When the wind is blowing from the north-east (direction of greatest fetch), it can drive powerful waves towards the Holderness coast. Occasionally, areas of extremely low pressure move down the North Sea, funnelling water and creating storm surges several metres high. These low-frequency, high-magnitude events can lead to significant erosion and flooding – in 1953 more than 300 people lost their lives along the east coast of England during such an event. As a result of these powerful north-east waves, longshore drift operates from north to south along the Holderness coast.

In response to the rapid rate of erosion and the threat to settlement and infrastructure, parts of the coastline have been protected with hard-engineering structures such as sea walls, rock armour and groynes (see 3.9). Although these interventions have helped to protect specific localities, such as Hornsea and Mappleton, they have deprived areas further south of sediment, thereby exacerbating coastal erosion. The lack of a beach renders cliffs much more vulnerable to undercutting and collapse (Figure **3**).

**Figure 3** *Recent erosion threatening the settlement of Skipsea, where rates of erosion are 2 metres a year*

## Flamborough Head

Jutting into the North Sea from the east coast of England, Flamborough Head is one of the most recognisable features on a map of the UK (Figures **1**, **4** and **5**). The main reason for the formation of the headland is because it is made of chalk – a resistant, sedimentary rock.

Chalk has a very distinctive white colour, as can be seen in Figure **4**. The layers or beds of the chalk are clearly visible and are roughly horizontal (Figure **5**). Vertical cracks run through the chalk (*joints*). In some places whole sections of chalk have been displaced along lines called *faults*. These joints and faults are weaknesses in the chalk, which are readily exploited by the processes of weathering and erosion to form narrow clefts in the coastline. One major faultline has been exploited to form Selwick's Bay (Figure **4**).

**Figure 4** *Distinctive chalk cliffs at Selwicks Bay, Flamborough Head*

**Figure 5** *Landforms of coastal erosion at Flamborough Head*

The sea is actively eroding and undercutting the base of the cliffs leading to frequent rockfalls. The high tide line is clearly shown by the dark staining at the foot of the cliffs in Figure **5**. Over time the cliff retreats, forming wave-cut platforms and stacks.

When waves approach the coastline they are bent or refracted by the shape of the coast. The waves are therefore curved and have low energy in the bay, resulting in a deposited beach. The more exposed headlands bear the full force of the incoming waves – this is why they are often characterised by steep cliffs and other features of coastal erosion.


**Figure 8** *1:50 000 OS map (1850)*

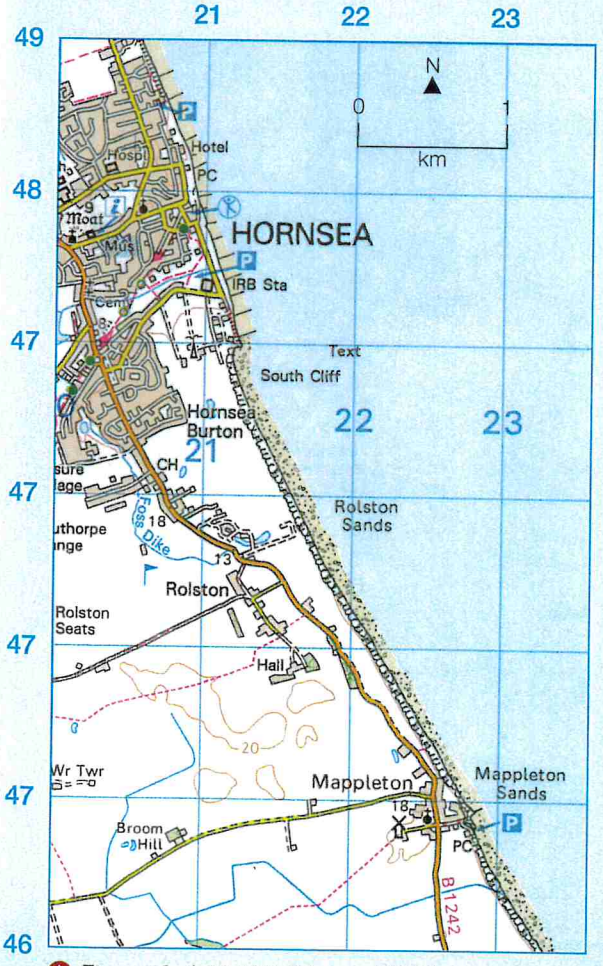


**Figure 9** *1:50 000 OS map (2010)*

## ACTIVITIES

S **1** Design a large (A3) information poster to summarise the process and landforms of the Holderness coast. Use Figure **1** as a base map and begin by showing the operation of the sediment cell, inputs, outputs, transfers and stores. Are there any feedbacks in operation? Add text boxes to describe processes and landforms and try to incorporate some labelled photos. This should provide you with a comprehensive overview of this case study.

**2** What are the factors affecting the cliff profiles and rates of cliff retreat along the Holderness coast?

S **3** Study Figure **5**.

- **a** Was the photo taken at high tide or low tide? Justify your answer.
- **b** Draw a sketch of the photo and label the main landforms and evidence of coastal processes
- **c** How might this landscape change in the next century?

**4** Consider the possible impacts of sea level rise on coastal process and landforms along the Holderness coast. How might this impact on the sediment cell?

**5** With specific reference to the coastal system, what are the arguments for and against protecting the Spurn Head coastline?

S **6** Figure **8** is a 1:50 000 OS map (1850) of part of the Holderness coast. Figure **9** is a 2010 map of the same stretch of coastline. The 1850 map has been scaled so that it is the same scale as the modern map and can therefore be readily compared. Investigate the changes to the coastline between 1850 and 2010.

- Create your own grid or use a sheet of tracing paper and draw the extent of both the past and present coastlines. Follow the high tide line on both maps. Add information onto your map, such as settlements, roads and coastal defences. Indicate the direction of maximum fetch and the direction of longshore drift.
- Use two colours to show accretion and erosion.
- Use the scale to work out the rates (metres per year) of accretion and erosion for selected locations.
- Write a brief commentary describing the variations in accretion and erosion. Is there evidence that the coastal defences may have been responsible for increased erosion to the south of Hornsea?

## STRETCH YOURSELF

Use Google Earth to investigate the downdrift impacts of coastal defences on beaches and cliff erosion. You could focus on Mappleton and see if there is any evidence that the coastal defences have interfered with longshore drift causing beach depletion and excessive cliff erosion further south. Use annotations to document your evidence.