Case study 47. North Norfolk Coast

Authors: Sue Rees and Oli Burns

Main driver: Habitat creation, improved and more sustainable defences

Project stage: Constructed – several schemes in different years: Brancaster 2002; Holme Dunes 2004; River Glaven 2006; Cley to Salthouse 2007; Titchwell RSPB 2011 (Photo 1); Blakeney Freshes 2014

Photo 1. Titchwell (source: Mike Page RSPB)

Project summary:

The North Norfolk coast has a high landscape, biodiversity and geodiversity value, with a range of statutory designations. The risk of saline flooding to farmland, freshwater/wet grassland conservation sites and property and infrastructure is managed through a suite of measures including seawalls and natural barriers. A series of schemes have been developed in the past 15 years driven by the Shoreline Management Plan and other initiatives that work with natural processes.

Key fact:

Between 2002 and 2015 a series of projects have restored more natural function to around 8km (18%) of the North Norfolk coast (Map 1). These locations showed good resilience to the 2013 storm surge. For example, the now naturally functioning shingle ridge at Cley, although breached in the event, closed naturally within weeks despite initial concerns that it would need artificial manipulation.

Map 1: North Norfolk Coast National Character Area (source: Natural England 2013)

1. Contact details

Contact details	
Names:	Sue Rees and Oli Burns leading on case study – various other contacts locally
Lead organisations:	Environment Agency and Natural England
Partners:	National Trust, RSPB, Norfolk Wildlife Trust, plus many others locally
e-mail address:	oliver.burns@environment-agency.gov.uk

2. Location and coastal/estuarine water body description

Coastal/estuarine water body summary	
National Grid Reference:	TF690443 to TG095440 (taken from SSSI citation)
Town, County, Country:	Norfolk
Regional Flood and Coastal Committee (RFCC) Region:	Anglian, Eastern
Transitional and coastal water body size (km^2):	167.118km^2
Transitional and coastal water body and location:	Norfolk North (Coastal)
Water Framework Directive water body reference:	GB640503300000
Land use, geology, substrate, tidal range:	Coastal, intertidal, agricultural, barrier beach system, wetlands Chalk bedrock overlain by Quaternary deposits

3. Background summary of the coastal/estuarine water body

Socioeconomic/historic context

The north Norfolk coast extends for some 40km between Hunstanton and Weybourne. The area consists primarily of intertidal sands and muds, saltmarshes, shingle barriers and sand dunes. There are also extensive areas of brackish lagoons, reedbeds and grazing marshes. The coast is of great physiographic interest and provides a classic example of a British barrier beach system, with the shingle spit at Blakeney Point and barrier island at Scolt Head of special importance. Extensive areas of saltmarsh, with characteristic creek patterns, have formed behind a protective barrier of sand and shingle beaches, whilst large areas of clean mobile sand, subject to fully marine conditions, characterise the open coast. The large amount of sand present along the frontage has led to the formation of significant areas of dune habitat, often overlying shingle deposits, which demonstrate succession from embryonic, mobile dunes through to fixed, well-vegetated dunes.

In places, saline lagoons fed by percolation of seawater through the sand or shingle barrier or via overtopping have developed naturally or have been created artificially by alterations to tidal flooding regimes. These marine and coastal habitats form a complex mosaic with several wetland habitats such as reedbed and grazing marsh. The terrestrial and freshwater wetland habitats have been

formed through reclamation and subsequent agricultural management of former saltmarsh habitat. The distribution and extent of the main habitat types of relevance are described in the Coastal Habitat Management Plan (CHaMP) (Natural England 2003).

The coast of north Norfolk is one of the most important wetland complexes in Britain for waterfowl. The mosaic of coastal, terrestrial and freshwater habitats supports a rich invertebrate fauna which in turn supports internationally important bird assemblages throughout the year.

Flood and coastal erosion risk management problem(s)

The north Norfolk coast has a unique and complex set of values and land uses. The Shoreline Management Plan (SMP2) published in 2010 lists a series of issues facing communities along the north Norfolk coast. These include questions about:

- how the SMP2 supports the existing seawalls in the short and long term
- how to increase the role of natural processes and reduce the dependence of the north Norfolk coast on man-made intervention

Changes on the coast are influenced by a range of processes with islands, headlands and offshore sand banks affecting the level of energy reaching the coast via waves and tidal currents.

Much of the coastal system has been affected by past intervention, with large areas of the former coastal flood plain now cut off behind sea defences. The implications of flood and coastal risk management (FCRM) policies for conservation interests are set out in the North Norfolk CHaMP, which informed the SMP. The dilemma of whether and how to continue interventions to prevent flooding where there were apparent conflicts of interest was triggered by a surge event in 1996. It was clear that the approach of using hard defences, shingle reprofiling and a 'hold the line' policy was not sustainable or desirable in the long term. However, experience of returning to a more naturally functioning coastline appeared to suggest limited options and was not likely to be popular across a range of sectors. There was tension between the desire to maintain the status quo, which reduced the risk of tidal flooding of the hinterland (including freshwater sites) in the short term, and the need to ensure the future of the intertidal, shingle and sand features which are valuable both as natural forms of flood and coastal erosion protection and for their significant conservation interests.

Past sea defences (including stone-filled gabions protecting a sand dune ridge) west of the Royal West Norfolk Golf Club protected 40ha of freshwater grazing marsh designated as a Site of Special Scientific Interest (SSSI) and as a Special Protection Area (SPA). Winter storms resulted in regular damage to these structures, impairing their ability to reduce flood risk and protect the conservation interest. Rebuilding the defences on the line of sand dunes would have been detrimental to the sand dune interest of the Special Area of Conservation (SAC) and may not have been technically feasible. It was concluded that this line of defence was not economically viable and a partial realignment of the site was proposed. An EU LIFE funded project enabled:

- implementation of a realignment project at Brancaster (TF7679444886) in 2002 (~0.75km frontage)
- restoration of dune function
- creation of 7.5ha of intertidal habitat
- protection and enhancement of freshwater habitat

This was a crucial project as it demonstrated that softer alternatives to traditional hard engineering might be possible and helped engage a range of partners to develop better solutions to other flood and coastal erosion risk management (FCERM) issues elsewhere on the coast.

An additional scheme that was to be funded by the LIFE project was re-evaluated and it was agreed that the original design did not meet all of the objectives, as well as being a high cost for a relatively short period and focusing too much on 'preservation' rather than allowing natural evolution of the coastline. The relevant parties re-considered the approach and developed a scheme between Cley and Salthouse that took greater account of the natural coastal system, but included elements of habitat creation beyond the site. Later projects such as those at Titchwell also learnt from this work, developing a scheme to allow enhancement of seawalls fronting important reedbeds alongside the breaching of other seawalls to create new intertidal habitat.

Although an adaptive management approach is proposed for future epochs, defences are at risk from extreme events. The need to respond to extensive breaching of seawalls in the 2013 surge event led to a redesign of the structures at Blakeney Freshes which accepted that overtopping might occur in future storms but, as a result of the modifications, would cause less structural damage. Many of these works are linked to wider habitat creation programmes but these are not covered in this case study.

Other environmental problems

The north Norfolk coast contains a large number of nationally and internationally important designated sites including SAC, SPA, SSSI and Ramsar sites, as well as Water Framework Directive water bodies, all of which require careful management to ensure they are protected and enhanced. One of the most important environmental issues facing the north Norfolk coastline is the need to balance the conservation requirements of both freshwater and brackish/saline habitats. The natural evolutionary trend of much of this coastline in response to relative sea level rise is to migrate landwards, placing pressure on existing freshwater habitats located in the hinterland (for example, leading to erosion or overtopping of embankments designed to prevent saline ingress) while simultaneously detrimentally affecting intertidal/coastal habitats by restricting natural evolution. The loss or damage of these important habitats has a knock on effect on biodiversity and coastal geomorphology, and can also increase the risk of significant flooding (for example, via breaching of the barrier beach).

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood and coastal erosion risk management problem(s) and solution(s)

Considerable information has been gathered since the 1996 floods through Environment Agency monitoring programmes and others, the CHaMP and SMP, and at individual scheme levels. The Anglian Coastal Monitoring Programme captured the impacts of the more recent 2013 tidal surge event, as well as the subsequent recovery.

What was the design rationale?

Although the schemes had different designs, they all recognised the need to work with natural processes and allow coastal evolution in order to provide flood and coastal erosion protection, while also protecting freshwater habitats and enhancing coastal/brackish habitats.

Brancaster (2002)

The objective was to allow natural coastal evolution while protecting freshwater habitats. Deteriorating rock armour (rip-rap) and gabions fronting sand dunes were removed to allow roll-back and the development of a more natural form. A secondary defence embankment was created landwards of the dunes, with intertidal habitats created between the new defence and the dunes to protect the embankment from wave attack.

Holme Dunes (2004, see Photo 2)

The aim was to protect sand dune habitat, freshwater habitat and one property by working with coastal processes. 'Dragon tooth' fencing was used to aid sand trapping in front of an eroding dune ridge which protects the freshwater area and property. Previous methods such as beach dewatering, geotextile matting, and hard engineered sand trapping measures had been less successful or destroyed by storms.

Cley to Salthouse (2007 onwards, see Photo 3)

Here the aim was to restore the natural functioning of the shingle barrier beach after decades of intervention to facilitate natural post-storm recovery and maintain appropriate flood protection whilst reducing or removing maintenance requirements. The existing drainage system within the hinterland was also improved to return water to the sea following overtopping and reduce the impact of tidal flooding on freshwater habitats (see River Glaven, below). Roll-back, flattening and occasionally

breaching of the shingle ridge has occurred in response to storms, but was followed in each case by natural recovery and gradual development of a more sustainable (dissipative) beach profile.

River Glaven (2006, see Photo 3)

In parallel with the changes to the management regime of the Cley to Salthouse shingle barrier, the River Glaven into which the coastal marshes behind the beach drain at low tide was realigned ~250m inland through Blakeney Freshes for a distance of approximately 1km. The original river channel lay immediately landward of the barrier and was vulnerable to blockages by shingle during storm events, which restricted gravity drainage from the marshes and affected the management of water levels for nature conservation. The new alignment eliminated this risk and accommodated future natural evolution of the shoreline.

Titchwell coastal change project (2011)

Primarily aimed at sustaining freshwater sites for at least 50 years, this project also included managed realignment and 11ha of intertidal habitat restoration (part of a former saltmarsh that had been embanked in the 1970s to create brackish wetlands) in front of a new secondary defence to reduce the risks posed by relative sea level rise.

Blakeney Freshes (2014, see Photos 4 & 5)

The scheme's aim was to reinstate an appropriate standard of flood protection to freshwater habitats and properties while also reducing future maintenance requirements, particularly during post-storm recovery. The seawall profile was redesigned to:

- promote dissipation rather than reflection of waves and to reduce run-up
- promote effective drainage of sea water to limit the impact on grazing marsh and grassland
- provide an interim approach that accepts some limited flooding of grazing marsh rather than abandonment of the current position of defence
- provide time to develop habitat compensation as set out in the SMP

Project summary	
Area of transitional and coastal water body or length benefiting from project:	Length of coastline benefiting directly: 8km (plus more indirectly). Area: not available due to variety of measures used
Types of measures/interventions used (Working with Natural Processes and traditional):	• Managed realignment • Soft engineering measures • Withdrawal of management/no active intervention • Redesigning and re-engineering existing defences
Numbers of measures/interventions used (Working with Natural Processes and traditional):	• Managed realignment/intertidal habitat creation • Secondary defence construction (flood embankments) • Withdrawal of beach maintenance to reinstate natural coastal processes and geomorphic evolution • Soft engineering (dragon tooth dune fencing) to trap Aeolian sand and protect vegetation • Drainage improvements (for example, sluice refurbishment) • Reconnection/realignment of degraded/disconnected tidal drainage channels • Creation of wider, flatter flood embankments to permit periodic overtopping and reduce post-surge maintenance requirements (from scour)
Standard of protection for project as a whole:	Information not available for all sites. For Brancaster the original standard of protection of the gabions and declining

	dune field was 1 in 5. The new setback seawall provides a 1 in 50 standard of protection.
Estimated number of properties protected:	Information not available for all sites. However, 88 properties benefited from the combined Cley to Salthouse and River Glaven schemes.

Photo 2: Holme Dunes

Photo 3: River Glaven realignment under construction behind the Cley to Salthouse shingle barrier

Photo 4: Blackeney Freshes before (left) and after (right)

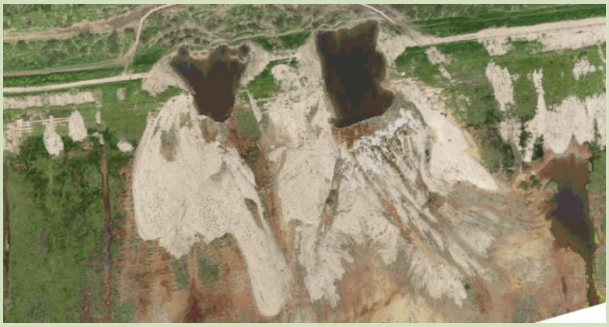

Photo 5: Blackeney Freshes before (left) and after (right)

How effective has the project been?

The combined storm surge and high tides in December 2013 tested the earlier schemes. Reports suggest that the schemes coped well (see, for example, AMEC 2014) and in some cases contributed directly towards protecting the coast and/or aiding its recovery. For example, the Cley to Salthouse barrier was breached during the event, resulting in extensive flooding of the hinterland, but the drainage of saline flood water worked as planned and the breach was naturally sealed without intervention within 6 weeks. In addition, the Titchwell managed realignment is known to have coped well and contributed towards the prevention of any significant detrimental impacts to the site's brackish and freshwater habitats, while significant (up to 2m deep) flooding of the Cley and Salthouse coastal marshes in January 2017 was successfully drained through the realigned River Glaven within 8 to 9 days

The ongoing monitoring of the performance of these schemes, as well as general geomorphic trends along the north Norfolk frontage, has contributed towards a greater understanding of the functioning of a variety of habitats in response to a range of pressures, including extreme storm surges and concurrent high spring tides. This information demonstrates the capacity for schemes that work with natural processes to provide and/or maintain effective and robust flood defences while also meeting statutory environmental obligations to conserve and enhance key habitats and species.

5. Project construction

How were individual measures constructed?

A combination of engineering (for example, installation of the dragon tooth fencing at Holme Dunes and repair of the Blakeney Freshes embankments incorporating new design features) and no active intervention (for example, the withdrawal of beach maintenance on the Cley to Salthouse shingle barrier) approaches were used.

How long were measures designed to last?

Constructed elements of the schemes have design lives of between 10 and 50 years. The natural elements (for example, newly created saltmarsh) will be much longer term, having been designed with a view to protecting against (and evolving with) sea level rise.

Where there any landowner or legal requirements which needed consideration?

The whole area is a complex of various protected sites covered by national and international legislation. This required each project to evaluate impacts and there are instances where this has led to the need to provide compensatory habitat, thus adding to costs in some cases.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/natural Flood Management (NFM) measures	
Year project was undertaken/completed:	2002 to 2014
How was the project funded:	Multiple sources used for different projects: • Brancaster: Defra flood defence grant-in-aid (FDGiA) and Living With the Sea EU LIFE • Titchwell: combined RSPB and EU LIFE+ funding • Holme Dunes: Environment Agency/English Nature (Natural England)/Norfolk Wildlife Trust • Blakeney Freshes: Defra FDGiA and Norfolk County Council • Cley to Salthouse: n/a (wider costs captured in River Glaven project) • River Glaven: Defra FDGiA, EU Objective 2 fund, East of England Development Agency (EEDA) and Department of Trade and Industry (see Defra, 2010)
Total cash cost of project (£):	• Brancaster: £389,000 • Titchwell: €1.5 million (~ €1 million EU LIFE+ funding) • Holme: unknown • Blakeney Freshes: £407,000 (£396,000 FDGiA, £11,000 from Norfolk County Council) • Cley to Salthouse: £0 in itself, see River Glaven project for details on associated works • River Glaven: £2,349,000 (£1,495,000 FDGiA, £854,000 match funding)
Overall cost and cost breakdown for WWNP/NFM measures (£):	Information not available for all sites. River Glaven: £2,264,391.71 on WWNP/NFM measures, £84,608.27 compensation to National Trust.
WWNP/NFM costs as a % of overall project costs?	Information not available for all sites. River Glaven: 60% associated with construction of WWNP/NFM measures.
Unit breakdown of costs for WWNP/NFM measures:	Not available.
Cost–benefit ratio (and timescale in years over which benefit cost ratio has been estimated):	Holme Dunes: 20.0 (according to SMP Appendix E) The combined Cley to Salthouse and River Glaven projects led to a reduced annual maintenance cost of £90,000 for the Environment Agency. This related to the cessation of the annual bulldozing of the shingle bank to maintain a design crest elevation.

7. Wider benefits

What wider benefits has the project achieved?

As well as the principal aims of improving the standard of flood and coastal erosion protection and conserving and enhancing the environment, these projects in combination have also benefited the aesthetic value of the coastline, created habitats that are more resilient to the effects of climate change, and even contributed towards climate regulation (for example, carbon sequestration on newly created saltmarshes). In addition, the River Glaven scheme included the construction of a new visitor centre and interpretation boards, resulting in educational benefits.

How much habitat has been created, improved or restored?

The amount of habitat created, improved or restored varies between sites. At Titchwell and Brancaster, the managed realignment schemes created 11ha and 7.5ha of intertidal habitat (saltmarsh and mudflat) respectively. For the Cley to Salthouse scheme, the focus has primarily been on restoring more natural functioning, meaning it is more difficult to quantify the direct habitat benefits. The works at Holme Dunes, Blakeney Freshes and the River Glaven did not directly create new habitat, but ensured a more sustainable means of protecting existing features (for example, ~160ha of freshwater grazing marsh in the case of Blakeney and ~220ha at Cley and Salthouse Marshes).

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

Some maintenance is required of built elements (for example, sluice gates and flood defence embankments). Overall however, the schemes in North Norfolk have reduced maintenance requirements compared with the antecedent management approaches. Needs vary according to the results of monitoring.

Is the project being monitored?

All of the projects fall within the area covered by the Anglian Regional Coastal Monitoring Programme, in addition to individual scheme level monitoring.

Has adaptive management been needed?

Many of the schemes listed here are themselves adaptive management techniques in response to previous unsuccessful management practices (for example, former hard engineering measures at Holme Dunes and Brancaster and unsustainable beach management at Cley to Salthouse). Further adaptation may be required in some cases if indicated by monitoring.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

The North Norfolk Coast case study is an important example of gradually building confidence and trust in WWNP measures among stakeholders and the public by opportunistically implementing multiple relatively small-scale measures over several years. The success of these various schemes (for example, in surviving the 2013 tidal surge event and improving the resilience of the shoreline to subsequent storms) has helped the process of consensus building. This is a valuable lesson for areas where WWNP measures are viewed as inferior to hard engineering.

During the River Glaven works, a Memorandum of Understanding was drawn up between the Environment Agency, Natural England, the National Trust and the Norfolk Wildlife Trust which has led to additional funding being found to create a new visitor centre and interpretation boards (Defra 2010) with associated tourism and educational benefits.

10. Bibliography

AMEC, 2014. *Coastal Habitats 2100: The East Coast response to tidal surges*. Project report for Environment Agency.

DEFRA, 2002. *Managed Realignment Review: Project report.* Flood and Coastal Defence R&D Programme. Policy Research Project FD2008. London: Department for Environment, Food and Rural Affairs [covers Brancaster scheme along with many others].

DEFRA, 2010. *Coastal schemes with multiple objectives and funders. Case Study Report 2 – Blakeney Freshes River Glaven realignment and Cley to Salthouse drainage improvements.* Defra and Environment Agency FCERM R&D Programme. Project FD2635. London: Department for Environment, Food and Rural Affairs

ENGLISH NATURE, 2003. *North Norfolk Coast Coastal Habitat Management Plan*. Peterborough: English Nature.

ENVIRONMENT AGENCY, 2009. *Coastal morphology report: Holme Next to the Sea*. Peterborough: Environment Agency.

NATURAL ENGLAND, 2013. *NCA Profile: 77 North Norfolk Coast (NE488).* Peterborough: Natural England.

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's Joint Flood and Coastal Erosion Risk Management Research and Development Programme.