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Coastal erosion – Back to Nature

What has caused the personal disaster for Sue Earle, described in Figure 1? On a quiet summer's day the British coastline can seem a peaceful place. Waves gently lap at the foot of the beach while children play on the sand. Yet this is also a battle zone, a front between the land and the sea where tremendous energy is exerted by the waves attacking the coast, and where considerable sums of money are spent protecting the cliffs and beaches.

Coastal erosion is caused in several ways (Figure 2). The rate of erosion largely depends upon the type of rock forming the coast. The Holderness coast of East Yorkshire where Sue Earle's farmhouse was located is composed of weak glacial till, which is easily eroded.

Coastal protection strategies

'The best defence against coastal erosion is a good beach.'
US Army Corps of Engineers

Mappleton is the small village on the Holderness coast whose fate is described in the newspaper article (Figure 1). It is threatened by coastal erosion. This is the fastest-receding stretch of coastline in the world; since Roman times it has retreated by around 6 km. Dozens of villages and towns have been lost (Figure 3).

Why is such rapid erosion happening here? The plain of Holderness did not exist before the Ice Age. It was once a wide bay backed by chalk cliffs running from Flamborough Head to Hessle, west of the city of Hull. Today Holderness is made up of glacial tills – sands and clays deposited by ice sheets during the Ice Age (Figure 4). The tills are soft and unstable and have little resistance to erosion. The low cliffs repeatedly slump down along rotational slip planes, lubricated by water which reduces friction and makes the sands and clays slip easily. The sea washes the slumped material away. This rapid coastal retreat will continue until the old buried cliff-line along the eastern edge of the Yorkshire Wolds is once again exposed. This is composed of much more resistant chalk rock, which will again form impressive white cliffs such as those north of Bridlington.

Figure 1: Report in The Observer, *1 December 1996*

GREAT BRITAIN GETS SMALLER BY THE DAY

At twilight the burning remains of Sue Earle's clifftop farmhouse at Cowden were reflected in the tide lapping Mappleton Sands below. It had taken 10 hours on Friday to demolish the building, set fire to the broken timbers and clear the site. A pall of smoke drifted over the North Sea, obscuring the flashes from a lighthouse on distant Flamborough Head.

The £250,000 house was destroyed, by court order, because it was on the edge of a clay cliff that had been badly undermined by the sea. It was in danger of sliding onto the beach below. Naturally the law couldn't allow that. So on Friday they pulled the house down and charged its occupants £3,500 for the privilege. They now live in a caravan.

This could have been prevented by spending money on coastal defences.

James Warrington, chairman of the parish council, watched smoke rising from the Earles' ruin. He sees the evict-and-demolish policy of East Yorkshire Council as almost contempt for the land. "We're losing the very soil and it's probably being washed up on the Dutch coast." He has researched the fate of his bit of coast. He found that since 1786 the distance between Mappleton church and the cliff edge had been reduced by 3.5 km. In 1990–91 the rot stopped.

"We campaigned strongly and Holderness District Council came up with a scheme for sea defences, using giant rocks – 60,000 tonnes – and groynes," says Mr Warrington. "By this time a four hectare field of mine had been reduced to two hectares. Brussels promised to contribute, but only if it was to promote leisure: a car park, picnic area etc., rather than just sea defences. So we could spend only part of the total £1.9 million on what we actually needed it for. The scheme has saved Mappleton, but not enough money was spent and our farms are still threatened."

Figure 2: The processes of coastal erosion

The energy released by waves can cause great damage. Waves exert a pressure of up to 30 tonnes/m^2. Weathered and weak rock is washed away from the cliffs. The waves can compress air into cracks and joints in the cliff face. The compressed air is released with explosive energy as the water retreats, loosening even the strongest rocks. This process of erosion is called *hydraulic action*.

The sea erodes the land in three other ways:

- *Corrasion*: the waves throw rocks and pebbles against the cliffs, wearing them away. This is often the most important method of coastal erosion. It operates fastest on coasts that are exposed to storm waves.
- *Attrition*: the rocks and pebbles are worn away as they crash against each other within the water. In the process they become smaller and more rounded.
- *Solution*: the water itself is slightly acidic and can dissolve some minerals within rocks, such as calcium carbonate in limestones. Recent research suggests that this form of erosion is not as important as previously thought, since there is a limit to the amount of calcium carbonate which seawater can hold in solution. The evaporation of salts can produce salt crystals whose expansion can cause rock to break up.

Often the most effective form of erosion operating on coasts is not the sea at all, but sub-aerial processes such as rain and frost. Surface run-off, or throughflow, can erode the cliff faces. Rainwater can provide the lubrication for slumping to occur. Frost action can cause blocks to fall. In such cases the action of the sea is limited to transporting away the debris from the base of the cliff.

Figure 3: The Holderness coast, showing its retreat since Roman times

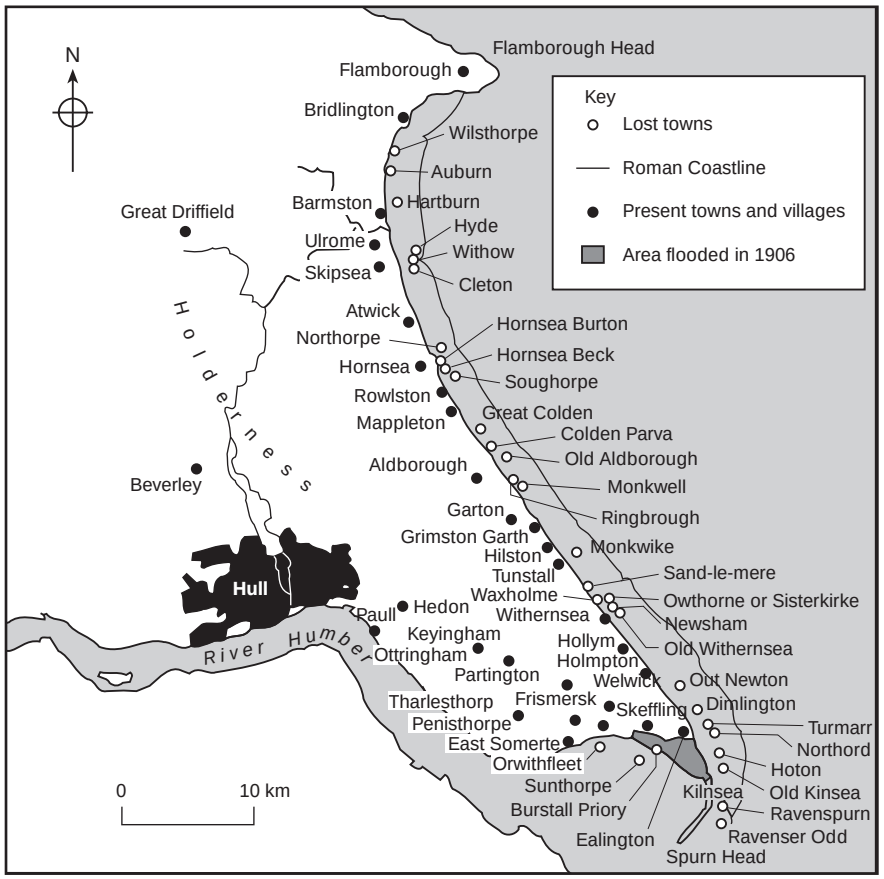
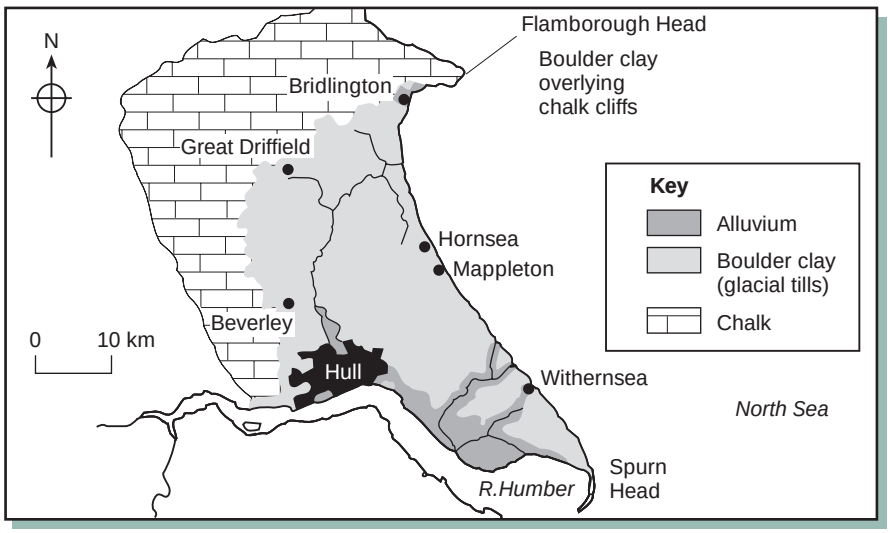


Figure 4: The geology of the Holderness peninsula



The sea defences constructed at Mappleton have contributed, unfortunately, to the destruction of Sue Earle's home, described in Figure 1. The £1.9 million scheme, completed in 1991, includes two large rock groynes and a protective barrier of granite boulders laid along the beach close to the cliff base. Although it protects the area of cliff behind the defences, the rate of erosion of the unprotected cliff to the south has trebled. This is because the groynes have destroyed the balance within the coastal system (see Figure 5) and have stopped the supply of beach material by cutting off the longshore drift. The narrower beach south of the defences means that waves crash against the cliff foot more often and with more energy.

Managed retreat

Hard sea defences such as those at Mappleton do not work in the long term. They have to be repaired regularly, and they may exacerbate damage elsewhere, as has happened at Cowden. More than 10% of the British coastline is now protected by hard defences.

Geographers have tried to persuade local authorities to adopt policies of 'managed retreat', whereby natural processes are allowed to take their course and people affected are paid compensation – this would often be cheaper than the cost of the massive 'hard engineering' defence schemes.

In August 1998 the House of Commons Agriculture Committee gave its support to the managed retreat policy. Their report stated that continuing to build ever higher defences to keep out the rising sea is no longer an option, and retreat to new positions inland should begin immediately in some places:

Figure 5: The coastal system

The coastline can be viewed as a **system**, with inputs and outputs. The inputs are sand, mud, gravel and other eroded materials forming the beach. The sea, through the process of **longshore drift**, transports this material along the coast until it is deposited somewhere else. Provided the amount of material coming into the coastal zone equals the amount of material leaving it, the section of coast is said to be in balance, or in **equilibrium**. This equilibrium can be upset by various natural events, such as rising or falling sea levels; however, nowadays the coastal equilibrium is usually upset by the actions of people, such as by the construction of groynes and other coastal defence works.

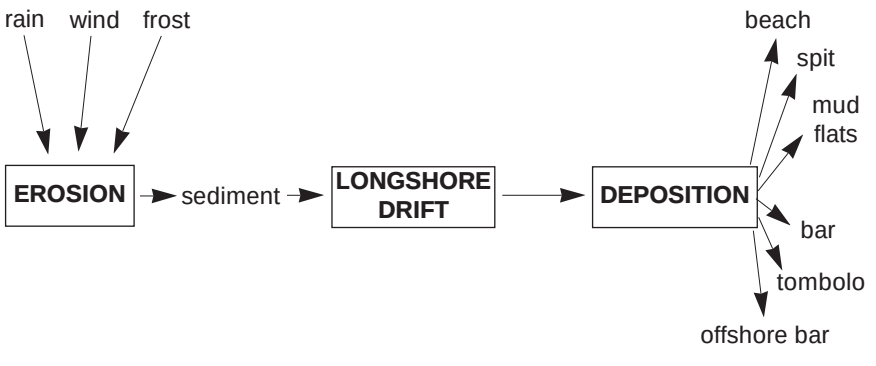


Figure 6: Report in the Daily Telegraph*, 6 August 1998*

If it goes on like this, there won't be any farms left

Sue Earle lives on what is left of Grange Farm at Cowden, near Hornsea in East Yorkshire. Over the past eight years she has lost eight acres to the sea, a third of her arable land. In November 1996 East Yorkshire council demolished her three-bedroomed Victorian farmhouse because it was just five metres from the cliff edge and considered too dangerous to live in. The same thing happened to several of her neighbours. Ms Earle and her uncle, who lives with her, received a bill for £3,500 that they have still not paid.

They now live in a wooden hut built at their own expense and are suing the council for compensation. On hearing yesterday's announcement by the Agriculture Select Committee that more farmland should be allowed to fall into the sea, Ms Earle said: "They want shooting. Let them come and live in my hut and I'll go to their houses. Why did we fight two world wars? To protect our land. If it goes on like this, there won't be any farms left. I don't think they should protect every inch of land, but they should try to save as much as possible. I lost my farm, which was worth £250,000, and my loss of income for all this time has been huge."

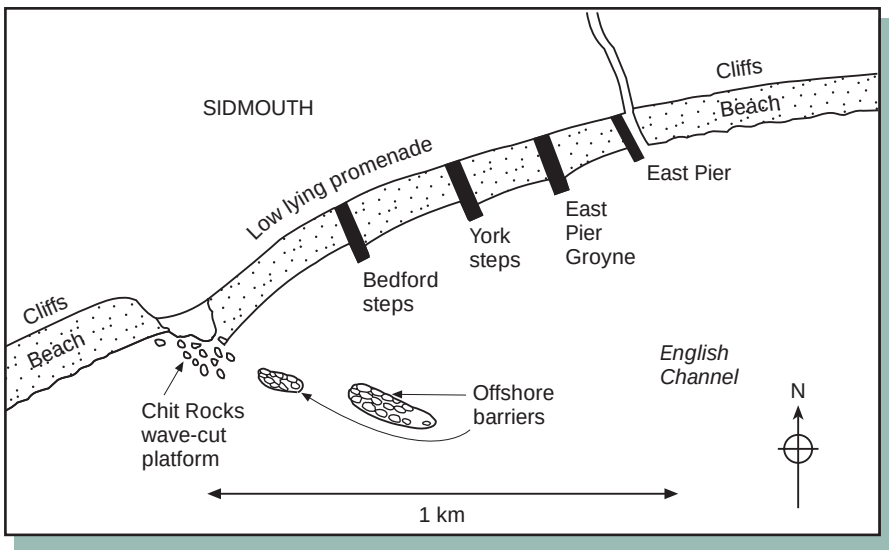
Ms Earle says that erosion of her farmland accelerated after sea defences were built to protect the village of Mappleton, one mile north of Cowden, in 1991. Two rock groynes were built and sediment was prevented from drifting along the coast to the beach. "The cliff erodes faster because there is no beach to protect it", she says.

'In spite of the introduction of defensive measures, the underlying natural processes of erosion and deposition have remained fundamentally unaltered, albeit varying in their location, effects and intensity. The depredations of coastal erosion are particularly obvious on the vulnerable eastern English coast, which is mostly composed of softer rocks and clay. Archival and cartographic evidence indicates that the East Riding of Yorkshire has suffered continual loss of land to the sea since records began; a loss which at present amounts to 12 hectares of land a year.'

Managed retreat, or 'managed realignment', involves dismantling any existing coastal defences and allowing the sea to encroach inland to a predetermined 'set back' line. This allows for the dissipation of the energy of the waves and tides, as well as the predicted sea level rise resulting from global warming and isostatic readjustment. Managed retreat is consistent with the natural cycles of erosion and deposition. The formation of beaches, mudflats and sandbanks will enhance natural coastal defence.

Opponents of managed coastal retreat point out that wherever coastal land is lost, the livelihood of individual people is threatened. Certainly any policy should include proper compensation for those who lose their property – an issue that Sue Earle had to fight for (Figure 6). Managed retreat has been criticised as simply a cost-cutting manoeuvre.

Figure 7: Sketch map of Sidmouth's coastal protection works



Managed retreat is an example of 'soft engineering'. Other soft engineering strategies include beach replenishment and the construction of offshore reefs that decrease wave height and absorb some of the energy, as well as altering the direction of the waves.

Hard engineering – a case study

In some places too much property is threatened by coastal erosion to allow a policy of managed retreat. Here the traditional approach is hard engineering works, such as those at Mappleton. This policy is still continuing at several locations today.

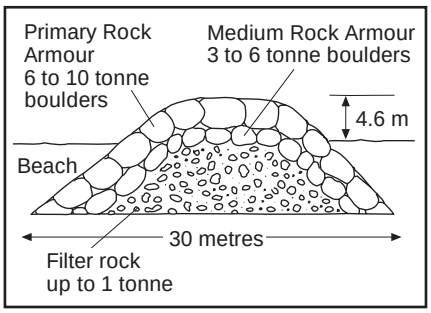
At Sidmouth in Devon, a coastal protection engineering strategy costing many millions of pounds has been put in place (Figure 7). Offshore rock barriers, groynes and seawalls have been constructed. However, longshore drift moved much of the beach westwards and reduced the protection to the western part of Sidmouth's seafront. Between January and May 2000 work took place on the third phase of the project, which itself cost over £600,000, partly funded by the Ministry of Agriculture, Forestry and Fisheries.

This third phase, intended to reduce the movement of beach material from east to west, involved further major engineering works:

- A new rock groyne, 64 m long and 4.6 m above beach level, has been constructed of boulders at Bedford Steps (Figure 8). The groyne is made of 4,350 tonnes of primary rock armour (6–10 tonne boulders, trucked in from Cornwall), 3,400 tonnes of medium armour and 2,100 tonnes of filler rock, trucked in from Somerset.
- 2,500 cu m of new shingle has been imported and placed between the York Steps and East Pier groynes to increase the width of the upper berm between those locations.
- Up to 20,000 cu m of beach nourishment material has been moved from west of Bedford Steps to east of the new groyne, thereby returning the material to its original location.

These massive engineering works to protect Sidmouth's seafront appear rather unsightly and out of place at this attractive and elegant seaside resort.

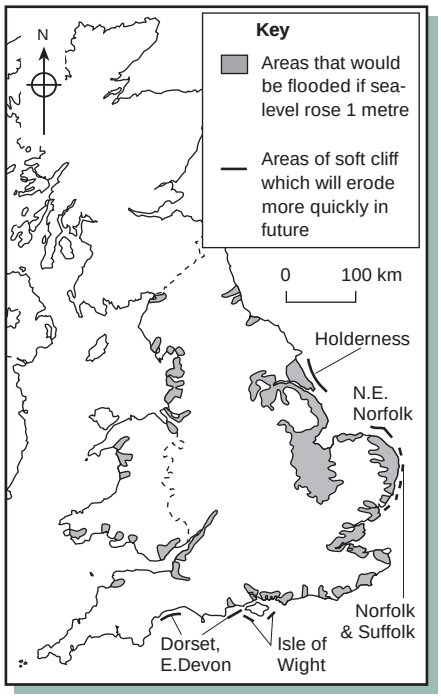
Figure 8: Cross-section through the new groyne at Bedford Steps, Sidmouth



Soft engineering – a case study

A different, soft engineering solution has been adopted at Seaford in East Sussex, a small coastal resort whose sea-wall, built in 1881, had to be regularly and expensively repaired following storm damage. Since 1987 a strategy of **beach replenishment** has been adopted at Seaford. A broader beach was built using shingle dredged from an offshore bank by a large suction dredger. Every year approximately 30,000 cu m of shingle are removed by longshore drift, and has to be replaced at an annual cost of £60,000, but this is much less than increased sea-wall defences would cost, and probably more effective too. Beaches dissipate wave energy by forcing the water to spread shallowly across a broad area. The beach is also a valuable tourist resource. Several major resorts including Miami and Rio de Janeiro replenish their beaches in this way every year.

Figure 9: The effects of a one metre rise in sea level on Britain's coastline



A new factor in the choice of coastal management strategy is the effect of global warming. The 20th century was the hottest for at least 500 years. Global average temperatures have increased by 1°C since AD1500; half of this increase has occurred since 1900. One of the effects has been a rise in global sea levels of between 10 and 25 cm since 1900. The anticipated further increase in global temperatures this century presents those involved in coastal protection with a new challenge; sea levels are predicted to rise by between half a metre and a full metre by 2100. The effects this would have on the British coastline are shown on Figure 9.

Conclusion

There has been a dramatic change in the way in which coastal protection is viewed by the British authorities. The traditional approach was to prevent coastal erosion at all costs, through the use of hard engineering solutions including sea walls, groynes and breakwaters. This expensive policy has, in some cases, caused more problems than it has solved – as allegedly has been the case at Cowden and Mappleton. New, soft engineering solutions include the controversial strategy of managed retreat, which was supported by the Agriculture Select Committee of the House of Commons in 1998. Beach nourishment and the construction of offshore reefs are more active forms of soft engineering.

The issues concerning coastal erosion are likely to be of increasing importance, should the predicted effects of global warming, such as the consequent rise in sea levels, occur. Whether a 'back to nature' strategy can be sustained in the face of potentially considerable loss of land is a moot point.

Bibliography

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Coastal management - Some Issues, Lynda Evans
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In addition to the usual sources, the following Internet sites were useful:
http://www.gov.uk
http://www.wwf-uk.org/news/news74.htm
http://www.rjcunningham.clara.net/rule_britannia

Focus Questions

1. Why is Mappleton threatened by coastal erosion?

2. How have human actions contributed to the erosion that destroyed Sue Earle's home? Include in your answer mention of the effect human actions have had on the coastal system at Mappleton.

3. (a)What do you understand by the policies of 'managed retreat' and 'beach feeding'?
(b) What do you consider to be the advantages and disadvantages of (i) hard sea defences? (ii) managed retreat? (iii) beach feeding?