# spacerFlood alert!

Underline

## Introduction

Since time immemorial, coastal areas of eastern England and the Netherlands have been inundated repeatedly. Storm winds have raised sea levels and generated huge waves. Coastal defences have failed. Agricultural land has been flooded. People and their livestock have perished.



Contact Floodline for the latest flood warning information:
**0845 988 1188**


## Death and destruction

In the south-west of the Netherlands on 18 November 1421, water from the North Sea swept through 72 villages and 10,000 thousand people died. Again in 1570, 1825, 1894, 1916 and 1953, disastrous breaches of Dutch coastal defences occurred. For the people of the Netherlands, these defences have always been vitally important: 40 per cent of their country lies below mean sea level.

Along the coast of eastern England, too, from the Humber to the Thames, there have been many failures of coastal defences.

In a storm in 1897, for example, a kilometre and a half of the shingle spit at Orford Ness in Suffolk was washed away. And on 6-7 January 1928, a northerly gale raised water levels in the Thames Estuary so much that disastrous flooding of London occurred. At several places in the City, Southwark, Westminster and Hammersmith, water overtopped the embankments and low-lying riverside districts were flooded. When a section of the embankment near Lambeth Bridge collapsed, water rushed into the basements of nearby houses so quickly that people were unable to escape and 14 were drowned.


**Fig 1:** The coast of eastern England

## Surges

The deviation of the observed tide at a given place and time from the tide that would occur if there were no meteorological influence is called a surge.

A surge is positive if the water level is higher than the tide caused only by astronomical forces, negative if lower. Positive surges occur when water is driven towards a coast, negative when it is driven away.

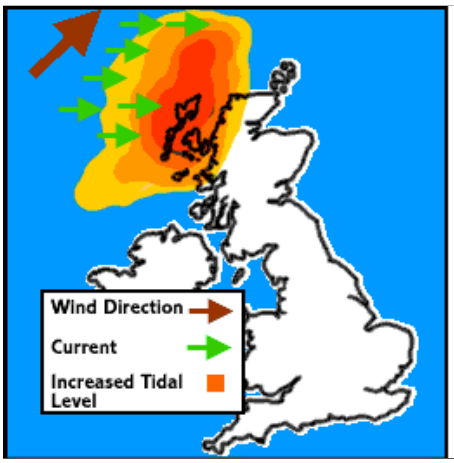
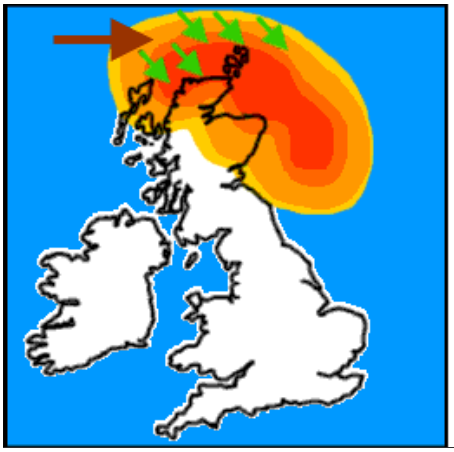



**Figure 1a.** Depressions traveling to the Northwest of Scotland with strong SW'ly surface winds generate a mean current which pushes water to the right of the wind direction. This causes an accumulation of water known as a positive surge.

This is an example of an external surge.

Print page
SpacerAbout
Met Office
A day in the life of...
Work experience
How to find us
News
What's new?
News release archive
Learn
About the weather
From the bookshelf
Training courses
How to become a weather observer
Services
Academic research
Library and archive
Links
Curriculum Online
NGfL
VTC
Nelson Thornes
MetLinkInternational
Educational webpages
Contact
Contact us




Surge Example

Surges are caused mainly by the action of wind on the surface of the sea, with barometric pressure a secondary factor. When pressure decreases by one millibar, sea level rises by one centimetre. Thus, a deep depression with a central pressure of about 960 mb causes sea level to rise half a metre above the level it would have been had pressure been about average (1013 mb). When pressure is above average, sea level correspondingly falls.

The effect of a strong wind coupled with very low pressure can be to raise sea level in eastern England more than two metres. Fortunately, though, large positive surges tend to favour mid-tide. They rarely coincide with high water.

The strong winds that create surges also generate large waves. Embankments are usually high enough and other coastal defences sound enough to protect against all but the highest of surges. However, waves wash away protective dunes, and batter sea walls relentlessly, weakening them until they fail. They break over coastal defences, too, undermining the foundations on the landward side, until structural failure occurs.

**Fig 3:** Waves breaking on the beach. Photo© Environment Agency

The greatest surge on record for the North Sea as a whole occurred on 31 January and 1 February 1953. Its amplitude reached 2.74 m at Southend in Essex, 2.97 m at King's Lynn in Norfolk and 3.36 m in the Netherlands.

Almost 100,000 hectares of eastern England were flooded and 307 people died. In the Netherlands, 50 dykes burst and 1,800 people drowned. The flood covered nine per cent of all Dutch agricultural land and three per cent of the dairy country. The sea reclaimed over 200,000 hectares of polder country.

**Fig 4:** The flooding of 1953. Photos © Environment Agency

## Storm tide warnings

To some extent, the disastrous surge of 1953 was predicted successfully by the Met Office and the Dutch Surge Warning Service, in that forecasts of dangerously high water levels were issued several hours before they occurred. Nevertheless, the committee appointed by the British government to inquire into the disaster recommended that a flood-warning organisation be set up. This recommendation was implemented, the name 'Storm Tide Warning Service' being adopted later. Its Dutch counterpart had been established soon after the great surge of January 1916, when the dykes of the Zuyder Zee were breached in many places and vast areas of the Netherlands inundated.

The storm that caused the disastrous surge at the end of January 1953 was among the worst to visit the UK in the 20th century. Hurricane-force winds had blown down more trees in Scotland than were normally felled in a year. A car ferry, the Princess Victoria, on passage from Stranraer in Scotland to Larne in Northern Ireland, sank with the loss of 133 lives. Only 41 of the passengers and crew survived. From Yorkshire to the Thames Estuary, coastal defences had been pounded by the sea and given way under the onslaught.

During the afternoon of 31 January, the shingle spit of Spurn Head in Yorkshire was breached. Soon after darkness fell, Lincolnshire bore the brunt of the storm. Sand was scoured from beaches and sand hills, timber-piled dunes were breached, the landward slopes of embankments were eroded, concrete sea walls crumbled, the promenades of Mablethorpe and Sutton-on-Sea were wrecked, and saline water from the North Sea flooded agricultural land.

Later that evening, embankments around The Wash were overtopped and people were drowned in northern Norfolk. Fifteen died in King's Lynn and another 65 between there and Hunstanton. At Wells-next-the-Sea, a 160-ton vessel was left high and dry on the quay.

**Fig 5:** Boats washed ashore by high seas.

Surges travel counter-clockwise around the North Sea basin, first southwards down the western side of the basin, then northwards up the eastern side. They take about 24 hours to progress from north-east Scotland to south-west Norway.

In 1953, because many telephone lines in Lincolnshire and Norfolk had been brought down by the wind, virtually no warnings of the storm's severity were passed to counties farther south until it was too late. Suffolk and Essex suffered most.

By midnight, Felixstowe, Harwich and Maldon had been flooded, with much loss of life. Soon after midnight, the sea walls on Canvey Island collapsed and 58 people died. At Jaywick in Clacton, the sea rose a metre in 15 minutes and 35 people drowned.

The surge travelled on. From Tilbury to London's docklands, oil refineries, factories, cement works, gasworks and electricity generating stations were flooded and brought to a standstill.

In London's East End, 100 metres of sea wall collapsed, causing more than 1,000 houses to be inundated and 640,000 cubic metres of Thames water to flow into the streets of West Ham. The BP oil refinery on the Isle of Grain was flooded, and so too was the Naval Dockyard at Sheerness.

## From depression to flood

In the early hours of 30 January, the storm that was to wreak so much havoc was an unremarkable depression with a central pressure of 996 mb located a little to the south of Iceland. Such a depression here was not unusual. During that day, however, the depression deepened rapidly and headed eastwards.

By 1800 UTC on 30 January, it was near the Faeroes, its central pressure 980 mb By 1200 UTC on 31 January, it was centred over the North Sea between Aberdeenshire and southern Norway and its central

pressure was 968 mb

Meanwhile, a strong ridge of high pressure had built up over the Atlantic Ocean south of Iceland, the pressure within being more than 1030 mb In the steep pressure gradient that now existed on the western flanks of the depression, there was a very strong flow from a northerly point. Winds of Force 10 were reported from exposed parts of Scotland and northern England and a gust of 56 m/s was measured on the Orkney Islands. The depression turned south-east and deepened to 966 mb before filling. By 1200 UTC on 1 February, it lay over northern Germany, its central pressure now 984 mb.

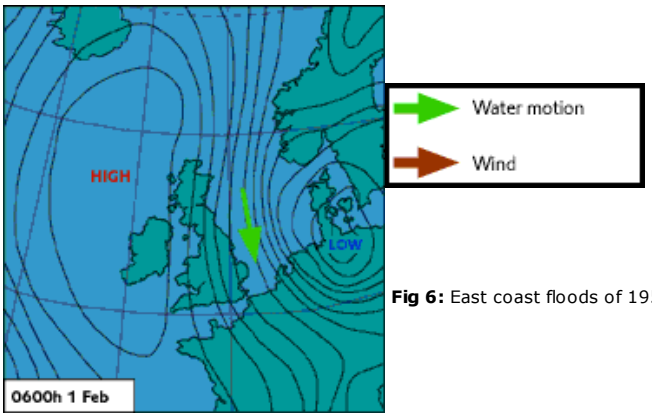



**Fig 6:** East coast floods of 1953

In the deep water of the open ocean in the northern hemisphere, winds drive water 45° to the right of the wind. In the southern hemisphere, they drive it 45° to the left. In shallow water, the angle between wind direction and resulting current is considerably less. The deviation is caused by the effect of Earth's rotation, the so-called 'Coriolis effect', through which moving objects are deviated to the right in the northern hemisphere, left in the southern. In western parts of the southern North Sea, where the water depth is around 15-25 m, the angle of deviation is 20-30°.

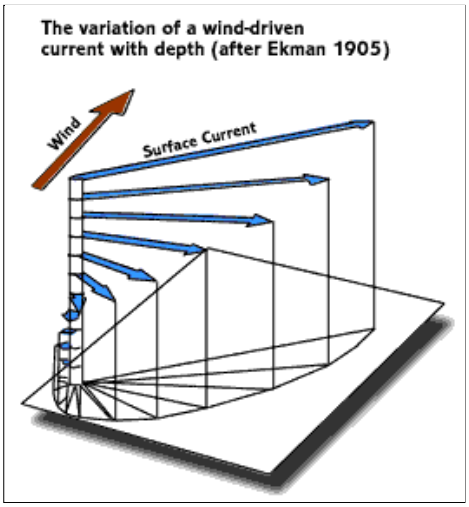



**Fig 7:** The variation of a wind-driven current with depth (after Ekman 1905)

All day on 31 January, winds blew from the north over western parts of the North Sea, with a strength of Force 10 or 11. They drove water south-south-westwards, and generated waves more than eight metres high. The surge originated in the waters off the north-east coast of Scotland and was amplified as it travelled first southwards along the eastern coasts of Scotland and England, and then north-east along the coast of the Netherlands. It reached Ijmuiden in the Netherlands around 0400 UTC on 1 February.

Since 1953, there have been other large surges in the North Sea, among them one, on 12 January 1978, that caused extensive flooding and damage along the east coast of England from Humberside to Kent. London came close to disaster, escaping inundation by only 0.5 m, and the enormous steel and rubber floodgates designed to protect the major London docks were closed for the first time since their completion in 1972.

## Flood defences

Concern over rising sea levels, isostatic subsidence of south-east England and the appalling consequences of a major flood in central London led to the construction of the Thames Flood Barrier near Woolwich. This was completed in 1982.

Incidentally, the earliest record of a flood in London, dated 1099, is found in the Anglo-Saxon Chronicle: 'On the festival of St Martin (11 November), the sea flood sprung up to such a height and did so much harm as no man remembered that it ever did before'.

Over the years, coastal defences in the Netherlands and eastern England have been raised and strengthened continually to protect against storm surges. Our coasts and estuaries are safer now than they have ever been. Nevertheless, surges remain a threat, as complete protection against the most extreme can never be guaranteed. At least the likelihood of being taken by surprise is now rather low, because weather and surge forecasting systems have improved greatly in recent years, and the Storm Tide Forecasting Service has established clear and effective procedures for alerting the authorities when danger threatens.

## Key Stage 3 Relevance

(using terminology in the latest version of the National Geography Curriculum)

### Geographical enquiry and skills

- Changes in coastal environments
- Extension of geographical vocabulary

### Knowledge and understanding of places

- How and why changes happen in places

### Knowledge and understanding of patterns and processes

- Relevant to all of this section of the curriculum

### Knowledge and understanding of environmental change

- Describe and explain environmental change and recognise ways of managing it

### Breadth of study

- Geomorphological processes
- Causes and effects of a hazard and human responses to it
- Knowledge of weather and climate
- Issues of topical significance

### Locational knowledge

- Parts of the UK
- The seas around the UK
- Reference to another country in Europe

Spacer
www.metoffice.com (C)Crown copyright