The Holderness coast: geomorphological and coastal processes

Specification topic: Geomorphological and coastal processes 3.1.3.3

Case study: The Holderness Coastline

The Holderness Coastline is a dynamic coastline, continually changing as a result of a range of geomorphological and coastal processes. Since Roman times the coastline has retreated by approximately 5km and at least 23 settlements have been lost to the sea.
Marine processes are both eroding and depositing material along this coastline. The coastline stretches from Flamborough Head in the north, a headland of resistant chalk, to Spurn Head - a spit in the south, at the mouth of the Humber Estuary.
Erosion is greatest between the south of Flamborough Head to the area north of Spurn Head. This occurs primarily due to the powerful destructive waves hitting the coastline in combination with the soft glacial tills that form the Plain of Holderness.
The waves along this coastline are impacted upon by a range of factors:

- Firstly, the fetch - which helps generate large waves - enables destructive waves to be driven by prevailing north easterly winds across the North Sea. Combined with this is the impact of the Coriolis Force which directs the waves at the coastline from a north easterly direction. This force can result in successive days of powerful destructive waves along the coastline which can remove metres of land at a time.
- Storm conditions within the North Sea, particularly during the winter months when Arctic maritime air pushes down towards the UK, creates bigger storm waves, which further erode the coastline due to the high energy they contain. These waves can be up to four metres in height.
- There is a large tidal range along the coastline: up to seven metres at certain times of the year. Scouring and abrasion at the sub-tidal foreshore leads to basal cliff erosion resulting in cliff retreat of, on average, 1.5 metres per year.

The wave energy combines with the lithology of the coastline to produce its distinctive coastal landscape. The hard rock coastline known as Flamborough Head is an exposed chalk headland with caves, arches and stacks that have been created from wave action over time. Waves hitting directly at the headland refract around it, directing the wave energy at the sides of the headland. Weaknesses (natural fault lines due to previous earth movement, together with fissures and joints in the chalk) are eroded rapidly by hydraulic action caused by storm waves forcing air into cracks (cavitation). Storm waves hurl material at the cliff face which chips off solid rock (abrasion/corrasion) to form caves and arches. Sub-aerial weathering processes (freeze thaw particularly, and chemical solution) then weaken rocks at the top of the arch until it collapses under gravity. This leaves a stack, later reduced to a stump.
The fact that Flamborough Head absorbs the wave energy would normally mean that areas next to a headland would be protected from high energy waves. However, the long fetch and regular storm waves, together with the lithology (rock type) of the coastline to the south of Flamborough Head means that the rate of erosion is still substantial.
South of the hard chalk rock at Flamborough Head lies a vast area composed of boulder clay. Deposited at the end of the last ice age, the unconsolidated material is soft and easily removed by the destructive waves which directly hit the clay cliffs. In front of the cliffs lie sandy beaches which do little to reduce the energy in the waves. The cliffs are very steep which means that the destructive waves hit directly at the foot of the cliff and weaken it. The base of the cliff is undercut, allowing the overhang to slump

down onto the beach below. This happens more so with boulder clay than many other rock types due to the large number of pore spaces in the unconsolidated material which absorb rainfall, making the material heavier and lubricating a slip plane. The structural failure of the cliff leaves large amounts of material at the base of the cliff, which should act as protection against the wave action, however, longshore drift quickly removes the material southwards, leaving the cliffs once again vulnerable to further wave action.

The human use of this land has contributed to these unstable cliffs. Foundations for houses and water / gas pipes along with agricultural field-drainage pipes have weakened the structure of the ground leading to an increased rate of erosion.

Sub-aerial geomorphological processes also impact upon the rate of erosion. Storm conditions, which regularly affect this coastline, bring strong winds and heavy rain which can destabilise slopes, prior to their removal by the waves. Heavy rain soaks into fissures in the clay and makes the cliffs more unstable than just from the waves themselves. The boulder clay acts as a sponge and, fully saturated, the weakened material slumps down, bringing vegetation, farm buildings and houses with it.

Physical weathering processes can also affect this coastline, leaving the cliffs more vulnerable to wave action. During the winter months freeze-thaw weathering can occur. The fractures in the boulder clay allow water to enter during the day and at night when temperatures drop it freezes and expands. This process of expansion and contraction, when the ice melts again, will weaken the cliff structure and make it fracture further. The cliffs are then more vulnerable than before. The east coast suffers some of the lowest winter temperatures in the UK due to Arctic maritime air masses bringing cold stormy weather, so this type of weathering is not uncommon.

The Holderness Coastline is also affected by littoral movement and subsequent deposition. When material has been eroded from the boulder clay cliffs it is then moved southwards along the coast by north easterly waves by the process of longshore drift. This process of zig-zag material transportation repeats until it reaches a coastline change, to the east of Hull, where the River Humber reaches the sea. There, the material is deposited as turbulence between the North Sea current and the River Humber current causes movement to slow. This deposited material has formed Spurn Head, a spit composed of sand and gravel.

The process of longshore drift leading to deposition occurs as a result of energy loss. Where the coastline changes direction and the River Humber enters the sea, the energy in the currents are reduced due to friction. This leads to deposition as the waves have less energy to carry the material along.

Spurn Head has grown and been washed away at several times in its history in a cyclical process of about 350 years. However, for the past 100 years it has been fixed in position by coastal defences. These defences have now failed and while the southern tip is stable, held in place by vegetation, the narrow spit neck in the northern section is being eroded by the waves and has recently been breached. The cost of repairing the spit neck is too high so at this point, nothing is being done to protect the northern section of the spit in the hope that sediment 'wash-over' will gradually move the entire spit westwards as a whole. The implications of the spit being entirely eroded has major consequences for the silting up of the Humber Estuary – one of the main trade estuaries of the UK containing the ports of Hull, Grimsby, Immingham and Goole.

Exam style question:

1. **Explain how a variety of coastal features may form to create a distinctive coastal landscape. (9 marks)**
2. **Describe and comment on the issues associated with coastal erosion (6 marks)**

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1. Explain how a variety of coastal features may form to create a distinctive coastal landscape. (9 marks)

By focusing on the Holderness coastline, both erosional and depositional processes occur here leading a variety of erosional and depositional features.

Focus needs to be on how destructive waves affect the Holderness Coast. Mention fetch, Coriolis force, strong winds and tidal range resulting in storm surges. Explanation is required about the formation of caves, arches and stacks at Flamborough Head as a result of direct wave action and refraction.

Description then needs to be given about how the waves undercut the base of the boulder clay cliffs to the south of Flamborough Head and result in slumping of cliffs. Wave action then removes the material out to sea and transports it along the coast via longshore drift.

Further south along the Holderness coast the focus will be on depositional landforms so therefore Spurn Head and the formation of a spit is needed here. The process of longshore drift needs to be described along with what happens when the coastline changes direction and friction increases. The Humber Estuary and its emergence into the North Sea allows deposition to take place and for the spit to develop over time.

Level 1 will focus on describing different landforms but won't link this to the processes of formation.

Level 2 will focus on the link between feature and process and begin to distinguish between different categories of feature.

Level 3 – Detailed explanation of how erosional and depositional features are formed and the key processes operating to form a distinctive coastal landscape.

Whilst the question doesn't specify that a case study is needed, for the highest level it is easier to develop the answer around a place as the locational detail is likely to improve the answer.

2. Describe and comment on the issues associated with coastal erosion (6 marks)

Answers will refer to some of the following:

- Cliff collapse – impact on houses, businesses, transport networks, local government, tourism etc.
- Reduction in beach size – impact on tourism, increased coastal erosion rate and impact on houses as a result of this.
- Planned hard engineering and likely costs; political consequences of decisions not to protect vulnerable coastlines; and – when constructed – the impact of hard defences on areas further down the coast which might experience increased coastal erosion as a result.

Level 1 (1-3 marks) will only focus on one issue in detail but may have other issues stated. The responses will be largely descriptive.

Level 2 (4-6 marks) a range of issues focused on in detail. There will be commentary evident of how the issue may develop in the long-term with links and/or ranking the issues, either by seriousness or urgency.