

6 Survey and monitoring of saltmarshes

6.1 Introduction

An essential component of the development of a management scheme to address saltmarsh loss, improve coastal defence value and/or enhance ecological status is to monitor the state of the physical and biological systems. A suitable monitoring strategy, therefore, needs to document and, where possible, quantify the physical and biological change associated with a scheme to refine predictions and to determine the need for any further management measures. Any monitoring strategy should incorporate sound data management, including (at a minimum) metadata (i.e. information) about the data gathered.

Crucially, the monitoring strategy needs to be sufficiently focused to ensure that useful results are derived. Therefore, the selection (and level of detail) of the parameters to be monitored should relate, as closely as possible, to the objectives for which the scheme was developed (e.g. if for ecological purposes, then the monitoring should provide detailed and objective measures of biological parameters and sufficient physical parameters to help explain any changes). The CIRIA Managed Realignment guide (Leggett *et al.*, 2004) includes some useful information on monitoring techniques for physical parameters in saltmarsh environments and the CIRIA guide on *Maximising the use and exchange of coastal data* (Millard & Sayers, 2000) provides sound guidance on data management issues.



Monitoring Blakeney, North Norfolk Site © Royal Haskoning

Whatever monitoring techniques are adopted, it is important to remember that saltmarshes are dynamic systems. It should be understood that change can be natural and, in many cases, is an essential feature of the habitat and how it functions. As discussed throughout this manual, factors influencing change include:

- Sediment availability (size and quantity);
- Sea level (absolute and relative changes);
- Tidal range and water levels (magnitude and frequency and in relation to saltmarsh level);
- Wave climate (magnitude and frequency);
- Location;
- Ecological processes (e.g. succession and colonisation);
- Human action (e.g. enclosure, grazing);
- Grazing (natural such as geese); and
- Pollution and pollutants (impacting upon and stored by the saltmarsh).

Measuring change (e.g. knowing that a saltmarsh is eroding or accreting or that a species is disappearing), however, does not of itself provide the knowledge necessary to determine policy or agree management action. For example although sea level rise may be occurring in a location with saltmarsh loss, the saltmarsh may actually be responding to (adapting and keeping pace with) sea level rise and the loss related to vegetation die-back. Many other factors are likely to have an influence. Tides and tidal range, sediment availability and the nature of the coast all influence the development of saltmarsh. Local weather conditions, including rainfall, discharge rates of rivers and the state of the tide, also contribute to the pressure put on saltmarsh stability; and erosion rates will depend on the strength of the feature being affected by the erosive force. In addition, changes in sea level *per se* (eustacy) are the result of global forces associated with the atmospheric temperature, whether due to human influences or not. Where the land level is stable or sinking (isostacy) the coast will be inundated. Given all of these factors, it may be difficult to determine the precise reasons for the loss of saltmarsh without expert guidance.

Despite this, the fact remains that in some areas (especially south east England) the overall area of saltmarsh is diminishing and, as a consequence, coastal defences are being undermined and land threatened with flooding. The measurement of change in saltmarsh, therefore, can provide a very powerful indication that an adverse effect is occurring, which needs to be addressed.

6.2 Habitat survey

To assess the significance of a particular feature or resource it is essential to know:

- where it is located;
- how wide spread it is;
- how much of it there is; and
- its quality.

Habitat surveys are a basic tool used to assess the value of particular coastal features (such as saltmarsh). They also help to provide:

- the basis for the selection of important conservation areas;
- an assessment of the need for conservation protection;
- a means of record change (in assemblages); and
- a basis of information to assist management decisions.

In the context of monitoring, however, this information is 'passive', as it is concerned with the existing location, scale and nature of the resource (as well as the characteristics of any prevailing activities). Taken on its own, it tells us little about change or the potential causes of change. To establish the status of the habitat and whether intervention is required, by way of protection and or management, information is also needed to establish, amongst other things:

- the extent of any loss due to human activity;
- whether the resource is eroding / accreting;
- whether the resource is suffering die-back;
- the efficacy of protective legislation; and
- the efficacy of management action.

To achieve this repeat surveys are needed. These may be considered as part of a suite of more 'active' approaches to surveillance or monitoring designed to measure change resulting from deliberate actions against a predetermined, desired outcome. Active approaches can be summarised under four headings (relevant definitions are provided in Box 6.1):

- **Monitoring** to help identify and assess impacts, determine action and give feedback on management effectiveness.
- **Surveillance** to identify unforeseen change and, where appropriate, ensure compliance with agreed legislative or other control mechanisms.
- **Prediction** to consider the possible outcome of policy decisions proposed by way of response to an unforeseen incident (e.g. oil pollution) or natural/man induced event (e.g. a storm or sea level rise).
- **Assessment** of the effectiveness of action (management). This is the final stage and allows us to learn from good and bad practice and feed across to other managers.

The methodologies adopted, for the most part, will be the same. It is the level of detail and frequency that might vary and, importantly, the interpretation that is put upon the information which will convert into knowledge. The knowledge gained is crucial to determining how effective management actions are and, hence, in promoting better decision making. The following section provides some specific guidance on survey, monitoring and surveillance methodologies for saltmarshes.

Box 6.1	Definitions
	<p><i>Survey</i> Surveying involves the collection of both quantitative and qualitative information about a feature or features using a standardised methodology, but where there is no pre-formed view on the likely findings. Thus, other than identifying what will be surveyed (a species, plant community, habitat or human activity), the primary aim is to obtain data and information on the nature, scale and location of the chosen subject.</p>
	<p><i>Surveillance</i> Repeat surveys provide a means of identifying change over time, for example, in the status of habitats and species or the rate of exploitation of a natural resource. As with the original survey there is no predetermined notion as to what change might be expected and, hence, such surveys should cover areas where current problems do and do not exist. The purpose of the new survey is to establish the nature of any change from the previous 'norm' and provide early warning of change.</p>
	<p><i>Monitoring</i> This implies the need to assess and understand the outcome of a particular course of action, such as the management of a habitat or species or the extent to which resource depletion is sustainable. This may relate to compliance with a standard or deviation from an acceptable state. Monitoring may be quite widespread (e.g. a whole estuary) but should be in proportion to the scale of management action and its potential impacts. Monitoring is often a specific requirement of the consents and licences needed for a management scheme.</p>

6.3 Measuring change

The first step in a measurement campaign (whether as survey, monitoring or surveillance) is usually a desk study to determine what data and information exists already. This should allow, amongst other things, an overview to be made of the regional and local coastal processes and sediment budgets, as well as local habitat changes, and provides a baseline for the local situation against which future change can be compared. Sources of existing information include literature, historic maps and charts, geological maps, aerial photographs and satellite imagery.

The sections that follow provide an indication of appropriate methodologies/available techniques for determining change at different geographical scales.

6.3.1 Satellites as a means of monitoring saltmarsh change

Relatively detailed, ground-based surveys (such as those undertaken by Burd, 1989; Hemphill & Whittle, 2002; Stark et al., 2002) provide the necessary information to establish change in saltmarsh. Changes may be quite small (a few mm change in level) but, nonetheless, significant. However, such survey is resource intensive and expensive to undertake on a regional scale. Remote sensing can provide the opportunity for more frequent observations, albeit at a coarser scale and to determine longer term changes (decadal).

Satellites (currently under-utilised as a source of information on change in coastal habitats) can cover large areas and record cumulative and significant effects (potentially over a period of weeks). However, they are less useful for measuring more rapid or small-scale change. Until recently, a further impediment was the very coarse scale of resolution that could be obtained (of ten to twenty metres, which limited the level of detail

available), but recent improvements in periodicity and resolution has reduced this (in some cases to about a metre) and thus, at a strategic level, the need for more traditional forms of spatial survey might be reduced. However, for this to be achieved there must be a clear relationship established between the satellite imagery and the situation 'on the ground'. This rectification is achieved by comparison with direct land measurements. In some cases this is needed on an image-by-image basis and so can be less attractive (as the ground survey is needed anyway), however, the larger the area to be covered and the greater the frequency between surveys the more attractive this approach becomes.

The European Space Agency and the EC through the European Environment Agency are currently developing a maritime information system devoted to integrating Earth Observation data into policy and decision-making in the coastal zone (see CoastWatch, which forms one part of a the European Global Monitoring for Environment and Security initiative <http://www.coastwatch.info/cw/index.php>). It is not clear if this will be developed as a separate initiative or as part of a wider marine information system. However, it could provide a useful source of information at national/regional scales and may be especially valuable in determining the overall status of the saltmarsh resource.

6.3.2 Other remote sensing techniques

The Environment Agency has demonstrated the use of remotely sensed data to map habitats in the coastal environment, particularly in the intertidal zone. These techniques are capable of distinguishing saltmarsh, algae and bare mud, in addition to water and terrestrial vegetation. Thus the general extent of saltmarsh can be mapped using this method. The method employed involves the use of Light Detection and Ranging (LIDAR); an airborne mapping technique which uses a laser to measure the distance between the aircraft and the ground. The technique, used in conjunction with other remote sensing instruments, results in the production of cost-effective terrain maps, which are used to measure land topography and can be used to assess coastal erosion and geomorphology. (The information can also be used to define or characterise land to be set aside for managed realignment). The combination of a terrain map and vegetation coverage (supplemented with habitat survey) can be used to determine if vegetation is at the right niche level in relation to the tidal frame and be used to indicate the way the saltmarsh at a location is functioning.

The Environment Agency has also generated routines to allow for the removal of surface features from the data sets, including vegetation, such that it may be possible to measure gross change in saltmarsh surface levels using successive surveys. Successful measurement of erosion or accretion helps to identify areas that show a net decrease in the area of saltmarsh. It also provides a means of assessing the effectiveness and long term evolution of those areas currently subject to management, particularly where re-creating or restoring saltmarsh is a key component.

Ground-based measurements of saltmarsh vegetation reflectance, using a portable spectroradiometer, can also be used in combination with remote sensing data to inform saltmarsh management (through the provision of a spectral signature), for example, in relation to grazed and non-grazed saltmarshes. This approach can also, with expert interpretation, distinguish different (assemblages of) vegetation, although again ground truthing is probably required. This technique may, however, be particularly valuable

where patterns are not easily visible at ground level or when disturbance to ground-nesting birds should be avoided.



Combined LIDAR and bathymetric survey of the Lymington saltmarsh / mudflat system
© New Forest District Council (elevation data provided by Infoterra)

In March 2000 a three year project entitled *Collaborative Agreement for developing remote sensing techniques for marine SAC monitoring* was initiated between English Nature and the Environment Agency's National Centre for Environmental Data and Surveillance (NCEDS). Three main areas of study were identified that are critical for the use of remote sensing in habitat monitoring: Data preparation and accuracy, Image classification and habitat mapping, and Morphological change. The full report can be downloaded at: www.english-nature.org.uk/pubs/publication/PDF/552R.pdf.

6.3.3 Saltmarsh morphology

Three key morphological attributes of saltmarshes provide a means of detailing both the existing nature of the habitat and the development of new habitat (e.g. as a result of managed realignment). These are:

- Extent - marsh area measured at low water.
- Creek density - measured as creek order and via cross sections.
- Topography - measured as surface elevation.

The extent, creek attributes and surface elevations (although the latter to +/- 0.1m only) of saltmarsh may be measured using remotely sensed data (as discussed above). Aerial reconnaissance, currently undertaken by the Environment Agency and local authorities in eastern and southern England, is a suitable technique for quantifying the extent of habitat and changes in habitat areas. Aerial survey has several advantages over other methodologies, including the existence of long-term archives for many areas. It is also a

well established technique and offers the ability to determine surface elevations. Other methods, including CASI (Compact Airborne Spectral Imaging) and LIDAR, offer individual advantages but not the range offered by aerial survey (where CASI will show vegetation cover but does not provide information on levels). The Environment Agency has in the recent past employed a five year rolling programme of aerial survey of coastal areas, with subsequent analysis of the photographs (although coverage may be variable in the future).

Aerial photos (particularly with forward motion compensation) may also be used to determine topography using photogrammetric techniques, although the level accuracy is only suitable for long-term changes or large magnitudes of change (suggested at over 0.1m vertically). Surface elevations of saltmarshes are more accurately surveyed using conventional ground survey techniques and these are currently measured within programmes such as the first Regional Strategic Monitoring Programme established by the Environment Agency's Anglian Region in 1990. This programme includes profiles, extending across saltmarshes where they occur. The programme covers both the open coast (bi-annually) and estuaries landward of the Coast Protection Act (1949) Schedule IV boundaries (on a five-year rolling programme). Within estuaries, bathymetric surveys (which may be undertaken by the Harbour Authority or the Environment Agency) usually incorporate the 'shoreline topography'. The resolution of bathymetric data is not comparable with the ground survey but does provide an indication of the whole estuary and how the system might be changing.

The combination of different methods of survey, monitoring or surveillance should be undertaken with great care and understanding of the differences in accuracy, resolution and the assumptions made.

6.3.4 Vegetation

Systematic surveys of landscapes, habitats and species are a first stage in understanding the biology/ecology of a saltmarsh. Scale is a key consideration when undertaking such surveys. Wide-scale saltmarsh survey, based on an assessment of existing survey data supplemented with field work to cover unsurveyed areas, was used to describe the resource in Great Britain in the mid to late 1980's (Burd, 1989). This information was also used to aid the selection of sites for statutory protection. Attempts have also been made to bring information together at a wider European scale (Dijkema, 1984). Though this study was hampered by the variety of definitions and survey methodologies adopted across Europe, it did provide a broad indication of the nature, scale and importance of the resource.

These studies provide a broad understanding of the distribution, scale and quality of the saltmarsh resource, as well as an indication of some of the issues affecting it. However, they do not tell us anything about change or the causes of change. For this, a series of comparable data are required. In some locations there has been a repeat using the same techniques as the Saltmarsh Survey of Great Britain and some work to quantify change (such as in the Wash) for English Nature.

Saltmarsh zonation and transitions are key elements in assessing and monitoring marsh vegetation. Identifying these elements often requires detailed site surveys timed to occur

at particular times of the year. A summary of the relevant communities used in surveys to classify saltmarsh in Great Britain is provided in Appendix A2. Classifications of vegetation can be used to broadly define the different intensities of survey applicable (as they define the variability in the vegetation assemblages) and indicate variability on a widespread geographical basis. The level of classification used must be that most appropriate to the issue for which the information is required. The field survey methodology developed for the National Vegetation Classification (NVC) is typically the most appropriate for the majority of surveys that aim to provide a detailed vegetation map and identify broad changes over time. Details of this can be found in Rodwell (2000).

6.3.5 Species specific studies

Habitats and vegetation patterns are not the only features that require monitoring. Some species have special significance either because of their rarity, special habitat requirements or economic significance. Three elements (Keddy, 1991) can be discerned when monitoring individual species:

- A species is rare or of special interest and managed to protect the population. Monitoring is undertaken to determine if we being successful.
- The species is invasive (and undesirable) and we need to assess if our control measures are effective.
- The species provides an indicator of change in the environment.

The expansion of *Spartina anglica* into many saltmarshes throughout the temperate regions of the world is a particularly important issue for saltmarsh and estuarine conservation. Studying this species should be relatively easy, as it occurs as an extensive monoculture in most of the areas where it has invaded. Airborne mapping would be particularly suitable for monitoring the spread of this species.

Establishing the location and population numbers of species, e.g. birds (especially breeding birds) or invertebrates, is also an essential prerequisite when seeking to establish the ecological value of a saltmarsh. It is important to know where the majority of a population of a species of conservation or commercial significance resides during critical periods of its life cycle. In saltmarshes, many species rely on a particular place in the marsh zonation (e.g. oystercatchers nest above the mean high water mark, where their nests are less likely to be flooded). Other species rely on the nature of the vegetation (e.g. a close-cropped sward is essential for grazing by the sometimes large and significant populations of winter ducks and geese). Several shore bug species (e.g. *Saldidae*, ground dwelling predators) live in different parts of the marsh. *Saldula pilosella* lives at the margins of sheltered pools on the upper shore, *Saldula littoralis* in dense vegetation and *Saldula palustris* occurs on more open sandy/muddy areas, extending further down the marsh than the other species (Kirby, 1992). Other invertebrates may rely on a single plant species for their survival and in some cases different parts of a single plant. Monitoring these species requires specialists in the monitoring techniques for each species or group of species (such as insects or birds).

6.4 Indicators for policy response and management action

6.4.1 Introduction

The importance of saltmarshes to the economic and social fabric of society broadens the need for monitoring, encompassing both the environmental and (socio-) economic issues. Linking these into an assessment of the effectiveness of policy and action, add another dimension to the complexity of a monitoring programme.

Information on future trends in the state of the environment, as well as prospects for socio-economic and sectoral interests, are crucial for determining progress against policy targets and to ascertain, amongst other things:

- Whether current policy measures can be expected to deliver the required improvements, taking into account trends in external factors.
- Whether additional policies might be considered to be necessary to achieve the expected improvements.
- Whether new policy needs are likely to emerge in unmonitored areas.

Developing indicators as an integral part of a strategy for policy formulation is a common approach. Using a variety of techniques, involving existing information and new data derived from remotely sensed sources and traditional survey, monitoring and research, it is possible to establish an integrated approach to saltmarsh management which matches the needs of the coastal zone generally and saltmarshes in particular. For example, we should be able to measure saltmarsh change, relate this to sea level rise and provide a means of assessing different options for sea defence according to economic and social criteria.

6.4.2 Common standards monitoring (CSM) for statutory sites

One of the special functions of the three country agencies (Countryside Council for Wales, English Nature and Scottish Natural Heritage) is the establishment of common standards throughout Great Britain for monitoring nature conservation and, particularly, the 'condition' of designated sites. The standards have been developed by these agencies together with the Environment and Heritage Service in Northern Ireland and have been agreed by the Joint Nature Conservation Committee (JNCC). The standards apply to statutory sites designated as Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific Interest (ASSIs). They also apply to areas designated as part of the Natura 2000 series (Special Protection Areas (SPAs) under the EC Birds Directive and Special Areas of Conservation (SACs) under the EC Habitats Directive), together with Ramsar sites designated under the Convention on Wetlands of International Importance.



Little Egret, *Egretta garzetta*, © Chris Gibson, English Nature

The nature conservation component which is assessed under CSM is not the site itself, but the feature (e.g. specific species and/or habitat) for which the site was designated; and sites may have more than one interest feature. Under CSM, 'conservation objectives' are set for each feature. Key Attributes of the feature (e.g. extent, quality, supporting processes) are identified and broad targets set for each. Monitoring is then carried out to assess the state of these attributes, and an assessment made on the condition of the feature as a whole.

Attributes and targets

For saltmarsh habitats, five mandatory attributes have been defined (see Box 6.2). The targets are for guidance only and should be interpreted in terms of local knowledge of the site, its history and its surroundings. When a target is not applicable to a particular site it should be excluded, but a record of why the decision was taken should be made (JNCC, 2004).

The presence of notable species (vascular plants) or other important features, e.g. transitions to other habitats, are considered to be discretionary attributes (i.e. indicators of local distinctiveness). It will not be appropriate to use these 'quality indicators' on every saltmarsh site, but where they are part of the reason for notification of the site they should form an integral part of any condition assessment.

Judging the condition of sites

The condition of the feature of interest is assessed against the categories listed in Box 6.3.

Box 6.2 List of mandatory attributes and associated favourable condition targets for saltmarsh	
Attribute	Target (examples)
Habitat extent (including the effects of sea level change)	No decrease in extent from established baseline (subject to natural change)
Physical structure (creeks and pans)	No further anthropogenic alteration of creek patterns or loss of pans compared to an established baseline
Vegetation structure (zonation and sward structure)	Site specific targets should be set according to conservation objectives or the management plan Maintain site-specific structural diversity
Vegetation composition (characteristic species or indicators of negative trends (e.g. the presence of invasive <i>Spartina</i>))	Maintain the frequency of characteristic species of saltmarsh zones (see Box 1 section 14 of JNCC (2004) report)
Other negative indicators	No obvious signs of pollution Turf cutting absent or rare

Further information is provided on the JNCC website:

http://www.jncc.gov.uk/csm/guidance/PDFs/CSM_coastal_saltmarsh.pdf

Methods of assessment

The condition of the site or feature of interest is assessed using a variety of methods which should be applied to the reporting unit, which may be a SSSI site unit or SAC. The reader is referred to the JNCC (2004) document for further guidance on suitable assessment methods.

6.4.3 Managed realignment

'Saltmarsh squeeze' (loss of habitat resulting from enclosure and erosion caused by sea level rise and/or other factors, see Section 4.2.3) has occurred in many coastal and estuarine areas, especially in south east England. Reversing this process through the Managed Realignment of flood defences is an increasingly common option for recreating saltmarsh and forms one of the generic options of any flood management strategy. Monitoring the effectiveness of such realignment is important in helping to determine the success of such schemes and can contribute to wider knowledge to help shape the policy on how far, and over what scale (temporal and spatial), this approach to management should be applied.

A summary of a detailed monitoring approach applied at a single site, by way of an example, is provided below:

1. Vegetation survey (based on the NVC classification and survey methodology) over the whole site following inundation, repeated over increasingly long time periods.

2. Establish permanent quadrats for more detailed species (plants and animals) monitoring and consider how surrounding local change might be determined (for background levels of change).
3. Establish frequency of site topographic survey and (within the area and, if appropriate at a control location) permanent locations for measuring sediment accretion and erosion.
4. Establish 'nested' quadrats for more detailed assessment of vegetation change (after Hodgson *et al.*, 1994).
5. As necessary, investigate the factors affecting saltmarsh stability (e.g. pollution, tidal scour, grazing by herbivores).

Box 6.3 List of mandatory attributes and associated favourable condition targets for saltmarsh	
Favourable - Maintained	An interest feature should be recorded as <i>maintained</i> when its conservation objectives were being met at the previous assessment and are still being met.
Favourable - recovered	An interest feature can be recorded as having <i>recovered</i> if it has regained favourable condition, having been recorded as unfavourable on the previous assessment
Unfavourable - recovering	An interest feature can be recorded as <i>recovering</i> , after damage, if it has begun to show or is continuing to show a trend towards favourable condition
Unfavourable - no change	An interest feature may be retained in a more-or-less steady state by repeated or continuing damage; it is unfavourable but neither declining or recovering. In rare cases, an interest feature might not be able to regain its original condition following a damaging activity, but a new stable state might be achieved
Unfavourable - declining	Decline is another possible consequence of a damaging activity. In this case, recovery is possible and may occur either spontaneously or if suitable management is undertaken
Partially destroyed	It is possible to destroy sections or areas of certain features, or to destroy parts of a site, with no hope of reinstatement because part of the feature itself, or the habitat or processes essential to support it, has been removed or irretrievably altered
Destroyed	The recording of a feature as destroyed will indicate the entire interest feature has been affected to such an extent that there is no hope of recovery, perhaps because its supporting habitat or processes have been removed or irretrievably altered

In some situations a detailed NVC survey monitoring approach may not be required. Important trends can still be deduced from a more targeted, specific approach. For example, monitoring carried out on Trimley Marshes Managed Realignment site (Posford Haskoning, 2004) employs the following approach:

1. Vegetation survey carried out biannually for five years.
2. General walkover survey to record all species.
3. Permanent quadrats (number depends on size of site) for more detailed species monitoring using Domin scores.
4. Estimate of the areal extent of saltmarsh (spot measurements using either tape measure or GPS; where GIS is used to estimate coverage increase/decrease).

It should be noted that whatever monitoring regime is adopted for a scheme, it should be proportional to the size of the scheme and/or the impacts of it. This can be determined at a number of stages in the process but would certainly form part of an Environmental Impact Assessment for planning approval or could form part of a Strategic Environmental Assessment of a plan (for example a flood management strategy or Shoreline Management Plan). Each site (and project) is likely to have a different range of sensitivities that will determine the parameters to be monitored and the level of detail required.