Marine Climate Change Impacts Partnership

MCCIP

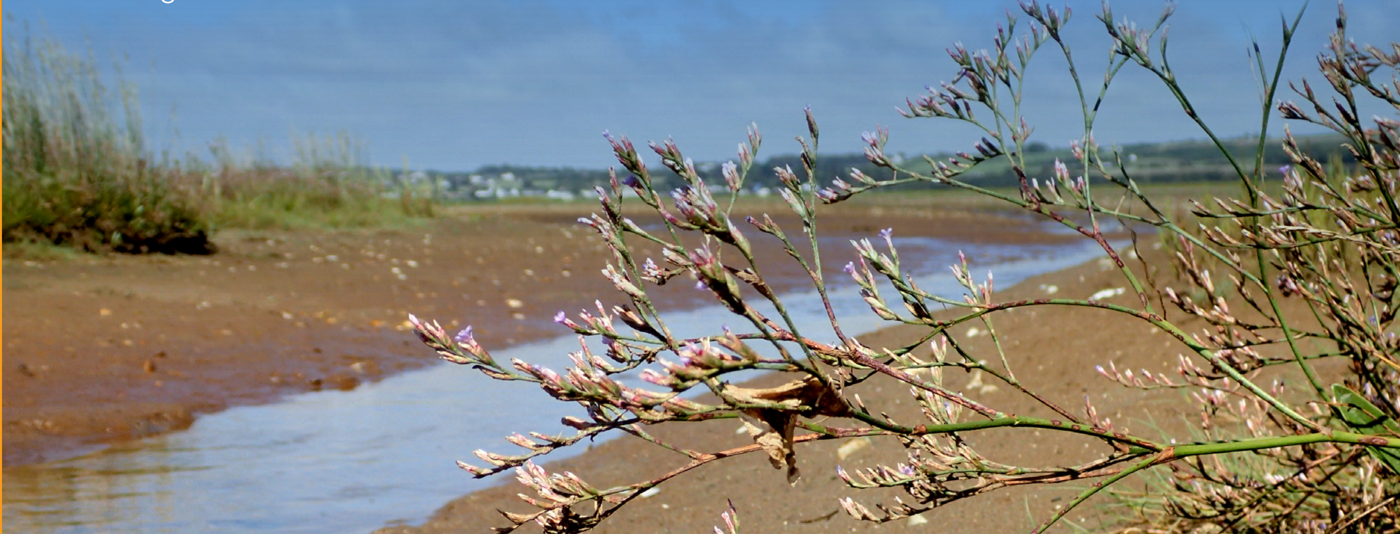
Climate change and marine conservation

Supporting management in a changing environment

2018

Saltmarsh

- The primary threats to saltmarshes from climate change are relative sea level rise, and changes to wind and wave energy, temperature and precipitation. These have caused saltmarsh loss and changes to species composition globally.
- In the UK, areas of high marsh loss, such as in the south and south-east of England, have been attributed to higher sea-level rise rates, low sediment availability, and the presence of hard defences[1]. These factors increase erosion at the seaward marsh edge and restrict the landward migration of marshes, in a process called 'coastal squeeze'.
- Human developments, such as coastal defence works and dredging, also have the potential to increase the vulnerability of marshes to climate change. By diminishing sediment supply to the coast, human development can slow down marsh growth and further reduce marsh recovery capacity.
- Long-term monitoring of marshes across sites, regions and connected systems, is crucial for informing management plans. Long-term monitoring has the added benefit of distinguishing natural marsh changes from climate change impacts[2].
- Protecting existing saltmarshes requires consistent and reliable evidence on the potential impacts of climate change on marsh functioning. Many uncertainties remain, particularly with respect to interactions between stressors and the natural erosion and accretion phases of saltmarshes[3].
- Restoring degraded saltmarshes is now commonplace within managed re-alignment sites[9]. Research suggests that restoration to comparable quality of natural reference sites has proven difficult in the short-term[4,5,6,7]. However, well-informed adaptive management plans aimed at restoring marsh function and diversity in degraded systems are still encouraged.
- Tidal salt marshes play an important role in the global carbon cycle, acting as a carbon sink with their high sedimentation rates, high soil carbon content, and burial of organic matter.



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Saltmarsh

Saltmarshes are wetland habitats, formed by salt-tolerant plants that colonise the upper limits of tidal shorelines in low-energy environments.

In the upper saltmarsh, plants form transitional communities with terrestrial vegetation[8]. In the UK, this is often truncated by sea defences and saltmarshes are therefore a nationally rare habitat[9]. Generally, saltmarsh vegetation displays a characteristic pattern of zonation in the tidal range. However factors such as sediment size, freshwater input, grazing intensity, nutrient level, invertebrate bioturbation and soil oxygen availability can affect the communities [10,11,12].

Saltmarshes deliver many natural benefits (ecosystem services) to human society. Marshes, which develop in low energy environments, attenuate wave energy to reduce flood risk[13,14,15], filter pollutants and nutrients from run-off[16,17] and play an important role in carbon sequestration and storage[18]. Their high sedimentation rates, high soil carbon content, and burial of organic matter make them an effective carbon sink[19].

Marshes support a high variety of species including invertebrates, birds and plants[20], and they provide space for recreational activities, notably bird-watching and walking. Marsh habitat is also known to support juvenile fish species[21] and provide vital refugia, increased surface area for food sources, and potentially, fry spawning sites during high tide[22].

There are 48,226 hectares of saltmarsh along Welsh, English and Scottish coastlines, mainly within embayments, estuaries and drowned river valleys[23]. About half this extent is found along Eastern England[24,25]. Saltmarsh distribution, characteristics and patterns of natural change are strongly affected by key environmental gradients across the UK. North-west to south-east around the UK, the rate of relative sea-level rise increases (due to differences in the rate of isostatic adjustment), tidal amplitude decreases, the average temperature increases and soil texture changes from sand- to clay-dominance[26]. Marshes have expanded in the north-west and eroded in the south-east over the past 150 years[1,24]. In England and Wales, the change in extent has occurred at rates between +1 and -83 hectares per year[24] and some plant communities are considered vulnerable on the European Habitats Red List[27].

Scientific evidence for climate change impacts

Key threats from climate change are sea-level rise, and changes to storminess, temperature and precipitation, which are all expected to impact the aerial extent of marshes (predominantly by interrupting sediment transport pathways), as well as the marsh plant species composition and associated ecological processes[28,29]. Table 1 summarises current knowledge of the most important climate change stressors of saltmarshes.

Lymington River Estuary
Peter Wakely © Natural England

Table 1. Climate change impacts on saltmarsh structure, composition and function.

Climate change drivers	Impacts
Relative sea level rise (affecting vertical marsh growth)	Evidence of vertical marsh accretion is sporadic across the UK. However, studies show that laterally eroding marshes in southern and south-eastern England are gaining elevation at rates comparable to local sea level rise[30,31,32] indicating that marshes have been keeping pace with current rates of sea level change. Marshes with higher tidal ranges and higher loads of suspended sediments will be resilient to sea level rise[33,34]. The sediment source required to maintain marsh accretion can come from external sources, or through erosion of the marsh edge itself[35].
Relative sea level rise (affecting lateral marsh growth)	Under sea level rise, deeper waters will allow bigger waves to reach the marsh, causing erosion at the seaward edge. The eroded sediment is then deposited landward of the marsh, allowing marsh plants to develop up the shore (a process known as 'roll-over')[36]. In the UK, 88% of estuaries are bounded by artificial defences[37], meaning that landward marsh migration will not occur naturally, and most marshes will shrink without removal of hard defences. This process is known as 'coastal squeeze'.
Relative sea level rise (affecting wave energy)	Sea level rise could mean that waves propagate further up the coast and increase rates of lateral marsh erosion[38,39]. In the UK, wave energy in front of saltmarshes is poorly monitored, and although wave heights may increase with climate change, this may be difficult to detect.
Relative sea level rise (affecting sediment transport)	Sea level rise can alter tidal amplitude, which changes the relative flood-ebb dominance, and can change the direction of net sediment transport[40,41]. Tidal amplitude is predicted to decrease across Scotland, in the southern Irish Sea, Celtic Sea, Western English Channel, and increase in the northern Irish Sea and eastern English Channel[42]. Change in tidal amplitude may be as much as 1 metre if mean sea level rises by 1 metre[42], which could happen by 2100 if CO_2 emissions remain at their present levels[43]. How this will affect sediment transport pathways is unclear. Sea level rise is expected to increase the erosion rates of soft-sediment cliffs along eastern England, providing a local source of sediment that can be transported onshore[44]. Coarse-grained sediment flow is expected to remain stable in the immediate future[44,45,46], however, little is known about suspended sediment flux.
Changes in storminess	There is currently no clear pattern of change in storminess across the UK[47], although there is some evidence that clustering of extreme sea level events is increasing[48]. Even moderate storms are having a more severe effect on coastal flooding[49] because of the background rise in mean sea level[50,51]. Storms can deliver large volumes of sediment to the saltmarsh, as well as cause marsh edge erosion[52]. As such, the impacts of storms are complex and affected by sediment availability near the marsh.
Precipitation change and river flow	Across the UK, winter rainfall has intensified and is occurring in clustered events due to a warmer atmosphere[53]. Models predict wetter winters and drier summers in the future[54]. There is some evidence that brackish plant species are increasing their coverage due to greater freshwater input in north-east UK[25]. UK river flow rates have generally increased in winter, and slightly decreased in summer[55,56]. There has been no appreciable change in sediment flux to the coast since the 1970s[57]. Whether stronger flow in winter is depositing greater volumes of sediment within or from estuaries is unknown.
Changes in temperature	Soil, air, and sea surface temperatures are increasing across the UK[58,59,43]. Several marsh plant species are expected to decline in cover as suitable conditions shrink with rising temperatures[60]. It has also been suggested that warmer spring seasons may help promote the growth and accelerated spread of the invasive *Spartina anglica* species[61]. *S.anglica* out-competes native species producing a monoculture which has much less intrinsic value to wildlife than the natural species-diverse marsh[37].

Whilst the impacts of climate change on saltmarsh geomorphology and plant ecology are fairly well understood, very little is known about impacts on other functional groups, including microbes and animals[62,63,64].

Figure 1. Map of main areas of saltmarsh (EMODnet and regional authorities) and the Marine Protected Areas (MPAs) around the UK (JNCC), including those which are designated to protect saltmarsh.

Saltmarshes

MPAs that protect saltmarshes

UK MPAs (MCZ, NCMPA, SAC, SPA , SSSI)

This map reflects the best available information in 2018.

What is already being done to support management of saltmarsh in a changing climate?

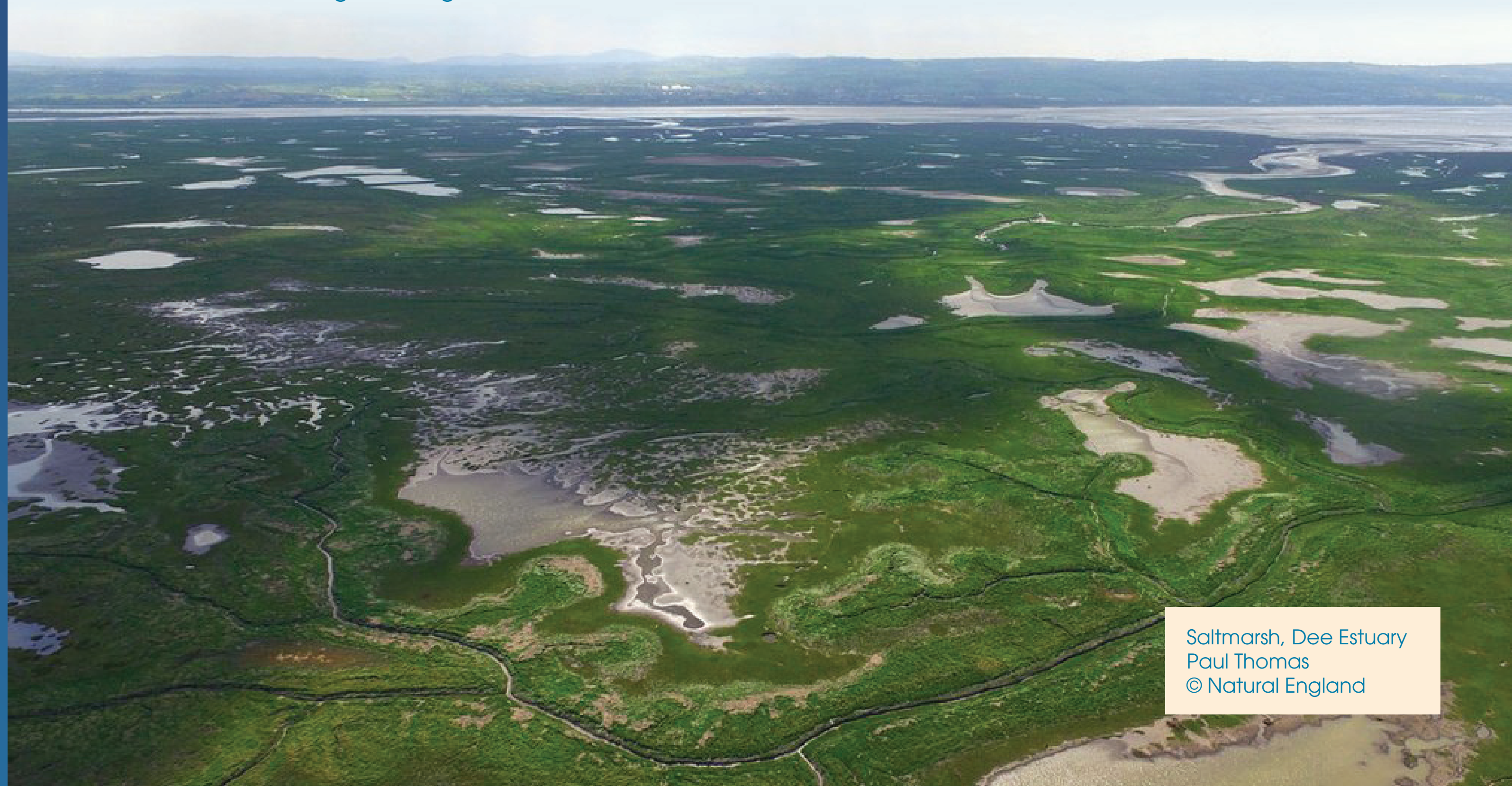
Historically, marshes were converted to agricultural and development land, especially during the 18th and 19th centuries.

Since then there has been growing concern that marshes are vulnerable to sea level rise[65]. They provide many benefits[23] and they are included in national and international nature protection legislation.

Measures that support management of saltmarshes in a changing climate include:

- Legislative protection for a large proportion of UK saltmarshes within statutory protection mechanisms, including Special Areas of Conservation, Special Protected Areas, Marine Conservation Zones (England and Wales only), Nature Conservation Marine Protected Areas (Scotland only), Sites of Special Scientific Interest, Areas of Special Scientific Interest (N. Ireland), Ramsar sites, and National Nature Reserves. Collectively, these contribute to a network of Marine Protected Areas.
- Regular monitoring of coastal processes and ecosystem health, for example, monitoring by the Channel Coastal Observatory[66] and monitoring for the Water Framework Directive and EU habitats directive[67].
- Creating space to encourage the development of new saltmarshes using managed realignment and regulated tidal exchange schemes. There are currently over 60 such sites in the UK[68]. Equally, embankments may fail and storm events that damage sea walls may lead to a decision not to repair breaches in what is known as 'unmanaged realignment'.
- Introducing sediments near the intertidal area (sediment recharge) to counter erosion in areas where sediment supply is limited[68,69,70].
- Constructing breakwaters to protect existing coastal infrastructure[71] whilst creating new habitat for marsh growth at the same time[72].
- Applying 'green engineering' techniques which involve the use of natural material, such as brushwood, to build polders to slow erosion rates and sometimes restore saltmarsh and enhance biodiversity[70,73], or planting[74].

Cycles of erosion and accretion at the marsh edge are a part of natural saltmarsh dynamics[75] and this should be recognised when considering whether erosion control or sediment recharge are appropriate at a site. Restoration schemes can take time and may not fully compensate for species richness, structure and function[6,76,77]. Restoration schemes should therefore consider the recovery time for the habitat to be functional again[78], and explore novel ways to ensure restored sites can meet equivalent ecological status to natural reference sites. It is likely that marshes in a good condition will be more resilient to climate change impacts. Despite difficulties in forecasting whether restoration schemes will be completely successful or not, restoration schemes are encouraged, given the current status of saltmarshes in vulnerable areas like the southern UK.



Saltmarsh, Dee Estuary
Paul Thomas
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What management measures for saltmarsh could also enhance resilience to climate change?

Adaptive Management Plans (AMPs) could be effective for managing saltmarshes under climate change.

AMPs seek to understand changes and uncertainties on a site-by-site basis and monitor outcomes to ensure management options remain relevant for the changing environment. Steps towards adaptive management have been made through the Shoreline Management Plans[79] which include interventions such as managed realignment, green engineering and accepting habitat change with sea level rise[80,81].

A practical approach to help make AMPs more effective would be to ensure the boundaries of protected areas (e.g. MPAs) take into account predicted changes in the coastline, including spaces where coastal habitats may move inland with sea level rise.

When creating new marshes, potential connectivity between sites and with other ecosystems should also be investigated and exploited, to enhance marsh resilience and climate change adaptation.

What wider management options could feasibly be considered?

The following options could be considered:

- Managing the coastal environment at a holistic scale, rather than just the saltmarsh feature. For instance, a `catchment-river-estuary-coast' management scheme would include natural flood alleviation up stream, as well as sediment transport processes in the intertidal zone[82].
- Continue to assess the pressures, processes and management interventions of marsh resilience using long-term environmental datasets, remote sensing and numerical modelling.
- Creating more natural shorelines to restore the function of natural coastal processes and minimise constraints to sediment transport[68].
- Better monitoring of tidal flat dynamics, which are intricately linked to the fate of marsh edge changes[3,83,84,85], to predict when and where marshes are most vulnerable.
- Incorporating the management of land, water and living resources when planning and deciding on saltmarsh conservation and sustainable use policies (a strategy known as the `ecosystem approach')[86].
- Further research to understand the extent of natural capital that saltmarshes provide. These benefits should then be taken into consideration as part of future management plans and development projects[87].
- Ensuring widely-used management practices, like livestock grazing, do not hinder marsh resilience under climate change[88,89,90].

Plant species *Atriplex Hastata* found in coastal saltmarsh © NRW

Practical actions that could support management of saltmarsh in a changing climate

Identify pressures	• Establish the hydrodynamic, sedimentary and community regime of each site. This can show how resilient a system may be, and therefore how vulnerable it is to climate change impacts. • Identify the likely impacts that may affect a site at relevant scales (marsh-, catchment-, or landscape-level). • Routinely monitor sites to detect changes in key environmental parameters associated with saltmarsh degradation, as well as recognise deterioration and consequent damage to land-based assets to link patterns of change to their causes. Monitoring needs to be long-term to distinguish human-driven degradation from natural erosion-expansion cycles.
Intervention	• If intervention is deemed necessary, options include modifying the local environment to preserve existing marsh ecosystems. For example, installing breakwaters to dissipate wave energy[72], sediment nourishment to allow marsh to grow with sea level rise[68,69,70] or adapting grazing management plans to avoid ecosystem degradation[20]. Options also include restoring degraded marsh systems or creating new space for marsh growth (for example, managed realignment and regulated tidal exchange schemes[68] and planting of native wetland plants[91,92]). • Engage with stakeholders early-on. Lack of engagement may delay intervention processes and damage to the saltmarsh could become too severe to respond. Management options could then be limited to major interventions, such as restoration. • Identify opportunities for novel management and assess their feasibility and implement in experimental trials. If successful, these could be adopted as policy[93]. • Consider where active intervention is required on a case-by-case basis. Trade-offs with managed realignment/ adaptive management plans should be carefully considered. Consulting existing Shoreline Management Plans and estuary strategies can provide a suitable baseline upon which to make a long-term decision.
Restoration	• If restoration is viable, carefully review successes and failures from other similar sites, especially ones with similar environmental context. Information is freely-available online e.g. ABPmer[68], and from other organisations with relevant experience, including open-access reports for `lessons learned'[94]. • Ensure new flood regimes are suitable for the full zonation of marsh plants and habitats (comparable to `natural' reference sites); hydrological functioning including channel networks evolve naturally (no significant erosion); the site remains stable over the long term (there sufficient sediment supply); relevant stakeholders are fully engaged, and ensure monitoring continues to determine success and failure of schemes. Interventions should be planned and executed with the aim of restoring estuary equilibrium form. • Continue to seek opportunities for managed realignment sites to ensure the UK coastline is robust against climate change impacts.

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