British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

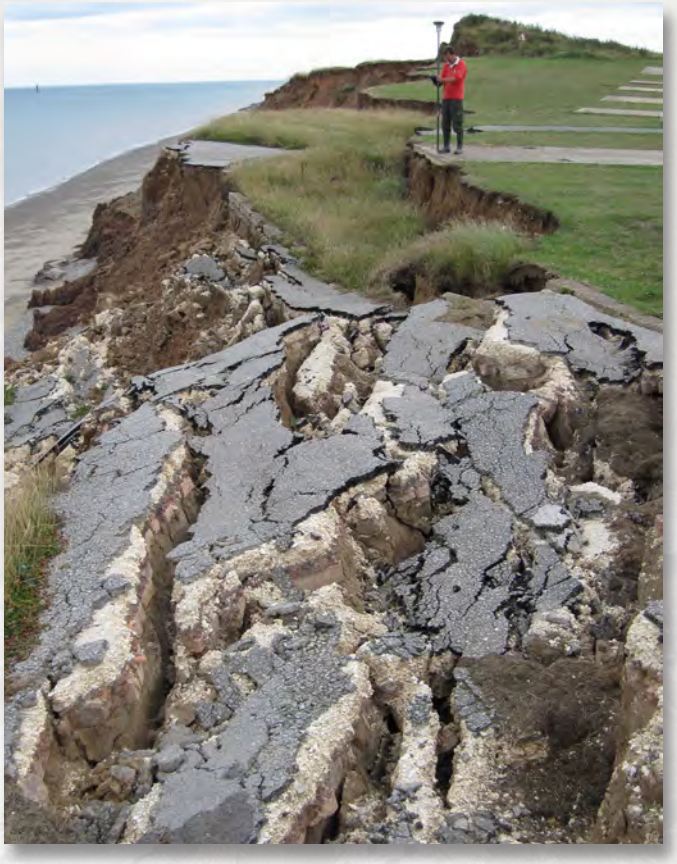
UK Geohazard Note

May 2012

Coastal Erosion

Overview

- Coastal erosion can be defined as the removal of material from the coast by wave action, tidal currents and/or the activities of man, typically causing a landward retreat of the coastline.
- The effects of coastal erosion can be observed on cliffs, tidal flats and salt-marshes, and beaches.
- Those most directly at risk from coastal erosion are those living in coastal lowland areas or along 'soft' sediment coastlines where coastal erosion can cause flooding, rock falls, loss of land and damage to infrastructure.
- Surveying and monitoring of coastal areas helps to gain better understanding of the physical processes involved as well as identifying susceptible locations at an early stage.



Cliff erosion at Aldbrough, Holderness Coast, East Riding of Yorkshire. Image © NERC.

Why does it occur?

The occurrence of coastal erosion is dependent upon the balance between the resistance, or erodibility, of the coastline and the strength, or erosivity, of the waves and tides affecting the area. These conditions are, in turn, reliant upon a number of factors, including:

- topography
- the composition and structure of the geological formations exposed at the coast
- the state of man-made coastal defences
- local currents and tidal range
- wave climate (as characterised by wave height, period, direction and fetch)
- groundwater
- sediment supply, and
- relative sea level

Consequently, rates of coastal erosion and accretion are very variable at regional, national and international scales.

What are the consequences?

Coastal erosion typically results in a landward retreat of the coastline. This can increase the risk of coastal flooding and result in loss of land and damage to buildings, infrastructure and agricultural land. Sudden coastal erosion events, particularly those in the vicinity of coastal cliffs, may directly endanger the lives of people. The movement of salt-water into freshwater areas (saline intrusion) can occur during coastal flooding and can impact upon the biodiversity of previously freshwater or terrestrial ecosystems.

What is the cost to the UK economy?

It has been estimated that across England and Wales 113 000 residential properties, 9000 commercial

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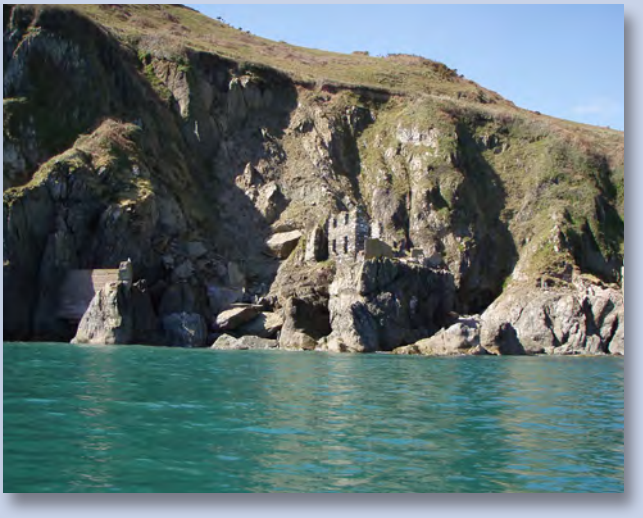
UK Examples

Hallsands, Devon: The ruined village of Hallsands lies at the south-western end of Start Bay, Devon. The cliffs in the vicinity have a slope-over-wall form, with the lower wall at Hallsands distinguished by a discontinuous raised platform of quartz and mica schists at approximately 7 m above sea level. This platform provided the foundation for the village and was originally fronted by a sand and gravel beach. In 1897 the Board of Trade licensed the removal of material from the intertidal zone at Hallsands. Approximately 1600 tonnes was removed daily for the extension of the Royal Dockyard at Devonport. By 1904 it was estimated that the beach level had fallen by as much as 6 m and that 97% of the former beach volume had been removed. In January 1917, a north-easterly gale with waves over 12 m in height combined with the gravel extraction and subsequent beach lowering led to the destruction of the village.



Hallsands, Devon. Image © NERC.

Happisburgh, Norfolk: The village of Happisburgh supports a population of approximately 1400 people in 600 houses. Now a coastal village, Happisburgh was once some distance from the sea, separated from the coastline by the parish of Whimpwell. Historic records indicate that over 250 m of land were lost between 1600 and 1850 AD. Coastal defences at Happisburgh have slowed down the rate of retreat, but large sections are now in disrepair and the area is believed to be subject to some of the highest coastal erosion rates in the UK. Monitoring surveys of the cliffs at Happisburgh by the BGS using dGPS and terrestrial LiDAR reveal a loss of 105 m of land between 1992 and 2004 (i.e. >8 m/year).

Holderness coast, East Riding of Yorkshire: The Holderness–Spurn Head coast is one of the most dynamic stretches of coastline in the UK. The relatively 'soft' glacial geology is subject to erosion and the average rate of coastal retreat is 1 to 2 m/yr although locally it may be much higher. Ongoing monitoring of beach profiles and cliffline position is undertaken by the BGS in order to aid understanding of the erosion mechanisms in operation.

properties and 5000 hectares of agricultural land are within areas potentially at risk of coastal erosion, which translate to a capital value of assets at risk of approximately £7.7 billion for England and Wales (DEFRA, 2001). A large proportion of the coastline is defended and replacement costs for these defence structures were estimated in 2001 at £10 300 km/yr for tidal flood defences, £32 300 km/yr for coastal flood defences and £53 700 km/yr for coast protection (DEFRA, 2001). Future climate change is likely to require a further increase in investment in order to mitigate the potential for future losses.

Susceptible locations

Coastal erosion is most likely to occur in coastal lowland areas and along 'soft' sediment coastlines. Such areas in the UK include the East Anglian coast, east Yorkshire and the Thames Estuary. The actual degree of coastal erosion can be dependent upon the state of coastal defences and areas down-drift

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of coastal defences may experience higher than expected erosion rates. Predicted future increases in relative sea level and storminess are likely to increase the area of the UK subject to coastal erosion in the future.

Scientific detail

Monitoring and measurement

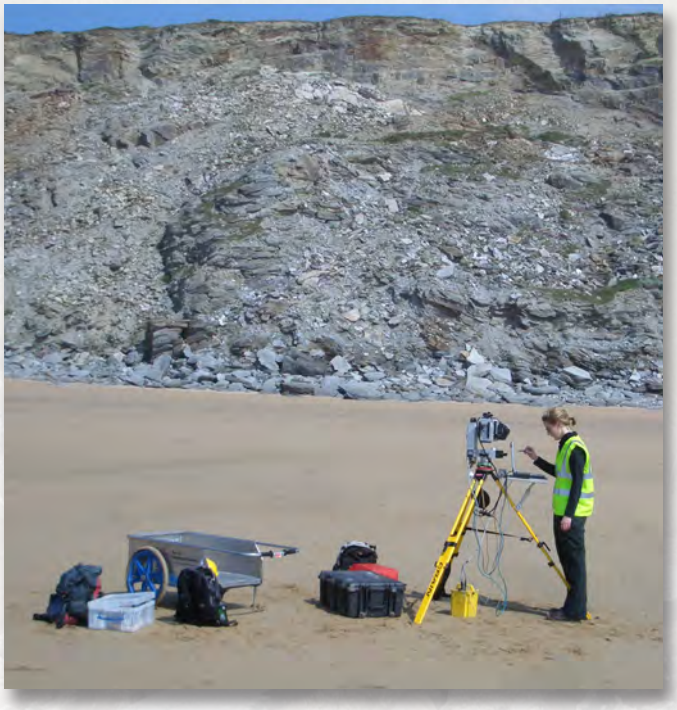
Repeat dGPS (an enhanced GPS that provides improved location accuracy) surveying and terrestrial LiDAR surveys provide perhaps the most accurate measurement of coastal profile change. Three–dimensional computer models of the coastline can be produced and volumetric change calculated. Aerial photographs and historic maps may also provide information on temporal variation in coastline position, although attention should be paid to the definition of the coastline provided in these data sources. For example, the land–water interface detailed in aerial photographs is tide–dependent and so information on the tide state must also be collected. Quantitative video monitoring of the coastline is also increasingly being employed.

How often is the hazard measured?

The BGS possesses the capability to respond to significant coastal erosion events using dGPS and terrestrial LiDAR surveys. Extensive repeat surveys of coastal erosion have been undertaken by the BGS at a number of locations throughout the UK, providing significant datasets spanning the last decade (http://www.bgs.ac.uk/research/climatechange/environment/coastal/caseStudies.html).

How is the hazard characterised?

Rates of erosion are the internationally recognised severity measure for coastal erosion and are used by BGS. These are typically averaged for a given spatial extent and timescale. Care must be taken in the choice of these conditions so as to minimise the effect of masking site-specific effects and/or the natural temporal periodicities of coastal erosion. Confidence intervals may also be given. Sediment volume eroded may also be used to characterise the severity of coastal erosion but may conceal risks in low-lying areas. In exceptionally severe cases figures for loss of life may be quoted.



LiDAR scanning of cliff sections. Image © NERC.

Secondary hazards

Coastal erosion may cause damage to buildings, infrastructure and utilities and any resulting debris may enter the coastal system, potentially endangering humans and coastal ecosystems. Disruption to gas utilities may also provide a fire hazard, disruption to water pipes a flooding hazard and disruption of the sewerage network a health hazard. Coastal erosion may increase flood risk. Finally, coastal erosion can result from coastal landsliding.

Triggering mechanisms

Factors such as the occurrence of storm events, changes to the state of engineered coastal defences, changing land use and sea level rise may alter the balance between resistance of the coastline and the strength of the eroding forces, triggering coastal erosion.

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Scenarios for future events

Predictions of future increases in relative sea level and storminess may result in increased coastal erosion rates in locations throughout the UK. Changes to storm tracks and tidal currents could also lead to alteration in the movement of coastal sediments, potentially creating new risks from coastal erosion. Coastal lowland areas and those with softer, less resistant geology will be among those most affected. The current trend towards the replacement of 'hard' coastal defences to softer strategies such as beach nourishment and managed realignment may in selected cases result in temporary increases in coastal erosion. Average annual damages with present levels of protection maintained have been estimated as £262.8 million per year for sea and/or tidal flooding and 16.6 million per year for coastal protection (DEFRA, 2001).

Monitoring and response by BGS

The BGS continues to monitor coastal erosion rates at Aldbrough, on the Holderness Coast, East Riding of Yorkshire. The BGS retains significant erosion datasets for locations throughout the UK and possesses the capability to respond to coastal erosion events using a variety of techniques. These include dGPS survey, terrestrial LiDAR scanning, in-field digital data capture and sediment analysis as well as desk-based examination of historic coastal erosion rates from resources such as aerial photographs and historic maps and other published sources. The BGS is developing its capacity to build 3D computer models of coastal morphodynamics. In addition, the 24-hour on-call Landslide Response Team monitors media alerts for landslide events and are available for rapid deployment to coastal landslide events. In addition, BGS also receives anecdotal evidence for coastal erosion through its Enquiries Service and through clients and customers.

Coastal defence measures at Hopton-on-sea, Norfolk, UK: wooden revetments and groynes. Image © NERC.

Partnerships and external sources of data

- DEFRA: The UK's Flood and Coastal Erosion Risk Management policy is set out by government, led by the Department for the Environment and Rural Affairs (www.defra.gov.uk).
- Environment Agency: The Flood and Water Management Act states that the Environment Agency must 'develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England' as part of its strategic overview role for flood and coastal erosion risk management (www.environment-agency.gov.uk/).
- Outside of BGS, expertise in coastal erosion lies within research organisations (e.g. universities and coastal groups) and environmental consultancies. Local authorities also possess significant site-specific knowledge.
- Foresight Flood and Coastal Defence Project http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence

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References and further information

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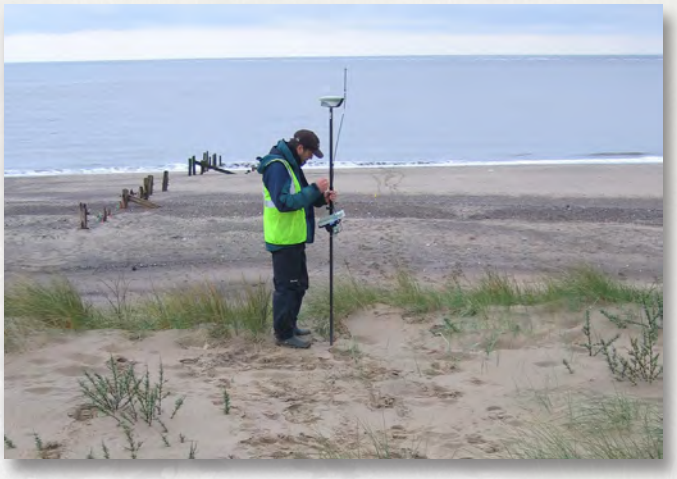
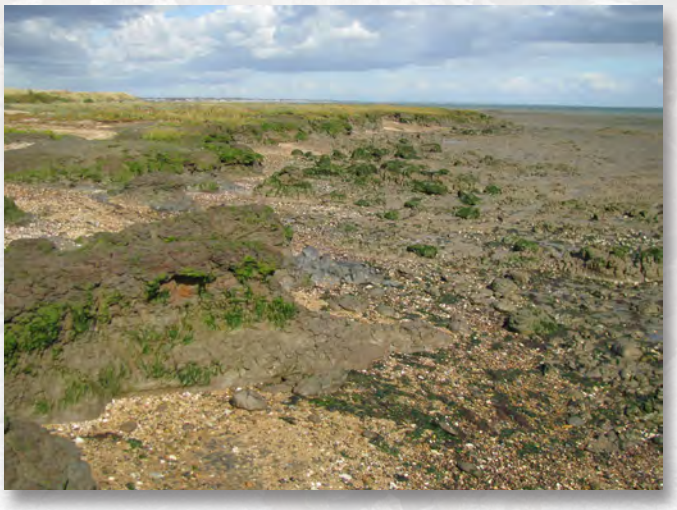


Differential GPS beach profiling at Spurn Point, Holderness, UK. Image © NERC.



Saltmarsh erosion in Essex. Image © NERC.

Further information

The BGS Coastal Erosion team can be contacted by:
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BGS Coastal Webpages: http://www.bgs.ac.uk/research/climatechange/environment/coastal/home.html