooks, S., Jenkins, W. A., Sifleet, Craft, C., Fourqurean, J.W., Kauffman, J.B., Marbà, N., Megonigal, P., Pidgeon, E., Herr, D., Gordon, D. & Baldera, A. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. *PloS One*, 7(9), e43542. doi:10.1371/journal.pone.0043542

Pitney Bowes. 2009. Mapinfo Professional V.10.

Pitney Bowes. 2011. Mapinfo Professional V.11.

Posford Duvivier Environment. 1998. *Distribution of coastal habitats in Scotland*. Unpublished report to SNH Maritime Group. Contract No. BAT/97/98/11.

Pretek. 2013. RoboGEO georeference photo software.

Rodwell, J.S. 1991a. *British Plant Communities Vol. 1: Woodlands and Scrub*, Cambridge University Press.

Rodwell, J.S. 1991b*. British Plant Communities; Volume 2: Mires and Heaths*, Cambridge University Press.

Rodwell, J.S. 1992. *British Plant Communities: Volume 3: Grassland and Montane Communities*, Cambridge University Press.

Rodwell, J.S. 1995. *British Plant Communities: Volume 4: Aquatic Communities, Swamps and Tall-Herb Fens*, Cambridge University Press.

Rodwell, J.S. 2000. *British Plant Communities: Volume 5: Maritime Communities and Vegetation of Open Habitats*: Vol 5 Rodwell, ed., Cambridge University Press.

Rodwell, J.S. 2006. *National Vegetation Classification: Users' handbook*.

Salafsky, N., Salzer, D., Stattersfield, A. J., Hilton-Taylor, C., Neugarten, R., Butchart, S. H. M., Wilkie, D. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. *Conservation Biology: The Journal of the Society for Conservation Biology*, 22(4), 897–911. doi:10.1111/j.1523-1739.2008.00937.x

SEPA. 2007. *Scotland's WFD aquatic monitoring strategy*, Stirling.

SNH. 2009. *Point Data Set of Saltmarsh Locations and areas*. Unpublished.

SNH. 2010. *SCM guidance for supralittoral sediment: Saltmarsh*, Inverness.

Spot LLC. 2013. Spot Satellite GPS Messenger.

www.snh.gov.uk

ISBN: 978-1-78391-184-4

Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

You can download a copy of this publication from the SNH website.

recycle

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad