REPORT

Blakeney Harbour Coastal Restoration Feasibility

Final Report

Client: Norfolk County Council

Reference: PC7123-RHD-XX-XX-RP-0103-S2-C01-X

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Date: 27 October 2025

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Acronyms

Acronym	Definition
AEoI	Adverse Effect on Integrity
BHA	Blakeney Harbour Association
BOD	Below Ordnance Datum
BTO	British Trust for Ornithology
Cefas	Centre for Environment, Fisheries and Aquaculture Science
EA	Environment Agency
EQS	Environmental Quality Standards
EUNIS	European Nature Information System
GES	Good Environmental Status
HMWB	Heavily Modified Water Body
HRA	Habitats Regulations Assessment
ICW	Integrated Constructed Wetland
IFCA	Inshore Fisheries and Conservation Authority
INNS	Invasive Non-Native Species
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LAC	Limits of Acceptable Change
LSE	Likely Significant Effect
LT	Long Term
MarESA	Marine Evidence-based Sensitivity Assessment
MarLIN	Marine Life Information Network
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MS	Monitoring Specification
NaFRA2	National Flood Risk Assessment 2
NBIS	Norfolk Biodiversity Information Service
NBN	National Biodiversity Network
NNR	National Nature Reserve
OD	Ordnance Datum

Acronym	Definition
OS	Ordnance Survey
PBDE	Polybrominated Diphenyl Ethers
PFOS	Perfluorooctane Sulfonate
PMG	Project Management Group
ReMeMaRe	Restoring Meadow, Marsh and Reef
RGCG	River Glaven Conservation Group
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SCOS	Special Committee on Seals
SMP	Shoreline Management Plan
SMU	Seal Monitoring Unit
SPA	Special Protection Area
SPM	Suspended Particulate Matter
SSSI	Site of Special Scientific Interest
SUP	Stand-Up Paddleboarding
UCL	University College London
WFD	Water Framework Directive
WG	Working Group
WNNMP	The Wash and North Norfolk Marine Partnership
WWF	World Wide Fund for Nature

Glossary of Terminology

Terminology	Definition
Allochthonous saltmarshes	The marsh is mainly formed from the accumulation of imported mineral sediments.
Anastomosing channels	A network of interconnected channels generally indicative of low energy flow regime.
Astronomic water levels	Levels that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions.
Autochthonous saltmarshes	The marsh is mainly formed from *in-situ* accumulation of organic plant matter, usually in micro-tidal settings <2m.
Bathymetry	Mapping of underwater topography and the measurement of depth in water bodies.
Bioaccumulation	The concentration of substances inside the bodies of individuals.
Biomagnification	A process by which substances become increasingly concentrated in the tissues of organisms as they move up the food chain.
Biogenic reef	A reef formed by living organisms, such as mussels or oysters, that create habitat structures.
Bivalve molluscs	A class of aquatic molluscs with laterally compressed bodies enclosed in a hinged shell. This includes oysters, mussels and scallops.
Blue carbon	Carbon captured and stored by marine and coastal ecosystems, such as saltmarshes and seagrasses.
Bonamiosis	A disease caused by Bonamia parasites.
Byssal threads	Fibers made by proteins used by some bivalves to attach to hard substrata.
Chart Datum (CD)	Local reference level datum, typically related to the lowest astronomic level at specific location.
Ecosystem	A biological community of interacting organisms and their physical environment.
Ecosystem services	The benefits that humans receive from ecosystems, including provisioning, regulating, cultural and supporting services.
Epifauna	Animals that live on the surface of the seabed or attached to submerged objects or organisms.
Epiphyte	A plant that grows on the surface of other plants, such as algae on seagrass leaves.
Eutrophication	Excessive nutrient enrichment in water bodies, leading to algal blooms and oxygen depletion.

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Terminology	Definition
Fucoid algae	A group of brown algae, belonging to the order Fucales.
Habitat connectivity	The degree to which different habitats are linked, allowing species to move and interact across landscapes.
Halophytic plants	Plants adapted to grow in saline conditions, such as those found in saltmarshes.
Highest Astronomic Tide (HAT)	The maximum level under average meteorological conditions which can be expected during that year.
Hypoxia	Oxygen deficiency.
Intertidal	The area between low water and normal high water, typically exposed during the tidal cycle.
Lidar	Light Detection and Range used to measure topography or land levels.
Lowest Astronomic Tide (LAT)	The lowest level under average meteorological conditions which can be expected during that year.
Macrotidal	A coastal area with a tidal range greater than four meters.
Managed realignment	A coastal management strategy that allows the shoreline to move naturally, often by breaching sea defences.
Mean high water neaps (MHWN)	The height of mean high water on a neap tide is the average throughout the year when the range of the tide is at its least.
Mean high water springs (MHWS)	The height of mean high water on a spring tide is the average throughout the year when the range of the tide is at its greatest.
Mean low water neaps (MLWN)	The height of mean low water on a neap tide is the average throughout the year when the range of the tide is at its least.
Mean low water spring (MLWS)	The height of mean low water on a spring tide is the average throughout the year when the range of the tide is at its greatest.
Mycorrhizal Fungi	The symbiotic association between specific fungi and the roots of vascular plants.
Ordinance Datum (OD)	Nationally consistent level datum.
RCP	Representative Concentration Pathway (used in UKCP18) as the basis for projecting sea level rise due to climate change.
Recurved spit	A coastal landform formed by the deposition of sediment, curving inward due to wave action and longshore drift.

Terminology	Definition
Sediment budget	The balance between sediment being added to and removed from a coastal system
Spat	Juvenile stage of bivalves (e.g. oysters or mussels) after settlement.
Subtidal	The area of shore that is always submerged underwater, even at low tide.
Thermal Expansion	The increase in the volume of a substance due to a rise in temperature.
UKCP18	United Kingdom Climate Projections 2018
Warping up	Increase in the level of salt marsh with the deposition of sediment.

Non-Technical Executive Summary

This report assesses the potential for restoring coastal habitats in Blakeney Harbour, Norfolk, with the aim of enhancing biodiversity, supporting climate resilience, and benefiting local communities. Commissioned by Norfolk County Council, the study builds on previous research and stakeholder engagement to identify feasible restoration opportunities within Blakeney Harbour.

The focus is on five key habitats: seagrass beds, saltmarsh, native oysters, blue mussels, and vegetated shingle. The study involved reviewing existing physical, chemical, ecological and environmental data, conducting site visits and stakeholder consultations, and developing a conceptual model of the harbour's geomorphology. It also assessed habitat requirements and pressures.

Blakeney Harbour is ecologically rich, but faces challenges of high sediment movement, water quality issues and climate change. The area is also highly important for its recreational use with many opportunities for appreciating the natural value of the site, including walking, sailing, seal trips, kayaking and paddleboarding. The area currently has limited management which. although it provides an open area for enjoyment. also means that there is no control over recreational use, other than through limits related to infrastructure, such as parking areas. This was identified during the stakeholder consultation as a potential issue in the future given the increasing number of people undertaking the above activities.

Although the habitats and species in the area are generally in a healthy state, there are certain habitats and species that have declined over recent decades and some that are at risk of climate change, principally through sea level rise that is likely to change the area available for some habitats including saltmarsh (potentially reducing areas available) and seagrass (potentially increasing areas available for certain species). It is important that pressures and threats to the ecosystem are understood before embarking on habitat creation and restoration initiatives, certainly to the extent that it can be ascertained that such measures would not curtail the success of the initiatives. This study, and the previous studies, have compiled information to support this understanding and offer potential reasons for the observed declines, but there are still some gaps in knowledge as to exactly why some habitats, such as seagrass, mussel beds and cockle beds have declined.

Given the above, there are multiple opportunities that appear to be feasible for habitat restoration and creation that could reinstate some of the declining habitats and increase biodiversity in the harbour area. The following opportunities are recommended in Blakeney Harbour:

Restoration and/or creation is recommended for:

- Seagrass habitat.
- Blue mussels.
- Native oysters.

Active management is recommended for existing habitats such as:

- Saltmarsh.
- Brackish and freshwater marshes.

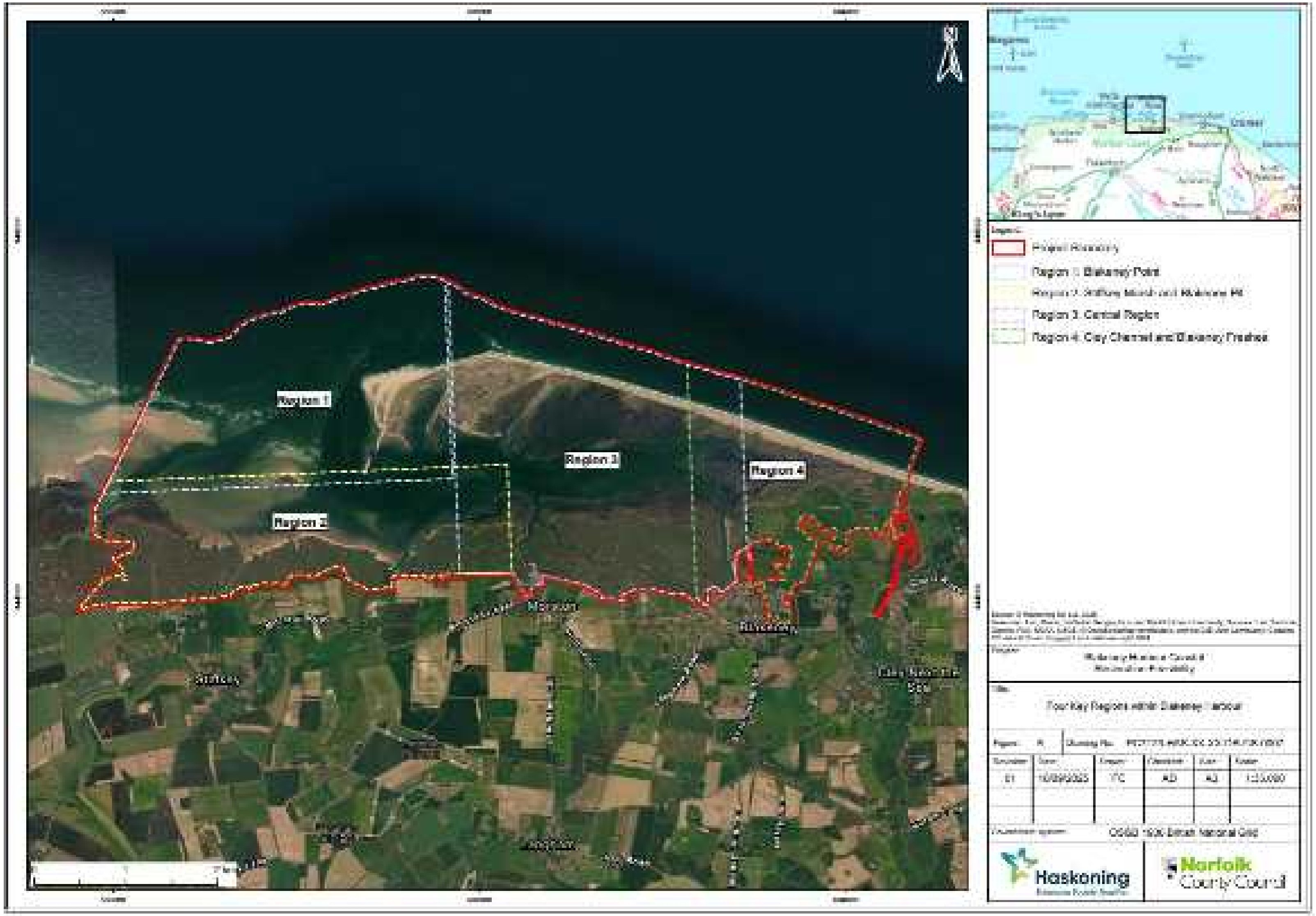
Natural progression should be allowed where feasible, especially for:

- Saltmarsh.
- Vegetated shingle.
- Other naturally evolving species and habitats.

Opportunities for lagoon and island creation are highlighted to:

- Support nesting bird populations.

Informed by the Geomorphological Conceptual Modelling report, the Blakeney Harbour area was divided into four regions, as shown in the figure below. For each of these regions, recommendations were made, which are summarised in the table below and shown on **Figure 26** (see the main body of the report).


Region 1
Region 2
Region 3
Region 4
Morston
Blakeney
Project Boundary
Region 1: Blakeney Point
Region 3: Central Region
Region 4: Cley Channel and Blakeney Freshes
Four Key Regions within Blakeney Harbour
OSGB 1936 British National Grid
Haskoning
Norfolk County Council

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	Saltmarsh	Vegetated Shingle	Blue Mussel	Native Oyster	Other habitats / species[1]
Region 1: Blakeney Point						
Restoration and/or creation	**Yes**	**Maybe**				
Continued management of existing habitat			**Yes**			
Do nothing – allowing the natural progression of existing habitats	**Maybe**	**Yes**				
Region 2: Stiffkey Marshes and Blakeney Pit						
Restoration and/or creation	**Yes**			**Yes**		
Continued management of existing habitat						
Do nothing – allowing the natural progression of existing habitats		**Yes**				
Region 3: Central Region						
Restoration and/or creation	**Yes** (for seagrass in the areas identified in **Figure 24**)	**Yes**		**Yes**	**Yes**	
Continued management of existing habitat						
Do nothing – allowing the natural progression of existing habitats	**Yes** (for some the remaining seagrass)		**Yes**			
Region 4: Cley Channel and Blakeney Freshes						
Restoration and/or creation		**Yes**, this will depend on if the defence is				**Yes** – Through the restoration and enhancement

[1] *Other habitats and/or species means that the primary target of the recommendation is the restoration or enhancement of a habitat or species not otherwise listed.*

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	Saltmarsh	Vegetated Shingle	Blue Mussel	Native Oyster	Other habitats / species[1]
		maintained or not				of freshwater marsh by creating scrapes and higher ground which benefit nesting birds and ditch-dwelling invertebrates.
Continued management of existing habitat						
Do nothing – allowing the natural progression of existing habitats		**Yes,** this will depend on if the defence is maintained or not				

Following on from this study, there are several next steps to take. This includes, but is not limited to, undertaking surveys of the existing habitat, analysis of sediment and water quality and the determination of potential flood risk in the area.

1 Introduction

1.1 Aim of this report

The Blakeney Harbour Coastal Restoration Feasibility Project follows on from an initial phase involving a Marine Recovery Workshop, delivered by The Wash and North Norfolk Marine Partnership (WNNMP), that identified support among partners for exploring potential marine and coastal habitat restoration opportunities, with Blakeney Harbour identified as a potential site for such initiatives. Following this workshop, a Working Group (WG) was established to progress the outcomes of the workshop. A study for the World Wide Fund for Nature (WWF) (2024) also investigated the feasibility of multi-habitat coastal restoration in North Norfolk as part of their 'Wholescape' Programme.

In order to facilitate the next stage of work, a Project Management Group (PMG) was established from the WG members. Haskoning were then contracted, by Norfolk County Council (NCC), to undertake the following tasks:

- Collate and analyse existing ecological, hydrological, geological, and climate data required for designing a multi-habitat coastal restoration programme in the area.
- Ground truth desk-based data and collect and analyse some additional data required to assess whether the priority coastal habitats and species listed above are feasible to restore within the assignment area in the face of a changing climate.
- Recommend where within Blakeney Harbour coastal habitat restoration is likely to be most successful long-term and identify trial site locations.
- Recommend what assemblage of habitats and/or species should be the focus of restoration efforts to address the priority outcomes listed above.

The key objective of this next phase of the study is therefore to determine where coastal habitat restoration is likely to be most successful and what assemblage of habitats and/or species should be the focus of restoration efforts to address the priority outcomes put forward in earlier studies.

This report represents the findings of the study including data review, stakeholder engagement, a site visit and conceptual geomorphological modelling. It details the findings of the above tasks and provides a conclusion determining the potential feasibility for coastal habitat restoration and the recommendations for location for habitat restoration initiatives within Blakeney Harbour. The report also recommends possible next steps to take the project forward.

1.2 Project outline

The aim of the project is to recommend where within the study area (**Figure 1**) coastal habitat restoration is likely to be most successful in the long-term and identify trial site locations for multi-habitat restoration initiatives and recommend the assemblages of habitats and species for the restoration.

The WG identified priorities for the work to support as follows:

- Ecosystem functionality and connectivity.
- Climate adaptation.
- Coastal livelihoods.

It also identified five priority habitats and species to focus on:

- Seagrass (*Zostera noltii*).
- Saltmarsh.
- European flat oyster (*Ostrea edulis*).
- Common/blue mussel (*Mytilus edulis*).
- Shingle beach.

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Figure 1 Study Area for Blakeney Harbour Coastal Restoration Feasibility Project (land ownership: National Trust and The Crown Estate)

2 Baseline data collated for the study

2.1 Summary of existing desk-based research

Data has been collated using a variety of sources including the following:

- On-line searches.
- 'WWF Report: Feasibility of multi-habitat coastal restoration in north Norfolk (2024).
- Norfolk Historic Environment Records and aerial photography.
- Historic Environment Advice.
- Norfolk Biodiversity Information Service data request.
- Request for data to the WG.
- Known information from previous work in the area by the Haskoning team.

2.2 Findings of the data review phase

Several sources of data were collated and reviewed to provide background information on a number of topics, including the following:

- Existing habitats and species distribution.
- Historic habitat and species distribution.
- Condition and status of designated sites.
- Use of the area including commercial and recreational.
- Water quality.
- Ecosystem services derived from the ecological resources.
- Coastal morphology and key processes in the area.

An interim report was produced (Haskoning, 2025a) (**Appendix A**) that summarised the data reviewed and identified data gaps that would require further work to provide a robust baseline. **Table 1** lists the data gaps that were identified within the Interim Report.

Table 1 Data gaps identified within the Intermin Report (Haskoning, 2025a)

Data Gap	Objective for filling gap
Constraints and opportunities mapping to include intertidal habitat distribution/condition and morphological context of the study area	Up to date constraints and opportunities mapping would provide valuable information to determine the potential for expansion of existing habitats and to identify where habitat is not likely to be possible because there are major constraints. Although there is some recent (last three years) information on certain habitats this does not provide overall coverage of the area.
Subtidal habitat data	Although there is a broad scale of mapping of subtidal habitats available it would be preferable to have more up to date information on particular habitats. This would increase the knowledge of the ecosystem, which is important when considering multi-habitat/ecosystem approaches.

Data Gap	Objective for filling gap
	Many habitats rely on others and the knowledge of habitats throughout the study area both in intertidal and subtidal environments would provide a robust dataset.
Sediment quality data	To provide data on whether sediment quality within the harbour has been affected by contaminants such that it would affect the feasibility of the area providing habitat for certain species, particularly benthic filter or deposit feeding species.
Ecological-biological connection	It is identified that a further understanding on the ecological and biological connections between the priority habitats and species would be valuable in understanding connectivity and where habitats could provide a vital link for certain species.
(Historical) Bathymetry Data	Although there is a timeseries available of above-water topography, which covers the majority of the tidal flats, channels and open coast beach, there is only limited bathymetric data available. There is some data for the area alongside the Quay and The Cut but very little information for the outer harbour area.
Coinciding topographic and bathymetric data	There is no concurrent topographic and bathymetric data available, meaning that there is a disconnect between above and underwater topography. To be able to understand sediment budgets in the area, but also to form a robust baseline, it is valuable to have topography and bathymetry that is collected within a sufficiently close timeframe and that overlaps.
Tidal Currents	Very limited data was collated on tidal currents throughout the estuary. The tidal currents are responsible for shaping the tidal flats and channels, and understanding their distribution across the estuary would enable assessment of tidal forcing on estuary habitats as well as support the calibration of future numerical models.
Inner-estuary wave data	Although wave data is available offshore, no information is available on the wave propagation into the estuary. Although it is likely that the tidal flats will damp a significant amount of wave energy coming into the estuary, measurements or wave modelling could confirm this. This would support assessment of the erodibility of the inner estuary and interaction with habitats

Data Gap	Objective for filling gap
Flood risk	National Flood Risk Assessment 2 (NaFRA2) provides an initial indication of the flood risk to property inland of the estuary. This is currently being published and at this stage, it is too early to tell whether the outputs will be suitable for the purpose of this project. Alternatively, the Environment Agency have a coastal flood risk model available but have indicated that this model would need updating based on new recent knowledge.

Following the identification of the above data gaps, two additional scope items were agreed with Norfolk County Council and the PMG to fill some of the data gaps. These were:

- **A site visit within the harbour area**, including meeting with local stakeholders including Norfolk Seaweed and the National Trust in order to further inform the habitat and species data together with further understanding of existing pressures and management.
- **Development of a conceptual geomorphological model** in order to further understand the sediment processes within the harbour and what constraints or opportunities these could provide.

The outcomes of these two studies are discussed in **Sections 2.4** and **2.5.**

2.3 Stakeholder Consultation

Three stakeholder events were held with the objective of engaging local stakeholders to provide information on the distribution and condition of existing and historic habitats and species and pressures on the area and insight into the needs for habitat restoration within the harbour area.

2.3.1 First event (online)

The first online event was held on Tuesday 8th April 2025 at 18:00hrs and was attended by 34 stakeholders, representing 19 organisations. The aim of the initial stakeholder event was to primarily initiate dialogue with key local groups, introducing the project, gauge the local appetite for a potential restoration, and gather foundational knowledge regarding concerns, current harbour usage, aspirations, and pressures. With this in mind, invitations were sent to specific local stakeholders (such as the Blakeney Harbour Association, Cley Harbour Committee, local sailing clubs, and parish and district councillors). All subsequent events, including the two held since, are and will remain open to all.

The first half of the event included a presentation summarising the background to the project, including the aims and objectives, and the aim of stakeholder engagement. The second half of the event was a 'question and answer' session; potential questions were circulated to the stakeholders in advance of the event to inform this session. These questions aimed at providing an opportunity for stakeholders to be involved in the project in a number of ways including:

- Ensure understanding of the project and what it aims to achieve.
- Raise any concerns over the proposed project.
- Inform the aspirations for the habitats and species in the area.
- Ensure that what is important to local people is raised at an early stage for consideration.
- Provision of data to further the understanding of the area and the ecosystem services (i.e. fisheries, recreational benefits, coast defence function) provided.

The questions were as follows:

- What are your aspirations for the area in terms of the habitats and species that use the area (for example, do you recall a particular time when certain habitats were abundant and supported more species or when the Harbour Area provided opportunities for particular activities that are no longer feasible)?
- What is important to you when you think about the Blakeney Harbour area?
- What benefits do you get from the habitats and species in the Blakeney Harbour area?
- How would you like to be involved in the restoration of the habitats and species in the area and how could you help?
- What do you feel are the key pressures within Blakeney Harbour?
- Do you feel that those pressures are being managed to the extent that habitat restoration could be successful?
- Do you have any concerns over habitat restoration measures being implemented in Blakeney Harbour?
- Do you have any data that could help the study to further understand the baseline conditions, for example, historic photographs, survey information, anecdotal information on the Blakeney Harbour area?

Appendix A of the Engagement Output Report (Haskoning, 2025b) (provided as **Appendix B** to this report) includes a copy of the mural board developed during the event which records stakeholder answers to the above questions.

2.3.2 Second event (in person)

Stakeholder event 2 was held on Tuesday 3rd June 2025 at Blakeney Village Hall between 10:00hrs and 17:00hrs. The purpose of the event was to allow people who use Blakeney Harbour, or simply know it well, to have the chance to find out more about the project and directly inform this work.

This event aimed to improve understanding of:

- The local factors that could impact the success of coastal habitat restoration, if progressed in the future.
- The benefits that local people would like to see supported by coastal habitat restoration, if progressed in the future.
- The concerns surrounding potential coastal habitat restoration and how we could address these concerns through collaboration.
- The level of local interest in supporting potential coastal habitat restoration.

Stakeholder event 2 was attended by at least 59 people; 20 attendees belonged to organisations represented on the PMG or the wider project Group WG and 39 attendees were local stakeholders representing a range of groups. Some local attendees may not have signed in to the event, so this number could be an underestimate.

Stakeholder event 2 provided useful data and information, which has been used in the production of this report, on:

- Management of the harbour, including pollution sources and the possible implications of increasing numbers of people enjoying watersport activities.
- How strategic influences, such as the Shoreline Management Plan (SMP), will be considered within the feasibility study.
- The impact of previous initiatives, and how these have eroded stakeholder trust.
- The influence of external projects/pressures such as the Wash Barrage, poor water quality, lack of vermin control.
- The dynamic nature of the harbour area.

The second stakeholder event also highlighted some preconceived ideas about the aims of the feasibility project resulting from previous initiatives that the local community consider were forced onto them with limited appreciation of the impact they would have at a local level. This also links to a strong sense of not wanting change, particularly in terms of regulation of the harbour.

The Engagement Output Report (**Appendix B**) summarises four key themes which have also been considered during the analysis of data and production of this report:

- There is a general consensus that the community are not supportive of restricting access across Blakeney Harbour, although some stakeholders did note that higher numbers of visitors do affect bird distributions.
- There is a feeling that the current habitats do not require intervention and that the harbour is evolving naturally.

- There are issues around the management of recreational activities, although many members of the community do value the unique way in which the harbour is currently managed.
- The community are clearly passionate about the area and are keen to play their part in future management.

2.3.3 Third event (online)

Stakeholder event 3 was held online on 2nd October 2025 between the hours of 18:00hrs and 20:00hrs. The purpose of the event was to share results and hold a question and answer (Q&A) session. A transcription of the Q&A session is provided in the Stakeholder Event 3 webinar minutes, provided in **Appendix C**. The event was advertised using the following channels:

- Utilising the contact lists from previous events.
- Advertising was sent to the WNNMP's North Norfolk Advisory Group. These groups comprise a broad mix of local community members, partners, and ENGOs relevant to the area.
- The BHA and Cley Harbour Committee promoted the workshop within their respective networks.
- The Parish Councils of Blakeney, Cley, Morston, and Stiffkey were asked to advertise the event.
- The National Trust also assisted by promoting the event through their local contacts.

The event was attended by 49 participants, 16 of which were from organisations represented on the PMG and ten of which were from organisations represented on the wider WG. There were 15 local community members (i.e. had no affiliation known to local organisations) and the remainder of attendees were from organisations that were outside of the PMG and WG.

2.3.4 Additional Stakeholder Discussions

Further discussions were held with the following stakeholders:

- Norfolk Seaweed – provided information on the Outer Harbour area in terms of the uses of the area and the habitats present both historically and existing.
- Interview undertaken by Norfolk Seaweed with a gentleman that used to operate a mussel farming business in Blakeney Harbour.
- Blakeney Harbour Association – discussions around the siltation of The Cut, including presentation of bathymetric survey results.
- Cley Harbour Committee – discussions on the activities undertaken within the Cley River and the development of this area historically.
- Norfolk Rivers Trust – provided information on the works being undertaken in the river catchments feeding into Blakeney Harbour.
- Natural England – discussions relating to the consent pathways to undertake any works within the Blakeney Harbour area and the habitats and their status in the area.

2.4 Site Visit

The site visit was held on the 11th and 12th August 2025, which enabled observation of the intertidal areas during spring tides. The visit on the 11th commenced with a boat trip around high water, with Norfolk Seaweed, to view the outer harbour area and the fringing habitats around the edge of the outer harbour. It also involved walking around Blakeney Point with the National Trust warden and Countryside Manager. This provided a valuable insight into the development of the area and the uses of the site by wildlife and people. The visit on the 12th of August involved walking around the coast path from Blakeney towards Cley to observe the habitats on either side of the seawall and the feasibility for habitat restoration in these areas. The findings of the site visit are discussed below.

Outer Harbour Area

There are various activities occurring within and around the harbour that provide ecosystem services to the local community and enable them to enjoy the habitats and the benefits that those habitats bring to the area. The main activities observed included boating activities (**Plate 1**) and boat trips out to see the seals on Blakeney Point together with walking around the coastal path.

Plate 1 Area around Morston Quay

The habitats are highly diverse in the area (**Plate 2**) and are relatively unspoilt from infrastructure with a mostly natural development of habitats within the outer harbour area. The dominant habitats are saltmarsh, mudflats and shingle beach with sand dunes, mussel and cockle beds and relatively small areas of seagrass (**Plate 3**) in lower intertidal zones. There are some coarser areas on the mudflats, mostly resulting from the presence of cockle shells, which provide a habitat for algae and the settlement of mussels and other sessile invertebrates (**Plate 4**).


Plate 2 showing diversity of habitats around Morston Marshes


Plate 3 Seagrass (Z. noltii) at low tide around Morston Marshes


Plate 4 Juvenile mussels (M. edulis) and cockle shells (Cerastoderma edule) on Morston Flats

Within the outer harbour are oyster rafts which are managed by Norfolk Seaweed for commercial purposes (**Plate 5**). This activity provides an ecosystem service through provisional services and also functions to improve water quality through the filtration action of the oysters. The oysters are specifically selected to ensure they do not have the capability for reproducing and therefore cannot spread throughout the area.

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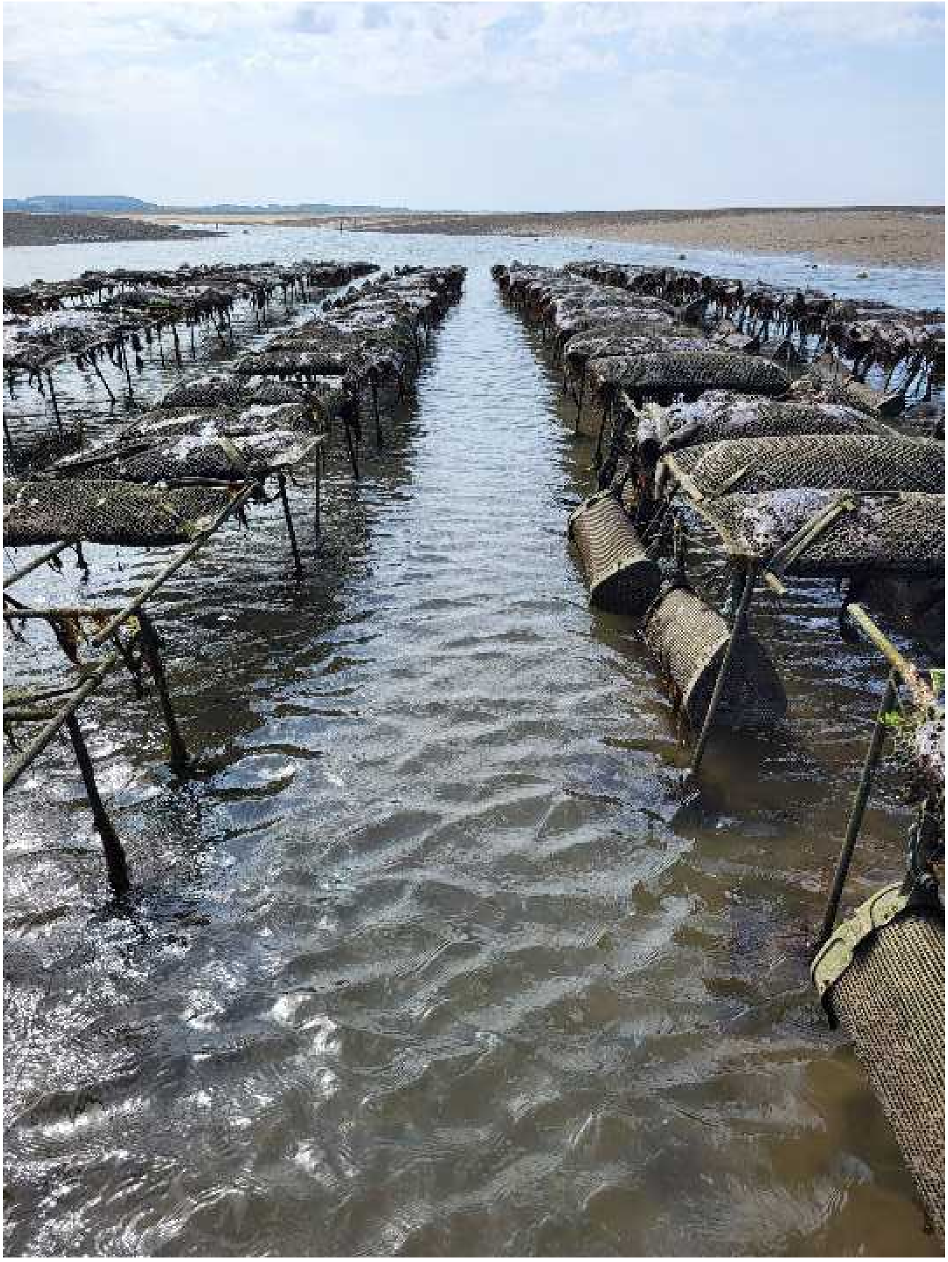

Plate 5 Oyster farm off Morston Flats (Crassostrea gigas)

On Blakeney Point, the habitats observed include the shingle spit, vegetated shingle areas and sand dunes (**Plates 6 and 7**) with sandflats, mudflat and saltmarsh areas. This area provides an important habitat for seals, which haul out on the sandflats and for ground nesting birds, such as plover that nest on the higher areas of shingle. Additionally, the fish populations support internationally important colonies of terns breeding on Blakeney Point (Harwood, Berridge and Perrow, 2016). Although the point is relatively mobile it does provide shelter to small inlets on the inside of the end of the point, providing a habitat for saltmarsh (**Plate 8**) and potentially seagrass.

Plate 6 Sand dune and vegetated shingle areas on Blakeney Spit

Plate 7 Sand dune and sand/shingle beach on the outer edge of Blakeney Spit


Plate 8 Saltmarsh fringing the edges of Stanley Cockle Bight (remaining saltmarsh underwater as high spring tides)

The outer harbour area is extensively used for boating and recreational activities although it is relatively unspoilt although it was acknowledged during the stakeholder consultation that recreational activities are increasing and that this was of concern to some local residents. The northern edge of the harbour area is a lot less accessible and therefore not so affected but with the increase in small leisure craft, such as paddle boards and kayaks this may change. However, the access along the spit is limited by the walking distance which is likely to discourage many people from visiting this area and the area is controlled by the amount of parking available for visitors to the area. Access is controlled by the National Trust to areas where there are specific sensitivities such as the Blakeney Spit area that is important for ground nesting birds and seals. This area is wardened during the sensitive periods and monitoring of the success of breeding for the seals and birds is carried out.

Inner Harbour Areas

The areas in the inner harbour are dominated by saltmarsh (**Plate 9**) and mudflats with saltmarsh creeks and narrow channels used for navigation (**Plate 10**). Many of these areas are accreting and there is evidence of scrub and grasses encroaching onto the saltmarsh, this is also confirmed by discussions with Cley Harbour Committee members who mentioned about the extensive areas of couch grass within the saltmarshes in this area. This is also the case for the Stiffkey Marshes and is reported in the Site of Special Scientific Interest (SSSI) Condition reports (Natural England Designated Sites View) that mention extensive areas of sea couch and not many saltpans in the marsh.


Plate 9 Saltmarsh within the Cley Channel area taken from the seawall between Blakeney and Cley


Plate 10 Recreational use of the Cley Channel

Much of the landward area on the south side was enclosed by a seawall and has developed into fresh or brackish water marsh (**Plate 11**) and is drained with sluices providing a means of water management. These areas are used for agriculture and the seawall provides a popular footpath for coastal walking. This area does provide a valuable fresh/brackish marsh area but is at risk of overtopping during storms, particularly with sea level rise, as occurred during the winter of 2013/2014 when the seawall breached and saline flooding occurred over a large area of the Blakeney Freshes. Repairs were made to the breached areas to improve the resilience but as discussed in Section 4 of the Geomorphological Conceptual Modelling Report (**Appendix D**) there remains a risk of flooding during extreme events.

Plate 11 marsh habitat within Blakeney Freshes

2.5 Geomorphological Conceptual Modelling

A Geomorphological Conceptual Modelling Report was produced by Haskoning (2025c) (and provided as **Appendix D** of this report) to review the physical processes and coastal geomorphology of the Blakeney Harbour system. Historical and current baselines of the coastal geomorphology, as well as projected future changes were described within the report. The Geomorphological Conceptual Modelling Report largely informed the physical baseline section of this feasibility report (**Section 4.1**). Generally, the Blakeney Harbour system is a mobile and dynamic region, with a long history of changes to the location of Blakeney Spit. The system has been divided into four regions, to assess each of the unique sections separately, namely: Blakeney Point; Stiffkey Marshes and Blakeney Pit; Northern Marshes (Central Region); and, Cley Channel and Blakeney Freshes (see **Figure 5**). **Section 4** presents the baseline conditions for these regions and their species and habitats.

Within the Geomorphological Conceptual Modelling Report, climate change scenarios have been described. It is projected that a sea level rise of 0.3m, 0.6m and 0.9m might be achieved by 2050, 2075 and 2100, respectively (**Figure 2**). As such, the Geomorphological Conceptual Modelling Report made the following predictions:

- The front face of the open coast might set back by 85m by 2075 and 130m by 2100.

- Blakeney Spit and the channel may progress further west, encroaching into the western sand banks, with the encroachment of the channel putting Stiffkey Marshes under greater pressure.
- Potential for an increased release of sediment movement into the main body of Blakeney Harbour
- The central region between Morston and Blakeney channels is likely to remain mobile, with the potential for further infill to the area between the channels.

Within this feasibility study, the climate change scenarios projected within the Geomorphological Conceptual Modelling Report (**Appendix D**) have been drawn upon for each region. This is particularly important when presenting opportunities for restoration, as it is critical that any suggested interventions provide long-term ecological benefits. Given the predicted changes to the harbour under the climate change scenarios, a phased approach to restoration was also considered, recognising that it may only be feasible to sustain certain habitats in their location for a shorter time but that they may then adapt to provide habitat for colonisation by other species. Examples of this could be creation or extension of areas of seagrass that favour certain tidal positions in areas where saltmarsh vegetation may no longer be viable due to sea level rise and areas where greater saline flooding of upper marshes reduces the potential for scrub encroachment and enables the restoration of upper marsh vegetation.

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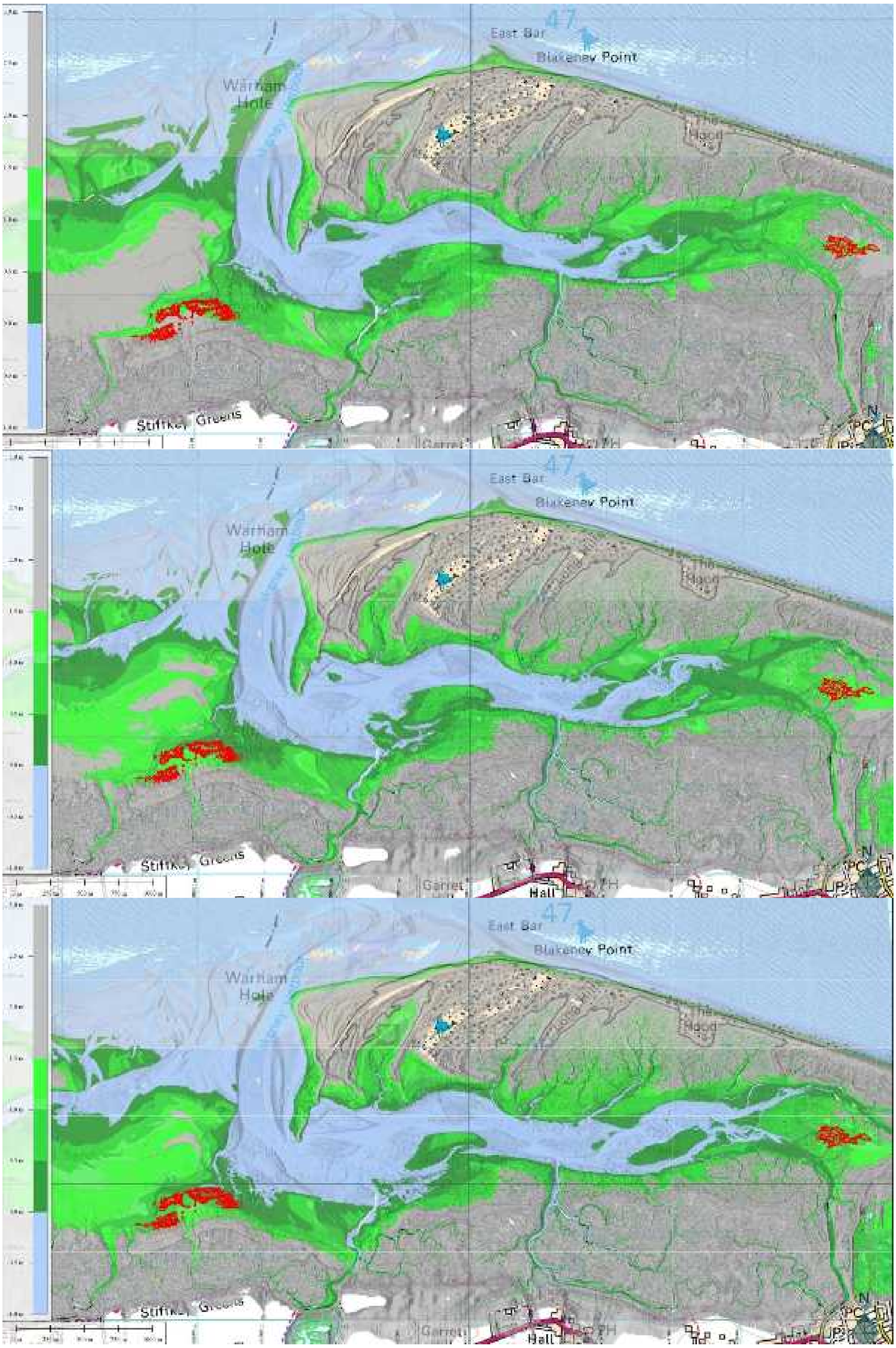

Figure 2 Elevation of Blakeney Harbour at present (top), under potential 0.3m sea level rise (middle) and potential 0.6m sea level rise (bottom). Red areas show the current extent of seagrass.

3 Requirements for key habitats

3.1 Introduction

The following sections outline the key physical, chemical and biological requirements for the various habitats that were prioritized for the study. If restoration or creation of habitats is to be successful, then these conditions would need to be present already or created to optimize success. In order to ensure that conditions are optimal, existing pressures should also be reduced to allow habitats to recover. Other parameters are important for the success of any habitat restoration initiatives, and this includes the maintenance of connectivity of habitats and the presence of multiple habitats in any area both of which increase the resilience of the habitats to change. These are also addressed in this section.

3.2 Physical

The physical conditions of an environment can greatly influence the habitats that are formed there and the species that are present. In addition, the presence of some habitats can provide opportunities for other species to colonise, often providing mutual benefits to each (multi-habitat benefits are discussed further in **Section 5.2.1**). Coastal dynamics, such as waves and currents are important factors to consider. Fast current speeds can erode habitats such as saltmarsh, whereas slower speeds increase deposition, which may create a more soft-sediment dominant environment. In a highly depositional environment, marine and coastal plants may become smothered with sediment, which could inhibit photosynthesis and growth. Filter feeding reef-formers such as oysters and mussels may also become smothered by high sedimentation rates. Similarly, areas of exposure to strong wave action are likely to be rocky shores, whereas sheltered regions support seagrass, saltmarsh and mudflats.

Tides, driven by gravitational interactions between the sun, moon and Earth, are also responsible for sediment transportation, deposition and shoreline formation, as well as the provision of food, cycling of nutrients and the creation of habitats. Where there is a large tidal range (macrotidal), periods of exposure and submersion underwater are more significant. As such, tidal flats, mudflats and saltmarshes may dominate. Where tidal ranges are small (microtidal), there is less variation, and waves may influence habitat formation more. The tidal range is greater than four metres on the North Norfolk coast, meaning that Blakeney Harbour is macrotidal.

The intensity of coastal energy partially determines the sediment type and subsequently the species that inhabit such areas – high-energy coasts tend to have coarser sediments and low-energy coasts deposit finer sediments and sand. Soft sediments, including silt and sand, can support burrowing, infaunal organisms such as worms, clams and plants such as seagrasses. Whereas hard sediments provide substrate for filter-feeding species such as mussels and oysters and algae that require substrate for attachment. The composition of the sediments is also important. For example, seagrass beds generally prefer finer material that contains more organic matter, as this provides a source of nutrients. They also require clear water to allow for sufficient light attenuation to enable photosynthesis, so sediments with greater cohesion and less suspension are preferable for them.

The elevation also helps determine the habitats present. For example, in the correct conditions, saltmarsh initially colonises areas between approximately Mean High Water Neap (MHWN) and Mean High Water Spring (MHWS) tide levels, with areas higher than this up to Highest Astronomical Tide potentially forming high marsh and transitional species, and lower than this down to Mean Low Water Springs (MLWS) tide forming mudflat (Allen, 2000). In terms of species, the upper intertidal zone is only submerged during high tide, meaning that the species present (for example barnacles) can withstand significant exposure to sun and air. In the middle intertidal zone, the regular submersion and exposure supports species such as seaweeds and mussels. Such species rely on tidal flows for spawning and filter feeding. In the low intertidal zone, there is much less exposure to air, so this zone may contain sponges and various species of algae on hard substrate and seagrass on sedimentary habitats.

With melting ice sheets and glaciers and thermal expansion due to climate change, sea levels are rising in many locations. Rising sea levels result in higher tides, which can cause shifts in species distributions and ecosystem changes. Additionally, tidal patterns can also change with climate change and weather, leading to unpredictable tides and implications for species and habitats that rely on the regular cycling of food, nutrients and genetic material.

3.2.1 Physical Requirements for Seagrass (*Z. noltii*)

Seagrass requires both efficient levels of light and carbon to photosynthesis. *Z. noltii,* the dwarf seagrass, has evolved with smaller shoots and prefer habitats in the intertidal to shallow subtidal zones. Seagrass requires a minimum 10% of the surface irradiance of light (Greve and Binzer, 2004). However, due to their naturally favoured position, the species are vulnerable to physical changes in sea level (Greve and Binzer, 2004). Further pressures are added due to thermal expansion and high tidal ranges in the project area. Areas of Blakeney Harbour are also vulnerable to increased chances of flooding (North Norfolk District Council, 2015) due to their low-lying nature, which could, conversely, open opportunities for expansion in some areas.

Z. noltii can survive and grow in fine, rich-organic mud or muddy sand. However, a study on restoring *Z. noltii* meadows (Valle, et al., 2015), found that the translocation success was significantly more successful in sandy sediments, but long-term survival was observed in muddy sediments if they were sheltered from high water currents. Greve and Binzer (2004) concluded that seagrasses do not exist at flow velocities above 1.5m/s.

The geomorphological study that was undertaken to provide background information for this report (see **Section 2.5** and **Appendix D**) identified that seagrass was mostly observed in areas that were 1.4m ordnance datum (OD), which is just below the height of MHWN in the tidal cycle (although recognising that MHWN varies slightly around the harbour area). **Figure 3** shows areas of existing seagrass, in relation to tidal elevation.

Overall, for successful survival rates, seagrass should be placed in sheltered environments with low wave action with large amounts of light irradiance.

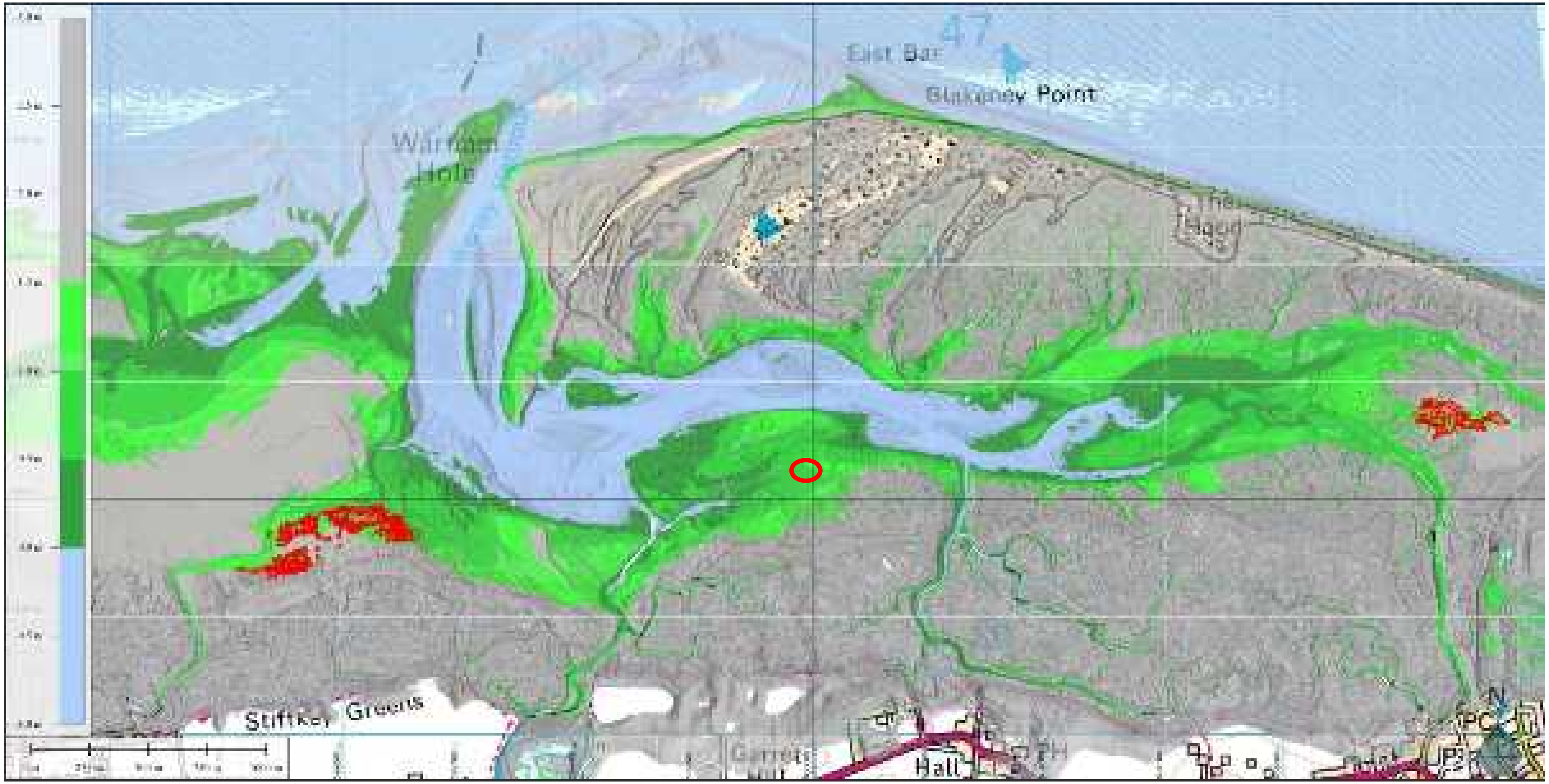

Figure 3 Elevation of Blakeney Harbour. Areas below 1.4-1.5mOD (shown as darker shades of green) indicate potential locations for seagrass restoration / creation. Red areas show existing seagrass beds. The red circle indicates the approximate location of a patch of seagrass observed during the August 2025 site visit

3.2.2 Physical requirements for Saltmarsh

Saltmarshes are generally found between the MHWN and the MHWS, ideal locations have gentle slopes where there is room for vertical accretion to keep up with Sea Level Rise (Hudson et al., 2023). Tidal processes are essential for saltmarsh development; as tides flood the marsh, sediment is provided to allow compaction, which converts sedimentation into long term marsh accretion (Hudson et al, 2023).

There are two types of saltmarshes, allochthonous saltmarshes (the marsh is mainly formed from the accumulation of imported mineral sediments) and autochthonous saltmarshes (the marsh is mainly formed from *in-situ* accumulation of organic plant matter, usually in micro-tidal settings <2m). However, in the UK, most marshes will be a mixture of the two types (Hudson, et al., 2023).

3.2.3 Physical requirements for Native Oyster (*O. edulis*)

Native oysters can be found in subtidal waters, from shallow coastal waters to deeper inshore habitats (ranging in water depths from 10-80m) usually on hard substrates on a range of sediment types, such as mud, rocks, muddy sand, muddy gravel with shells and hard silt (Perry and Jackson, 2017, Preston et al, 2020).

Native oysters prefer areas with weak tidal strength <1 knot (<0.5m/s) but are resilient to wave exposure (Perry and Jackson 2017). They have a large temperature range, being able to survive and reproduce in habitats from 3-30°C, which shows potential for climate change resilience (Preston, et al., 2020).

3.2.4 Physical requirements for Blue Mussel (*M. edulis*)

The blue mussel, commonly known as the common mussel, are intertidal species that can form biogenic reefs and prefer hard substratum for settlement, such as artificial surfaces, bedrock, and existing biogenic reef (Marine Life Information Network (MarLIN), 2016). They can withstand extreme wave exposure and strong tidal currents (1.5-3m/s or 3-6 knots), however they are vulnerable on steep or vertical rock surfaces due to additional drag from epifauna and epifloral, such as barnacles and fucoids, making their fixation to the substratum weaker (MarLIN, 2016). They have a temperature range of 10-20°C, but they have been observed to stop filtering at temperatures lower than 6.1°C and completely closing their valves (Kittner and Riisgård, 2005). However, they have an upper, sustained thermal tolerance limit of approximately 29°C (MarLIN, 2016).

3.2.5 Physical requirements for Shingle beach

Shingle coasts form in wave dominated locations, where shingle (pebbles larger in diameter than sand (>2mm) but smaller than boulder (<200mm)), is available to be deposited, or was previously deposited from extreme climate changes such as ice ages (Joint Nature Conservation Committee (JNNC), 2004, Maddock, 2008).

There are multiple types of shingle habitats; the habitats that directly relate to Blakeney Harbour are fringing beach and a recurved spit. Where shingle occurs close to or above the high tide mark and is relatively stable, vegetation can colonise the shingle habitat. The types of plants are highly specific as they exist within a habitat with very little organic matter and sediment to provide fine structure.

3.3 Chemical

Good sediment and water quality are critical for the healthy functioning of an ecosystem. The availability of suitable concentrations of dissolved oxygen and nutrients in the water enable flora and fauna to live and grow, whilst an excess of nutrients may lead to eutrophication and cause harmful algal blooms. Furthermore, good sediment quality plays a role in nutrient cycling and storage, including the storage of carbon. The presence of certain contaminants in water or sediments can cause toxicity in species, affecting internal processes such as reproduction or respiration and may prevent organisms from being able to live in the area. Excessive contamination can bioaccumulate in organisms and biomagnify in predators, which can be detrimental to the food web as a whole.

The 'Clearing the Waters for All' guidance provides conditions for good water quality standards and the advice can help waters meet Good Environmental Status (GES). GES is a concept defined by the Marine Directive that describes the condition of the marine environment based on different indicators, several of which are related to water and sediment quality, that are measured and monitored and compared against criterion.

3.3.1 Chemical requirements for Seagrass (*Z. noltii*)

Z. noltii as mentioned before can be found in a range of sediment types and have successful long-term survival in both littoral muddy and sandy sediments, but for an increased likelihood in successful translocation, sandy sediments would be more appropriate (Valle, et al., 2015).

Seagrasses grow at salinities between 5 ‰ and 45 ‰, but *Z. noltii* has been observed to be resilient to large changes in salinities due to their natural location being found in areas of mass salinity change, such as estuaries (Greve and Binzer, 2004).

Sulphide concentrations inhibit seagrass growth as sulphide is a plant toxin inhibiting respiration, however sulphide reacts with oxygen to form an oxidised version of sulphide, which is not harmful to seagrass (Greve and Binzer, 2004). Therefore, to prevent any respiratory failure, seagrass should be placed in areas with high oxygen levels in the sediment.

Seagrass can benefit from the moderate anthropogenic addition of nitrogen and phosphorus, with some *Z.noltii* meadows in Portugal noted for being in great health while receiving effluents from wastewater treatment plants and a food factory (Vieira et al., 2022). Despite the importance of nutrients for growth, excessive nutrient input into a water body can result in eutrophication, which results in excessive algal growth and hypoxia. The excessive algal growth can smother seagrasses or inhibit photosynthesis, whilst hypoxia reduces respiration.

Within Blakeney Harbour, the presence of seagrass beds in various locations around the outer and inner harbour areas indicates that water quality conditions are suitable. There have been recent declines in seagrass distribution (see **Figure 16** and **Figure 17**), the cause for which is unknown, however, it is possible that poor water quality has driven this reduction in the extent of seagrass.

3.3.2 Chemical requirements for Saltmarsh

When saltmarshes occupy areas of sheltered water bodies like Blakeney Harbour, saltmarshes can play a crucial role in storage of carbon and regulating water quality.

Saltmarshes can help absorb inorganic nutrients, such as phosphates and nitrates, but elevated levels of nutrients can reduce future resilience of saltmarshes. For example, high levels of inorganic fertilisers from agricultural run-off has shown to weaken the resilience of saltmarshes (Deegan, et al., 2012, Hudson et al, 2023). Saltmarshes can reduce faecal organism concentrations and absorb heavy metals such as mercury, cadmium and uranium from the water, thereby improving water quality, which helps align with Water Framework Directive (WFD) standards for good water quality levels (low heavy metal and nutrient concentrations) (Buhmann, et al., 2015; WFD, 2015).

However, for the development of saltmarshes, areas should have sediment with organic-rich (nitrate concentration of 10mgl^{-1}) sediment as this supports the growth of halophytic plants (Buhmann, et al., 2015, Hudson, et al., 2023).

Saltmarsh vegetation exists where many other plants are unable to compete due to the salinity of the water. As soon as the saltmarsh vegetation enables accretion to a level where it is no longer regularly inundated with saline water, terrestrial vegetation can colonise and the saltmarsh is outcompeted. This is observed in several areas of Blakeney Harbour where higher marsh is being colonized by terrestrial grasses and scrub vegetation.

3.3.3 Chemical requirements for European Flat Oyster (*O. edulis*)

O. edulis are bivalve molluscs and are therefore highly susceptible to poor water quality containing large amounts of heavy metals. Ideal locations for the species, would be next to biofilters, such as seagrass, forming a mutualistic relationship (Preston, et al., 2020, Gamble, et al., 2021).

They require their habitats to have good levels of oxygen (>3.5 mg/l) and salinity levels ranging from 25-35‰ to survive (Preston, et al., 2020). However, due to decreasing levels of pH in the ocean because of climate change, this poses a threat to mollusc calcification rates (Cyronak, et al., 2015), however a study completed by Prado, et al., (2016) suggest that *O. edulis* is more tolerable to changes in ocean acidification and warming than other molluscs, and observed that there is a potential for increased tolerance towards bacterial infection under more acidic conditions.

3.3.4 Chemical requirements for Blue Mussels (*M. edulis*)

MarLIN (2016) has established that blue mussels (also known as common mussels) have an intermediate tolerance towards heavy metal, synthetic compound, and hydrocarbon contamination with a relatively low sensitivity to changes in the water column. However, if there are any effects from chemical changes, they are predicted to have high to very high recovery rate. But it should be noted that in extreme cases, it has been observed that no growth occurs when the species is in a climate with the pH being 6.7 or lower (Berge, et al., 2005).

To conclude, blue mussels are likely to recover in climates where there are temporary fluxes in bad water quality and will likely recover within a few weeks. However, to optimise growth and reproduction, blue mussels should be placed in areas with good water quality standards (WFD, 2015).

3.3.5 Chemical requirements for Shingle beach

There are no specific chemical requirements for shingle beaches. The coarse nature of the shingle means that there is very little organic matter present within the shingle habitat, other than that which has come from storm debris, washed up algae and wind-blown seeds.

3.4 Biological

For appropriate restoration for one habitat or species it is important to consider interconnectivity between all species and habitats present in the ecosystem.

A species and habitat can have symbiotic or co-dependent relationships. Habitats provide areas for essential biological processes for species, such as nursery, spawning and foraging areas and help regulate conditions by filtering harmful substances and oxygenating the water column. On the other hand, species can be natural biological filters for harmful chemicals, natural cleaners eating parasitic organisms, and can help habitats propagate by spreading saplings and seeds.

If key habitats or species are removed, or do not have a sustainable population in an ecosystem, the ecosystem can collapse. For example, if a species that consistently regulates the population of other species is removed from the food web, populations of grazing species can increase which can increase pressures on the habitat and accelerate deterioration to eventual collapse. However, the same outcome can occur if the reverse happens and an abundance of one species occurs in an ecosystem. Therefore, it is wise to consider balance when implementing restoration techniques to ensure that the additional increase of certain species from restoration will only cause positive changes in the ecosystem.

3.4.1 Biological requirements for Seagrass (*Z. noltii*)

Seagrass can be prone to epiphytic coverage, which can deteriorate photosynthetic capacity (Brodersen, et al., 2015). However, seagrass provides habitat for grazing fish, which can help control epiphytic levels on seagrass (Gamble et al., 2021). Grazing from both seabirds and fish can help with plant propagation as seeds and rhizomes, allowing further colonisation of seagrass (Greve and Binzel, 2004, Gamble et al., 2021). It is also recognised that grazing from birds, particularly where large flocks of geese are present, can significantly decrease the area of a seagrass bed in a short space of time.

Mean growth rate per month is shown to become positive in seagrass colonies when >10,000 shoots or seeds are planted, however there is a significant increase in survival rate when there are more than 100 seeds planted (van Katwijk et al., 2015).

3.4.2 Biological requirements for Saltmarsh

Saltmarshes comprise a range of halophytic plants that range across the tidal cycle depending on their environmental requirements. Plant community structure and growth are dependent on positive species interaction (Siliman, 2014).

Saltmarshes rely on coastal systems, both tides and input of organic matter, to establish pioneer marshes and fortify current marshes. They provide nursery and stock habitats and cleaner water systems for other species in the ecosystem, such as bivalve molluscs and fish. Previous projects have shown that saltmarshes that are planted together with other species are more resilient. For example, Essex Wildlife Trust and the Environment Agency began a collaborative saltmarsh restoration pilot project on the Colne Estuary, Essex in 2018. There is a mutualistic relationship between marshes and species that use it as habitat. Burrowing crabs, sediment-depositing mussels, and mycorrhizal fungi can double plant growth by increasing oxygen and nutrient supply in the soil (Siliman, 2014).

3.4.3 Biological requirements for European Flat Oyster (*O. edulis*)

O. edulis are highly gregarious, meaning that oyster larvae prefer habitats where other oysters are already present. Oyster reefs are formed from large numbers of living oysters and dead shells which form a biogenic habitat, that in turn provides further substrate for larvae to settle (Preston, et al, 2020).

The species growth is determined by the phytoplankton abundance (growth > 0.5, gonad development > 1.68 chla in µg/l) and the concentration of suspended particulate matter (SPM) (<60 mg/l) (Preston et al., 2020). Seagrass and saltmarshes are natural accumulators of SPM and direct sources for phytoplankton

(Siliman, 2014, Gamble, et al., 2021). Therefore, it could be considered viable to develop mutualistic habitats with oysters, seagrass and saltmarshes as they are able to survive and grow in similar conditions, whilst supporting each other.

There are some species that are detrimental to the health of certain bivalves as was, and still is in some areas, evident from the spread of *Bonamia ostreae*, a parasite that can be lethal for shellfish and had a devastating effect on native oyster populations. The movement of oysters is strictly controlled in order to control any spread of the parasite.

3.4.4 Biological requirements for Blue Mussel (*M. edulis*)

M. edulis, like the *O. edulis*, is a gregarious species found in high densities that can form multiple layers, which are bounded by byssus threads (MarLIN, 2016), however mortality rates can increase as underlying mussels are starved or suffocated by the accumulation of silt, faeces and pseudofaeces, especially in rapidly growing populations (Richardson, Seed, and Naylor, 1990).

Blue mussels are vulnerable to predation pressures, such as dogwhelks, flounders, species of crab and birds including oystercatchers, with significant changes in population occurring from over predation (Holt, et al., 1998).

Blue mussels have two stages in settlement during their life cycle, the pediveliger settling on filamentous substrates and then moving on to suitable adult substrata by bysso-pelagic drifting (MarLIN, 2016), therefore the species relies on currents and tidal cycles to provide areas for settlement after the juvenile stages of their lifecycle is complete. Adult blue mussels require hard substrata (including bedrock, anthropogenic structures and other organism), which they attach to with detachable byssal threads (Wilcox and Jeffs, 2017).

To conclude, to reach the biological requirements for blue mussels, species should be in a habitat that has active tidal currents and some protection from predation to allow settlement, growth and spawning.

3.4.5 Biological requirements for Shingle beach

Although shingle habitats do not require any biological conditions to form, they can provide habitat for some species. Blakeney Point provides habitat for three pioneer communities and some grassland communities (Natural England, 2010).

3.5 Diversity and connectivity of habitats

For habitats to succeed in an area and provide a suitable area for species to thrive there needs to be a diversity of habitats to provide the ecological functions needed by species and connectivity between the various habitats. Many species require different habitats for various activities, including feeding areas, roosting or resting areas and spawning and nursery habitats to provide safe havens for larvae and juveniles. These habitats will have different features but will need to be connected to ensure safe migration between them.

A well-functioning ecosystem is key for habitat connectivity and providing support for key species that use an area. If any part of an ecosystem is degraded the survival of a species could be impacted. A good example of the importance of diversity and connectivity of habitats is when considering fish usage of an area. A fish species will use many different habitats during its life cycle and many fish have seasonal use of specific habitats that are vital to their survival. Fish spawn in particular areas when conditions are just right, often migrating great distances to return to the same spawning areas year on year. The juveniles then require specific habitats to feed and grow in a sheltered area that is high in productivity. They would then live in areas suited to their particular requirements, be that the open ocean, estuaries and rivers or reef areas. If any of these habitats is affected, it can impact on the overall success of the species. There are then knock on effects along the ecosystem as fish prey on other smaller organisms and also provide an important food source for many other species, including the seals and birds that use Blakeney Harbour.

Understanding how habitats interact and their use by species is therefore critical to maintaining the ecosystem function of an area. There is still uncertainty over the connectivity of systems, particularly in the water environment, where there are so many variables acting on the ecosystem. Examples are given above to show how the functioning of particular habitats and species increases with connectivity with another habitat or species. This has been considered in the recommendations to take forward for habitat restoration initiatives.

4 Description of baseline conditions (existing and historic) within Blakeney Harbour

4.1 Physical

This section summarises key points from the Conceptual Geomorphological Assessment (**Section 2.5** and **Appendix D**).

The system round Blakeney Harbour (**Figure 4**) consists of:

- Mixed sand and gravel beach-barrier spit (Blakeney Spit) including coastal sand dunes.
- Finer-grained back-barrier mudflat, saltmarsh and grazing marsh.
- Subtidal channel (Blakeney Channel) and ebb-tide delta.
- Open-coast sandflat.

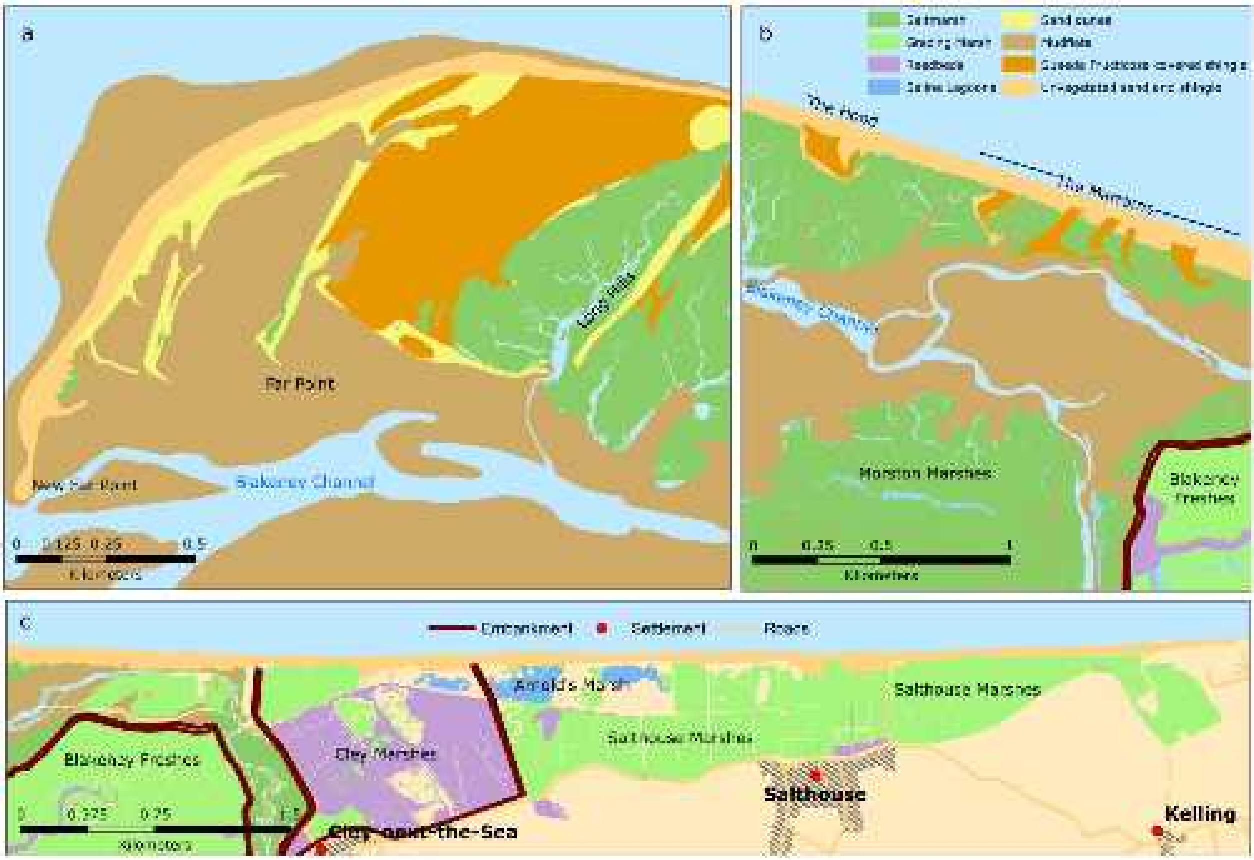

Figure 4 Key geomorphological elements of Blakeney Harbour and Blakeney Spit. The spit comprises three sections: a. Blakeney Point; b. the Hood and the Marrams; c. the Cley-Salthouse barrier (Pollard, 2020)

The geomorphology of Blakeney Spit has changed over time. Westwards migration of the Blakeney Point has occurred at a mean 100-year rate of about 3.5m/year ending where tidal flow takes place through Blakeney Channel (Andrews, 2020). Pollard et al. (2020) showed that over a 130-year period (1886-2016), Blakeney Spit has, on average, retreated in a landward direction, at a mean retreat rate of 0.60m/year. Barfoot and Tucker (1980) described the changes that have taken place at Blakeney Point between 1921 and 1979. They showed that it remained relatively stable due to sand dune colonisation with vegetation which appeared, and became well established, in the 1920s.

The Blakeney Harbour region is a complex and varied environment. Therefore, it was deemed appropriate to separate out four key regions for habitat creation / restoration initiatives, based on the Geomorphological Conceptual Modelling Report, and consider each of them separately. This is because each region experiences varying conditions (i.e. coastal morphological processes), and each region is expected to be affected by future climate change scenarios differently.

These regions are as follows (**Figure 5**):

- Region 1: Blakeney Point.
- Region 2: Stiffkey Marsh and Blakeney Pit.
- Region 3: Central Region.
- Region 4: Cley Channel and Blakeney Freshes.

The current and future baseline conditions for each of these regions are discussed below.

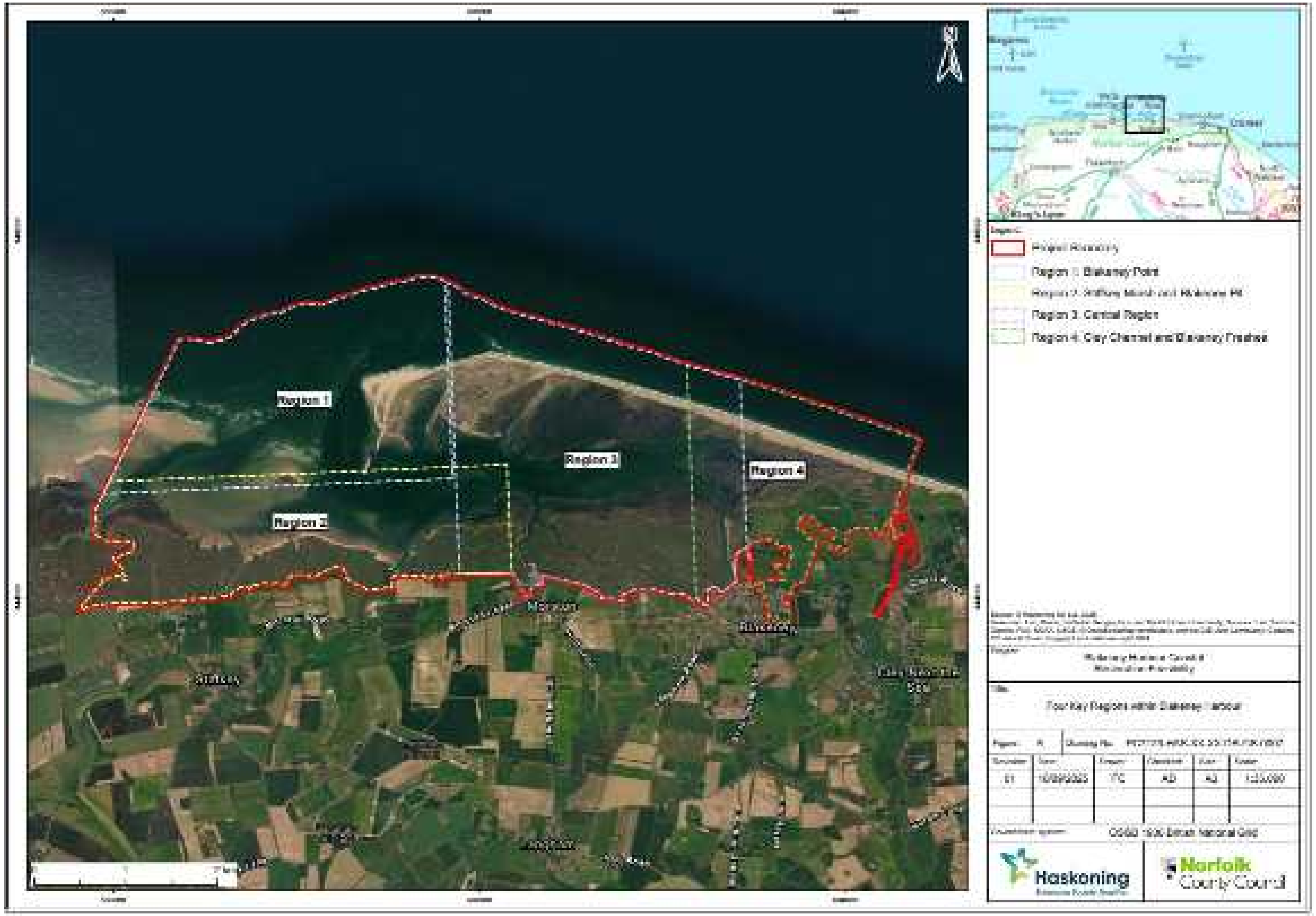

Figure 5 Four key regions of Blakeney Harbour

4.1.1 Region 1: Blakeney Point

The key features of this region are shingle ridges, dune habitat and a lower lying inlet with drying mudflats and fringing saltmarsh together with sand flats (**Figure 6**). The latest report from Natural England (2021) on the vegetated shingle in the harbour confirms that it is in favourable condition, meaning it is currently reaching all requirements under SSSI regulations. There is a patch of seagrass within the lower lying inlet (Stanley Cockle Bight) protected by Blakeney Spit, although the extent of the seagrass is not known. As mentioned in the Geomorphological Conceptual Modelling Report, the shingle ridges move westwards, although their overall function is mostly maintained. The inlet region that supports the saltmarsh, mudflat and seagrass habitat currently experiences relative stability, with a limited supply of fine material. A potential oyster restoration zone was identified within Restoring Meadow, Marsh and Reef (ReMeMaRe) maps that encroaches into the western edge of the site (**Figure 7**).

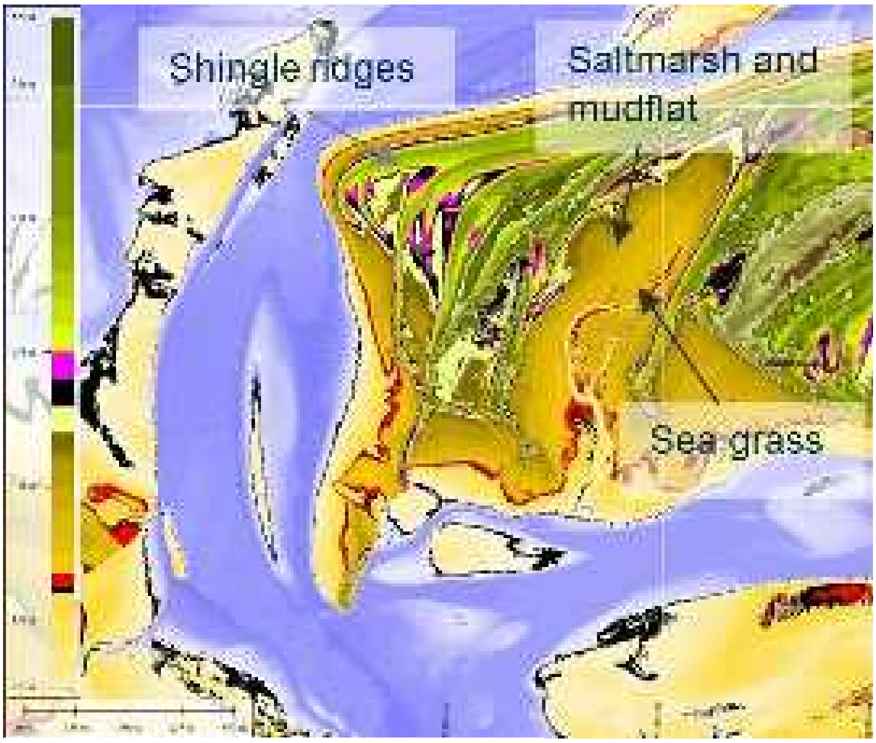

Figure 6 Region 1: Blakeney Point

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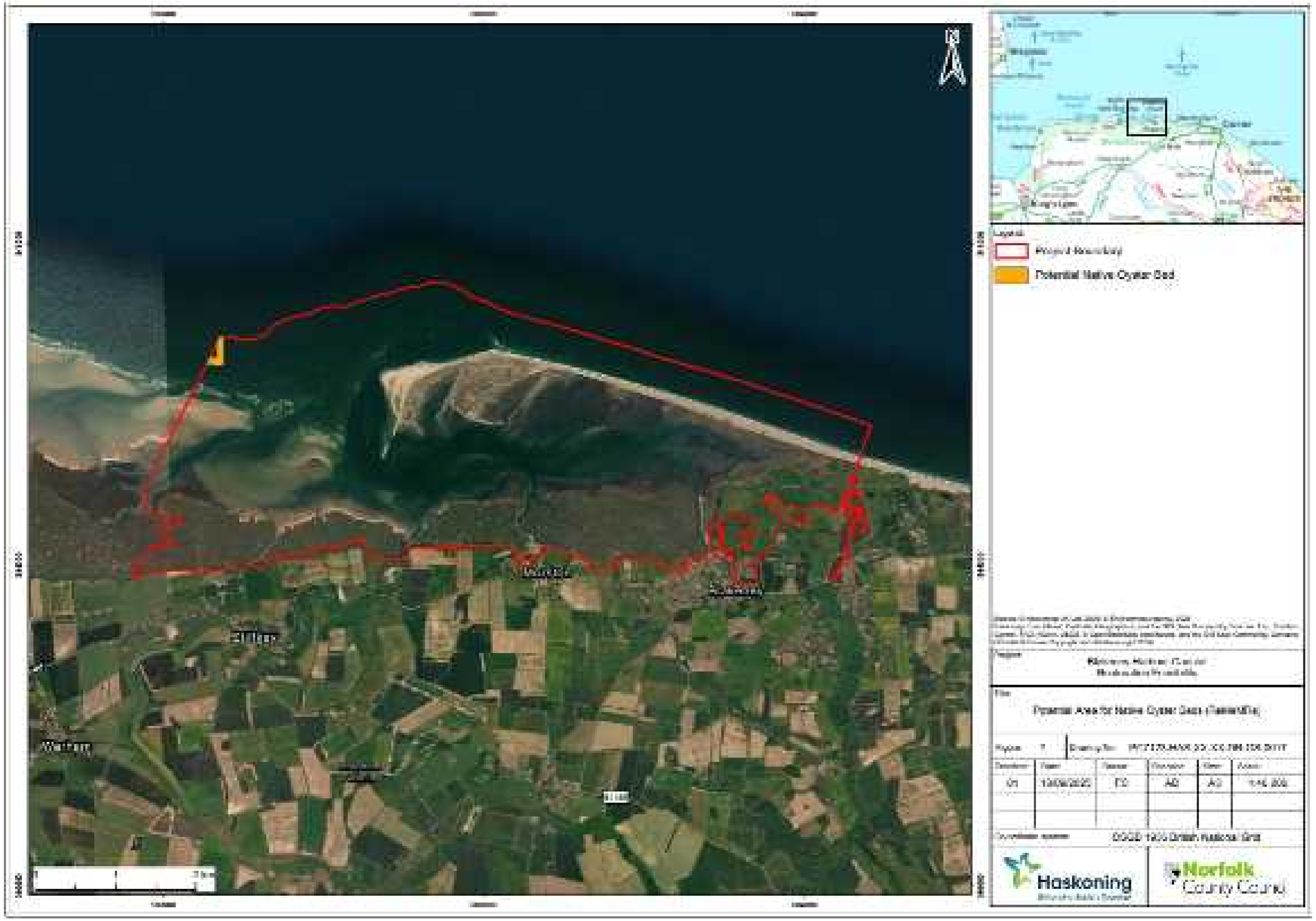

Figure 7 Location of potential native oyster bed (ReMeMaRe)

In the future, the region is expected to have a limited risk of significant breach of the shingle ridges. With sea level rise of around 0.3m (potentially within the next 25 to 30 years), assuming no significant additional sediment supply, the inlet will experience deeper water depths, with a larger area of inlet being submerged at MHWN, potentially increasing the area where sea grass could colonise as the saltmarsh vegetation is pushed further up the shoreline. At present, seagrass was observed in this area in 2018 but was not observed in a 2023 survey. The reasoning for this is not known but it could potentially be due to saltmarsh vegetation outcompeting the seagrass or predation by birds or fish.

4.1.2 Region 2: Stiffkey Marsh and Blakeney Pit

The key features of this region are the sandbanks, seagrass, South Side (Morston) marsh, and the South Side mussel bed (**Figure 8**). **Figure 8** also shows the oyster cages where Pacific oysters are commercially harvested. The eastern patch of seagrass was observed during the site visit (**Section 2.4**) and was small in size. New Far Point is the southern edge of Blakeney Point and, as it has developed southward over time, it has constricted flows in the channel as it pushes the channel south against Stiffkey Marsh. As such, the flows in this region are strong. There is a strong flood dominance in this region, as described in the Geomorphological Conceptual Modelling Report and shown in **Figure 9**. Although this does not lead to the formation of large sandwaves, the meeting of the flood and ebb tides in area B on **Figure 9** shows that sediment is pushed to the centre of the existing mussel beds. This has formed small ridges of sediment around the mussel beds.

Figure 8 Region 2: Stiffkey Marsh and Blakeney Pit

Figure 9 Tidal flow directions. Dark red arrows indicate flood dominance and pink arrows indicate ebb dominance

Region 2 is expected to undergo significant future changes, due to sea level rise and changes to Blakeney Point. These projections are detailed within Section 5.2 of the Geomorphological Conceptual Modelling Report (**Appendix D**). However, generally, there is potential both for change in the position of the New Far Point and for increased flow and change in the pattern of flow through the entrance to the main Harbour area.

4.1.3 Region 3: Central Region

The key features of this region are a section of extensive saltmarsh and a long stretch of shingle along the Blakeney spit, some of which supports vegetation, along with areas of coastal dunes (**Figure 10**). The region, particularly the main channel and the shape and extent of the saltmarsh, has been moderately stable over the past 200 years. However, the shingle has experienced erosion and is further set back compared to the 1800s. There is no clear evidence of diminishing volume. Shingle ridges are expected to continue to roll-back. In places, as part of this rollback process, there is expected to be overwash and failure of the ridge.

There is little evidence of changes in the level of saltmarsh in the past two decades, based on LiDAR, suggesting that there is minimal deposition of fine sediment, as discussed in the Geomorphological Conceptual Modelling Report (**Appendix D**).

An 1815 Ordnance Survey (OS) map (**Figure 11**) revealed that there were historic Native Oyster pits within Region 3.

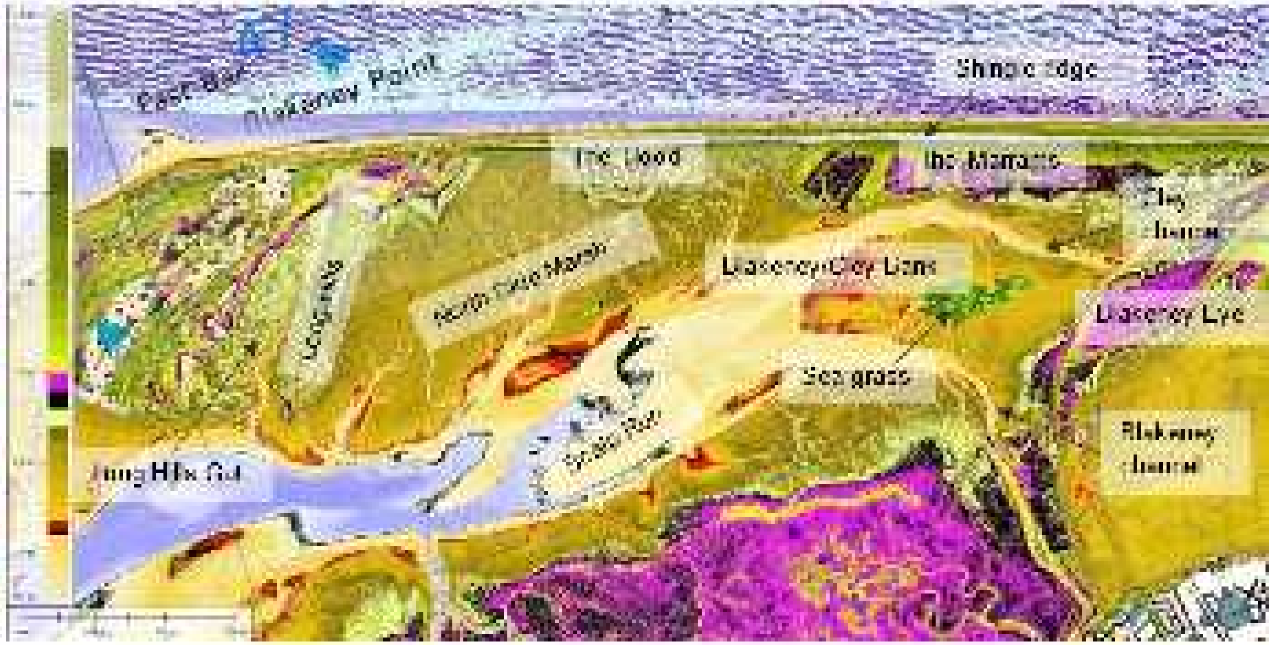

Figure 10 Region 3: Central Region

Figure 11 Native oyster pits in Blakeney Harbour, 1815. Circle indicates location of the pits.

Future changes in this region include the roll-back of the shingle ridge, potentially by 130 m by 2100. Assuming continued sediment supply, it would be anticipated that while there may be increased risk of breach to the ridge during more extreme events, it might be anticipated that the ridge will rebuild as part of the process of roll back. The Geomorphological Conceptual Modelling Report considered it unlikely that a fully tidal breach would develop. There is also expected to be deeper flooding over the marsh area with sea level rise. This potentially increases the opportunity for increased deposition, critically depending on the level of suspended sediment within the water column.

4.1.4 Region 4: Cley Channel and Blakeney Freshes

This region covers the two principal features of the maintained channel of the River Glaven through the high level marsh of the Cley Channel and the large enclosed (defended) area of the Blakeney Freshes (**Figure 12**). For the past couple of decades, the Cley Channel has been managed with local dredging. This is to maintain navigation, principally by clearing the channel where the over steepened edges have collapsed into the main channel.

The Blakeney Freshes were reclaimed in the early 13th century and have developed since then as important fresh/brackish water marsh with areas of pasture, reed beds, drainage ditches and areas of open water. Some of the old drainage creeks are evident within the varied topography, most notably the old Great Barnett creek (**Figure 12**). Blakeney Freshes are fed by freshwater from the River Glaven, a chalk stream, with water levels on the marsh currently controlled by the Environment Agency, who operate a sluice and by adjusting smaller inflow ‘flaps’ on the eastern side of the site (Downes, 2018).Current management policy (North Norfolk SMP 2008) suggests the need for transition from holding the line to one of managed realignment, with the need to adapt management to avoid sudden change.

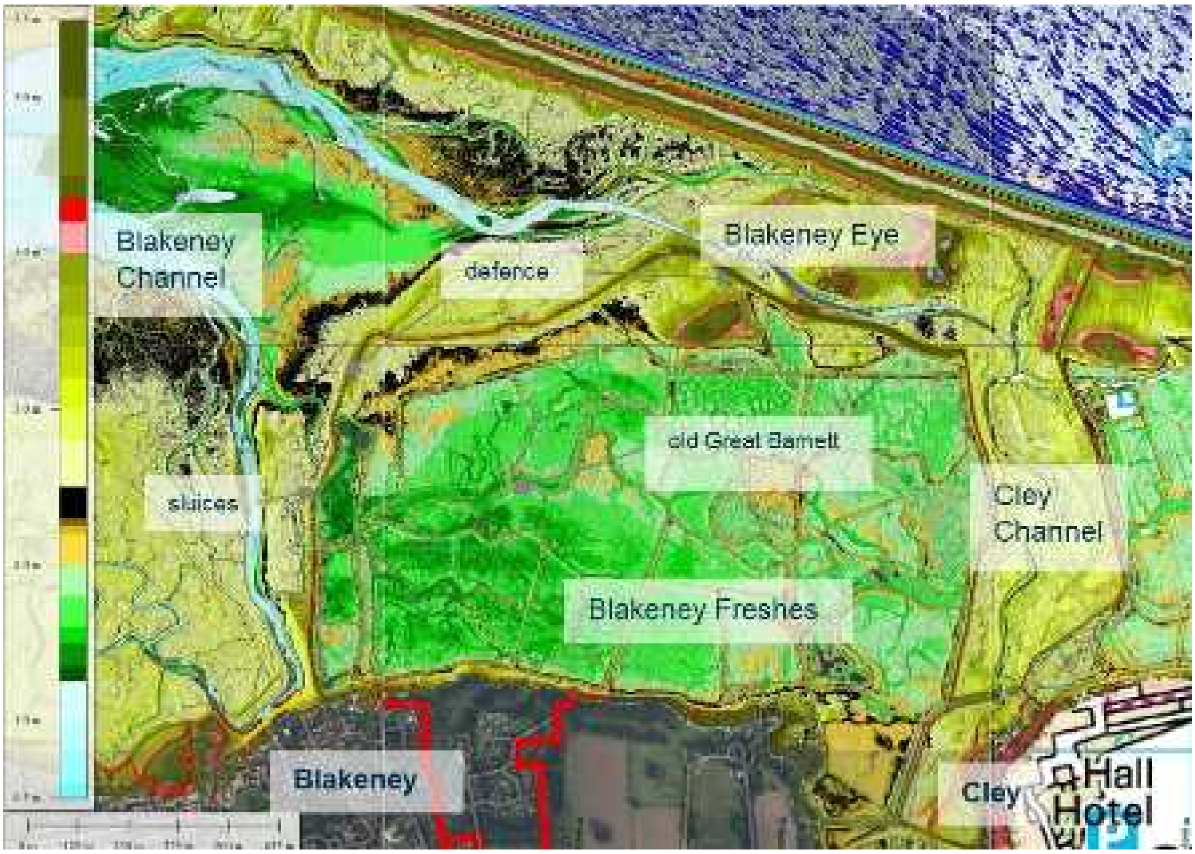

Figure 12 Region 4: Cley Channel and Blakeney Freshes

Within this region, sea level rise is expected to subject the high marsh within the corridor of the Cley Channel to flooding on normal high waters. More regular flooding can shift plant communities, favouring more flood dominant species such as *Spartina spp*. Additionally, this may increase the risk of increased erosion and change sediment redistribution which can alter the functioning of the marsh. Within the Blakeney Freshes, there is expected to be more significant future changes, with more frequent overtopping of the existing defences. At present it is assessed that the defence could be overtopped on a 1 in 20 to 1 in 50 year event. The risk of overtopping of the embankment will increase with sea level rise. The Geomorphological Conceptual Modelling Report states that by 2050 under the mid sea-level rise scenario, over half of the Freshes could be inundated for longer than ten days, a potentially critical threshold for current wet grassland survival, should the embankment fail.

4.2 Chemical

The WFD results in the designation of all surface waters (rivers, lakes, transitional (estuarine) and coastal waters and groundwater) as waterbodies and provide targets for the achievement of good ecological status by 2027. The Environment Agency is the responsible authority for WFD compliance in England. The WFD applies to a distance of one nautical mile (nm) offshore.

The WFD specifies the factors, referred to as quality elements, which must be used in determining the ecological status or ecological potential and the surface water chemical status of a surface waterbody.

4.2.1 WFD bodies relevant to Blakeney Harbour

The WFD waterbodies that are relevant to this Project are shown on **Figure 13**, and a summary of the water body information is displayed in **Table 2 and Table 3.**

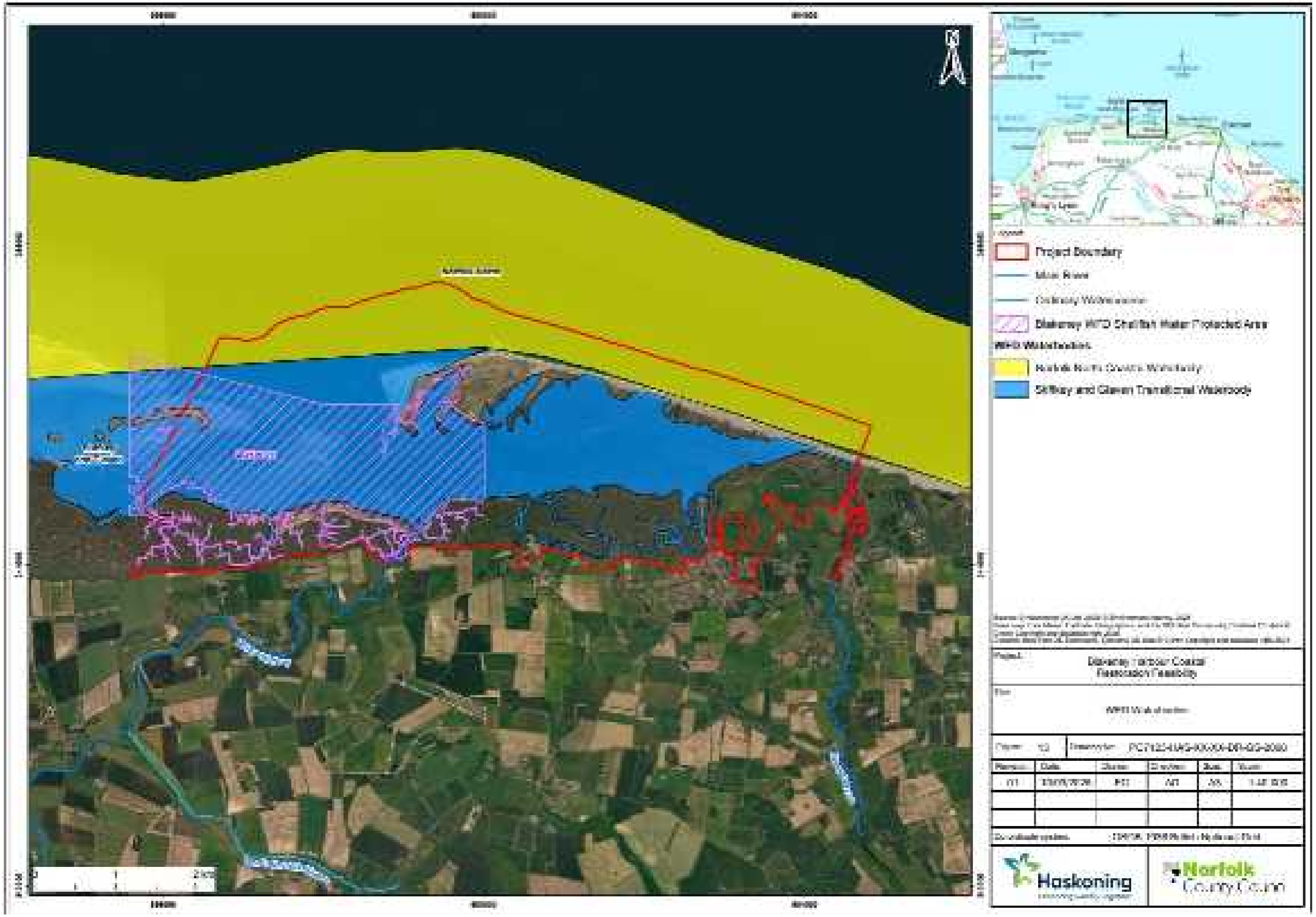

Figure 13 WFD waterbodies at Blakeney Harbour

Table 2 Water body information for coastal and transitional water bodies around Blakeney Harbour

Water body parameters	Stiffkey and Glaven	Norfolk North
Water body ID	GB520503403600	GB640503300000
Water body type	Transitional	Coastal
Water body total area (km^2)	16.54	168.314
Ecological status	Bad (2022) Due to 'Bad' status of biological quality elements and phytoplankton and 'High' status of physico-chemical quality elements and arsenic, copper and zinc	Moderate (2014) Due to 'Moderate' status of biological quality elements, invertebrates and physico-chemical quality elements
Chemical status	Fail (2019) Due to priority hazardous substances, mercury and its compounds and Polybrominated diphenyl ethers (PBDE)	Fail (2019) Due to priority hazardous substances, mercury and its compounds and PBDE
Target water body status and deadline	Good ecological status by 2027 Good chemical status by 2063	Good chemical status by 2063
Hydromorphology status of the water body	Hydromorphological supporting elements 'not high' and hydrological regime 'supports good'	-
Is it a heavily modified water body (HMWB)?	No	Yes

Table 3 Water body information for the riverine water bodies around Blakeney Harbour

Water body parameters	Stiffkey	Glaven	Binham Tributary
Water body ID	GB105034055840	GB105034055780	GB105034055830
Water body type	River	River	River
Water body total area (km^2)	32.201	19.777	4.489
Ecological status	Moderate (2022) Due to ‘High’ status of fish, invertebrates, phytobenthos sub elements and several physico-chemical quality elements and specific pollutants	Moderate (2022) Due to ‘Moderate’ status of biological quality elements and macrophytes and phytobenthos	Moderate (2022) Due to ‘Bad’ status of biological quality element and fish and ‘Moderate’ status of physico-chemical quality elements
Chemical status	Fail (2019) Due to priority hazardous substances, benzo(g-h-i)perylene, mercury and its compounds and PBDEs	Fail (2019) Due to priority hazardous substances, mercury and its compounds and PBDE	Fail (2019) Due to priority hazardous substances, mercury and its compounds, Perfluorooctane sulphonate (PFOS) and PBDE
Target water body status and deadline	Good chemical status by 2063	Good ecological status by 2027 Good chemical status by 2063	Good status for biological quality elements and fish by 2027 Good status for chemical conditions by 2063
Hydromorphology status of the water body	Hydromorphological supporting elements ‘not high’ and hydrological regime ‘does not support good’	Hydromorphological supporting elements ‘not high’ and hydrological regime ‘supports good’	Hydromorphological supporting elements ‘not high’ and hydrological regime ‘supports good’

Water body parameters	Stiffkey	Glaven	Binham Tributary
Is it a HMWB?	Yes	No	Yes

4.2.2 Summary of chemical information

The data presented in **Table 2** and **Table 3**, in addition to the information presented in a report by WWF (2023) (which provides the findings of an earlier stage of the project) shows that there are several pollutants of concern in and around Blakeney Harbour. These include mercury and its compounds, PBDEs and PFOSs. Such chemicals were used in many consumer products in the past and are very persistent. This is of concern as some of these chemicals can bioaccumulate (gradually build up in an organism over its lifetime), can be persistent (Costa and Giordano, 2014) and can be biomagnified in food chains (become increasingly concentrated in higher trophic species). Monitoring information presented in the WWF report (2023) reports that concentrations of mercury within the study area are indeed elevated in biota, with concentrations of mercury within sampled common dab (*Limanda limanda*) consistently above Environmental Quality Standards (EQS) - thresholds that define acceptable levels of individual substances, above which there may be adverse effects on ecological receptors. It is unknown what has caused the elevated concentrations of mercury in the study area. Similarly, PBDE concentrations within sediment and biota samples also significantly exceeded EQS. The limited sampling data available around Blakeney Harbour for PFOS and benzo(g-h-i)perylene reported concentrations that were within EQS.

Within Stiffkey and Glaven catchments and Blakeney Harbour, there is also *E.coli* in the shellfish and waters (Centre for Environment, Fisheries and Aquaculture Science (Cefas), 2017). Higher levels of bacteria closer to the shoreline may impact on the microbiological quality of nearby shellfish beds and impede the compliance of the shellfish water with the requirements of the Shellfish Waters Directive (Cefas, 2017), which Blakeney Shellfish Waters (5) are designated under (**Figure 13**). For *Mytilus* spp., *C. gigas* and *O. edule* within Blakeney Shellfish Waters, Cefas have assigned a classification of Long Term (LT) Class B. This means that the waters have consistently (over five years) met the thresholds for Class B, including that 90% of samples must be ≤ 4,600 *E. coli*/100g. These classifications are used to determine the suitability of shellfish for human consumption, based on microbiological standards. Consultation with a local ex-mussel fisherman revealed that the water quality dropped from Grade A to Grade B, and later bordered on Grade C, which severely impacted mussel harvesting due to purification requirements. A current classification of B indicates a high level of *E. coli* contamination. The *E. coli* presence is likely caused by multiple sources. During the stakeholder consultation meetings, it was suggested that excrement from increased seal populations could have contributed to this. Seal faeces can contain *E. coli* (Vingino *et al*., 2021) and is also nutrient-rich (Bokhorst *et al*., 2019), so this is a possibility. However, all potential sources of *E. coli* in the harbour need to be investigated to build an accurate picture of risks to water quality, including by seal faeces for *E. coli* presence. This would include undertaking an updated study based on previous work by Cefas (2017), which approximated the average loadings of faecal coliform concentrations from several sources, including from common seals and grey seals.

The chemical and nutrient pressures within the region could potentially be attributed to nearby wastewater processing and discharge, agriculture (including fertiliser usage), industry, landfill and waste management, urban development, shipping and discharge from boats (WWF, 2023; Cefas, 2017). Dredging also has potential for remobilisation of contaminants and nutrients and is often required in coastal waters, for example for channel widening, maintenance and silt removal. In Blakeney, for example, the Blakeney Channel and Cley Channel have been previously dredged to maintain navigation access. However, it is acknowledged that the sediments dredged from the channels are mostly coarser sandy sediment which have less of an affinity for retention of contaminants. Additionally, vessel mooring activity within the harbour may cause sediment disturbance due to tides and winds causing chains to scour the seabed, which can also resuspend sediment (Byrnes & Dunn, 2020). Around Blakeney Harbour, the re-suspension of PBDE-contaminated sediment is considered a likely pathway for PBDEs entering the environment (WWF, 2023).

The Norfolk Rivers Trust is an independent charity that aims to restore, protect and enhance the rivers of Norfolk. As part of this, they have identified some key water and sediment quality concerns affecting the rivers upstream of Blakeney Harbour. They also deliver initiatives and schemes to conserve and restore the rivers, some of which are displayed in **Table 4**. During consultation with the Norfolk Rivers Trust, high phosphorus concentration was considered the main concern in the Glaven and Stiffkey, which was attributed to small water treatment centres and septic tanks in the Stiffkey catchment that cause localised phosphate spikes. Norfolk Rivers Trust mentioned that agriculture has a comparatively small role to play in the deterioration of water quality in the Stiffkey and Glaven.

Table 4 Key chemical pressures in the rivers upstream of Blakeney Harbour and initiatives implemented by the Norfolk Rivers Trust

River	Identified Water and Sediment Quality Challenges	Initiatives to Improve Water Quality
Stiffkey	○ Agriculture and sewage leads to significant nutrient input into this chalk stream. Due to historic leaching of fertilisers, there are high nitrate levels in the aquifer and groundwater. ○ There are a high number of septic tanks on the river, particularly in the Fulmodeston and Saxlingham areas ○ The increased plant and algal growth due to the high nutrient input can deplete the oxygen levels in the water and threaten the natural chalk stream flora and fauna ○ As Stiffkey has a low gradient, was historically straightened and is disconnected from the floodplain, the river is particularly vulnerable to siltation. Most of the silt is from roads, fords and farm access tracks.	○ There have been a few schemes that restore floodplains along the Stiffkey, including Swanton Novers and Warham, which provide benefits to the water quality along the river (Norfolk Rivers Trust, n.d. a). ○ As part of the Water Sensitive Farming Initiative, there was an on-farm nature-based solution in 2020 which aimed to improve water quality on the River Stiffkey (Norfolk Rivers Trust, n.d. b). It also provided wider benefits such as water storage, habitat creation and increased biodiversity ○ An Integrated Constructed Wetland (ICW) was also created in 2023 in Stiffkey village, which aimed to provide natural wastewater treatment and subsequently improve water quality and the status of surrounding habitats (Norfolk Rivers Trust, n.d. c). A total of three ICWs have been constructed on the river in the past three years. ○ There are ambitions to put wetlands below every water treatment works in the Stiffkey catchment.
Glaven	○ This river has high levels of dissolved oxygen, supporting aquatic plants and animals ○ The concentrations of ammonia and phosphate are low and the river supports a range of species that require clean water, all of which indicates that there are low levels of pollution	○ The River Glaven Conservation Group (RGCG) is a 25-year-old organisation of locals, landowners, conservation bodies and river restoration professionals that aims to improve water quality in the River Glaven (RGCG, n.d.) ○ There have been efforts to reduce siltation and sedimentation by increasing sediment retention, through the restoration of ponds and the installation of new wetlands (Norfolk Rivers Trust, n.d. d)

4.3 Biological

A desk-based review has been conducted to understand the current and past extent of habitats and species in the Blakeney Harbour area followed by the site visit and consultation (both discussed in **Section 2**) to further investigate particular habitats and species

4.3.1 Key species and habitats

Figure 14 shows the distribution of saltmarsh, seagrass, blue mussel and vegetated shingle in each of the four regions of Blakeney Harbour, as defined in **Section 2.5. Table 5** shows the data used for this figure.

It should be noted that the observational data approximates location and further surveys of existing habitat should be undertaken, as suggested in **Section 6.2.2**.

Table 5 Summary of data used for Figure 14

Habitat / species layer	Source
Blue mussel observations	Observed during site visit National Biodiversity Network (NBN) atlas
Blue mussel habitat	Norfolk Biodiversity Information Service (NBIS)
Coastal vegetated shingle	NBIS
Saltmarsh	Environment Agency
Dwarf seagrass observations	Natural England Marine Biological Association Joint Nature Conservation Committee (JNCC)
Seagrass extent 2024	Natural England

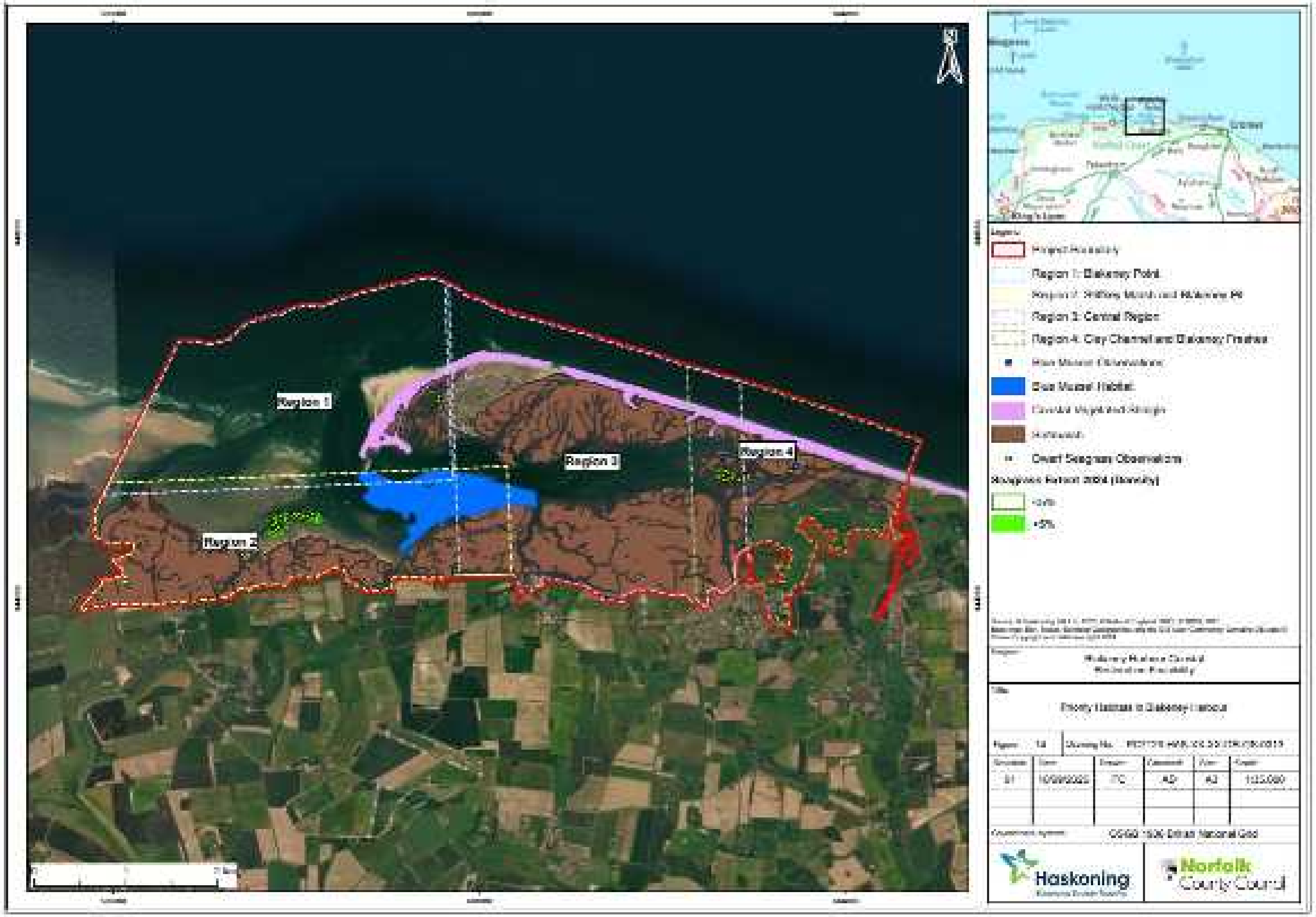

Figure 14 Priority habitats at Blakeney Harbour

4.3.1.1 Saltmarsh

Saltmarshes can provide habitats for a range of key species, providing ecosystem regulation, nesting habitat, and a source of carbon storage. For example, saltmarshes support the four species of terns that often use Blakeney Point as an area for breeding (JNCC, 2024). Saltmarshes are also the most widespread and important of the Blue Carbon habitats outside of the tropics (Hudson, et al., 2023). They bury and store more carbon than any other subtidal (seagrass), and terrestrial (forests) habitats (Mcleod, et al., 2011). Long-term storage of carbon is linked to highly productive ecosystems, depositional environments that trap carbon from both autochthonous and allochthonous sources, and low oxygen concentrations in the sediment that promote the preservation of carbon-rich organic material (Hudson, et al., 2023).

In the past century the UK has lost up to 50% of its natural saltmarsh habitats due to land reclamation, coastal squeeze, pollution and drainage (JNCC, 2003) and this trend continues with most saltmarshes being in unfavorable condition (Natural England, 2015).

Using the past 16 years as a comparison, the saltmarshes in the project site show little change.
The area has a vast extent of saltmarsh, particularly along the southern edge of Blakeney Harbour mainly comprising Stiffkey marshes, Morston to Blakeney Marsh and Blakeney Freshes (behind the seawall and converted from saltmarsh to freshwater/brackish marsh. However, there have been some changes to certain sections of the marshes in the past. The Restoring Meadow, Marsh and Reef (ReMeMaRe) mapping of saltmarshes uses 2006-09 as a baseline condition against laser imagery of saltmarsh extents between 2016 to 2019 (Environment Agency, 2025). Since 2009, the extent of saltmarsh has remained relatively stable with 786ha showing no signs of change, with 44ha gained in the area, but 53 ha has been lost (see **Figure 15**). While there is high confidence in this mapping, it should be noted that some instances of change may be a result of the seasonal differences in the timing of image capture. It should be noted that within the harbour in the past (dates not known) *Spartina* was planted, likely at the seaward edge of the marsh in an attempt to stabilize areas that could have been eroding, and has encroached on large areas of the harbour. This species is known for its ability to outcompete other species on the lower marsh and form a monoculture. It has likely had an adverse effect on the lower marsh areas in the harbour over the years.

Anecdotal evidence (local stakeholder consultation) indicates that the planting of *Spartina* grass occurred historically in the harbour, with an increasing distribution over the years. This subsequently resulted in a decrease in the distribution of mudflats. Current extent of saltmarsh at Blakeney Harbour is shown in **Figure 14.**

Figure 15 Saltmarsh loss within Blakeney Harbour (Source: ReMeMaRe; Environment Agency (EA), 2025)

4.3.1.2 Blue Mussel

Blue mussel beds are fundamentally important as biogenic reef habitats and are critical for ecosystem functioning. For example, due to their roles as filter feeders, blue mussels can remove suspended particles, bacteria and excess nutrients from the water system. Historically, blue mussels in Blakeney Harbour could also be farmed and consumed, however, this no longer occurs due to the smothering from sediment movement and water quality degradation.

There have been widespread declines in blue mussel beds across The Wash (and in Europe in general) due to a variety of compounding factors such as overfishing, invasive non-native species (INNS) and disease (Cooper, West and Frost, 2025). From the late 1980s/in the 1990s, there was increased fishing pressure and declining stocks of cockles and mussels in The Wash (Dare et al., 2004). There was reported to be "negligible" spatfall and recruitment of intertidal mussels during this time (Dare *et al*., 2004). In Blakeney Harbour, the loss of blue mussels may have worsened due to the eastward flow of water on the North Norfolk Coast, which may transport mussel larvae away from the area, causing lower and more sporadic recruitment of cockles and mussels (Dare *et al*., 2004; Cooper, West and Frost, 2025). However, in The Wash, there has been evidence of recovery since 2023 (Cooper, West and Frost, 2025).

The latest data shows blue mussel habitat extents in the Blakeney Harbour (European Nature Information System (EUNIS), 2007 habitat maps), indicating the presence of over a hectare of blue mussel habitat associated with intertidal sediment. Observation mapping services, such as the NBN atlas, show the presence of blue mussels around the project site. The current extent of blue mussels at Blakeney Harbour are shown in **Figure 14**. The site visit observed blue mussel habitat in this area, mostly with juvenile blue mussels in the areas that were observed (as shown in **Plate 4**).

4.3.1.3 Native Oysters

Native oyster beds provide numerous benefits for other species. With their excellent water filtration capabilities, filtering up to 200 litres of water per day (Thomas *et al*., 2022), oysters can remove pollutants, improving water quality and clarity. This ultimately benefits species such as seagrass, as clearer water improves photosynthesis. Furthermore, since oyster reefs provide rough, three-dimensional substrates, they provide niches and habitat that can benefit a variety of species and prey. This role as an ecoengineer boosts marine biodiversity and productivity, including birds and fish. It has been estimated that 10m^2 of restored oyster reef produces 2.6 kg of fish and large crustaceans per year (Peterson, Grabowski and Powers, 2012).

Native oyster reefs have been historically decimated in the UK and Europe due to a combination of factors, including disease, over-exploitation and the introduction of the invasive Pacific oyster in the 19th Century. In the UK, populations have declined by 95% and the species is on the brink of extinction (Preston *et al*., 2020). There are currently no native oyster beds in Blakeney Harbour.

However, an 1815 OS map (**Figure 11** in **Section 4.1.3**) shows that on the southern side of the main channel between Morston and Blakeney, there is an area noted as being oyster pits. Since the first introduction of Pacific oysters to the UK was in 1890 (Humphreys *et al*., 2014), it is assumed that these are native oyster beds. As such, there is evidence of historic native oyster beds in the area. It should be noted that the conditions where these pits were identified are likely to have changed since the 1800s.

Due to the critical need for native oyster recovery, the Environmental Agency (2024) developed an online layer that recommended potential areas for native oyster foundations. This data is based on sediment type, current energy criteria and local expert advice. Only a small section of the designated restoration area for this project shows potential areas for native oyster restoration (12.9m^2) (**Figure 7**). Oysters are tolerant of moderate wave exposure and require areas of oxygenated water, therefore the site may be suitable for native oyster restoration. This is further explored in **Section 5.2.2**.

4.3.1.4 Seagrass

Seagrasses are flowering plants that, when growing in large groups, form meadows. Seagrass meadows are highly valuable habitats and act as biodiversity hotspots. By providing nursery grounds for commercially valuable juvenile fish and shellfish, seagrass meadows also support coastal livelihoods and food security. As primary producers, seagrasses can sequester huge amounts of carbon and are globally responsible for the storage of 10% of the total burial of marine carbon (Fourqurean *et al*., 2012).

Seagrass habitats have declined due to anthropogenic pressures and climate change over the past century. Green, et al., (2021) found that the UK seagrass population have potentially declined by 44% since 1936, which could have potentially stored 11.5 million tonnes of carbon. The information of seagrass history in Blakeney harbour is limited past 2008 but more recent surveys have shown changes over time.

There are recent records of dwarf eelgrass being found in the study area. EUNIS habitat maps (2008) show 14.38ha of seagrass beds within the project site and observation mapping services, NBN and MarLIN, both confirm the areas drawn via the EUNIS habitat maps that dwarf eelgrass is present. **Figure 16** and **Figure 17** show the extent of seagrass loss from 2016 to 2024 in Blakeney Harbour as recorded by surveys undertaken for the EA. One of the areas, showing as a point source of data behind Blakeney Point (**Figure 6**) was observed as a small patch of seagrass in 2018 but not seen in 2024.

The 2024 extent of seagrass is shown in **Figure 18** to **Figure 20**. An additional area was observed during the site visit, that was known to Norfolk Seaweed, which was a narrow strip of *Z. noltii*, the same species as observed in the other areas. This area is shown on **Figure 19,** identified as ‘additional area’ of seagrass.

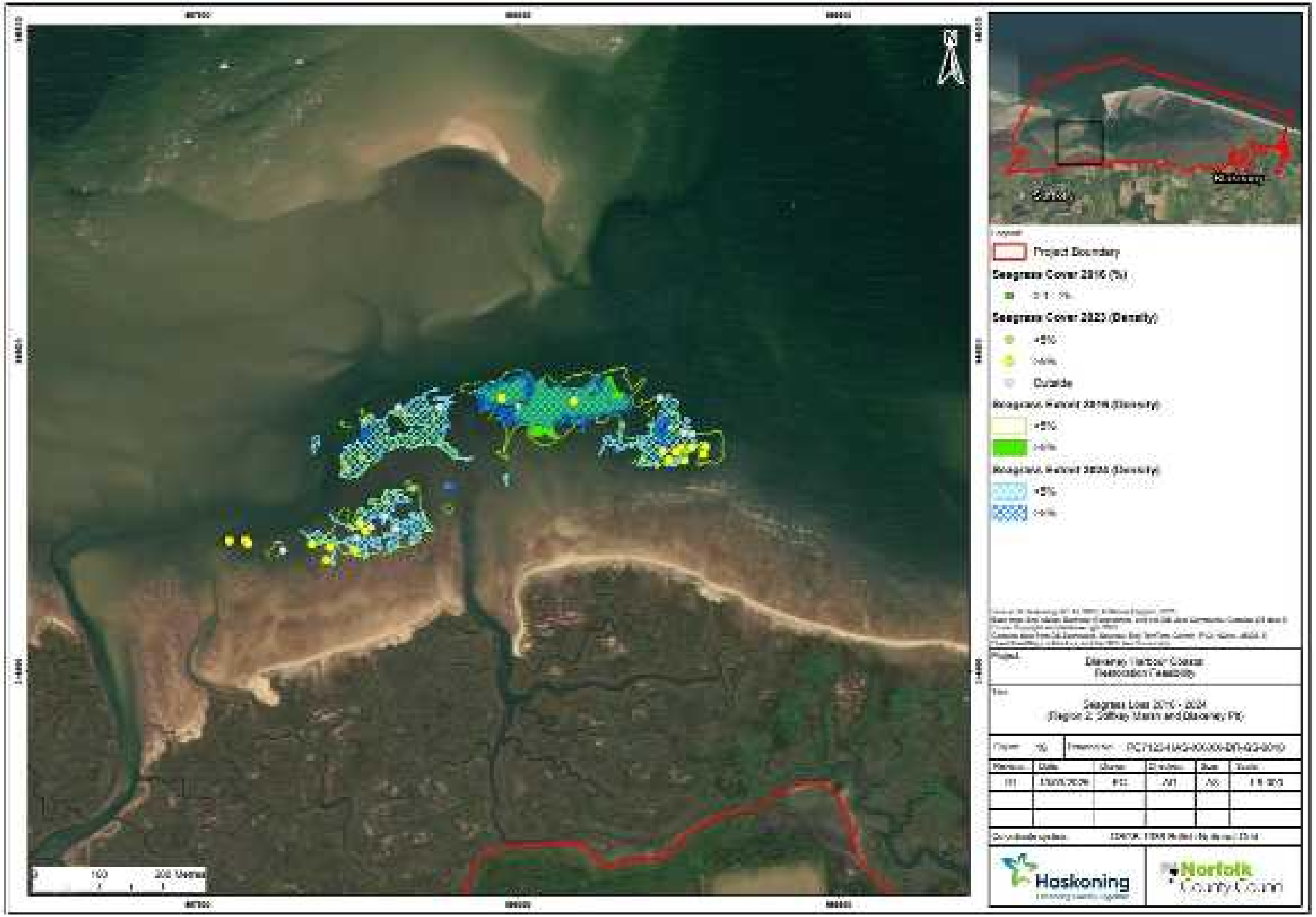

Figure 16 Seagrass loss in Region 2: Stiffkey Marsh and Blakeney Pit (source: Environment Agency, 2025)

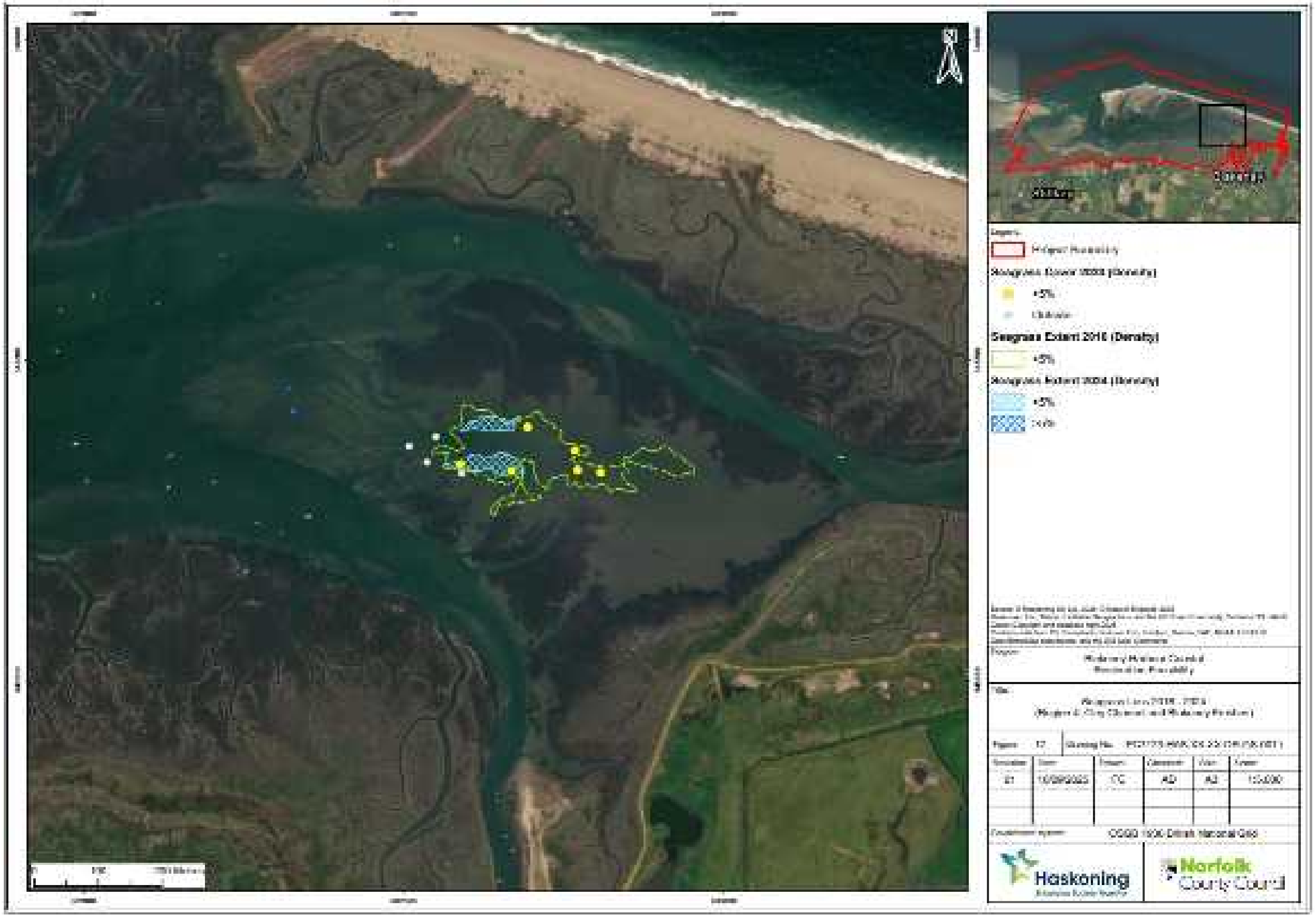

Figure 17 Seagrass loss in Region 3: Central Region (source: Environment Agency, 2025)

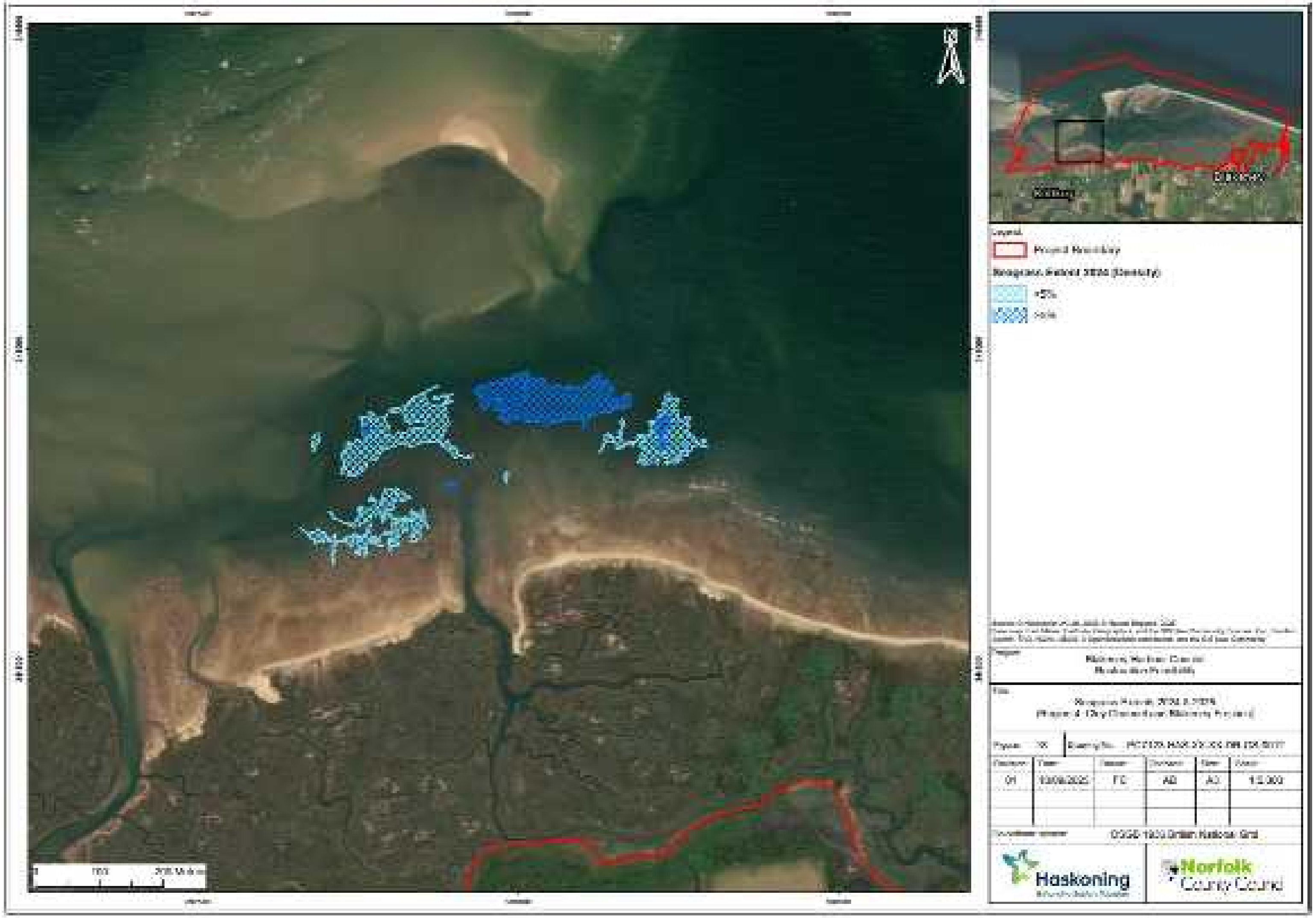

Figure 18 Current extent of seagrass in Region 2: Stiffkey Marsh and Blakeney Pit

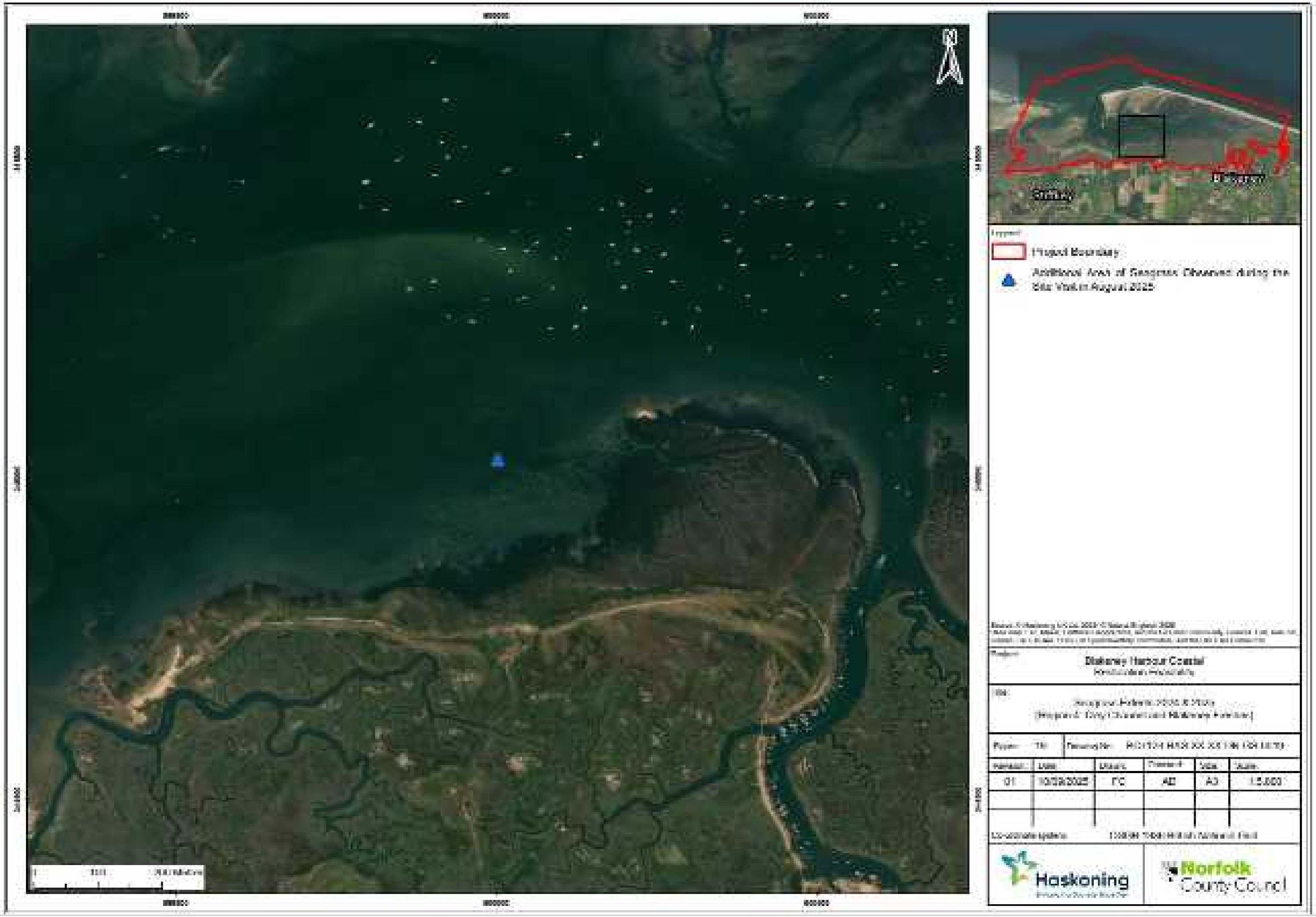

Figure 19 Location of an observation of seagrass within in Region 2: Stiffkey Marsh and Blakeney Pit, identified during a site visit in August 2025

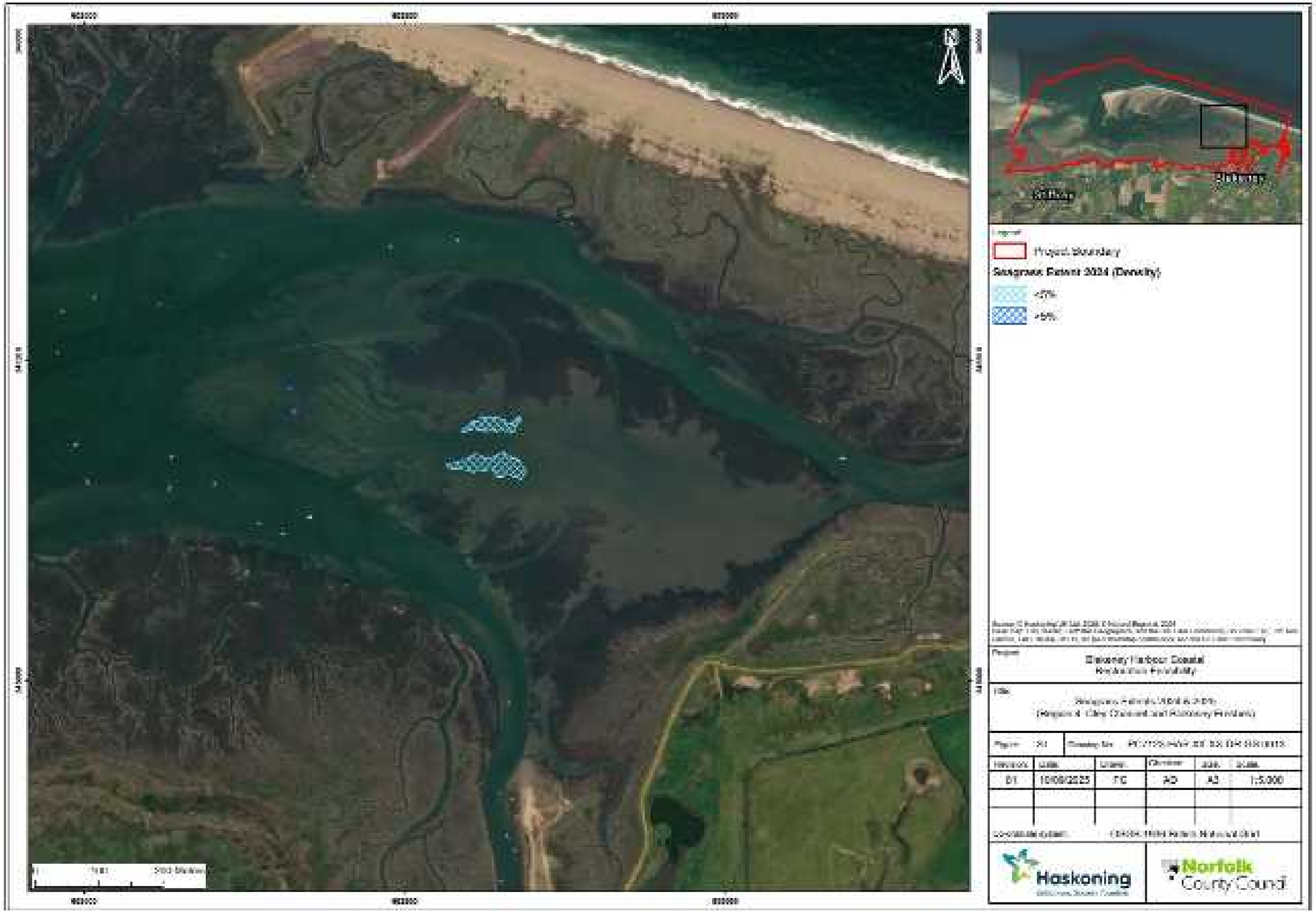

Figure 20 Current extent of seagrass in Region 4: Central Region (source: Environment Agency, 2025)

4.3.1.5 Vegetated Shingle

Coastal vegetated shingle comprises of shingle (often in structures such as spits, barriers, bars or islands), with communities of fauna. Such fauna may include sea kale *Crambe maritima* and sea pea *Lathyrus japonicus*, but the diversity of species may include grasses, mosses and scrubs. These plants can be grazed on. In lower hollows, wetland communities can exist. The habitats support breeding birds, such as gulls, waders and terns and provide habitat for invertebrates, which act as prey species for other species.

The general trend of shingle around the UK is that the beaches are retreating landward (Natural England, 2020), which is mainly due to sea level rise, storm events, and coastal defences cutting off sediment supply. However, within Blakeney Harbour, EUNIS habitat data shows that there is approximately 89.2 hectares of shingle beach. This includes shingle ridges that can shelter areas behind them from incoming wave and tidal energy. The current extent of vegetated shingle at Blakeney Harbour is shown in **Figure 14,** although it is acknowledged that the vegetation will only occur at, and above, the high tide areas and will not be present along the entire area but is patchily distributed along the shingle ridge.

4.3.2 Other Species

The North Norfolk coast is a crucial area for marine mammals, such as pinnipeds, and seabirds that use the area as a nesting ground in the summer. Every year, around 4000 grey seal pups are born at Blakeney point, which contributes to the largest seal colony in England (National Trust, 2025). Grey Seal numbers in the wider south-east England Seal Monitoring Unit (SMU) are increasing (Special Committee on Seals (SCOS), 2024). However, Harbour/Common seal populations are decreasing in north-east populations (Thompson, et al., 2019). In the Wash & North Norfolk Coast SAC, common seal counts have declined and are now ~25% lower than in 2015 (SCOS, 2024). This matches trends of increases in phocine distemper virus cases in Common seal populations and may also be due to predation on common seals by grey seals as raised during the stakeholder consultation. Despite this, the Wash and North Norfolk Coast SAC is responsible for the majority of common seal pup production in the south-east SMU and the common seal pup was higher in 2023 than in 2022 (SCOS, 2024).

In terms of fish, the local consultation identified that the area used to support good populations of a variety of fish including large numbers of eels, sea trout, mullet and sand eels. Consultation with a professor from University College London (UCL), who has undertaken a decade of fish surveys in the area, reported that climate change has caused changes in fish occurrence. For example, sea bass are now being found in in the marsh (attracting people to the area for recreational fishing), whereas common smelt were not present in more recent surveys, when they have been present in the past. While some species have been reportedly declining in the area, for example sea bass, UCL report that the harbour has abundant flatfish populations. Additionally, he reported that sea lampreys were found more recently. The area is also important for eel species, as they enter the harbour and go into the Blakeney Freshes, as well as the saltwater channels of the Cley marshes.

There is a variety of different bird species found in the Blakeney area, which seems logical due to the diversity of habitats available for birds including shingle beach areas above high-water mark, saltmarshes for roosting and shallow water areas for feeding. The area supports nesting mainly for four species of tern: arctic, little, common and sandwich terns, with 20% of the UK's sandwich tern and 18% of little terns UK populations between April to August (National Trust, 2025). Ringed plover, redshank and oystercatcher also use the area for breeding and roosting. One of the biggest threats to the breeding birds, particularly around Blakeney Point is predation of eggs and chicks. This was discussed during the site visit with the National Trust and was acknowledged by several people during the stakeholder consultation. The main problem was the large number of rats in the area.

The JNCC Population trends for breeding birds in the UK (2024) shows that some species of birds that use Blakeney as a key breeding habitat are declining:

- Little Tern: Declining nationally due to habitat loss and disturbance.
- Oystercatcher: Declining in some areas due to food availability and climate impacts.
- Ringed Plover: Declining due to recreational disturbance and habitat degradation.
- Redshank: Declining, especially in breeding populations on saltmarshes.

The 2024 British Trust for Ornithology (BTO) report states that, in England, while the populations of oystercatchers and redshanks have increased by 1% and 9%, respectively, from 2023-2024, common terns have decreased by 19% (BTO, 2024). The 2024 BTO reports that the East of England, which Blakeney Harbour is located in, has had 21 significant increases and 26 significant decreases in bird populations (BTO, 2024).

4.4 Protected Status

Within Blakeney Harbour there are numerous designated sites that provide protection for many of the features mentioned above. **Figure 21** and **Table 6** show the designations and the key objectives respectively.

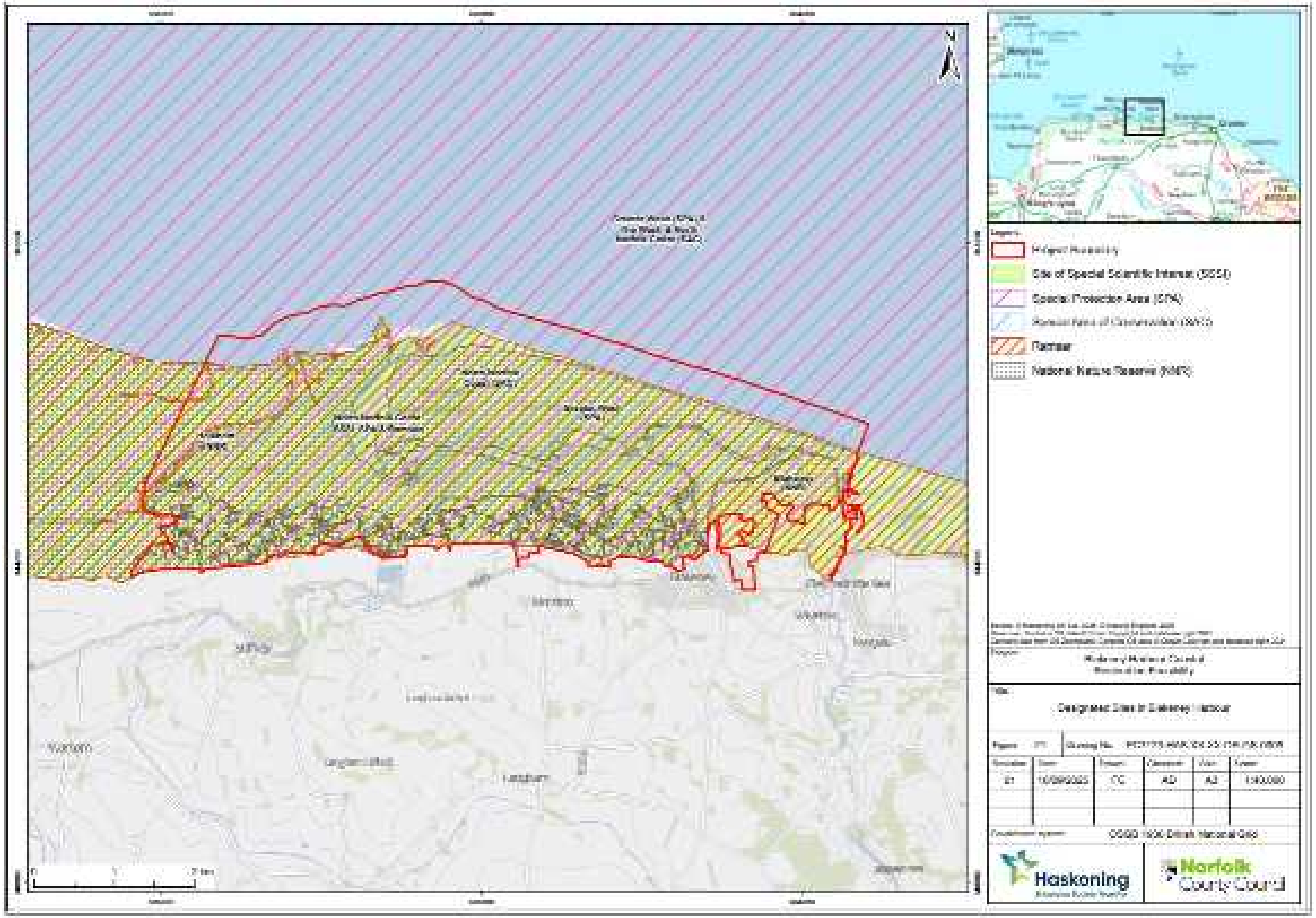

Figure 21 Protected sites at Blakeney Harbour

Table 6 Summary of the protected sites at Blakeney Harbour

Type of Designated Site	Name	Objectives/Restoration works
National Nature Reserve (NNR)	Blakeney	The National Trust implements a series of monitoring schemes to help protect the species both endemic and migrating in the Blakeney area. This includes: • Monitoring migrating eel populations: the National Trust Ranger team monitor populations of new arrivals from the Sargasso Sea and current population of eels in the Marshes using a technique of installing eel mops at sluice gates from May to June • Blakeney Point holds one of the largest grey seal populations in the UK, therefore an annual seal pup survey is completed to monitor population levels. • Organise beach cleans • Each nesting season temporary fences and signs are placed near bird nests to protect them from public disturbance. • April to August nesting period four species of tern: Arctic, Little, Common and Sandwich terns. Blakeney point provides nesting for 20% of Sandwich terns and 18% of little terns UK populations. • During the nesting period rangers live in the old lifeboat house, so there is 24 hour monitoring and protection. • To prevent terns nesting in vulnerable areas, as terns will tend to follow other terns in choosing nesting sites, clay models of terns are placed to trick species into nesting in more protected areas. • Monitoring of pink-footed geese.
	Holkham	Holkham Estate manage the landscape within this NNR, including by managing agriculture and forestry, as well as delivering ‘WONDER’ projects that aim to enhance natural capital and biodiversity.
Royal Society for the Protection of Birds (RSPB) Important Bird Area	North Norfolk Coast	The objective is to conserve key bird populations.

Type of Designated Site	Name	Objectives/Restoration works
SSSI	North Norfolk Coast	Natural England undertake monitoring on the condition of habitats. **Section 4.4.1** explains the conditions within this SSSI further.
Special Protection Area (SPA)	North Norfolk Coast	The qualifying features of the SPA are seven breeding bird species (including three tern species), four non-breeding bird species (including two goose species) and waterbird assemblages. The conservation objectives are to ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring: • The extent and distribution of the habitats of the qualifying features. • The structure and function of the habitats of the qualifying features. • The supporting processes on which the habitats of the qualifying features rely • The population of each of the qualifying features. • The distribution of the qualifying features within the site.
SPA	Greater Wash	○ Developed for the protection of red-throated diver (*Gavia stellata*), common scoter (*Melanitta nigra*), and little gull (*Hydrocoloeus minutus*) during the non-breeding season, and for breeding sandwich tern (*Sterna sandvicensis*), common tern (*Sterna hirundo*) and little tern (*Sternula albifrons*) ○ The overarching conservation objectives for the protected features of this site are to ensure they either remain in, or reach, favourable condition. ○ Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring; The extent and distribution of the habitats of the qualifying features; the structure and function of the habitats of the qualifying features; the supporting processes on which the habitats of the qualifying features rely; the population of each of the qualifying features, and; the distribution of the qualifying features within the site. (Natural England, 2019).
Ramsar site	North Norfolk Coast	Due to the pressure of tourism, a tourism visitor strategy was being discussed as the main conservation strategy according to the Ramsar Site Information Service (1999) to prevent the public damaging the local environment.

Type of Designated Site	Name	Objectives/Restoration works
Special Areas of Conservation (SAC)	The Wash & North Norfolk Coast	The site is designated for sandbanks, mudflats, large shallow inlets and bays, reefs, Salicornia, Atlantic salt meadows, scrubs and harbour seals. The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species. • The structure and function (including typical species) of qualifying natural habitats. • The structure and function of the habitats of the qualifying species. • The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely. • The populations of each of the qualifying species. • The distribution of qualifying species within the site.
	North Norfolk Coast	The site is designated for coastal lagoons, perennial vegetation of stony banks, scrubs, embryonic shifting dunes, “white dunes”, “grey dunes” and humid dune slacks. The objectives are to ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring: • The extent and distribution of qualifying natural habitats and habitats of the qualifying species. • The structure and function (including typical species) of qualifying natural habitats. • The structure and function of the habitats of the qualifying species. • The supporting processes on which qualifying natural habitats and the habitats of qualifying species rely. • The populations of each of the qualifying species. • The distribution of qualifying species within the site.

4.4.1 SSSI conditions

SSSIs are divided into areas, which are referred to as SSSI units. These SSSI units are monitored to observe the quality of the conditions for the habitats within the unit.

Natural England categorise SSSI units into either favourable, unfavourable recovering, unfavourable no change, unfavourable declining, part destroyed or destroyed status (further information regarding requirements to obtain each status can be found in **Table 7**).

In the project area there are 22 separate SSSI units; habitats in 13 units are currently at a favourable status, two units have habitats that are unfavourable, but recovering, two units have habitats that are unfavourable with no change, and five units have habitats that are unfavourable and are declining. It should be noted that the latest field surveys for 14 of the units were carried out over a decade ago.

A comparison between current SSSI unit status and future SSSI unit status could potentially be used as a framework to establish a clear goal for the Blakeney Harbour multi-habitat restoration project.

Table 7 Requirements for obtaining the different statuses for SSSIs

Status	Requirements
Favourable	The designated feature is being adequately conserved. The results from monitoring demonstrate that the feature is meeting all the mandatory site-specific monitoring targets set out in the monitoring specification (MS). The MS sets the minimum standard for favourable condition for the designated feature and there may be scope for the further (voluntary) enhancement of the feature."
Unfavourable recovering	Often known simply as 'recovering'. The feature is not yet fully conserved but the necessary actions to achieve favourable condition have: • Been identified and recorded. • At least one action underway. • No actions behind schedule. Provided that the recovery work is sustained, the feature will reach favourable condition in time. At least one of the designated feature's mandatory attributes is not meeting their targets (as set out in the site-specific MS).
Unfavourable no change	The feature is not being conserved. It will not reach favourable condition unless there are changes to the management or external pressures. This is reflected in the results of monitoring over time, with: • At least one of the mandatory attributes not meeting its target (as set out in the site-specific MS). • The results not moving towards the desired state. The longer the feature remains in this poor condition, the more difficult it will be, in general, to achieve recovery. If the feature is unfavourable, it should be recorded as unfavourable – no change, if the necessary actions to achieve favourable condition have:

Status	Requirements
	• Not been identified and recorded. • None of the actions underway. • At least one action behind schedule. 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	The feature is not being conserved and will not reach favourable condition unless there are changes to management or external pressures. The feature condition is becoming progressively worse. This is reflected in the results of monitoring over time, with: • At least one of the designated feature's mandatory attributes not meeting its target (as set out in the site-specific MS). • The results moving further away from the desired state. The longer the feature remains in this poor condition, the more difficult it will be, in general, to achieve recovery.
Part destroyed	Lasting damage has occurred to part of a designated feature, such that it has been irretrievably lost and will never recover. No amount of management will allow the feature to ever reach favourable condition.
Destroyed	Lasting damage has occurred to an entire designated feature such that the feature has been irretrievably lost. No amount of management will bring this feature back. This feature will never recover. For example, a finite mineralogical feature has been totally removed from its surroundings without consent and is lost forever

Further analysis of the SSSI units in the Blakeney Harbour restoration area has been carried out to understand the extent of the unfavourable units. **Table 7** and **Figure 22**, explain and show the current conditions of each SSSI unit in Blakeney Harbour.

The figure shows that several of the units for Blakeney Harbour are in unfavourable condition (Source Natural England Designated Sites Viewer). This is mainly due to the following factors:

- Recreation and visitor disturbance. For example, records of damage adjacent to the footpaths on the fixed dune grassland.
- Scrub dominance in some sand dune and humid dune slack regions.
- INNS, including lupin, yucca, Duke of Argyll's tea plant and Rosebay willowherb.
- Limitations in sediment supply.

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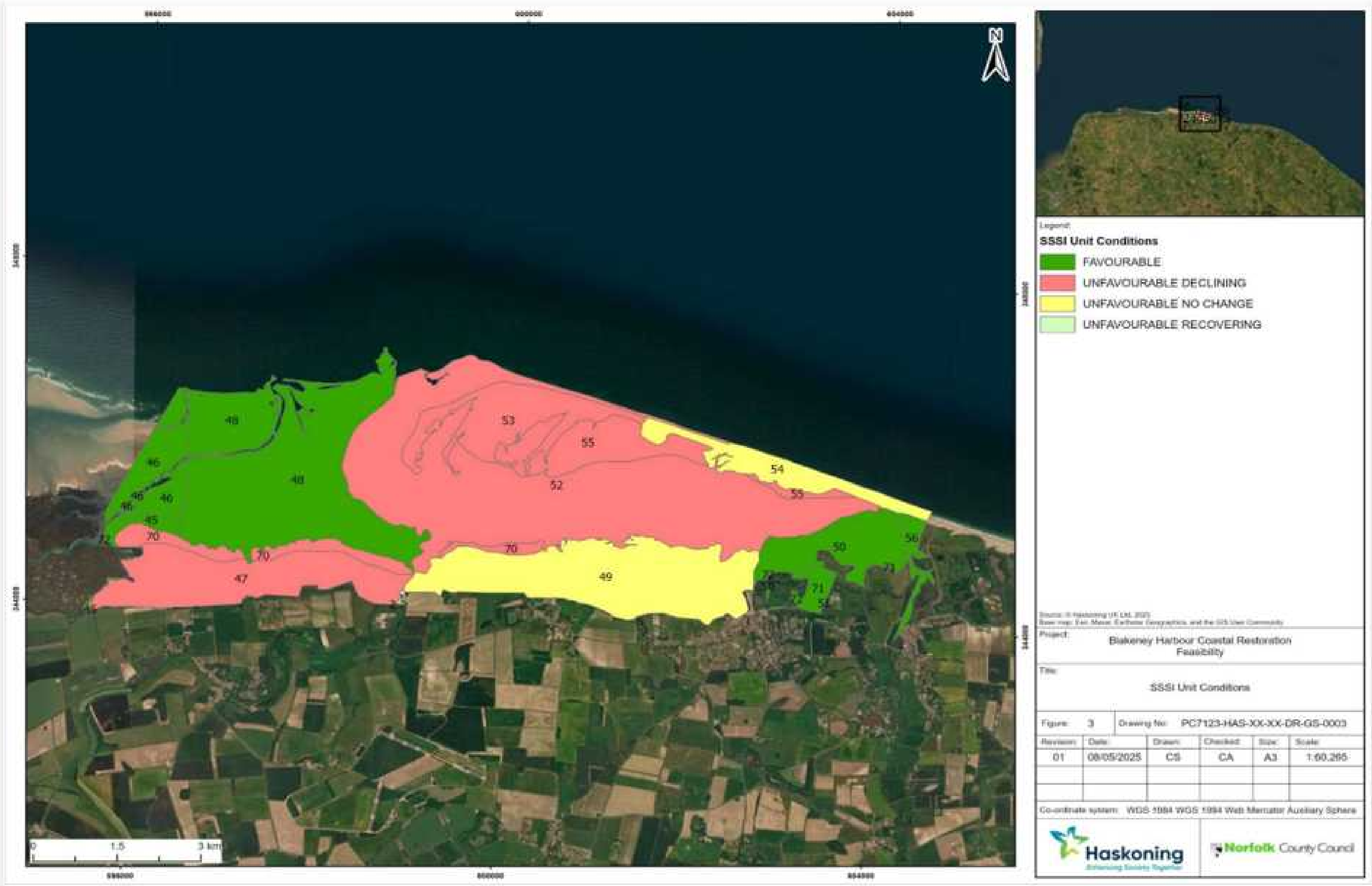

Figure 22 SSSI unit conditions (Source, Natural England Designated Sites Viewer)

4.5 Ecosystem services

Ecosystem services are the natural benefits that are provided by ecosystems to humans. According to the Millenium Ecosystem Assessment (an assessment organised by the United Nations that assessed the human impact on the environment), ecosystem services can be grouped into the following categories: provisioning; regulating; cultural services; and supporting. Blakeney Harbour provides many ecosystem services in each of these categories, which are summarised in **Table 8**.

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Table 8 Ecosystem services derived from Blakeney Harbour

Ecosystem Service Type	Ecosystem Service	How it is derived from Blakeney Harbour
Provisioning	Food provisioning	There are Pacific oysters that are grown and harvested in a farm run by Norfolk Seaweed. There is also Blakeney and District Wildfowlers Association, an organisation of local sustenance wildfowlers that source geese and ducks from the marshes (Blakeney Harbour Association (BHA), n.d.). Furthermore, saltmarsh and seagrass habitats act as nursery grounds for species, including potentially commercially important fish species. Eastern Inshore Fisheries and Conservation Authority (IFCA)'s Byelaw 12: Inshore Trawling Restriction prohibits the use of trawling nets between Blakeney and Mundesley (Eastern IFCA, 2019).
Regulating	Erosion regulation	Coastal sand dunes, saltmarsh and seagrass beds anchor and stabilise the sand and soft sediment and trap sediment in their roots, maintaining a balance between erosion and accretion.
	Flood/coastal defence	Habitats and species such as saltmarsh and seagrass absorb wave and tidal energy and act as buffers between the sea and land. This lowers the risk of flooding on land. Mudflats also act as natural floodplains which can protect inland areas from being flooded.
	Carbon storage	Saltmarsh, mudflats and dunes have high carbon sequestration capabilities. Due to high rates of primary productivity, salt marsh species have among the highest rates of carbon sequestration. In dry dune grasslands, species sequester a mean (± standard deviation) of 58.2 ± 26.2 g C m^2/year (Beaumont *et al.*, 2014). Furthermore, cockles and blue mussels, as calcifying organisms, also store carbon in their shells.
	Climate change resilience	As mentioned above, several of the habitats at Blakeney Harbour improve flood and coastal defence, which are likely to increase under changing climate conditions. Additionally, as mentioned above, several species and habitats act as carbon storage which, in the longer-term, improves climate resilience.
	Air quality regulation	Saltmarsh, sand dunes and grazing marsh can improve air quality due to the capturing of pollutants. Gas regulation is the primary ecosystem service value obtained from sand dunes (Yang and Tang, 2019).
	Sediment regulation	Coastal sand dunes, saltmarsh and seagrass beds anchor and stabilise the sand and soft sediment.

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Ecosystem Service Type	Ecosystem Service	How it is derived from Blakeney Harbour
	Water quality regulation	The presence of intertidal habitats (such as saltmarsh) and filter feeders (including blue mussels) contributes to water purification through filtering of excess nutrients and pollutants. However, consultation with local stakeholders reported that the water quality was poor in areas.
Cultural	Recreation	Recreation is a hugely important ecosystem service that is provided by Blakeney Harbour. The region is important for sailing, birdwatching, seal watching, hiking, Royal Yachting Association powerboat courses, stand-up paddleboarding (SUP) and kayaking (BHA, n.d.). Local stakeholders affirmed the importance of recreational use of Blakeney Harbour during the consultation process, particularly stressing the value of SUP and kayak use in the area. The Blakeney Harbour Association also reflected concerns of some local users that too many boats in the region may reduce sailing races (BHA, n.d.). The consultation process revealed that some locals agree that dogs and visitor pressures should be managed more. In order to manage the recreation of the site, the National Trust do not allow dogs during nesting bird season or seal pupping season. They also remove seal corpses to dissuade rats, which otherwise eat birds' eggs and chicks. After a search of available online sources, no information could be found about how the National Trust currently manages visitor numbers. Car parking restrictions are likely to be restricting numbers visiting the harbour. It is difficult to envisage how further management measures could control dogs in the area without introducing bye-laws.
	Ecotourism	There is a successful ecotourism industry in Blakeney Harbour, which is largely made up of family-owned generational businesses. A review of online sources indicated that at least five companies run boat-based seal trips into the harbour several times a day. In line with requirements by the Maritime and Coastguard Agency, the boats are not able to go into open sea. A review of online sources could not provide information on the overall management of these trips or the approximate number of people on each boat. Seal trips aim to see seal pups (common seal pups in the summer and grey seal pups in the winter) and there appears to be no protective measures on any of the companies' websites to ensure the sustainable management of the trips or practices to minimise seal disturbance. It is mentioned that the animals are "used to" the boat presence and the companies advertise that their boats get "close to" the seals (Bishop's Boats, n.d.). On some of the trips, dogs are also allowed, despite the National Trust reporting that dogs can cause alarm to seals (The National Trust, n.d.). However, the BHA does offer advice on 'Living with Seals', which gives guidance about staying away from seals and recognising their three-step disturbance response

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Ecosystem Service Type	Ecosystem Service	How it is derived from Blakeney Harbour
		(BHA, n.d.) and the National Trust also have advice on caring for seals at Blakeney Point, including prioritising that seals are not approached or disturbed (National Trust, n.d.). Bird tours are also offered by some of these tour companies, aiming to spot terns in the summer months.
	Employment	There are many businesses within the harbour, including boat builders, boat repair companies, sailing and powerboat tuition and hire companies, seal trip operators and bird watching operators.
	Access to nature	There are existing footpaths and car parking facilities, as well as vessel access to the harbour. Consultation feedback shows that the use of coastal path (inc. cycling) and access to the coast was extremely important to local people.
	Education	The Norfolk Rivers Trust undertook educational sessions in local schools, teaching students about the Blakeney Harbour environment and its role as a nursery ground and important habitat (Norfolk Rivers Trust, 2017).
Supporting	Biodiversity	The varied habitats at Blakeney (e.g. mudflats, saltmarsh, sand dunes) support a variety of birds, invertebrates and fish.
	Habitat and nursery grounds	The variety of habitats at Blakeney (e.g. mudflats, saltmarsh, sand dunes) provide several different habitat niches for terrestrial, infaunal, epifaunal and pelagic species. Saltmarshes and seagrasses, in particular, act as nursery grounds for pelagic and invertebrate species.
	Primary productivity	Seagrasses, salt marshes and sand dune flora photosynthesise, converting sunlight and carbon dioxide into organic compounds.
	Predator/prey interactions	By providing different niches and habitats and supporting biodiversity, the site contributes to the normal functioning of predator and prey interactions. However, consultation reported that predators (primarily rats) are out of control, despite efforts by the National Trust to keep rat populations under control (detailed under ‘recreation’ above). The population of grey seals has increased dramatically at Blakeney Point over the years, and it now has the largest grey seal colony in England (The National Trust, n.d.). This is partially due to the lack of natural predators and the remote location of Blakeney (The National Trust, n.d.). In certain areas of the UK,

Ecosystem Service Type	Ecosystem Service	How it is derived from Blakeney Harbour
		including the Wash and North Norfolk Coast SAC, harbour (common) seal populations have been declining in recent decades (Wilson and Hammond, 2016; Russell *et al.*, 2024). This may be due to reductions in the abundance of their prey, sandeel (Wilson and Hammond, 2016), or other factors such as disease. While there is no explicit evidence, there may also be intra-specific competition (e.g. for space or food) between common and grey seals. Grey seals have also been observed preying on common seals (van Neer, Jensen and Siebert, 2015; Russell *et al.*, 2024). This may explain why common seal populations are decreasing as grey seal populations increase.

4.6 Pressures

Key pressures at Blakeney Harbour have been identified through a combination of the desk-based review, consultation (set out in **Section 2.3**) and the report produced by the WWF (2014). These include:

- Highly dynamic sediments - shaped by coastal erosion and hydrodynamic forces, this destabilises habitats, including mussel beds and saltmarshes. Consultation with an ex-mussel fisherman undertaken as part of this study revealed that the location of mussel beds had to be changed several times as the mussels kept becoming smothered by mobile sediments.
- Poor water quality – primarily caused by wastewater discharge and diffuse pollution, this can cause the over enrichment of water with nutrients.
- Climate change – accelerated sea level rise may have contributed to increased erosion of habitats, such as saltmarsh. Furthermore, engagement with local fishers undertaken as part of this study showed that the range limits of some species have shifted due to climate change, with sea bass, bream and octopus becoming pushed further north.
- INNS – There are growing numbers of INNS within the North Norfolk Coast (WWF, 2023). INNS are introduced by agriculture and shipping (although, the short distances travelled by vessels mooring in Blakeney Harbour probably limits this (WWF, 2023)). INNS can outcompete native species. It is noted that *Spartina* species were introduced to the harbour many years ago (date unknown but potentially in the 1930s according to stakeholder notes) and encroached on many areas of the harbour (according to stakeholder observations) and, as is common with this species, forming a monoculture which outcompetes other species.
- Anthropogenic activities – physical disturbances from anchors and propellors, as well as recreational activities, place pressure on sensitive habitats and species. Increasing numbers of visitors increases levels of disturbance and the greater accessibility resulting from increased water sports means that more people can access areas that previously would have been inaccessible to many people. Additionally, bait digging and over-fishing of benthic shellfish have been identified as possible threats or historic threats that may have affected the fauna in the harbour.
- Predation – predation on birds' eggs and chicks can affect numbers of breeding birds. Predation on habitats such as seagrass can also affect distributions as geese can feed on seagrass beds causing considerable declines in abundance in a short period of time.

MarLIN assess the sensitivities of species and habitats to a variety of pressures, following the Marine Evidence-based Sensitivity Assessment (MarESA) approach (which supersedes and replaces the MarLIN approach) (Marlin.com, n.d.). In this case, the definition of sensitivity is given as "*the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery*" (Marlin.com, n.d.).

Despite being generic and not site-specific, these sensitivities can provide valuable information when restoring or creating habitat. As such, the sensitivities for each of the key species / habitats in Blakeney Harbour to the pressures outlined above is provided in **Table 9**. The table shows the high sensitivity of oysters and seagrass to many of the pressures that are prevalent in Blakeney Harbour.

Table 9 Summary of MarLIN sensitivities to key pressures for species found in Blakeney Harbour

Species	Pressure	MarLIN indicator	MarLIN Sensitivity	Notes on the general sensitivity to the pressure (not specific to Blakeney)
Blue Mussel (*M. edulis)*	Highly dynamic sediments	Smothering, Increase in turbidity	Low	On a small scale, *M. edulis* can adjust its position to resurface when it is buried by sediment.
	Poor water quality	Changes in nutrient levels	Low	*M. edulis* may benefit from slight enrichment. Subtle increases in seawater nutrient levels increase food availability and decrease the organism's vulnerability to predators. Stark increases in nutrient enrichment may have adverse effects, as it may result in deoxygenation and algal blooms.
	Anthropogenic activities	Abrasion Extraction of species	Low	Trampling may have an impact on *M. edulis* populations, depending on the density and depth of the mussel bed. Overfishing may reduce recruitment leading to a reduced population.
	Climate change	Increase in temperature	Very Low	*M. edulis* are eurythermal, meaning that they are able to tolerate a range of temperatures.
	INNS	N/a	N/a	No information
	Predation	N/a	N/a	No information
Native Oyster *(O. edulis)*	Highly dynamic sediments	Smothering Increase in turbidity	High	When turbidity is high, the process of removing excess sediment within the mantle of the oyster is energetically very expensive. In turn, long periods of turbidity cause a decrease in growth rate in the organism.

Species	Pressure	MarLIN indicator	MarLIN Sensitivity	Notes on the general sensitivity to the pressure (not specific to Blakeney)
				O. edulis is unlikely to survive smothering, the filter feeders cannot burrow out of the sediment. Smothering will therefore also have an impact on recruitment.
	Poor water quality	Introduction of other substances	High	Chemical contamination leads to high mortality rates in *Ostrea edulis*, especially in juveniles.
	Anthropogenic activity	Abrasion Displacement Fishing	High	*O. edulis* is known to have unreliable reproduction and low levels of recruitment, making the species sensitive to overfishing. Also, it may be caught as ‘by-catch’ when fishing for other species.
	INNS	Introduction or spread of non-indigenous species	High	Invasives can destroy oyster beds, compete for habitat and prevent bed recovery.
	Climate change	Temperature increase (local)	Low	The species is highly resilient to local temperature increase.
	Predation	N/a	N/a	No information
Seagrass *(Z. noltii, and Zostera marina)*	Highly dynamic sediments	Smothering, Increase in suspended sediment	Very High	High turbidity will reduce light attenuation. Seagrass can most likely survive a month, but the long-term prevention of light attenuation will result in a reduction in the population. Seagrass is highly intolerant to smothering.
	Poor water quality	Changes in nutrient levels	Very High	Nitrate enrichment reduces growth rate. Nitrate enrichment also causes and increases growth of epiphytes or blanketing algae which results in seagrass loss.

Species	Pressure	MarLIN indicator	MarLIN Sensitivity	Notes on the general sensitivity to the pressure (not specific to Blakeney)
	Anthropogenic Activity	Abrasion Physical disturbance	Very High	Coastal engineering works, causing sediment disturbance, has contributed to the global decline of seagrass beds.
	INNS	Introduction of non-native species	High	Introducing the invasive pioneer species e.g. *Spartina anglica* reduces the area of sediment available for seagrass colonization.
	Climate change	Temperature increase	Low	Seagrass is not known to be sensitive to the temperature increase caused by climate change
	Predation	Extraction of species	Moderate	Wildfowl graze on significant amounts of seagrass. However, the species can typically recover from normal grazing activity.
Pioneer saltmarsh (*Suaeda maeitima* and *Spartina salicornia)*	Highly dynamic sediments	Smothering Increase in suspended sediment	Low/ Moderate	Typically, salt marsh species are adapted to lower light levels so smothering will not have a large impact on species within the habitat. Species and smothering material will have differing impacts on sensitivity. Increased siltation may increase sedimentation rates above growth rates leading to smothering
	Poor water quality	Changes in nutrient levels	Low	Moderate enrichment in salt marsh habitats is beneficial.
	Anthropogenic Activity	Abrasion Physical disturbance	Low	Abrasion from trampling and vehicles common in saltmarshes.
	INNS	Introduction of non-native species	Low	The introduction of non-native species may reduce species richness within salt marsh habitats

Species	Pressure	MarLIN indicator	MarLIN Sensitivity	Notes on the general sensitivity to the pressure (not specific to Blakeney)
	Climate change	Increase in temperature	Very Low	Salt marshes and vascular plants are terrestrial in nature and so are more tolerant to temperature fluctuations than intertidal flora.
	Predation	Extraction of this species	Low	Grazing by livestock also causes trampling and livestock feces introduce nutrients to the habitat.

5 Feasibility of habitat restoration

5.1 Constraints

5.1.1 Physical

There are many physical factors and fluvial/coastal processes that determine the likelihood of success for restoration of intertidal habitat, as discussed in **Section 3.2**. The presence of existing saltmarsh and seagrass, as well as blue mussel beds (albeit mostly juveniles were observed during the site visit and with beds susceptible to smothering) in the Blakeney Harbour area (**Figure 14),** indicate that the general physical conditions of the site are suitable to support these habitats. For example, the exposure to waves, tides, elevation and sediment type. Historic maps also show that oysters were present in the harbour many years ago and the presence of the oyster farm run by Norfolk Seaweed show that oysters can successfully grow in the area (these are pacific oysters and are not able to reproduce so it is not known about the success of larval growth and settlement for oysters or how native oysters may survive). However, as per stakeholder feedback, it is also important to consider future changes to the environment to avoid attempts at habitat restoration being unsustainable in the longer term. The relatively low rate of sea-level rise compared to accretion rates means that the system is unlikely to be drowned in future scenarios.

Sediment movement is also a large physical constraint for both intertidal and subtidal habitats and species, as mentioned in **Section 3.2**, if sedimentation and/or turbidity is too high, filter-feeders such as blue mussels and oysters can become smothered, as can seagrass beds. In addition, photosynthesis can be impaired in saltmarsh and seagrasses. Movement of sediment affects invertebrates in several ways, particularly filter feeding species and those reliant on larval settlement. In adult oysters for example, the sedimentation can damage the feeding apparatus (Hughes and zu Ermgassen, 2021) and means that feeding requires more energy expenditure (Housego and Rosman, 2015). Even a few millimetres of sediment are enough to potentially bury settlement substrate for larvae (Poirier *et al*., 2021). A study found that spat (oyster larvae that has permanently attached itself to a substrate) densities were approximately three times lower in the presence of siltation (Poirer *et al*., 2021). However, in moderately turbid environments, juvenile and adult oysters can thrive (Poirer *et al*., 2021).

Stakeholders noted that the Blakeney Harbour system is dynamic and there have been relatively large changes in the outer spit recently that resulted in large scale sediment movement.

5.1.2 Chemical

A number of stakeholders reported poor water quality at various locations in the harbour (**Appendix B**). Since the Cefas grade for shellfish waters in Blakeney is LT Class B, any bivalves that are introduced as a result of this project would only be commercially viable with cleaning after harvesting; however, poor water quality can still hinder restoration efforts. For example, as filter feeders, bivalves can concentrate pollutants such as heavy metals and microplastics. Additionally high levels of nutrients, presence of *E. coli* and harmful algal blooms can impede bivalve survival and growth. Water quality should be addressed before any habitat restoration is undertaken for mussels and oysters, as poor water quality could undermine any efforts undertaken. Conversely, it is recognised that oysters can clean up water. Current restoration efforts for oysters, at a scale that makes a significant contribution to oyster populations, is focussed on areas off the coast. The North Sea used to provide a significant habitat for oysters but this has depleted considerably. There is an initiative at Wells-next-the-Sea where oysters are being grown in a facility on land for subsequent relocation off the coast. Such initiatives are more likely to be successful in the long term than within coastal harbours where water quality is likely to remain a constraint for the near future.

Similarly, nutrient overload can favour growth of algae over salt-tolerant flora, as well as causing eutrophication and hypoxia. Pollutants can also change sediment pH and hinder microbial processes that are essential for nutrient cycling and the success of saltmarshes and seagrasses. As mentioned in **Section 4.2**, there is *E. coli* present in the water sources, as well as high concentrations of phosphates in the rivers that feed Blakeney Harbour. The initiatives planned and undertaken by Norfolk Rivers Trust in recent years (**Table 4**) will aim to reduce phosphate concentrations further.

Water quality has also been identified as a factor in declines in seagrass beds worldwide, in particular with respect to nutrient enrichment, which is likely related to the excessive growth of epiphytes, and the effects of reduced light penetration caused by eutrophication (JNCC, 2014). The same report comments on the effect on organic enrichment on seagrasses and suggests that although coastal and marine sediments where seagrasses grow are often anoxic and highly reduced due to the high levels of organic matter and slow diffusion of oxygen from the water column to the sediment, seagrasses are adapted to these conditions. However, if the water column is organically enriched, plants are unable to maintain oxygen supply to the meristem and die fairly quickly. The enrichment of the water column could therefore significantly increase the sensitivity of seagrasses to this pressure.

The earlier phase of this project (WWF, 2023) investigated some of the pressures acting on the harbour area and found that water quality was a potential issue. Water quality could be a key factor, or certainly a contributing factor, to the declines in seagrass and, as mentioned above, were identified as an issue for commercial growth of mussels in the harbour. For habitat restoration to be successful it is recommended that this constraint is considered further with a view to what could be done to improve water quality in the area. It may be that once water quality improves that natural habitat restoration occurs. However, it may be necessary and would increase the rate of recovery if restoration initiatives were implemented. Certainly, this is the case for species such as native oysters that are no longer known to occur in the harbour area and for seagrass, where only one species is known to occur, and that is subject to declines in the harbour area.

5.1.3 Biological

It is important to consider predator-prey interactions when considering the feasibility of habitat restoration and creation. The availability of food sources can inhibit the success of restoration and creation efforts. For example, if considering creating islands for birds then there must be sufficient prey availability. Bait digging and over-fishing of benthic shellfish have been identified as threats, for example, by reducing the availability of prey for oystercatchers (WWF, 2023). Stakeholders also reported issues with lack of control of vermin (rats specifically) and other predators across the harbour (**Appendix B**). This could restrict the populations of ground nesting birds. The status of breeding and non-breeding birds is already poor, (as discussed in **Section 4.3.2**), so it is important to reduce the rats and, where possible, encourage the recovery of prey species. It should also be acknowledged that if high numbers of geese occur in an area they can feed on seagrass and deplete the population of seagrass considerably. Geese do overwinter in this area and are likely to feed on large areas of intertidal seagrass.

Furthermore, as stated by the Wash and North Norfolk Marine Partnership, Blakeney Harbour has increasing numbers of INNS, which can be introduced through ballast water and hull fouling (WWF, 2023). However, since the vessels within the harbour do not tend to travel long distances, this is unlikely to be a significant pressure. Species including the slipper limpet and Pacific oyster can be highly invasive and, as shown in **Section 4.4**, there are non-native species, albeit terrestrial species (e.g. lupin), in the SSSI. INNS are damaging as they can dominate and out-compete local species for food, resources and space, altering ecosystem functioning and decreasing biodiversity. As discussed in **Section 4.5**, there is also potential competition between grey and harbour seals for food and/or space, which may be reducing harbour seal populations in the area. However, this is speculative.

The biological suitability of sites within Blakeney Harbour could be a constraint to the success of the specific restoration and creation initiatives suggested. The availability of larvae and presence of diseases can hinder bivalve mollusc restoration / creation. Natural recruitment relies on the availability of a close source of larvae. Furthermore, seagrass and saltmarsh recruitment need a source of genetically diverse seed. Harvesting of seagrass from existing beds would deplete the abundance of existing beds which have been shown to be declining in distribution (**Figure 16 to Figure 17**) and seagrass should only be harvested from healthy populations that are at greater than 60% cover of individuals. Since there is already evidence of saltmarsh, seagrass and blue mussels (**Figure 14**), it would be advantageous to place areas of created habitat nearby existing patches. For native oysters, increased hatchery support may be needed to overcome the bottleneck of limited natural recruitment and the absence of nearby populations.

Bonamiosis is a disease, caused by *Bonamia spp*. parasites. The disease is partially responsible for the collapse of native oyster populations in the UK, after it was introduced in the 1980s. *O. edulis* are the primary carrier of this disease, but there is evidence that *C. gigas* may act as a non-typical host and transmit the disease to native oysters (Lynch *et al*., 2010). The majority of European populations of *O. edulis* are infected with *B. ostreae* (Sas *et al*., 2020). However, Brancaster, on the North Norfolk coast, was considered Bonamia-free – meaning that no *B. ostreae* has been detected in water tests and surveys to date (Sas *et al*., 2020). Furthermore, since the harbour area is used for commercial farming of Pacific oysters, which are strictly controlled to ensure they do not carry the disease, it is likely that the water is free of disease.

5.1.4 Anthropogenic

Anthropogenic constraints should be considered in the feasibility of habitat restoration, while recognising that nature is an essential part of wellbeing and provides a livelihood for many. In Blakeney Harbour, there are numerous recreational and economic ecosystem services provided. However, the harbour is not restricted in terms of management of the moorings, nor does it have caps on visitor numbers. There is a carrying capacity on how much anthropogenic influence a habitat or ecosystem can take before showing changes and deterioration.

According to stakeholder engagement (**Section 2.3**), it was felt that high visitor numbers could already be causing impacts on habitats and species in some locations of Blakeney Harbour (Haskoning, 2025b; **Appendix B**). This includes by reducing bird numbers, causing direct damage to salt marsh habitat by trampling and causing erosion of banks due to mudsliding (Haskoning, 2025b; **Appendix B**). For example, it is noted in **Section 4.3.2** that the status of ringed plover is 'declining', potentially partly due to recreational disturbance, although the populations at Blakeney Spit are carefully monitored. Disturbing birds can result in a reduced amount of time spent feeding (Yasué, 2005), increased stress / energetic costs (Thiel *et al*., 2011) and the avoidance of suitable habitat (Burton, Rehfisch and Clark, 2002). Additionally, increasing numbers of watersports, such as kayaking and paddleboarding, increases the amount of disturbance to saltmarsh, particularly further up small creeks.

5.2 Opportunities

Habitat restoration is a critical step in reaching biodiversity goals, together with pressure reduction. Working towards wider goals to meet Global Biodiversity Framework Targets, including to "*ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal and marine* *ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity*" even with small scale projects can make a difference.

In the following sections, the recommendations for interventions in each region have been considered. The goal of the recommendations is to improve ecosystem functionality and connectivity within Blakeney Harbour, while also focusing on climate adaptation and coastal livelihoods. The key habitats considered are defined as ecosystem engineers and provide habitat and important functions (building of predator-prey relationships and ensuring that there is a connection pathway for energy, nutrients and genetic material) for many other species. The restoration of these habitats would provide much wider benefits than just the species as an individual but would increase heterogeneity into the ecosystem and increase connections between more isolated patches of habitat. Where possible, the creation / restoration of several habitats in combination with each other has been prioritised in order to facilitate a multi-habitat approach.

Habitat restoration initiatives are often most successful if implemented in areas where such habitats are already present but would benefit from extension of the distribution or where such habitats/species have occurred in the past, as long as the reason for any declines can be ascertained and have been reduced to an acceptable level or eliminated. The investigation for potential initiatives has therefore focussed on areas where each habitat/species is present, or was known to occur in the past, but also where existing conditions appear to be suitable and constraints are manageable or not overly restrictive.

It should be noted that there is always uncertainty over the success of initiatives as there are so many variables to ensure success. Even when attempting to take account of the key variables there is the chance of natural events or anthropogenic pressures that prevent the success of the restoration initiative. The understanding, and reduction, of key pressures is important for the successful implementation of some of these measures and is discussed further in **Section 5.2.7.** Monitoring of the initiatives is critical for adapting the restoration to try and take account of the results and also to learn lessons for future initiatives.

An important factor in the success of some initiatives is the scale of the restoration, with larger scale initiatives having greater chances of success as there is greater scope for the continuation of the habitat restored/created, even with the loss of a percentage of the individuals that inevitably occurs.

Another important factor is sourcing of individual species for restoration initiatives. There are many considerations to bear in mind including the following:

- Potential for transportation of diseases and bacteria.
- Potential for transportation of INNS.
- Establishing healthy donor populations that are robust enough to provide a supply of individuals;
- Transportation times and methods for the sourced individuals.
- Consents and permissions for sourcing species.

5.2.1 Multi-habitat approach

A multi-habitat approach, whereby a combination of species and habitats are restored or created, has several benefits over a single species focus. By supporting multiple habitats, the ecosystem is more resilient to climate change and extreme events (McAfee *et al*., 2022). Furthermore, the species can create more suitable environments for each other, for example seagrass stabilises sediment, providing optimum conditions for bivalve molluscs. By providing more niches and types of habitats, the area becomes more complex and can support a higher biodiversity. Additionally, multihabitat approaches can provide a greater array of ecosystem services.

Many of the species/habitats that have been the focus for this study are known as ecosystem engineers in that they create habitats that can be used by many other species and significantly increase the biodiversity within an area.

5.2.2 Recommendations for Region 1: Blakeney Point

Seagrass

It is recommended to undertake a survey within the low-lying inlet behind Blakeney Point (Stanley Cockle Bight) to identify the scale and quality of habitats (mudflat, seagrass and saltmarsh distribution and condition). It is known that seagrass was found in this area in 2018 but not observed during a survey of the area in 2024 (based on Environment Agency data). The patch was very small in 2018 so it may just have been missed or may have disappeared. The reason for not observing seagrass in the latest survey should be investigated. It may be that the patch was too small and that even a minor event could have smothered the seagrass. It is also possible that the seagrass bed was too small to sustain grazing from overwintering birds or that water quality declined and the seagrass was outcompeted. Restoration of a larger area of seagrass could alleviate some of the issues but this depends on the survey results showing that there is enough bare mudflat at the correct depth for a seagrass bed to succeed. It may also be feasible that the rhizomes are still present and could provide an additional source of seagrass colonisation.

Following this survey, if deemed appropriate (i.e. there is enough mudflat habitat without saltmarsh vegetation cover at the correct tidal level, suitable base habitat is available and that if the small area of seagrass is still present or there is a reasonable prediction of why it could have disappeared and that this could be managed in the future), it would be recommended to plant further seagrass within the low-lying inlet. This could be in the form of seeds (sometimes planted within protective bags, such as hessian bags) mixed with sediment, or plants with good rhizomes. As this area is quite sheltered it may be feasible to use seeds although it is recognised that quicker establishment, and a greater likelihood of success exists with transplanting all, or parts of, a seagrass plant.

Seagrass can be present where the elevation is below MHWN, which is approximately 1.4-1.5m BOD in the case of Blakeney Point. Within the low-lying inlet, there is an area approximately 100m wide that is lower than 1.5 m OD and could be suitable for seagrass (**Figure 23**). Although this is a relatively small area for a restoration initiative, the area does appear to have many benefits including a shallow water area, an area at the correct tidal profile and has shown that seagrass has the potential to grow in this area. Furthermore, with increasing sea level rise, a larger area of the inlet will be submerged at MHWN, so the suitability of this inlet for larger patches of seagrass would increase over time. This area could provide a more long-term option for the future when planting of seagrass could be undertaken as sea level rise enables a larger area to be available at the correct tidal level. One of the objectives for planting seagrass in the shorter term could be to provide a source of seagrass in the longer term to enable a natural spread into these areas as sea level rises. The seagrass would bind the sediment in these areas to give greater stability.

The potential issue of grazing by geese and other birds should be considered during any more detailed planning to ensure that the seagrass plants are not eaten within the short term before the bed has the chance to develop. The potential to plant the seagrass in the shallow subtidal may reduce the risk of grazing in the short-term. Planting of species other than *Z. noltii,* such as *Z. marina,* could also be considered if planting more subtidally. This species could help to prepare the substrate for *Z.Noltii* to colonise the areas that accrete to a slightly higher level as a result of the presence of *Z. marina*.

During a site visit undertaken in August 2025, it was noted that the water in the inlet was clear and there was limited supply of fine material, and although it is acknowledged that this was just one point in time, this provides suitable conditions for seagrass growth as they require clear water with minimal turbidity in order to photosynthesise effectively. The Geomorphological Conceptual Modelling Report indicated that it is also unlikely for this inlet to silt up in the future.

The overall suitability of the inlet for seagrass creation / restoration would depend on the outcome of the proposed habitat survey and a further feasibility survey potentially with modelling. If deemed suitable, the seagrass patch would increase diversity within this inlet and enable it to support species that seem to be less abundant now than they used to be, including providing nursery grounds for fish species (local community consultation indicated that the harbour area used to support a diversity of fish species with high abundance). With sea level rise, the presence of saltmarsh in small inlets such as this could be at risk and establishing seagrass beds in such areas could help to retain carbon reserves in such areas. Furthermore, in combination with the existing fringing saltmarsh, there would be additive benefits of wave attenuation, sediment stabilisation and nutrient pool enhancement through the production of detritus from both habitat types.

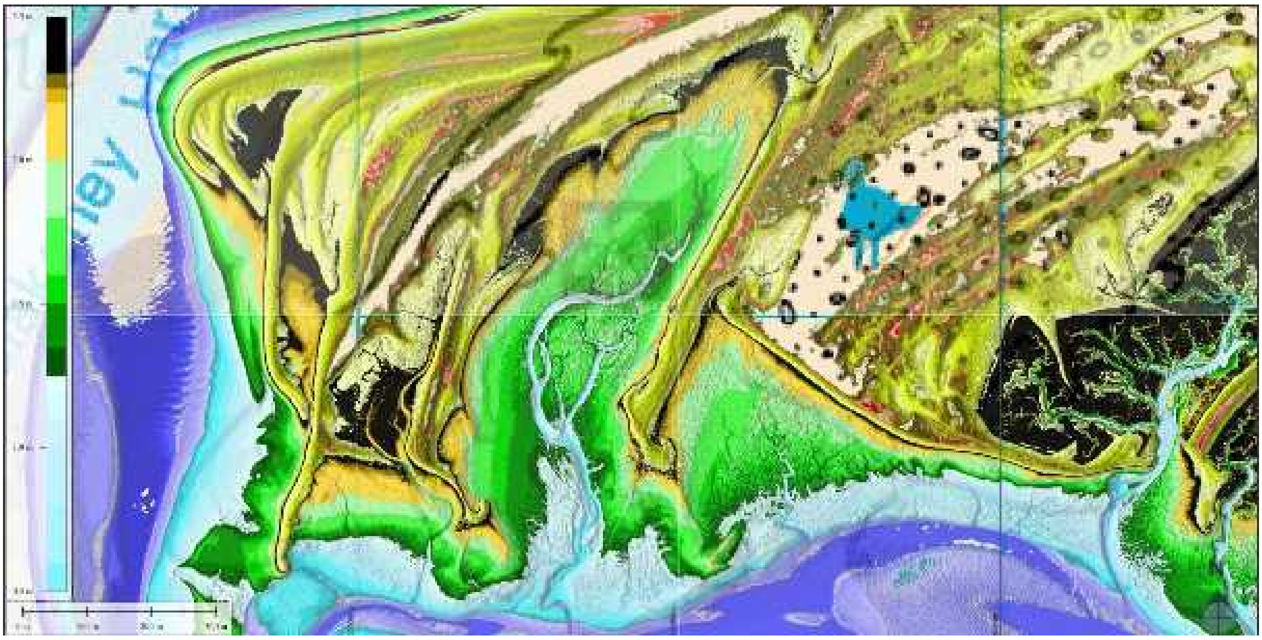

Figure 23 Elevation of Region 1: Blakeney Point. Elevations of 1.4-1.5m BOD or lower (darker shades of green) indicate areas of potential positions for seagrass

Saltmarsh
With future changes, the saltmarsh area is expected to be flooded with saline water more regularly in the northern edge in the top of the inlet. However, this is likely to limit the scrub encroachment currently experienced which could be beneficial for the upper marsh areas. It is not proposed to undertake any restoration of saltmarsh unless scrub clearance became necessary to retain the upper marsh but this would be a medium- to long-term management task until sea level rise floods the upper marsh which would naturally oust the scrub vegetation.

Vegetated Shingle
If the shingle supply remains sufficient along the frontage, as at present, the shingle ridges will be naturally maintained to prevent a breach into the area of the saltmarsh. It is recommended to continue the protection measures currently in place in the shingle banks, as by reducing the number of people from walking on these shingle banks to prevent destruction of vegetation and excluding people from the end

ridges, these measures will also help to stabilise the ridge, protecting and sheltering the saltmarsh behind them.

As described in the Geomorphological Conceptual Modelling Report, there will be ongoing set back of the open coast as a result of sea level rise, with the potential encroachment of the shingle ridge across the head of the existing inlet possibly over the next 50 years, with a subsequent shift of the nose of the point to the west into the entrance channel, which would then move west in itself. Subject to maintaining the supply of sediment across the open coast, it would be anticipated that, while the open coast shingle barrier width may decrease, there is limited risk of a significant breach. Because these shingle ridges are large and very mobile, intervention methods are considered unfeasible. However, it is recommended to continue the management measures currently in place in order to ensure that the ecological roles of the ridges continue being fulfilled, even when the shape and size of the ridges change in the future. This includes excluding people from walking on the ridges, which may otherwise erode the structures. As long as the shingle supply is maintained and the ridges remain high enough, the functional role of the shingle ridges will continue. This includes providing area for seals and ground nesting birds, such as terns and plover. These species are important in Blakeney Harbour, considering the national importance of seal populations in the North Norfolk coast and the stresses facing bird populations. For example, the JNCC population trends for breeding birds in the UK (2024), shows that Ringed Plover are declining, partly due to habitat degradation.

Oyster and Mussel beds
This area was considered for restoration/creation potential for other habitats and species but it was felt that the natural development of the area was important and likely to be the desired objective. It was not considered that there are suitable areas of habitat for mussel and oyster within this region although it is noted that a potential oyster restoration zone was identified (within the ReMeMaRe maps and is shown on **Figure 7**) that has a small area just encroaching into the western edge of the site.

Multi-habitat approach
This area is already highly diverse with a good diversity of habitats in a small area around Blakeney Point, including sand dune, sand and mudflats, saltmarsh and shingle beach with vegetated shingle areas. The system here seems to function well to provide a good stable habitat mosaic.

The potential for restoration of seagrass beds in this region would involve the close proximity of seagrass and saltmarsh which could provide benefits to both in that nutrient pool enhancement may be achieved as discussed in **Table 15** in **Section 5.2.6**. The saltmarsh developed already in the inlet would provide a good degree of shelter for the seagrass bed. It would also provide filtration of the water to improve water clarity which is important for seagrass photosynthesis.

Table 10 provides a summary of the recommendations for Region 1: Blakeney Point.

Table 10 Summary of recommendations for Region 1: Blakeney Point

<table>
<tr><th rowspan="2">Recommendations</th><th colspan="6">Are the recommendations appropriate for the species or habitat?</th></tr>
<tr><th>Seagrass</th><th>Saltmarsh</th><th>Vegetated Shingle</th><th>Blue Mussel</th><th>Native Oyster</th><th>Other habitats / species</th></tr>
<tr><td>Restoration and/or creation</td><td>Yes</td><td>Maybe (potential for scrub management)</td><td>It was considered more beneficial to continue existing management.</td><td>No areas were identified that would be suitable in terms of sediment dynamics and exposure.</td><td>No areas were identified that would be suitable. The small patch identified within the study area, from the ReMeMaRe maps, was considered too small for meaningful restoration as part of this study.</td><td rowspan="2">It was considered more desirable to allow the natural progression of other existing habitats.</td></tr>
<tr><td>Continued management of existing habitat</td><td>Seagrass is not currently managed</td><td>N/A saltmarsh is not currently managed.</td><td>Yes</td><td rowspan="2">There are no existing blue mussel beds</td><td rowspan="2">N/A as there are no existing native oyster beds</td></tr>
<tr><td>Do nothing – allowing the natural progression of existing habitats</td><td>Maybe (if restoration/ creation is deemed unfeasible)</td><td>Yes (although there is also the potential for scrub management)</td><td>It was considered more beneficial to continue management.</td><td>Yes</td></tr>
</table>

5.2.3 Recommendations for Region 2: Stiffkey Marsh and Blakeney Pit

Seagrass
The existing western patch of seagrass (shown in **Figure 18**) is relatively large and is thought to be largely sheltered by sand banks from the strong tidal flows in Region 2. This region has, however, been subject to minimal erosion around the edges of the seagrass bed, mostly in the areas that are less dense (<5% cover), although some of the less dense areas have increased in distribution. The main denser area of the bed has remained relatively stable. The exact cause of any losses is not known, but given their minimal nature and that they are within the low density seagrass areas they could just be natural changes or grazing by geese, etc. This area is also more open than the inner areas of the harbour and as such could be less affected by water quality issues as it could be expected to be subject to a greater extent of flushing. It is therefore recommended that restoration of seagrass in this general area could be feasible as the conditions are obviously suitable in the recent years. Mapping of the habitats to determine areas that provide similar conditions would show the areas that could be included within any initiative. As an initial step to determine the potential for seagrass the area was mapped to show the extent of the intertidal that occurs at a similar level, relative to the tide, to the seagrass bed. This is shown for the harbour as a whole in **Figure 3.** This shows that the areas to the east of the existing bed could be suitable for extending the seagrass bed. This area offers a good level of shelter from the main inlet and would provide additional protection to the saltmarsh behind. The existing area of seagrass could be extended quite considerably in this area if the habitat is appropriate.

The eastern patch of seagrass (which was identified during the site visit and shown on **Figure 19** as additional area of seagrass) is sheltered by the banks of coarser substrate, stabilised to some degree by the mussel beds in front of it and may be a suitable location for further seagrass expansion. In the future, this coarser substrate, with the colonising mussel bed is expected to remain, despite the potential for the periodic smothering of the mussels. Local consultation with an ex-mussel farmer in the area indicated that mussels tend to disappear and reappear in different areas, thought to be connected with the sediment movement. Therefore, the area behind the mussel bed is expected to remain relatively sheltered. The elevation is suitable for further seagrass colonisation (**Figure 8**) and the significant changes to the region due to sea level rise (as detailed in Section 5.2 of the Geomorphological Conceptual Modelling Report (**Appendix D**)) would be unlikely to negatively impact seagrass. Instead, it is likely that a greater area would become suitable for seagrass, although this may be more suitable for *Z. marina*, rather than *Z. noltii* as the deeper water would favour the initial species. The proximity of the mussel bed with this seagrass would have mutually beneficial advantages for both habitats and the wider region. For example, the seagrasses trap and stabilise sediments, which improves stability for mussel settlement. Photosynthesis also oxygenates the water for mussel respiration. Meanwhile, the mussels filter the water, improving the water quality and clarity, which aids photosynthesis for seagrass. Seagrasses also benefit from nutrient-rich deposits from the bivalves (McAfee *et al*., 2022).

Mussel Beds
There is the potential for expansion of the existing mussel bed. The expansion of existing habitat is beneficial as it helps combat habitat fragmentation and improves connectivity between patches of habitat. Since the tidal flows are powerful in the region, the mussels would be subject to regular flushing, which is important for these filter feeders. Furthermore, the presence of existing mussel beds indicate that the water quality is suitable, although it is acknowledged that it is not suitable for commercial mussel farming purposes without further cleaning of mussels. It is recognised that the area may not be suitable for commercial farming of mussels but as a means of increasing diversity and filtering water mussel bed expansion could be a potential initiative. The existing mussel beds would also act as a source of larvae and genetic material to the extended mussel area. However, this area is discussed as being in an area likely to experience morphological change in the medium to long term as discussed in the

Geomorphological Conceptual Modelling Report (**Appendix D**). Stakeholder consultation with an ex-mussel fisherman corroborates this, stating that the mussel beds have moved several times due to smothering. The Geomorphological Conceptual Modelling Report however also stated that there is currently not enough evidence to suggest that the recent smothering of the mussel beds is part of a longer-term process. Mussels have the ability to withstand turbidity to a certain extent; however, they can become smothered and/or have their feeding apparatus damaged if there is too much suspended sediment. Suspending or elevating the mussels, for example by introducing a layer of culch (broken shell, stones) to the existing substrate to provide a hard, stable habitat for mussel spat to colonise. There is potential for hanging them on ropes or introducing hard artificial structures such as cages which would allow the mussels to be higher in the water column, avoiding smothering. However, the introduction of hard artificial structures can introduce INNS and alter the habitat from a sediment environment. The mussels on ropes could potentially increase biodiversity in the area and provide spat for settlement onto the cultch but would not be seen as restoration of habitat. Alternatively, additional mussels could be added to expand the mussel bed with the caveat that it may be a transient population, and they may become smothered in the future with changing sediment dynamics. Providing additional mussel habitat would allow additional nursery grounds for fish and shellfish, as well as improving the water quality within the Blakeney Harbour system and providing a potential source of mussel spat for natural expansion of mussel beds within the harbour.

Native oyster

There are no known areas of native oyster in the harbour currently but there are historic records that indicate that oysters used to occur in the Blakeney Pit area. There is potential that should the mussel bed be successful in this area that oysters may potentially be introduced in the subtidal area in the lee of any mussel bed that develops. Oysters prefer a slower flow of water than mussels and preferentially settle on old oyster shells so this initiative would require the import of clean oyster shells. The suitability of the habitat would need to be assessed in the future, if the mussel bed continues to develop, as the conditions in this area do not appear to be feasible at the moment.

Saltmarsh

The saltmarsh in this region is expected to undergo increased submergence in the upper marshes under future scenarios. This may be beneficial for the existing saltmarsh and rejuvenate the upper marsh as it would prevent further terrestrial scrub encroachment which currently threatens the existing saltmarsh. It is proposed that the saltmarsh should be left alone to embrace the potential positive effects of sea level rise in Region 2. There are some areas of erosion of the saltmarshes on the seaward edges but these appear to be localised and could provide opportunities for increased diversity with the potential for seagrass to colonise such areas. Given this fact and the extent of the saltmarsh habitat and the potential for increased issues at the seaward edge of the marshes in the future due to sea level rise it is considered that the optimal option for increasing biodiversity is to leave these eroded areas and monitor their natural development and succession to other habitats.

Multi-habitat approach

The opportunities for multiple habitat approaches in this region are discussed above with the potential for multiple species shellfish beds and the proximity of the seagrass restoration to the saltmarsh edges to improve the potential coast protection function through stability of the seaward side of the marsh. In addition, the proximity of the eastern patch of seagrass with the mussel beds could provide mutual benefits for both habitats.

Table 11 provides a summary of the recommendations for Region 2: Stiffkey Marsh and Blakeney Pit.

Haskoning
Enhancing Society Together

Table 11 Summary of recommendations for Region 2 Stiffkey Marsh and Blakeney Pit

<table>
<tr><th rowspan="2">Recommendations</th><th colspan="6">Are the recommendations appropriate for the species or habitat?</th></tr>
<tr><th>Seagrass</th><th>Saltmarsh</th><th>Vegetated Shingle</th><th>Blue Mussel</th><th>Native Oyster</th><th>Other species / habitats</th></tr>
<tr><td>Restoration and/or creation</td><td>Yes</td><td>It was considered more beneficial to leave the areas and allow natural succession and eventual inundation with sea level rise.</td><td rowspan="3">N/A in this region as there are no shingle ridges and it is unfeasible to create them.</td><td>Yes</td><td>Potential in the future but not currently considered feasible</td><td rowspan="2">It was considered more desirable to allow the natural progression of the existing habitat. This may restore other species, but this is not the primary objective.</td></tr>
<tr><td>Continued management of existing habitat</td><td>Seagrass is not currently managed.</td><td>Saltmarsh is not currently managed.</td><td>The blue mussel bed is not currently managed.</td><td rowspan="2">N/A as there are no existing native oyster beds</td></tr>
<tr><td>Do nothing – allowing the natural progression of existing habitats</td><td>It was considered more beneficial to plant additional seagrass.</td><td>Yes</td><td>It was considered more beneficial to restore and expand the existing mussel bed, noting that this may be a transient population.</td><td>Yes</td></tr>
</table>

5.2.4 Recommendations for Region 3: Central Region

Seagrass
There is an existing seagrass area on Blakeney Cley Bank. However, the seagrass in this area has declined significantly between 2016 to 2024 (**Figure 17**). The reason for this decline is not known, but given the extent of the decline, it is not considered feasible to restore seagrass in this area until the reason behind the decline is understood. It is possible that water quality deterioration could be the cause of the decline as this area is close to the riverine inputs from the Glaven and relative to other areas in the harbour is relatively sheltered so would not experience the same level of flushing as in the outer areas of the harbour. Other possibilities include sedimentation, given that the Cley channel is silting up as well, although this is considered to be more likely due to slumping of saltmarsh edges (local consultation with Cley Harbour Committee members). If the threat can be managed or removed, then seagrass restoration in this area would be encouraged as it is clear that the habitat conditions were amenable to seagrass colonisation. It is noted that in the latest survey (Environment Agency, 2025) there was mention of the presence of *Ruppia sp*. in the key for the survey results. This species can tolerate a wide range of salinities but is reported to require higher levels of light when compared to eelgrass and therefore clearer water (MarLIN, habitat preferences). This would indicate that the decline in eelgrass was unlikely to be due to reduced light attenuation. The potential to investigate habitat restoration using *Ruppia sp*, (although not a true seagrass species or a true marine plant but rather a freshwater species with a wide salinity tolerance (MarLIN, Sensitivity review for *Ruppia* biotope)), could be considered for this area and potentially others, although MarLIN reports that it displays a similar sensitivity towards pressures as seagrass beds. Consultation with UCL also recommended that *Ruppia sp.* and *Zostera sp.* should be considered in the project. As discussed in **Section 3.3.1** seagrasses are sensitive to nutrient and organic enrichment and this could be the reason for the declines seen in the seagrass beds in the harbour area, particularly in these areas closer to the fluvial inputs.

To optimise the success for the existing seagrass within this region, it is recommended to monitor and ensure, as far as possible, that flows remain open (which may help to reduce nutrient enrichment to some degree) and that there is no excessive siltation.

Additionally, there are small inlets in the southern part of Region 3 near Scalp Run (shown in **Figure 10**) that are sheltered and at the correct elevation for new seagrass to cultivate. Following a detailed survey, it may be feasible to introduce seagrass to these inlet areas.

Native Oyster
Within these inlets near Scalp Run, there is the potential for Native Oyster establishment in the subtidal areas. The inlets are more sheltered and, as shown in **Figure 11**, it is close to areas of historic native oyster pits. The sediment in this region was observed to be slightly coarser, which would benefit oysters in terms of larval settlement and lower suspended sediment concentrations than with finer sediment. A survey of these inlets and areas of coarser sediment would be required before confirming suitability for native oysters. However, it may be possible to combine seagrass planting with the creation of native oyster beds in the inlets. This would increase the suitability of the conditions for both species. Seagrasses trap and stabilise sediments, which improves stability for oyster settlement, while photosynthesis also oxygenates the water for oyster respiration. Oysters filter the water, improving the water quality and clarity, which aids photosynthesis for seagrasses. Seagrasses also benefit from nutrient-rich deposits from bivalves (McAfee *et al*., 2022).

Mussel and cockle beds with potential for native oysters
Consultation with local stakeholders confirmed the occurrence of a cockle bank somewhere near Morston. The exact location of this within Region 3 is unknown and it is not known if the bank comprises old cockle

shells or supports a living cockle bank. It is possible that if the area is cockle shells it could support mussel habitat if mussel spat was released. The existing cockle bank could act as substrate for larval settlement. However, if the area is an existing live cockle bed it would not be recommended to introduce mussel spat to the area, although this may happen naturally over time. The cockle bank, if comprising of just cockle shells and providing a hard substrate, could also be used for oyster settlement, if the cockle shells were mixed with clean oyster shells to encourage settlement of oyster spat.

Shingle Vegetation

As mentioned above, the shingle ridge is likely to experience an increased risk of breaching during extreme events. However, due to the mobility of sediment along the spit, it is anticipated that such breaches would naturally repair themselves. Any attempt at managing or artificially rebuilding the ridge is likely to increase vulnerability; as seen from previous management of the shingle ridge further to the east at Cley. It is possible to plant additional vegetation in the shingle ridges to increase stability of the sediment. However, with increasing sea level rise, these plants may be drowned. Additionally, if the conditions were suitable for such vegetation, it is likely that they would already be there.

Saltmarsh

As with other areas, the saltmarsh in this region is experiencing areas of erosion on the seaward edge and along some of the creeks (**Figure 15**). On the landward side, it is likely that there is some degree of encroachment by terrestrial vegetation that is reducing the marsh vegetation as upper marsh accretes and reaches a level in the tidal cycle where terrestrial vegetation can outcompete the saltmarsh plants. Sea level rise should help to combat this over time but in the meantime there could be potential for increasing the diversity of the marshes in this area through the removal of terrestrial vegetation and creation of scrapes/pans in the saltmarsh to increase diversity and provide areas for breeding and roosting birds such as redshank that are known to be declining and rely on habitats such as this. The saltmarsh in this area is likely to be less disturbed than other areas and could provide useful habitats for such species.

Multi-habitat approach

This region seems to offer the best opportunities for multi-habitat approaches with a variety of potential habitat restoration initiatives that could be implemented and integrated. It is recognised that natural oyster reefs restoration adjacent to saltmarsh or seagrass beds have greater diversity of fish and invertebrates. Placement of the habitats to ensure that species can gain the benefits of each habitat is important. As the regions have been split to try and consider similar physical conditions, the transfer of material, be it genetic, trophic or individuals should be feasible. The potential for shellfish beds to be created/restored could significantly improve the biodiversity in this area through the potential development of more stable biogenic reefs which would provide a habitat for many species of invertebrate.

The proximity of the saltmarsh and seagrass beds is likely to be of benefit to the successful maintenance of diversity for many species, for example fish that use the estuary would be able to find habitat to use for nursery areas, shelter and feeding rather than just an area that fulfils one or two of these functions.

Table 12 provides a summary of the recommendations for Region 3: Central Region.

Table 12 Summary of recommendations for Region 3: Central Region

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	**Saltmarsh**	**Vegetated Shingle**	**Blue Mussel**	**Native Oyster**	**Other species / habitats**
Restoration and/or creation	**Yes** (for seagrass in the areas identified in **Figure 24**)	**Yes**	Due to the mobility of the region, any attempts to intervene with the shingle ridges are expected to increase vulnerability to breaching.	**Yes**	**Yes**	It was considered more desirable to allow the natural progression of the existing habitat. This may restore other species, but this is not the primary objective.
Continued management of existing habitat	Seagrass is not currently managed	Saltmarsh is not currently managed		There is no management currently	N/A as there are currently no native oyster beds.	
Do nothing – allowing the natural progression of existing habitats	**Yes** (for some the remaining seagrass)	It was considered more ecologically beneficial to restore areas of existing saltmarsh, particularly as these identified patches are potentially less disturbed than in other areas.	**Yes**	N/A as it is unknown if blue mussels are currently present.		**Yes**

5.2.5 Recommendations for Region 4: Cley Channel and Blakeney Freshes

Seagrass, Mussel beds, Oyster beds and vegetated shingle
Given that this area comprises narrow channels and seawalls fronted by saltmarsh and backed by freshwater/brackish marsh there are no identified opportunities for creation of restoration of seagrass, mussel beds, oyster beds and vegetated shingle. The key opportunities arise around the marsh areas as discussed below.

Saltmarsh and grazing (fresh and brackish) marsh
Within the fresh and brackish marsh areas of Region 4 that exist behind the seawall (Blakeney Freshes), there is potential to use dredged sediment from the maintenance dredging described in **Section 4.1.4** to build areas of higher ground within the marsh to create island for birds. This could provide elevated areas for nesting birds such as redshank, plovers and other wading species and ducks, the status of some of which are declining in Blakeney Harbour (**Section 4.3.2**). By building up the marshes with dredged sediment, assuming that the sediment is suitable for habitat restoration, (i.e. is free of contaminants) the marshes may become more resilient to climate change, increasing their capabilities as a natural buffer for storms and waves.

Scrapes (shallow water areas) could be created in both the fresh and brackish marshes of Blakeney Freshes, as well as in the saltmarsh seaward of the seawall. Scrapes, like the islands (discussed above), would benefit bird species such as redshank. The creation of scrapes in-combination with islands would likely have added benefits. While areas of higher ground provide habitat for birds, the scrapes also provide feeding grounds for wading birds like lapwings and redshanks. By adding greater topographical diversity on the marshes, they can support a greater diversity of wetland plants that favour different conditions. Additionally, the diversity of invertebrates would increase, providing vital sources of prey for birds. Scrapes also improve drainage and can help with sediment and nutrient retention, reducing runoff.

Additionally, since the region is important for eel species, it was recommended, during consultation with UCL, that deeper, more permanent habitats could also be added in the Blakeney Freshes. However, it was also reported that pipes for water management may currently act as a barrier for migrating European eels when accessing the Blakeney Freshes.

Furthermore, it is recommended to manage and the remove the terrestrial grasses and scrub vegetation that has outcompeted the saltmarsh species on the seaward side. Consultation with the Cley Harbour Committee members identified that the saltmarshes in this area were becoming overgrown with couch grass with an estimated 60% couch grass in some of the upper marsh areas. Although sea level rise will eventually reduce this issue, the management could help the upper marsh species to be maintained although accepting that this could be a task that requires regular maintenance to ensure its success.

The saltmarsh in the harbour is unable to roll back naturally in many areas, particularly in the south of the harbour as it is constrained by the sea defence. This is causing the squeeze of coastal habitat which reduces the width of the saltmarsh over time and will become an increasing issue with sea level rise. By managing the encroachment of terrestrial vegetation, the saltmarsh is given a longer lease of life.

Within the Freshes, current management policy (North Norfolk SMP, 2009) suggests the need for transition from holding the line to one of managed realignment, with the need to adapt management to avoid sudden change. Considering this, and the expected increase in overtopping, there are several opportunities for intervention with the defence and these would need to be determined prior to any management being initiated in this area. It is also recognised that not all of the Blakeney Freshes area is within the study area and therefore any decisions would need to involve all of those concerned with land

and stakeholder interests in this area. With that in mind, the following options have been considered at an initial level just to look at the potential for habitat restoration initiatives and not with any level of assessment of the overall effect on existing habitats and land use.

Firstly, the defence can be further maintained, alongside continued freshwater marsh management and scrub removal. This would allow the established freshwater communities to be preserved. This, however, does not appear to be in line with the SMP Policy. It is recognised that there are ecosystem services delivered through the marshes here and the fields are used for agricultural purposes; this needs to be taken into account for the development of any initiatives alongside the costs of maintaining the defences to protect the freshwater habitats.

Alternatively, the defence could be breached or abandoned. If the area was breached this would result in dramatic changes to the habitats over a short space of time and would result in many habitats and species being rapidly killed off from the saline intrusion and the loss of the freshwater and brackish habitats and species. There would be a few years where the area would consist of dead vegetation until sediments settled in the area to provide mudflats which would eventually be colonised by invertebrates and annual saltmarsh vegetation which would start to grow once the topography reached the correct tidal level, namely MHWN or above. There may be issues with public perception relating to the interim habitats that would be highly evident, this would need to be managed carefully through public consultation and signage. However, due to saline intrusion in the Blakeney Freshes from flood events, the distribution of species known to be tolerant of saline conditions increased between 2003 and 2017 (Le Cruz, 2017), suggesting that some plant species within the Freshes may be partially tolerant to further inundation. The development of saline lagoons could also be considered as an option for this area.

Another option could be to undertake management of saline intrusion using the existing sluices and/or lowered defences in some areas. Areas could be flooded at different states of the tide to control the amount of water left on site at any time. The protection of some areas of the marsh and fields could be maintained and gradually the flooded areas could become more brackish and eventually potentially saline. This would increase the diversity within the site and provide a location for increasing saltmarsh to replace what could be lost as a result of sea level rise on the existing saltmarsh.

Multi-habitat approach

The opportunities in this area include for several potential initiatives that could provide multiple habitat advantages. The provision of scrapes and islands within existing marshes, both saline and freshwater/brackish marshes, increases the diversity and potentially improves the area for birds that are currently under threat, such as redshank and lapwing, who use such areas for feeding and roosting. The potential for reverting some areas to saline habitats also offers opportunities for increasing saltmarsh and potentially lagoon habitats in some areas.

Table 13 provides a summary of the recommendations for Region 4: Cley Channel and Blakeney Freshes.

Table 13 Summary of recommendations for Region 4: Cley Channel and Blakeney Freshes

Recommendations	**Are the recommendations appropriate for the species or habitat?**					
	Seagrass	Saltmarsh	Vegetated Shingle	Blue Mussel	Native Oyster	Other species / habitats
Restoration and/or creation	This area comprises of saltmarsh and freshwater / brackish marsh and seawalls. There are no areas identified that are suitable for seagrass restoration / creation in terms of exposure, sediment and water flows.	**Yes**, this will depend on if the defence is maintained or not around Blakeney Freshes. If it is agreed that the area will be left to realign then there is potential for saltmarsh creation.	**T**his area comprises of saltmarsh and freshwater / brackish marsh and seawalls. There are no areas identified that are suitable for shingle restoration / creation, for example due to sediment supply.	**T**his area comprises of saltmarsh and freshwater / brackish marsh and seawalls. There are no areas identified that are suitable for blue mussel bed creation in terms of exposure, sediment and water flows.	**T**his area comprises of saltmarsh and freshwater / brackish marsh and seawalls. There are no areas identified that are suitable for native oyster bed creation in terms of exposure, sediment and water flows.	**Yes** There is the potential for island and lagoon creation which would benefit **nesting birds**
Continued management of existing habitat	N/A Seagrass is not present.	N/A Saltmarsh is not currently managed	N/A vegetated shingle is not present.	N/A blue mussels are not present.	N/A native oysters are not present.	**Yes** If the defences continue to be maintained, **brackish and freshwater marsh** (and associated

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	Saltmarsh	Vegetated Shingle	Blue Mussel	Native Oyster	Other species / habitats
						species) will be maintained.
Do nothing – allowing the natural progression of existing habitats		**Yes,** this will depend on if the defence is maintained or not				If this option is chosen, existing freshwater marsh, and associated species, may be destroyed by more regular saline flooding.

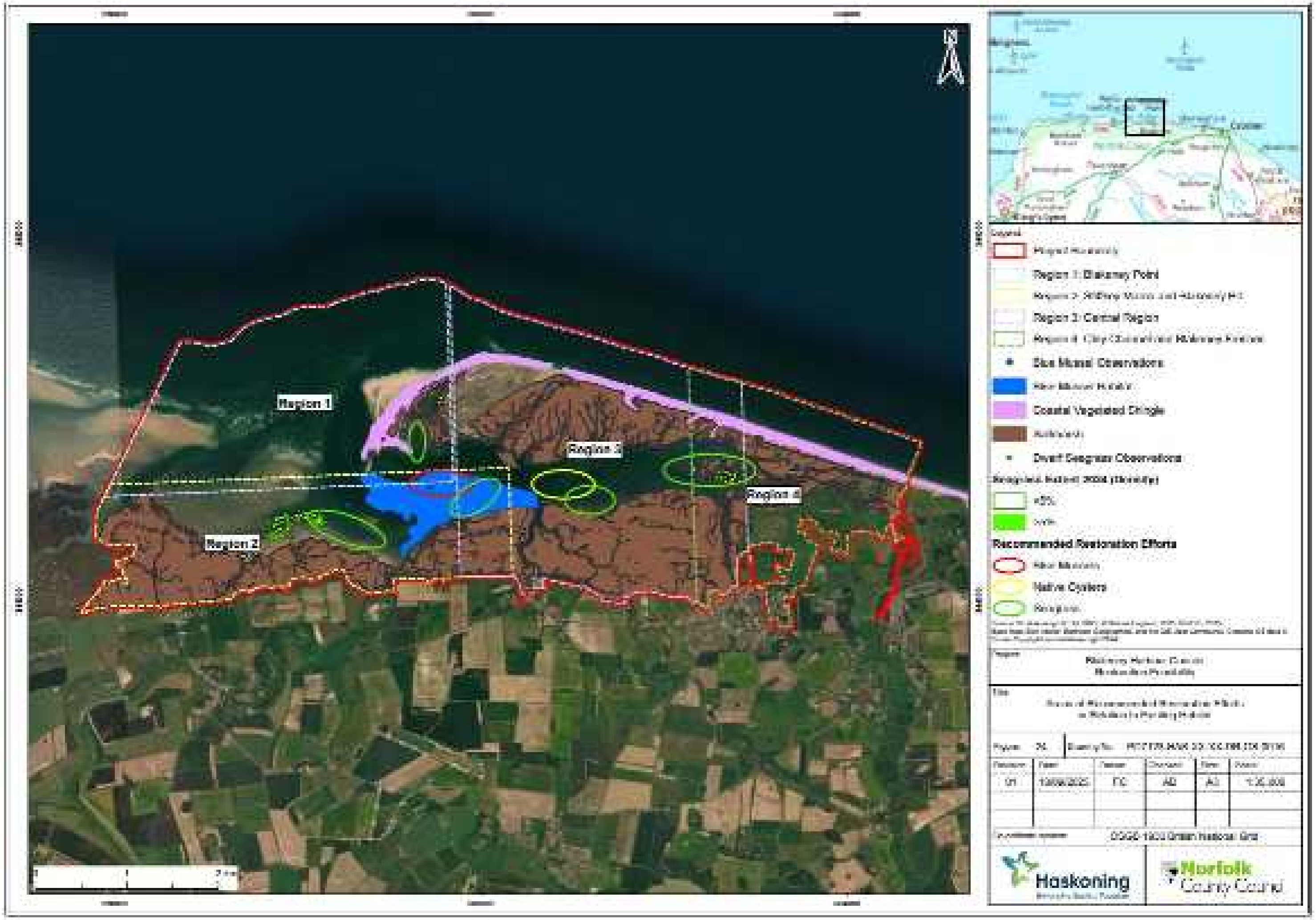

Figure 24 Location of recommended restoration efforts with the existing habitats at Blakeney Harbour

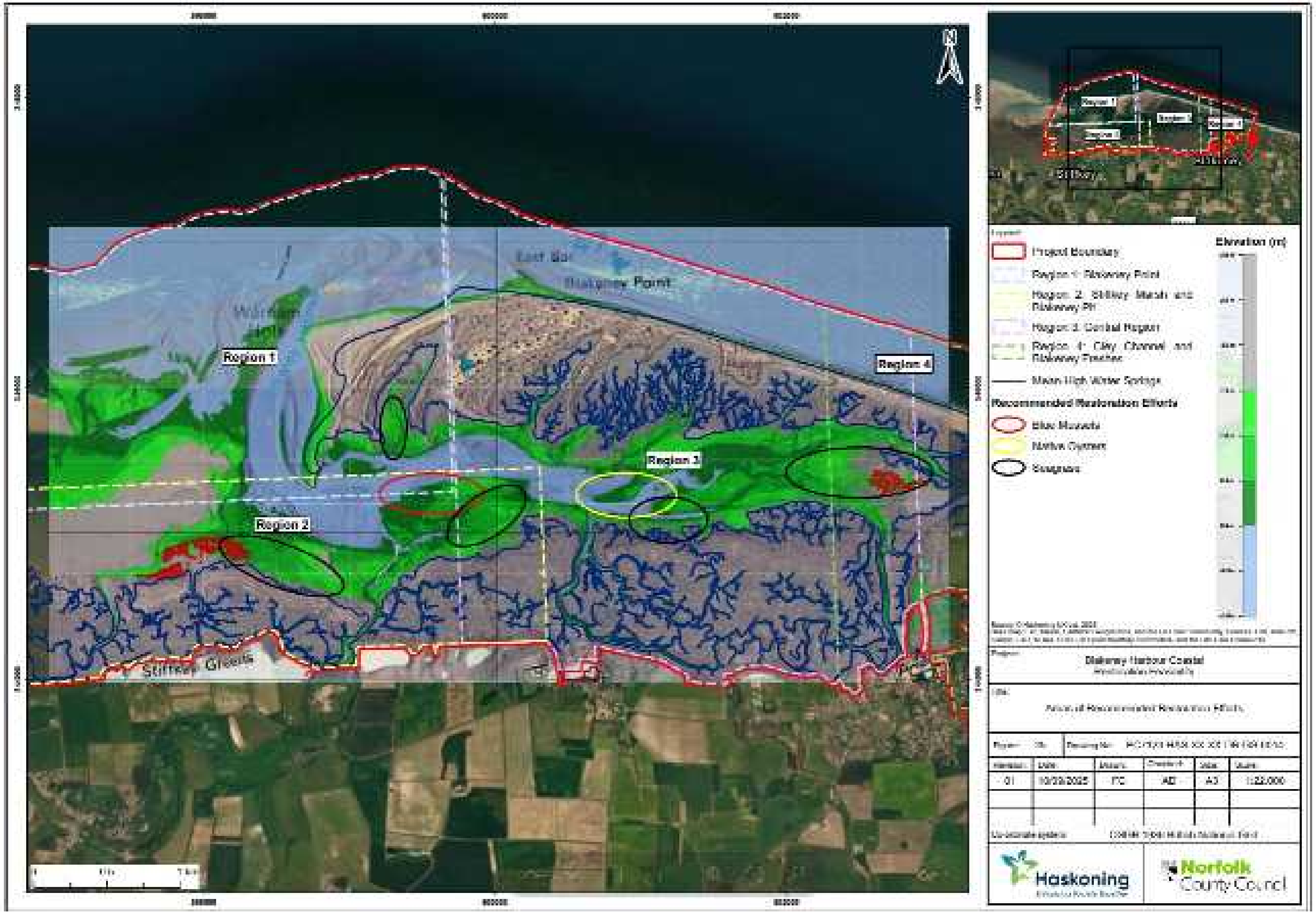

Figure 25 Location of recommended restoration efforts with the elevation of Blakeney Harbour

Table 10 to **Table 13** have identified the potential opportunities for the restoration / creation of habitats and species in each region. For each of these opportunities, the environment has been for assessed for the presence of physical, chemical, biological and anthropogenic constraints that may hinder restoration efforts. Furthermore, the conditions of the environment have been assessed, according to the key requirements for each species / habitat that have been set out in **Sections 3** and **5**. The output of this assessment is found in **Table** 14.

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Table 14 Suitability of the environment to support recommended restoration initiatives

Region	Habitat / Species	Is it currently present?	Was it present historically?	Is the profile and position in the tidal range suitable?	Is there suitable substrate?	Is there suitable water quality and clarity?	Is the area large enough and sheltered enough?	Are there pressures that may reduce the success?	Is there a risk of smothering?	Is there a risk of INNS?
1	Seagrass	**Yes** (**Figure 14**), however, the extent of seagrass is unknown Next steps should include a survey of seagrass extent.	**Yes**, a patch was identified in 2018.	**Yes**, within the low-lying inlet, there is an area approximately 100m wide that is lower than 1.5 m OD and could be suitable for seagrass (**Figure 3**). With increasing sea level rise, the areas suitable for seagrass are expected to increase.	**Yes**, there is fine-grained material in the Blakeney Harbour and seagrass was recorded relatively recently in the area. Next steps should include a survey to identify the sediment type in the inlet and whether there is a constraint due to an existing pressure.	**Yes**, water clarity within the inlet was observed to be good. Next steps should include a water quality survey to measure concentration of nutrients and pollutants to determine suitability.	**Yes**, the identified inlet area is sheltered. The area is small (100 m wide). However, with increasing sea level rise, it is expected to grow.	Potentially, there may be excessive grazing from overwintering birds.	Potentially, the cause of the disappearance of the patch identified in 2018 should be identified to better inform this.	Potentially. The risk of INNS is assumed to be small, since there is no mention of marine INNS in consultation or in the desk-based review.
2	Seagrass	**Yes** (**Figure 14**)	**Yes**, although certain areas have declined (**Figure 16**).	**Yes**, the profile and position are suitable for seagrass as there are extensive areas below MHWN (**Figure 3**)	**Yes**, there is fine-grained material in the Blakeney Harbour and seagrass already present.	Since there is existing seagrass, it is assumed that the water conditions are suitable.	**Yes**, the identified area is sheltered by the existing mussel bed. The area for cultivation is large and may link with existing seagrass patches.	Potentially, there may be excessive grazing from overwintering birds.	It is not considered likely, since the seagrass patch would be sheltered by the mussel bed. The mussels would also reduce turbidity.	Potentially. The risk of INNS is assumed to be small, since there is no mention of marine INNS in consultation or in the desk-based review.
2	Blue Mussel	**Yes** (**Figure 8** and **Figure 14**)	**Yes**, although the beds have moved several times.	**Yes**, there is an existing population of blue mussels, so the conditions are considered suitable.	**Yes**, there is an existing population of blue mussels, so the conditions are considered suitable.	Since there is an existing population of blue mussels, it is assumed that the water conditions are suitable. Next steps should involve a water quality survey to measure concentration of nutrients and pollutants.	The exact size of the existing distribution of blue mussels and potential area for expansion is unknown. Next steps would include a survey of the existing distribution and abundance of blue mussels.	The greatest pressure expected for this habitat is the risk of smothering.	Potentially. Historically blue mussel beds have been smothered and moved several times. The extension of the nearby seagrass beds may help to stabilise sediment.	The risk of INNS is unknown, however, there was no mention of INNS during consultation undertaken with an ex-mussel fisher.
3	Seagrass	Yes, on the Blakeney Cley Bank.	Yes, although seagrass in this area has declined significantly	**Yes**, the profile and position are suitable for seagrass as it is below MHWN (**Figure 3**)	**Yes**, there is fine-grained material in the Blakeney Harbour.	Potentially due to the sheltered nature of the inlets.	The inlets identified for seagrass restoration are small but are sheltered.	Potentially. The inlets may have poorer water quality due to reduced flushing.	Potentially, there may be reduced flushing in the inlets that could lead to increased sedimentation.	Potentially. The risk of INNS is assumed to be small, since there was no mention of marine

Region	Habitat / Species	Is it currently present?	Was it present historically?	Is the profile and position in the tidal range suitable?	Is there suitable substrate?	Is there suitable water quality and clarity?	Is the area large enough and sheltered enough?	Are there pressures that may reduce the success?	Is there a risk of smothering?	Is there a risk of INNS?
		However, there is no seagrass identified in the small inlets mentioned above in the recently eroded saltmarsh areas.	between 2016 to 2024.				The inlets may eventually connect with wider seagrass patches as the suitability for seagrass increases with sea level rise.	Other pressures may include sedimentation and excessive grazing from overwintering birds.		INNS in consultation or in the desk-based review.
	Saltmarsh	Yes (**Figure 14**), although it is eroding on the seaward edge.	Yes, although the extent has declined in some areas (**Figure 15**)	Yes, since there is existing saltmarsh.	Yes, since there is existing saltmarsh.	Assumed to be, since there is existing saltmarsh.	The recommendation within this region is to restore existing saltmarsh through the removal of terrestrial scrub vegetation and by creating scrapes. Therefore, the area and shelter are not relevant.	This region is expected to have less disturbance than other regions. However, there is a continued pressure of the increased erosion on the seaward edge and restrictions on movement of the landward edge currently due to the presence of the seawall.	The recommendation within this region is to restore existing saltmarsh through the removal of terrestrial scrub vegetation and by creating scrapes. Therefore, the risk of smothering is not relevant.	The risk of INNS is assumed to be small, since there was no mention of marine INNS in consultation or in the desk-based review.
	Blue Mussel	Unknown. There are potentially currently or historically mussels within a cockle bank identified by stakeholders. Next steps should include a survey of the area. If live cockles are found, this restoration effort would be unfeasible.	Unknown. There are potentially currently or historically mussels within a cockle bank identified by stakeholders.	Unknown. The exact location of the cockle bank, where the mussels are recommended to be introduced, is unknown. Next steps should include surveys of the area.	Unknown. If there are found to be cockle shells, they can be used as substrate for the mussels. An OS map indicated that the substrate within this region may be coarser, favouring bivalve settlement.	Unknown. Although there are existing populations of mussels, previous studies (WWF, 2023) has shown that water quality has deteriorated. This could potentially be limiting growth of a mussel bed.	The size is unknown until the recommended surveys are undertaken. However, it is likely that the area could be extensive and would be sheltered from stronger tidal flows by Scalp Run.	Unknown. There is not much known about this area. The pressures may be easier to identify after the recommended surveys have been undertaken. Water quality could be an issue.	Unknown. The risk of smothering may be easier to identify after the recommended surveys have been undertaken. There is potentially a risk of smothering given the historic situation with mussel beds.	The risk of INNS is assumed to be small, since there was no mention of marine INNS in consultation or in the desk-based review.
	Native Oyster	No	Close to an area of historic Native Oyster pits (**Figure 11**)	Unknown. Next steps should include surveys and/or modelling of the area.	Potentially. An OS map indicated that the substrate within this region may be coarser, favouring bivalve settlement. Potential to import old oyster shells to improve settlement	Unknown. Pacific oysters flourish in the harbour and native oysters could too and are likely to result in improvements to water quality through their filtration capabilities.	Yes. The inlets are sheltered. The inlets are small, but if mussel restoration is deemed feasible in the old cockle bank, native oyster may be introduced here as well,	Unknown. There is not much known about this area. The pressures may be easier to identify after the recommended surveys have been undertaken.	Unknown, but if the sediment is indeed coarser, as expected, there is less likely to be a risk of smothering.	The risk of INNS is assumed to be small, since there was no mention of marine INNS in consultation or in the desk-based review. Care would need to be taken to ensure

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Region	Habitat / Species	Is it currently present?	Was it present historically?	Is the profile and position in the tidal range suitable?	Is there suitable substrate?	Is there suitable water quality and clarity?	Is the area large enough and sheltered enough?	Are there pressures that may reduce the success?	Is there a risk of smothering?	Is there a risk of INNS?
					potential for oyster spat could be investigated.		increasing the area of restoration and improving connectivity.			any oysters introduced are free of disease or INNS.
4	Saltmarsh	Yes (**Figure 14**)	Yes.	Yes, since there is existing saltmarsh.	Yes, since there is existing saltmarsh.	Assumed to be, since there is existing saltmarsh.	The recommendation within this region is to restore existing saltmarsh through the removal of terrestrial scrub vegetation and by creating scrapes. Therefore, the area and shelter are not relevant.		The recommendation within this region is to restore existing saltmarsh through the removal of terrestrial scrub vegetation and by creating scrapes. Therefore, the risk of smothering is not relevant.	Potentially. The risk of INNS is assumed to be small, since there is no mention of marine INNS in consultation or in the desk-based review.
	Other habitats and/or species – Through the restoration and enhancement of freshwater marsh by creating scrapes and higher ground which benefit nesting birds and ditch-dwelling invertebrates.	Not applicable.	Not applicable.	Not applicable. The profile will be changed with the restoration initiative to provide topographical diversity for other species such as nesting birds.	The restoration measure would not depend on the substrate type as it involves the build-up existing marshes with dredged sediment.	It would be important to monitor the ditches, once created, to ensure the water quality remains good. Potential pollution sources to the freshes should be identified.	Yes, the area is large enough for meaningful ecological benefits. The success of the initiative would not depend on the degree of shelter.	There is a risk of shifting communities to increasingly saline species.	No the area is enclosed behind a seawall. Therefore, the risk of smothering is not relevant. However, there is a risk of overtopping in the future.	The risk of INNS is unknown, there are some terrestrial species of INNS known from the area so any movement within the site would need to be carefully controlled.

5.2.6 Opportunities for the co-location of species

As mentioned in **Section 5.2.1**, where suitable, a multi-habitat approach has been recommended due to the additional ecological benefits that can be gained from the co-location of species and habitats.

Table 15 provides a summary of the potential for the co-location of species and where the different approaches may be implemented in Blakeney Harbour. The following combinations of species / habitats were selected due to the potential for additive benefits of co-locating species. Only feasible combinations of species were included below, as the co-location of species is only practicable if both species require similar conditions.

Table 15 Summary of the potential for co-location of species at Blakeney Harbour

Multi-Habitat Approach	Benefits	Negatives	Feasibility / Confidence	Potential locations within Blakeney Harbour
Bivalves with saltmarsh	Saltmarsh acts as a natural buffer from waves and tides, stabilising sediments for bivalves. Photosynthesis also oxygenates the water for bivalve respiration. Bivalves filter the water, improving the water quality and clarity, which aids photosynthesis for saltmarsh. Furthermore, bivalves provide an increase in nutrient supply that can be used by halophytic plant species, developing the saltmarsh. By providing several niches for fish and shellfish species, the measure is likely to benefit the fish stocks and the coastal livelihood of the Blakeney area.	There have been negatives identified for bivalve interactions with plants, including spatial competition and increased epiphyte growth (Gagnon *et al*., 2020). However, these are not specific to saltmarsh species and blue mussels or native oysters (Gagnon *et al*., 2020).	The confidence of this approach is moderately high. There have been studies undertaken that prove both beneficial and negative interactions. Therefore, while there is a high confidence in the implementation, the beneficial outcome of the approach is less confident.	This approach may be unsuitable at Blakeney Harbour, as saltmarsh creation is not recommended as a measure and the potential sites for bivalve restoration and introduction are not located near existing saltmarsh.
Bivalves with seagrass	Seagrasses trap and stabilise sediments, which improves stability for bivalve settlement. Photosynthesis also	The beneficial interactions of co-location have been reportedly weak in some cases, for example where density is low (Fales *et al*.,	The confidence of this multi-habitat approach is high, considering that there have been numerous studies on their interactions, including a meta-analysis (Fales *et al*., 2020).	This approach may be suitable in Region 2: Stiffkey Marsh and Blakeney Pit (see **Section 5.2.3**).

Multi-Habitat Approach	Benefits	Negatives	Feasibility / Confidence	Potential locations within Blakeney Harbour
	oxygenates the water for bivalve respiration. Bivalves filter the water, improving the water quality and clarity, which aids photosynthesis for seagrasses. Seagrasses also benefit from nutrient-rich deposits from the bivalves (McAfee *et al*., 2022). By providing several niches for fish and shellfish species, the measure is likely to benefit the fish stocks and the coastal livelihood of the Blakeney area	2020). There have also been reported negative effects of spatial competition, where bivalve cover is high (Fales *et al*., 2020).		
Native oysters with blue mussels	These species may use the other as a substrate for larval settlement. The combined reefs have been termed 'Oyssel Reefs' (Reise *et al*., 2017). The species on the top benefits from substrate provisioning and better feeding positions. The species at the bottom benefit from increased protection from predators and detrimental epibionts.	A study by Reise *et al*. (2017) reported that there is a transient primary period whereby settling fast-growing oysters smothered and overtopped existing mussel beds. However, after this, oyster larvae preferentially settled on their own shells, allowing a co-existence of blue mussels under a canopy of oysters.	The concept of combining oysters with mussels as a multi-habitat approach is much less developed than other combinations. There are not many examples of this in practice, with the primary study located in the Wadden Sea (Reise *et al*., 2017). This study was also based on the invasion of Pacific oyster, rather than the intentional introduction of Native oysters as a restoration effort.	This approach may be potentially suitable in Region 2: Stiffkey Marsh and Blakeney Pit (see **Section 5.2.3**).

Multi-Habitat Approach	Benefits	Negatives	Feasibility / Confidence	Potential locations within Blakeney Harbour
	Due to differences in preferential settling, the mussel and oyster species can be mixed and also spatially separated (Reise *et al*., 2017).	The species at the bottom are at risk of sedimentation and hypoxia (Lenihan, 1999).		
Saltmarsh with seagrass	When close to each other, these plants have been shown to have additive and/or synergistic benefits, such as wave attenuation and nutrient pool enhancement through the production of detritus. By doing so, the habitat quality is improved for both species (Gallagher *et al*., 1984; Plumlee *et al*., 2020). By providing features and fulfilling similar roles, combining seagrass and saltmarsh would increase connectivity for species that use them as habitat and/or nursery grounds.	There is likely to be a degree of redundancy as the roles of seagrass and saltmarsh are similar.	The confidence in this approach is moderate. There have been studies that have identified the benefits of the co-location of these species within temperate estuaries, however these have not necessarily had a focus on restoration (Baillie *et al*., 2015). Therefore, the long-term ecological benefits may be less understood than with other multi-habitat approaches.	This approach may be potentially suitable in Region 1: Blakeney Point (see **Section 5.2.2**).

5.2.7 Pressure reduction and management

It is important to address and reduce the pressures mentioned in **Section 5.1** and within **Table** 14 to ensure the long-term success of the initiatives suggested in **Sections 5.2.2** to **5.2.5**. In some instances, pressures should be reduced prior to any habitat creation or restoration, for example excessive declines in water quality, INNS and disease should be absent before creating new habitat. However, in other situations, the habitat creation or restoration can itself reduce the pressure. For example, where there is moderately poor water quality, creating beds of bivalve molluscs could improve certain aspects of water quality and clarity. There is an important balance between attempting restoration when existing habitats are declining and waiting until pressures are removed. If it is clear that a pressure is causing significant decline, then restoration is unlikely to be feasible. However, it is often not clear what pressures are responsible for declines, and it may be a combination of many pressures. In some instances, it may not be possible to remove the pressure(s) completely and there may be some uncertainty as to whether an initiative may be successful in this instance. It should be noted that it is somewhat unrealistic to postpone habitat restoration or creation initiatives until there is an entirely pressure-free environment.

5.2.7.1 Reduction of chemical pressures

At Blakeney Harbour, declining water quality is considered to be a key pressure that would need to be addressed alongside habitat restoration. Consultation with the Norfolk Rivers Trust revealed that there are already some measures that have been planned to improve water quality upstream. For example, by planting hedgerows along farms tracks, to reduce runoff into the rivers. Furthermore, phosphate stripping has been proposed at Langham Water Treatment Works. There are ambitions to create wetlands below every water treatment works in the Stiffkey catchment. These measures, alongside those already undertaken by the Norfolk Rivers Trust (**Table 4**), would greatly improve the water quality of the rivers upstream of Blakeney Harbour and therefore the quality of the water entering the harbour from riverine inputs, particularly by lowering the concentrations of phosphate and nitrate.

Furthermore, as stated in **Section 4.2**, stakeholders noted that the poor water quality in Blakeney Harbour may be partly attributed to excessive seal faeces. However, as stated above, further investigation, including microbial source tracking, would be required to corroborate this theory as there is currently no evidence to prove that this is the case.

There are multiple potential causes of the poor water quality, and a combination of efforts, including those above, should be considered to reduce chemical pressures. These measures, in combination with creating areas of bivalve molluscs, seagrass and/or saltmarsh (as discussed in **Sections 5.2.2** - **5.2.6**), would improve the water quality of Blakeney Harbour.

It is recommended that as a first step, further work is undertaken on the potential for water quality being the issue for the observed seagrass declines and acting as a constraint for mussel growth in the harbour, noting that mostly juvenile mussels were observed during the site visit (although this is not to say that there are no adult mussels present as they would have provided the spat). Restoration of several areas of mussels may be the best option to reduce the chances of pressures affecting the success of the restoration measure.

5.2.7.2 Reduction of biological pressures

As discussed in **Section 5.1.3** and in stakeholder consultation, significant populations of predators, particularly of rodents, are a stressor for the bird species at Blakeney Harbour. Measures to control predator populations, for example installing traps or rodent-proof barriers, have been taken but further measures may be necessary to alleviate this pressure and would need further discussion with the National Trust. It would be important to ensure that non-target species are not affected by any predator control measures. Furthermore, due to the issues with water quality at Blakeney Harbour, chemical control measures, for example rodenticides, should be discouraged. Community engagement practices could also be employed to educate visitors to the harbour on proper waste disposal and rodent deterrence.

Measures to reduce INNS would also ease biological pressures. Effort could be taken to remove the INNS present within the SSSI, albeit that they are terrestrial species, for example the lupin within the fixed dune grasslands. The introduction of new INNS that may hinder restoration efforts should also be prevented. This may include producing resources for boat users that educates them on the risks of INNS and correct boat cleaning practices.

5.2.7.3 Reduction of anthropogenic pressures

It is extremely important to conserve people’s access to nature and their right to enjoy Blakeney Harbour for a variety of recreational uses. Nature’s contribution to good mental health is increasingly recognised and valued (White *et al*., 2021). However, stakeholders have raised concerns regarding the scale of visitors and the potential impacts on the local environment. It is likely that with increasing access to watercraft, such as kayaks and paddleboards, there will be increasing recreational pressure. A study could be undertaken to understand these trends and visitors’ use of the harbour. There is an ongoing project run by Norfolk Coast Protected Landscape which may help fill this gap. The Limits of Acceptable Change (LAC) project is designed to manage the environmental impacts of visitors on sensitive sites. The second phase of this LAC project is focused on the gathering and assessment of visitor numbers at key sites, as well as the development of sustainable site management options. It is important to note that the LAC project is primarily concerned with addressing wider visitor pressure (as opposed to specific local use). However, as the LAC project develops its data and management framework, there is clear potential for its findings and established practices to inform our understanding of harbour management and visitor impacts, should a suitable connection emerge. Management strategies may then be implemented based on this feedback, if necessary.

It is possible to reduce recreational pressures in the harbour without reducing visitor numbers or restricting recreation. For example, producing educational resources and ensuring that there are sufficient numbers of bins can help reduce litter. Furthermore, ensuring that there is appropriate signage detailing the ecological sensitivities of the area may promote responsible behaviour and reduced disturbance. Activities that have been recognised as potentially disturbing the environment, such as bait digging and off-leash dog walking, may be regulated. Bye-laws and voluntary codes of conduct could be implemented to control bait digging and good practice measures encouraged for both bait digging and dog-walking in sensitive areas. In addition, measures such as use of eco-moorings could alleviate some of the effects from the number of moorings in the harbour area. Eco-moorings are used successfully in other areas (for example Studland Bay in Dorset) where sensitive habitats prevail and are designed to reduce drag of rising lines during the ebb and flow of the tide.

5.2.8 Ecosystem services

Coastal habitats provide a wealth of ecosystem services, although these are under pressure when habitats and species are not functioning effectively due to pressures which often result from exploitation of the ecosystem services themselves. The ecosystem services value of coastal habitats include:

- Climate regulation through carbon storage.
- Supporting water quality improvements.
- Provisioning of fish, shellfish and plant resources.
- Provision of facilities for commercial and recreational benefits.
- Coastal protection through attenuation of waves and as a barrier to flooding.

Local community engagement and involvement in the recommended initiatives is essential to the success of the measures. There are numerous ways in which the local community can be involved, from raising awareness of the importance of the habitats, volunteering for planning and restoration tasks and helping to manage specific activities.

When planning any restoration initiatives, the views of local people are highly important as they will know the habitats and effects of any changes in the area better than anyone. The concerns over management of the enjoyment of the harbour are obviously important for the local community and gaining support for particular initiatives could involve discussions over the objectives and how the outcomes could provide wider benefits to the local community. These concerns need to be addressed at each step of the process, as this project has been trying to do from the outset.

The development of habitat initiatives to increase the biodiversity of the site would also provide additional ecosystem services through provision of additional habitats, many of which used to be present but have been lost from the area due to various reasons. The local consultation identified that the area used to support good populations of a variety of fish including large numbers of eels, sea trout, mullet and sand eels. While some fish populations are reportedly declining, as mentioned during consultations with UCL (**Section 4.3.2**), other fish species are considered to be quite abundant. Encouraging greater habitat diversity, particularly habitats that provide nursery and feeding grounds for fish (such as seagrass beds and mussel beds) and improving water quality could help to increase fish populations into the harbour again.

5.2.9 Climate Adaptation

Climate adaptation is an essential consideration when selecting any of the recommendations of this report. The allowance of the natural migration and progression of existing habitats can allow local environments to adapt to changing conditions. Whereas habitat and species restoration / creation initiatives must ensure that the proposed measures are resilient to continued climate change.

The Geomorphological Conceptual Modelling Report (**Appendix D**) considered sea level rise projections of 0.3 m and 0.6 m, the outputs of which have been used to inform this feasibility study. In some species, for example seagrasses, there may be greater opportunity for restoration in the future due to sea level rise. However, sea level rise may drown saltmarsh in lower marsh areas but would effectively encourage the restoration of higher marsh that is currently being affected by encroachment of terrestrial vegetation. In regard to increasing sea temperatures, the MarLIN sensitivities of each of the species / habitats recommended in this report are low or very low (**Table 9**). Another aspect of climate change is increasing acidification of the oceans. This presents substantial risks to the shells of calcifying organisms, such as the blue mussels and native oysters.

Another aspect of climate adaptation is assessing ways in which the initiatives may enhance the climate resilience of coastal communities. This relates to some of the ecosystem services mentioned in **Section 4.5** and **5.2.8**. For example, the role of saltmarsh as a natural buffer can potentially protect coastal communities from flooding. Additionally, the role of seagrass as a blue carbon store will increase carbon storage.

5.2.10 Coastal Livelihoods

Coastal communities rely on Blakeney Harbour for a multitude of socio-economic reasons, including recreation, enjoyment and historically fishing. It is imperative that the livelihoods of local people are improved and not negatively impacted by the recommendations in this report.

The recommendations of this report aim to increase the biodiversity of Blakeney Harbour. This enhances the enjoyment of the harbour, including activities such as birdwatching, walking and boating. Supporting bird and seal populations may also benefit the local economy through existing bird and seal tours.

As mentioned above, stakeholder consultation revealed that there used to be good populations of commercially valuable fish including large numbers of eels, sea trout, mullet and sand eels. Encouraging greater habitat diversity, and the provision of habitats acting as nursery and feeding grounds for fish (such as seagrass beds) may revitalise the populations of these species. This may have commercial and economic benefits for the local community.

Furthermore, this study has suggested recommendations to improve water quality. This may help with public health concerns, particularly pertaining to the reports of *E. coli* in the water, boosting public enjoyment of the water for swimming and watersports.

5.3 Consenting process

If any of the above suggested initiatives are considered to influence the features of the SPAs or SACs at Blakeney Harbour (**Section 4.4**), a Habitats Regulations Assessment (HRA) must be undertaken.

The HRA process consists of several phases:

- Stage 1 Screening – To determine if the initiative would have a likely significant effect (LSE) on the features of a site (SPA, SAC or Ramsar site).

- Stage 2 Appropriate Assessment – Where LSE cannot be excluded, further information is prepared by the applicant to inform an Appropriate Assessment. This determines if the initiative could adversely affect the integrity of the site in view of its conservation objectives.

- Stage 3 HRA Derogation – Where an Adverse Effect on the Integrity (AEoI) of a site cannot be ruled out, consent should not be granted, unless the project satisfies each of the following tests:
  - There are no feasible alternative solutions that would be less damaging or avoid damage to the site
  - The proposal needs to be carried out for Imperative Reasons of Overriding Public Interest (IROPI)
  - The necessary compensatory measures can be secured

These consenting requirements should be considered when determining the suitable habitat creation and/or restoration initiatives at Blakeney Harbour. Discussions held with Natural England indicated that restoration measures are likely to need to reach a Stage 2 Appropriate Assessment as part of the HRA process as any activity to create or restore habitat is likely to affect a feature of interest. It will be important to ensure that any measures are linked to the overall conservation objectives for the site to enhance the likelihood of consenting, particularly with regard to the unfavourable condition of some of the features currently within the designated sites.

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6 Conclusions

6.1 Findings of the study

The feasibility of restoring and/or creating habitats at Blakeney Harbour has been assessed through a combination of desk-based review, site visit, stakeholder consultation and the interpretation of the outputs from the Geomorphological Conceptual Modelling Review (**Appendix D**).

As mentioned in **Section 4**, due to the complexity and diversity in the Blakeney Harbour system, the project area was divided into four regions. There are several opportunities for habitat creation and/or restoration within each of the four regions of Blakeney Harbour (**Figure 26**).

Within Region 1, it is recommended to create a seagrass bed in a potentially suitable inlet (shown on **Figure 25**), whilst continuing existing management of the vegetated shingle ridges. Saltmarsh may also be restored, by clearing scrub vegetation. Within Region 2, it is recommended that the existing population of blue mussels is potentially expanded, with seagrass planted behind the mussel bed (**Figure 25)**. In Region 3, it is recommended to consider planting seagrass and introducing native oysters into inlets (shown on **Figure 25**) and/or blue mussels onto an existing cockle bank. There is potential for the saltmarsh in Region 3 to be enhanced through the creation of scrapes and higher ground, as well as scrub removal. Finally, in Region 4, it is recommended to enhance saltmarsh areas in the upper marsh and give further consideration to the options available for the Blakeney Freshes area within the study area, given the SMP policy to work towards managed realignment. In the interim period, scrapes could be constructed to retain and enhance the freshwater marsh.

These opportunities are summarised in **Table 16**.

While these have been identified as potentially suitable recommendations, there are further steps that must be taken (identified in **Section 6.2**) before any of the recommendations are implemented.

Table 16 Summary of recommendations

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	**Saltmarsh**	**Vegetated Shingle**	**Blue Mussel**	**Native Oyster**	**Other habitats / species**[2]
Region 1: Blakeney Point						
Restoration and/or creation	**Yes**	**Maybe**				
Continued management of existing habitat			**Yes**			
Do nothing – allowing the natural progression of existing habitats	**Maybe**	**Yes**				

[2] *Other habitats and/or species means that the primary target of the recommendation is the restoration or enhancement of a habitat or species not otherwise listed.*

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	**Saltmarsh**	**Vegetated Shingle**	**Blue Mussel**	**Native Oyster**	**Other habitats / species**[2]
Region 2: Stiffkey Marshes and Blakeney Pit						
Restoration and/or creation	**Yes**			**Yes**		
Continued management of existing habitat						
Do nothing – allowing the natural progression of existing habitats		**Yes**				
Region 3: Central Region						
Restoration and/or creation	**Yes** (for seagrass in the areas identified in **Figure 24**)	**Yes**		**Yes**	**Yes**	
Continued management of existing habitat						
Do nothing – allowing the natural progression of existing habitats	**Yes** (for some the remaining seagrass)		**Yes**			
Region 4: Cley Channel and Blakeney Freshes						
Restoration and/or creation		**Yes**, this will depend on if the defence is maintained or not				**Yes** – Through the restoration and enhancement of freshwater marsh by creating scrapes and higher ground which benefit nesting birds and ditch-dwelling invertebrates.
Continued management of existing habitat						

Recommendations	Are the recommendations appropriate for the species or habitat?					
	Seagrass	Saltmarsh	Vegetated Shingle	Blue Mussel	Native Oyster	Other habitats / species[2]
Do nothing – allowing the natural progression of existing habitats		**Yes,** this will depend on if the defence is maintained or not				

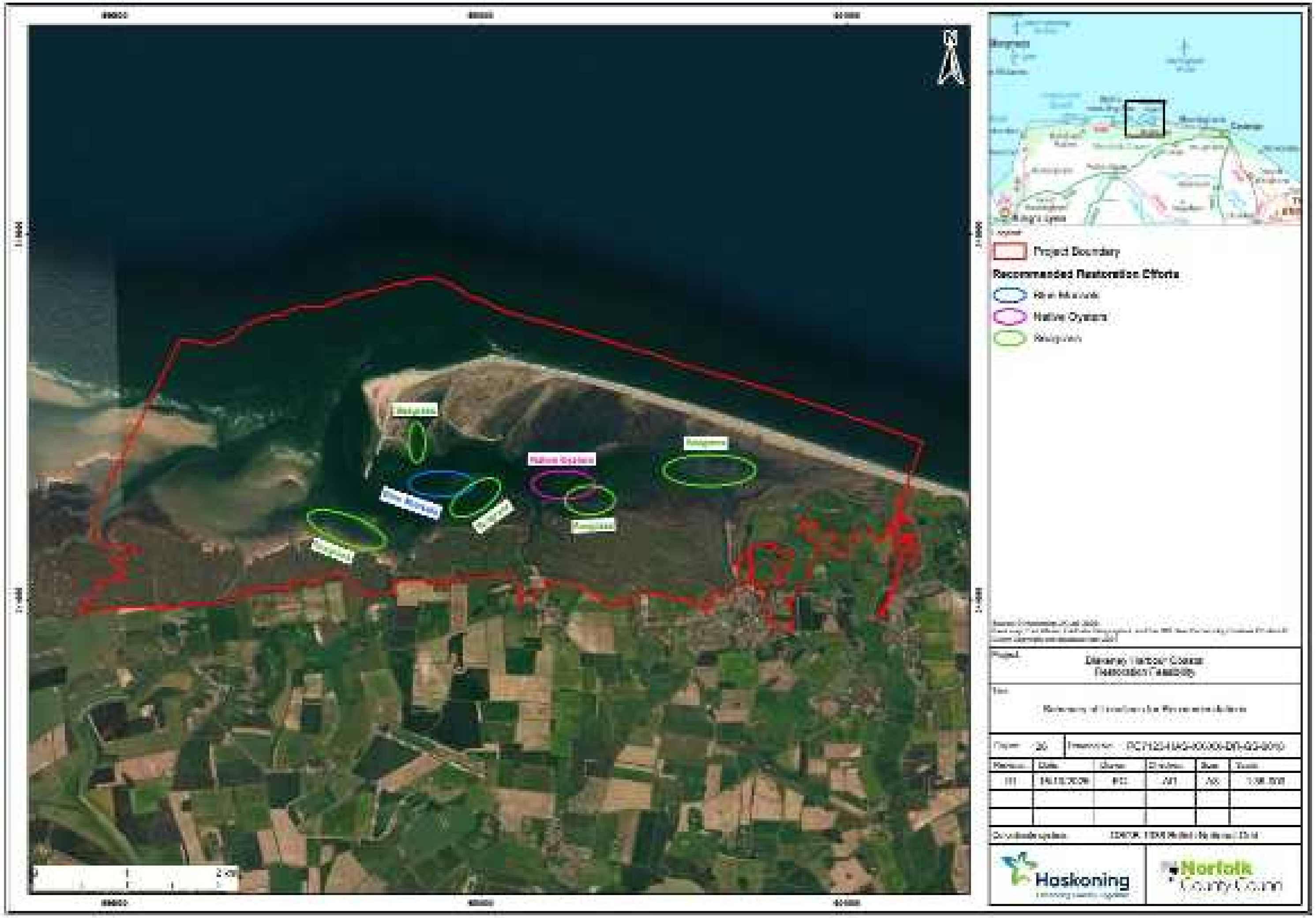

Figure 26 Summary of Locations of Recommendations

6.2 Next Steps

6.2.1 Questions that arose during the study

The study posed many questions that required answers before considering the benefits of habitat restoration that were beyond the full scope of the study. The key questions have been introduced below to help to inform any further work:

How to initiate recovery of connectivity?
A seascape approach considers the connectivity of habitats and transport mechanisms for transport of nutrients, trophic pathways and larval dispersion. The overall picture of habitat distribution shows that there is connectivity between the marshes in the harbour area with good distribution between the marshes and a good network of creeks within the marsh. However, the habitats further down the tidal cycle, towards MLW, are a lot more fragmented and it is these habitats that really need to be restored. The initiatives recommended are focussed therefore on these habitats, such as seagrass, mussel beds and oyster beds and trying to integrate them into each region of the harbour as far as possible, given the feasibility issues with some of the regions. However, the issues and pressures in the harbour are more likely to affect these areas, which is probably one of the, if not the key, reason why they are so fragmented now. This includes issues such as water quality, sediment mobility, recreational pressure and increase in predators. Studies to look at the pressures and how they could be managed and to what degree the management may be successful would provide a vital insight into the level of success and duration for habitat restoration.

What should we be aiming for in terms of recovery potential?
The baseline that we should be aiming for is not what has been lost in the last few decades but what could the harbour possibly support, which can be seen from historic data to include productive bivalve populations, numerous fish species and healthy coastal habitats. Investigating options for managed realignment of the coast could provide a good opportunity for increasing the habitat area and in turn increasing biodiversity and coastal protection functions.

It is acknowledged that habitats and species are not fixed in time and that they evolve over different timescales and in response to differing factors. It is also acknowledged that some habitats will not be sustainable in the longer-term but this does not mean that they are not worth investigating further and implementing as they could provide transient benefits to other habitats and species. This needs to be accepted in defining any objectives for habitat and species creation and restoration.

One such factor, that is becoming increasingly obvious as a driver for change in many habitats and species is climate change, which is going to have far-reaching effects on our coastal habitats and species distributions. Understanding the adaptations that are likely to be needed can improve resilience and support these changes in a more focussed and driven way. The figures produced showing climate change scenarios for the future give an initial idea of the extent of change that could be expected. Nature is going to need help to build resilience in time and restoration initiatives are going to be critical. It is recognised however, that there will be some degree of uncertainty over some of the initiatives, but flexibility is needed and lessons can be learnt from previous examples of restoration initiatives in other areas.

How could habitat initiatives be scaled up?
The scaling up of restoration efforts is an essential consideration to achieve landscape-scale benefits. While landscape-scale restoration requires more time and planning resources, the benefits are much greater. Large-scale recovery of processes, such as connectivity and hydrological dynamics, is required more than ever in our increasingly stressed marine landscapes. Therefore, the resilience of ecosystems to

future changes relies on landscape-scale restoration. It is important to consider long-term scenarios when making planning decisions, as well as employing adaptive monitoring to ensure that the benefits can be sustained in the short-term.

A mindset shift from 'project' based restoration to 'landscape' based restoration can be assisted through the sharing of resources and knowledge across sectors and between restoration projects. Strategic collaborations between public, private and philanthropic sectors have become more available, enabling the finances required for landscape-scale recovery, for example, the United Nations Decade on Ecosystem Restoration Finance Task Force (Ockendon *et al*., 2025). When monitoring large scale restoration efforts, emerging technology such as remotely sensed data and satellite imagery should be utilised. Ultimately, consultation with a diverse and large group of stakeholders will enable the successful scaling-up of restoration efforts.

How may natural capital be considered?

Similarly to ecosystem services, natural capital is defined as the aspects of nature that provide benefits to people. It is a concept that considers the economic value of these services, valuing nature as a stock of assets that require investment. A 2024 report found that natural capital assets in England are at 'high' or 'medium-high' risk (Lusardi *et al*., 2024). For example, marine assets, and associated benefits such as erosion control and flood protection, have been identified as high risk (Lusardi *et al*., 2024). Therefore, the importance of investing in natural capital is increasingly stressed. Acting quickly to prevent further degradation is critical to ensuring the resilience of processes that are integral to ecosystems.

There are three ways to reduce the risks to natural capital: restoring ecosystems; reducing impacts of drivers of change; and making natural capital central to decision -making (Lusardi *et al*., 2024). The recommendations of this report provide opportunities to both restore ecosystems and reduce risks to natural capital, for example by addressing water quality concerns.

Next steps following on from this report should include applying natural capital principles. This would include first identifying the existing ecosystem stocks and their associated benefits. Then, an economic value for these assets could be produced, using indicators, such as tonnes of CO_2 stored by different habitats, where appropriate. The predicted future changes to these services and stocks should also be quantified. The findings can be used to compare restoration scenarios and do-nothing scenarios and assess the trade-offs between the economic costs and gains of restoration. Defra's 'Enabling a Natural Capital Approach' guidance (Defra, 2025) can prove useful in these next steps.

6.2.2 Next steps for studies to consolidate the findings

As discussed in **Table 14**, it is recommended that there are some further investigations into the suitability of some of the sites proposed for habitat restoration / creation. Using a combination of desk-based and site-based research, the following are recommended, in descending order of priority:

- Assessment of the intensity of pressures, and potential for increasing pressure, within the Harbour and how these pressures could be influencing the existing habitats and species. Although this was undertaken to some extent, further studies are needed to fully investigate this and recommend appropriate actions to remedy any significant pressures. This may include further understanding recreational activities, water quality, bait-digging or monitoring the extent of grazing, particularly by geese.
- Determination of the potential carrying capacity of the harbour area for increasing numbers of recreational activities including walkers, boat users and seal trips.

- The existing presence / absence / extent of the habitat/species and sediment type within the recommended restoration site. This could also include a survey on estuarine fish populations, as recommended by consultation with an academic stakeholder from UCL. Any potential effects of the recommended restoration efforts on existing estuarine fish populations should be assessed.
- Analysis of the potential improvement of water quality conditions that could arise from the works by the Norfolk Rivers Trust and the timescale for such improvements. Any further measures that would need to be undertaken to ensure adequate conditions should be investigated. Survey of water quality within recommended sites. This should include testing the water for concentrations of pollutants, nutrients, *E. coli* and common diseases.
- Survey of sediment quality. This should include testing for concentrations of pollutants for comparison against EQS.
- Survey of the habitat for INNS. While these have reportedly been a growing concern in North Norfolk, there is no recent evidence of their presence or absence in Blakeney Harbour. However, the encroachment of *Spartina anglica,* that was thought to have been planted in the 1930's, which has spread rapidly, altering tidal flows (according to stakeholder consultation) would be interesting to investigate in terms of its level of influence and whether there is potential for management.
- Determination of potential flood risk. This may include using the NaFRA2 to ascertain flood risk, which would be particularly important when considering the recommendations for Region 4: Cley Channel and Blakeney Freshes (**Section 5.2.5**).

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Appendix A: Interim Report

REPORT

Blakeney Harbour Coastal Restoration Feasibility - Interim Report

Additional data required for assessing habitat restoration feasibility

Client:	Norfolk County Council
Reference:	PC7123-RHD-XX-XX-RP-0100-S8-C02-X
Status:	Final/C02
Date:	2 May 2025

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Date:	01/05/25
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Date:	01/05/25
Classification:	Project related

Table of Contents

1 Introduction

1.1 Aim of this report

The Blakeney Harbour Coastal Restoration Feasibility Project follows on from an initial phase involving a Marine Recovery Workshop, delivered by The Wash and North Norfolk Marine Partnership (WNNMP), that identified support among partners for exploring potential marine and coastal habitat restoration opportunities, with Blakeney Harbour identified as a potential site for such initiatives. Following this workshop a Working Group (WG) was established to progress the outcomes of the workshop. A study for the World Wide Fund for Nature (WWF) (2024) also investigated the feasibility of multi-habitat coastal restoration in north Norfolk as part of their 'Wholescape' Programme.

The objectives of this next phase of the study are to determine where coastal habitat restoration is likely to be most successful and what assemblage of habitats and/or species should be the focus of restoration efforts to address the priority outcomes put forward in earlier studies.

This report represents the interim report following the initial data review phase. It provides a description of the information that is considered necessary in order to determine the location for habitat restoration initiatives within Blakeney Harbour and then provides a summary of the data available and where there are key data gaps that require survey or modelling work to fill the gaps. The report discusses the priorities for the survey work and what gaps they are intended to address.

1.2 Project outline

The aim of the project is to recommend where within the study area (**Figure 1**) coastal habitat restoration is likely to be most successful in the long-term and identify trial site locations for multi habitat restoration initiatives and recommend the assemblages of habitats and species for the restoration.

The WG identified priorities for the work to support as follows:

- Ecosystem functionality and connectivity
- Climate adaptation
- Coastal livelihoods

It also identified five priority habitats and species to focus on, as follows:

- Seagrass (*Zostera noltii*)
- Saltmarsh
- European flat oyster *(Ostrea edulis*)
- Common/blue mussel (*Mytilus edulis*)
- Shingle beach.

Figure 1 Study Area for Blakeney Harbour Coastal Restoration Feasibility Project (land ownership: National Trust and The Crown Estate)

2 Data required for validation of existing desk-based research and to design coastal restoration projects

2.1 Summary of existing desk-based research

Data has been collated using a variety of sources including the following:

- On-line searches
- 'WWF Report: Feasibility of multi-habitat coastal restoration in north Norfolk (2024)
- Norfolk Historic Environment Records and aerial photography
- Historic Environment Advice
- Norfolk Biodiversity Information Service data request
- Request for data to the Working Group
- Known information from previous work in the area by the RHDHV team

2.2 Data requirements for validation

In order to design a multi-habitat restoration project a large amount of data is required. **Table 1** lists the data and outlines why the data is important for the design phase and what the status of the information is (i.e. compiled, available online or unavailable).

Table 1 Data availability and purpose for the study

Data	Purpose	Source	Notes	Availability
Landownership data	To ensure that landowner consents are not going to be an issue. It has been stipulated that the sites need to be within the study area, where the land is owned by organisations within the PMG.	Information provided as part of the 'Information To Tenderers'. Land within the study area is owned by organisations within the WG.	Permissions for survey work would need to be gained from various organisations, including The Crown Estate, National Trust, Natural England, Marine Management Organisation, depending on the type of survey work undertaken. This includes for landowner permissions and consents necessary within the designated sites.	Compiled (shared by WG)
Designated status of the area	To assess the potential constraints and opportunities relating to features of conservation interest	DEFRA's Magic Mapping for designated site status and Natural England's Designated Sites View system for more detailed information WWF. (2024). Feasibility of multi-habitat coastal restoration in North Norfolk World Wide Fund for Nature (WWF).	Organisation Boundaries (land and marine based) and designated sites In addition to online sources the WWF report shows the proportion of designated sites within the North Norfolk area and the Site of Special Scientific Interest (SSSI) condition value including area of habitats grouped by seagrass density value.	https://magic.defra.gov.uk/MagicMap.html Available online and through WWF report provided by the WG. SSSI feature assessments may have been updated on the Designated Sites View (DSV) by Natural England since the feasibility report was delivered in April 2024, for example, vegetated shingle. Other SSSI feature assessments are planned for the future.
	National Trust	List of indicator species are monitored in 'Blakeney National Nature Reserve and by whom'		Compiled (shared by WG)
Historic records of habitat distribution	To determine the potential for habitats to succeed in any given area	(ReMeMaRe) Datasets 2024	Saltmarsh Change since 2006-2009 baseline survey to 2022 (EA) Seagrass beds Historic locations 2020 (MMO) Native Oyster Reefs Historic locations 2020 (MMO) Historic and current sites (OBIS)	https://www.data.gov.uk/dataset/2d5d8f23-3582-491b-aae4-c987ffabb910/saltmarsh-change https://theriverstrust.maps.arcgis.com/home/item.html?id=416679a1e77e414dbb491e18ad843de1 https://theriverstrust.maps.arcgis.com/home/item.html?id=fdfd31df186548a4bbeefb5a60963159

Data	Purpose	Source	Notes	Availability
			Historic habitats and fisheries in coastal waters 2022 (EA)	https://www.data.gov.uk/dataset/039aa55c-3d32-4cb3-b67e-d6991c3af5f6/historical-oyster-habitat-and-fisheries-in-english-coastal-waters
		MMO (2019) Identifying sites suitable for marine habitat restoration or creation. ABPmer and AER.	General overview of the status of saltmarsh, seagrass and native oyster reefs	Available online 20190430_MMO1135_Identifying_sites_for_habitat_creation_datalayers_Report_a.pdf
		MMO – Explore Marine Plans	Seagrass extent is mapped on the marine plans' explorer (no. 20 on the list) in addition to broad species data (birds and seals) potential seagrass creation and restoration is mapped but not present in the Blakeney area	Available online https://explore-marine-plans.marineservices.org.uk/marine-plans-explorer
		Thurstan et al., (2024) *Records reveal the vast historical extent of European oyster reef ecosystems*	UK Oyster reef records within a European context	Available online https://www.nature.com/articles/s41893-024-01441-4#Sec2
		Murdock, A., Hill, A.N., Cox, J. & Randall, R.E. 2010. Development of an evidence base of the extent and quality of shingle habitats in England to improve targeting and delivery of the coastal vegetated shingle HAP. Natural England Commissioned Reports, Number 054.	Spatial dataset of the inventory for coastal vegetated shingle in England.	Available online file:///C:/Users/928200/Downloads/NECR054%20edition%201%20(5).pdf
		Sneddon, P., & Randall, R.E. 1993. Coastal Vegetated shingle structures of Great Britain: main report. Peterborough, Joint Nature Conservation Committee	Shingle community classifications and descriptions	Available online https://hub.jncc.gov.uk/assets/aa6b4652-8944-4c24-8f95-148045d140ce

Data	Purpose	Source	Notes	Availability
		JNCC (2004) Common Standards Monitoring Guidance for Vegetated Coastal Shingle Habitats.	Origin, extent, definitions, community composition, vegetation, regional distribution, dynamics and assessment methodology of vegetated coastal shingle habitats	Available online https://data.jncc.gov.uk/data/7607ac0b-f3d9-4660-9dda-0e538334ed86/CSM-VegetatedCoastalShingle-2004.pdf
		exegesis SDM Ltd. and Doody, J.P. 2009. Development of a Coastal Vegetated Shingle Inventory for England. Natural England Commissioned Reports, Number 015.	Information on the size (in hectares) of the coastal vegetated shingle at Blakeney	Available online https://data.jncc.gov.uk/data/7607ac0b-f3d9-4660-9dda-0e538334ed86/CSM-VegetatedCoastalShingle-2004.pdf
		Environment Agency (2022)	The extent and zonation of saltmarsh	https://www.gov.uk/government/publications/the-extent-and-zonation-of-saltmarsh-in-england-2016-2019
		NBN Atlas	Point data for *Mytilus edulis*	https://species.nbnatlas.org/species/NHMSYS0020975310#overview
		EIFCA	Historical data on mussel beds	Data requested
Existing habitat distributions	To assess the existing distributions and the declines over the years (when compared with the historic data in the previous rows). Existing information should have been collated within the last three years.	Links referred to in the document *Restoring Meadow, Marsh and Reef (ReMeMaRe) Datasets 2024*	Saltmarsh Extent and zonation 2022 (EA) Preferred locations 2024 (EA) Seagrass beds National seagrass layer 2022 (NE) EA_SeagrassUpdate2025 Vegetated shingle surveyed from Blakeney Point to Salthouse in 2021 and updated on DSV in August 2024	Compiled (shared by WG) https://www.data.gov.uk/dataset/0e9982d3-1fef-47de-9af0-4b1398330d88/saltmarsh-extent-zonation https://www.data.gov.uk/dataset/aa1787a7-71fb-4c44-bf27-7825f9c5ee64/national-seagrass-layer-england Compiled (shared by WG) but sensitive and not currently publicly available information – EA_Seagrass Update2025

Project related

Data	Purpose	Source	Notes	Availability
				Available but sensitive: Preferred Saltmarsh locations 2024 New layer based on the MMO Saltmarsh Potential layer that has been extensively refined following review by Environment Agency and Natural England staff. Reviews focussed on determining the likelihood of successful restoration resulting in areas being given a Red/Amber/Green status. Green areas are the most preferred locations. Layer is not publicly available due to some sensitivity around some preferred locations. An updated screenshot has been provided on the 10/04/25, the layer is not yet available as it is awaiting to be cleaned.
		WWF. (2024). Feasibility of multi-habitat coastal restoration in North Norfolk World Wilde Fund for Nature (WWF).	Map of existing saltmarsh, seagrass in the broader area and oyster bed potential	Compiled (shared by WG)
		NBIS	Habitat layers for: Mussel beds (dating from 2014) Coastal vegetated shingle Potential vegetated shingle Saltmarsh Seagrass *Sabellaria spinulosa* Subtidal sands Grazing marsh Intertidal mudflats Coastal sand dunes Reedbeds	Compiled (shared by WG) NE have noted that the confidence in the mussel beds is low – it has not been determined if the 2014 layer was mapped or if was based on historical beds.

Project related

Data	Purpose	Source	Notes	Availability
			eMapper - Sparse point data of saltmarsh species and marine mammals	eMapper for NBIS (online)
		Defra MAGIC Mapper	The MAGIC Mapper has useful layers including: Living England Habitat Map (updated 2024) which includes coastal habitats such as saltmarsh, sand dunes and vegetated shingle Intertidal Substrate Foreshore (2004) which includes sediment types and	Available online https://magic.defra.gov.uk/MagicMap.html
		Blakeney Harbour Coastal Restoration Feasibility Project Stakeholder Event 1 – Interactive Webinar – Tuesday 8th April	Anecdotal information on locations of mussel beds and seagrass habitats in the area	Compiled (shared by WG)
Potential identified habitat creation and/or restoration locations		Links referred to in the document Restoring Meadow, Marsh and Reef (ReMeMaRe) Datasets 2024	Saltmarsh Potential habitat creation sites within the current floodplain 2020 (MMO) Seagrass Potential 2020 updated in 2024 (EA) – identifies two potential (grey) sites and one potential preferred (green) areas within the Blakeney site and an additional larger potential preferred to the east of the site Native Oyster Reefs Potential 2024 (EA)	Saltmarsh Potential (MMO) - Potential habitat creation sites within floodplain https://theriverstrust.maps.arcgis.com/home/item.html?id=432e71d9c0db44f6a3231cadfca30805 https://www.gov.uk/government/publications/identifying-sites-suitable-for-marine-habitat-restoration-or-creation-mmo1135 Seagrass Potential https://www.data.gov.uk/dataset/5b943c08-288f-4d47-a924-a51adda6d288/seagrass-potential

Data	Purpose	Source	Notes	Availability
				Native Oyster Potential Maps https://www.data.gov.uk/dataset/31530300-0f98-42ac-9b68-b6c980f5383c/native-oyster-bed-potential
		Feasibility of 'managed realignment' a report to the Environment Agency by ABPMer	A mini-feasibility study of implementing coastal defence 'managed realignment' was completed for the Morston-Blakeney area. This delivery pipeline will comprise a list of coastal adaptation and habitat restoration projects that could be prioritised and implemented over the next two decades.	The report has been submitted in draft and will be made available to the Working Group in due course
Habitat creation and restoration techniques	To identify factors to consider when defining suitable survey locations	MMO (2019) Identifying sites suitable for marine habitat restoration or creation. ABPmer and AER.	Mudflats and saltmarshes: Potential habitat creation sites within the current floodplain (applying the techniques known as 'managed realignment' or 'regulated tidal exchange'), Potential beneficial use (mud) – stretches which may benefit. Potential beneficial use (mud) - potential material sources (maintenance dredge disposal sites). Biogenic reefs: Potential European flat oyster (*O. edulis*) restoration - historic and current sites. Seagrass beds: Potential seagrass creation / restoration – historic sites.	https://www.gov.uk/government/publications/identifying-sites-suitable-for-marine-habitat-restoration-or-creation-mmo1135 https://environment.data.gov.uk/searchresults?query=mmo1135&searchtype=&orderby=default&pagesize=20&page=1 https://experience.arcgis.com/experience/dd2c3b9285144e1f943f5aa28a794021/page/Data-Viewer/?dlg=Viewer
		Environment Agency Handbooks	Saltmarsh Habitat Restoration Handbook Seagrass Restoration Handbook	Available online

Data	Purpose	Source	Notes	Availability
			European Native Oyster Restoration Handbook Restoring Estuarine and Coastal Habitats with Dredged Sediment	
Sediment characteristics in the study area (type and mobility)	To determine the optimal locations for certain habitats to thrive	NBIS layers WWF Report (2024) Priority Habitats Inventory England Open-source layers if required: Marine Habitat Classification for Britain and Ireland BGS EUNIS		Available online https://www.data.gov.uk/dataset/4b6ddab7-6c0f-4407-946e-d6499f19fcde/priority-habitats-inventory-england
		Environment Agency (2013) Coastal Morphology Report Norfolk (Wells-next-the-Sea to Blakeney)	Cross section plots of 6 transects at Blakeney Point	Available online https://coastalmonitoring.org/anglian/analysis_programme/Coastal%20Morphology%20Report%20Wells%20to%20Blakeney%20Norfolk%20RP031N2013.pdf
SMP Policy for area	The SMP sets out the intent of management for the coast. It provides the context within which decisions regarding flood and coastal management will be made.	SMP5 - Hunstanton to Kelling Hard (2010)	Policy Units PDZ2 & PDZ3	Available online https://environment.data.gov.uk/shoreline-planning/shoreline-management-plan/SMP5
		Coastal Data Explorer. Rivers Trust (2023)	The Coastal Data Explorer is part of the Catchment Based Approach (CaBA) Data Hub. It provides a curated catalogue of data, maps and applications suitable for supporting collaborative catchment management planning. The datasets are displayed, interpreted and grouped to help partnerships identify issues and	https://theriverstrust.maps.arcgis.com/apps/webappviewer/index.html?id=d5a3fcd28b9c4cde9caf894cbc690e4a

Data	Purpose	Source	Notes	Availability
			opportunities for collaborative action.	
		Catchment Data Explorer. Environment Agency (2023)	An interactive website to explore and download information about the water environment in your area and access river basin management plans. You can find catchments and water bodies of interest using a map, or by searching for names, view summary information about catchments, download data and follow links to other useful sites.	https://environment.data.gov.uk/catchment-planning
		The Local Nature Recovery Strategy data viewer. Defra (2023)	The Local Nature Recovery Strategy data viewer provides access to national scale open data held by Defra to assist in the preparation of their Local Nature Recovery Strategies (LNRS). The data can be viewed in an interactive map and download links are provided to the external sites that host the data. The data is grouped by the relevant subsections of the Environment Act 2021 and each data layer has a summary document that indicates how it may be used in developing a LNRS.	https://experience.arcgis.com/experience/7c5242fdec7f433aa4ee4510383e3909/page/Home/?data_id=dataSource_19-18a2d1a13ec-layer-143%3A2%2CdataSource_16-17f6510d4a6-layer-14%3A17%2CdataSource_16-18364f57c11-layer-3%3A1
Results of condition assessments	To understand the existing status of the habitat (given its designated status) and where there is a need for improvements to habitats	Designated sites view provides some information on certain features within the condition assessments	Vegetated Shingle (feature based) condition assessment 2021 Blakeney-Kelling The Wash and North Norfolk Coast SAC has information for sandbanks, mudflats and sandflats, coastal lagoons, reefs and large shallow inlets and bays.	Compiled (shared by WG) https://sac.jncc.gov.uk/site/UK0017075
Details of pressures on the ecosystem	The presence of bye-laws or management and the area	WWF. (2024). Feasibility of multi-habitat coastal restoration	Sensitivity of coastal habitats to pressures and potential remediation	Compiled (shared by WG)

Data	Purpose	Source	Notes	Availability
	covered enables an understanding of whether the pressure is likely to be an ongoing issue or whether it can be managed to the extent that habitat restoration would be feasible.	in North Norfolk World Wide Fund for Nature (WWF).		
		MMO East Marine Plans	MMO have provided email correspondence listing relevant East Marine Plans including: MPA policies, biodiversity policies and any other relevant policies in the area.	Compiled (shared by WG)
Fishing activity		WWF. (2024). Feasibility of multi-habitat coastal restoration in North Norfolk World Wide Fund for Nature (WWF).	There are seagrass beds and Atlantic oysters present (being grown for commercial use) in Blakeney Harbour, close to the mouths of the Rivers Stiffkey and Glaven. Information is available on the Norfolk Rivers Trust site on fish species using Blakeney Harbour.	Compiled (shared by WG) https://norfolkriverstrust.org/
		Defra MAGIC Mapper	Classified Bivalve Mollusc Harvesting Areas (2011) Shellfish waters (2011)	Magic Map Application
		Fishing areas and areas covered by Bye Laws (MMO)		https://explore-marine-plans.marineservices.org.uk/marine-plans-explorer
	Fishing Debris	Marine Conservation for Norfolk Action Group (MCNAG)	Work being undertaken by the MCNAG includes encouragement of management of marine debris	https://mcnag.org/
Dredging areas		MMO Marine Plans Explorer	Marine activity data/license applications – open designated marine disposal site at wells next the sea but no other activity currently recorded in the area.	
Recreational Pressure		MMO Marine Plans Explorer	Low recreational vessels, and non-port service craft.	

Data	Purpose	Source	Notes	Availability
			RYA general boating area. Medium – medium high motor boating potential Low- medium personal watercraft potential. Medium – medium high sailing potential. Low – medium beach activity. Some historically significant shipwrecks just outside of the site (x3).	
		MMO MCT's Non-Licensable Activity post workshop data MMO MCT's Non-Licensable Activity post workshop data	Non-licensable activity data for Cromer Shoal Chalk Beds MCZ collected by MMO in workshops autumn 2024 Non-licensable activity data for The Wash and North Norfolk Coast SAC collected by MMO in workshops autumn 2024	https://defra.maps.arcgis.com/home/item.html?id=55f2d26551c241469036abfd6c13828f https://defra.maps.arcgis.com/home/item.html?id=5bde00b3b7ac4d76ba605350a8106986
		The Wash and North Norfolk Coast Limits of Acceptable Change by Footprint Ecology (2022)	The study focusses on the nature conservation impacts arising from recreational use and the area consists of the North Norfolk and Lincolnshire coast, from Gibraltar Point in Lincolnshire, around The Wash, and along the North Norfolk Coast east to Weybourne.	Available online: https://norfolkcoast.org/projects/limits-of-acceptable-change/
		Blakeney Harbour Coastal Restoration Feasibility Project Stakeholder Event 1 – Interactive Webinar – Tuesday 8th April	Anecdotal information suggesting to contact regular boat users in the area that operate sailing tours out of Blakeney	Minutes available
Pollution sources		North Norfolk Shoreline Management Plan (PDZ3) November 2010	Food health standards North Norfolk Council monthly checks on oysters (mainly *E.coli*)	Available
		WWF. (2024). Feasibility of multi-habitat coastal restoration	Key pressures within North Norfolk that may impact restoration of coastal habitats	Available

Data	Purpose	Source	Notes	Availability
		in North Norfolk World Wide Fund for Nature (WWF).	Overview of chemical pollutants and their effects on habitats. Identifies there are data gaps within the literature on the effects of certain pollutants on the marine environment.	
		NRT_EnvironmentalDNAReports2024	Environmental DNA Reports: Bacteria report Pollution tracker report Bacteria results data	Compiled (shared by WG)
		Stacey, F and Howard-Williams, E (2024). Quantifying the potential contribution of saltmarshes and seaweed farming to mitigating nutrient pollution in Norfolk. WWF-UK commissioned report	Pollution pathways in Norfolk	Provided by WWF
Water and sediment quality data in the study area		Stiffkey and Glaven catchments and Blakeney Harbour (2018 report)	This report presents results of water quality investigations undertaken in the Stiffkey & Glaven catchments and in Blakeney Harbour.	Compiled (shared by WG)
		WWF. (2024). Feasibility of multi-habitat coastal restoration in North Norfolk World Wide Fund for Nature (WWF).	Coastal and Transitional Water Quality Status	Compiled (shared by WG)
		Existing oyster farm, water quality data	Information collated for water quality on a regular basis.	Information to be provided by the owners of the oyster farm.
		Blakeney Harbour Association Sedimentation Committee	Sedimentation data	Information has been requested.
Ecosystem Services	To determine the benefits gained from the habitats in the Harbour for people (local community and visitors)		Further information expected to be collated during the stakeholder engagement in June.	

Data	Purpose	Source	Notes	Availability
Resilience of the habitats to provide ecosystem services		A Review of the Ecosystem Services Provided by the Native Oyster (*Ostrea edulis*): Implications for Restoration Preston J., Gamble, C., Debney, A., Helmer, L., Hancock, B. and zu Ermgassen, P.S.E. (eds) (2020). European Native Oyster Habitat Restoration Handbook. The Zoological Society of London, UK., London, UK.	Ecosystem services of *Ostrea edulis*	https://www.researchgate.net/publication/363097655_A_Review_of_the_Ecosystem_Services_Provided_by_the_Native_Oyster_Ostrea_edulis_Implications_for_Restoration
		Saltmarsh Management Manual. Environment Agency (2007)	Ecosystem services, function and value of saltmarsh	https://assets.publishing.service.gov.uk/media/5a74dd4e40f0b65f61322dad/scho0307bmkh-e-e.pdf
		The ecosystem service role of UK Seagrass meadows Project Seagrass – May 2021	Ecosystem services of seagrass meadows	https://www.projectseagrass.org/wp-content/uploads/2022/06/ES-of-UK-seagrass-Unsworth-et-al.pdf
		Structural and functional effects of Mytilus edulis on diversity of associated species and ecosystem functioning	Ecosystem services of *Mytilus edulis*	https://www.researchgate.net/publication/250219021_Structural_and_functional_effects_of_Mytilus_edulis_on_diversity_of_associated_species_and_ecosystem_functioning Various online journals available
		Stacey, F and Howard-Williams, E (2024). Quantifying the potential contribution of saltmarshes and seaweed farming to mitigating nutrient pollution in Norfolk. WWF-UK commissioned report	Bioremediation potential of saltmarsh and seaweed habitats to excessive nutrients	Provided by WWF
Management measures on the existing pressures	To determine how much management is ongoing in the area and potentially	Limited information available. Byelaws for EIFCA will be available to determine fisheries management.	Further information expected to be collated during the stakeholder engagement in June.	Fishery byelaw areas and measures available online.

Data	Purpose	Source	Notes	Availability
	determine how effective it is at reducing issues.			
		WWF comment - Management measures for sea-based pressures		WWF comment that all the pressures listed in the table have associated management measures available. Information is available in the WWF (2023) report, particularly on water quality and sources of pollution. Information is also available on management measures within the Natural England Designated Sites Viewer.
		WWF comment - Management measures for land-based pressures		Further information is available from the North Norfolk Landscape Recovery project providing details of the work being undertaken to create new wildlife habitat from arable land (NCC/NRT/Holkham) and work being undertaken through the Norfolk Rivers Trust is available on their website (https://norfolkriverstrust.org/) which includes habitat creation and enhancement measures in the rivers feeding into the harbour to improve water quality.
Aerial Imagery	To understand the historical development of the coast, including vegetation coverage	National Network of Regional Coastal Monitoring Programmes Historic Environment Records	Available for: True colour: 2011-2016, 2018-2023 False colour: None RAF National Air Survey 1944-1946, RAF Floodlight Images, 1988 Colour Vertical Survey, and Oblique images by Norfolk Landscape Archaeology and other sources.	https://coastalmonitoring.org/cco/
		Defra MAGIC Mapper	Aerial Photography layer	https://magic.defra.gov.uk/MagicMap.html

Project related

Data	Purpose	Source	Notes	Availability
LiDAR data	To understand the historical development of the estuary and beach topography. Baseline for any future predictions. Needed to calibrate any numerical model of future estuary development. Provides information for where habitats could develop.	Defra Data Services Platform (Environment Agency LIDAR surveys)	The following DTMs / DSMs are available: 2023 1m 2021 1m 2020 1m 2019 1m 2018 1m 2017 1m 2016 1m 2015 1m 2014 1m 2008 25cm (partial cover) 2003 2m (partial cover) 1999 2m (partial cover)	DEFRA
		Environment Agency (2013) Coastal Morphology Report Norfolk (Wells-next-the-Sea to Blakeney)	Difference model of changes in elevation between 2012 and 2008 LiDAR surveys (overlaid on 2012 photography)	https://coastalmonitoring.org/anglian/analysis_programme/Coastal%20Morphology%20Report%20Wells%20to%20Blakeney%20Norfolk%20RP031N2013.pdf
Topography transects	To understand historical beach development and potential for future development of habitats	National Network of Regional Coastal Monitoring Programmes	Transects only available along open coast. 1991-2022, generally bi-annual	https://coastalmonitoring.org/cco/
Bathymetry data	To understand the historical development of the foreshore's / deeper estuary channels' bathymetry and predict future development potential for habitats	Norfolk Seaweed	From Norfolk Seaweed anecdotal advice "Acoustic hydrographic survey data of our sea farm lease in the subtidal zone from July 2023 (SEP Hydrographic) repeated in April 2024 (Exo-Environmental). These charts are available."	
		Blakeney Harbour Association	Raw Bathymetric data for Blakeney Harbour (2023)	Requested via Norfolk Seaweed and via e-mail to Blakeney Harbour Association directly
		Admiralty Seabed Mapping Service	2015-2017 Holkham Bay to Weybourne survey – 1m	https://seabed.admiralty.co.uk/selected-items?x=110852.18&y=6982094.59&z=11.30

Data	Purpose	Source	Notes	Availability
Tidal levels	Tidal levels are necessary to understand flood risk and to determine wetting / drying extent and times in the estuary. Needed to drive numerical models of future estuary development.	Environment Agency's Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018) Wells Harbour Tidal Gauge	The CFB provides Extreme Water Levels linked to an annual exceedance probability The tide gauge provides historical water level data at the harbour of Wells-next-the-Sea, which is representative for the Blakeney estuary	https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018 Harbour Master Wells-next-the-Sea
Tidal Current Velocity	Tidal currents are the forcing that shapes the estuaries channels and flats. Useful for model calibration.	Not available		
Wave climate	Waves are the driving force behind sediment transport along the open coast and the development of the spit. Needed to drive numerical models of future estuary development.	ERA5 Climate Reanalysis (ECMWF) National Network of Regional Coastal Monitoring Programmes (hosted on Cefas Wavenet)	Historical wave data based on climate reanalysis. Data available for 1940-2025 Blakeney Overfalls Waverider Buoy (53°03'26"N, 001°06'13"E) Data available for 2009-2018	https://climate.copernicus.eu/climate-reanalysis https://wavenet.cefas.co.uk/details/362/EXT
		Environment Agency (2013) Coastal Morphology Report Norfolk (Wells-next-the-Sea to Blakeney)	Significant wave height at the Blakeney Overfalls (NWB1) wavebuoy from December 2011 – November 2012 Direction wave plot for the Blakeney Overfalls (NWB1) wavebuoy from December 2011 – November 2012	https://coastalmonitoring.org/anglian/analysis_programme/Coastal%20Morphology%20Report%20Wells%20to%20Blakeney%20Norfolk%20RP031N2013.pdf
		NNRCMP. Blakeney Overfalls – Annual Wave Reports 2006-2023.	Long-term averages of wave parameters. Joint occurrence of sign wave heights and water levels at Cromer Significant Wave Heights annual exceedance probabilities	https://coastalmonitoring.org/reports/index.php?link=&dla=download&id=2341&cat=261/WaveReport2023_BkO.pdf

Data	Purpose	Source	Notes	Availability
			Significant wave height long-term wave rose plot and joint distribution heat maps between several wave parameters	
		JNCC. 2007. Coastal geomorphology of the North Norfolk Coast	Coastal geomorphology at the site and information on the alongshore wave energy at the site	https://jncc.gov.uk/jncc-assets/GCR/gcr-site-account-2038.pdf
Future Sea Level Rise	To understand future sea levels.	Met Office UKCP		https://ukclimateprojections-ui.metoffice.gov.uk/ui/home
Flood risk within study area	To understand the baseline flood risk before any habitat restoration has taken place.	EA Coastal Flood Risk Model	The EA undertook coastal flood risk modelling in 2018. The model has now been updated by EA and includes future climate scenarios: 17th December 2024: A 'National assessment of flood and coastal erosion risk in England 2024' report - this report will use our new National Flood Risk Assessment (NaFRA2) data and our updated National Coastal Erosion Risk Map (NCERM) 28th January 2025: NaFRA2 'Risk of flooding from rivers and sea' and 'Risk of flooding from surface water' data on 'Check your long-term flood risk' and available on data.gov.uk 28th January 2025: an updated NCERM on Check coastal erosion risk for an area in England, Shoreline Management Plan Explorer and available on data.gov.uk 25th March 2025: NaFRA2 'Flood zone' data on 'Flood map for planning' and available on data.gov.uk These layers will be viewed on Check Your Long-Term Flood Risk (CYLTFR) and Flood Map for Planning (FMfP), with data feeds available on the Defra Data Services Platform (DSP).	Model needs to be requested from the Environment Agency. NaFRA: https://environment.data.gov.uk/explore/8d57464f-d465-11e4-8790-f0def148f590?download=true

Data	Purpose	Source	Notes	Availability
		National Flood Risk Assessment (NaFRA2)	NaFRA2 provides an overview of the local flood risk based on a national assessment method for a limited number of extreme events and climate change scenarios.	
Existing projects for habitat restoration			The Solent seascape project Essex Native Oyster Restoration Initiative Tees River Trust: seagrass and oyster reintroduction, mussel restoration project, intertidal habitat creation The National Trust: Coastal adaption project at Northey Island: saltmarsh managed realignment MaRePo Johnson et al Marine Restoration Potential (MaRePo). Natural England Research Report JP054. Mapping of the restoration potential of marine habitats including kelp and *Ostrea edulis* Seagrass restoration Wadden Sea | Witteveen+Bos LIFE Recreation ReMEDIES (a marine conservation partnership focusing on how sensitive seabed habitats are impacted by recreational activities). Wilder Humber | Lincolnshire Wildlife Trust	Available online https://solentseascape.com/ https://nativeoysternetwork.org/portfolio/enori/ https://www.teesriverstrust.org/oyster-reintroduction https://www.nationaltrust.org.uk/visit/essex-bedfordshire-hertfordshire/northey-island/coastal-adaptation-project-at-northey-island Compiled (shared by WG) https://www.witteveenbos.com/projects/seagrass-restoration-wadden-sea https://saveourseabed.co.uk/ https://www.lincstrust.org.uk/what-we-do/conservation-projects/wilder-humber https://www.seawilding.org/

Data	Purpose	Source	Notes	Availability
			Seawilding | Native Oyster and Seagrass Restoration, Scotland, United Kingdom Restoration | Cley Harbour	https://www.cleyharbour.co.uk/restoration-1
Previous or ongoing surveys			Natural England SSSI condition monitoring reports: Birds – 2021 'Bird Features Monitored Overview' and 'SSSI Bird feature condition assessments march' Veg shingle – 2021 'Vegetated shingle (feature based) condition assessment' attached Geo – 2022 'North Norfolk Coast (GCR)' Note: Dunes – 2024/25 Not ready yet, should be by the end of March Otter – 2025/26 Postponed to next year	Compiled (shared by WG)
Coastal Processes Information (including erosion / accretion trends)	To form a basic understanding how the estuary and the open coast systems function and interact.	SMP5 - Hunstanton to Kelling Hard (2010) Environment Agency - LIDAR (see above) National Network of Regional Coastal Monitoring Programmes – transects (see above)	Policy Units PDZ2 & PDZ3 The SMP provides a conceptual understanding of how the coastal system functions but was published in 2010. Erosion / accretion trends based on later data can be derived from LIDAR / transects.	https://environment.data.gov.uk/shoreline-planning/shoreline-management-plan/SMP5 Data on sedimentation requested from Blakeney Harbour Association
Survey permissions		Natural England anecdotal advice	Crown Estate permission Landowner permission Drone flying permissions - consent and licenses required. NE request to see survey plans if carried out.	

Project related

Data	Purpose	Source	Notes	Availability
			Advised to request a time limited consent across the project boundary for duration of project (e.g. for 5 years monitoring) to cover all potential works under one consent up to a certain date.	

2.3 Data Gaps

Following review of the available information, as detailed above in **Table 1**, the data gaps that exist are as follows:

- **Constraints and opportunities mapping to include intertidal habitat distribution/condition and morphological context of the study area:** up to date constraints and opportunities mapping would provide valuable information to determine the potential for expansion of existing habitats and to identify where habitat is not likely to be possible because there are major constraints. Although there is some recent (last three years) information on certain habitats (as shown in **Table 1** above) this does not provide overall coverage of the area. This would involve a site visit from two experts to use their experience of coastal habitats and morphological conditions to provide an expert opinion on the constraints and opportunities available for habitat restoration and creation.
- **Subtidal habitat data:** although there is a broad scale of mapping of subtidal habitats available it would be preferable to have more up to date information on particular habitats. This would increase the knowledge of the ecosystem, which is important when considering multi-habitat/ecosystem approaches. Many habitats rely on others and the knowledge of habitats throughout the study area both in intertidal and subtidal environments would provide a robust dataset. This survey would target the mussel beds in the shallow subtidal area. It is recognised that there may be further information available that could become clearer during the stakeholder engagement on this subject, in particular with reference to previous mussel bed conditions and potential for smothering. The current mapping for mussels is understood to date from 2014.
- **Sediment quality data:** Although there is only limited data for sediment quality there is information on water quality available which is described in detail in the WWF Ecosulis report (2023) and it is understood that further information could be provided on the water quality sampling results for the Norfolk Seaweed's licensed oyster beds. Given that there is a successful oyster farm in the area it is assumed that water quality conditions are suitable for bivalve habitats to succeed (assuming that sediment deposition is not considered to be too great a constraint). This will be investigated further during the analysis of available data.
- **Ecological-biological connection:** It is identified that a further understanding on the ecological and biological connections between the priority habitats and species is required. It is thought that once the data has been reviewed the connections will become more apparent and recommendations on which combination of restoration would best support the highest ecosystem services, or the most appropriate restorations given the economic and cultural context.
- **(Historical) Bathymetry Data:** although there is a timeseries available of above-water topography, which covers the majority of the tidal flats, channels and open coast beach, there is only one bathymetric dataset available which covers the foreshore and the ebb delta but does not cover the deeper tidal channels at the estuary mouth. Further historical bathymetric data does not appear to be available although we are currently awaiting discussion with the Blakeney Harbour Association which may lead to further information. The data that is currently available is dated and likely a mixture of multiple survey campaigns (2015-2017). Recent bathymetric data would be required, though, as it is essential as a baseline for the understanding of coastal and estuarine processes and any future numerical modelling of the area. This data would be important to estimate the potential for smothering to occur in the area, which as identified above, would be important for habitats such as mussel beds.
- **Coinciding topographic and bathymetric data:** there is no concurrent topographic and bathymetric data available, meaning that there is a disconnect between above and underwater topography. To be able to understand sediment budgets in the area, but also to form a baseline

as set out above, it is essential to have topography and bathymetry that is collected within a sufficiently close timeframe (less than one week) and that overlaps. It is understood that there is information available from the Blakeney Harbour Association and a meeting has been sought to determine what is available and whether this will be able to address this data gap.

- **Tidal currents:** no data is available on tidal currents throughout the estuary. The tidal currents are responsible for shaping the tidal flats and channels, and understanding their distribution across the estuary would enable assessment of tidal forcing on estuary habitats as well as support the calibration of future numerical models. Variability is mainly related to the spring and neap tidal cycle. To capture this, a month of measurements should be sufficient (to be planned based on predictions of astronomical tide).
- **Inner-estuary wave data:** although wave data is available offshore, no information is available on the wave propagation into the estuary. Although it is likely that the tidal flats will damp a significant amount of wave energy coming into the estuary, measurements or wave modelling could confirm this. This would support assessment of the erodibility of the inner estuary and interaction with habitats. Further assessment on water conditions could be aided using HOBO data loggers, collecting continuous water level data in areas of interest at the site.
- **Flood Risk:** NaFRA2 provides an initial indication of the flood risk to property inland of the estuary. This is currently being published and at this stage, it is too early to tell whether the outputs will be suitable for the purpose of this project. Alternatively, the Environment Agency have a coastal flood risk model available but have indicated that this model would need updating based on new recent knowledge.

It is the intention that some of these gaps should be filled with site specific survey work to enable the next phase of the study to determine appropriate locations for the coastal restoration.

3 Surveys and Modelling required for validation

3.1 Survey work to fill data gaps identified above

The following surveys have been identified following the review of available information.

- **Site visit including intertidal habitat and species mapping with recorded information on visible pressures**: In order to determine the potential for habitat restoration and creation in the intertidal and coastal areas, it is recommended to undertake a site walkover around the study area. This would ground truth the NBIS data on E-mapper and the aerial photography that has been provided by the PMG and add information on habitat and species condition and relevant pressures. The survey would be undertaken on consecutive low spring tides over a period of two days and would aim to capture the following information:
    - Coastal and Intertidal habitat distribution (ground truthing NBIS provided data)
    - Coastal and Intertidal habitat condition
    - Sediment characteristics on the intertidal areas
    - Pressures affecting the habitats within the study area
    - Identification of any additional pressures not noted already, for example potential for debris, recreational pressure points, obvious areas of enrichment, invasive species presence, erosion or accretion, morphological constraints.
    - Opportunities for habitat restoration and creation

  The estimated cost for this walkover survey would be £4600 based on two experienced people (coastal ecologist and coastal morphologist) undertaking the walkover survey.
- **Subtidal habitat and species mapping**: Ground truthing of the NBIS provided mapping of subtidal seagrass beds, mussel beds and sediment banks would provide valuable information for determining the potential for creating and/or restoring such habitats. Any visible constraints would also be mapped. The survey would record sediment type (determined visually), visible pressures and visible constraints to habitat creation.

  The survey would involve the following:

  <u>Sediments and habitat extent mapping</u>
    - Following identification of habitats and species from all available sources identify key areas for ground truthing (up to 10 areas)
    - Record the extent of the habitats (including, oyster bed, mussel bed, seagrass meadow) using GPS enabled device and subsequently map using GIS products
    - Access the seagrass and mussel beds. Survey the beds using kayak/paddleboard to avoid disturbance caused to the habitats or species and practical considerations such as access.

  <u>Subtidal habitats transect survey</u>
    - Snorkel survey
    - Along a determined transect line, visibility allowing, obtain photographs of quadrats and transect video of the habitats to measure habitat type, percentage cover, canopy height of seagrass, general health of habitat and species diversity
    - Collect samples of seagrass to confirm species

  This survey is estimated to cost £4800.
- **Sediment sampling**: Sediment would be sampled from between 8-10 locations and tested for various parameters including nutrients, BOD, COD, Hydrocarbons, metals, particle size distribution. This would supplement the information available, particularly for the water quality, through the WWF report (Ecosulis, 2023) study to provide an indication of potential issues for habitats. Cost is estimated at **£18,000** but is dependent on the variables to be analysed and the number of samples so can be adjusted.

- **Coinciding topographic and bathymetric data:** a comprehensive, detailed, coinciding bathymetric and topographic survey is essential as a baseline for any future modelling of the estuary and the open coast. RHDHV commissioned this type of survey for the Bacton Sandscaping Scheme (further along the North Norfolk coast), for which the surveyor utilised terrestrial LIDAR for the topography and a jet ski-based single-beam echosounder for the bathymetry. For Blakeney, a combination between drone-based LIDAR or photogrammetry and jet ski-based echosounder surveys would be most appropriate given the scale of the estuary. This is estimated to cost **£5,000**, however, this would need to be confirmed with quotes from contractor. Potentially, efficiencies can be achieved if the surveys were to coincide with the regular surveys undertaken at the Bacton Sandscaping Scheme.
- **Tidal currents / inner-estuary wave data:** current and wave measurements could be acquired in a single campaign. Ideally, this would include a number of measurements across the estuary, of which one should be located in the mouth of the estuary. This would provide information regarding the wave propagation through the estuary and as well as the distribution of tidal currents. This would provide the abiotic boundary conditions within which habitat development can or cannot take place. It could also include turbidity measurements, which will provide insight in the sediment transport in the estuary, which, for example, is important when considering processes like smothering. It would also provide significant support to any future 2D numerical hydrodynamic (and morphodynamic modelling, if turbidity is included) modelling but is not essential. Wave propagation could be estimated based on the offshore wave climate instead. The cost for deployment of 2 AWACs (measuring currents, waves and turbidity) over a period of 1 month is in the order of £50,000. The cost for deploying 4 AWACs is in the order of £75,000.

3.2 Modelling work

The following modelling studies have been identified following the review of available information:

- **Flood Risk Modelling:** it is expected that NaFRA2 outputs can be used to provide an assessment of flood risk in the area and that therefore additional flood risk modelling will not be necessary. This could, however, be of use in future stages of the project to test the benefits of different restoration options.
- **Hydrodynamic Modelling**: to understand wave propagation throughout the estuary and to understand tidal currents and associated bed shear stresses throughout the estuary, it is recommended that 2D hydrodynamic modelling is undertaken. A recent topographic and bathymetric dataset is essential for this. Estimated costs £25,000.
- **Tidal Flow Modelling**: to understand tidal currents the estuary, it is possible to undertake limited tidal modelling of a spring-neap tidal cycle in a different numerical model suite. A recent topographic and bathymetric dataset is essential for this. Tidal gauge data from Wells Harbour can be used to calibrate the model. This would not directly generate associated bed shear stresses; however, these can be estimated based on the model results. This will allow for an expert-judgment on likely areas at higher risk of smothering rather than more predictive modelling. Estimated costs £5,000.
- **Future Potential of habitats:** the success of habitats such as salt marsh depend on sufficiently available space bounded by lower and upper tidal levels (representing a certain frequency of inundation); for example, salt marsh can only generally reside between extreme high water and mean high water neaps and therefore the area within which they thrive is spatially constrained. These tidal levels will change in future, e.g. high water might increase from 3m OD to 4m OD (fictional levels for example only), and thus the available space, will change with rising sea levels based on the future topography of the estuary. It is essential to quantify the available space for various habitats. There are three tiers of options for this assessment:
    - **Habitat Potential Mapping excl. estuary response:** this would assess the available area for various habitats by contouring the most recent topographic data based on relevant tidal levels,

adjusted for sea level rise (SLR) over periods of interest. This assumes that the estuary has no capacity to grow with SLR and that it will eventually drown. Cost: £3,000

- **Habitat Potential Mapping incl. estuary response:** in addition to the above (the lower bound), two additional scenarios would be defined: one in which bed levels fully keep up with SLR (the upper bound), and one scenario in which the bed levels grow with SLR based on a rate determined from historical data utilising expert judgment (the best estimate). Cost £5,000
- **Morphological & Vegetation Numerical Modelling:** this approach would utilise a 2D process-based numerical model (such as Delft3D) to calculate changes in bed levels under waves and currents coupled with a vegetation module. This coupling enables feedback between the morphological changes and vegetation growth and vice versa. This is currently the most advanced methodology available. The model results will show the development of the bed levels in the estuary over time as well as the development of salt marsh habitat. The inclusion of SLR will enable assessment whether salt marsh habitat can keep up with sea level rise and whether enough accommodation space is available. Additionally, it will provide insight in turbidity levels throughout the estuary, which can be used to inform assessment of the potential of smothering. The hydrodynamic modelling mentioned above is a prerequisite. The additional cost to the hydrodynamic modelling is approximately £60,000.

- **Assessment of potential for smothering in subtidal areas:** An estimate

3.3 Priorities for survey and/or modelling

The surveys identified above are tabulated below (**Table 2**) with the estimated costs and priorities. Please note that as it is not certain that the surveys and/or modelling would be commissioned the costs have not been confirmed but are estimated based on our experience of similar surveys on other projects.

Table 2 Surveys and modelling work to fill data gaps

Survey/modelling	Estimated Cost	Priority	Notes
Site visit including intertidal habitat and species mapping and assessment of the morphology of the area with recorded information on visible constraints and opportunities	£4600	Essential to provide robust overview for the team	Potential to assume that the habitat mapping from e-mapping is up to date and robust and just undertake a one-day walkover to record pressures. This alternative option would cost £2000 but not provide full coverage of the area but more of a generalised approach.
Subtidal habitat and species mapping	£4800	Recommended to confirm location and condition of mussel beds	Alternatively, it can be assumed that local mussel beds are present in accordance with the information from NBIS. For condition, during the stakeholder consultation, there may be further information available on this.
Sediment sampling	£18.000	Useful	Would provide information on current status of sediment in specific locations. However, it is acknowledged that there are no industrial sources of contaminants and that the main inputs are likely to be nutrient based and could be inferred by water quality data.
Coinciding topographic and bathymetric data	£5,000	Essential (depending on data that is available from the	To gain a robust integration between topography and bathymetry

Survey/modelling	Estimated Cost	Priority	Notes
		Blakeney Harbour Association)	
Tidal currents / inner-estuary wave data	£50,000-75,000	Recommended	Such measurements would be better undertaken during winter conditions to capture more extreme conditions. Optimally it would be undertaken twice to also capture calm conditions. This is not essential but it would improve some of the other analyses
Hydrodynamic Modelling	£25,000	Recommended	To understand wave conditions and the influence of currents and shear stresses within the estuary.
Tidal Flow Modelling	£5,000	Recommended	To understand tidal flow and estimate potential sedimentation in the area, which is important for estimating the potential for smothering.
Habitat Potential Mapping **excl**. estuary response	£3,000	Essential	Basic mapping takes into account SLR but not that estuary has the capacity to adjust to SLR. See below for alternative option.
Habitat Potential Mapping **incl**. estuary response	£5,000	Recommended	Estuary response provides additional information on suitable locations for habitat restoration.
Morphological & Vegetation Numerical Modelling	£60,000	Recommended	Cannot be undertaken without hydrodynamic modelling (above for £25.000). But is important for determining suitability for bivalve beds in terms of smothering potential. A basic assessment could be undertaken using the LiDAR/bathymetry and evidence of previous smothering.

3.4 Requirement for licences/consents for survey work

As the surveys are all within the study area which has been delineated based on the land ownership of members of the WG, it is presumed that landowner consent would be given. However, this would be confirmed with the relevant landowner prior to the survey to request details of the access requirements and timings that would suit the landowner. This would include Crown Estate consent for any surveys.

Should drone based surveys be undertaken then permissions for the flights would be required.

SSSI/Habitats Regulations Assessment Consent – The survey methodologies and timings would all need to be agreed with Natural England as they would be undertaken within the designated sites. It is recommended that one, time limited consent application should be made to cover all the survey activities chosen. Minimising any disturbance to features of interest, including birds and seals would be very important.

The methodology for the surveys is provided above in **Section 3.1**. Once the decision has been made on which surveys to take forward the consent and permission process will be started. The surveys would be undertaken in the summer, unless specified differently in **Section 3.1** above. The majority of the surveys are non-intrusive and would involve mapping features and conditions of habitats and species. The only surveys that would involve placement of equipment or removal of samples would be the tidal and current data acquisition survey and the sediment sampling survey respectively. Should these surveys be selected then permissions and consents may be needed, depending on the equipment used and the number of samples taken.

Health and safety assessments would be undertaken for all surveys with potential risks and likelihood determined and implications predicted. Local involvement in the survey planning would be incorporated to ensure a thorough understanding of tidal movements and access to the intertidal area. For the intertidal and subtidal surveys, access to the habitats would be needed via vessel and this would be carefully managed to reduce health and safety risks. Support from local vessels would be sought for the surveys.

4 Conclusions

The initial data review has been completed and the data collated to determine what is available against the requirements for determining the potential locations for habitat restoration and creation. There is a reasonable amount of information available to aid in the decision making but there are data gaps identified, which if filled, would provide greater confidence in the recommendations for restoration and creation initiatives within the study area.

The surveys and modelling detailed above are discussed in terms of the type of data and whether they are considered to be essential, recommended or useful. In summary the lists below outline the findings of the data review and gap analysis.

The essential work is considered to be the following:

- Detailed site visit to determine key constraints and opportunities
- Coinciding topographic and bathymetric data
- Habitat Potential Mapping **excluding** estuary response

Following on from this there are some tasks that are recommended, but not essential. The justification for these decisions is provided above together with the benefits the results would provide.

- Tidal currents / inner-estuary wave data
- Hydrodynamic Modelling
- Tidal flow modelling
- Habitat Potential Mapping **including** estuary response (as opposed to the habitat potential mapping excluding estuary response included above)
- Morphological & Vegetation Numerical Modelling
- Subtidal habitat and species mapping

The item that has been identified as a data gap and would be useful is as follows:

- Sediment sampling

The timings for some of the surveys and modelling will be dependent on availability of resources. For many of the surveys, the summer months provide optimal conditions, but it should be noted that for the wave modelling the optimal period would include winter months to capture the extreme conditions.

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Appendix B: Engagement Output Report

REPORT

Blakeney Harbour Coastal Restoration Feasibility - Engagement Output Report

Stakeholder Event 2

Client:	Norfolk County Council
Reference:	PC7123-RHD-XX-XX-RP-PM-0102-S8-C02-X
Status:	Final/C02
Date:	18 August 2025

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Document title:	Blakeney Harbour Coastal Restoration Feasibility - Engagement Output Report
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Reference:	PC7123-RHD-XX-XX-RP-PM-0102-S8-C02-X
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Status:	Final/C02
Date:	18 August 2025
Project name:	Blakeney Harbour Coastal Restoration
Project number:	PC7123
Author(s):	Victoria Clipsham
Drafted by:	Victoria Clipsham
Checked by:	Chris Adnitt
Date:	18/06/25
Approved by:	Chris Adnitt
Date:	23/06/25
Classification:	Project related

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Appendices

1 Introduction

1.1 Project outline

The Blakeney Harbour Coastal Restoration Feasibility Project follows on from an initial phase involving a Marine Recovery Workshop, delivered by The Wash and North Norfolk Marine Partnership (WNNMP), that identified support among partners for exploring potential marine and coastal habitat restoration opportunities, with Blakeney Harbour identified as a potential site for such initiatives. Following this workshop a Working Group (WG) was established to progress the outcomes of the workshop. A study for the World Wide Fund for Nature (WWF) (2024)[1] also investigated the feasibility of multi-habitat coastal restoration in north Norfolk as part of their 'Wholescape' Programme.

The objectives of this next phase of the study are to determine where coastal habitat restoration is likely to be most successful and what assemblage of habitats and/or species should be the focus of restoration efforts to address the priority outcomes put forward in earlier studies.

The project aims to recommend where within the study area (Figure 1-1) coastal habitat restoration is likely to be most successful in the long-term and identify trial site locations for multi habitat restoration initiatives and recommend the assemblages of habitats and species for the restoration.

Figure 1-1 Study area for Blakeney Harbour Coastal Restoration Feasibility Project (land ownership: National Trust and The Crown Estate)

The WG identified priorities for the work to support as follows:

- Ecosystem functionality and connectivity

[1] *World Wide Fund for Nature (WWF) (2024) Feasibility of multi-habitat coastal restoration in North Norfolk*

- Climate adaptation
- Coastal livelihoods

It also identified five priority habitats and species to focus on, as follows:

- Seagrass (*Zostera noltii*)
- Saltmarsh
- European flat oyster *(Ostrea edulis*)
- Common/blue mussel (*Mytilus edulis*)
- Shingle beach.

1.2 Progress to date

The Interim Report (report reference “PC7123-RHD-XX-XX-RP-0100-S8-C02-X”) was finalised in May 2025. This report summarises the initial data review phase. It provides a description of the information that is considered necessary to determine the location for habitat restoration initiatives within Blakeney Harbour and then provides a summary of the data available and where there are key data gaps that require additional survey or modelling work. If these data gaps are filled, there would be greater confidence in the recommendations for restoration and creation initiatives within the study area.

Following finalisation of the interim Report and subsequent discussions with the Project Management Group (PMG), it was confirmed that the following additional scope items will be undertaken to fill the identified gaps.

- Site visit including intertidal habitats and species mapping and assessment of the morphology of the area with recorded information on visible constraints and opportunities.
- Development of a geomorphological conceptual model to build an understanding of the driving forces and geomorphological development of the harbour based on historical data and expert judgement.

1.3 Stakeholder engagement

Local consultation is critical for this project to fully understand the situation and to gain community buy in. The project has scheduled three stakeholder events in total, two online and one in person. The overarching objectives of all events are to:

- Present the project and work being undertaken.
- Gain further insight into the aspirations of stakeholders.
- Increase understanding of the area and the ecosystem services provided by the habitats and species.
- Gain knowledge for the local area for habitats, species, pressures and management measures.
- Discuss potential initiatives and gain additional ideas.
- To provide the opportunity for questions to be asked and concerns to be discussed.

1.4 Summary of Event 1

The first online event was held on Tuesday 8th April 2025 at 18:00hrs and was attended by 34 stakeholders representing 19 organisations as outlined in Table 1-1.

Table 1-1 Attendance breakdown at Stakeholder Event 1 (online), broken down by organisation and PMG/WG/Local stakeholder

No.	Organisation	Number of attendees
Attendees outside of the PMG / WG: 11 attendees across 7 organisations		
1	Blakeney Harbour Association	1
2	Blakeney Sailing club	2
3	CEC (Skipper from Wells)	1
4	Cley Harbour Committee	1
5	Coastal Exploration Company / sustainable tourism	1
6	Morston Parish Council	1
7	North Norfolk District Council	4
Attendees represented on the wider WG: 6 attendees across 5 organisations		
8	Eastern IFCA	1
9	Marine Conservation Society	1
10	MMO	1
11	Norfolk Wildlife Trust	1
12	Oyster Heaven / Nature regeneration	2
Attendees represented on the PMG: 17 attendees across 7 organisations		
13	Cefas	1
14	National Trust	1
15	NCPL	3
16	Norfolk Seaweed Ltd	3
17	RHDHV	2
18	The Crown Estate	2
19	WWF	5

The first half of the event included a presentation summarising the background to the project, including the aims and objectives, and the aim of stakeholder engagement. The second half of the event was a 'question and answer' session; potential questions were circulated to the stakeholders in advance of the event to inform this session. These questions aimed at providing an opportunity for all stakeholders to be involved in the project in a number of ways including:

- Ensure understanding of the project and what it aims to achieve.
- Raise any concerns over the proposed project.
- Determine the aspirations for the local community for the habitats and species in the area
- Ensure that what is important to local people is raised at an early stage for consideration
- Provision of data to further the understanding of the area and the ecosystem services (i.e. fisheries, recreational benefits, coast defence function) provided.

The questions were as follows:

- What are your aspirations for the area in terms of the habitats and species that use the area (for example, do you recall a particular time when certain habitats were abundant and supported more

species or when the Harbour Area provided opportunities for particular activities that are no longer feasible)?
- What is important to you when you think about the Blakeney Harbour area?
- What benefits do you get from the habitats and species in the Blakeney Harbour area?
- How would you like to be involved in the restoration of the habitats and species in the area and how could you help?
- What do you feel are the key pressures within Blakeney Harbour?
- Do you feel that those pressures are being managed to the extent that habitat restoration could be successful?
- Do you have any concerns over habitat restoration measures being implemented in Blakeney Harbour?
- Do you have any data that could help the study to further understand the baseline conditions, for example, historic photographs, survey information, anecdotal information on the Blakeney Harbour area?

Appendix A includes a copy of the mural board developed during the event which records stakeholder answers to the above questions.

1.5 Aim of this report

The aim of this report is to provide a summary of the second stakeholder event held on Tuesday 3rd June 2025. The report will identify themes from the event and provide a summary of the key themes that will be used to inform analysis of the feasibility for habitat restoration in Blakeney Harbour.

The report is structured as follows:

- Section 2 provides an overview of the second stakeholder event in terms of its purpose and aims, event format and attendance.
- Section 3 summarises the information gathered during the event.
- Observations and key themes are reported on in section 4.
- Section 0 provides the overall conclusions.

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2 Stakeholder event 2

2.1 Purpose and aims

Stakeholder event 2 was held on Tuesday 3rd June 2025 at Blakeney Village Hall between 10:00hrs and 17:00hrs. The purpose of the event was to allow people who use Blakeney Harbour, or simply know it well, to have the chance to find out more about the project and directly inform this work.

This event aimed to improve understanding of:

- The local factors that could impact the success of coastal habitat restoration, if progressed in the future.
- The benefits that local people would like to see supported by coastal habitat restoration, if progressed in the future.
- The concerns surrounding potential coastal habitat restoration and how we could address these concerns through collaboration.
- The level of local interest in supporting potential coastal habitat restoration.

2.2 Format of the event

The event was workshop-style, with presentations delivered at 10:15hrs, 12:30hrs and 15:00hrs by Emma Irving (Norfolk Coastal Protected Landscape), Charlie Cutt (WWF) and Chris Adnitt (Haskoning). The presentations provided an introduction to the project and progress to date. Questions were taken from the audience resulting in relatively extensive discussion which is summarised in section 3.1.

In between the presentations, stakeholders were asked to annotate hard copy maps to record opportunities and challenges across three themes:

- Habitat and species sightings (observed increases or decreases).
- Constraints – activities, pressures and management (or lack of) that could negatively impact potential habitat restoration success.
- Opportunities – activities, opportunities and management measures that could support potential habitat restoration success.

The information captured from the annotated maps is summarised in section 3.2.

Stakeholders were also asked to annotate flipchart paper to explore local interest, concerns and ideas for next steps, focusing on three questions:

- What outcomes or next steps would you like to see from this project if coastal habitat restoration (in some form) is found to be feasible or not feasible?
- Are you interested in being involved in project progress in the future? If yes, how would you like this to be coordinated/organised?
- Do you have any concerns about potential habitat restoration?

The information captured from the flipcharts is summarised in 3.3.

2.3 Attendance

Stakeholder event 2 was attended by at least 59 people as shown in Table 2-1. Of these, 20 attendees belonged to organisations represented on the PMG or the wider project WG. 39 attendees were local stakeholders representing a range of groups. Some local attendees may not have signed so this number is expected to be higher. Attendance increased around the presentation times. All presentations were well attended, and the morning slot had the highest attendance.

Table 2-1 Attendance breakdown at Stakeholder Event 1 (online), broken down by organisation and PMG/WG/Local stakeholder

No.	Group represented	Number of attendees
Attendees outside of the PMG / WG: 39* attendees across 24 groups *Some attendees represented multiple groups, so number adds up to >39		
1	Blakeney Harbour Association	4
2	Business Owner	1
3	Blakeney Parish Council	1
4	Flood Warden	1
5	Blakeney Sailing Club	1
6	Cley resident	3
7	Cley Harbour Committee	1
8	Cley Parish Council	1
9	North Norfolk District Council	1
10	Fisher	1
11	Local charity	1
12	Local resident	9
13	Local sailor	3
14	Local resident	1
15	Morston resident	1
16	Morston Parish Council	2
17	Boatyard owner	1
18	Neil Thompson Boats	4
19	Blakeney and District Wildfowlers Association	1
20	Recreational user	3
21	Retired longshore fisher	1
22	Stiffkey resident	2
23	Wells resident	1
24	The Wash and North Norfolk Marine Partnership – North Norfolk Advisory Group	1
Attendees represented on the wider WG: 2 attendees across 2 groups		
25	Norfolk Wildlife Trust	1

No.	Group represented	Number of attendees
26	RSPB	1
Attendees represented on the PMG: 18 attendees across 7 groups		
27	NCPL	4
28	WWF	2
29	Natural England	2
30	The Crown Estate	2
31	National Trust	4
32	Norfolk Seaweed	2
33	Haskoning	2

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3 Data and information gathered

3.1 Discussion post presentations

3.1.1 Project aims

- There was a general view from several attendees that habitats around Blakeney are in good condition, are well connected and are being managed locally. It was questioned whether habitat restoration should actually be focused on locations where there is a lack of habitat or where habitat is not considered to be in such good condition?
- There was some misunderstanding between the aims of this project and the Limits of Acceptable Change (LAC) project which also tackles coastal pressures. The LAC project did inform this project, but they are two separate initiatives.
- There was some confusion around the current phase of the project; stakeholders assumed that a Plan had already been produced, and the purpose of the event was to consult on that Plan, rather than this being early engagement in the scoping phase of the project. Stakeholders were keen to be able to access previous reports and have access to a project timeline.
- There was a general mistrust in people outside of the area implementing change due to experience from previous initiatives.

3.1.2 Management of the harbour

- Degraded/dumped boats are a pollution issue in Morston which the Blakeney Harbour Association are trying to respond to.
- There was a general consensus that the fact that the harbour is not managed and boats do not have to be licensed is unique and should be retained.
- Some stakeholders did, however, note that jet skis can be problematic.
- Restricting access was raised as a concern and something to be avoided. Local access to the marsh was stated as hugely beneficial for health and wellbeing. Attendees were very passionate about their area and didn't want it to change, but recognised some changes had happened.

3.1.3 Strategic influences

- Concern was raised about whether the project will be taking account of the Shoreline Management Plan policy when considering future sea defence management (allowing the freshwater marsh to naturally convert to saltwater marsh if the sea breaches into the freshwater after 2030). It was confirmed that this will be considered within the feasibility study.

3.1.4 Previous initiatives

- Concern was raised that this project would lead to designation following an attempt previously to create a Marine Conservation Zone (MCZ) in the area which created a lot of backlash. Natural England provided reassurance that an MCZ is not being explored currently or as part of this project.
- In addition, there was a previous attempt to change a section of the Special Area of Conservation (SAC) without local consultation.
- The above concerns lead to suspicion for some stakeholders over the proposed project and its effect on local access to the area.

3.1.5 External projects/pressures

- The Wash Barrage was raised as a potential pressure.

3.1.6 Future engagement

- Some stakeholders commented that it was difficult to find out about the event, noting that the workshop was intended to be targeted at harbour users.
- Future engagement will need to involve the whole community.
- Stakeholders expressed the need for future consultation related to next steps and consider holding future events in the evening to allow those who are working during the daytime to attend the events. All Parish Councils should be invited and a range of communication channels (Facebook, Instagram, Notice Boards etc.) should be used to publicise future events.

3.1.7 Potential useful resources

- A previous meeting/presentation was held in Wells about coastal pressures and the outputs could potentially be a key resource.

3.2 Opportunity and challenges mapping

Figure 3-1, Figure 3-2 and Figure 3-3 provide an overview of the habitat and species sightings, points identified relating to restoration constraints and points identified relating to restoration opportunities respectively. Table 3-1, Table 3-2 and Table 3-3 provide the corresponding key to the numbers shown on the figures.

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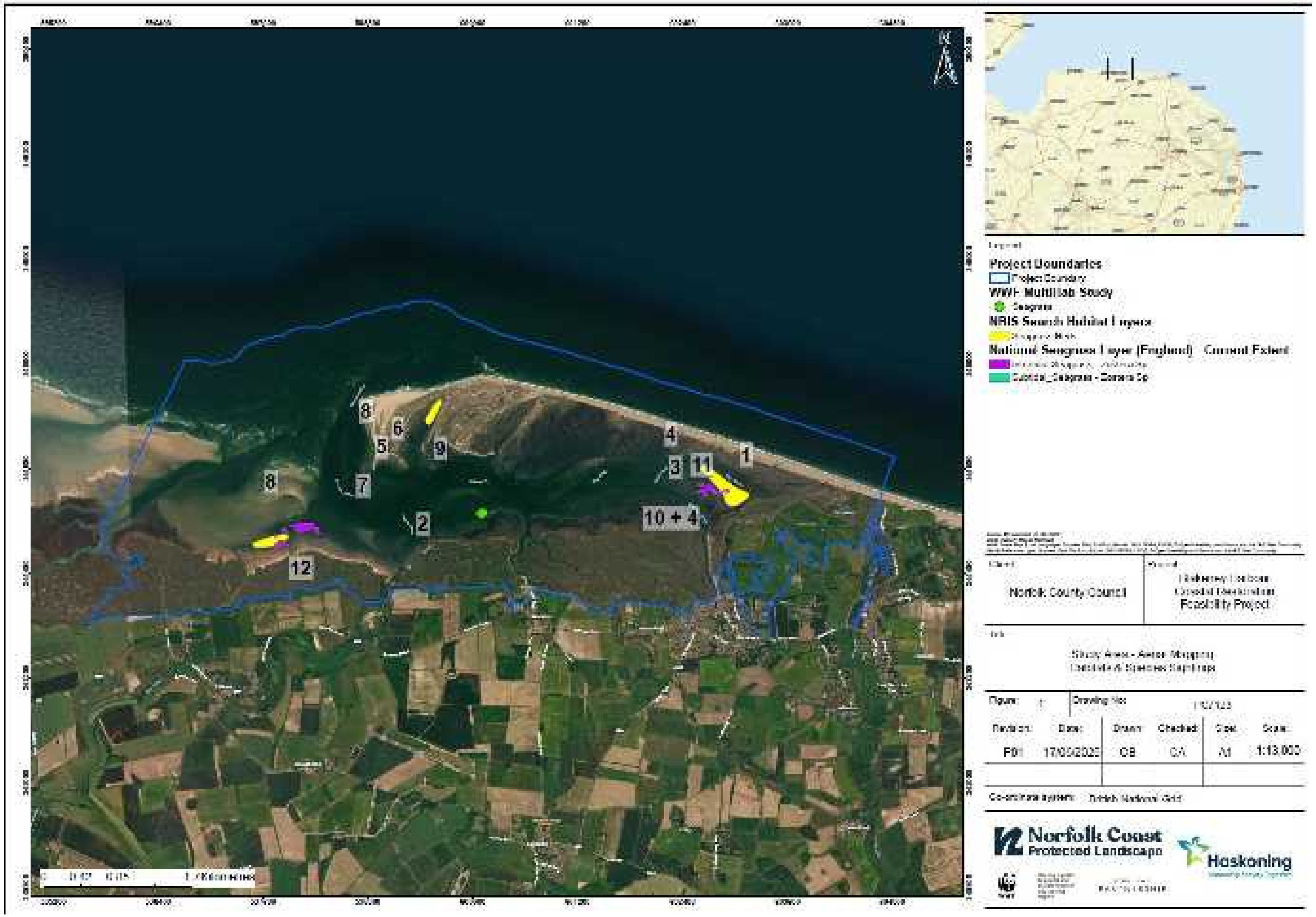

Figure 3-1 Habitats and species sightings (observed increases or decreases) mapping

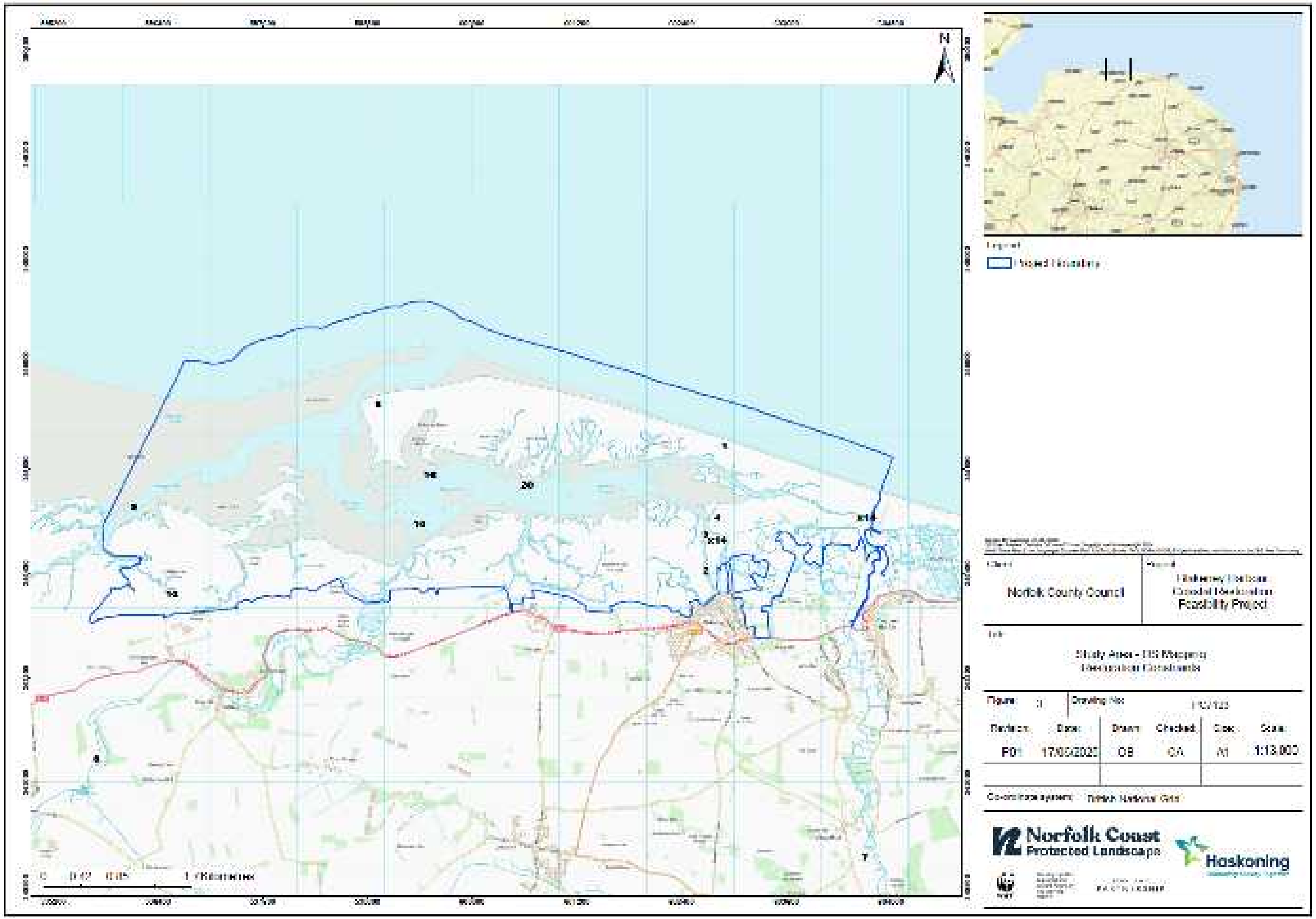

Figure 3-2 Points identified by local stakeholders related to restoration constraints mapping

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Figure 3-3 Points identified by local stakeholders related to restoration opportunities mapping

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Table 3-1 Habitats and species sightings (observed increase or decrease)

No. (see Figure 3-1)	Description
1	Avocets and terns nesting
2	Presence of mussel beds up until 1850's – early 2000's No longer present – shingle beds were smothered
3	Presence of seagrass?
4	Sandy area is now muddy
General	Reducing water quality across the harbour?
5	Tern colony – numbers greatly reduced – visitor pressure, increase in rats/vermin
6	Oystercatchers – numbers greatly reduced – visitor pressure, increase in rats/vermin
Coastal path	Erosion of saltmarsh by trampling? Increase in rats? Could do well with management – board walks?
General	Overuse, too high visitor numbers? Erosion of banks – people mud sliding down banks?
7	Disappearance of spit – main feeding area of terns etc. – reduction in tern numbers. There used to be little tern rafts here too. Previous location of seal colony – now disappeared.
8	Current locations of seal colony
General	Local marine biologist has records on changes in Blakeney Harbour? Useful reference?
9	Mussels tested here are Grade C – why? National Trust survey on water quality?
10	Curlews congregate here (fewer so far in 2025). Until this year, Pensthorpe had a curlew breeding programme, and the tagged birds were referred here. Pensthorpe have now stopped this breeding programme.
11	Shelducks breed here every year always in this spot. I then see the young chicks and the brood grow up until they're old enough to leave their parents and disperse.
12	Natural mussel beds – old sewage pipe (walk from new NT bridge) – stream end of sewer pipe and turn right ¾ mile.

Table 3-2 Points identified by local stakeholders related to restoration constraints

No. (see Figure 3-2)	Description
1	Lack of vermin control. Lots of rats on marsh
2/3/4	Old dumped boats (biodiversity navigation issue) BHA already clean these up free of charge to NT or any other body
5	Main sailing area (club) Has been sailed for 100's of years and not been impacted
6	Passive management of tern colony *
7/8	Glaven and Stiffkey pollution from land (agriculture/sewage) **
6	Too many seals! – Effect on fish?
9	Maintain boat access to/from Wells (via the inner creek) NB: another stakeholder responded by saying "Nonsense"
10	Sedimentation of mussel beds – do we know why 80's/90's
11	Visitor pressure

No. (see Figure 3-2)	Description
	We need the visitors to make a living
12	Speed boats Have been using the harbour for decades, the mud tends to keep number low.
13	Stony road bridge, Stiffkey – bad design causing erosion of saltmarsh. But needed for safety.
14	Foot paths that don't go to the beach but visitors think they do – unnecessary trampling
15	Kite surfers NB: another stakeholder had said "We don't have them here"
16	Balance of fresh water vs sea for birds
17	Available funding for "on the ground" staff
18	Flood management and silting up – Environment Agency and residents
19	Increase in speed boats, water skis and jet skis
20	Lack of control of drones
21	Water quality – issue with E. coli etc.

Table 3-3 Points identified by local stakeholders related to restoration opportunities

No. (see Figure 3-3)	Description
1	Predator control to protect tern colony
2	No dog policy during breeding bird season.
-	Telling local stories, public engagement projects and local history
-	Citizen science monitoring (designated volunteers in the area)
-	Electric motors on boats Financial implication would mean death of the harbour
-	More rangers/patrol boats What for? Why? Enforcement of rules and public engagement
-	Licensing boats What benefit does this bring?! What is the license for?
-	Clear up abandoned boats
-	Opportunity to build understanding of coastal geomorphology to allow adaptive planning e.g. for terns and shellfish.
-	Integrate adaptive management for Cley and Blakeney Freshes. Managed retreat and compensatory freshwater habitats.
-	Strategic use of dredged sediment. BUDS e.g. Cley Harbour
-	Control rats [predators] that predate on migratory birds – and gulls
-	Dogs on leads or no dogs to stop them destroying nests and eating eggs and killing fledglings
-	Stop use of drones – I've seen them disturb wildlife
-	Stop people emptying boat loos into water
-	Control growth of grasses that are taking over salt marshes

3.3 Ideas for locally-informed coastal management

Table 3-4 summarises the responses from stakeholders on outcomes and next steps, involvement going forward and any concerns about coastal habitat restoration.

Table 3-4 Ideas for locally-informed coastal management

Next steps if coastal habitat restoration (of some form) is found to be feasible
• Re-route Glaven to reduce silting • Aggregate all possible ways young people could engage, learn and enjoy the area – or even employment opportunities. • Project report to provide examples of how habitat restoration can be undertaken. Real life case studies – what is meant by linking habitats. Difficult to envisage outcomes of project "on the ground". • Very hard to say without the report yet. • Catchier name: 'Blakescape'? 'Blakeney Coastscape'? • STOP DRONES! ALREADY SEEN THEM INTERFERING WITH TERNS. • Ideas and methods that are replicable and scalable. • Pilot studies • Community involvement • Higher media coverage to provide [arrow pointing to above point]
Next steps if coastal habitat restoration (of some form) is found not to be feasible
• Are there resources in this initiative scenario to plan the 'what-ifs' – should the shingle spit be breached significantly? Just a thought, thanks. • Sharing of data collected • Clear reasoning why! • If not feasible, explore managing those pressures i.e. water quality, agri run-off etc. • Get an overview of issues in the area. • Look at other issues that could be addressed – water quality.
Future involvement and ideas for how this could be coordinated/organised
• Community engagement like this • Open communication between organisations for potential impact • Instagram • Who is missing from the conversation? • Local residents – how to consult and communicate with us. • Blakeney Area Historical Society • Cley Harbour Committee • Parish Councils • Cley Harbour Association • GIRAMS – visitor pressure • Young people . How do we engage and encourage the young into all aspects of maintaining/improving/enjoying the area • Communication channels (easy access promotion media) targeted at key stakeholders.
Concerns about potential coastal habitat restoration

• Maintenance of coastal path
    ○ Cars using footpaths
    ○ Clearing away old unused boats from Freshes Creek

- Dog walkers (and dogs!) walking over the marsh – disturbing birds nesting etc.
- Erosion

- Pollution from the rivers spilling into the harbour
- Distrust in large organisation that do not have true investment in the land and communities
- Cycling on coastal paths
- Access vs restrictions to specific areas
- A major concern for me/locals is whether the intention is to prevent access to the land/sea interface
- As above, locals understand and respect the land in questions and know how to keep the habitats intact. The vast majority of visitors are purely seal trippers so this is much less relevant relevant to them. We locals do not want our use of the land affected.
- Sea level rise is, surely, a key factor – time, scale?
- Boat / kayak use – very much what Blakeney is about but could/should minor creeks being 'non boat access'.
- Don't agree with above – rowing boats – kayaking – paddle boards okay.
- Control visitor pressure
- Restoration not replacement
- Communication is key – the local community must be more involved. They hold all the info you need in the main.
- Yes. As a local resident of nearly 40 years I am concerned my recreational access will be limited. I have walked on the marsh at Stiffkey daily for years. I also boat in Blakeney. I have not observed any loss of habitat, it looks the same as it has for years.
- "Agree" [referring to the comment above]
- I disagree. Talk to the people who work as bait diggers. They hardly recognise this place [referring to the comment above]
- From previous research and pilot studies, what knock on effects from one restoration project have on the others (can they be counterproductive?)
- Agree – protect NWT areas and plans, neighbouring the project area [referring to the comment above]
- Yes. This feels very external to north Norfolk – we are being 'done to' by outside organisations who want to 'manage' our coastline. As a local resident I only heard about this project by chance. Consultation and communication is key to ensure local support.

Ideas to alleviate any concerns about potential coastal habitat restoration

- A ban of free roaming dogs?
- More dog walking areas designated
- More of today and use all media types.
- Agreement not to restrict access as part of any restoration. I do not want to be confronted by fenced off areas and signs telling me what I cannot do.
- Combine it with dredging Blakeney Cut to make sure it's accessible to boat users etc. for years to come.
- Consultation and communication with local residents not just local businesses.
- I do not agree if it means stopping access to areas, we have always had access to
- Species restoration won't happen unless there is better predator control
- Agree [referring to the above]

3.4 Other comments captured

The following comments/points were also noted during the event:

- The Blakeney Harbour Association requested to be consulted on any results / plans as they are responsible for the management of the harbour use. Many stakeholders expressed that they value having a free harbour.
- One stakeholder who voluntarily manages the navigational aids throughout the estuary commented that there has been great change within the estuary which means the harbour is less sheltered from strong winds and waves. They are interested in why the navigable channel to sea is curving as this used to be more straight out to sea.

- There was an offer from the Cley Harbour Project around the potential beneficial use of dredged sediment from the Cley channel.
- A local newsletter could be a good way to reach local people.
- There was mention that existing seagrass beds in the harbour were sprayed on through seed pellets. It will be useful to determine whether this did happen, and if it did, the drivers behind it (part of a previous restoration initiative?).

4 Observations and key themes

The detail provided in section 3 will be used within the assessment of habitat restoration feasibility, alongside the assessments being undertaken (site visit and conceptual geomorphological model) and analysis of existing data. The aim of this section is therefore not to repeat this information, but to pull together observations and key themes which can be used to inform the conclusions of the feasibility study and shape any next steps identified.

4.1 Attendance and format of event

Overall, the attendance at the event was considered to be good with the majority of the key stakeholders being represented in some way. The venue worked well, with plenty of space for the activities planned and discussion between the stakeholders and members of the project team and PMG. The three advertised presentation slots provided a focus for the day, with stakeholders generally targeting a presentation slot and then staying on after the presentation to complete the activities and have focused conversations with the project team and other members of the PMG.

There were a number of observations and comments around the advertising of the event, the invitees and the event timing. The focused invitee list was a conscious choice by the PMG to reflect the relatively early stages of the project, and the timings were considered appropriate to allow stakeholders to attend during their lunch break or similar, although it was recognised that an evening event would have allowed more local people to attend who work during the day

If the current phase of the project concludes that habitat restoration is feasible, the next stages of the project should consider wider and more varied engagement to fully capture the interests of the local community and fully involve them in the design of any habitat restoration.

It should also be considered as to whether the demographic of the attendees accurately represents the demographic of the Blakeney community, and whether there should be a focus on involving the future community of Blakeney in decisions being made now (ie. through the involvement of schools/other child/youth groups and younger families).

4.2 Preconceived ideas

The community clearly carries scars from previous initiatives that they consider were forced onto them with limited appreciation of the impact they would have at local level. Combined with the comments noted in section 4.1 on advertising and invitees for the event, there was a general feeling that the project was intentionally providing a lack of transparency to potentially cover up hidden agendas or ulterior motives. In reality, project partners are very keen to engage local people and incorporate their knowledge and views at the earliest possible scoping stage to help shape the feasibility recommendations, long before potentially developing a programme in the future.

4.3 Community support for the project

The general attitude from several members of the community is that the informal management of the harbour is working well and the existing habitats are in a good condition, although this was not agreed by all. There was a strong feeling sense of not wanting change, particularly in terms of regulation of the harbour, and, as mentioned in section 4.2 above, there were concerns over a hidden agenda.

There are two main reasons for this overall lack of support and wanting to maintain the status quo:

- A lack of understanding of what the project is trying to achieve. Questions were asked around what habitat restoration looks like in reality, and how this is undertaken. The feasibility report should therefore provide examples of what habitat restoration actually is, how it is done and examples of it having been successfully implemented at other locations. Pilot studies could also be considered as an interim next step.
- Linked to the above, and more importantly, some lack of understanding of the benefits of habitat restoration to the community. Table 3-3 does show that the community do see some opportunities, albeit possibly isolated and not part of a bigger picture. Building on these opportunities and setting them out within the overall context of habitat restoration and coastal management, should help to on-board the community and allow them to fully engage with, and steer, the process. This should remove the feeling of this being an initiative that is being forced onto them. If the conclusion of this feasibility stage is that habitat restoration is possible, it would be useful to consider an interim stage to work with the community to raise awareness and education before proceeding to further develop any restoration plans.

4.4 Direct issues to be considered for habitat restoration feasibility

Habitat restoration within the harbour would need to consider the following key issues:

- Any requirements to restrict access across large parts of the harbour would be seen negatively, although it was felt that high visitor numbers could be causing impacts on habitats and species in some location e.g. reducing bird numbers, causing direct damage to salt marsh habitat by trampling, causing erosion of banks due to mudsliding.
- The fact that the harbour is unmanaged, and the strong consensus for it to remain this way, may mean that any habitat restoration initiative cannot be implemented successfully. Examples would include not being able to manage jet ski, water ski, drone or kitesurfing activity, or not being able to control or manage the number of craft using the harbour or the way in which they operate (e.g. in terms of waste disposal, appropriate removal of abandoned/unused craft).
- The Blakeney Harbour system is dynamic and there have been relatively large changes in the outer spit recently which have had impacts on the location of seal colonies, navigation routes etc. The feasibility study will need to consider likely future changes to avoid attempts at habitat restoration being unsustainable.

4.5 External factors and habitat restoration feasibility

There were a number of issues identified that do not fall within the scope of this project, ie. cannot be addressed or improved by this project, but the way in which they are managed in the future could directly impact the conclusions around the feasibility of habitat restoration.

- A number of stakeholders reported poor water quality at various locations in the harbour. This poor water quality is attributed to poor water quality within the rivers which discharge into the harbour.
- Stakeholders reported issues with lack of control of vermin (rats specifically) and other predators across the harbour. This could impact the feasibility of introducing or encouraging larger populations of ground nesting birds or similar.

5 Conclusions

This report provides a summary of the second stakeholder event held on Tuesday 3rd June 2025 for the Blakeney Harbour Coastal Restoration Feasibility Project. The details captured during this stakeholder event, and also from the first event held online on Tuesday 8th April, will be used alongside analysis of the data collated to date, as well as the results of the conceptual geomorphological model and site visit (currently in progress), to determine whether coastal habitat restoration is feasible in the study area and if so, where it is likely to be most successful in the long-term. The study will identify any trial site locations for multi habitat restoration initiatives, as well as recommending assemblages of habitats and species for the restoration.

In addition to using the details from the engagement event, the following key themes captured are useful for consideration during the analysis of data and reporting:

- There is a general consensus that the community are not supportive of restricting access across Blakeney Harbour, although some stakeholders did note that higher numbers of visitors do affect bird distributions.
- There is a feeling that the current habitats do not require intervention and that the harbour is evolving naturally.
- There are issues around the management of recreational activities, although the community do value the unique way in which the harbour is currently managed.
- The community are clearly passionate about the area and are keen to play their part in future management.

APPENDIX A

Stakeholder Event 1

Merged Mural Board

Use

How do you use the area around Blakeney Harbour, its land and waters?
For example, for work or recreation, etc.

paddle boarding	Birdwatching	sailing, walking, seaside stuff	Swimming	seal tours
Ice cream	eco-tourism (mainly at Wells harbour and Blakeney and Cley occasionally)	Aquaculture	dinghy sailing and racing	racing
Fishing	walking	creek paddling	crabbing	

Change

Do you recall a time when certain habitats or species were more abundant, or when the coastal area allowed for activities that are no longer feasible?

saw my first ever little egret 30 years ago , now there are many. over species have disappeared.	No mention I noticed of Mussel Beds - I heard there was a new Lay at Stiffkey Freshes (just S of Blakeney Point)	Lack of predator management has had a huge effect on tern populations on the point. More rats = fewer terns.		
Historical records describe abundant oyster beds	I recall collecting mussels there as a child			
I have looked for seagrass in the area but no luck yet - there are records of it though	Was there more samphire in the 70's?			

Support

Would you like to be involved in the restoration of coastal habitats and species in the area around Blakeney Harbour and how could you help?

I have access to boats which may be interested in helping gain access to more remote parts - We run eco-tours, so could include habitat work as part of a day out for paying clients	local community involvementl	I wonder about supporting the project in terms of offsetting carbon by contributing to the project.	What about Sea Cadets Corps/ Sea Scouts as a community involvement	
I am looking for case studies of where marine recovery supports livelihoods/local economies that I could feed into government advocacy - so this could be a valuable example	I have supported the motion for the ocean in my role with NNDC. Any thing that helps this such as sea grass is a plus.	We run trips which include wild walks / foraging (just to look, not gather), but I thought if we can add some restoration activity as part of the trip for clients who are interested, that gives a funding angle for environmentally-conscious tourists	One community I've not seen is the Wildfowlers / Longshoremen	
Potentially Orsted or other offshore wind developers could be interested I would think - if that's an industry you're looking to engage with	This is outside the coastwise area, but these habitats are all interconnected. We might be interested in habitat creation for carbon offsetting	The wider Norfolk Community I know would like to be involved in these projects.	I know an organisation I am connected to would love to get involved in sea grass planting.	EIFCA can facilitate engagement with local fishers. Could have some local knowledge/ historical knowledge that could help

Aspirations

What are your aspirations for the area around Blakeney Harbour, relevant to its coastal communities and wildlife?

- shingle recharge, more accreting marsh,
- Plant / extend Seagrass beds as a foundational species as a nursery for many other flora & Fauna, plus trapping Blue Carbon /
- Increase biodiversity
- The wider Norfolk Community I know would like to be involved in these projects.
- Would love to see it supporting a general reconnection with nature & the marine environment in the area
- Keep the harbour open for navigation purposes (1)
- Involve local schools
- Maintain access for visitors and locals alike (1)

Other ideas or data to contribute?

Do you have any data that could help us understand the Blakeney Harbour area? For example, historic photographs, survey information, or anecdotal information.

- Mussels - mapped in Defra Magic App - it's mainly historical data - heard there was a new lay at Stiffkey Freshes (just S of Blakeney Point) and have pic from Stiffkey Freshes, N end in the shallows of BLakeney Channel
- I have been looking at related projects - Project Seagrass of course, but am interested in the outputs of the Remedies project in Essex, and the Wadden Sea replanting projet in the Netherlands
- Blakeney Area Historical Society has a great deal of information on the history of the harbour an an archive.
- Some of the boatmen have been working the harbour for 50 years. Huge knowledge of shifting channels, changing wildlife, etc over that period.
- EIFCA may have historical data on mussel beds - can be looked into
- re: Data: good to include regular boat users in the area (e.g. Zoe Dunford who runs sailing tours out of Blakeney in the smaller creeks as well as main silling areas
- As a member of the Blakeney Harbour Assoc. sedimentation committee we have data which may be useful regarding incremental sedimentation.
- BHA can point you to the more regular users - it's a free harbour, so no need for registration makes it harder to track
- Bathymetric survey data
- BHA can provide up to date navigation routes within the harbour.
- The only dredging that I can remember in the harbour was about 20 years ago when the NT dug a trench across the harbour to lay a fresh water pipeline to the Lifeboat house. I imagine the NT will have a detailed chart of this pipe line trace.
- Seagrass seen in the Pit - Virtually no tourists go anywhere near the seagrass beds.
- Home - Save Our Seabed
- Wadden Sea Seagrass Restoration
- Cley Harbour have been running a community project to restore parts of the navigation to Cley inc de silting etc. Restoration | Cley Harbour
- Home - Essex Native Oysters
- Seawilding near Oban are doing amazing work on seagraas restoration and recently native oysters.
- Lincolnshire and Yorkshire Wildlife Trusts have been carrying out seagrass restoration on the Humber estuary for several years.

Benefits

What is important to you when you think about Blakeney Harbour and the surrounding coastal area?

Birdlife	Activity, atmosphere, nature	Fishing industry	Habitat designtion	Seals
Unique Ecology protection	Possible Seagrass Restoration?		Biodiversty	
Nature and habitats	Supports recreational & small scale commercial fishing - local income	sense of place	Tourism / economy	

Pressures

What are the key pressures impacting the area around Blakeney Harbour? Do you think that habitat restoration could be successful in the future given how these pressures are currently being managed?

Littering	agree, unsustainable tourism, global warming pressure, possible wash barrage.	Coastal erosion	boats	tourism
Coastal flooding	Coastal squeeze with the road stoppign the spread inland of the saltmarsh	silt form river	Concerns - "squeeze" of the Saltmarsh	pollution
				agriculture

Concerns

Would you have concerns if coastal habitat restoration were to happen around Blakeney Harbour in the future? What might help alleviate those concerns?

No particular concerns	If the pressures that destroyed habitats in the past are still there then it would be challenging e.g. pollution	Would long term funding be available?	Concerns about farm run-off / excess nutrients / higher algal bloom & so disruption of local ecosystem	would restoration of saltmarsh limit access for tourism
The Stiffkey Bridge "issue" is worth looking at: pressures for dog walkers and access but it resulted in trampling of the saltmarsh, vs. pressure to protect the habitat	turbidity of N Sea & whether seagrass would work (hence interest in NL and Essex projects)	Interested in Seagrass as a Foundation Species, but have heard anecdotally or higher algea bloom (= greener water) which may impact plant growth on seabed	Maintain access for visitors and locals alike	Squeeze of the saltmarsh
balance to strike between encouraging and enabling access vs. growing its use				

Appendix C: Stakeholder Event 3 – Blakeney Harbour Coastal Restoration Feasibility Project: Results Sharing Webinar and Q&A

Blakeney Harbour Coastal Restoration Feasibility Project

Stakeholder Event 3 – Blakeney Harbour Coastal Restoration Feasibility Project: Results Sharing Webinar and Q&A

Attendance Report

Table 1. Summary of meeting time, registration and attendance

Registration page views	327
Organisers/Presenters	3/5
Registered participants	58
Cancelled participants	1
Attended participants	49
Webinar meeting times	18:00 – 20:00
Webinar duration	2hrs
Average attendance time	1hr 28m

Table 2. Attendance breakdown by organisation and PMG/WG/Local stakeholder

*Those listed as Local Community Members had no affiliation known to local organisations. Therefore, there may be local businesses etc. that are not represented here that attended.

**These counts exclude Local Community Members from organisational counts

No.	**Organisation**	**No. of attendees**
Attendees represented on the PMG		
1	WWF	4
2	WNNMP (NCPL)	1
3	National Trust	3
4	The Crown Estate	1
5	Natural England	2
6	Norfolk Seaweed Ltd.	2
7	Haskoning	3
Totals	**7 organisations**	16
Attendees represented on the wider WG		
8	RSPB	2
9	Eastern IFCA	1
10	Cley Harbour Committee	2
11	BHA	1
12	University College London	4
Totals	**5 Organisations**	**10**
Attendees outside of the PMG/WG		
13	North Norfolk District Council	2
14	Blakeney Parish Council	1
15	Blakeney Sailing Club	1
16	Coastal Exploration Company / sustainable tourism	1
17	Solway Firth Partnership	1
18	The Blue Marine Foundation	1
19	Local Community Members*	15
Totals	**6 organisations****	**23**
Overall Totals	**16 organisations****	**49**

Comments from the webinar:

- Would it be possible to describe things simply? I understand some of the comments but…

- Climate change resilience comes up a lot when talking about restoration. In the Blakeney area it feels like it's not just resilience, but we need to be sympathetic to development. For example, some things are going to change with sea level rise and if we can change things that are more consistent to how that looks, it's going to be more sustainable and resilient in the long-term, i.e. the encroaching scrub on the saltmarsh and the rising sea levels might help with that but we could lose a lot of marsh whilst we wait. Also, the Blakeney Freshes where that is likely to breach and change from freshwater to salt.

    - CA: This is why we were looking at the mapping of the 0.3 and the different scenarios was to look at where the tidal height might change and will influence the saltmarsh growth. So, we wanted to map where mean high-water neaps would move to as this would indicate where the saltmarsh could retreat to. But equally as you say, there are some benefits as well. For example, the seagrass was found just below mean high water neep. So, if you increase that area you might lose some of the lower salt marsh, but you could gain some areas where seagrass should grow. So that's a good point to bring up.

- The guest speakers were very inspiring and it's very clear that collaboration is very powerful and important tool with these projects. Thank you to Shovi and Rosalie.

- **UCL:** I've been involved with terns for the last sort of 15 years, especially the idea of terns perhaps utilising the harbour. So, the species that really does that, they all do. But the species that's dependent on that to some extent, is the little tern.

  We've also sampled quite a lot of fish over the last 10 years. So, there's been a lot of fish work involving seine nets and understanding the fishing community. So, I was quite interested to hear that people have thought that fish numbers have declined. So, quite interested to know which species people thought are declining because we find quite abundant fish. The interaction with fish is quite interesting because a lot of fish move in from the sea on a rising tide, come into the harbour and then go out again. But at the same time, some fish are largely restricted to the harbour, so things like sand smelt are present in the harbour. Lots of flatfish present in the harbour and it seems to be quite important as a nursery area for bass. So, thinking about the sort of interaction and what habits to then put back. It'd be important to understand what's what effects, if any, any sort of seagrass restoration or oyster bed restoration would have on those fish populations, and that also includes eel, because we've worked a lot on eel as well with Zoological Society of London.

  The earlier presentation on the Solent, reminded me of having acoustic tags out in the harbour, so the whole area is important for eel because they go through the harbour and into the freshes, then also moving through the saltwater channels in Cley marshes and then go up the Glaven and the Stiffkey. So there's a real interaction of the whole system with eel. On that point about Blakeney freshes, and there's lots of things you could do for eels in the freshes, but that wouldn't involve putting in scrapes for birds you'd like to have, you know, more permanent in a deeper habitat for eel, and while also touches on water quality.

The earlier question about water quality, there are there are both point sources and diffuse sources down the rivers from the Glaven and Stiffkey which influenced the water quality in the harbour from our perspective, and I know my colleague Carl Sayer is really concerned about this, is that water quality is getting worse. You know, almost without question. So, Holt sewage works as a as potentially as a big impact. So that would be human effluent from that sewage works, plus there's lots of, you know diffuse nutrients coming from agricultural sources. And the Glaven itself somehow operates as a sink, because there's lots of, in stream lakes along the source of the Glaven, which would accumulate sediment until they don't. So sometimes that ends up, further downstream and the works associated with wind farm construction, you know, with the cabling route has also led to big slugs of sediment and various other things coming down into the harbour, so things to be concerned about. Just some information about the water quality there and I'd be concerned about in the longer term; we certainly must do something about that to get some of those other key habitats back.

- Not so many local people who have been speaking tonight, which is fine, there hasn't been time or room for that. But just to bring it up.

- But there was just one point on this. I think someone asked a question about which scrub was increasing in the area and the answer to that I believe is Spartina grass. Spartina is not a natural. It's an alien plant in the area. It was planted back in; I believe it in the 30s. Although, I'm not sure the exact year, but it has encroached from the sort of Clyde cut area into the Blakeney harbour quite rapidly. When I was a boy, you could walk across from the end of the Blakeney cut to the watch house and build sandcastles on the stretch of the stretch, which is now fully occupied by Spartina. And I believe that is what is the biggest enemy of the Blakeney harbour in terms of a rapid transformation and loss of tidal flow in the in the area. If tidal flow is the lifeblood of the harbour, then I think that's a key issue and it'd be quite interesting to study that and see what's happened and see how the harbour has changed because of the encroachment of spartina. I think that's probably an important part of this study in looking at the historical development as to where the harbour is today and important issue to consider in terms of restoring the harbour as much as the saltmarsh.

    - CA: We have talked to some people about the planting of Spartina, which has invaded a lot of estuaries in the UK. So, it's a big problem in lots of locations as it affects the diversity, leading to a bit of monoculture.

Q&A: answered

- The results don't seem to show the potential breach of the current barrier, which seems likely?

    - GG: As well as looking at how the harbour is behaving now, we've got to be conscious. There are some things that are going to happen. And therefore, it is as you say, it isn't resilience in the normal, you know, building back better and all the rest of it. It's how do you adapt and take a positive step, accepting that there are going to be these.

We looked at the vulnerability of the shingle bank and the saltmarsh behind. In some areas around the hood, there is a substantial wadge of material. Even with the projection of how that shingle bank is going to move back, it's likely to stay there. But you've got other areas between the hood and the marrams, that as it moves back, it's going to move the shingle bank into a new position that will then become vulnerable to overtopping.

- If sea levels rise, would the marsh top be self-levelling (i.e., does the rate of sediment deposition on the "tops" keep up with rising sea levels)?

    - GG: In pulling the geomorphology together, we've drawn on a whole variety of different sources of information. Evidence around the Stiffkey area suggests that sediment is building the saltmarsh and keeping pace with Sea Level Rise (SLR). However, over the main Northern marsh areas, sediment can only feed the saltmarsh during Mean High Water Spring tides, and the marsh response has been slow. With SLR, even with 0.6 m of rise, Mean High Water Neap tides will be confined by the channel. Nonetheless, there is more scope for sediment to spill into the upper marsh area. Assuming there is sufficient suspended sediment, we would expect the marsh to grow, but there are places where we are not observing a great deal of suspended sediment. We must emphasise that sediment is crucial; any work like dredging by Cley Harbour Commissioners (CHC) must ensure the sediment is fed back into the system to maintain this balance.

- Would overtopping of the shingle bank naturally mend itself? The coastline was historically many separate banks that consolidated into this single shingle bank, so longshore drift should plug any short-term breaches unless they are severely scoured by tides.

    - GG: The experience on the banks to the East, particularly the large section over Cley Marshes, shows that it has restored itself. There appears to be a good drift of sediment, even where the movement of the shingle bank has effectively "beheaded" the saltmarsh. The shingle banks typically respond by failing and then rebuilding—it's a stepwise progression rather than a smooth process like sand dune migration. If there is a good supply of sediment, we feel that the overfall integrity will restore itself. However, once we start approaching 1 m to 1.5 m of SLR, we may need to reassess the situation.

- Who thought fish were declining and what species are/ have been declining.

    - CA: The concern about fish decline stemmed from historical information regarding a drop in trout numbers and some other species.

    - UCL: I can address the trout question. It's immediately obvious that the water and habitat quality in both rivers significantly impacts sea trout, particularly those moving into the estuary at later stages of life. While natural trout populations have likely decreased in the rivers, these numbers are partially buoyed up by stocking with non-native, often triploid fish. We have tracked some of these stocked fish utilising the lower Glaven and the harbour, creating a mix of stocked fish and a decline in the natural trout population. I would fully accept that trout numbers have decreased over the last few years, but the impact is somewhat masked by the ongoing stocking efforts.

    - CA: I know water quality has been highlighted as a major issue in the harbour generally. It's a positive step that the Norfolk Rivers Trust is installing filtering habitat downstream of the sewage treatment works that feed into the catchment area. Hopefully, this will provide some degree of improvement to the water quality issues, though I recognise it won't resolve everything.

- There was a point about salt marsh scrub increasing in places, I was really curious to understand what 'scrub' that was. We see '[Unknown]' in particular places, but I wouldn't call that scrub. So, what is it?

    - CA: The "scrub encroachment" mentioned mostly referred to the increase in couch grass. In the Cley area, some people reported coverage of up to 60% at the top of the marsh in certain locations, which is quite significant.

- What were the issues of Water Quality - any clues to the likely sources? (e.g. Farm run-off? Sewage flows? Litter, etc.?)

    - Charlie Cutt: A complex mix! The data in the report summarises both chemical and nutrient pollution (which is likely due to a combination of agricultural run-off, sewage discharge, industry etc) as well as more hazardous pollutants such as mercury. So continued work on improving water quality entering the harbour is really important!

- *Can* Water quality be improved by e.g. Oysters & Seagrass? It's very tidal, so the entire body of water is effectively replaced twice a day.

    - Charlie Cutt: We have a report we can share that looks specifically at the potential for saltmarsh and seaweed to improve water quality in Norfolk. Hoping colleagues can help answer re: what the science says for oysters/seagrass! But we would still want to try and reduce the amount of pollution coming off the land too - tackling it at multiple points

    - Allie Wharf: Yes - oysters can help improve water quality even in a strongly tidal environment. One oyster can filter up to 200 litres of water a day.

- There some follow-up actions and some follow up questions mentioned by the consultant and wondered if there was a timeline now?

    - KAW: So, those recommendations are simply options for us to review and discuss what we would like to move onto in the next phase. In terms of timelines, we hope to start looking at and discussing these at the workshop tentatively planned for the end of November. This will allow the community to collectively decide on our path forward.

- CC: Regarding next steps, it's quite an organic process, as was explained brilliantly. We currently don't have any funding, so our immediate aim is to discuss these next steps with you as a community. At the next workshop, we can start drawing up what the project will look like, then cost it and apply for funding. This process will help us determine what we can achieve as a community and what additional, funded help we may require.

- SA: Having that initial evidence base really helps with obtaining funding; it successfully gained the attention of the Environment Agency for me, for example. I would strongly encourage focusing on those initial steps and playing it by ear almost—which sounds unorganised, but it is advantageous, especially with novel projects like this where there is limited existing research.

- CA: Just to reiterate what Kelly and Shovi said, these options were listed as an idea of what could be taken forward. They are intended to help shape the project and provide a springboard for future work

Q&A: unanswered

- Has anyone mapped or investigated introduced spartina lately? Is this still a problem and could this be restored?

- Is there any data on what current speeds is likely to lead to erosion? That can help with site selection / intervention?

- What is the trend for Grey Seal numbers?

Appendix D: Geomorphological Conceptual Modelling Report

REPORT

Blakeney Harbour Geomorphological Review

Client:	Norfolk County Council
Reference:	PC7123-RHD-XX-XX-RP-0105-S2-C01-X
Status:	Final/C01
Date:	24 October 2025

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Document title:	Blakeney Harbour Geomorphological Review
Subtitle:	
Reference:	PC7123-RHD-XX-XX-RP-0105-S2-C01-X
Your reference	
Status:	Final/C01
Date:	24 October 2025
Project name:	Blakeney Harbour Restoration Feasibility
Project number:	PC7123
Author(s):	David Brew & Greg Guthrie
Drafted by:	David Brew & Greg Guthrie
Checked by:	Claire Mellett
Date:	14/10/2025
Approved by:	Victoria Clipsham
Date:	24/10/2025
Classification:	Project related

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Glossary

Terminology	Definition
Anastomosing channels	A network of interconnected channels generally indicative of low energy flow regime.
Astronomic water levels	Levels that can be expected to occur under average meteorological conditions and under any combination of astronomical conditions.
Bathymetry	Mapping of underwater topography and the measurement of depth in water bodies.
Biogenic reef	A reef formed by living organisms, such as mussels or oysters, that create habitat structures.
Blue carbon	Carbon captured and stored by marine and coastal ecosystems, such as saltmarshes and seagrasses.
Chart Datum (CD)	Local reference level datum, typically related to the lowest astronomic level at specific location.
Ecosystem	A biological community of interacting organisms and their physical environment.
Ecosystem services	The benefits that humans receive from ecosystems, including provisioning, regulating, cultural and supporting services.
Habitat connectivity	The degree to which different habitats are linked, allowing species to move and interact across landscapes.
Highest Astronomic Tide (HAT)	The maximum level under average meteorological conditions which can be expected during that year.
Intertidal	The area between low water and normal high water, typically exposed during the tidal cycle.
Lidar	Light Detection and Range used to measure topography or land levels.
Lowest Astronomic Tide (LAT)	The lowest level under average meteorological conditions which can be expected during that year.
Macrotidal	A coastal area with a tidal range greater than four meters.
Managed realignment	A coastal management strategy that allows the shoreline to move naturally, often by breaching sea defences.
Mean high water neaps (MHWN)	The height of mean high water on a neap tide is the average throughout the year when the range of the tide is at its least.
Mean high water springs (MHWS)	The height of mean high water on a spring tide is the average throughout the year when the range of the tide is at its greatest.
Mean low water neaps (MLWN)	The height of mean low water on a neap tide is the average throughout the year when the range of the tide is at its least.
Mean low water spring (MLWS)	The height of mean low water on a spring tide is the average throughout the year when the range of the tide is at its greatest.
Ordinance Datum (OD)	Nationally consistent level datum.
RCP	Representative Concentration Pathway (used in UKCP18) as the basis for projecting sea level rise due to climate change.
Recurved spit	A coastal landform formed by the deposition of sediment, curving inward due to wave action and longshore drift.
Sediment budget	The balance between sediment being added to and removed from a coastal system
Subtidal	The area of shore that is always submerged underwater, even at low tide.
UKCP18	United Kingdom Climate Projections 2018
Warping up	Increase in the level of salt marsh with the deposition of sediment.

1 Introduction

1.1 Context and Study Area

In May 2023, The Wash and North Norfolk Marine Partnership held a ‘Marine Recovery’ workshop that identified support among partners for exploring potential marine and coastal habitat restoration opportunities. Blakeney Harbour was identified as a potential site for restoring habitats (particularly seagrass) by the National Trust who manage the Blakeney National Nature Reserve. At the same time, WWF-UK commissioned a desk-based study to assess the feasibility of multi-habitat coastal restoration in north Norfolk as part of their Norfolk Wholescape programme (WWF-UK, 2024). The findings of the study aligned with local stakeholder ambition, recommended Blakeney Harbour as a potential location for restoring multiple coastal habitats. Hence, this Blakeney Harbour Coastal Restoration Feasibility project is the product of increasing evidence and local stakeholder appetite for marine and coastal habitat restoration around north Norfolk.

The study area follows the Blakeney National Nature Reserve boundary and covers the mouth of Blakeney Harbour, extending north from Cabbage Creek to the sea, and east to meet Blakeney Point (Figure 1-1). A 0.37 km buffer (0.2 nautical miles) is applied to the boundary on the coastal side due to the dynamic nature of the area.

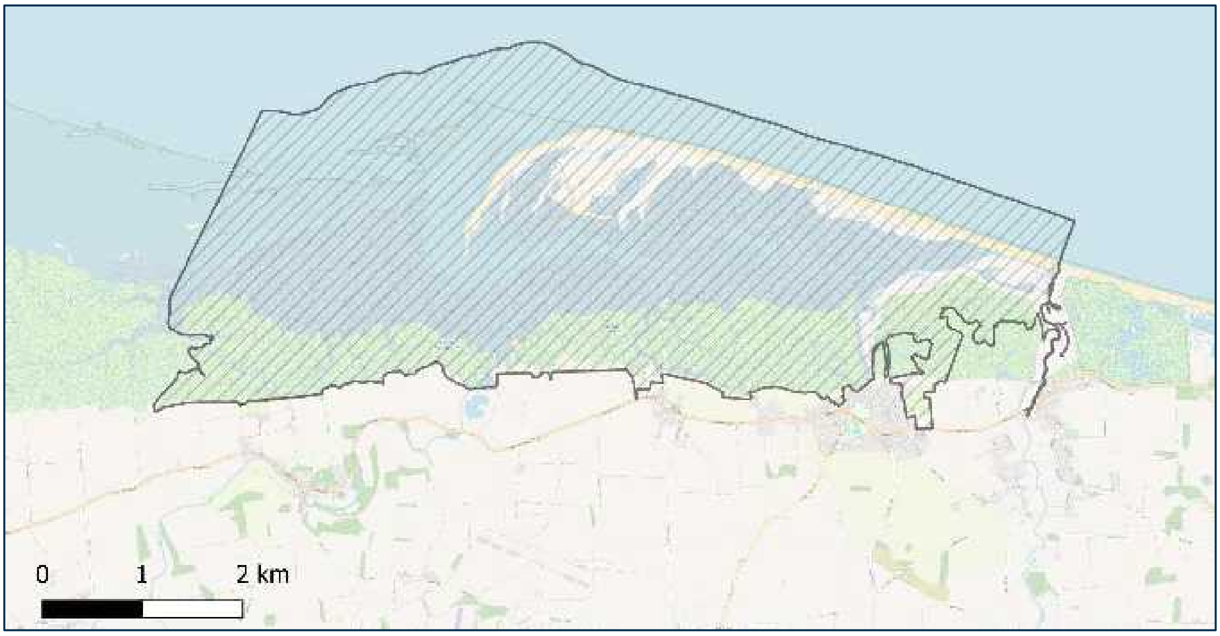

Figure 1-1. The assignment area for the Blakeney Harbour Coastal Restoration Feasibility project is shown within the grey boundary

1.2 Overall Objectives of the Feasibility Study

Five priority habitats and species for potential coastal restoration in Blakeney Harbour have been identified: seagrass, saltmarsh, shingle (mixed sand and gravel) beach, European flat/native oyster, and common/blue mussel. The objectives of the overall project are to focus in on Blakeney Harbour to:

- Collate and analyse existing ecological, hydrological, geological, and climate data required for designing a multi-habitat coastal restoration programme in the area.

- Ground truth desk-based data and collect and analyse some additional data required to assess whether the priority coastal habitats and species listed above are feasible to restore within the assigned area in the face of a changing climate.
- Recommend where within Blakeney Harbour coastal habitat restoration is likely to be most successful in the long-term and identify trial site locations.
- Recommend what assemblage of habitats and/or species should be the focus of restoration efforts to address the priority outcomes.

A key element of the feasibility study is to determine the requirements for optimal development of habitats to ensure connectivity and resilience based on parameters including:

- Water and sediment quality because of proximity of outfalls, dredge areas, and run off zones.
- Potential for erosion of habitats.
- Presence of existing priority habitats or key species, sediment type, and sediment mobility.
- Physical characteristics such as depth, temperature, and profile.
- Consideration of predicted impacts of climate change and associated processes including sea-level rise, temperature, and waves.

1.3 Objectives of this Geomorphological Review

The objectives of this report are to review the physical processes and coastal geomorphology of the Blakeney Harbour system and the historical baseline to build an understanding of the driving forces and geomorphological development of the Harbour. This report focusses on:

- Historical development of the spit at Blakeney Point. Changes to the spit are expected to be a key driver for change in the Harbour.
- Accretion/sedimentation within the Harbour. Both channel alignment and changes to intertidal flats and saltmarsh, and assess whether the Harbour is in equilibrium and, if not, what the path to equilibrium would be.
- Derive likely flow patterns based on the wetted area of the estuary over the tidal cycle.
- Identify sediment transport pathways in, out, and within the Harbour.

1.4 Methods

Completion of the review has utilised two main datasets:

- Existing data and publications, a baseline understanding of the habitats and their distribution is presented as a context for potential restoration.
- Historical trend analyses of historic Ordnance Survey (OS) maps, aerial photographs, habitat mapping, Lidar surveys, and topographic surveys and profiles.

2 Coastal Habitats

This section contains information on the baseline functions and natural characteristics of the coastal habitats of the Blakeney Harbour system, providing a physical context for the assessment of coastal change and how the site has evolved, and could potentially evolve. The contemporary geomorphological system that has developed around Blakeney Harbour can be divided into four main linked elements (Figure 2-1):

- Mixed sand and gravel beach-barrier spit (Blakeney Spit) including coastal sand dunes.
- Finer-grained back-barrier mudflat, saltmarsh and grazing marsh.
- Subtidal channel (Blakeney Channel) and ebb-tide delta.
- Open-coast sandflat.

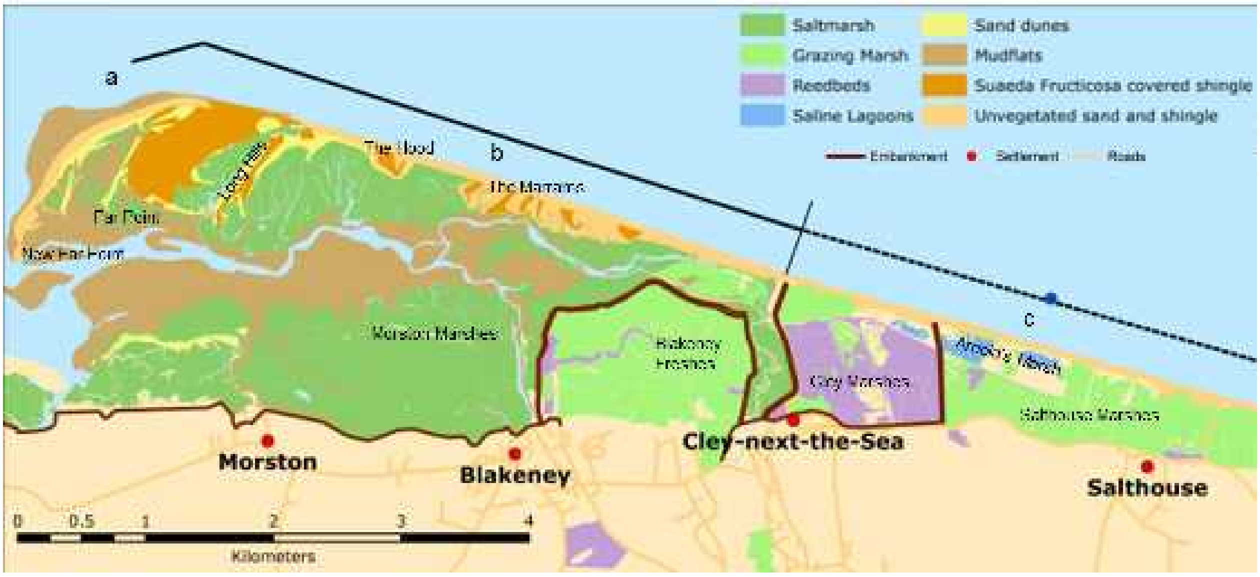

Figure 2-1. Key geomorphological elements of Blakeney Harbour and Blakeney Spit. The spit comprises three sections: a. Blakeney Point; b. the Hood and the Marrams; c. the Cley-Salthouse barrier (Pollard, 2020)

2.1 Mixed Sand and Gravel Beach-Barrier (Blakeney Spit)

Blakeney Spit is recurved spit formed mainly of a single mixed sand and gravel ridge (over 9km long) extending from a gravel beach at the foot of retreating till cliffs between Weybourne and Sheringham (May, 2003). It has grown from east to west along the predominant sediment transport direction and can be divided into three sections (Pollard, 2020) (Figure 2-1). The neck of the spit (Cley-Salthouse barrier beach) is composed of mixed sand and gravel and extends west for about 6km from a connecting point near Kelling. The barrier is backed by brackish, freshwater, and grazing marsh (including Blakeney Freshes). Towards Blakeney, the Blakeney Channel inlet exposes the back-barrier area to tidal influence, and the spit is characterised by two relatively high areas known as the Marrams and the Hood. West of the Hood, the spit ends at Blakeney Point, which is characterised by beach and sand dunes.

Within the study area, the main morphological features of Blakeney Spit are the lateral recurves that represent past locations of the end of the spit. Andrews (2020) highlighted six groups (Figure 2-1):

- The Marrams (extending east to west over 1,150m).

- The Hood (700m west of the westernmost Marrams lateral recurve).
- Long Hills (1,150m west of The Hood).
- Beacon Hill (the first is 300m west of the distinctive bifurcating Long Hills lateral recurve).
- Far Point (600m west of the easternmost component of Beacon Hill).
- New Far Point (500m west of Far Point).

Beach and coastal sand dunes at Blakeney Point gives the terminus of the barrier a different character from the mixed sand-gravel Cley-Salthouse barrier to the east.

The spit has and continues to be subject to significant change (discussed later in Section 3) with the principal changes being erosion and set back of the open coastal part and the more complex development of the western head of the spit (Blakeney Point).

2.2 Finer-grained Back-barrier Mudflat, Saltmarsh and Grazing Marsh

2.2.1 Mudflat and Saltmarsh

Active saltmarsh fringes the north and south sides of Blakeney Channel behind Blakeney Spit extending from Cley Marshes in the east to Stiffkey Marshes in the west (Figure 2-1). East of Blakeney, the saltmarsh has mostly been reclaimed into brackish, freshwater and grazing marsh, including Blakeney Freshes, part of which is in the study area. The saltmarshes along the northern fringe of Blakeney Harbour decrease in age from east (Cley) to west (Blakeney Point), with the oldest probably developing first during the 15th century (Pethick, 1980). Behind Blakeney Point, the saltmarsh forms between the lateral gravel recurves (Figure 2-2).

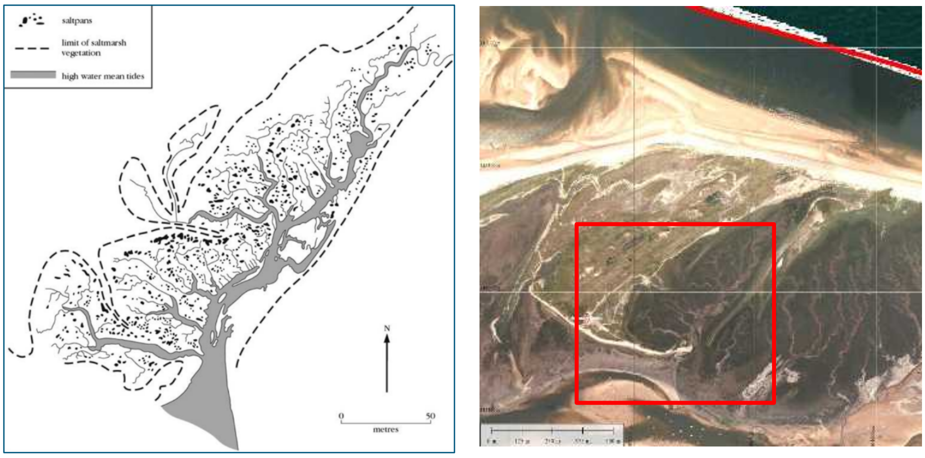

Figure 2-2. The distribution of creeks and saltpans on the saltmarsh immediately west of Long Hills (Blakeney C saltmarsh of Pollard, 2020) (Figure 2.1) at Blakeney Point (Pethick, 1984)

The intertidal elevations across Blakeney Harbour comprise a wide upper saltmarsh at a relatively consistent level at around 2.8m OD, progressing seawards to a narrower lower marsh at an elevation of around 1.5m OD adjacent to Blakeney Channel (Figure 2-3).

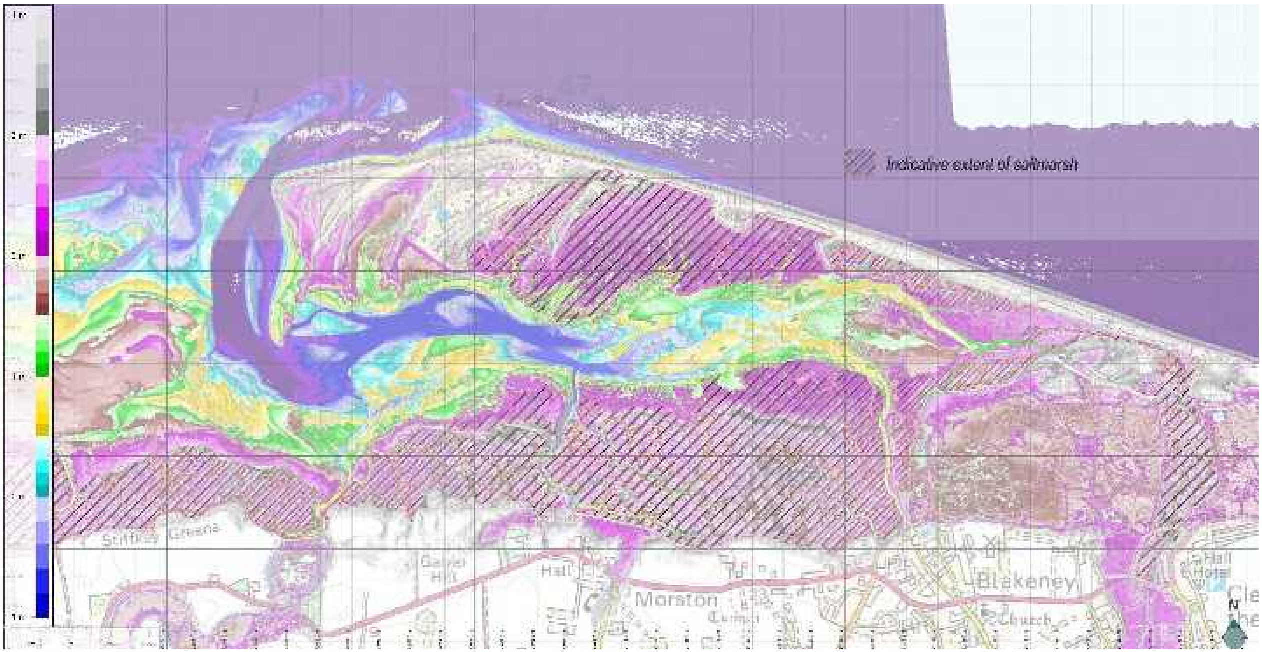

Figure 2-3. General elevation of upper salt marsh in Blakeney Harbour

Within the study area west of Blakeney Point, the saltmarsh (up to 1km wide at Stiffkey Marshes) is exposed to the northeast but locally sheltered by a 1.5-2km-wide belt of intertidal sandflat with low onshore-migratory bars. Aerial photographs show that the present-day low marsh at Stiffkey developed in the 1950s and 1960s (Pethick, 1980) but has been undergoing erosion since the late 1970s. The seaward margin has degraded into a hummocky topography drained by poorly defined anastomosing or interconnected channels (Pye and French, 1993), typically indicative of a lower energy flow regime.

2.2.2 Grazing Marsh

At the eastern end of the study area, Blakeney Freshes is 1.65km^2 of low-lying grazing marsh formed by the reclamation of saltmarsh behind Blakeney Spit (Figure 2-1 and Figure 2-4) (Christie et al., 2020). The marshes enclosed by an embankment contain a range of wintering and breeding birds, but also aquatic flora and fauna which inhabit 25km of drainage ditches that form a network across the site (Goldsmith et al., 2004).

Inside the embankment, the topography of Blakeney Freshes ranges from 1.1m OD to 5.3m OD with the vegetated surfaces having an average elevation of 1.96m OD (Christie et al., 2020).

The undulating surface topography is dissected by sinuous channels, remnants of former saltmarsh creek systems, and a network of linear drainage ditches. The main drainage system runs east to west across the site, linking freshwater input from the River Glaven in the east to two tidal sluices on the western margin. These sluices allow gravity drainage at times of low water into the maintained channel between Blakeney Quay and the outer Blakeney Harbour. Blakeney Freshes is a lowland wet grassland landscape, transitional between terrestrial and aquatic systems, with an abundance of grasses, reeds and sedges and characterised by periodic flooding with fresh or brackish water and a seasonally high water table.

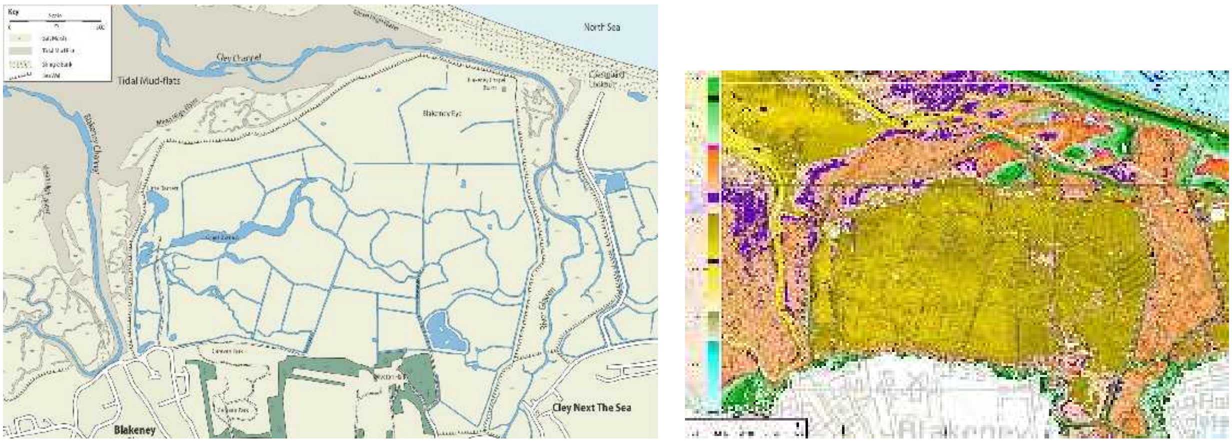

Figure 2-4. Geomorphological context (left) and elevation (right) of Blakeney Freshes at the eastern end of the study area (Goldsmith et al., 2004)

Within the grazing marsh, Goldsmith et al. (2004) identified four habitats:

- Pasture: most of the area is managed as semi-improved pasture for grazing comprising swards of common grasses interspersed with mainly common weeds (ragwort and thistles). The elevated area in the northeast of the site (Blakeney Eye, Figure 2-4) is more freely drained and contains gorse and other common herb species. The north and northwest areas are generally more saline. These pastures provide important feeding and roosting habitat for large numbers of geese and waders.

- Reed beds: most of the common reed stands are concentrated around the larger areas of standing water to the west of the site. Little Barnett and Great Barnett (Figure 2-4) are dominated by reeds in large mono-specific stands, which provide cover for mainly warblers and reed bunting.

- Drainage ditches: the salinity gradients across the drainage ditches result in different species assemblages of both submerged and emergent vegetation. Many of the ditches were heavily clogged with *Enteromorpha* sp., with common duck weed and ivy-leaved duck weed in many of the freshwater ditches. Generally high plant biomass resulted in high numbers of invertebrates including molluscs and beetles. Many waterfowl and other birds occur on or near the water demonstrating the value of the drainage ditches as important bird habitat.

- Open water: open water habitat is limited because of the encroachment of the reed beds. The remaining small areas of open water (ponds) can provide important habitat for plants, invertebrates, fish and birds. Residual water surfaces are typically at 1.70m OD (Christie et al., 2020).

Blakeney Freshes was originally tidal saltmarsh on the western margin of the paleo-estuary of the River Glaven. In the early 13th century, the estuary was about 750m wide and yet to be closed by the westward extension of Blakeney Point (Christie et al., 2020). It is possible that the marshes developed under the protection of the spit and reclaimed in 1650 or shortly thereafter. Since then, the embankment has been periodically damaged, repaired and rebuilt.

2.3 Subtidal Channel (Blakeney Channel) and Ebb-tide Delta

The saltmarsh and intertidal mudflats are drained and flooded along a network of channels that connect to the North Sea along Blakeney Channel (Figure 2-1). The flow out of Blakeney Channel also controls the development of an ebb-tide delta west of Blakeney Point (Royal Haskoning, 2010; Royal HaskoningDHV, 2018).

2.4 Open-coast Sandflat

To the west of the main Blakeney Harbour channel are the wide (1.5 km.) intertidal sand flats cut through by three significant creek systems: the Patch Pit Creek (in the area of the Stiffkey Freshes), the Cabbage Creek (running in an easterly direction from the Warham Marshes, through to the Warham Hole) and the more western High Sand Creek.

The sand flats between the Patch Pit Creek and the Cabbage Creek tend to slope sea ward in a relatively uniform slope from the upper marsh (at around 2m OD) down wide lower channel zone of the Cabbage Creek (at around 0m OD). Between the Cabbage Creek and the High Sand Creek, the main area of the sand flats sit at a higher level between around 2.0m OD and 1.5m OD.

The wide Cabbage Creek merges to the outer entrance to Blakeney Harbour and gains little protection from the main nearshore wave climate. In contrast the Patch Pit Creek gains significant wave protection for Blakeney Spit and the intertidal sand banks.

The area of Patch Pit Creek includes significant areas of sea grass. The open-coast sandflat north of Cabbage Creek is an important haul out area for seals.

2.5 Seagrass, Mussels, and Oysters

The intertidal sediments support fragmented areas of seagrass. Common/blue mussel are also present. Pacific rock oysters and sugar kelp are produced commercially in the area, and native oysters are also present as part of a restoration project (currently contained).
Areas of recorded seagrass and mussel beds are shown in Figure 2-5 (a) and (b). During the site visit (11th and 12th August 2025) local patches of seagrass were identified in Location A (Figure 2-5 (a)). Oyster beds have been established to the west of the mussel bed area.

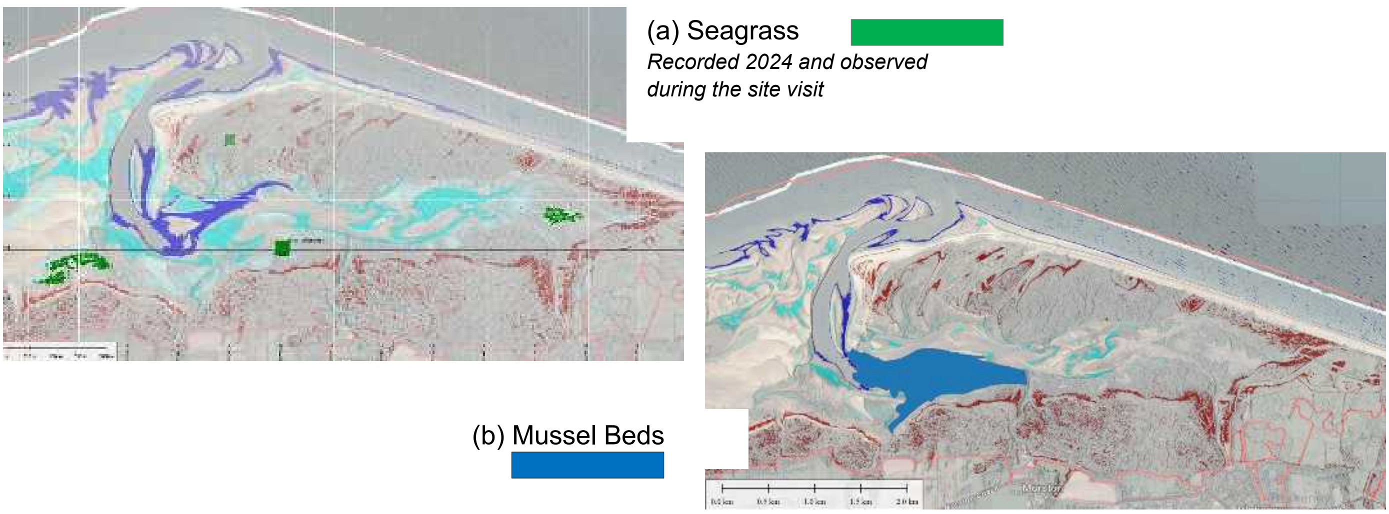

Figure 2-5. Recorded (a) seagrass and (b) mussel beds

Typically, the areas of seagrass occur in relatively sheltered positions at a bed level between 0.5m OD and 1.5m OD. The main mussel bed lies within the main channel, with a typical bed level varying between around 0.5m OD and 2m OD.

3 Coastal Process and Geomorphological Change

3.1 Water Levels

The Admiralty Tide Tables provide astronomical tidal levels at two relevant sites (Secondary Ports): at Blakeney Bar, offshore from the entrance to Blakeney Harbour, and at Blakeney Harbour. In both locations, information is only provided for high water levels.

Furthermore, all values provided in the Tide Tables are given relative to local Chart Datum (CD) (typically related to the lowest astronomic level at specific locations). Chart Datum, however, varies around the coast being specific to any Secondary Port. This is in contrast to land levels which are normally recorded relative to the nationally consistent Ordinance Datum (OD) and a correction factor has to be applied to recorded tide levels to allow comparison with land levels. While a correction factor (-0.8m) is provided for Blakeney Harbour there is no correction provided for Blakeney Bar.

To adjust for this, reference and interpolation has to be applied based on adjacent Secondary Ports at Skegness and Cromer. This correction is shown in Figure 3.1 aiming demonstrate how the tidal water levels for Blakeney Bar and Harbour have been derived for this report.

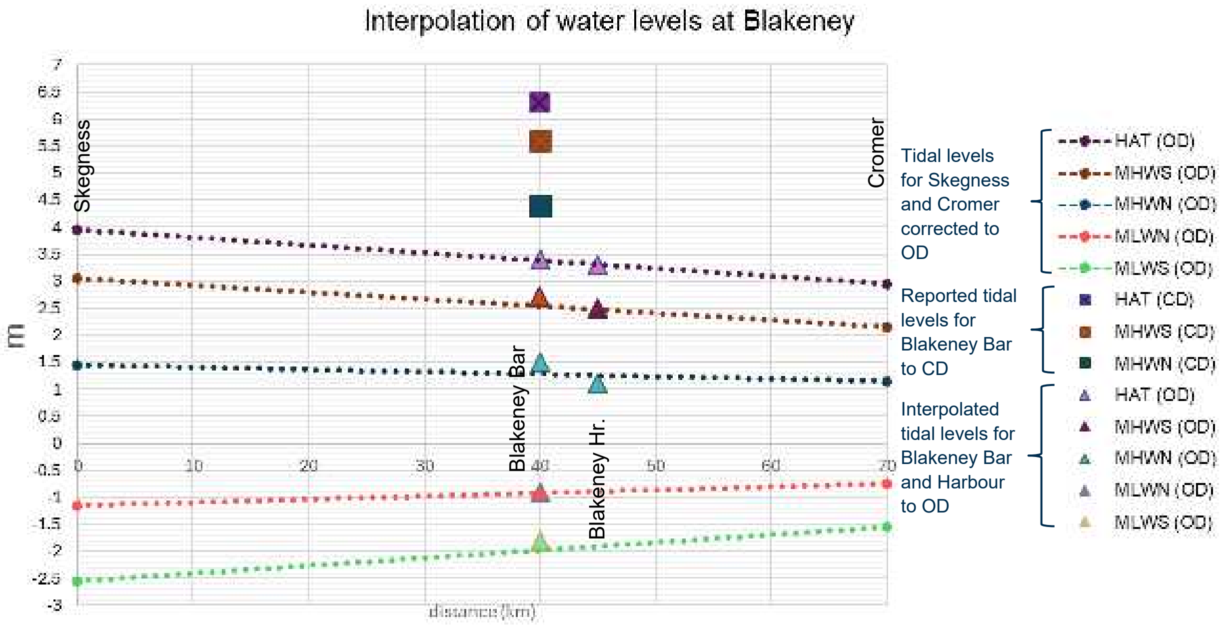

Figure 3-1. Interpolation of tidal water levels for Blakeney, based on Admiralty Tide Table data.

Note: comparison was made with tide level reported for Hunstanton and for Wells but neither Secondary Port was considered fully representative of the open coast water levels.

From the above analysis, predicted astronomical tide levels for Blakeney are shown in Table 3-1.

Extreme water levels taken from the Environment Agency's Boundary Conditions data reported for 2017 area also shown in Table 3.1. These values are reported to Ordnance Datum in the Boundary Conditions report.

Table 3-1. Predicted tidal elevations at Blakeney Harbour (Admiralty Tide Tables, 2025)

Tidal / water level condition	Blakeney Bar (m OD*)	Blakeney Harbour (m OD)
Mean Low Water Springs (MLWS)	-1.8**	~
Mean Low Water Neaps (MLWN)	-0.9**	~
Mean High Water Neaps (MHWN)	1.5*	1.1
Mean High Water Springs (MHWS)	2.7*	2.5
Highest Astronomic Tide (HAT)	3.4*	3.3
T1 – 1 in 1-year return period	3.72	
T10 – 1 in 10-year return period	4.13	
T50 – 1 in 50-year return period	4.48	
T100 – 1 in 100-year return period	4.63	

Notes:
** Estimated correction to OD.*
*** Interpolated from adjacent secondary ports.*

On a spring tide, high water at Blakeney Harbour typically occurs about 30 minutes after high water at Blakeney Bar. The tide at the entrance to the Harbour is already on the turn (on the ebb) while water is still on the flood further within the Harbour.

The general areas covered by different stages of the tides are shown in Table 3-1.

Over low water there is a relatively narrow deeper water channel(s) draining the various creeks and harbours. On the flood, tidal waters progressively flood the main outer channel area with the main flooding of the larger lower saltmarsh area occurring from around mid-tide.

Broader-scale flooding into the creeks and inlets occurs from two hours before high water (HW -2hrs), with large areas of the upper marsh being flooded by high water.

A significant volume of water enters (or leaves) through the relatively constrained entrance from mid-tide, generating strong flows (on both the flood and ebb tides), continuing through to (and after) high water.

It is only from mid-tide that there is a direct connection between the main Blakeney Channel and the wider sandflats to the west.

The baseline image in Figure 3.2 shows the variation in bed levels with an elevation scale bar showing levels relative to Ordnance Datum.

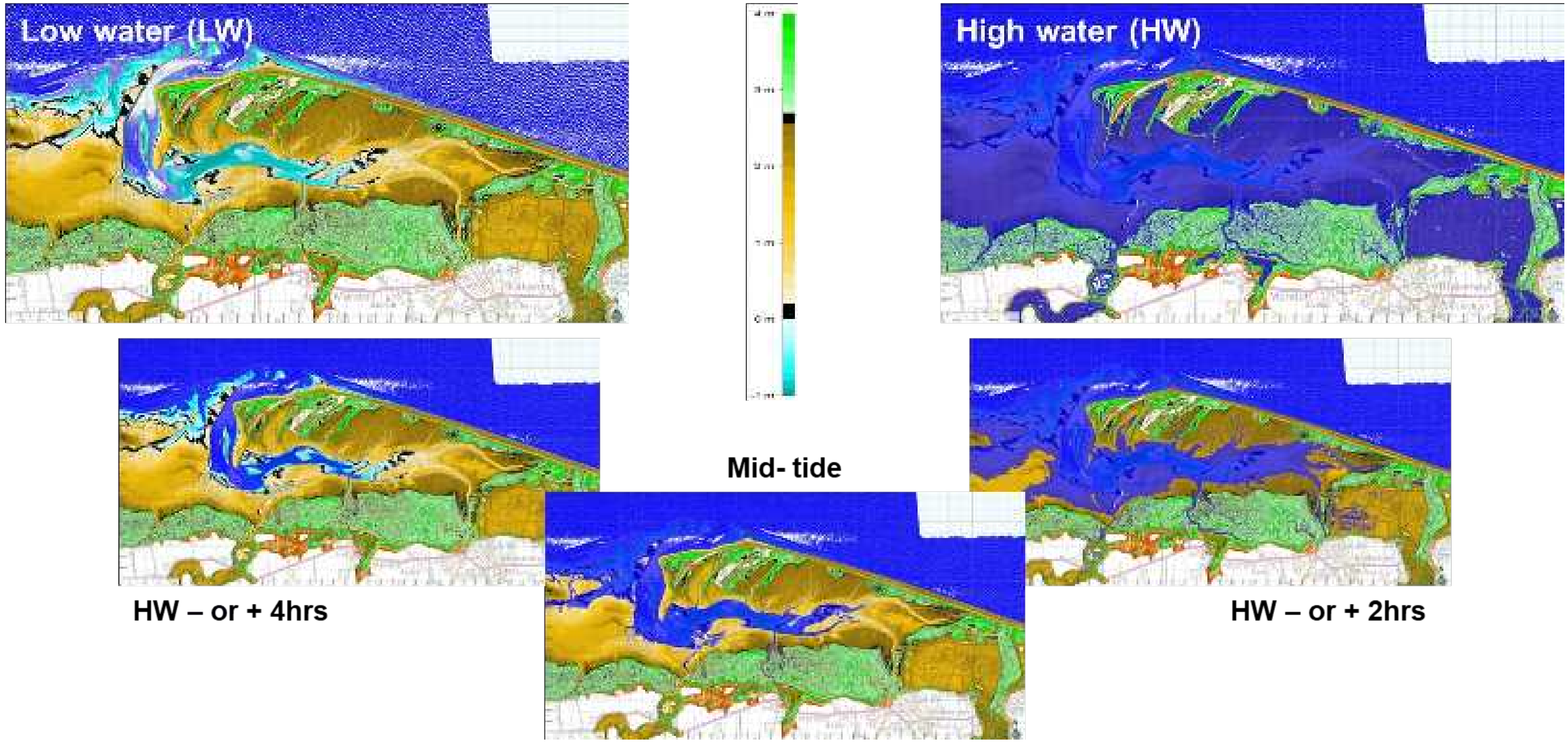

Figure 3-2. Coverage of water at different stages of a spring tide.

3.2 Tidal Flows

There is little or no measured data on tidal flows within the Harbour area. However, from site observations there are strong tidal flows influencing sediment behaviour within the main channels, extending up to both Blakeney Harbour and Cley.

In the nearshore area, at Blakeney Bar, maximum tidal flows occur at high and low water, with flows from west to east over high water and from east to west at lower tidal levels (Royal Haskoning, 2010). This is peculiar to this section of the coast and is explained by the variation in tidal levels over adjacent sections of the coast (Figure 3-3).

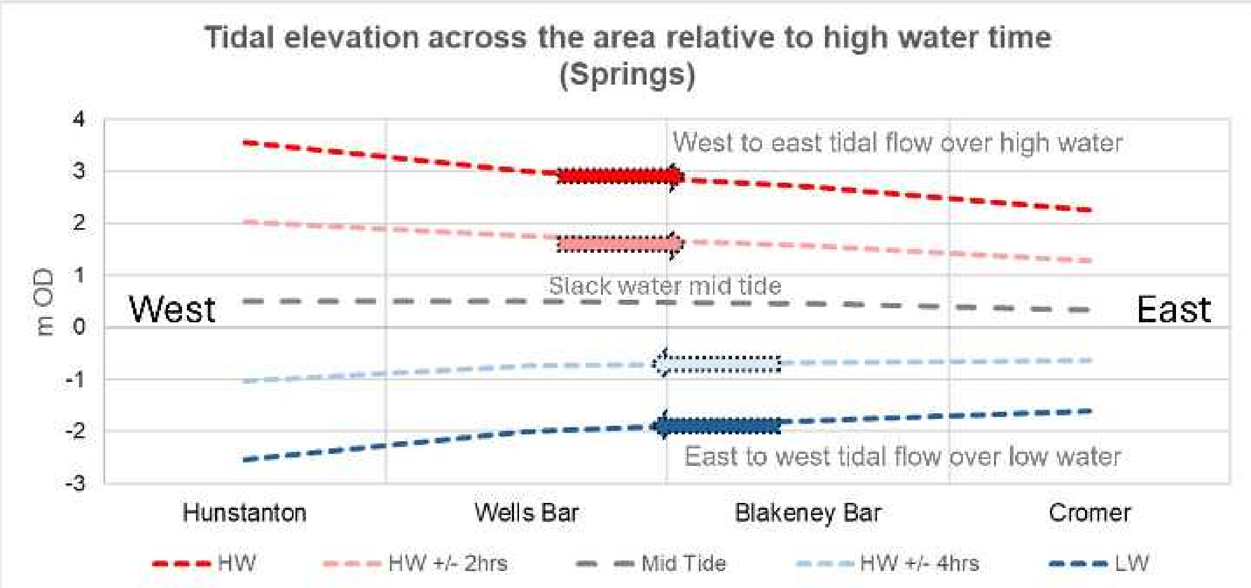

Figure 3-3. Variation in water levels across the open coast for various states of the tide

Maximum nearshore tidal flows are typically about 1.2m/sec over the upper part of the spring tide, with slightly lower flow (from east to west) over the lower part of the tide. This flow pattern gives rise to complex interactions and influences on the way in which flows enter and leave Blakeney Harbour over the tidal cycle. Indicative plots of the potential interpreted flow pathways are shown in Figure 3-4.

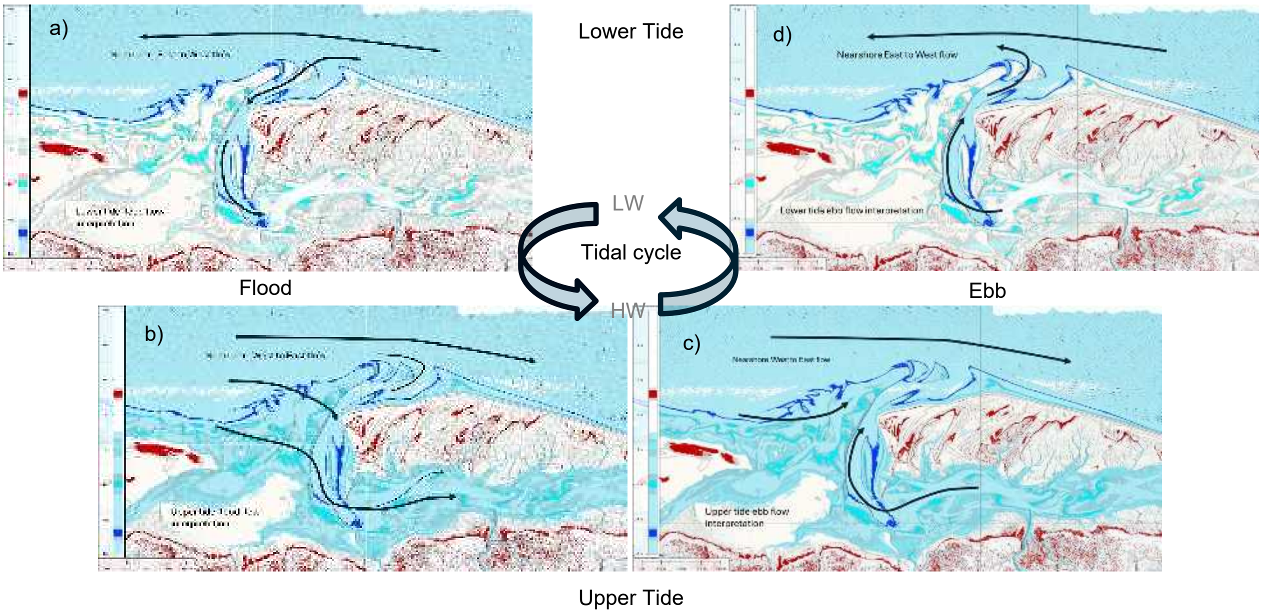

Figure 3-4. Indicative interpretation of tidal flows over tidal cycle

On the initial stages of the flood, the east to west nearshore flow enters the Harbour entrance channel from the east, being constrained by the high sandflats to the west before curving round to flow back to the east into the main body of the Harbour. As the tide rises (and the nearshore flow shifts to west to east), the primary flow floods more directly into the main Harbour across the western sandflats, shifting the flood flow pattern into the main Harbour area.

On the ebb, during the upper tidal period, flow from within the main area of the Harbour is held against the higher ground of Blakeney Spit by the west to east nearshore flow. As the tide lowers and the nearshore tidal flow shifts to east to west, the westerly flow from within the main Harbour area is constrained by the higher western sandflats. At the entrance, the flow changes direction to join the east to west nearshore flow through the various and changing channels between Warham Hole and the East Bar.

3.2.1 Bedforms

As part of the site inspection distinctive bedform patterns were observed that are potentially indicative of areas of strong flows. This has been examined further based on analysis of the most recent Lidar (2023) to identify where similar bedform features are present within the Harbour area. Based on the shape of these features it is possible to assess the direction of flow, indicated by the asymmetry of the bedform.

There are limitations in this analysis in that the bedforms tend to be small (typically in the order of 200mm) and not all bedform indicators have been identified. In addition, it would be anticipated that in areas of mobile sediment, the bedform features only pick up the form left by the last occurrence of strong flow (i.e. flood bedforms may be obscured by subsequent ebb flow across the area.

Notwithstanding this limitation, an initial assessment has been possible of potential strong flows within the area. The indicative bedforms features are mapped in Figure 3-5, adding to the overall assessment of bed mobility and dominant flow patterns.

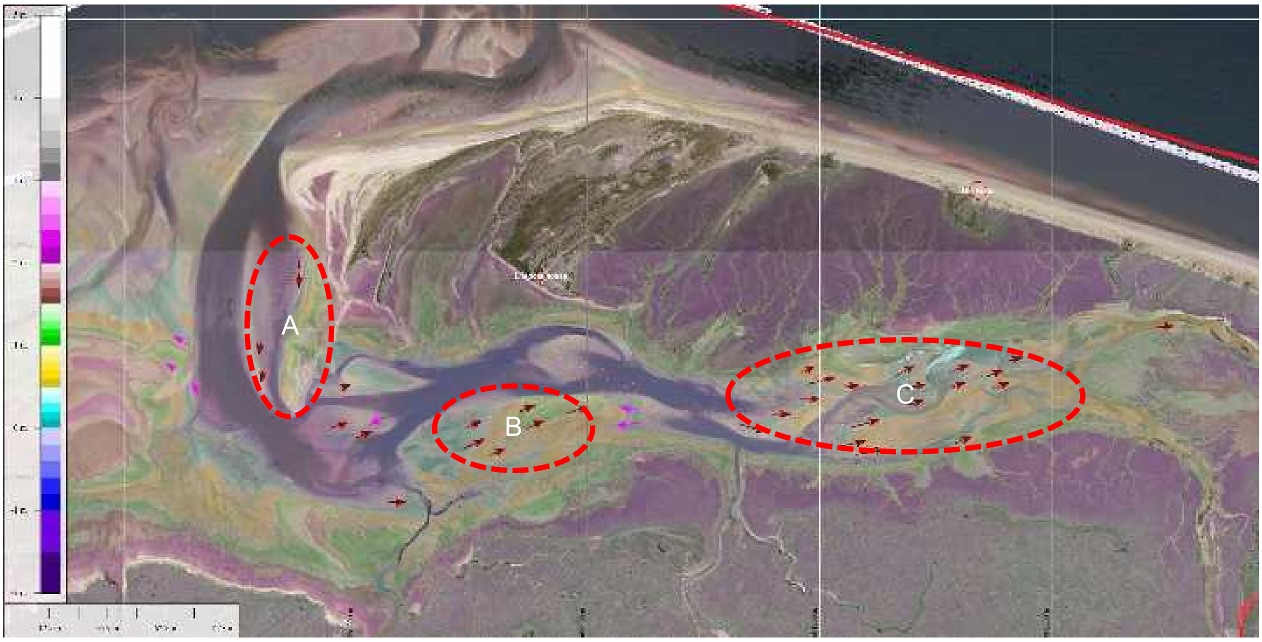

Figure 3-5. Locations of bedforms influenced by strong tidal flows.

Dark red arrows – indicative of flood dominance. Pink arrows indictive of ebb dominance

Three areas of bedforms indicating flood-flow dominance are identified:

- Area A, highlighted in Figure 3-5, is consistent with strong flood flows setting against Blakeney Spit over the upper flood tide (Figure 3-4 (b)). This flow pattern may have been enhanced by the development of the nose of shingle growing seawards from the western head of Blakeney Spit. This accretion is synchronous with the increased erosion to the western face of New Far Point.
- Area B suggests strong upper tide flows over the mussel beds to the south of the main channel (Figure 3-4 (b)).
- Area C indicates a more complex pattern of flood flow more generally in the upper part of the Harbour, suggesting significant potential for movement of sediment on the flood tide.

Only limited ebb dominant bedforms are identified:

- Along the eastern flank of Area B, possibly suggesting some ebb pressure as the ebb flow is redirected in a more northerly direction towards the southern side of Blakeney Spit through the alignment of the main channel.
- Similarly, there is some indication of ebb flow pressure against the effective flood-tide delta developed from the southern end of Area A.
- There is some indication of ebb flows exiting along local channels to the west, possibly during the slack water period around mid-tide.

In general, the location of these bedforms is consistent with the pattern of tidal flows. Their locations also indicate areas of potentially increased sediment mobility.

3.3 Offshore and Nearshore Waves

Under typical conditions, the wind climate at Blakeney Harbour is predominantly south-southwesterly, with wind speeds rarely exceeding 16m/s, resulting in a moderate wave climate. For example, the annual mean significant nearshore wave height at Cley wave buoy (7m water depth, 400m offshore) ranged from 0.55m to 0.72m between November 2006 and November 2009 (Environment Agency, 2014). During the same period, mean significant offshore wave heights at the Blakeney Overfalls wave buoy (23m CD, 10km offshore) were 0.8-1.0m. Between December 2011 and November 2012, the predominant direction of wave approach is from the north to north-northeast (Figure 3-6) (Environment Agency, 2013).

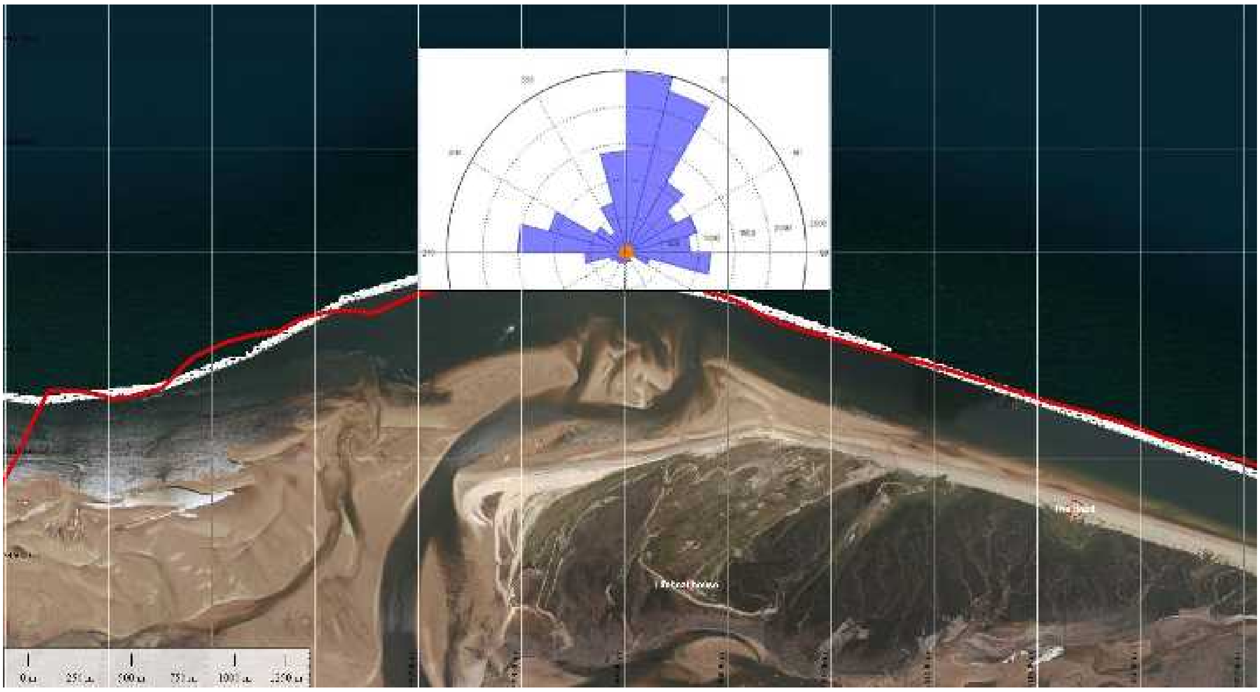

Figure 3-6. Wave rose for the Blakeney Overfalls wave buoy from December 2011 to November 2012 (Environment Agency, 2013)

Modelling demonstrates that under typical wave conditions this drives sediment west along the main open coast beach face. Beyond (to the west of) Blakeney Point waves will tend to be more oblique encouraging the development of the nose or spit of coarse sediment towards the entrance channel.

There is significant variation in estimates of longshore sediment transport along the open coast (Royal Haskoning, 2010) and it is possible that under certain major storm events (low probability, high energy) waves of sediment (sand) may be driven east from the large sandflats to the west.

3.4 Geomorphological Change

3.4.1 Blakeney Spit

The long-term (100 to 1,000-year) development of a mixed sand-gravel barrier is typically regulated by sediment supply, relative sea-level rise and local geology. These conditions determine whether a barrier migrates landwards (transgressive behaviour), seawards (regressive behaviour), or remains stationary and builds *in situ*. Over geological time, a barrier can exhibit more than one of these modes. Barriers have been observed to respond to multi-decadal sea-level rise through landward migration whilst maintaining their essential form.

3.4.1.1 Historical Cross-shore Development of the Open Coast to Blakeney Spit

Andrews (2020) showed that changes in barrier beach position between 1649 and the present day represent a mean landward rollover rate of about 0.85m/year. Pollard et al. (2020) showed that over a 130-year period (1886-2016), Blakeney Spit has, on average, retreated in a landward direction, at a mean retreat rate of 0.60m/year. Figure 3-7 shows that landward retreat has dominated over most of the spit's length between 1886 and 2016, reaching a maximum of 146m at the mid-point, seawards of Cley.

High rates of accretion, of up to 351m, have characterised the western end towards Blakeney Point. The periods 1886-2016, 1905-2016, and 1957-2016 describe a tendency towards accretion of the far western section, with maximum shoreline advance rates of 2-3m/year (Figure 3-7). Over the same periods, most of the spit was in retreat, with maximum retreat rates of 0.6-0.75m/year. This contrasts markedly with the period 1981-2016 where the seaward head of the Blakeney Point retreated at rates of about 0.3m/year.

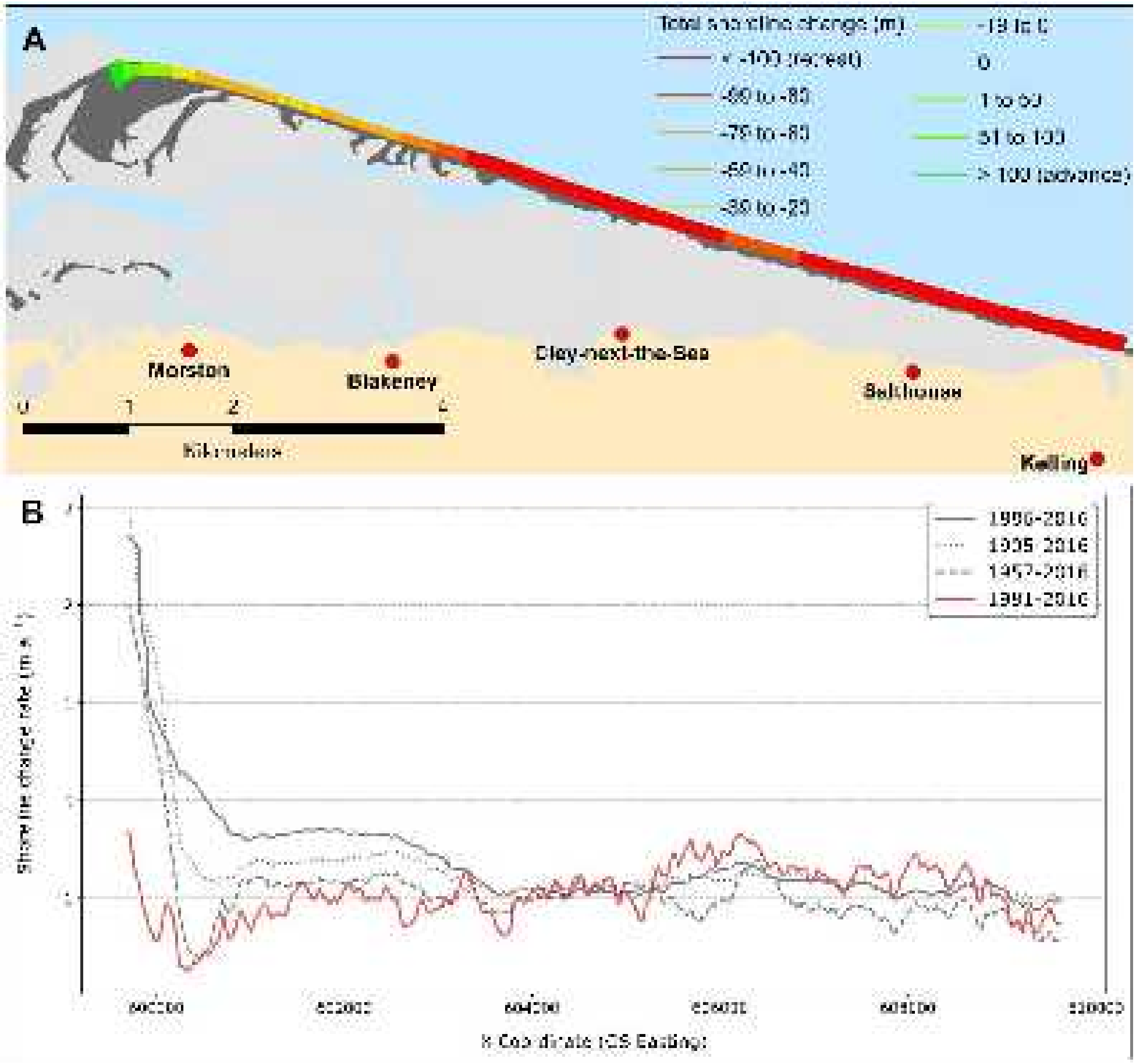

Figure 3-7. Changes in the position of mean high-water level. A: Total change in planform between 1886 and 2016. B: Shoreline change rate divided into four variable length, multi-decadal timespans (Pollard, 2020)

Environment Agency (2012) analysed seven beach profiles along Blakeney Spit to map shoreline position change at three datums; mean high water spring, mean sea level and mean lower water spring/neap between 1991 and 2011 (Figure 3-8). The results describe strong accretion at N2C1 with a mean of 4.7m/year and strong erosion at the adjacent N2C2 with a mean of -4.3m/year and a steepening profile. At all other profiles (N2C3 to N2C7), the spit has retreated by between 0.5m/year (N2C3) and 1m/year (N2C5) with no change in beach rotation, indicating rollover and lowering of the shingle ridge.

Figure 3-8. Location of beach profiles along Blakeney Spit (left) and measured retreat/accretion trends between 1991 and 2011 (right) (Environment Agency, 2012)

3.4.1.2 Historical Longshore Development of Blakeney Spit

Pollard (2020) mapped the historical growth of Blakeney Point through a time series of positions of 27 lateral recurved ridges that extend landwards from the main beach (Figure 3-9) The recurves are likely to have formed because of sediment transport to the east (opposite to the regional direction), which occurs during periods of reversal in wind direction and the resultant direction of wave approach. Barrier growth to the west resumed when the dominant direction of wave approach from the northeast returned, driving sediment transport to the west. Westwards migration of the Blakeney Point has occurred at a mean 100-year rate of about 3.5m/year ending where tidal flow takes place through Blakeney Channel (Andrews, 2020).

Where the stable lateral recurves are elevated above mean high-water spring, they become colonised by vegetated dunes. Between recurves, the relatively low, sheltered areas encourage the development of intervening saltmarsh (Figure 2-2). According to Pethick (1980), the inception dates for the saltmarshes highlighted on Figure 3.9 were about 1500 (Blakeney A), 1910 (Blakeney B), 1920 (Blakeney C), and 1850 (Blakeney D). The dates published by Pethick (1980) are based on historical maps and anecdotal evidence and reference the timing of saltmarsh development. The later dates for Blakeney A and Blakeney B therefore provide minimum ages of saltmarsh development, not spit formation.

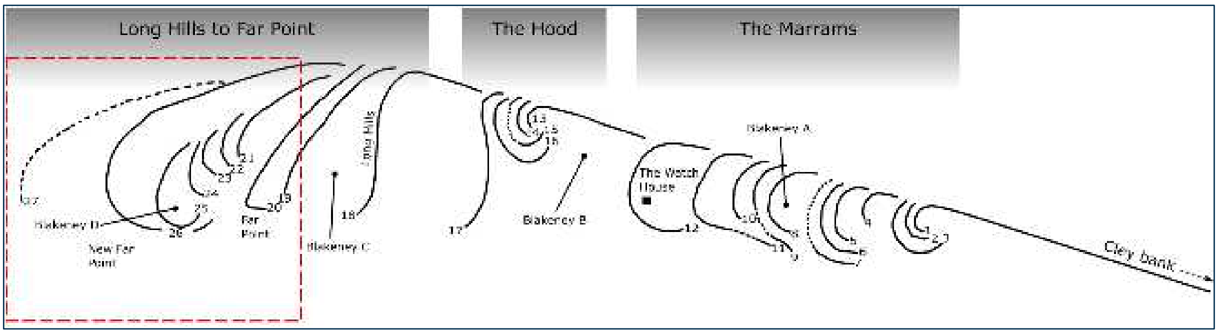

Figure 3-9. Lateral recurves at Blakeney Point (Pollard, 2020). The red dashed box indicates the area surrounding the western end of spit. The saltmarshes are Blakeney A, Blakeney B, Blakeney C, and Blakeney D

Barfoot and Tucker (1980) described the changes that have taken place at Blakeney Point between 1921 and 1979. They showed that it has remained relatively stable due to sand dune colonisation with vegetation which appeared, and became well established, in the 1920s (Figure 3-10). This analysis suggested that the westernmost lateral recurve, referred to as the New Far Point appeared in 1966 and persists in some form certainly through to the 1980's (Figure 3-10).

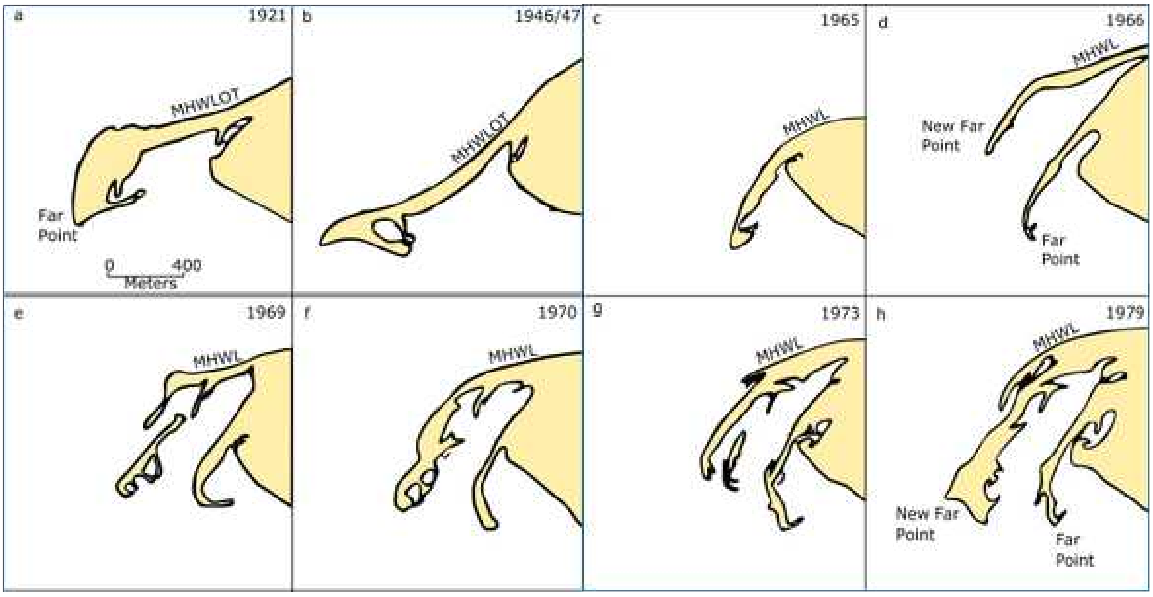

Figure 3-10. Evolution of Blakeney Point between 1921 and 1979 (Barfoot and Tucker, 1980)

The above analysis has been extended through to the present day, mapping the respective shorelines and channel position from historic OS maps from 1815, 1884, 1919, 1950's and 1965, comparing this with the position of the shoreline and channel taken from a combination of 2023 Lidar and air photography. The resulting shoreline evolution is shown in Figure 3-11.

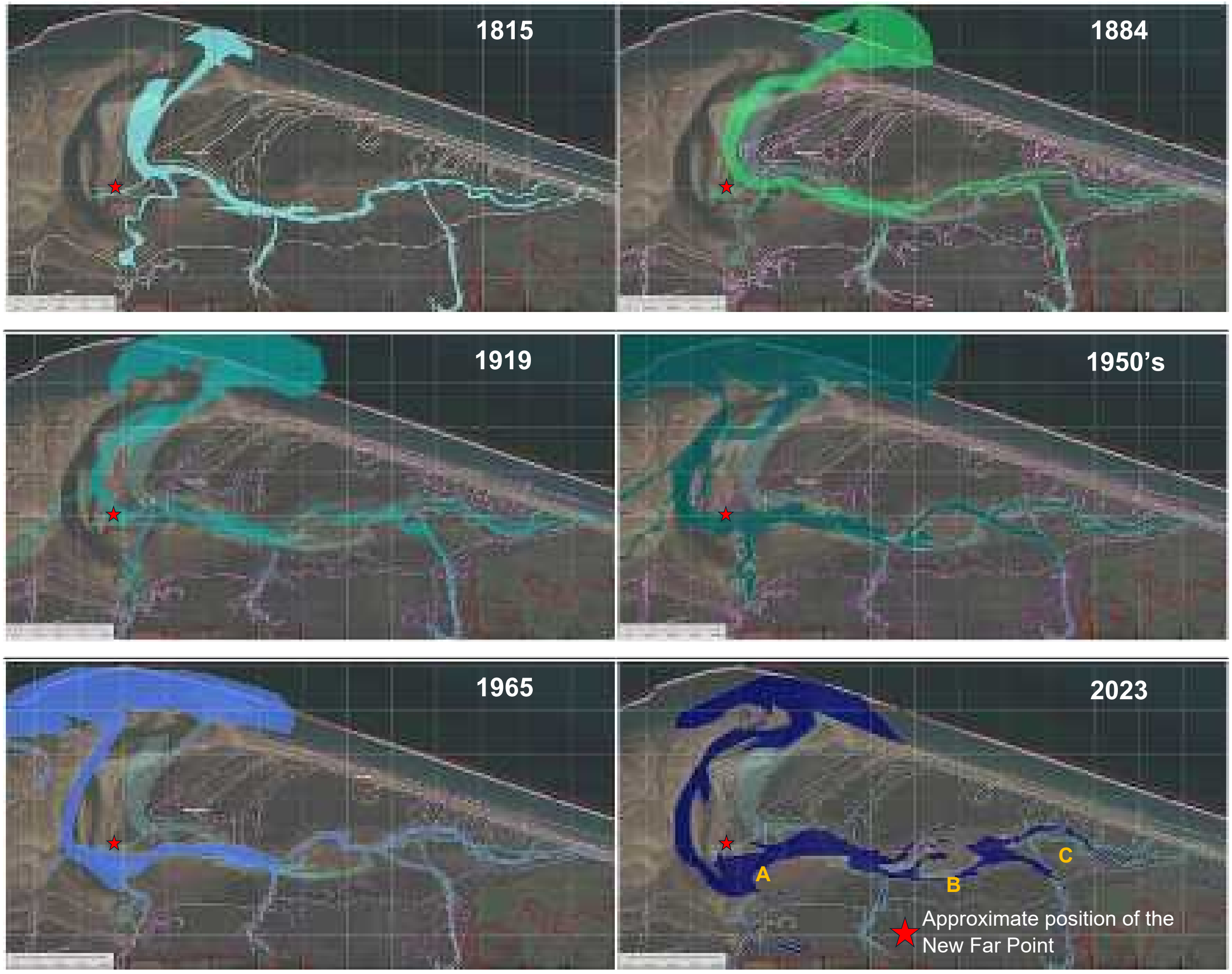

Figure 3-11. Change in position of channel and shoreline 1815 to 2023.

Base image – 2023 Air Photograph. Channel position for 1815 has been shown ghosted on subsequent plots for reference.

The 1815 plot shows the presence of the Long Hills and the development of the Far Point as indicated earlier in Figure 3.9. By 1884, the main change was the initial development of the New Far Point, pushing the outer entrance channel towards the west. This westerly movement of the outer entrance channel persists through to 1991, despite the apparent collapse of the New Far Point in a southerly direction by 1919.

The channel moved further west by the early 1950's, with the redevelopment of the New Far Point shingle ridge. Notably, there appears to be change at the offshore end of the entrance channel by 1950's and this appears to have been consolidated by 1965 with the entrance having moved significantly to the west. This appears to be associated with a retreat of the New Far Point but also the slight development of bars over the western face of the Spit feature.

There was little significant change or westward movement of the central section of the outer entrance channel through to 2023. However, the offshore entrance moved east and, potentially more significant in terms of change within Blakeney Harbour, the New Far Point had developed more to the south, tending to push the main channel south against the southern Stiffkey frontage (Location A shown on the 2023 plot in Figure 3.11).

In addition to the change in shape to the main western head of Blakeney Point, the analysis of historic maps highlights other areas of change further within the larger Blakeney Harbour. In particular:

- In Location A,
    - the growth of the New Far Point is likely to have increased flow between Blakeney Point and the southern shoreline, potentially increasing flows across the area of the mussel beds (Figure 2.5 (b)),
    - while also increasing and changing the orientation of the flow within the main channel in this area, alongside increasing the input and deposition of sediment immediately up stream of Blakeney Point.
- In Location B, with the changes at Location A, creating significant variation in the position of the channel and sand banks.
- Resulting in changes in the orientation of the channel feeding down to Blakeney Quay (Location C), with potential change to the area of marsh upstream of this channel.

3.4.1.3 Recent Change

Developing from the longer term pattern of historic change, a more detailed analysis of recent change has been undertaken making use of the Lidar data from 2003, 2008, 2013, 2014, 2015, 2018, 2019, 2020, 2022 and 2023. The changes between surveys are shown in Figure 3.12, highlighting the ongoing development of the shingle ridges to the western face of Blakeney Point, alongside the continuing development of the New Far Point (recognising the way in which the western face of New Far Point has undergone erosion with the partial breach occurring between 2021 and 2023).

Notwithstanding, local change (such as the change to the New Far Point), the overall impression at the broader scale is of a progressive pattern of change, reflecting the long term historical trends discussed earlier.

As part of this analysis of more recent change, land level difference plots have been produced and are shown in Figure 3.13, showing the major changes in terms of erosion and accretion over the whole area between 2003 through to 2023 (Figure 3.13 (a)) and the progressive change between 2003 and 2014 (Figure 3.13 (b)) and 2014 and 2023 (Figure 3.13 (c)).

These plots highlight features discussed earlier in terms of:

- The continuing and quite severe erosion of the open coast front face to Blakeney Spit (as discussed in Section 3.2.11) between the Marrams and Blakeney Point, with the associated growth westward of the East Bar.
- The continuing development of the western nose and the development of the new shingle ridges.
- The erosion, particularly with the development of the nose, of the westward face of the New Far Point, coupled to the extension of New Far Point.
- The potential erosion of the face of the Stiffkey Freshes Marsh as a consequence of the development of the New Far Point.
- The slight pattern of accretion to the South Side mussel beds and the slight increased erosional pressure of the area to the south of the Lifeboat House.

They also show the following changes further within Blakeney Harbour:

- High degree of variability in the channel position in the area just to the east of the Morston Channel.

- The potential pattern of net accretion to the marsh area between the Blakeney Channel and the entrance to the Cley channel.
- It is noted, however, that, overall, there is little change in the level of the main salt marsh behind the main Blakeney Spit.

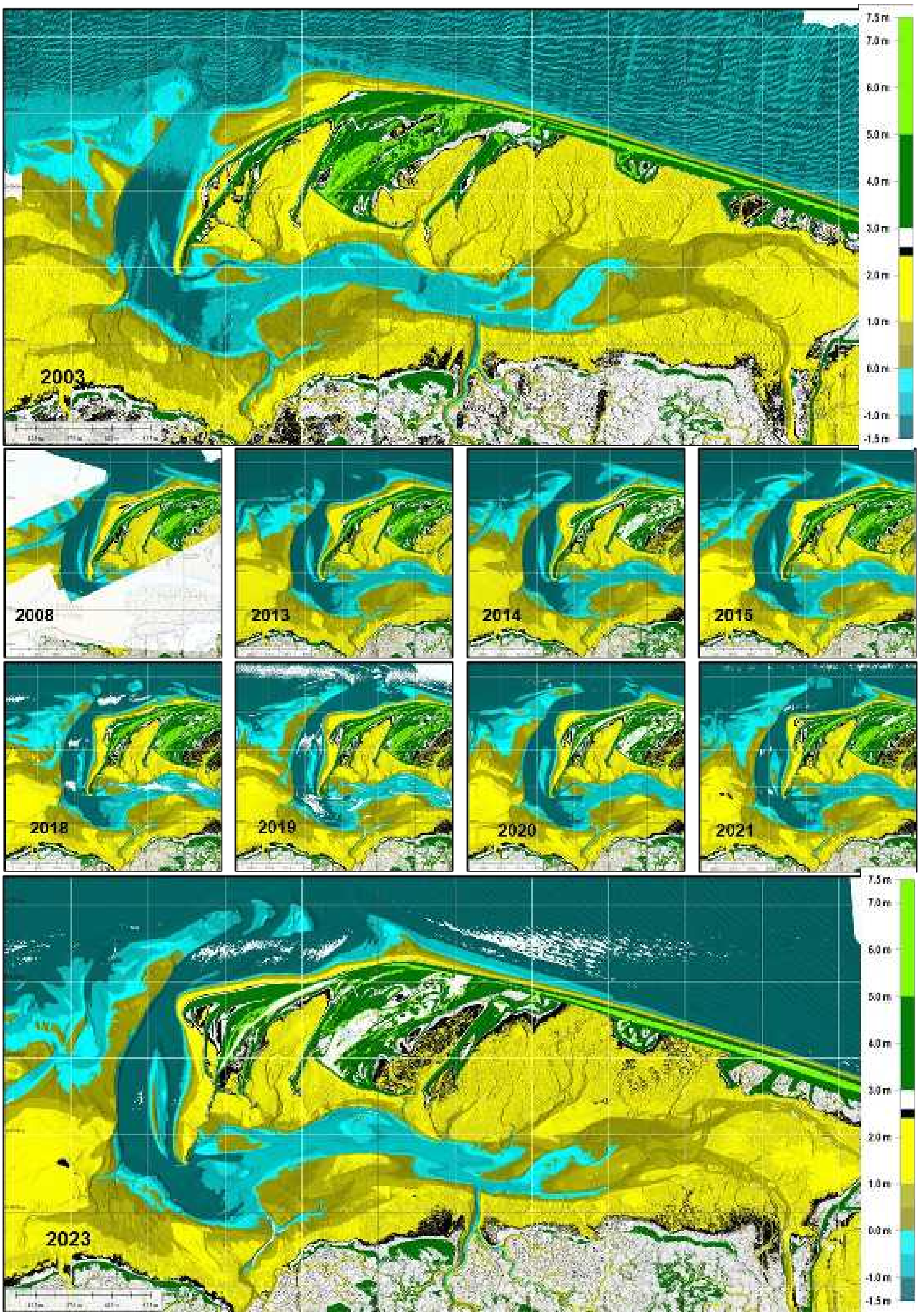

Figure 3-12. Development of Blakeney Point and the New Far Point from 2003 to 2023.

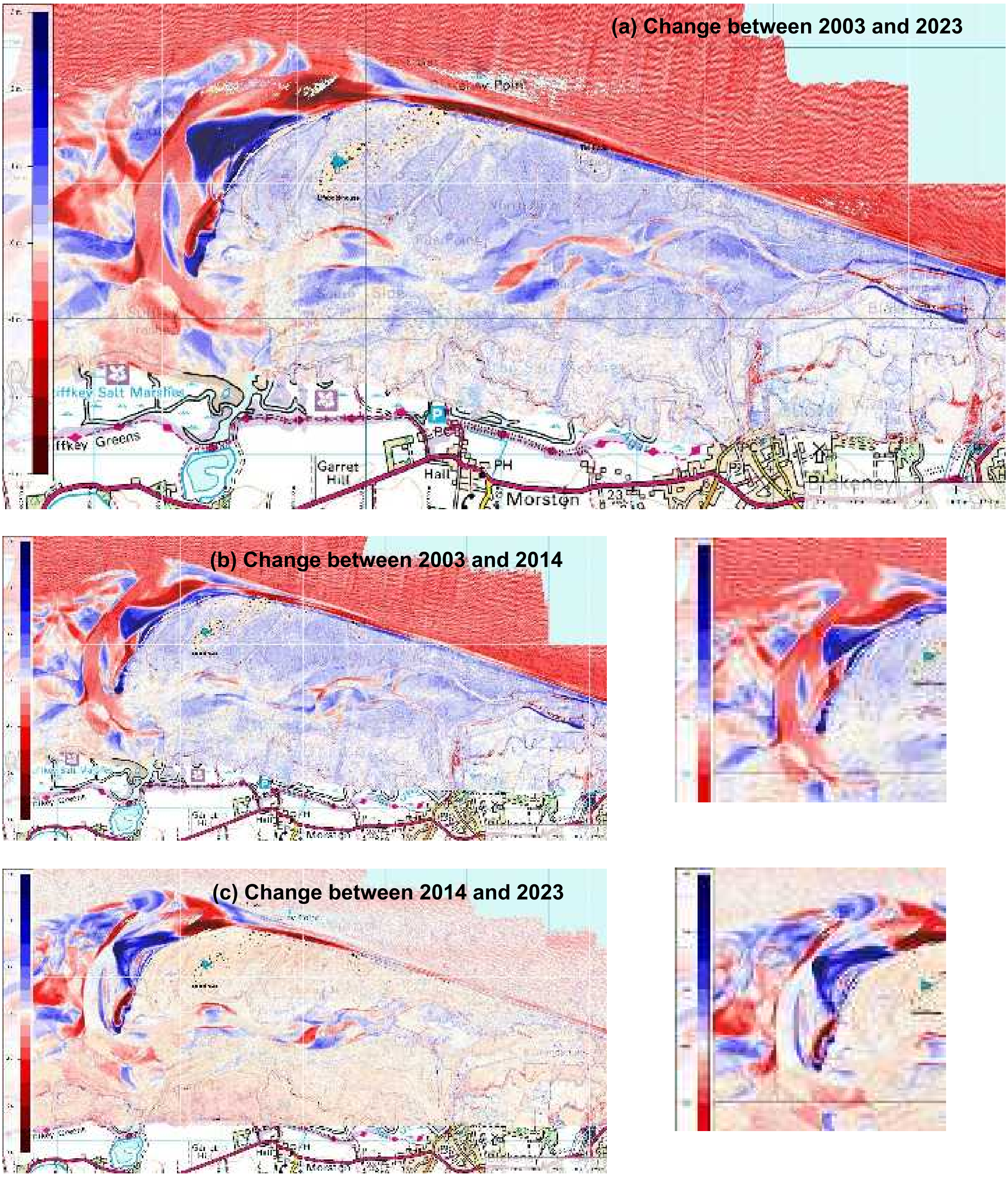

Figure 3-13. Change in levels (a) 2003 to 2023, (b) 2003 to 2014 and (c) 2014 to 2023.

Note: red shading shows erosion, blue shading indicates accretion.

3.4.1.4 Accretion and Erosion in Blakeney Harbour

A more detailed discussion is provided below of the changes observed at Stiffkey Marshes, in the area of the mussel beds, in the central area between the Morston and Blakeney Channels and across the marsh area between Blakeney and the Cley channels as indicated in Figure 3.14.

Figure 3-14. Feature areas discussed in text.

Stiffkey Marshes

Further to the main geomorphological changes identified above, Environment Agency (2007) analysed three beach profiles (N2D4, N2D5, and N2D6) across Stiffkey Marshes in the west of the study area containing large sections of landward saltmarsh. The saltmarsh was analysed for trends of vertical change between 1991 and 2006 every 20m along the profiles. Red lines in Figure 3.15 indicate an erosional trend for the saltmarsh and green lines indicate an accretional trend. The rates of change of saltmarsh elevation were several mm per year and therefore relatively minor. Where larger rates are shown this often coincides with vertical changes in and around the marsh drainage channels.

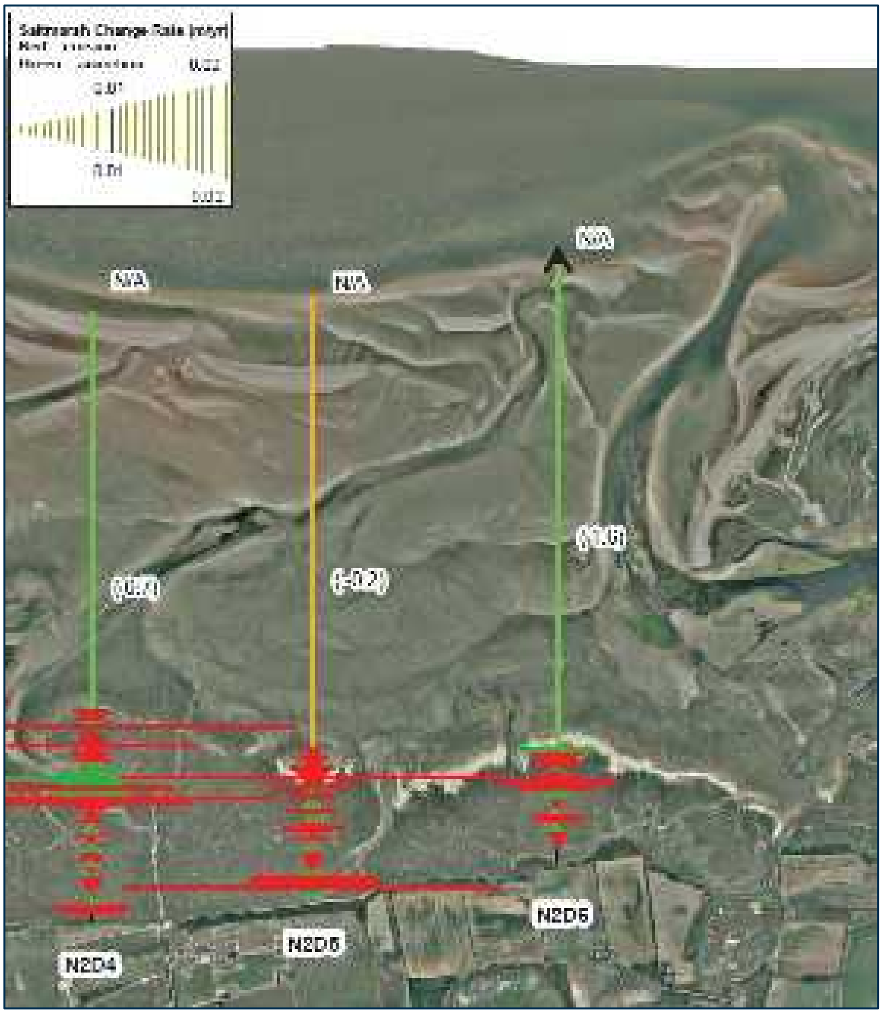

Figure 3-15. Location of beach profiles along Stiffkey Marshes and west Blakeney Spit and measured erosion/accretion trends between 1991 and 2006 (Environment Agency, 2007)

Andrews et al (1999) used caesium isotopes as a sediment marker to measure saltmarsh accretion rates across Stiffkey Marshes. They showed that vertical accretion of the marshes averaged 4.0mm/year over the past decade (Table 3.2). This rate is three times that of long-term sea level rise and suggests that fine-grained sediment supply would be adequate to keep pace with predicted sea-level rise in the future (French and Spencer 1993).

Table 3-2. Vertical accretion rates across Stiffkey Marshes (Andrews et al., 1999)

Location	Vertical Accretion Rate (mm/year)
Stiffkey *Spartina* marsh	6.4
Stiffkey mid marsh	3.6
Stiffkey upper marsh	2.1
Average	4.0

Mussel Beds

Figure 3.16 shows a typical cross-section along a transect shown as Section A on Figure 3.14.

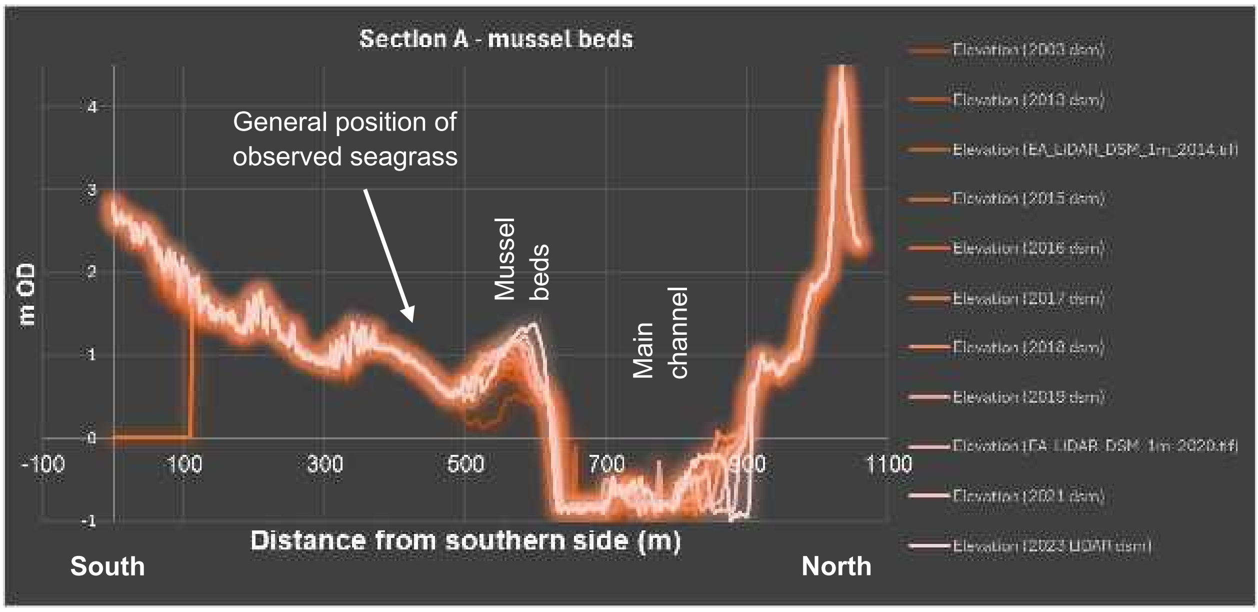

Figure 3-16. Variation in level across Section (mussel beds).

Note: darker lines from earlier surveys (from 2003), with lighter lines being more recent surveys through to 2023.

The following key aspects and features are identified:

- The growth in height of the mussel bed, typically in the order of 0.5m over the last 20 years.
- Erosion of the northern margin of the channel.
- Relative stability of the salt marsh to north and south.
- The position of the observed area of sea grass in the shelter of the mussel beds.

Banks and channels between Morston and Blakeney

Figure 3.17 shows a typical cross-section along a transect shown as Section B on Figure 3.14.

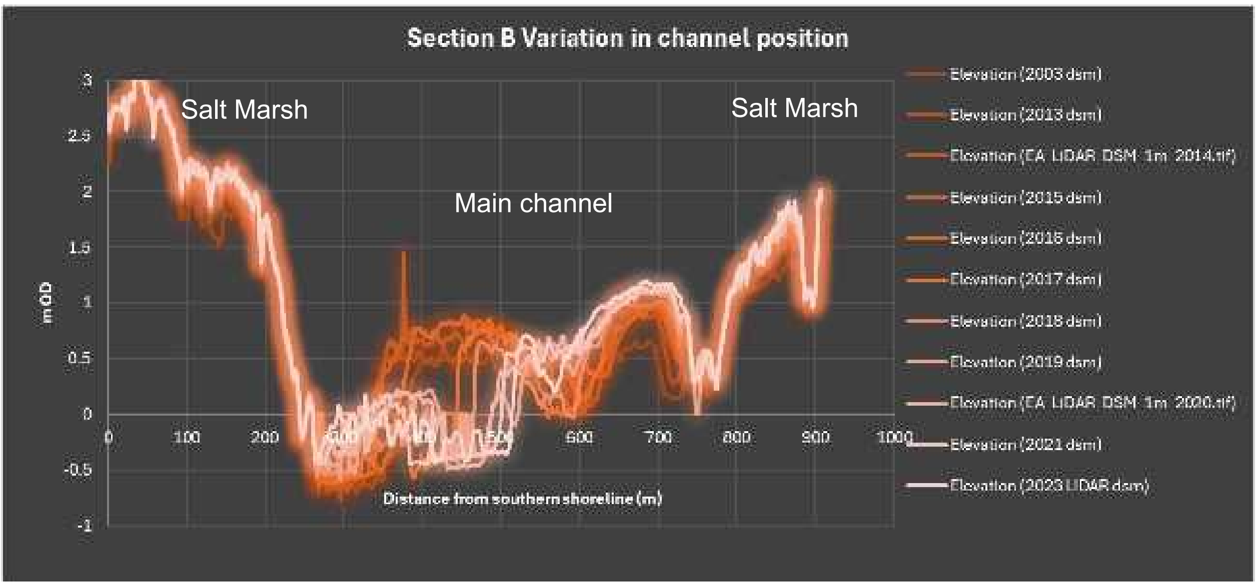

Figure 3-17. Variation in channel position 2003 to 2023 at Section B

Note: darker lines from earlier surveys (from 2003), with lighter lines being more recent surveys through to 2023.

The following key aspects and features are identified:

- The shift in channel position by over 300m, with variation in bed levels in excess of 1m.
- The slight apparent increase in the level of the fringe marsh to north and south.
- The relative stability of the upper marsh to both north and south.

Change in marsh/ mud flat between the Blakeney and Cley channel
Figure 3.18 shows a typical cross-section along a transect shown as Section B on Figure 3.14.

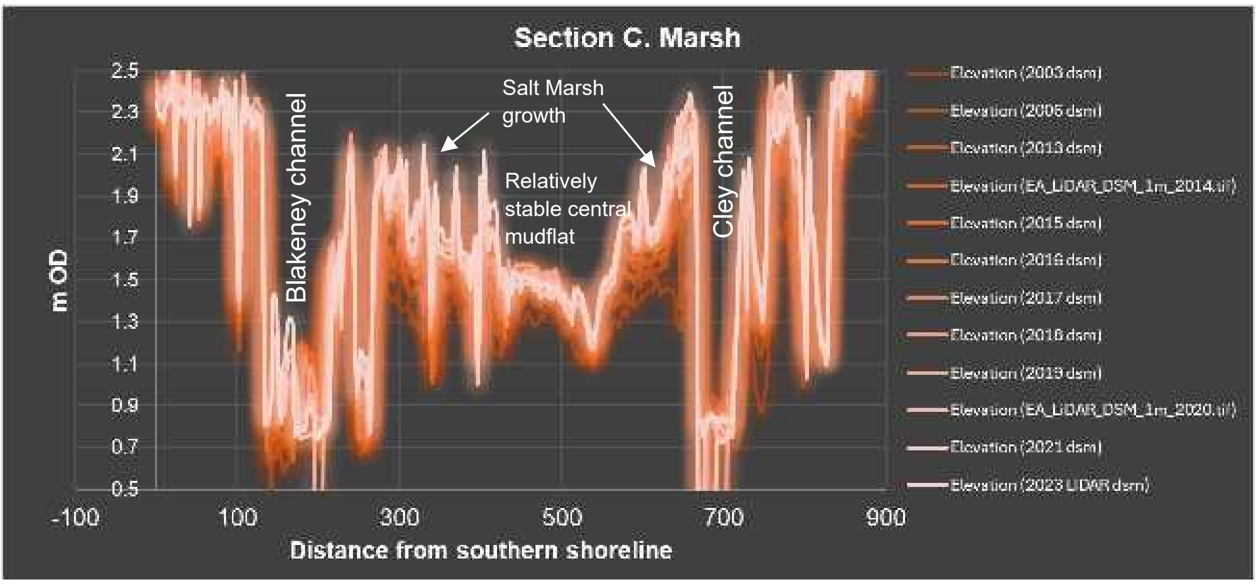

Figure 3-18. Variation and growth of marsh/mudflat between the Blakeney and Cley channels.

Note: darker lines from earlier surveys (from 2003), with lighter lines being more recent surveys through to 2023.

The following key aspects and features are identified:

- The increase in elevation, in areas, by around 0.6m.
- The lower and relatively more stable central section of the marsh/ mudflat. It is noted that this is an area identified as being populated by sea grass.

3.5 Management of Blakeney Spit

Blakeney Spit provides flood protection to the landward communities of Salthouse, Cley, Blakeney, and Morston. It can be broadly divided into two management sections. East of Cley, the barrier was actively re-profiled from the 1950s to 2005 to maintain the crest height at 8-9m OD (Bradbury and Orford, 2007). Barrier crest re-profiling was terminated after 2005, allowing the barrier to respond more naturally to hydrodynamic forcing conditions. The shift towards a less interventionist management regime aligns with the local and national strategy seeking to increase the proportion of coastal realignment sites in preference to hard engineered alternatives. West of Cley (the study area), the barrier has always remained unmanaged, where it is characterised by a crest height of 5-6m OD (Bradbury and Orford, 2007).

Along Blakeney Spit, elevated water levels and energetic wave conditions associated with storm events have frequently resulted in gravel barrier overwashing (November 2007 and December 2013) and in some cases breaching (December 2013) (Andrews, 2020; Pollard et al., 2021).

On 5th December 2013, Blakeney Spit was impacted by a storm surge event where peak offshore wave heights of 3.8m were recorded at the Blakeney Overfalls wave buoy. The event locally flooded Cley Marshes and extensively flooded Blakeney Freshes (Figure 3.19). The storm caused the infilling of near-barrier saline lagoons and the inundation of 91ha (one third of the total area of back-barrier wetland) of the Cley to Salthouse Marshes. In addition to extensive washover deposition driven landward from the barrier beach onto the adjacent saltmarsh surface, the 2013 event resulted in two breaches (outside and east of the study area), directly opposite Salthouse and approximately 1km to the west (Figure 3.20). Each breach was just under 100m wide.

Following the 2013 event, both breaches were naturally sealed by 24th January 2014, most likely the result of strong, persistent easterly winds and associated longshore sediment transport (Spencer et al., 2015). However, this event largely destroyed sections of the artificially steepened beach profile inherited from bulldozing in the 1990s that had already been subdued by previous storms, particularly the November 2007 surge (Brooks et al., 2016).

Figure 3-19. Cley to Blakeney Point barrier beach looking west on 9th December 2013 following the 5th December 2013 storm surge (Christie et al., 2020)

Figure 3-20. Salthouse Marshes between the Cley East Bank and Gramborough Hill showing location of geomorphic features associated with the 2007 and 2013 storm surges. Google Earth image 24th September 2017 (Andrews, 2020)

3.6 Management of Blakeney Freshes

Wave direction during the passage of the 2013 surge showed a gradual change from northwest to north at Blakeney Overfalls (Christie et al., 2020). The interaction of this wave field with the bathymetry of Blakeney Channel meant that considerable wave action was focussed into the west and northwest margins of the Blakeney Freshes embankment. The embankment enclosing the Freshes was breached in 13 places, over a total distance of 550m. Typical failure occurred due to failure to the back face, with failure migrating progressively seawards towards the outer slope. Modelling results of Christie et al. (2020) showed that 99.5% of the flood volume in the Freshes caused by the 2013 event resulted from embankment breaching.

To aid removal of floodwater, the Environment Agency restored the southern culvert to gravity drainage on 30th January 2014. Between July and December 2014, they repaired the failed sections of the embankment, in places re-profiling with a cross-shore profile characterised by a lower elevation (a design height of 4.25m OD compared to the pre-surge heights in the range 5.0 to 5.6m OD) and wider crest and shallower slopes than the pre-surge configuration. It has been argued by the Environment Agency that this geometry will be more resilient to damage and failure than the previous structure during future surge events because, although they will be overtopped during extreme events, catastrophic failure due to breaching will be prevented. Simulating the same storm event after embankment reprofiling showed that flooding of the Freshes is reduced by 97%, largely because the lower, wider embankments preclude breaching (Christie et al., 2020).

Figure 3.21 shows the general land levels within the Freshes together with an approximate long section along the defence comparing current and previous crest levels.

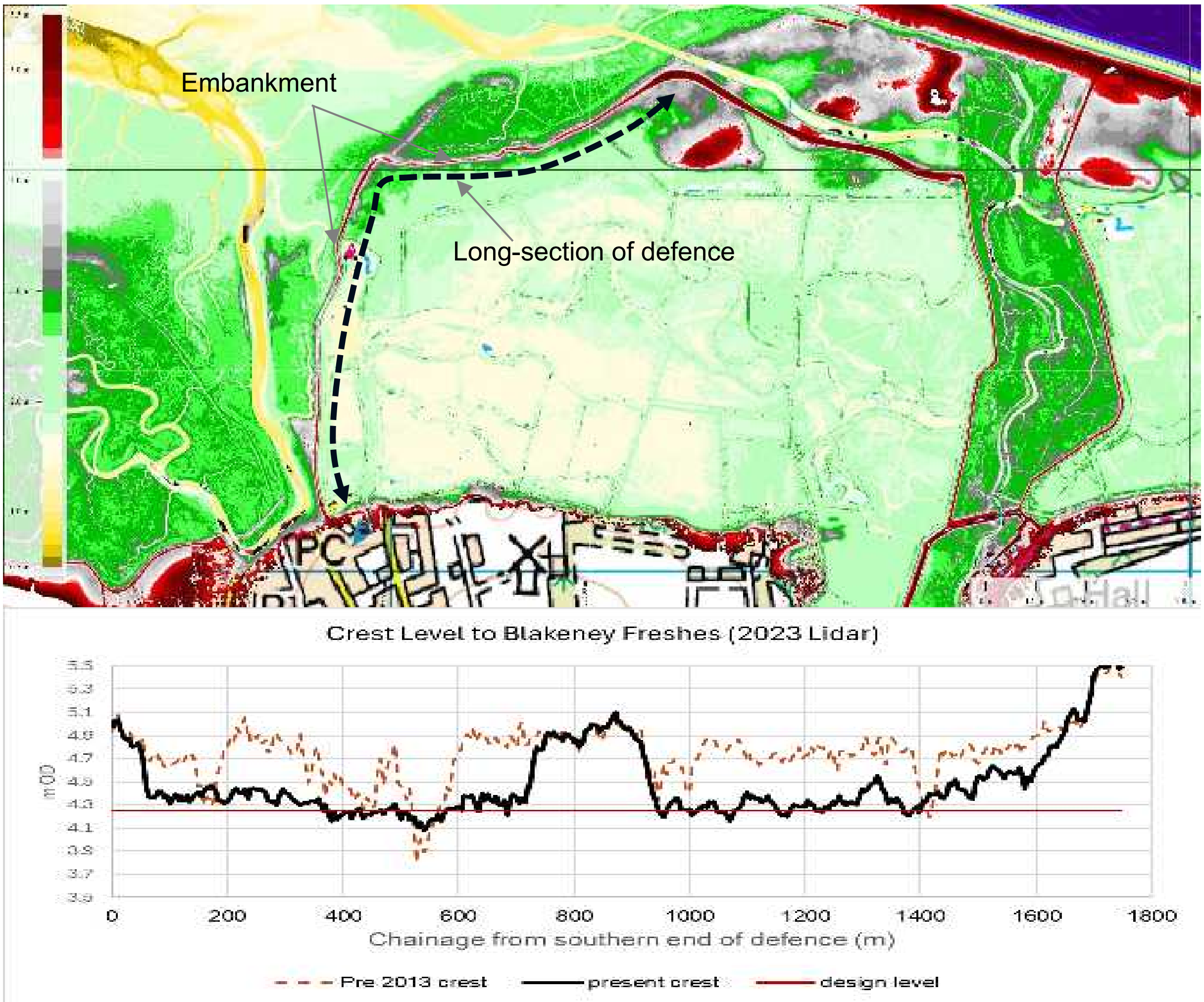

Figure 3-21. Land levels within Blakeney Freshes and Long- section along defence.

Typically, based on the tidal and extreme water levels set out in Table 3.1, assuming no freeboard for wave action, the defence might be overtopped on around a 1 in 20 (T20) to 1 in 50 (T50) year event.

Current land levels within the Freshes vary typically between 1.5m OD, towards the southwest, and around 1.8m towards the eastern side, with significantly higher levels (2m OD and above) associated with the northeastern corner in the area of Blakeney Eye.

Under future sea level rise scenarios (discussed further in Section 4), the frequency of storm surge induced overtopping of defences will significantly increase. Associated with this, land levels within the Freshes, relative to the tidal frame, will decrease, with the potential for increased inundation depths and drainage times, raising questions regarding the resilience of vegetation communities within the Freshes.

Current management policy (North Norfolk SMP) was for holding the line of the existing defences in the short term (typically through to 2025) with the intent to move towards Managed Realignment in the medium term (2025 to 2055).

While tidal flow is recognised to be only one factor influencing the behaviour of the area (the other major factor being wave exposure), the very basic interpretation provided above highlights the complex and large-scale variation in processes at work in shaping and influencing different areas and aspects of the wider regime.

4 Future Change with Sea Level Rise

Climate change is clearly happening with observed data showing the impact of this on sea levels. Notwithstanding this observed change, there remains some uncertainty as to the future rate of change. This is discussed in the UK Climate Projection 2018 (UKCP 18). UKCP 18 sets out a range of scenarios based on a range of emission scenarios (RCPs), providing a probabilistic assessment based on different models of different sea level rise scenarios.

The Environment Agency recommend consideration of two such scenarios in assessing coastal change – RCP8.5 70% and RCP8.5 95%. Projected sea-level rises for these scenarios (together with RCP8.5 50%) are shown below in Figure 4.1.

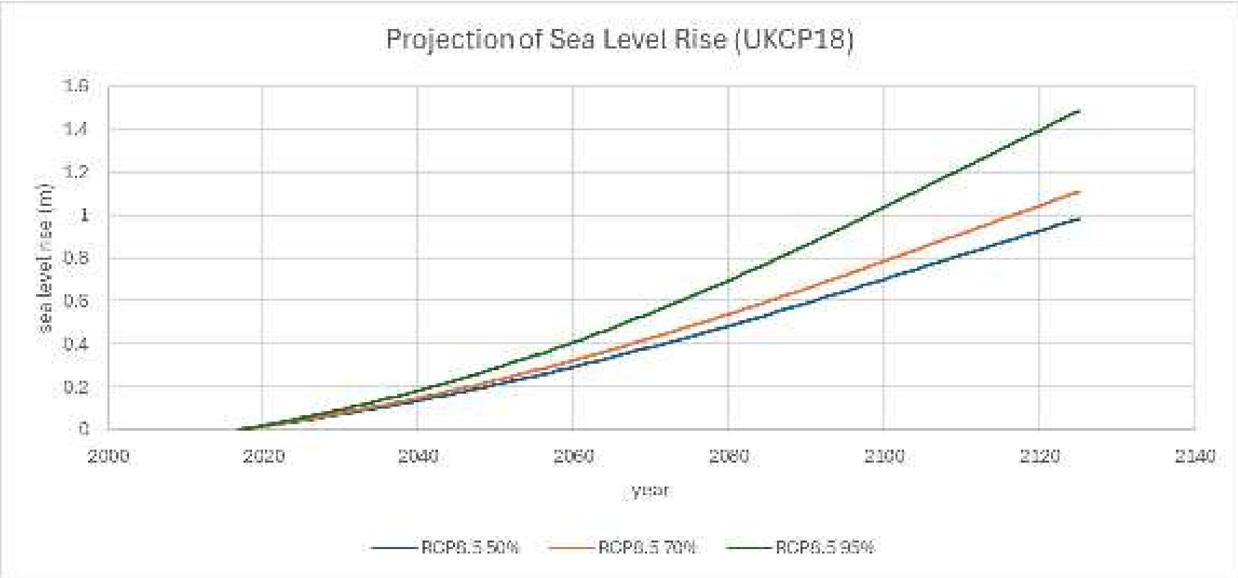

Figure 4-1. Sea level rise scenarios (UKCP 18) taken from a base year of 2017.

Sea level rise has, however, to be seen as an ongoing process well into the future. From this perspective Table 4.1 shows when, under different scenarios, certain values of sea level rise would be anticipated.

		sea level rise (m)				
Scenario	**base year**	**0.3**	**0.6**	**0.9**	**1.2**	**1.5**
RCP8.5 95%	2017	2051	2073	2092	2109	2126
RCP8.5 70%	2017	2058	2085	2109	2132	2156
RCP8.5 50%	2017	2061	2091	2118	2137	2171

KEY: years from 2025	25	50	75	100	>100

Table 4-1. Projection of when certain SLR values might be reached under different scenarios.

These values have been used in considering the potential impact on features and habitats within the study area.

4.1 Land levels relative to sea level

Figure 4.2 shows the existing land levels relative to tidal and externe water levels with sea level rise.

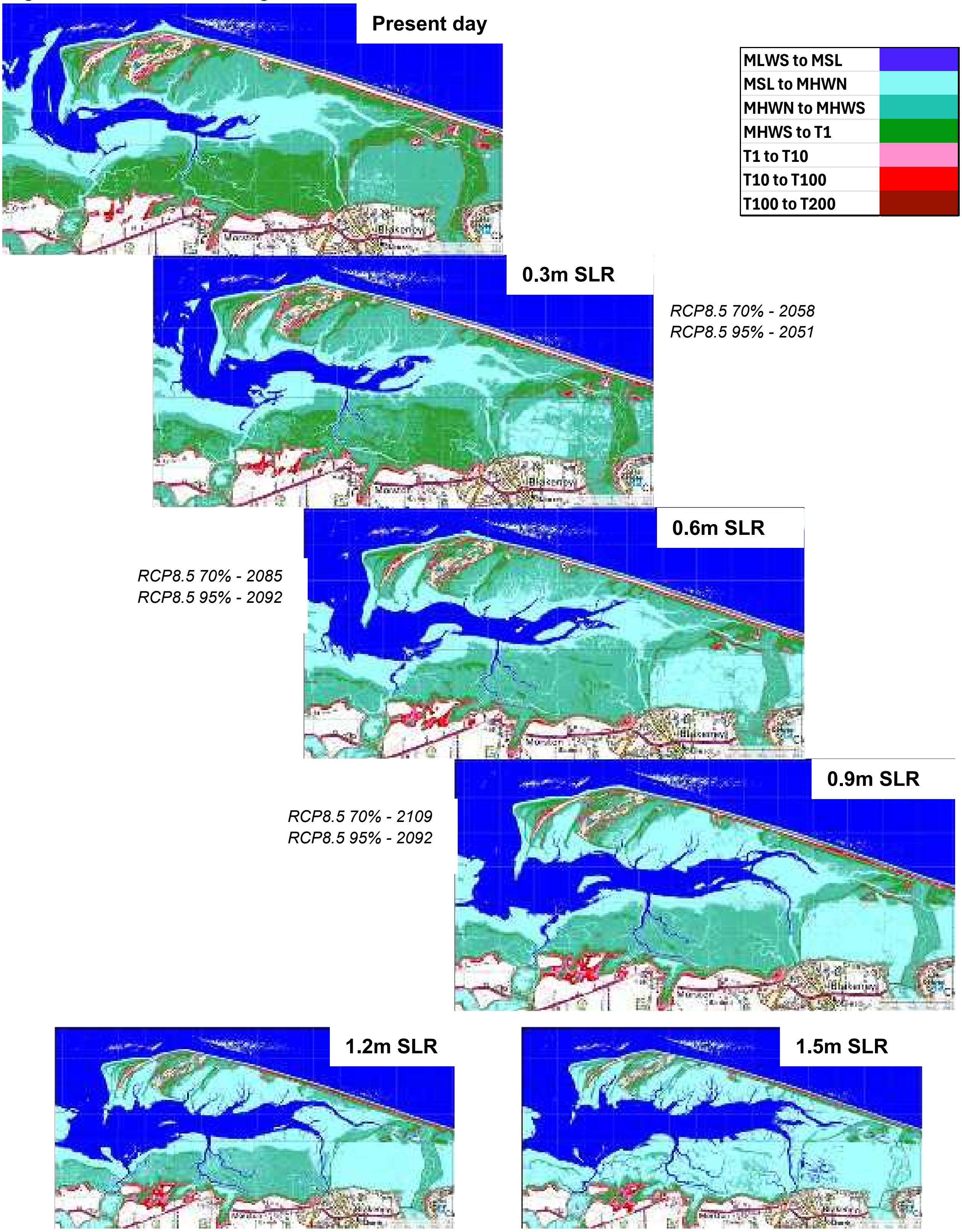

Figure 4-2. Existing land levels relative to tidal/ extreme water levels with sea level rise.

The main focus of this current study is on the opportunity for habitat restoration / enhancement over the short to medium term. However, in line with maintaining a sustainable system-based approach, this has to be viewed from a longer-term perspective of ongoing change.

With sea level rise the following general changes might be anticipated impacting across the wider area:

- Along the open coast, increased water levels will tend to increase the pressure setting back the shoreline, increasing the rate of roll back. This is captured in Figure 4.3 based on an assessment of current rates of erosion, incorporating the potential influence of sea level rise. Typically, it is assessed that the front face of the open coast might set back some 44m by 2050, 85m by 2075 and around 130m by 2100. It is anticipated that while set back in local areas might occur as local overwash, there remains the ability for the shingle ridge to rebuild on a setback alignment.

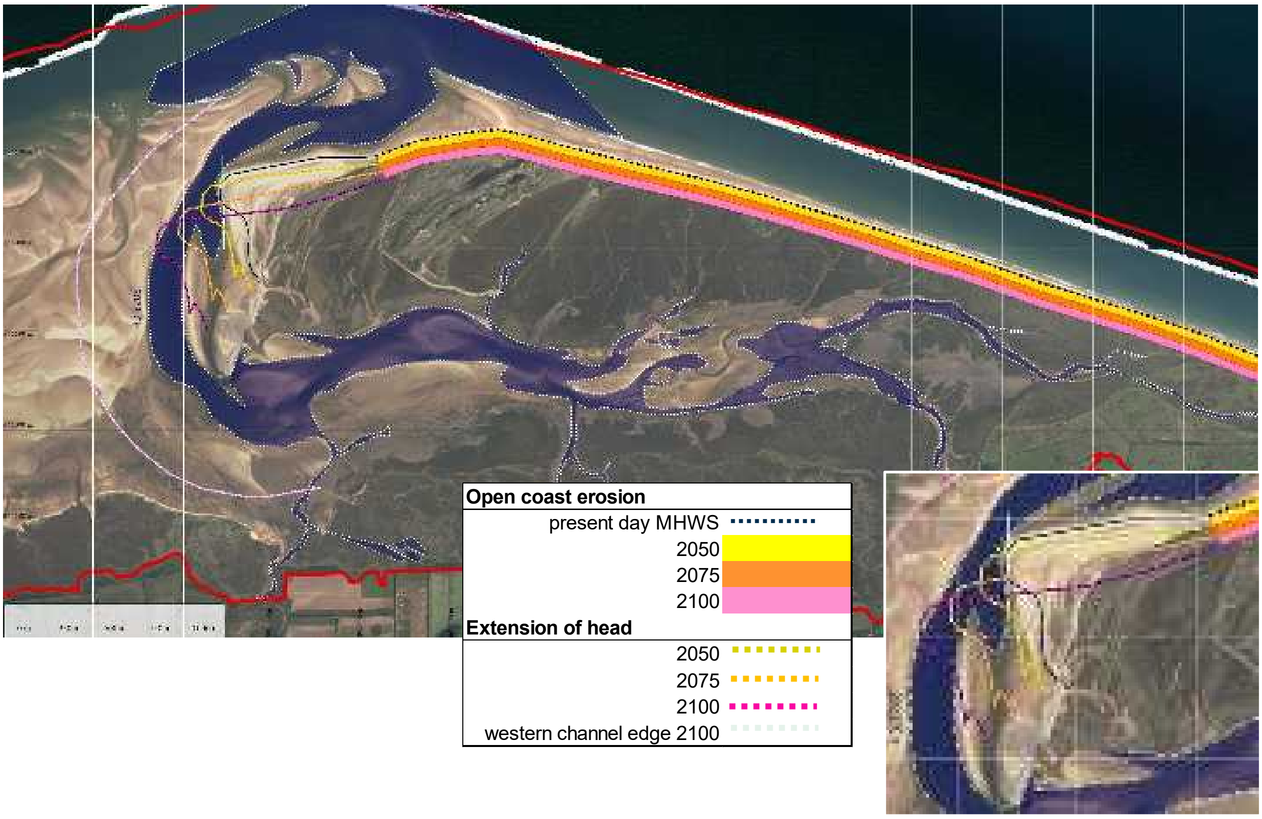

Figure 4-3. Indicative coastal change.

- The pattern of change around Blakeney Spit and the western nose of the Spit is far more complex and episodic. However, based on the historic analysis (Section 3.2) and the analysis of more recent changes, there appears to be a progressive movement of the head to the west. Projecting this trend into the future and allowing for the set back of the open coast, it might be anticipated that the general position of the western head would be as shown in Figure 4.3. The specific form of this change, based on what has occurred in the past, is likely to manifest itself as episodic development of shingle ridges extending further across the entrance channel, with a general southerly development of new "Far Points".
- Associated with this progressive change, it seems probable that the channel will move to the west, eating into the western sand banks and putting the Stiffkey marshes under greater pressure.

- As this overall change occurs, there is likely to be increased release of sediment, particularly sand, with increasing sand movement in to the main body of Blakeney Harbour (as seen most recently with the change to the existing New Far Point (Section 3.2.1.4)), with ongoing shift in the alignment and flows across the existing area of the mussel beds and the northern shoreline in the area of the Lifeboat House.
- Further within the Harbour, the central section of the channel (between the Morston and Blakeney channels) is likely to remain quite mobile (as at present), with the potential for further infill to the area between the Blakeney and Cley channels.

5 Geomorphological Summary of Local Areas.

The general assessment of future change is, necessarily, relatively speculative, attempting to project current patterns of change into the future. Notwithstanding this uncertainty, it is considered to provide a rational framework for assessing future change in specific areas and habitats.

Within this context, taking into account the underlying change in water levels, shown in Figure 4.2, alongside the more detailed analysis of recent patterns of change, the following overall assessment may be made with respect to these specific areas.

5.1 Blakeney Point

5.1.1 Key Features

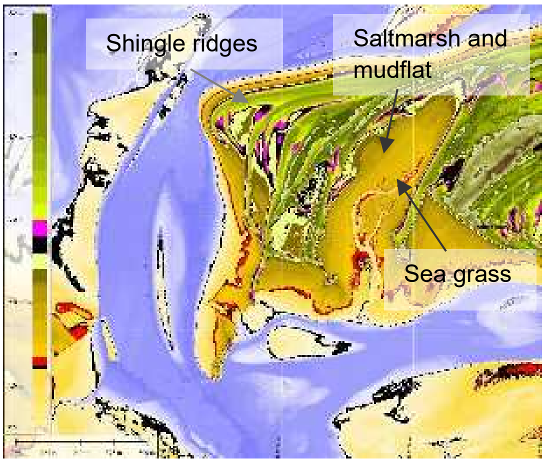

Figure 5-1. Blakeney Point

In addition to the general important dune habitat, this area includes two specific physical elements:

- Shingle ridges; currently being managed as an exclusion zone.
- Lower lying inlet with drying mudflats and fringe saltmarsh.

Current situation

Notwithstanding the significant change in the shape and position of the shingle ridges, at present the shingle maintains its overall integrity, continuing to provide protection to areas of marsh.

The marsh inlet appears to have remained relatively stable with only very slight indication of accretion (Figure 3.12, Section 3.2.13), suggesting limited supply of fine sediment.

At present only one area of sea grass has been identified, associated with the lower level of sea bed at the edge of the main creek. Consistent with the general assessment of the level at which sea grass has been identified (Section 2.5), the scope for natural increased sea grass colonisation is quite limited.

5.1.2 Future change

There will be ongoing set back of the open coast, with the potential encroachment to the shingle ridge across the head of the inlet possibly over the next 50 years. Subject to maintaining the supply of sediment across the open coast, it would be anticipated that, while the open coast shingle width may decrease, there is limited risk of a significant breach.

Typically, with sea level rise of around 0.3m (potentially within the next 25 to 30 years), assuming no significant additional fine sediment (silt) supply, the inlet will effectively deepen, with a larger area of inlet being submerged at Mean High Water Neap, potentially increasing the area where there might be sea grass colonisation.

Assuming, again, that there is no significant increase fine sediment supply, with ongoing sea level rise there is likely to be a reduction in saltmarsh.

5.1.3 Critical Factors

Future development of the open coast depends critically on maintaining sediment movement along the shoreline.

The inlet appears at present to be relatively stable with no indication of significant accretion, suggesting limited input of fine sediment. While it seems probable that there will be increased sandy sediment from erosion of the western sand flats, there is little to indicate that there would be significant additional fine sediment supply to the inlet.

5.2 Stiffkey Marsh and Blakeney Pit

5.2.1 Key Features

The area comprises the Stiffkey Marshes through to the South Side (Morston) Marsh, together with the South Side Mussel Bed to the south of main mooring area of Blakeney Pit. (Figure 5.2).

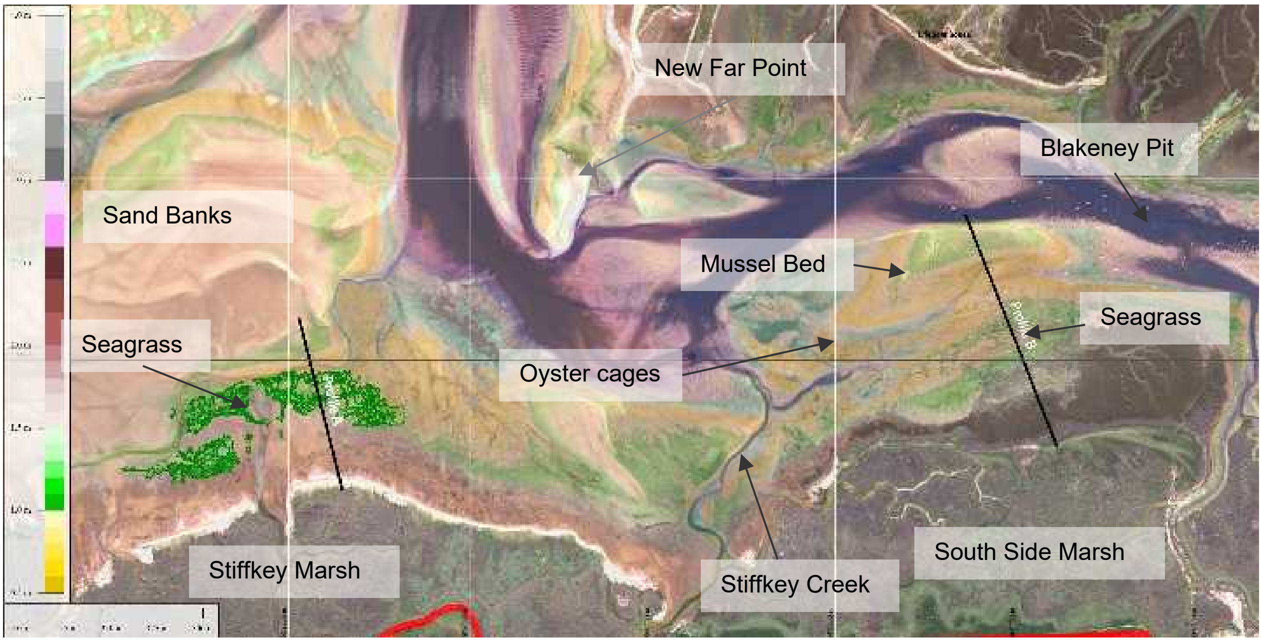

Figure 5-2. Stiffkey Marsh and Blakeney Pit

Current situation
The development of the area is strongly influenced by the New Far Point, which forms the southern extent of Blakeney Point. As the New Far Point has developed southward, this has tended to push the main channel south against the Stiffkey Marsh. This causes a constraint on the channel width, increasing flows particularly on the upper part of the flood (Section 3.1.1).

With this increased flow, as the Harbour area widens, sediment is carried into the estuary and is deposited as a series of banks. Recent change and breach in the New Far Point has opened a secondary channel resulting in the development of the bank within the lee of the Point and resulting in change in the channel position in that area.

More generally, the development of the New Far point has influenced the orientation of the main channel with strong flows depositing sediment over the crest of the mussel beds (Section 3.2.1.4).

Within the area, in addition to the main upper and lower saltmarsh areas (Section 2.2.1) and the mussel bed area, there is relatively extensive areas of sea grass fronting the Stiffkey Marsh along the southern side of Patch Pit Creek and an isolated patch of sea grass between the mussel bed and the South Side Marsh.

It is notable that these areas of sea grass are in relatively sheltered areas and occupy areas at a typical level between 0.5m OD up to around 1.5m OD (Figure 5.3).

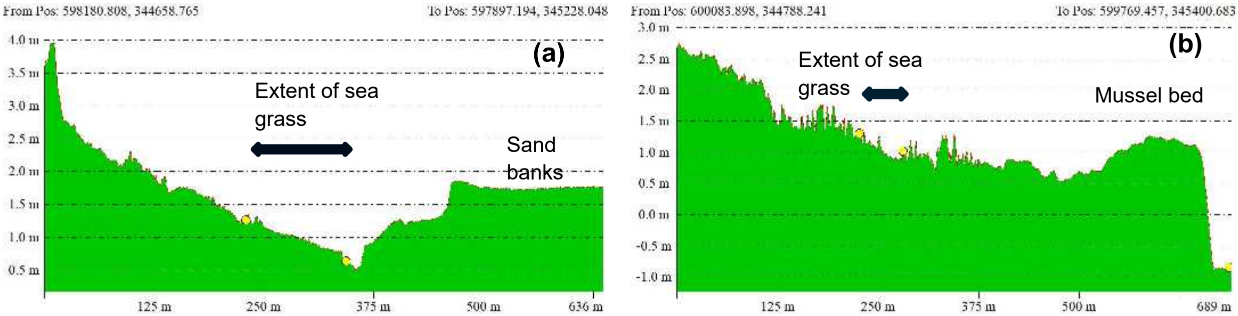

Figure 5-3. Sections through sea grass areas, a) Stiffkey Marsh and b) in lee of mussel beds.

It is further noted that in the case of the Stiffkey sea grass, there has been a general pattern of erosion (Figure 3.12, Section 3.2.1.3), which is consistent with recent reports of loss of sea grass. In contrast, in the case of the far more limited mussel-bed sea grass area, this area has been subject to slight accretion.

These patterns of change in terms of erosion and accretion have also impacted on the development of the saltmarsh, with evidence (Section 3.2.1.4) showing slight horizontal erosion of front face to the Stiffkey Marsh, while the front face of the South Side upper marsh appears to have remained relatively stable, with reported growth of the lower spartina marsh in this area.

Unlike the Blakeney Point area discussed above (Section 5.1), it is recorded that both the upper and lower marshes in both areas have accreted vertically.

5.2.2 Future change

The area will be subject to significant change, principally due to sea level rise. This takes two forms: that due to the basic increase in water level (Figure 4.2) and due to the projected change around Blakeney Point (Figure 4.3).

In terms of the underlying change in water level, Figure 4.2 shows that, based on current marsh levels across the whole frontage, even with 0.3m sea level rise, there would be significant change in the degree of tidal submergence of the upper salt marsh. This is shown as a more detailed comparison in Figure 5.4, comparing relative tide levels from present day and with 0.3m sea level rise.

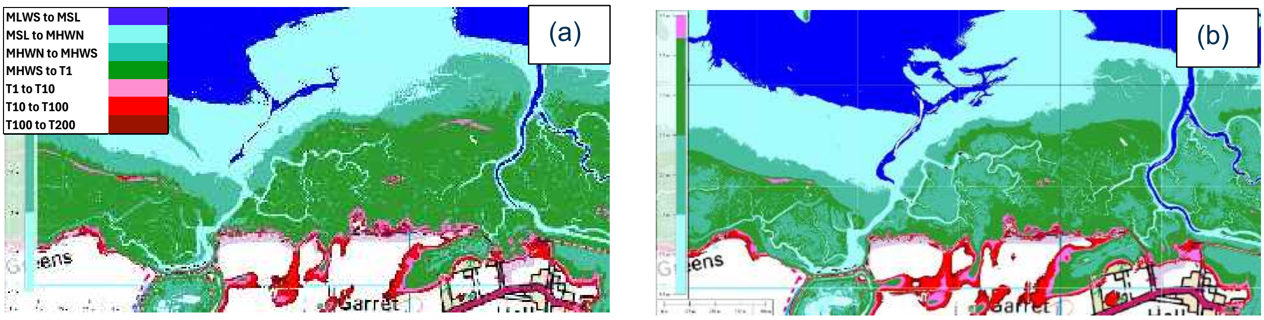

Figure 5-4. change in marsh levels relative to tidal conditions: a) present day, b) with 0.3m SLR.

While the general area of potential saltmarsh (i.e. above MHWN) only marginally changes, large areas of the upper marsh (currently defined at a level between MHWS and T1) moves into the MHWN to MHWS level band.

With further increase in sea level rise, this process of change continues and increases, as indicated in Figure 5.5.

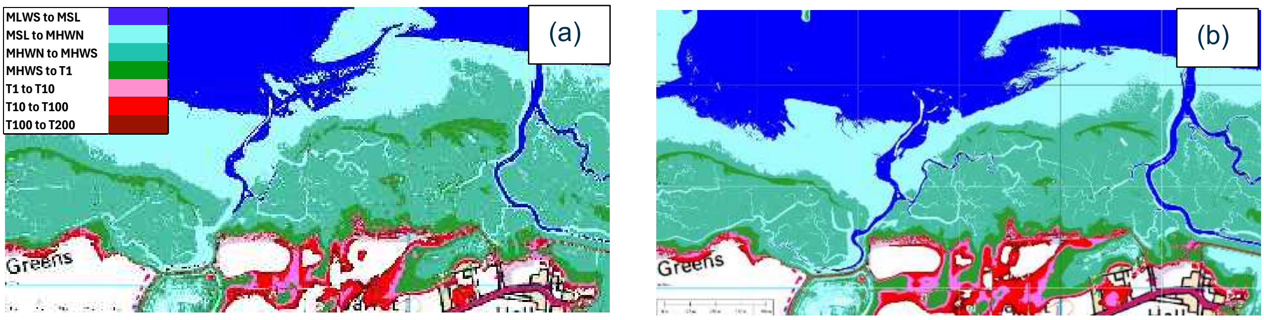

Figure 5-5. change in marsh levels relative to tidal conditions: a) 0.6m SLR and b) 0.9m SLR

Potentially, in relation to the areas of sea grass (with reference also to the images in Figure 5.3), there might be potential for some migration of sea grass into areas shown as being between MSL and MHWN with sea level rise.

Clearly, however, this would depend on the degree of increased exposure as a result of changes in the position of the main channel, as discussed previously in Section 4.1.

The above assumes no substantial change from the current land levels. As previously noted, there is the indication that there is potential for some fine sediment deposition, allowing some warping up of the marsh, which would modify the above pattern of change. To a degree the increased submergence of the upper marsh may act to rejuvenate this process in the upper marsh area.

Associated with the above change, across the areas of salt marsh, there would be significant change associated with the mussel bed area. This becomes more difficult to predict with any degree of certainty as change would be both in relation to the relative level of the mussel bank to tidal conditions but, also as critically, in terms of the balance between potential increase tidal flow and possible increase in sediment input through the constrained entrance to the main Harbour area.

5.2.3 Critical Factors

A critical aspect of uncertainty is clearly in relation to the change in Blakeney Spit. There is potential both for change in the position of the New Far Point and for increased flow and change in the pattern of flow through the entrance to the main Harbour area. Associated with this, there is likely to be significant local transition as part of the longer-term trend, as the system adjusts. The changes that have recently been observed with the local breakdown of New Far Point are an example of this, as was the increase in sediment over the mussel beds, associated with the change and partial breach through the New Far Point.

Notwithstanding the significant uncertainty around the detail of change in this area and recognising that there will continue to be these local changes and influences, it is considered that the main channel will continue to press to the south before running more to the northeast (towards Blakeney Pit) into the main area of the Harbour. As such it seems likely that the main area of the existing mussel beds will continue to be swept by strong flood flows. While, as at present, local change may result in transient smothering of the mussel beds, there is little evidence to suggest that there would be an increased risk of smothering as part of a longer-term process.

More generally, the change in the level of the various sections of marsh will be critically dependent on the availability of suspended sediment and the capacity for deposition over the marsh area.

5.3 Central Region

5.3.1 Key Features

The area covers the large extent of the North Side Marsh (Figure 5.6), formed within the influence of the Long Hills shingle ridge and the very early residual end of Blakeney Point at the Marrams. This also considers the more modern marsh area to the west of the Long Hills (which purely for reference has been called the Long Hills Gut), alongside the main channel area (referred to as the Scalp Run from the 1815 map) and the significant bank (the Blakeney/Cley Bank) that has developed between the Blakeney and Cley channels.

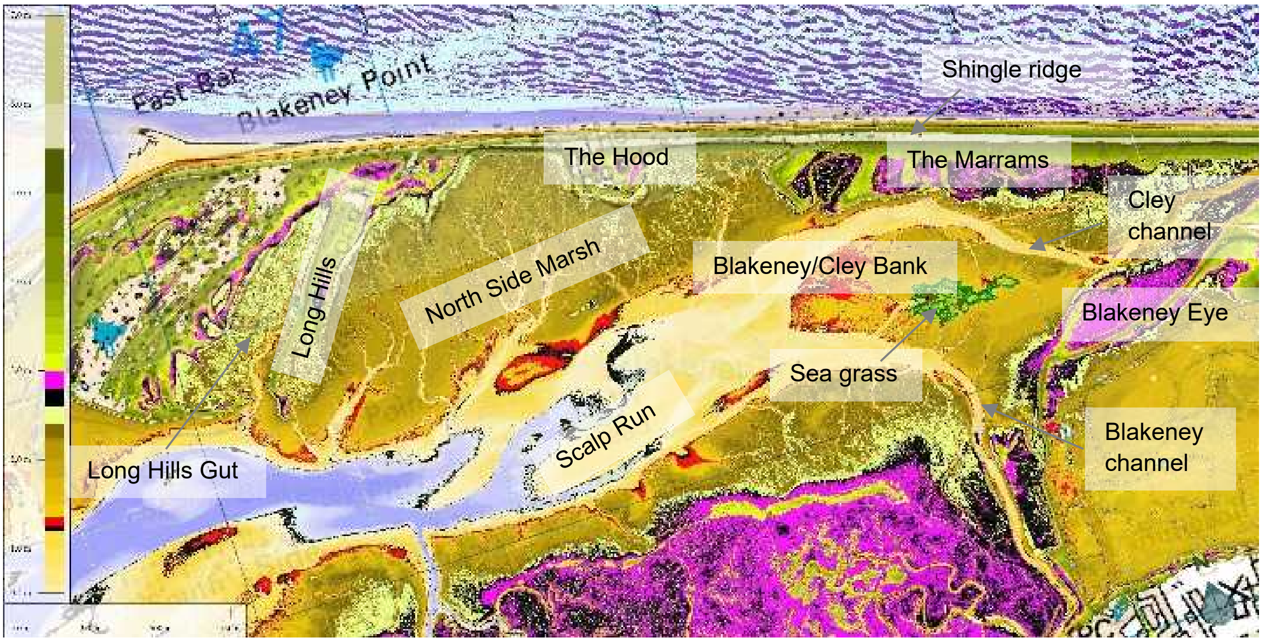

Figure 5-6. Northern Marshes

The area is dominated by the extensive salt marsh and, as noted in Figure 5.6, the whole area is fronted and protected by the main vegetated shingle ridge of Blakeney Spit, together with associated areas of coastal dunes.

In addition to the general intertidal mudflats flanking the main channel, there is a significant area of sea grass which has developed, specifically within central area of the Blakeney/Cley Bank.

Current situation

Considering initially the overall development of the area, with the notable exception of erosion and set back of the open coast shingle bank, in general, the basic shape and extent of areas of marsh and to a degree the position of the main channel has changed little over the last 200 years (Figure 5.7).

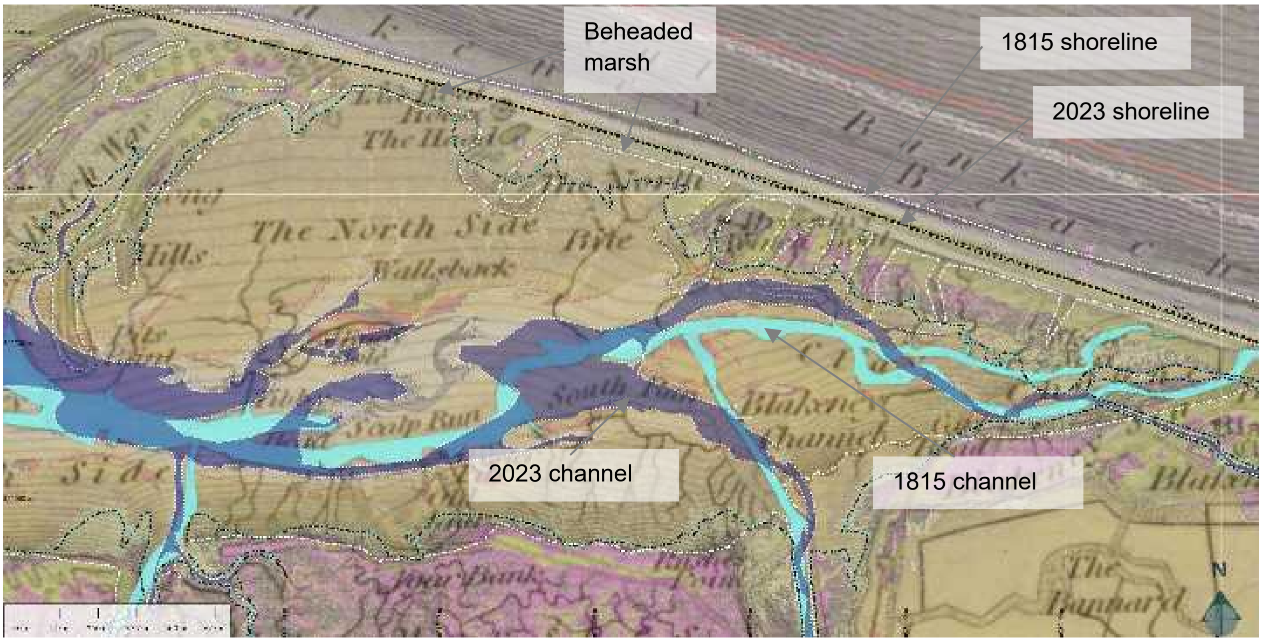

Figure 5-7. 2023 topography and channel position overlaid on 1815 OS map.

Light blue channel based on 1815 OS map. Dark blue channel based on 2023 Lidar.

Along the open coast the front face of the shingle ridge has set back between around 50m to 70m (commensurate with the more recent assessment noted in Section 3.2.1.1). This process, as discussed earlier, will continue. The main and obvious impact of this is in the loss (or beheading) of the of the marsh system either side of the Hood. This does mean that, although the shingle ridge appears at present to provide a competent defence, the ridge in these areas is increasingly vulnerable to failure.

In other areas, (as discussed in Section 3.2.1.4) while there is significant variation in the position of the channels and banks in the area of the Scalp Run (Figure 5.6), this appears to have had limited impact on the area of marshes to north and south. However, upstream of the Scalp Run there appears to have been a more fundamental shift in the position of the main channels, with the historic reorientation of the lower part of the Blakeney channel, and more recently, possibly associated with the change and eventual re-positioning of the Cley channel through the Blakeney Eye, a shift of the main channel to the north, creating the opportunity for development of the Blakeney/Cley Bank.

This bank has accreted around the edge, while retaining a more stable low-lying central section which is colonised by sea grass. This central area forms a very shallow channel, marginally below MHWN, connecting directly between the Cley Channel and the main channel at the upstream end of the Scalp Run. There is no evidence, however, that this channel is developing as an alternative to the main Cley channel which runs further north (Figure 5.6).

The Northern Side Marsh is well vegetated at a level typically between 2.2m OD and 2.5m OD, being around MHWS.

In contrast, the smaller Long Hills Gut Marsh is more consistently at a level of 2.4m OD to 2.5m OD, with a dominant creek running down the eastern side of the Gut, along the line of the higher Long Hills shingle and dune ridge. The Gut is enclosed along its southern side by a well vegetated shingle ridge, which is used as a popular landing area to Blakeney Point.

There is no clear evidence of any change in level over the main marsh areas over the last 20 years (Section 3.2.1.3) suggesting little evidence of the availability or deposition of fine sediment. Potentially, this reflects that over much of the area the level is already at or very close to MHWS and, as such, there is only limited opportunity for sediment to be carried across the area.

Clearly, since there has been little historic change in marsh extent over the last 200 years, as tidal levels would have been lower in 1815, there may have been capacity for very slow warping up of the marshes.

5.3.2 Future change

The important factors in terms of future change impact on the area are the behaviour of the open coast shingle ridge and the underlying increased level of flooding of the salt marsh.

In terms of the first, it is projected that the shingle ridge will attempt to roll back, typically by around 40m by 2050, 85m by 2075 and, potentially, by 130m by 2100 (Section 4.1).

As noted earlier, the most critical impact of this is likely to be in the length of coast where the shingle ridge already cuts across the rear saltmarsh.

By way of highlighting this, two comparative cross-sections are shown in Figure 5.7, showing; a) a typical cross-section where the shingle bank already cuts across the head of the marsh and b) ithe wider area of the Hood. Clearly, over the more vulnerable lengths there would be increased risk of failure and overwash as the shingle ridge sets back.

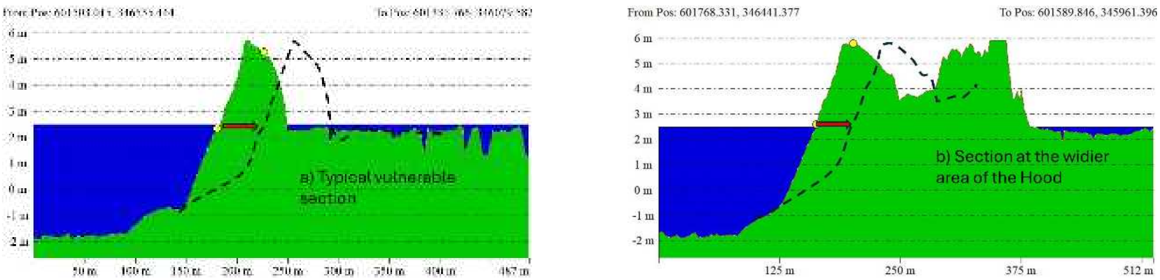

Figure 5-8. Comparison of roll back of shingle ridge.

As highlighted and discussed in Section 3.1, the central and eastern part of Blakeney Harbour is only critically influenced over the upper part of the tide, with all but the distinct main channel drying from mid-tide and below. Even on MHWN water levels are generally confined within the main and central area of the channels, such that over MHWN only limited parts of the Blakeney/Cley Bank are submerged (Figure 5.9).

Over Spring tides, however, the area affected increases dramatically, spreading across the whole area of the North Side Marsh.

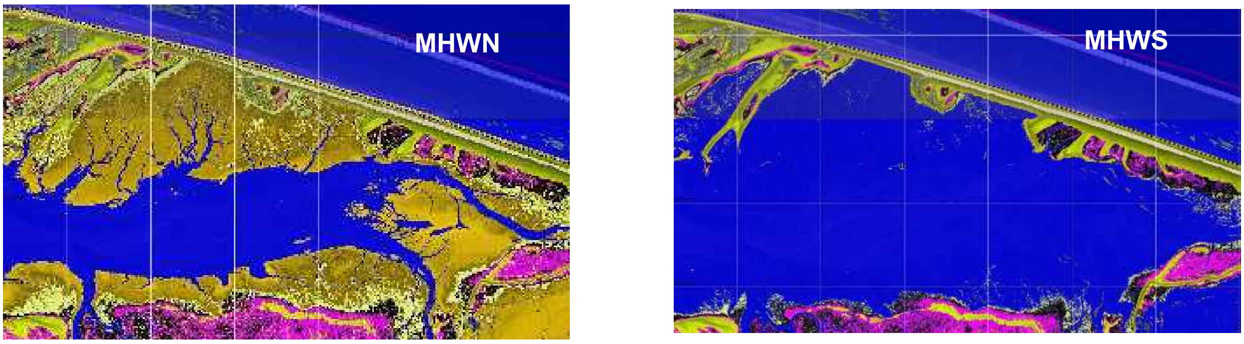

Figure 5-9. Tidal flood extent on MHWN and MHWS

Area flooded indicated in blue.

This aspect is shown in Figure 5.10, highlighting the potential change with sea level rise. The figure highlights that even with 0.6m sea level rise, over MHWN, the flood remains within the main channel. Clearly over Spring tides, the depth of flooding over the marsh area increases. This potentially increases the opportunity for increased deposition, critically depending on the level of suspended sediment within the water column.

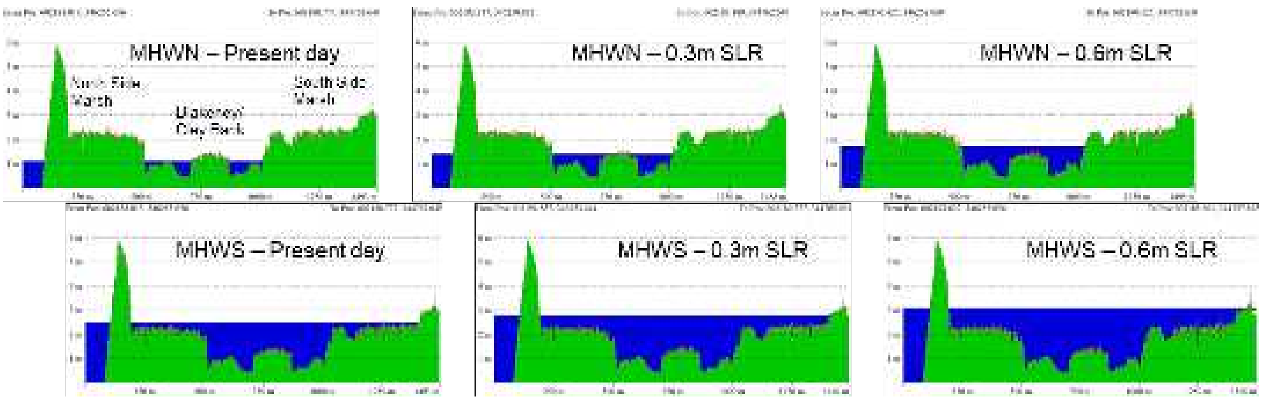

Figure 5-10. Change in extent of tidal flooding with sea level rise.

While there is likely to be increased flow with the increased tidal prism, it is considered that the main flows will be focussed within the main channels and there is nothing to suggest more fundamental change in terms of the level and form of the Blakeney/Cley Bank.

5.3.3 Critical Factors

From the above, the most critical factor influencing the area will be the longer-term behaviour and resilience of the open coast shingle ridge.

Assuming continued sediment supply, it would be anticipated that while there may be increased risk of breach to the ridge during more extreme events, it might be anticipated that the ridge will rebuild as part of the process of roll back. It seems unlikely that a fully tidal breach would develop.

More immediately, over the short to medium term, the critical factor will be the availability of fine sediment allowing the marsh area to warp up in response to sea level rise.

5.4 Cley Channel and Blakeney Freshes

5.4.1 Key Features

This area covers to two principal features of the maintained channel of the River Glaven through the high level marsh of the Cley Channel and the large enclosed (defended) area of the Blakeney Freshes.

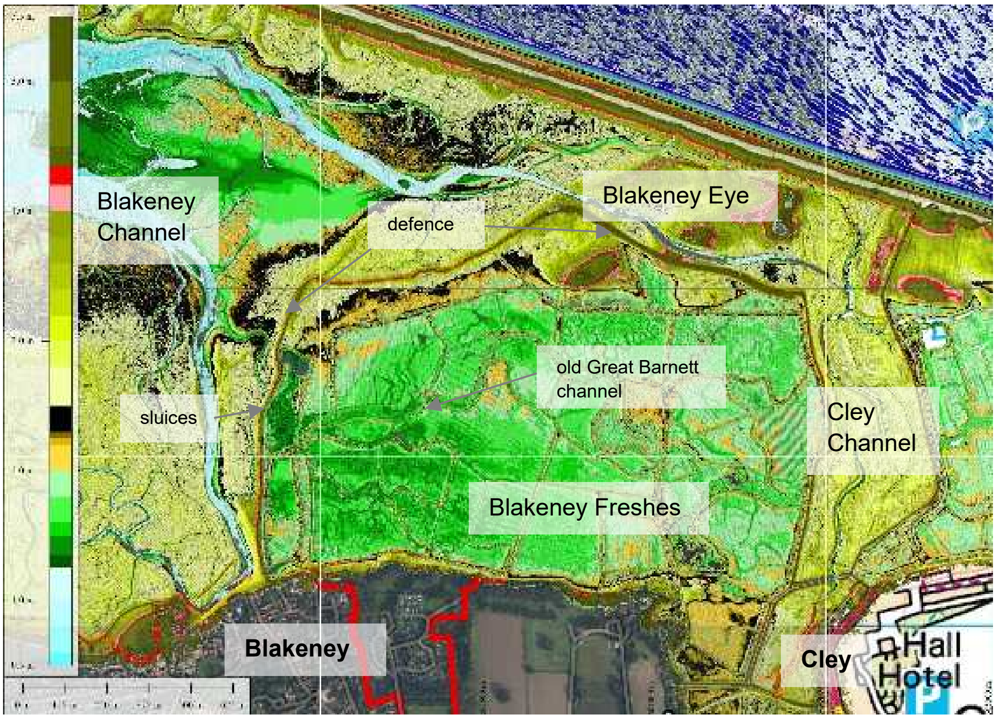

Figure 5-11. Cley Channel and Blakeney Freshes

Current situation
The Cley Channel is currently managed with local dredging being undertaken to maintain navigation, principally clearing the channel where the over steepened edges have collapsed into the main channel.

This work has been undertaken over the last couple of decades and has involved slight battering back of the channel edge, with sediment being spread over the high marsh. The typical level of this marsh is between 2.8m OD to around 3.0m OD and, as such, is well above normal high water levels, only being submerged on extreme water levels. Reflecting this high level, it is reported that the marsh has largely converted to grass. The marsh is effectively perched at a much higher level than the adjacent Blakeney Freshes to the west and the large Cley Marsh to the East (Figure 5.12).

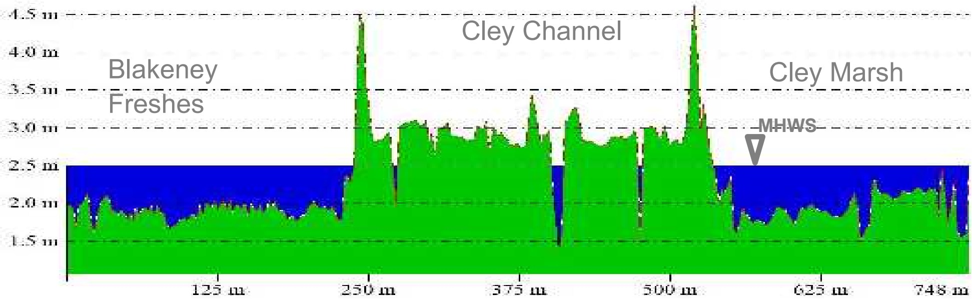

Figure 5-12. Relative levels of the Cley Channel.

The Blakeney Freshes were reclaimed in the early 13th century and have developed since then as important fresh water marsh with areas of pasture, reed beds, drainage ditches and areas of open water (Section 2.2.2). Some of the old drainage creeks are evident within the varied topography, most notably the old Great Barnett creek, as indicated on Figure 5.11.

Typical levels within the Freshes are between 1.5m OD to the western side, increasing typically to around 1.8m OD to the east (as shown in Figure 3.20). Much of the Freshes, therefore, lies between MHWN and MHWS and is defended by a significant length of defence with a design crest level of 4.25m OD.

Current management policy (North Norfolk SMP 2008) suggests the need for transition from holding the line to one of managed realignment, with the need to adapt management strategies to avoid sudden change.

5.4.2 Future change

With sea level rise, there will be an ongoing set back of the open coast shingle bank. In response to historic change the Cley Channel to the north, around the Blakeney Eye, has been moved in land. The shingle ridge now lies over the old channel but from the assessment of set back rates (Section 4.1) it seems unlikely that the shingle ridge would impact on the position of the new channel.

It is only with around 0.6m sea level rise (in potentially 50 to 60 years' time) that the high marsh within the corridor of the Cley Channel would be subject to flooding on normal high waters. In the intervening years there would be increased risk of flooding on extreme water levels.

More significant change is anticipated in relation to the Blakeney Freshes. At present it is assessed that the defence could be overtopped on a 1 in 20 to 1 in 50 year event. The intent of recent improvements to the defence has been that even when overtopped the defence is more resilient to complete failure, although on higher overtopping conditions the back face to the defence would still be vulnerable.

It is reported by Christie et al. (2020) that by 2050 under the mid sea-level rise scenario, over half of the Freshes will be inundated for longer than ten days, a potentially critical threshold for current wet grassland survival. The results of this research suggest that while effective defence redesign may increase the viability of reclaimed wetland habitats in the short term, as sea levels rise, lengthened inundation durations may render these habitats increasingly vulnerable to ecosystem change under extreme events.

Figure 5.13 shows this change in vulnerability in relation to a typical section of the western (Blakeney) embankment.

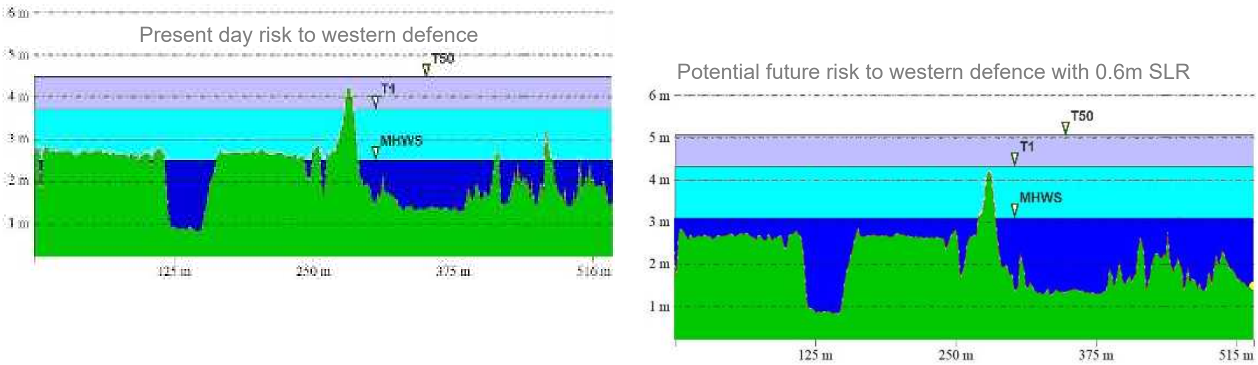

Figure 5-13. Comparison of current and future risk of overtopping to western defence.

Even should the defences be further improved, increasing sea level will increase the difficulty of drainage to the marsh due to more frequent tidal locking.

5.4.3 Critical Factors

The most critical factor in terms of both the geomorphology and opportunity for habitat creation or restoration relates to the ongoing and future management of the defences around the Blakeney Freshes. The current policy over the short term is to continue to manage these defences, but with the medium and longer-term intent to allow increased saline flooding. The work undertaken by the Environment Agency aims to make the defence more resilient to occasional overtopping (typically maintaining a standard of protection against a significant flood risk up to a 1 in 20 year occurrence) as discussed in Section 3.4 and highlighted above in Figure 5.13.

Given this current approach to management, there is no intent to raise defences and, with sea level rise, over the next 25 to 30 years there is the expectation that the risk of overtopping and flooding of the Freshes will increase. The critical decision, therefore, relates to how this increased risk is managed:

- Should this process be allowed to continue as at present, then potentially over the next 30 years flooding might be anticipated to occur annually. Over the period between year 30 and 50, at some point the degree and frequence of overtopping is likely to result in deterioration of the defence with significant chance of breach, opening the Freshes to regular saline flooding on every tide.
- A second option might be to physically breach the defence, accepting a more rapid transition of the Freshes from the current fresh water habitat.
- Alternatively, consideration could be given to allowing more progressive saline intrusion, such as allowing normal tidal flooding but continuing to protect the area under more extreme events.

Each option would result in a different pattern of transition, with the need, in each case, to examine the potential flood risk to assets to southern edge of the Freshes. In each case, it might be expected that natural drainage of the area would be through the Blakeney Channel, with the need to consider the influence of this increased pattern of flow on this channel.

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