

# Coasts: Geomorphology and Management

## Overview

- Coastlines reflect a delicate balance between erosion and deposition.
- Coastlines respond rapidly to environmental change, so that it is natural for coastlines to change over human timescales of years to decades.
- In view of the above, decisions over coastal management are rarely clear-cut.

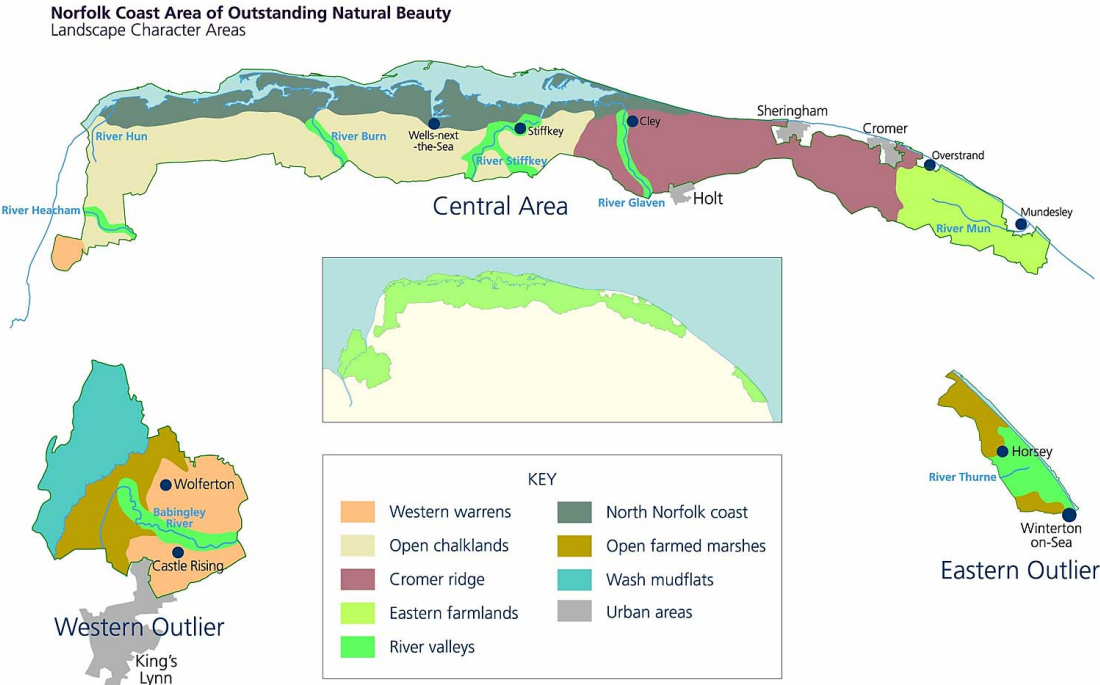
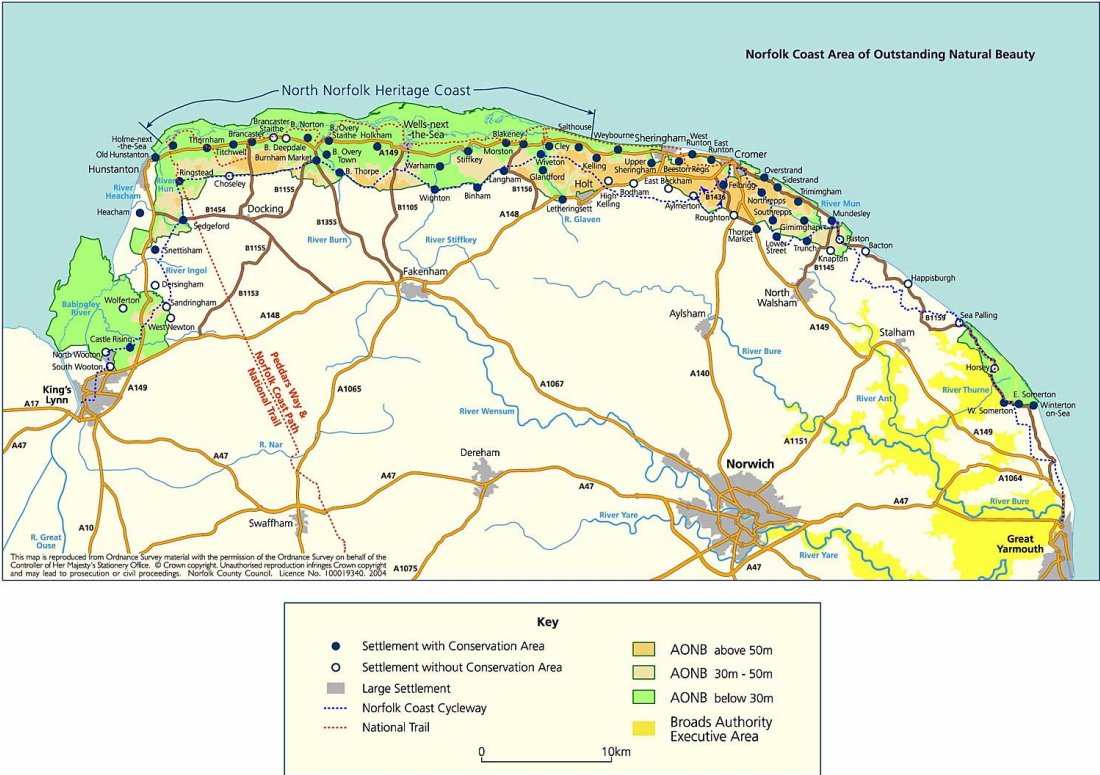
We will explore these issues mainly with reference to the coastline of East Anglia, England. East Anglia presents a smooth and curving coastline to the North Sea between the Thames Estuary in the south and The Wash in the north. The northeast-facing coastline either side of the town of Cromer is suffering active and rapid erosion. This erosion supplies sediment to form a complex of sand/shingle spits, barrier islands and salt marshes along the North Norfolk coast to the west and another complex along the Suffolk coast to the south.

## Factors controlling coastal morphology

**Sea-level change** The coastline of East Anglia as we know it is very much a temporary feature because sea-level has fluctuated considerably and rapidly in the past as a consequence of global glaciation. During the Last Glacial Maximum, sea-level was about 120m lower than at present. Sea level began to rise about 10,000 years ago as a result of the rapid melting of the Scandinavian and Laurentide ice sheets and by 7,000 years ago it was close to its present level. Hence the present East Anglian coastline has developed over less than 7,000 years (a very short time interval to a geologist).

**Lithology and topography** Cretaceous Chalk underlies most of the North Norfolk coast but this bedrock is mantled by till and is not exposed at the surface. The till consists of mud and sand partly because the rocks of the English midlands consist mainly of relatively soft Jurassic-Cretaceous aged mudstones, limestones and sandstones that yield fine-grained material when subjected to glacial erosion. A phase of marine erosion prior to the last ice age eroded a cliff in the bedrock a few kilometres inshore of the present coastline. Today, the processes of sediment transport and deposition that sculpt the North Norfolk coast are confined within a narrow corridor between the seashore and the fossil cliff. The active coastal zone will narrow further in future if sea level continues to rise.

**Waves** are important for two reasons. First, wave action controls where erosion and deposition occur along the coastline. Waves roll in from the North Sea to the north-east. The north-east-facing part of the Norfolk coast bears the full brunt of the waves and suffers erosion. Waves are incident on the North Norfolk and Suffolk coasts at an oblique angle so that newly-eroded sediment is transported along these coasts via longshore drift.



Second, wave action plays a role in creating and modifying barrier islands and spits such as Blackeney Point and Scolt Head Island on the North Norfolk coast and Orford Ness on the Suffolk coast.

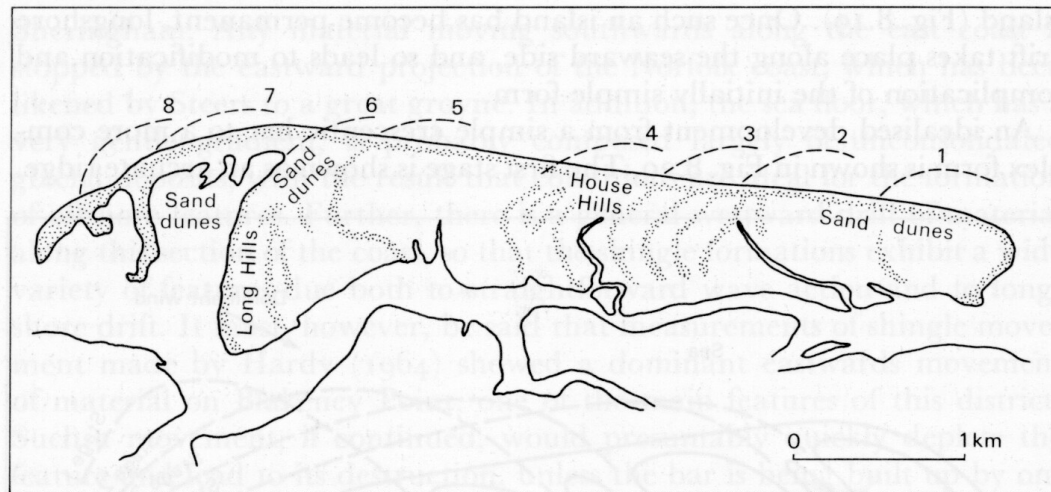
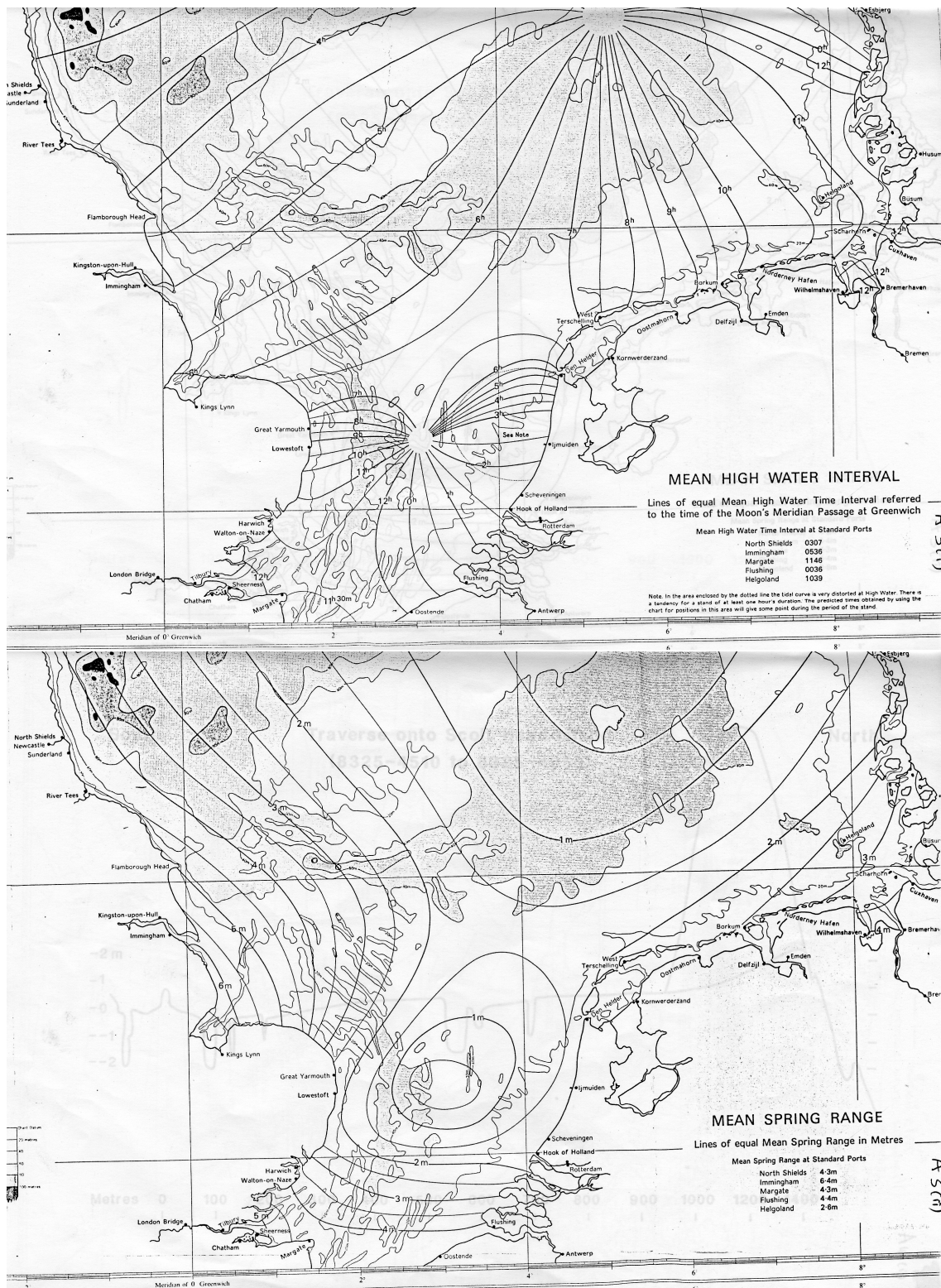


FIG. 8.21. Scolt Head Island. Shingle ridges and probable development (*after Steers*)

**Tides** The North Sea can be considered a closed basin which is being forced to oscillate by the tidal flow across its northern boundary with the Atlantic. Three amphidromic systems are present in which the tidal wave (high water) rotates anti-clockwise round an amphidromic point. Amphidromic points are displaced to the east within the basin because of Earth's rotation. A set of elongate sedimentary deposits termed sand waves have formed on the North Sea bed offshore East Anglia in response to the strong tidal currents. The long axes of the sand waves are parallel the tidal current. Comparison of present-day depths with old hydrographic charts shows that the sand waves have migrated north-westward parallel to their long axes by 100s of metres since 1850. Thus although the crest of tidal wave moves anticlockwise round the North Sea basin, the strongest flow of the water itself has the opposite sense at the seabed. Measurements of an intertidal sand bank at Wells-next-the-Sea over the course of a year showed that most sand transport occurs in the few days around the spring tides in each spring-neap cycle. Tidal range affects coastal geomorphology by influencing the width of the intertidal zone. The relatively high tidal range at the predominantly depositional North Norfolk coast leads to a wide belt of tidal mud flats, sand bars and flat beaches. The lower tidal range at the eroding north-east facing coast enhances erosion by concentrating wave action close to the cliff foot.

**Storms** Although the prevailing winds across Britain and Ireland are westerly, the dominant (strongest) storm winds are often in the north or north-east, accentuating wave action and erosion of the north-east facing coast. At the North Norfolk coast, the greatest potential for geomorphological change occurs when a northerly gale coincides with and amplifies the highest spring tide. The unusually high seas can breach the barrier islands/spits, scour the mudflats behind and initiate a new system of tidal creeks in a single day. Such events may strike infrequently (maybe around once a century) but they



have a great effect on coastal geomorphology.

**Vegetation** plays an important role in stabilizing the depositional coasts. Marram grass stabilizes sand dunes and aids construction of offshore sand bar islands such as Scolt Head Island and Blackeney Point. On the beaches behind such sand bars, tidal flow is naturally concentrated in the lower lying areas and salt-loving plants such as *Salicornia* begin to colonise the higher parts of the beach. Vegetation tends to trap mud, leading to aggradation of the higher parts of the beach while sinuous tidal creeks develop in the lower parts. Vertical accretion rates of 0.5–1 cm per year have been recorded at Scolt Head Island; thus a stretch of sandy beach can be covered by a muddy tidal creek system within a few decades.

## Coastal Management

### Types of sea defence

*Concrete sea walls* reduce wave energy but are expensive to build and maintain.

*Rock armour (rip-rap)* is when large hard rock boulders are placed in front of sea walls and sometimes used as groynes. Relatively expensive.

*Groynes* are walls built at right angles to the coast. Their purpose is to stop beach migration by longshore drift. They are traditionally made of wooden railway sleepers but they can be made of rock armour.

*Gabions* are wire netted blocks of medium-sized pieces of hard rock. Expensive and can be ugly.

*Revetments* are slatted and angled low wooden walls parallel to the beach. They act to absorb wave energy and protect soft cliffs. Ugly and liable to rapid damage.

**Should we manage the coast?** The following sequence of arguments illustrates some of the problems facing planners and engineers. The coastline of north-east Norfolk is suffering active erosion (e.g. [www.happisburgh.org.uk](http://www.happisburgh.org.uk)). The cost of erosion is high as farmed land is lost and property damaged. Holiday parks, beaches and other tourist attractions which are vital to the economy of the region are at risk. The residents therefore demand a program of sea defences to halt coastal erosion. However, erosion of this part of the coast is a natural state of affairs, as waves, tides and storms act on the soft till exposed at the present-day sea-level. We cannot fight Nature in the long-term, so planners and politicians adopt a policy of Managed Retreat whereby natural erosion is allowed to take its course and people affected are paid compensation. The cash sums involved in compensation are less than those involved in construction and continual maintenance of massive hard-engineering defence schemes. Managed Retreat does not cut the mustard with the residents of north-east Norfolk, who point out that if the coastline is breached by the sea then the lowlying region behind will be inundated. This inland region contains the Norfolk Broads National Park and sea defences along the north-east Norfolk coast are required to protect it. But the North Norfolk coast and the coastline of Suffolk are also areas of outstanding natural beauty. These complexes of barrier islands and tidal creeks are products of the constant flux of sediment eroded from the north-east Norfolk coast

and transported westward and southward via longshore drift. Protection of the north-east Norfolk coast would effectively destroy the North Norfolk and Suffolk coasts as we know them over the course of the next century.

## **Dublin Bay**

For centuries the shallowness of water and the existence of sandbanks at the entrance to Dublin Port were major hindrances to navigation. The sandbar at the mouth of the River Liffey posed a major problem with only 6 feet of water on the bar at low water. Many lives, ships and cargoes were lost in Dublin Bay due to the sandbanks and inability of ships to cross the rivermouth bar except at high tide. By the late 18th century this increasing volume of maritime trade and the emergence of larger ships made the problem critical. The South Wall was finished by the end of the 18th century and was hailed as an engineering feat without parallel. Whilst it prevented sands from offshore Sandymount from encroaching northward, it was ineffective in deepening the river channels and removing the rivermouth bar. At the turn of the 19th century eminent marine specialists were invited to submit further proposals for the improvement of access to the Port.

The North Bull wall was commenced in 1819 and completed in 1824. The materials used were granite and local limestone. The wall stretches for 9,000 feet from the shore at Dollymount to the North Bull light at the entrance to the Port. The 5,500 feet of wall at Dollymount to just beyond the Marian statue remains above water at all stages of the tide. The 3,500 feet from the statue to the light, which is known as the half tide wall, is covered at high-water. The water drops below this section of the wall midway through the ebb tide so that for the latter half of each outgoing tide the water is forced between the North Wall and Poolbeg lighthouses at the entrance to the port. The purpose of the half tide wall and of the Bull bridge is to act as safety valves to prevent damage to the wall from the pressure of full tide. Scour as the tide funnels through the gap between the north and south walls quickly cut a channel across the rivermouth bar and deepened the previous depth of 6 feet to 16 feet at low water. Sand dislodged from the bar and was carried out into the bay and then re-deposited on the North Bull bank to form Bull Island.