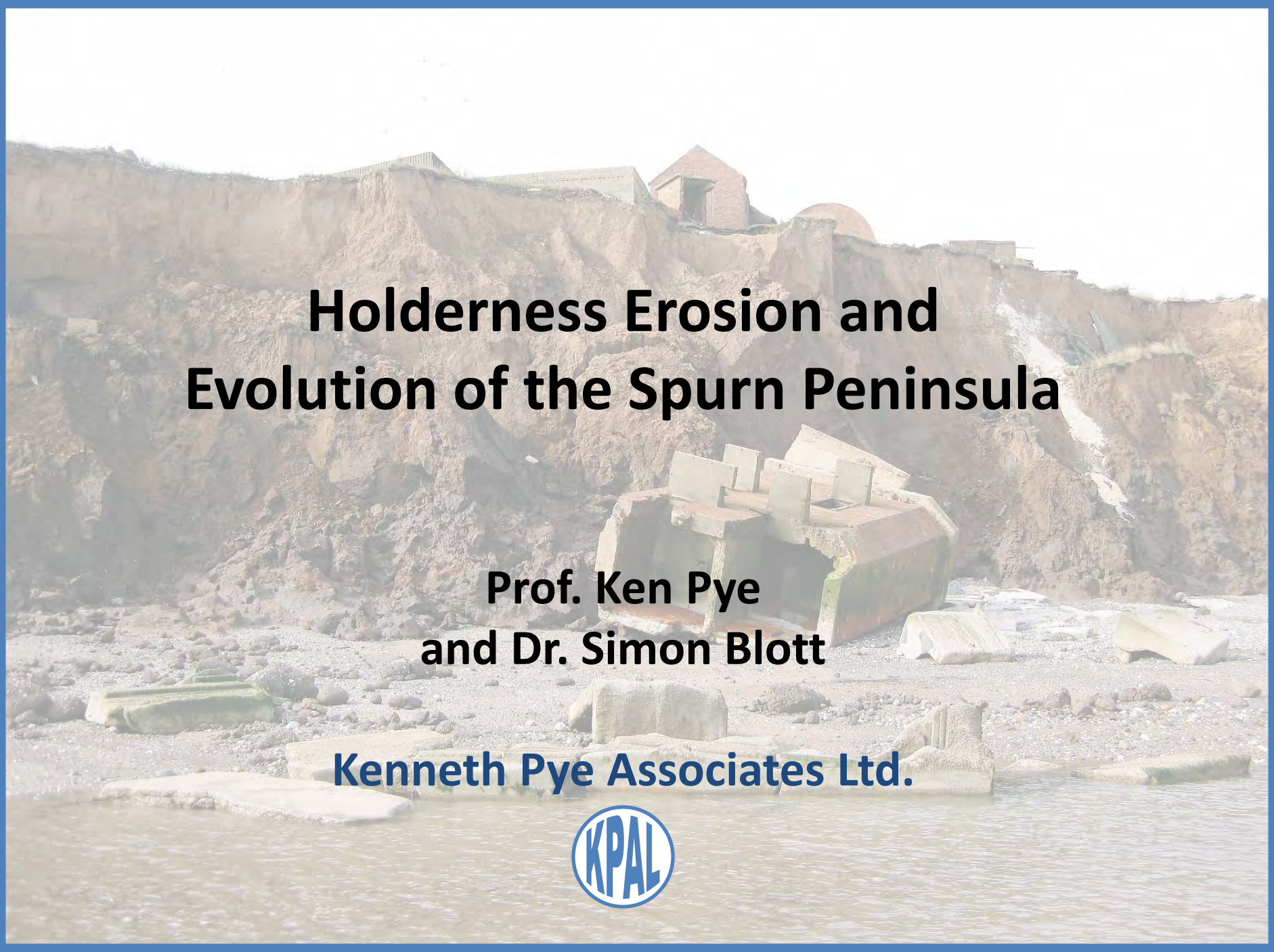


Holderness Erosion and Evolution of the Spurn Peninsula

Prof. Ken Pye
and Dr. Simon Blott

Kenneth Pye Associates Ltd.

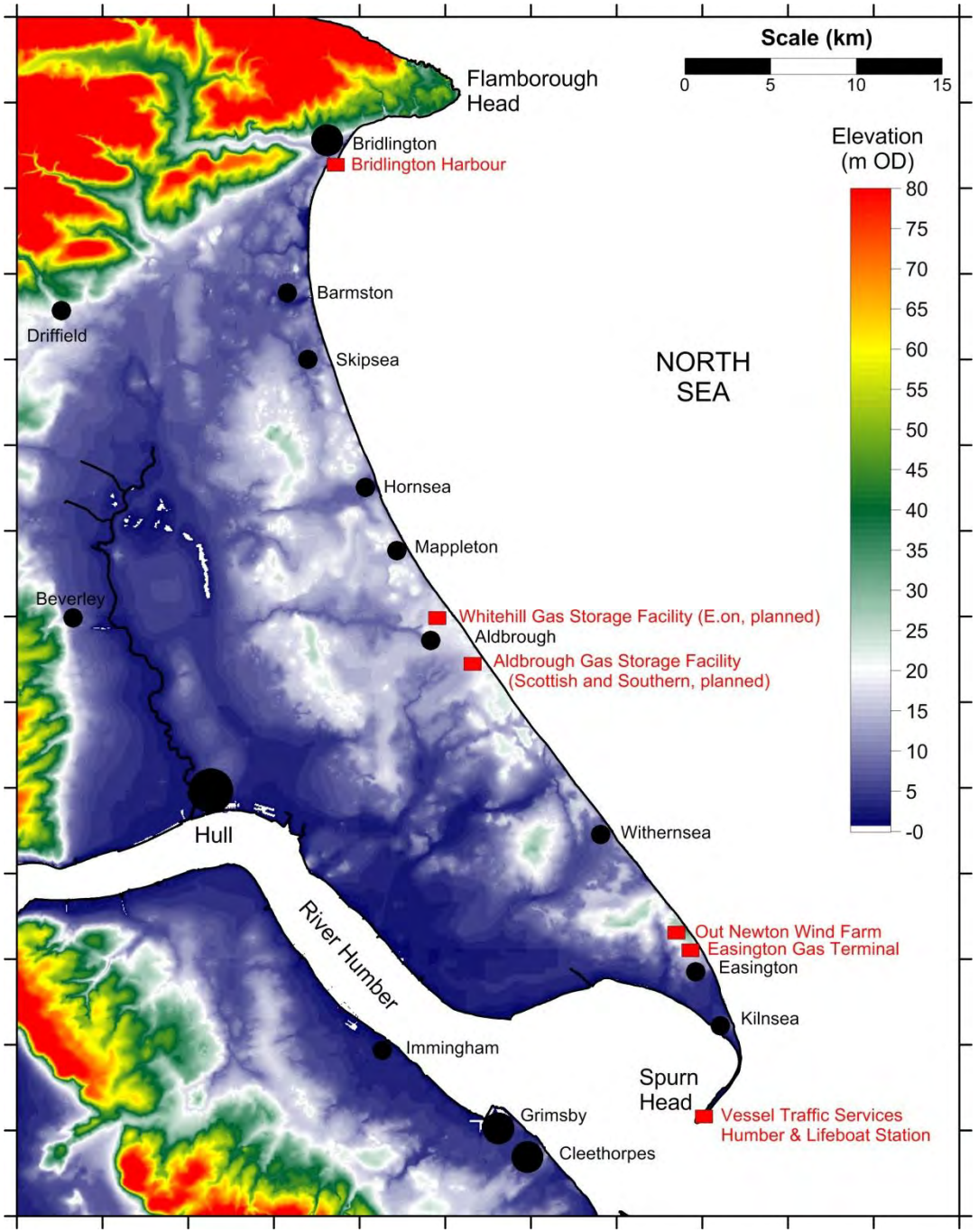
Outline of the Presentation

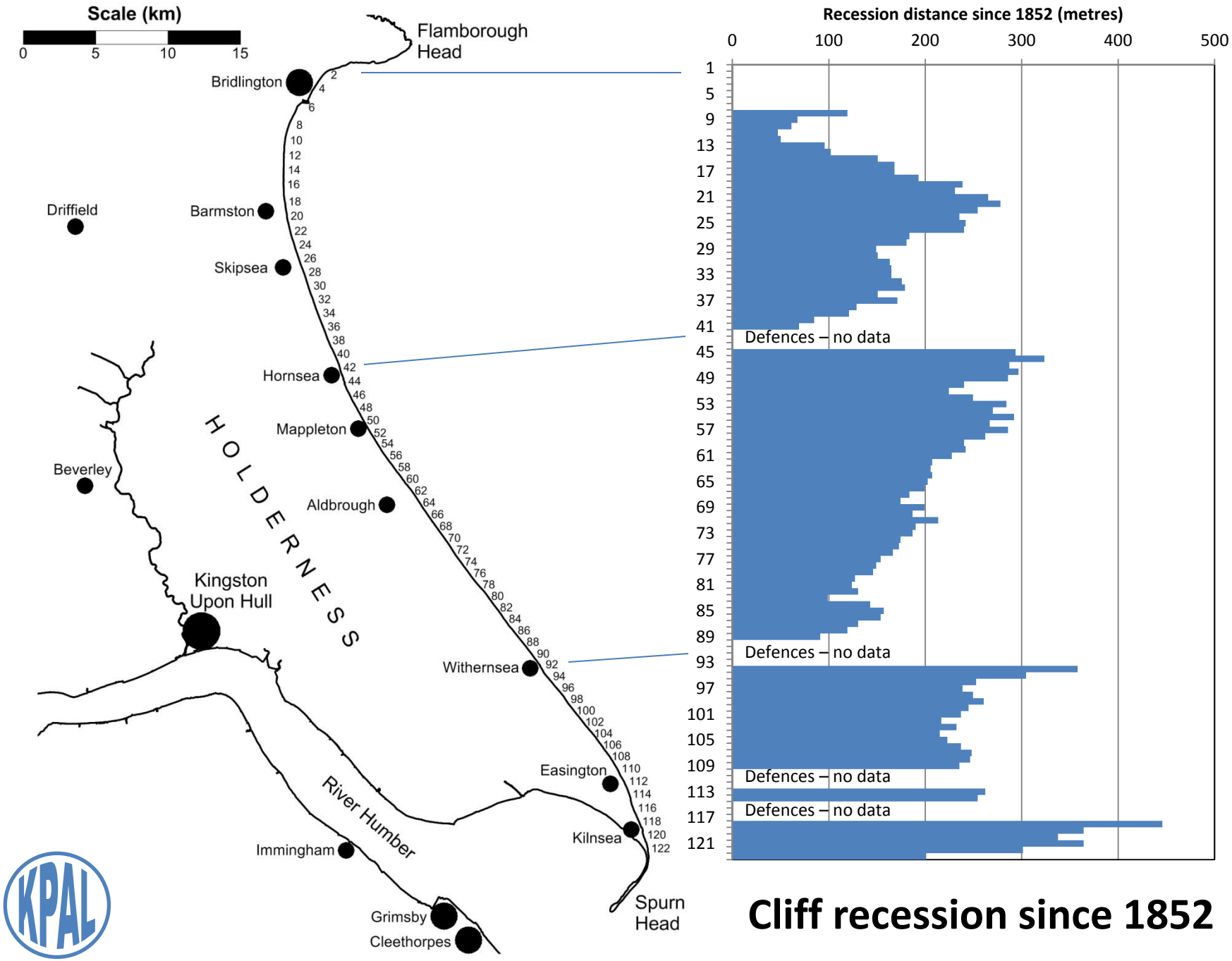
- Overview of historical erosion trends
- Effects of coast protection works
- Controls on unprotected cliff erosion
- Aldbrough area case example
- Kilnsea area case example
- Historical evolution of the Spurn Peninsula
- Coastal processes and sediment transport
- Projected coastal evolution
- Uncertainties and requirements for further work

The Holderness Coastline.

Terrain model from Ordnance Survey OpenData.

Major infrastructure shown in red.





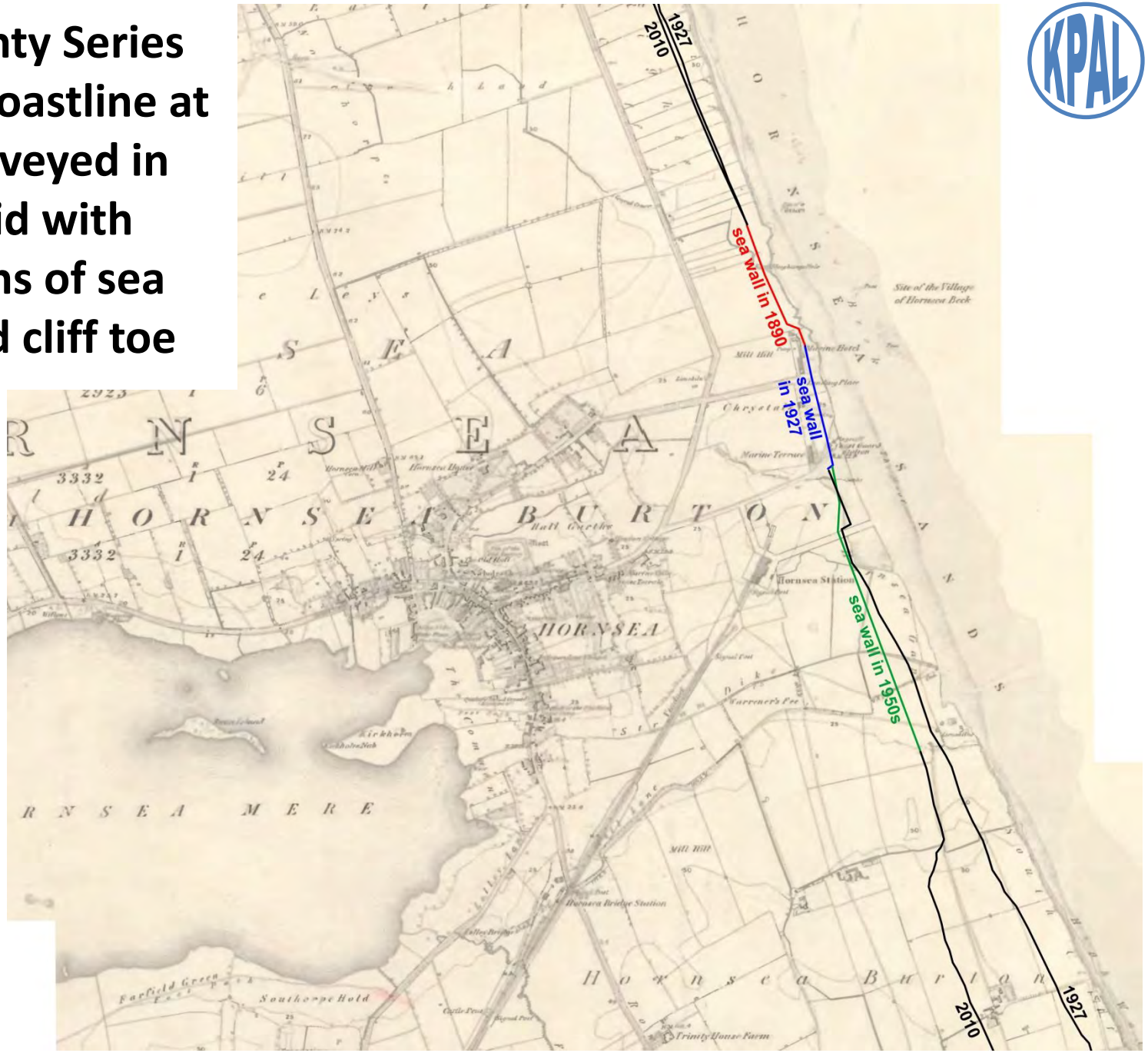
Cliff recession since 1852

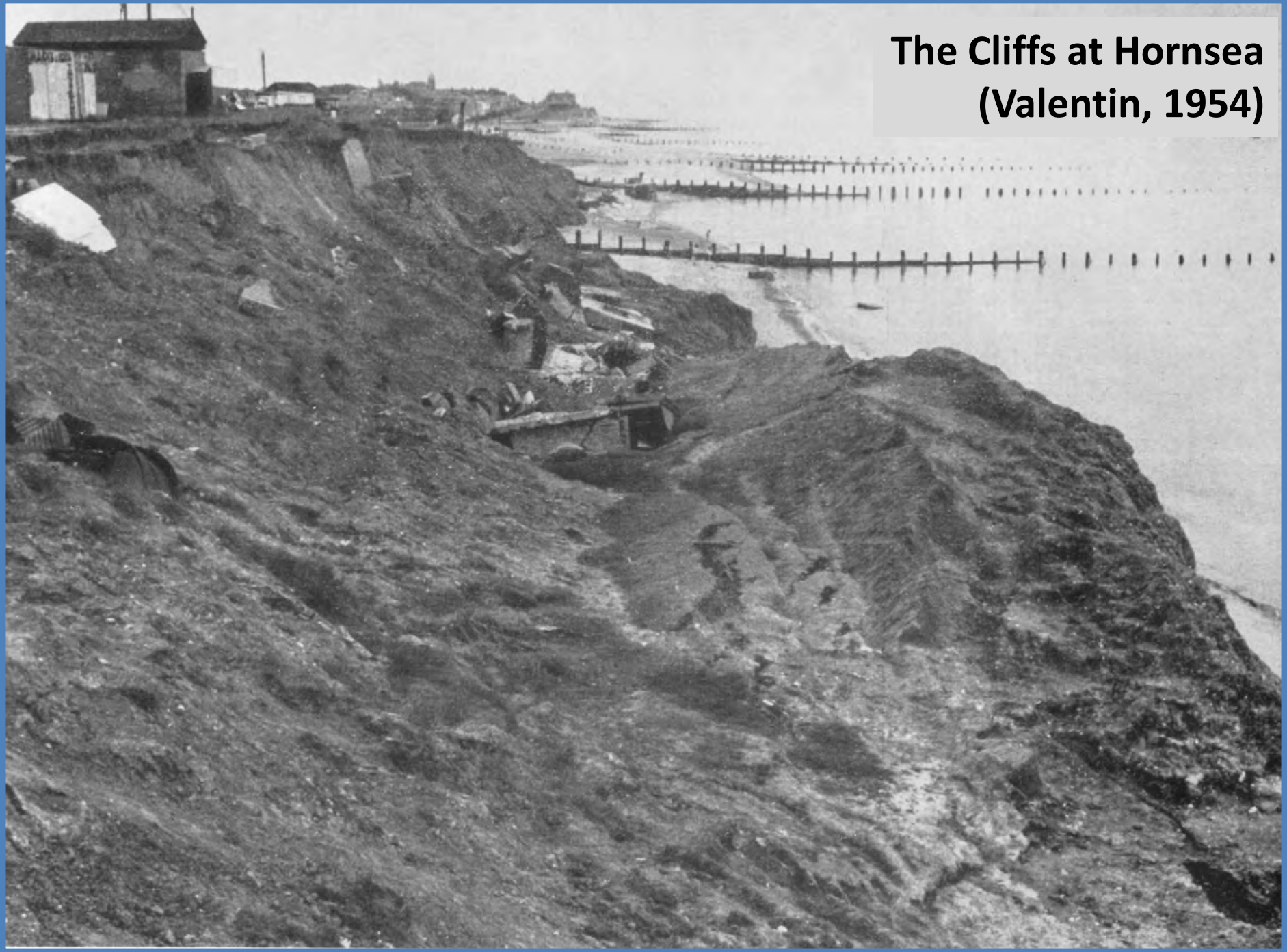
The coast at Withernsea

The sea defences at Withernsea

The sea defences at Hornsea

Six inch County Series map of the coastline at Hornsea, surveyed in 1852, overlaid with later positions of sea defences and cliff toe



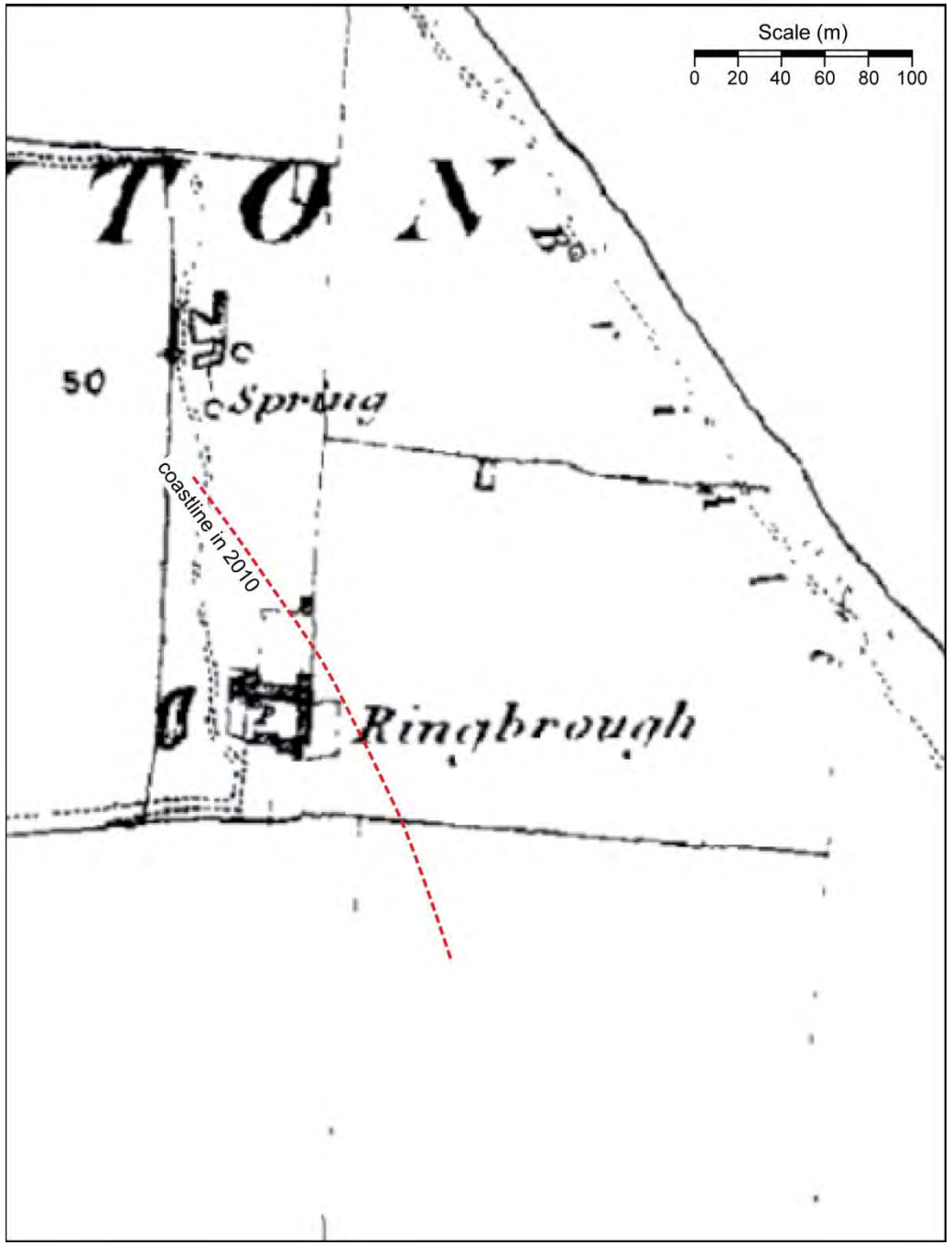

The Cliffs at Hornsea
(Valentin, 1954)

Air photograph of the southern end of Hornsea frontage, with cliff toe positions from OS maps

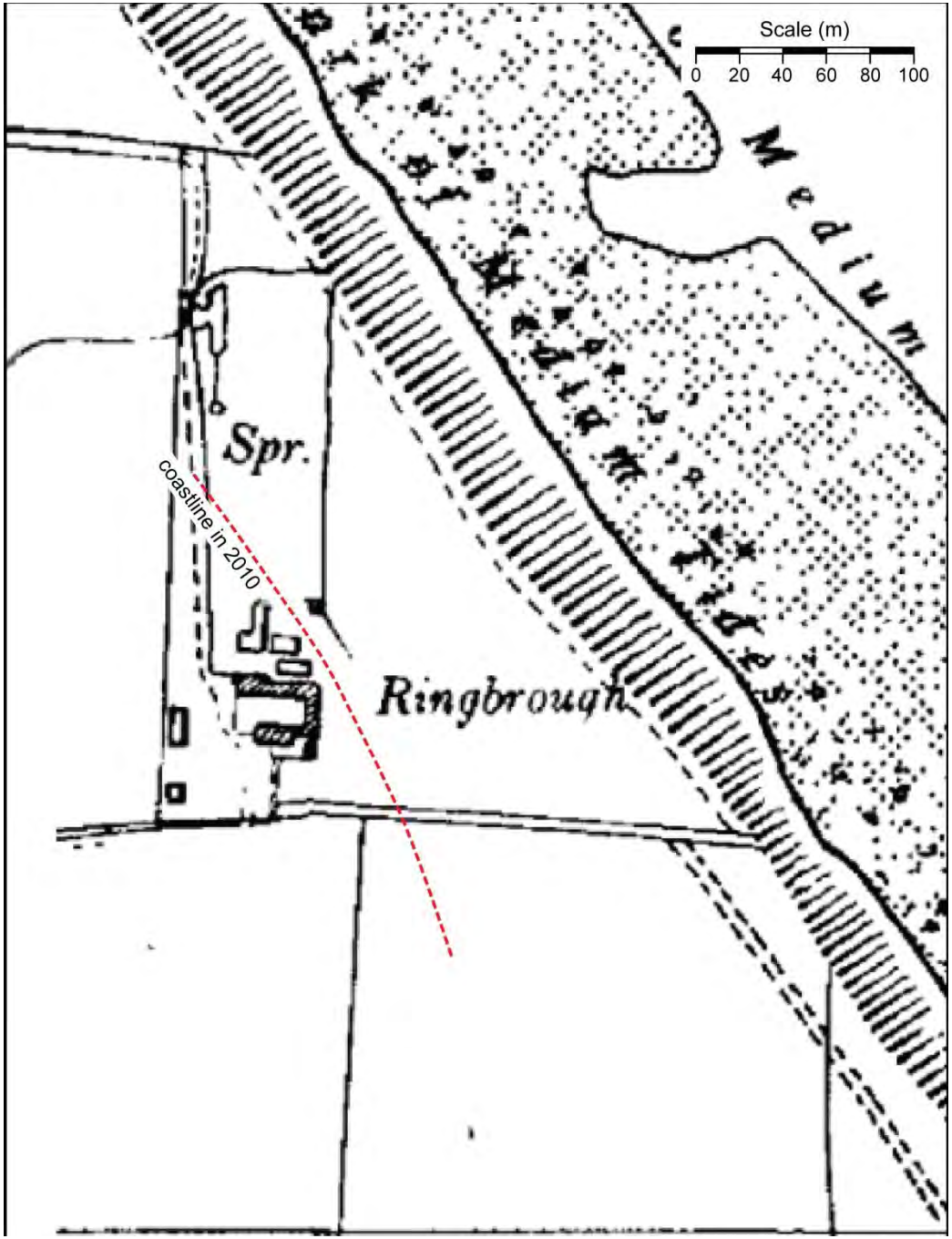
Air photo from Google Earth (taken 2007)

The cliffs near Mappleton

Six inch County Series map of the coastline at Ringbrough Farm, surveyed in 1852



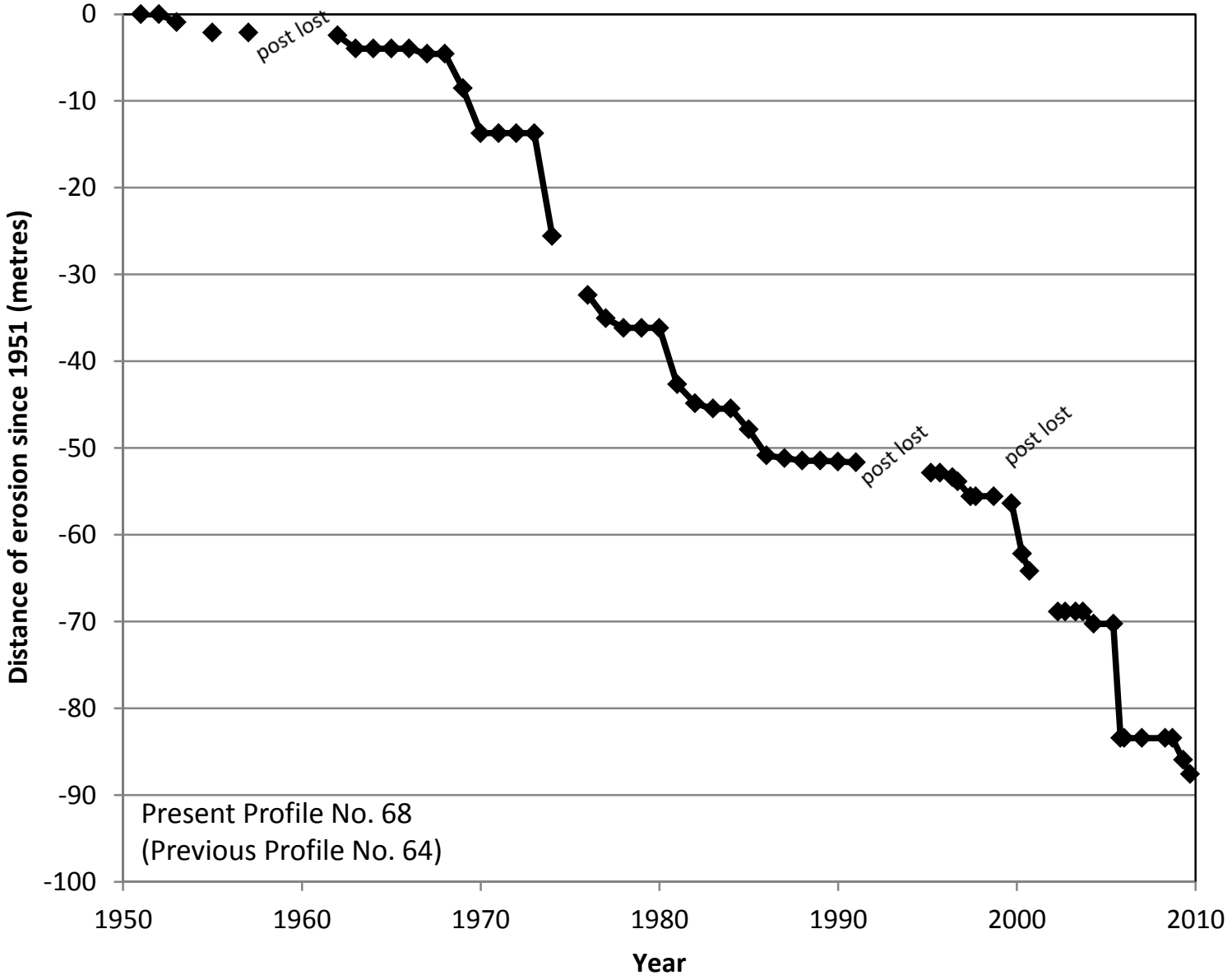
Ordnance Survey map of the coastline at Ringbrough Farm, surveyed in 1952



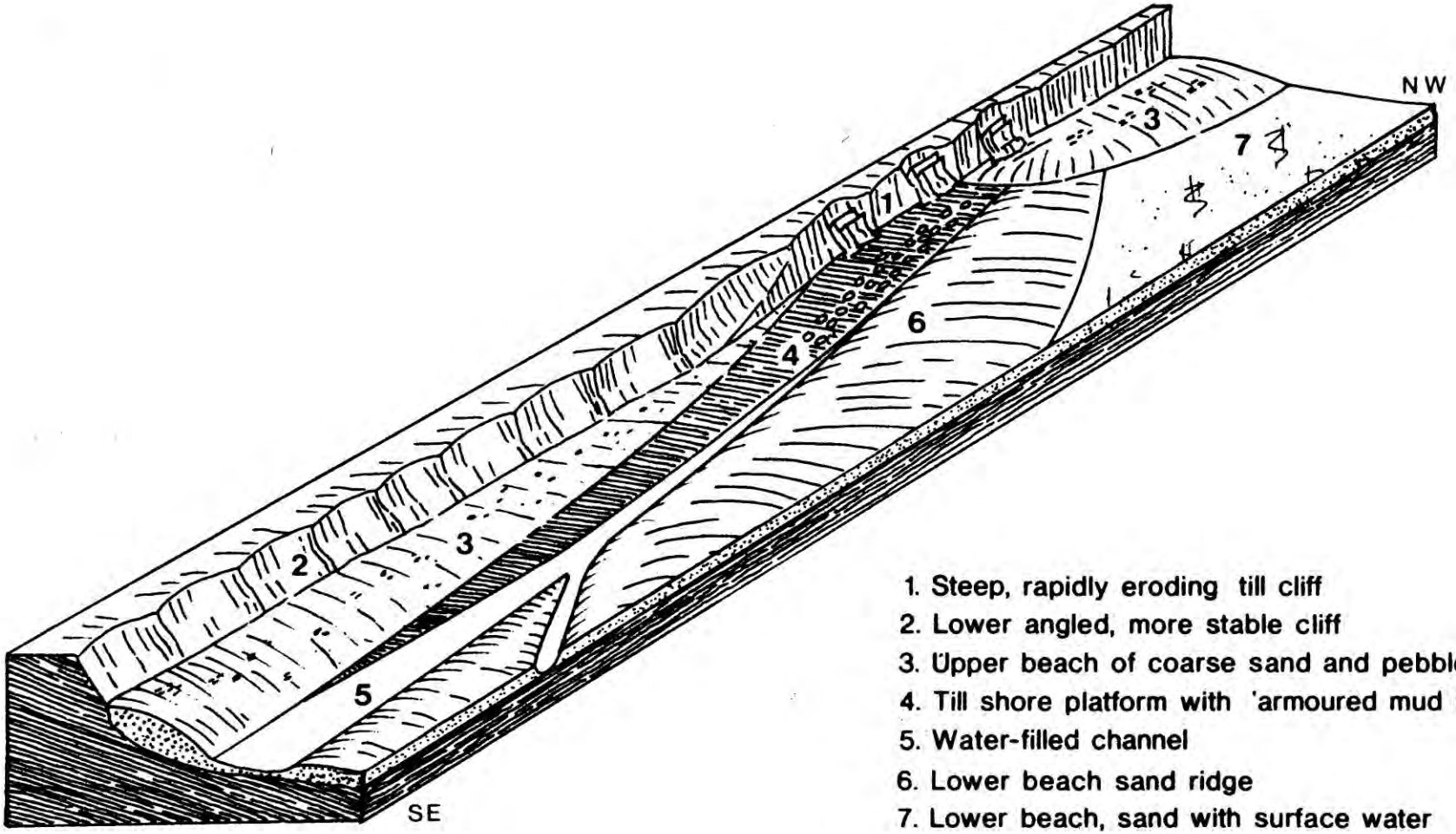
Aerial photographs of the coastline at Ringbrough Farm, taken in *c*. 2000

Aerial photographs of the coastline at Ringbrough Farm, taken 7th May 2007

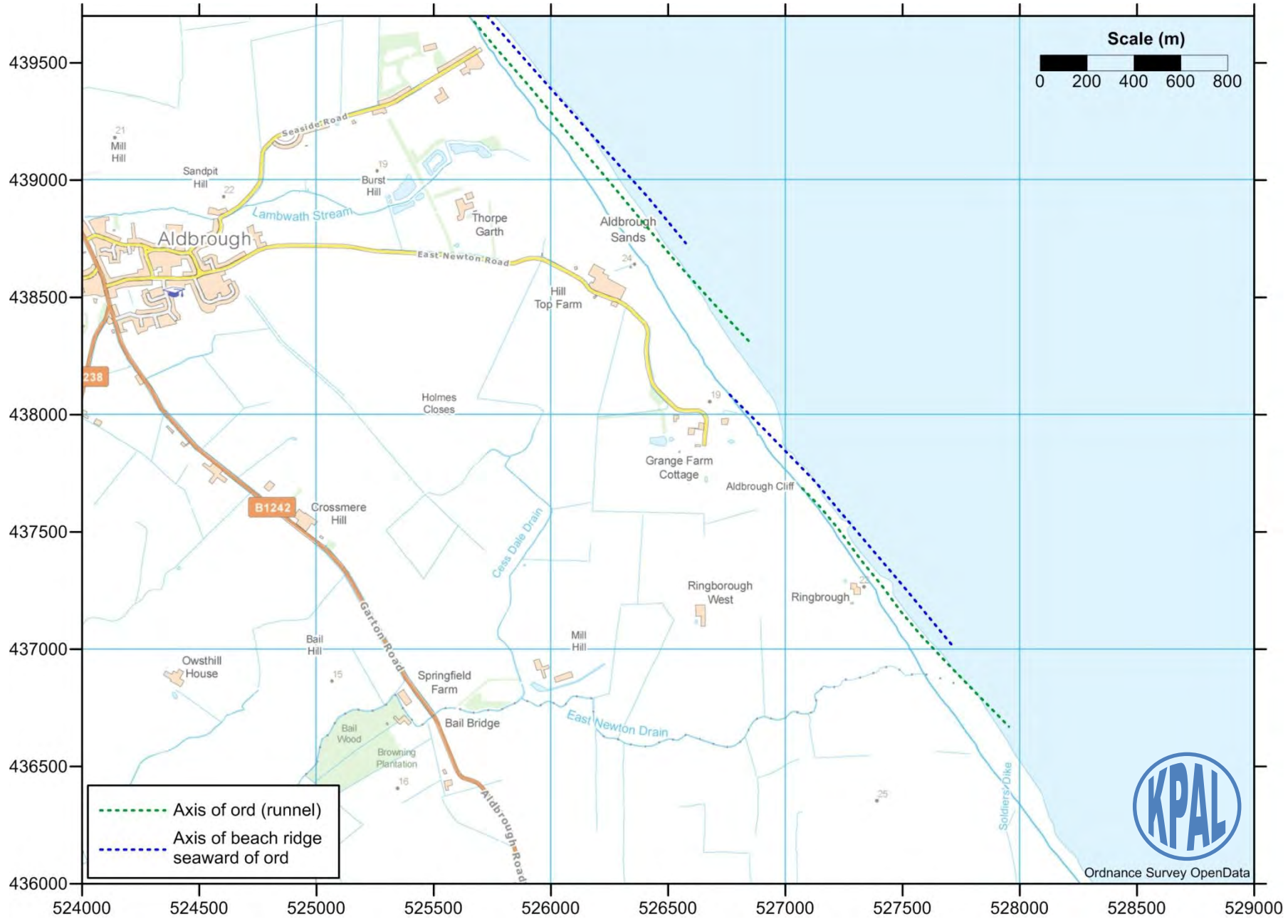
Distances of cliff erosion at Profile 68 (Ringbrough Farm) 1951 to September 2009



Schematic diagram of a Holderness ord (after Pringle, 1985)

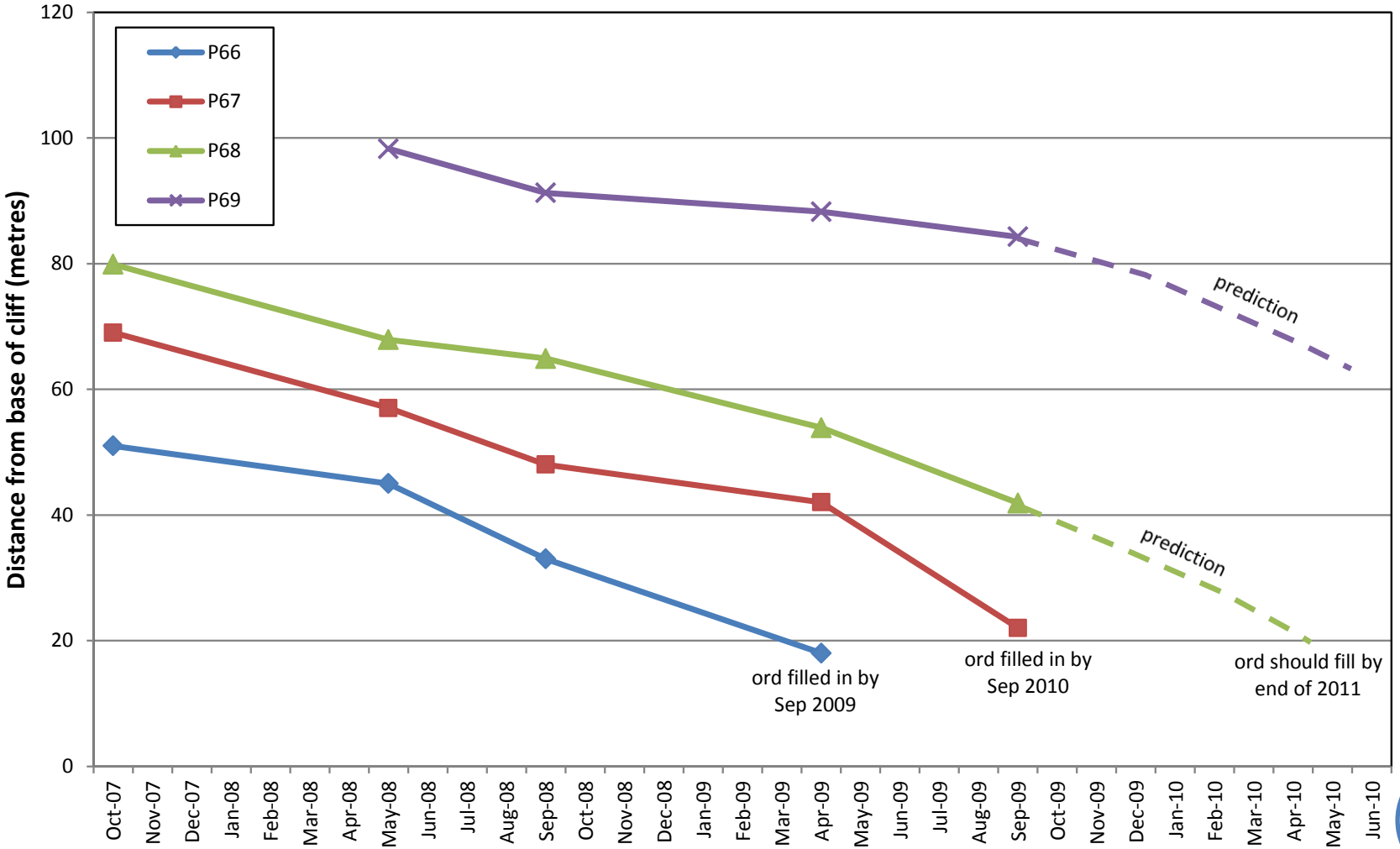


1. Steep, rapidly eroding till cliff
2. Lower angled, more stable cliff
3. Upper beach of coarse sand and pebbles
4. Till shore platform with 'armoured mud balls'
5. Water-filled channel
6. Lower beach sand ridge
7. Lower beach, sand with surface water


Scale (m)
0 200 400 600 800
Axis of ord (runnel)
Axis of beach ridge seaward of ord
Aldbrough
Mill Hill
Sandpit Hill
Burst Hill
Seaside Road
Lambwath Stream
Thorpe Garth
Aldbrough Sands
East Newton Road
Hill Top Farm
Holmes Closes
Grange Farm Cottage
Aldbrough Cliff
B1242
Crossmere Hill
Cass Dale Drain
Ringborough West
Ringborough
Garton Road
Bail Hill
Owsthill House
Springfield Farm
Mill Hill
Bail Bridge
Bail Wood
Browning Plantation
East Newton Drain
Aldbrough Road
Soldiers Dike
KPAL
Ordnance Survey OpenData
439500
439000
438500
438000
437500
437000
436500
436000
524000
524500
525000
525500
526000
526500
527000
527500
528000
528500
529000


KPAL

Measurements of the distances to the deepest part of an ord at four profile locations (P66 to P69) near Ringbrough Farm between October 2007 and September 2009

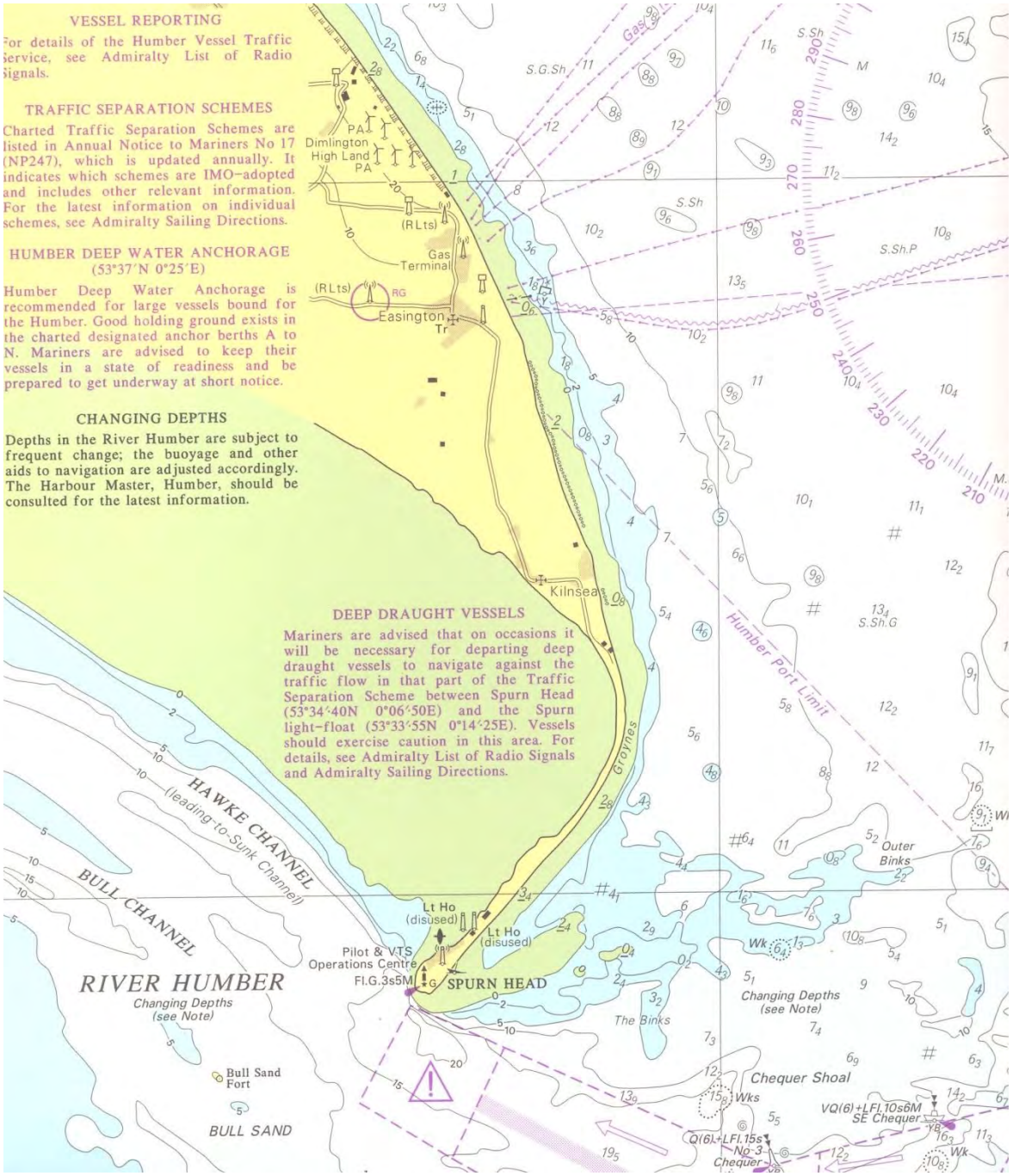


Superficial geology map of the Kilnsea and Spurn area

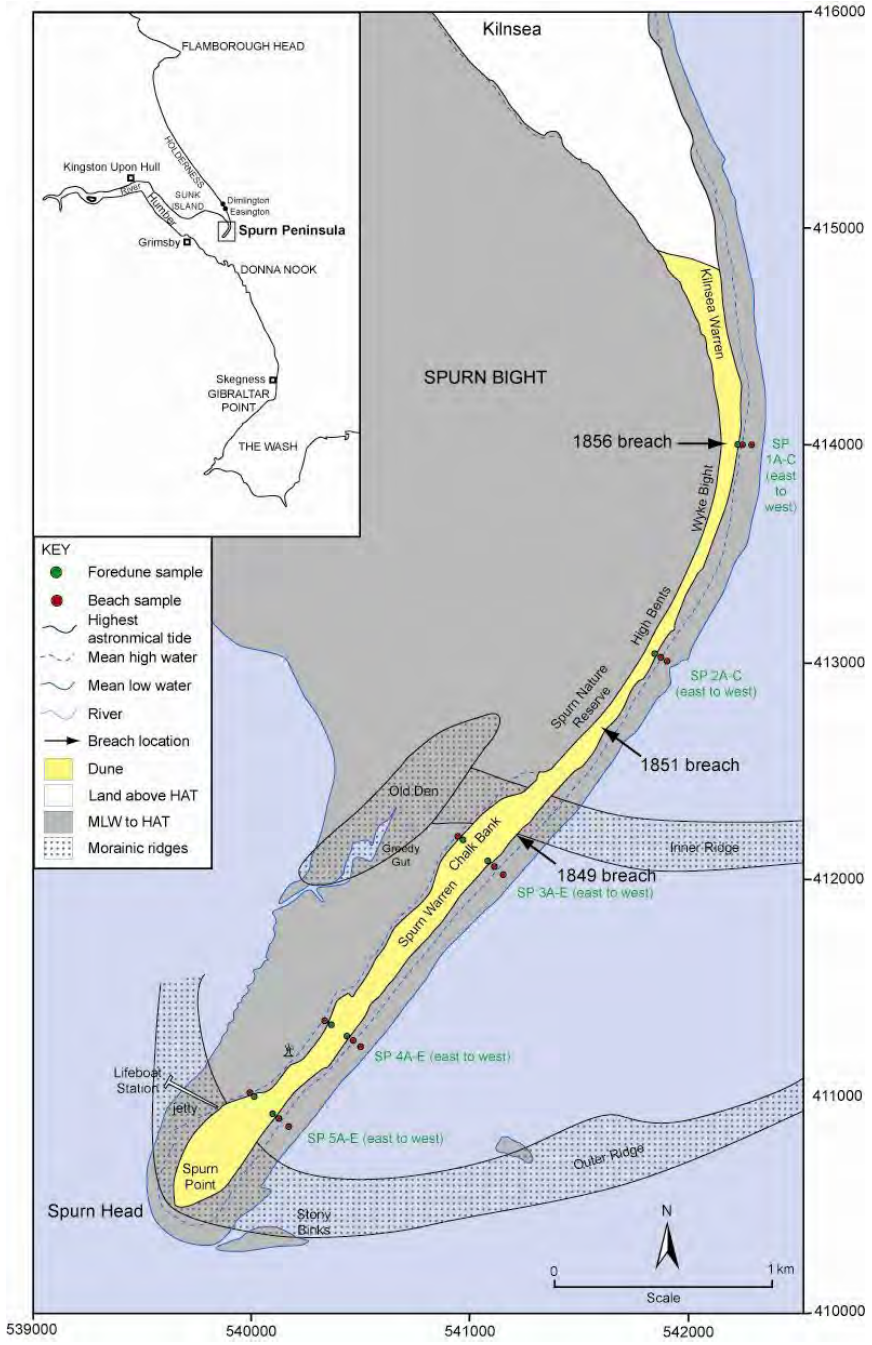
BGS 1:50,000 scale survey.

Admiralty chart of the southern Holderness coastline and Spurn Head

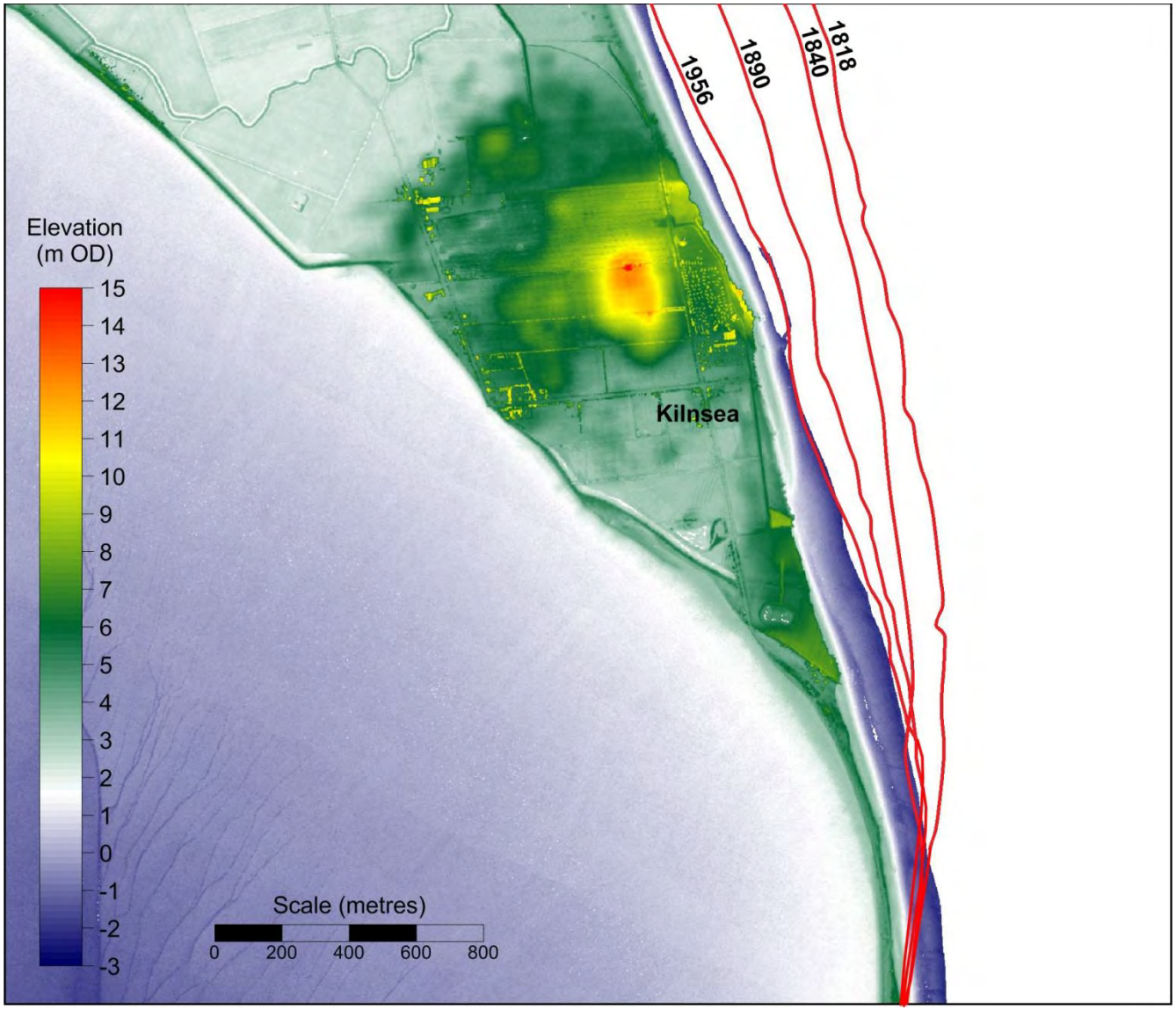
Chart 107 “Approaches to the River Humber”



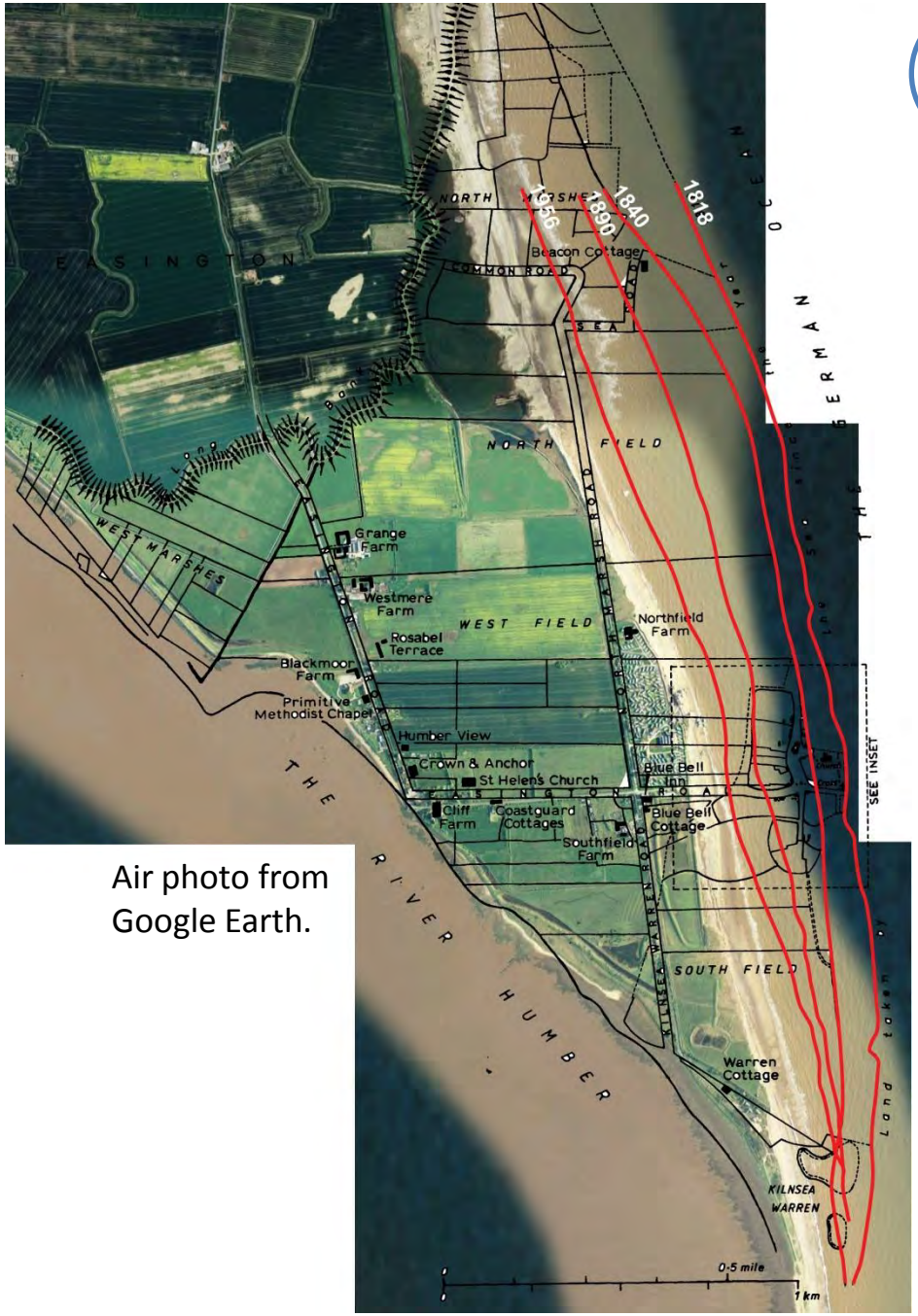
The Spurn Peninsula, showing dune and beach sampling locations



Digital Elevation Model of Kilnsea (LiDAR flown May 2000) with coastline positions from historical maps

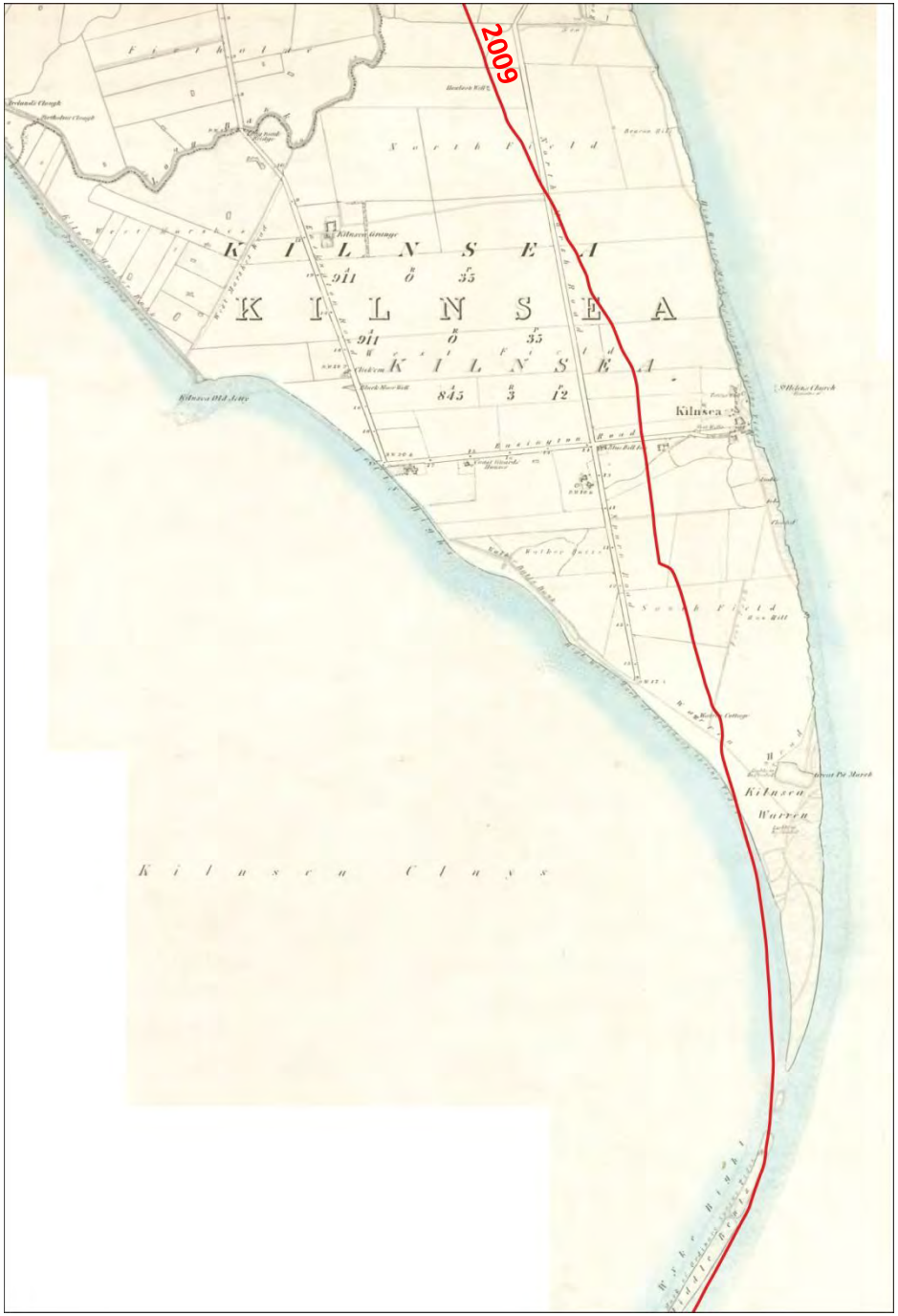


Aerial photograph of Kilnsea taken 2007, overlain with enclosure map surveyed 1818 and 1840, and cliff toe positions surveyed by the Ordnance Survey in 1890 and 1956.

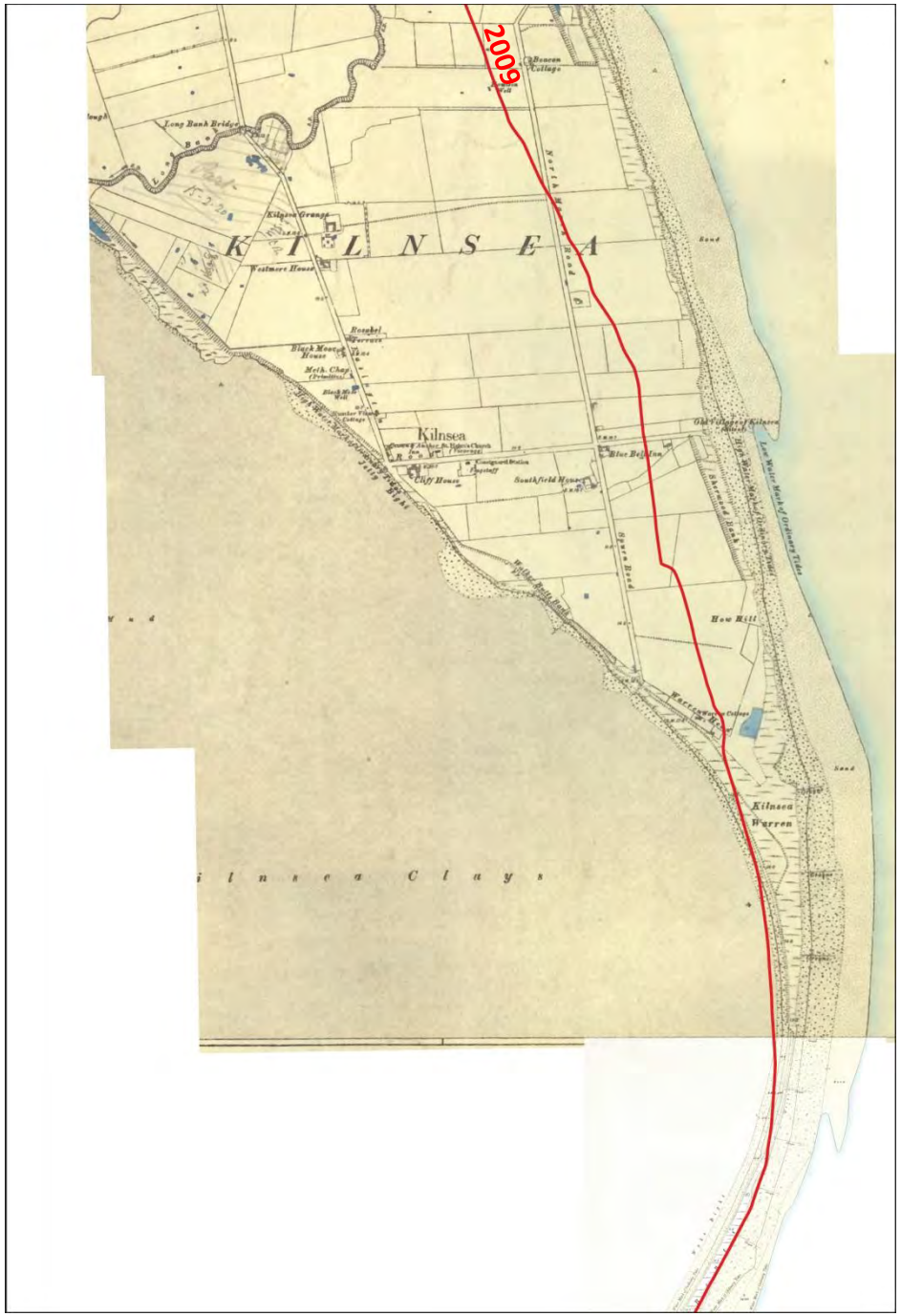


Air photo from Google Earth.

Ordnance Survey map of Kilnsea, published 1855.

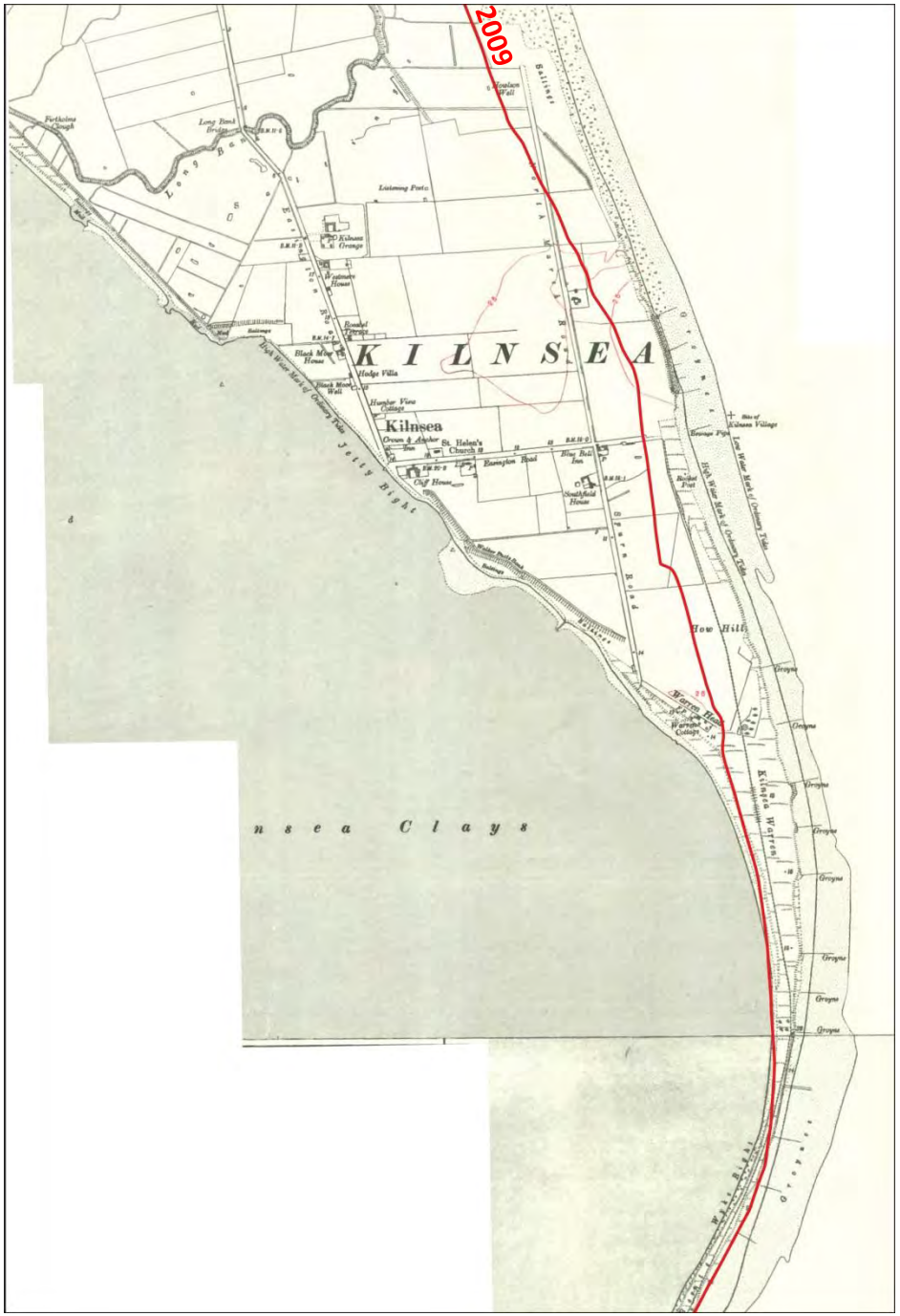


Ordnance Survey map of Kilnsea, published 1890.

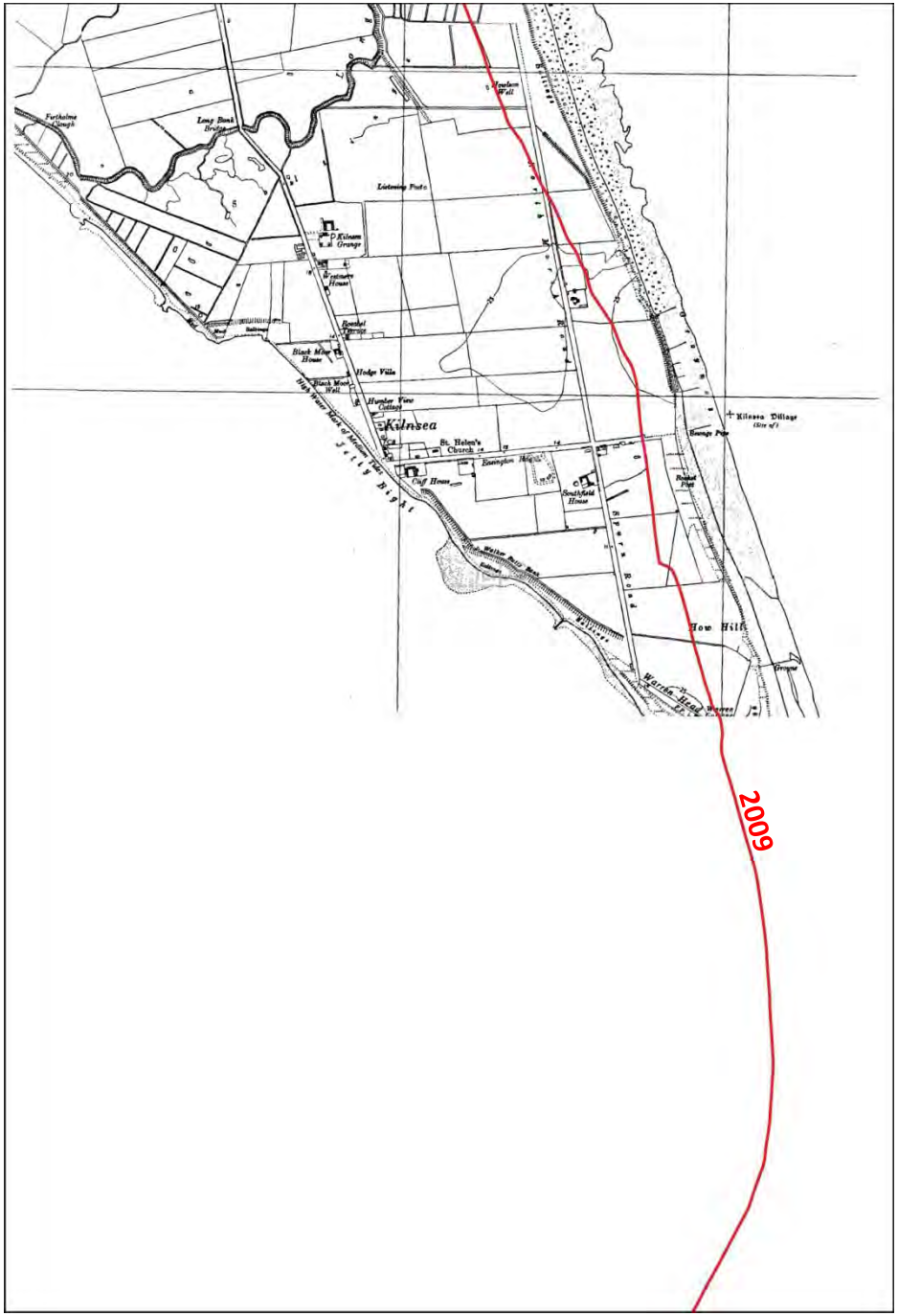


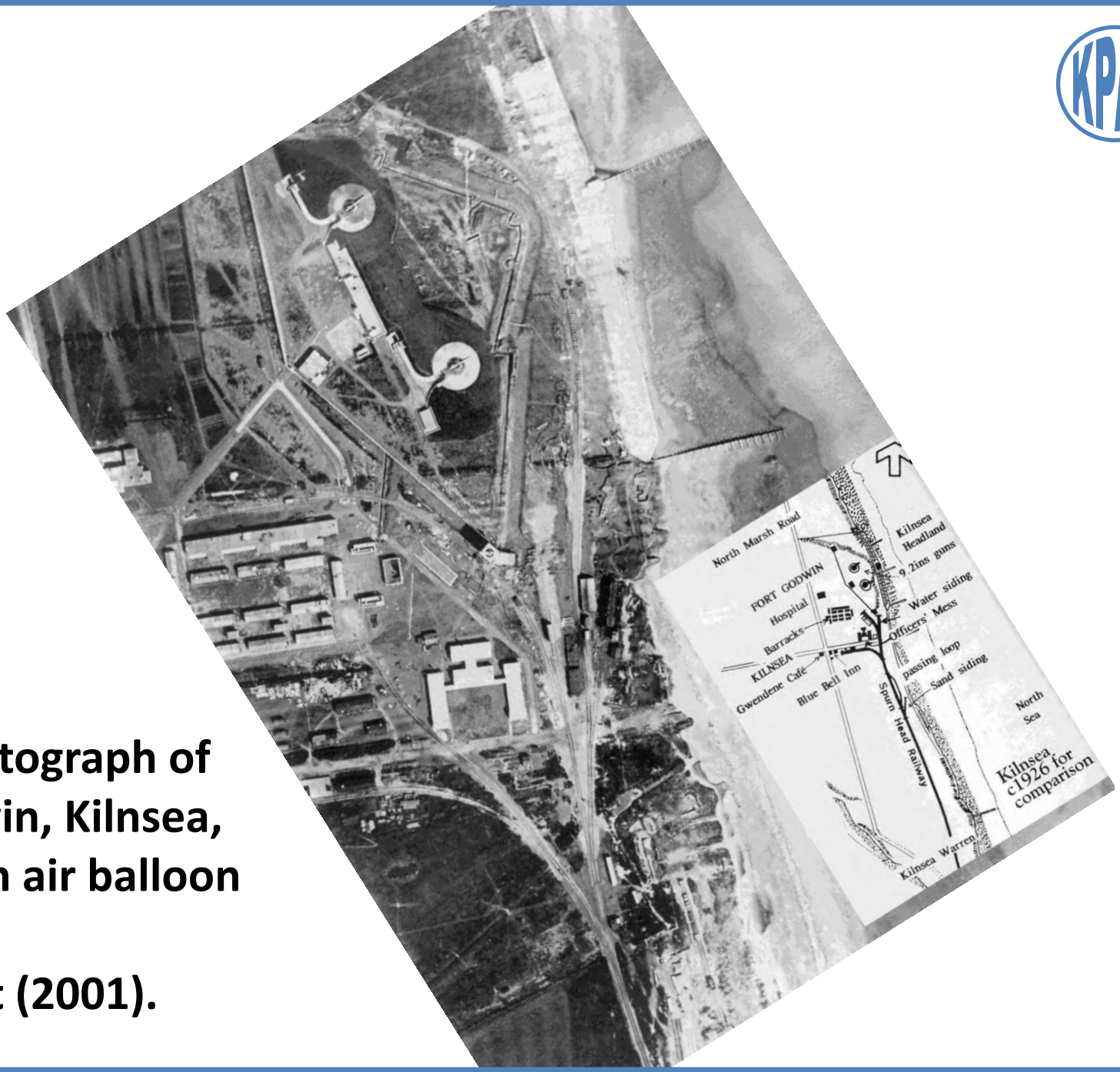
Ordnance Survey map of Kilnsea, published 1912.

Ordnance Survey map of Kilnsea, published 1929.



Ordnance Survey map of Kilnsea, published 1956.





Aerial photograph of Fort Godwin, Kilnsea, taken from air balloon in 1917.
After Frost (2001).

Kilnsea sea defences

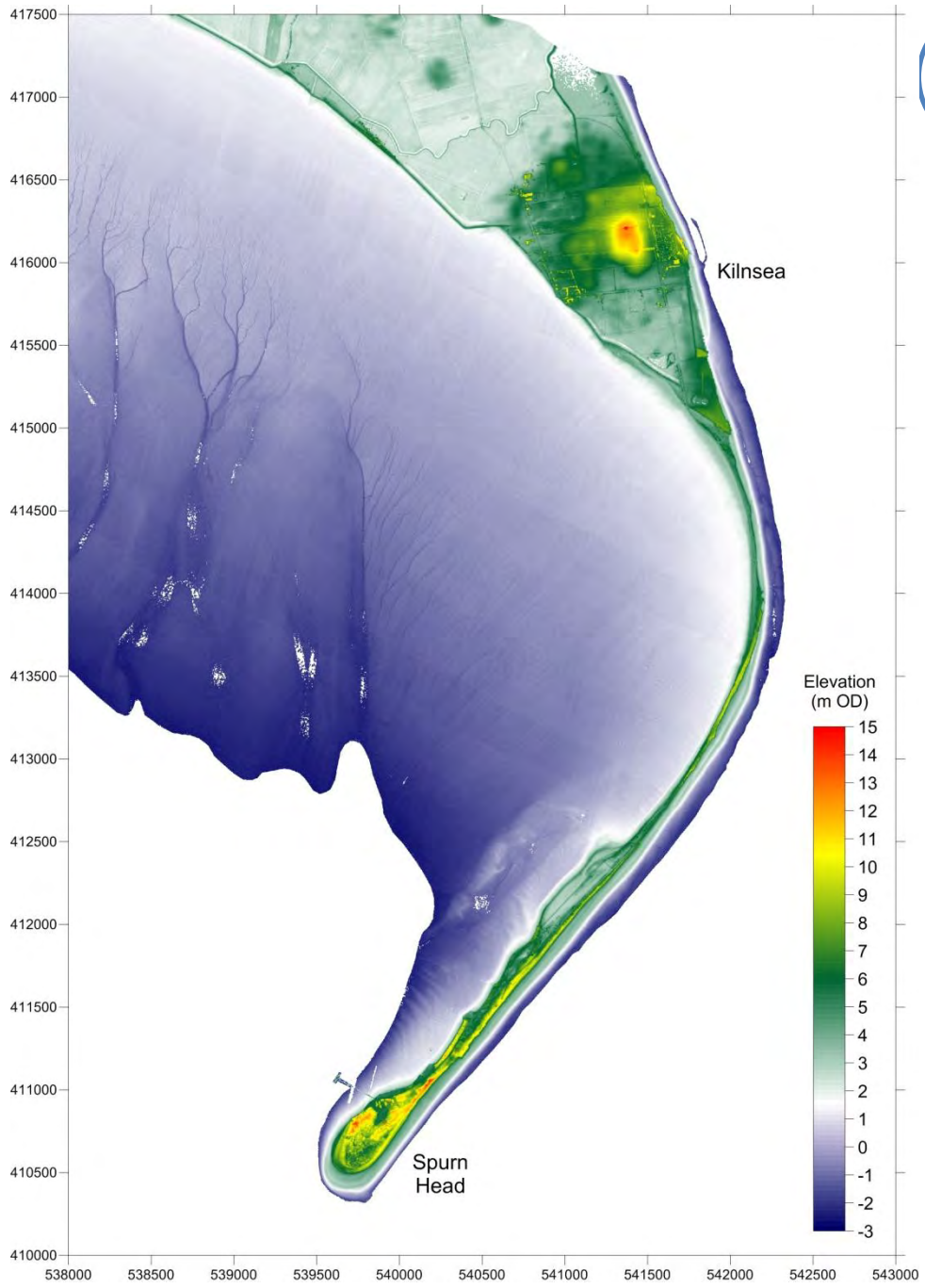
c. 1952

1953

1974

2010

Digital Elevation Model of Kilnsea and Spurn (LiDAR data flown May 2000)

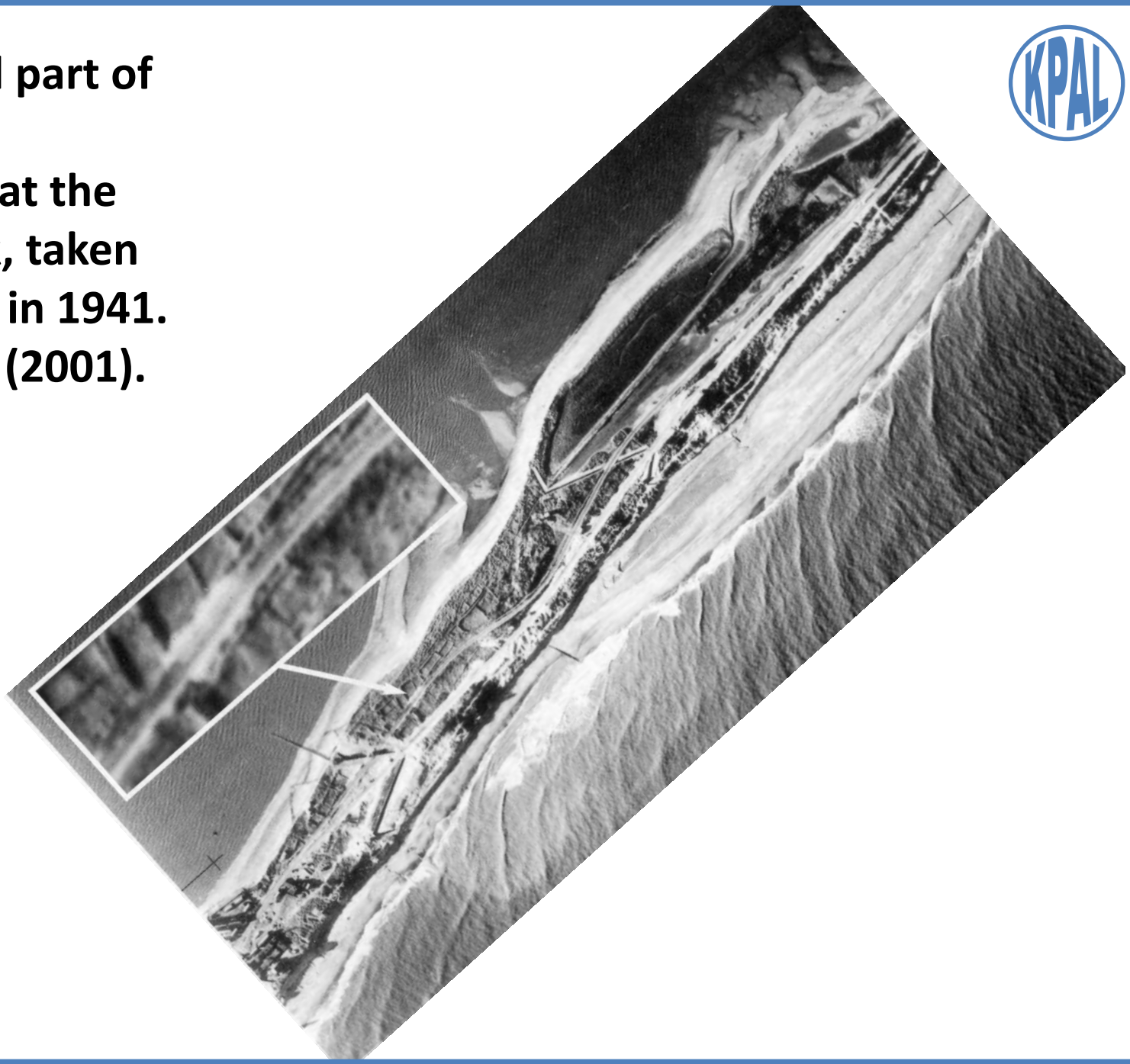


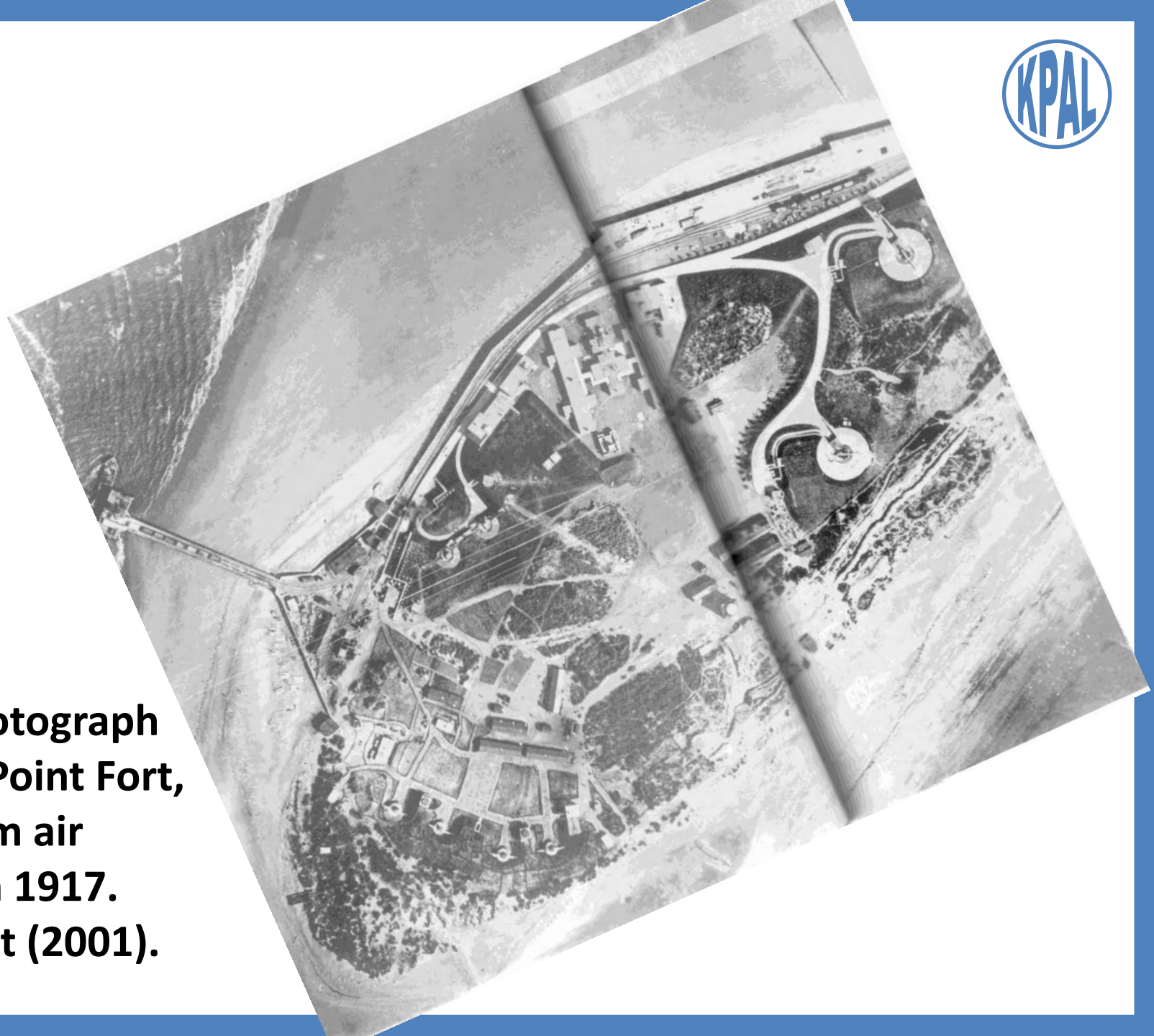
Aerial photograph of Spurn Head

The Narrows, Spurn Peninsula, taken in 2003

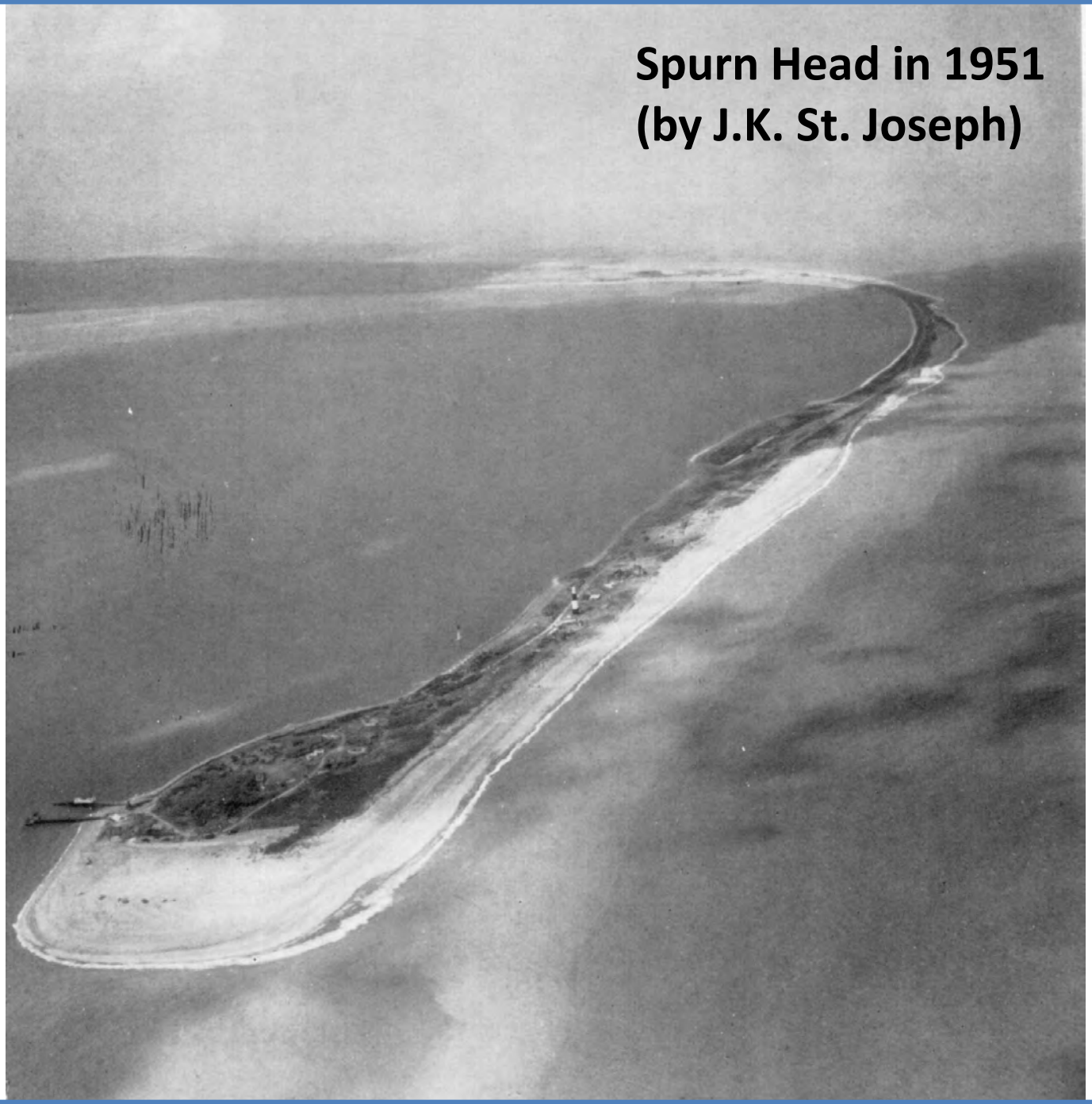
Ordnance Survey map of Spurn, surveyed 1852, superimposed with coastline surveyed in 2000 using LiDAR

The central part of the Spurn Peninsula, at the Chalk Bank, taken by the RAF in 1941. After Frost (2001).

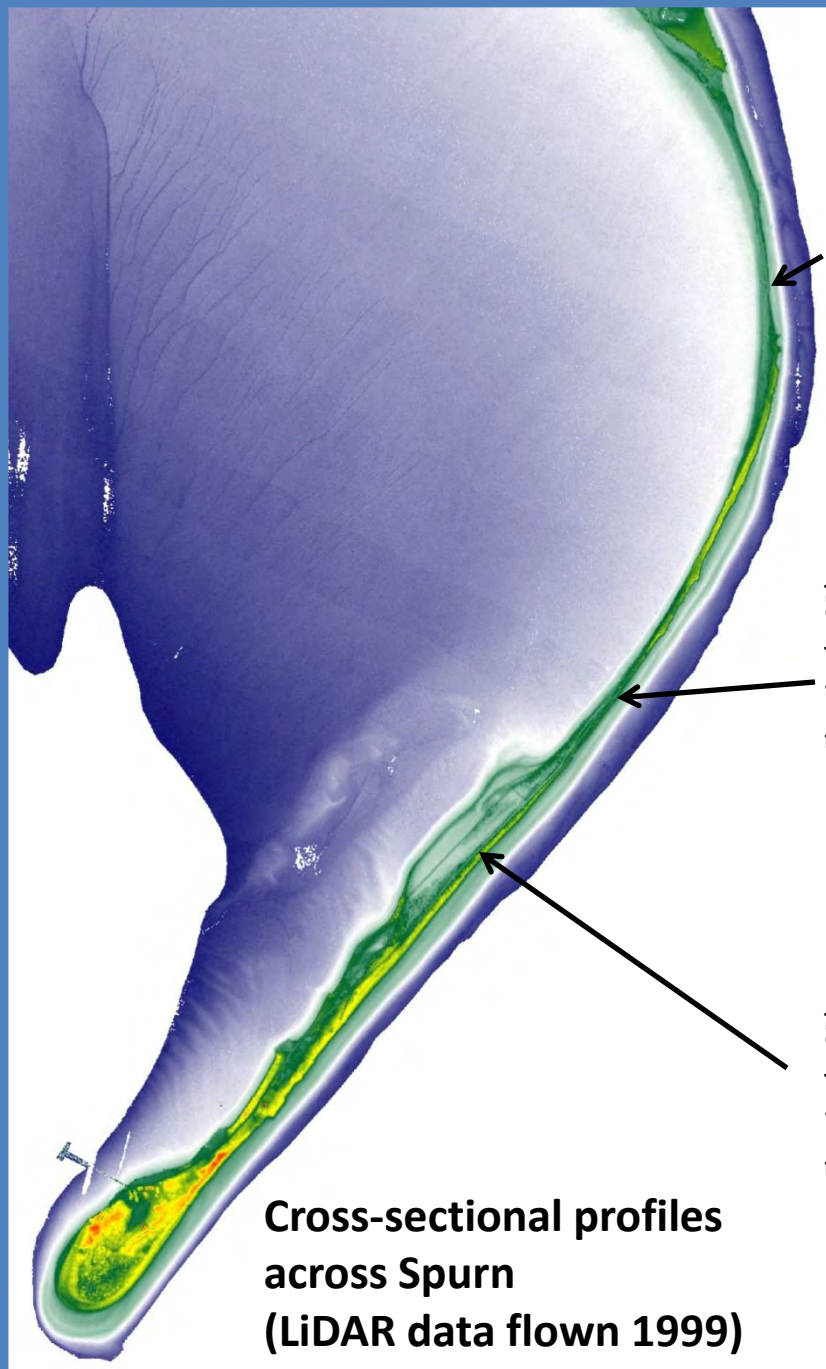




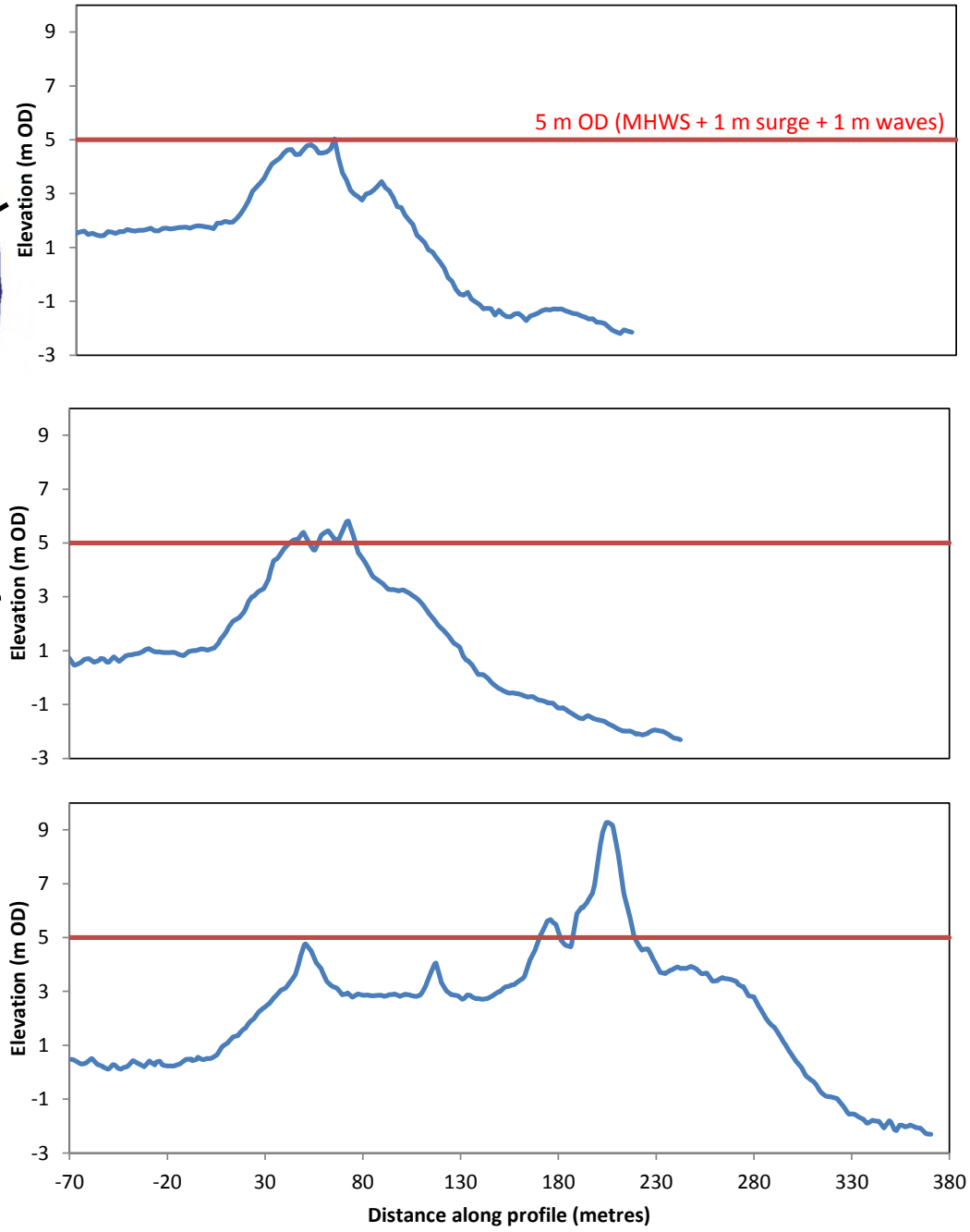
Aerial photograph of Spurn Point Fort, taken from air balloon in 1917. After Frost (2001).


Spurn Head in 1951
(by J.K. St. Joseph)

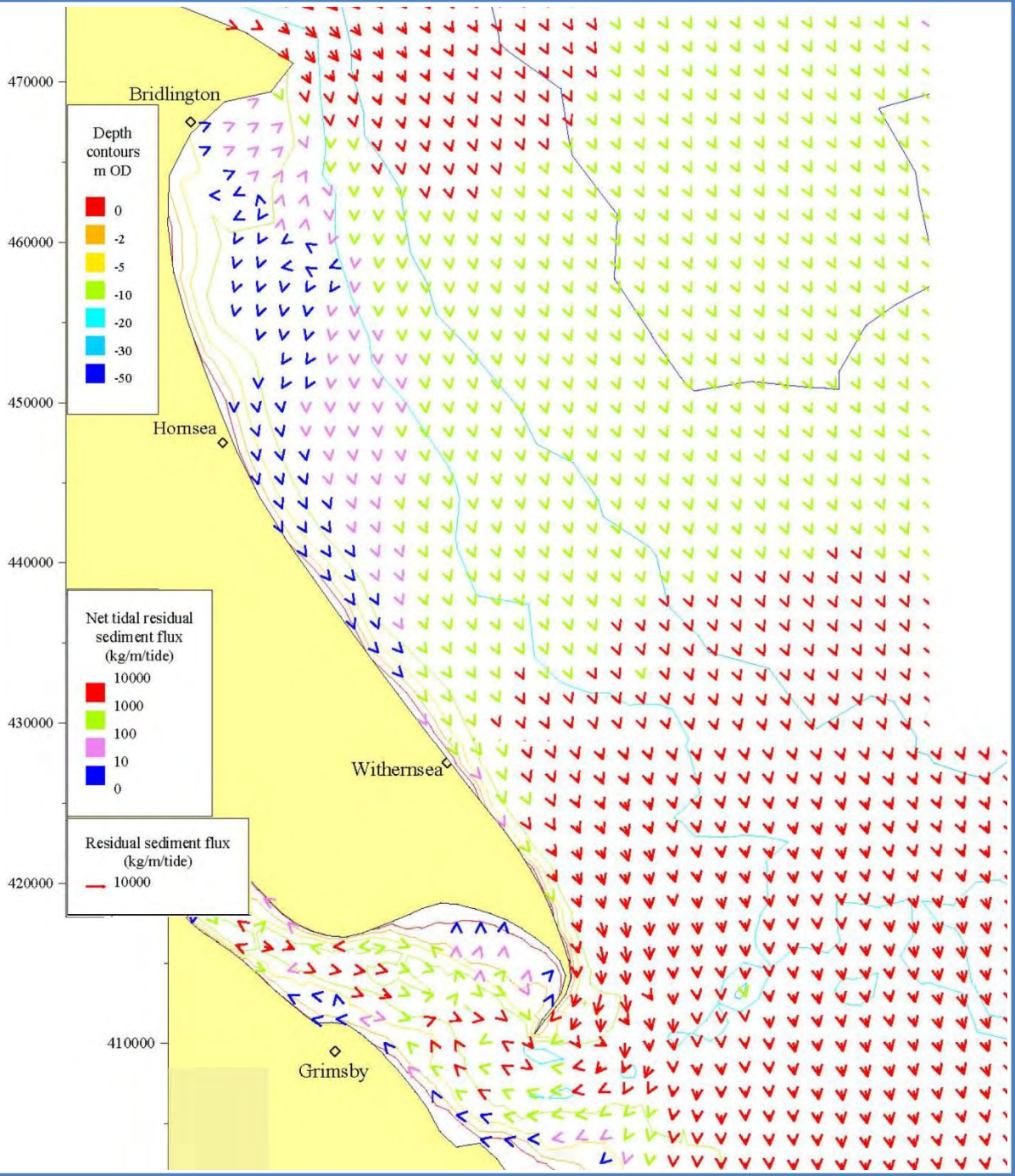
Aerial photograph of Spurn Head, taken 1996 (source: tlfe.org.uk)



Cross-sectional profiles across Spurn (LiDAR data flown 1999)

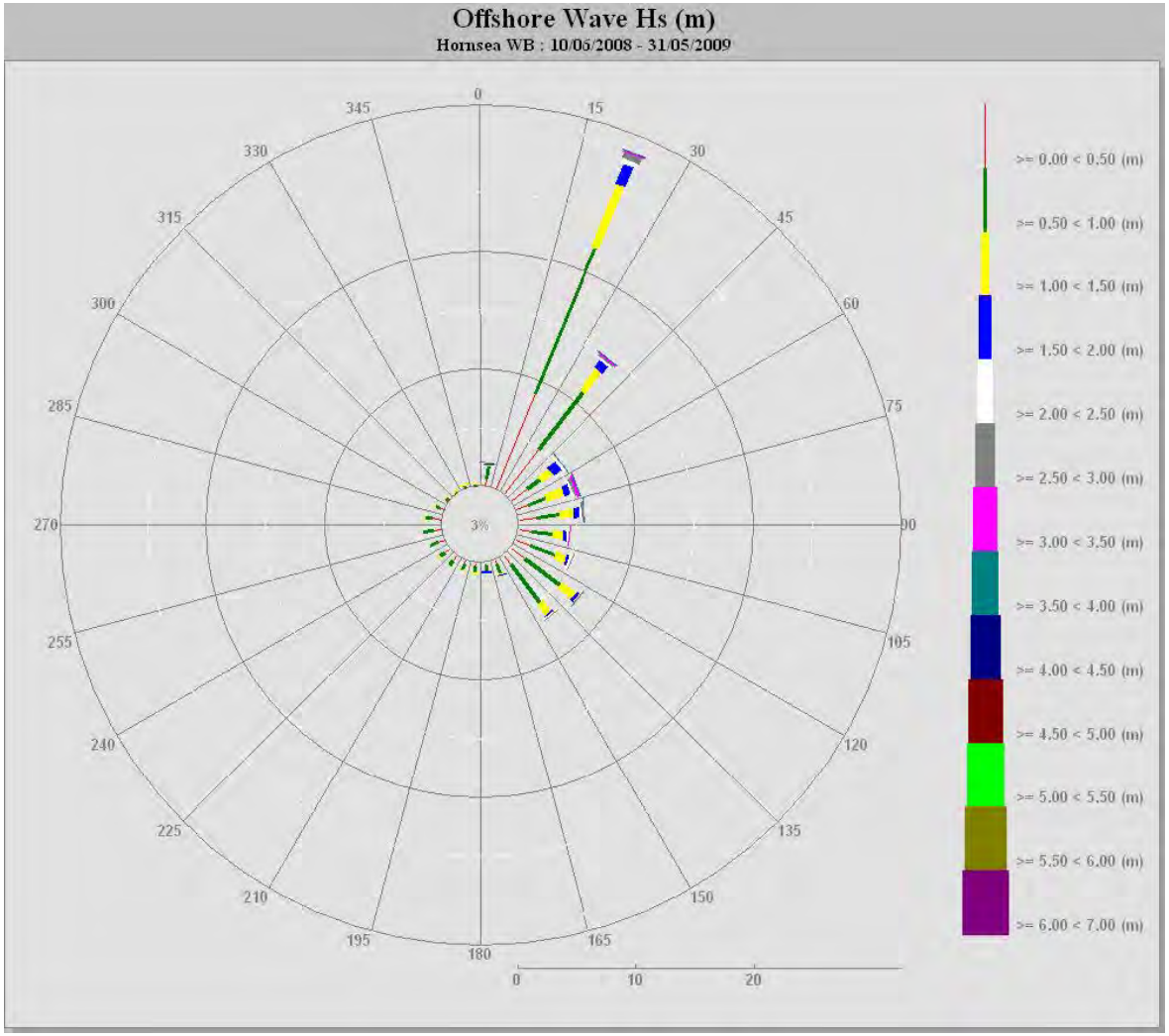


Net tidal residual sediment flux for a spring tide and 100 µm grain size.



Data from Southern North Sea Sediment Transport Study

Wave rose for the Hornsea waverider buoy (May 2008 to May 2009)

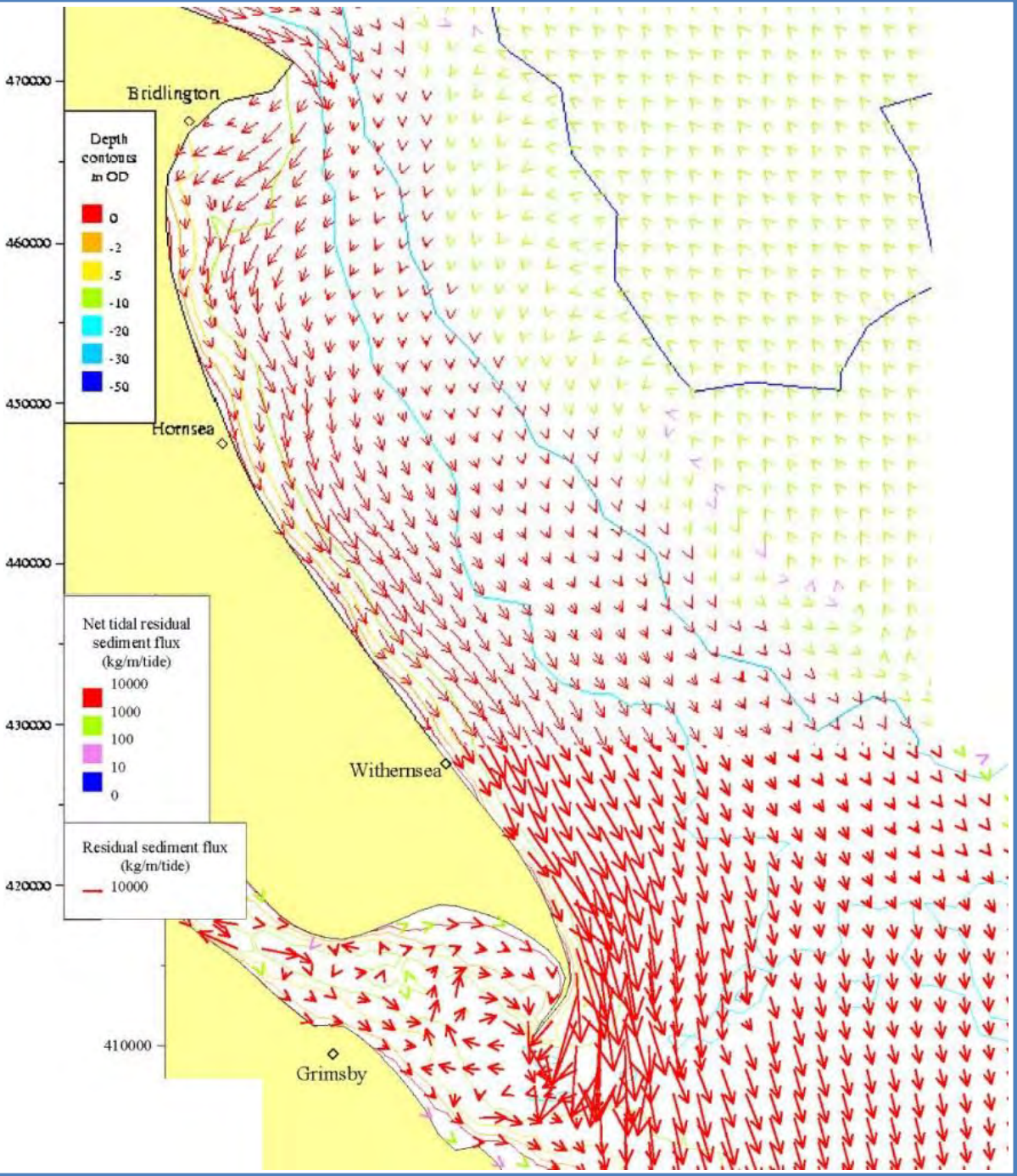


Data from East Riding of Yorkshire Council

Net tidal residual sediment flux for a spring tide and 100 µm grain size, combined with:

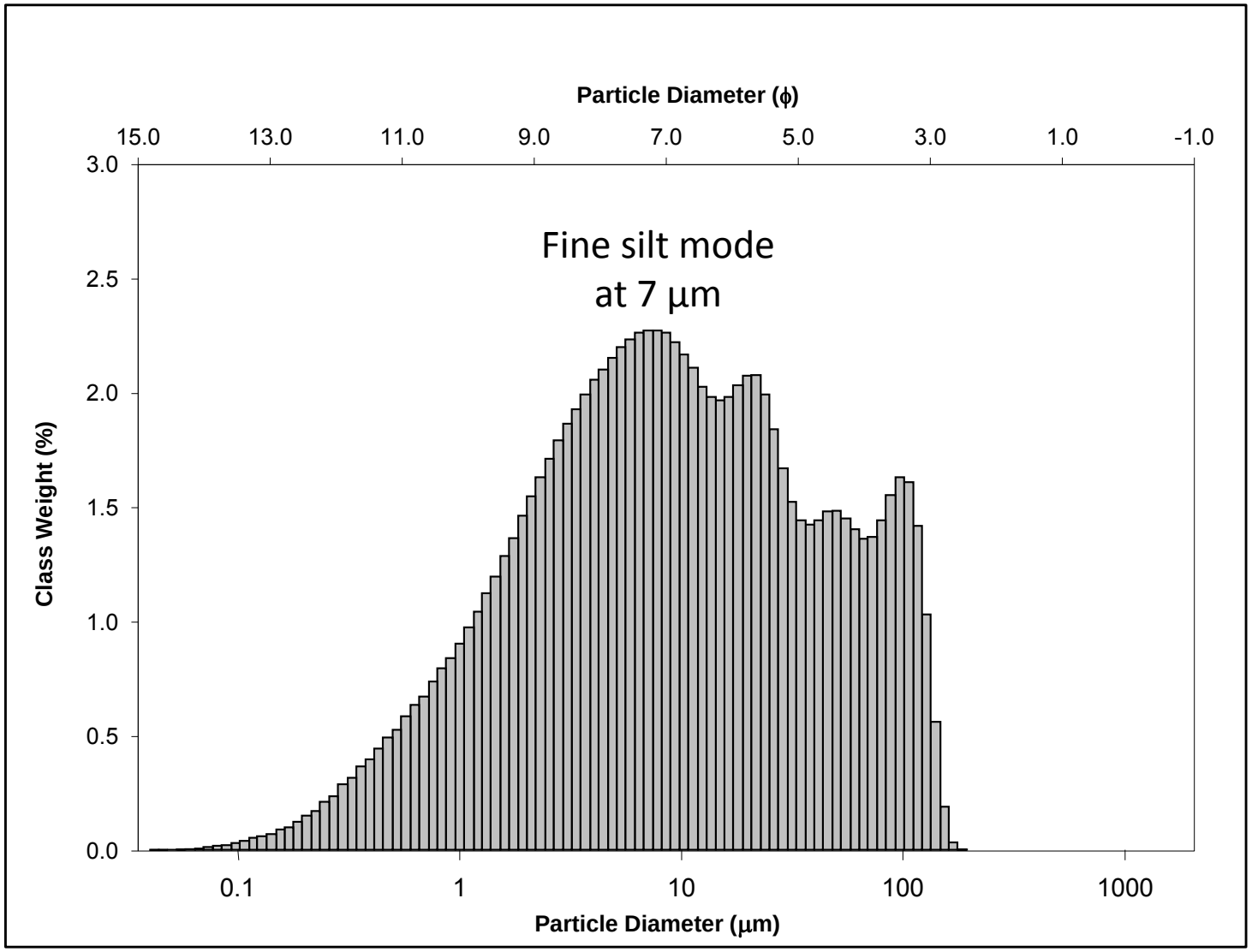
Storm surge (February 1993 event, *c*. 1 in 20 year return period)

Wind waves (5 m significant height, 10 second period)

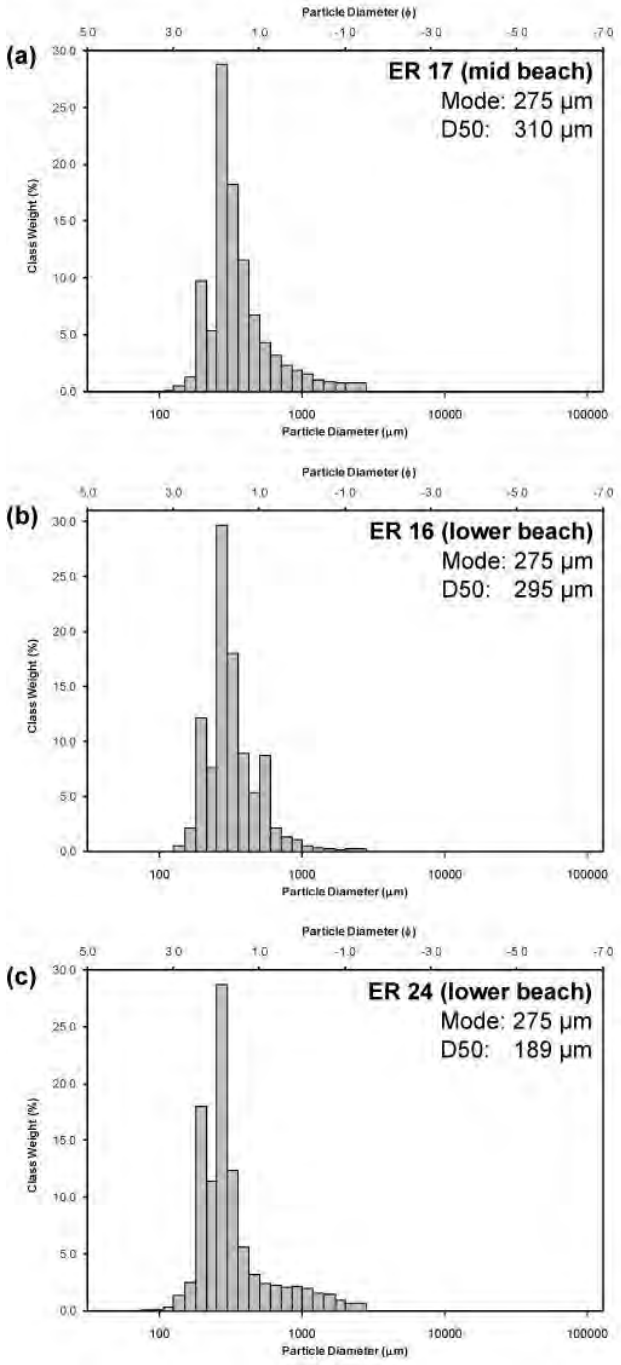


Data from Southern North Sea Sediment Transport Study

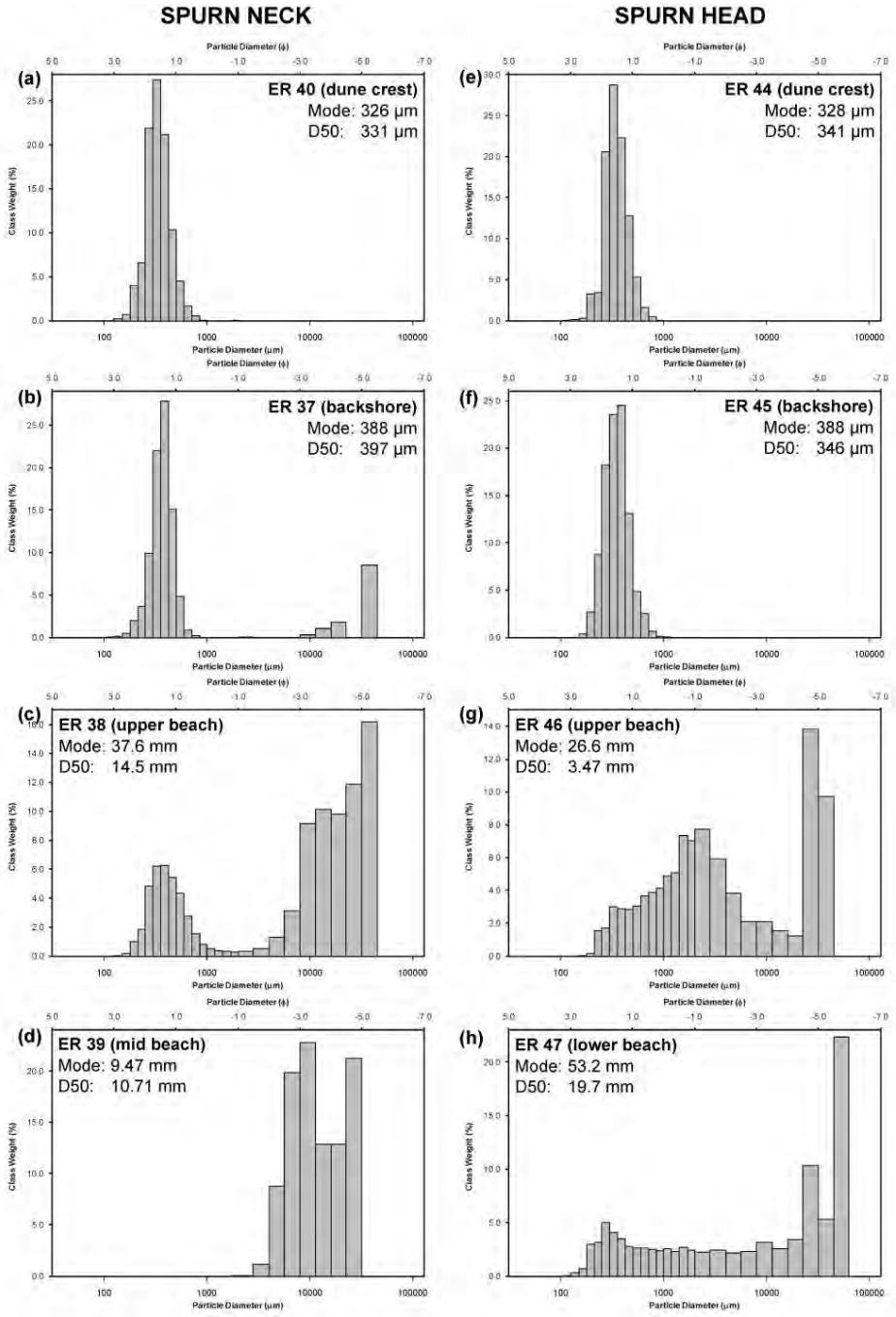
Particle size histogram for sediment collected from the till cliff at Ringbrough Farm, near Aldbrough



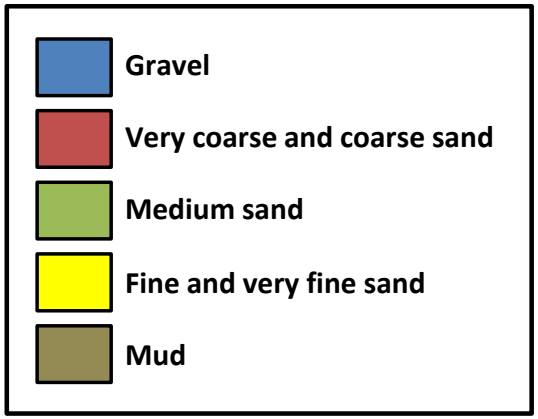
Particle size histograms for sediment samples collected at three cross-shore positions at Aldbrough

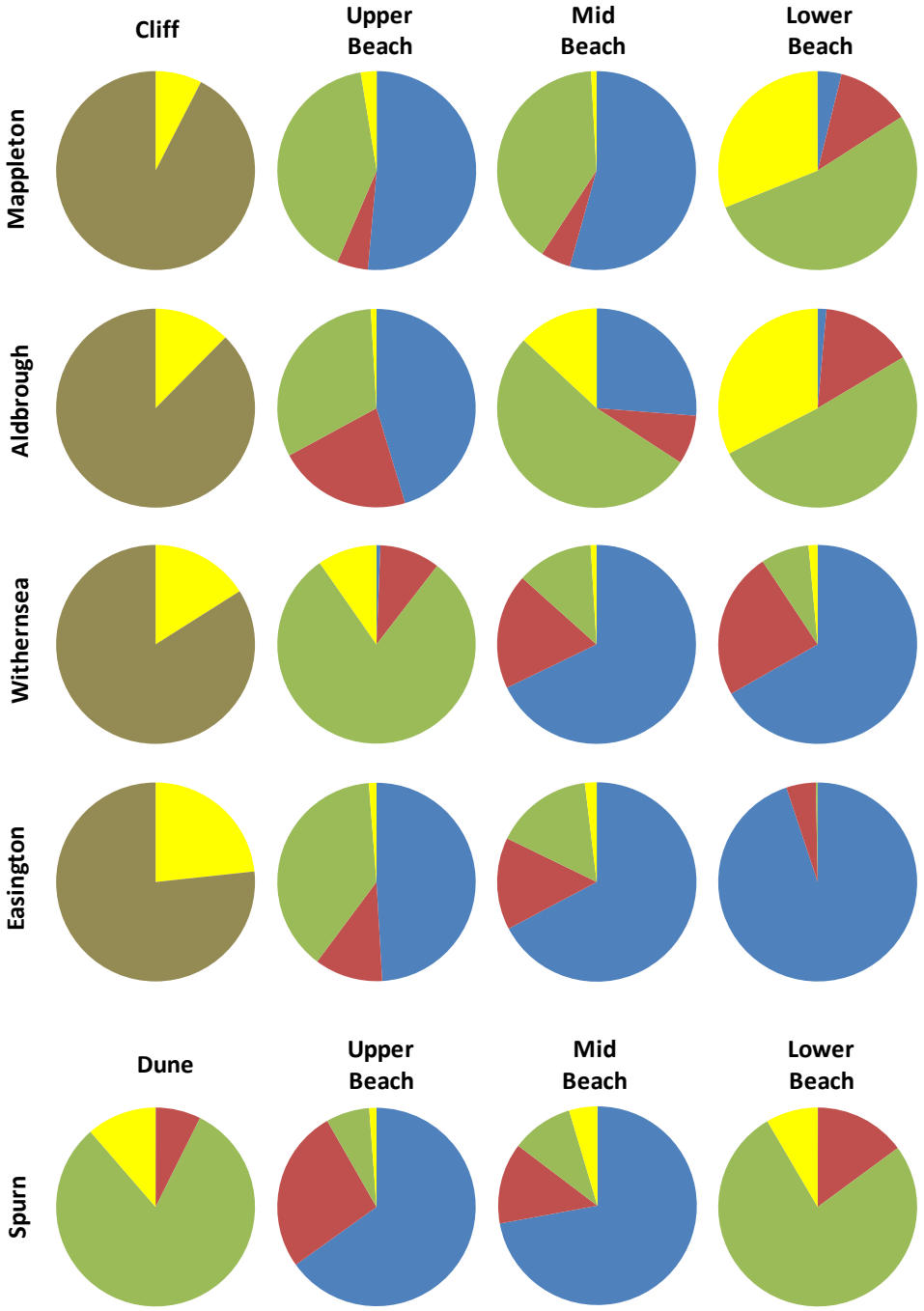


Particle size histograms for sediment samples collected at four cross-shore positions at two locations on the seaward side of Spurn peninsula

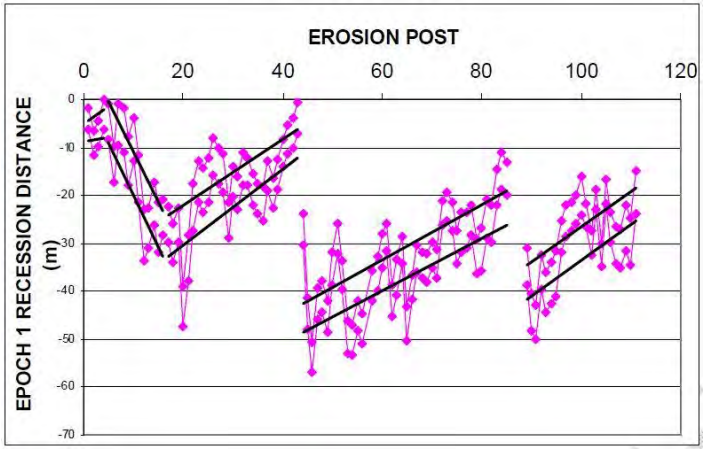


Comparison of percentages of gravel, sand and mud in cliff, beach and dune sediments along the Holderness coast and Spurn Peninsula

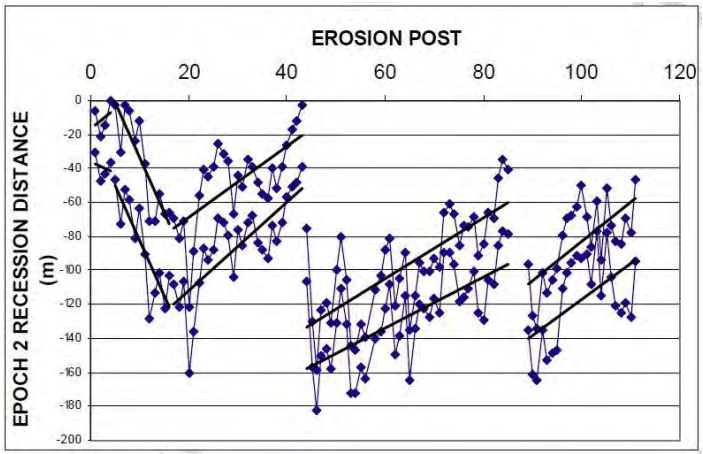




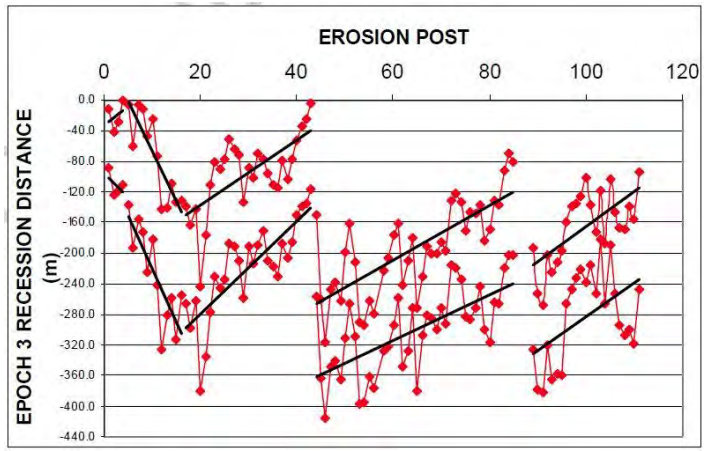
Upper and lower bounds of cliff recession rates in three epochs: 20, 50 and 100 years in the future.



20 years



50 years

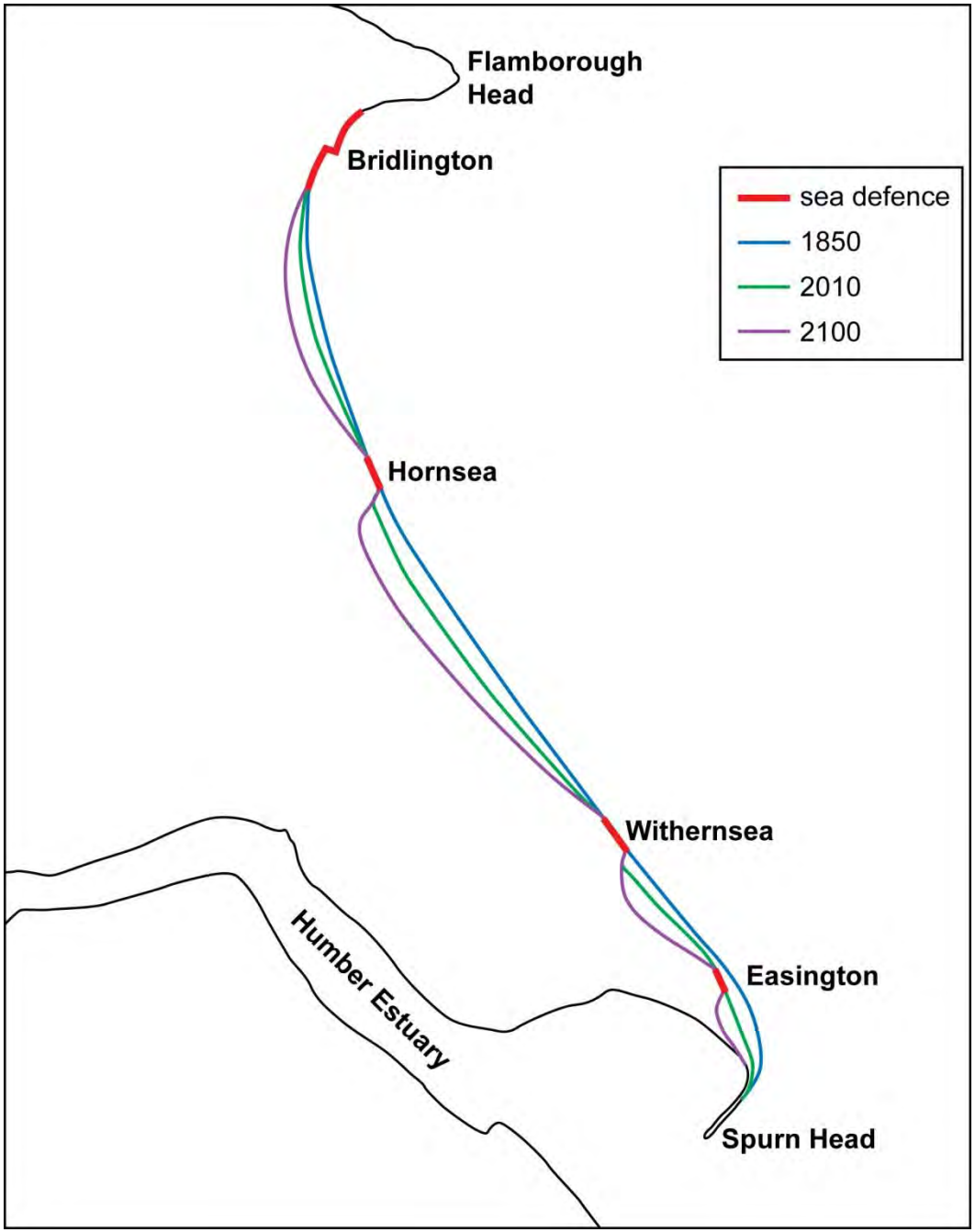


100 years

Data from Flamborough Head to Gibraltar Point Shoreline Management Plan.

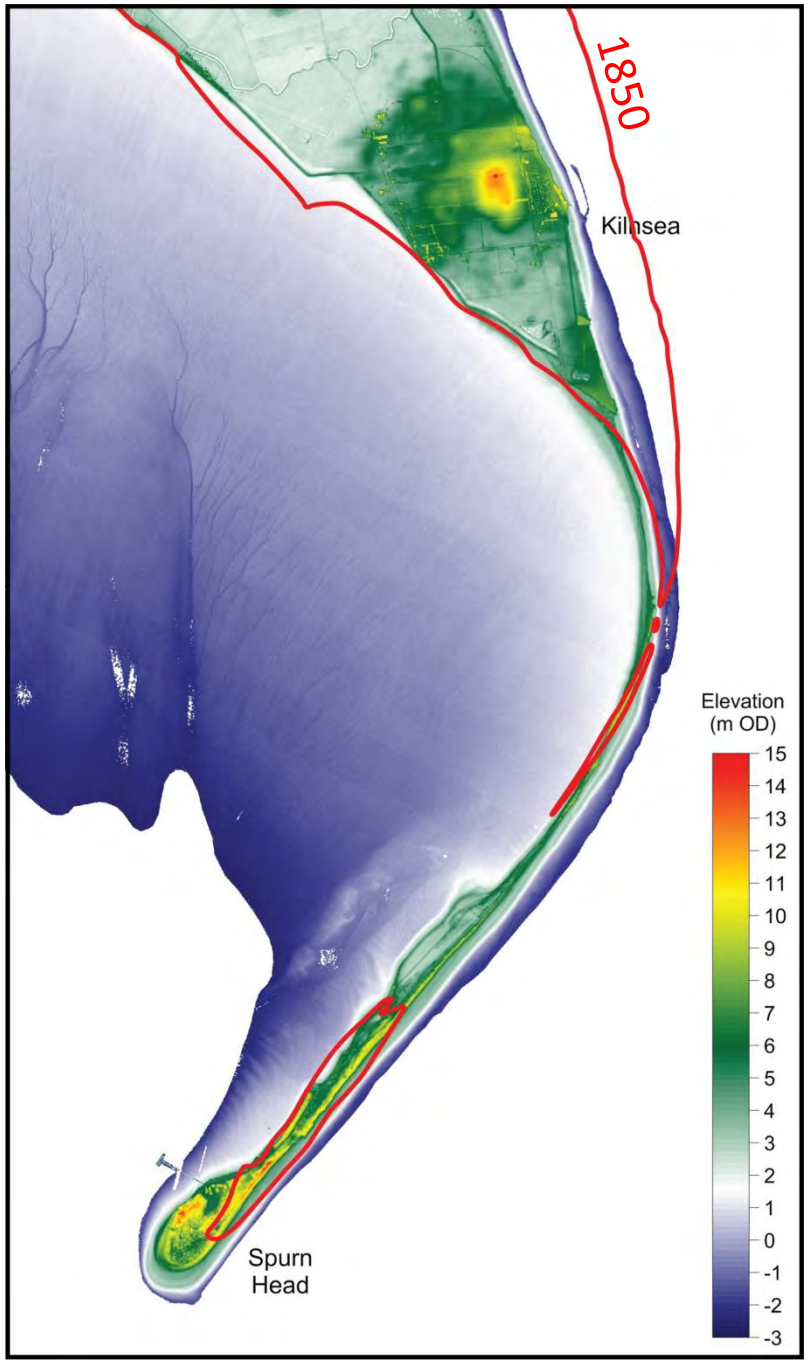
Cartoon diagram illustrating the future evolution of the Holderness coastline over the next 100 years

(not to scale)



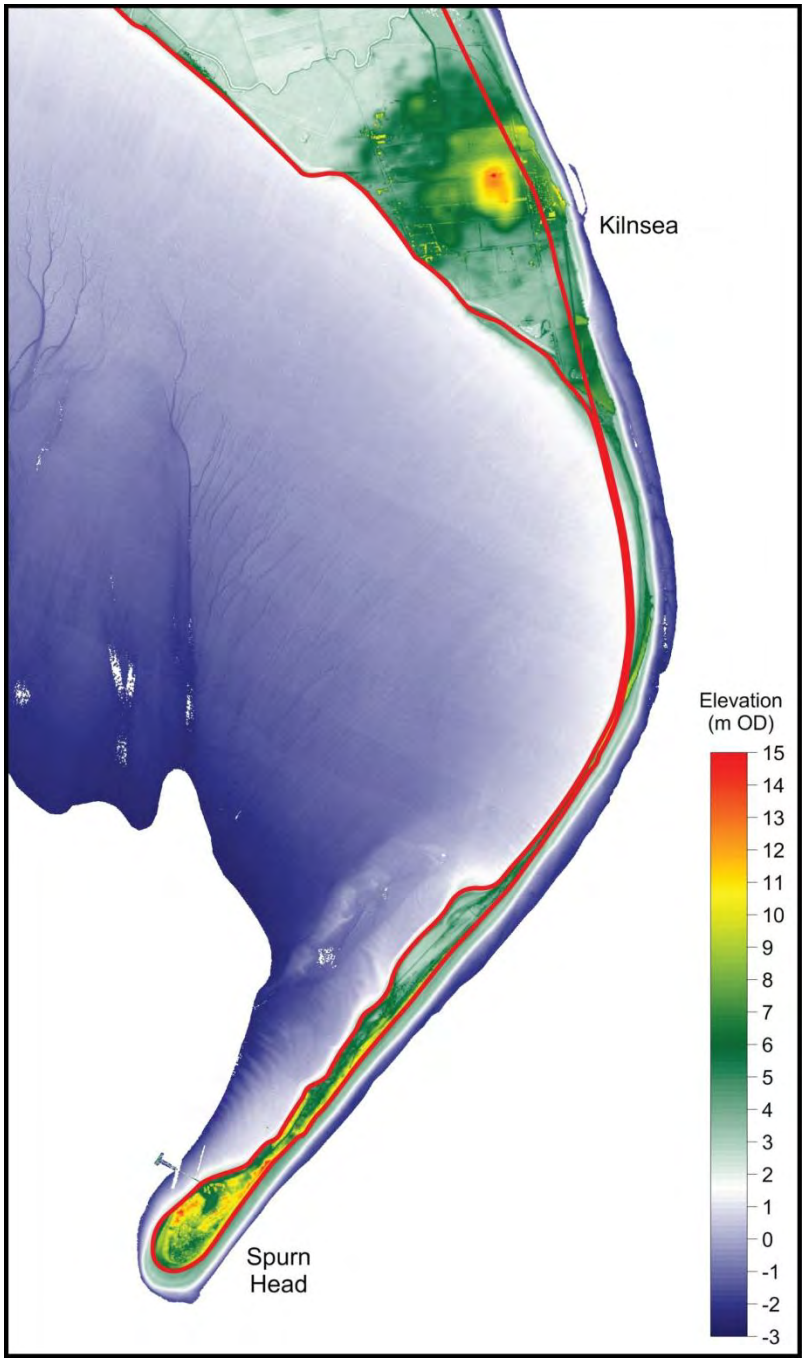
The likely future evolution of Spurn Peninsula

1850



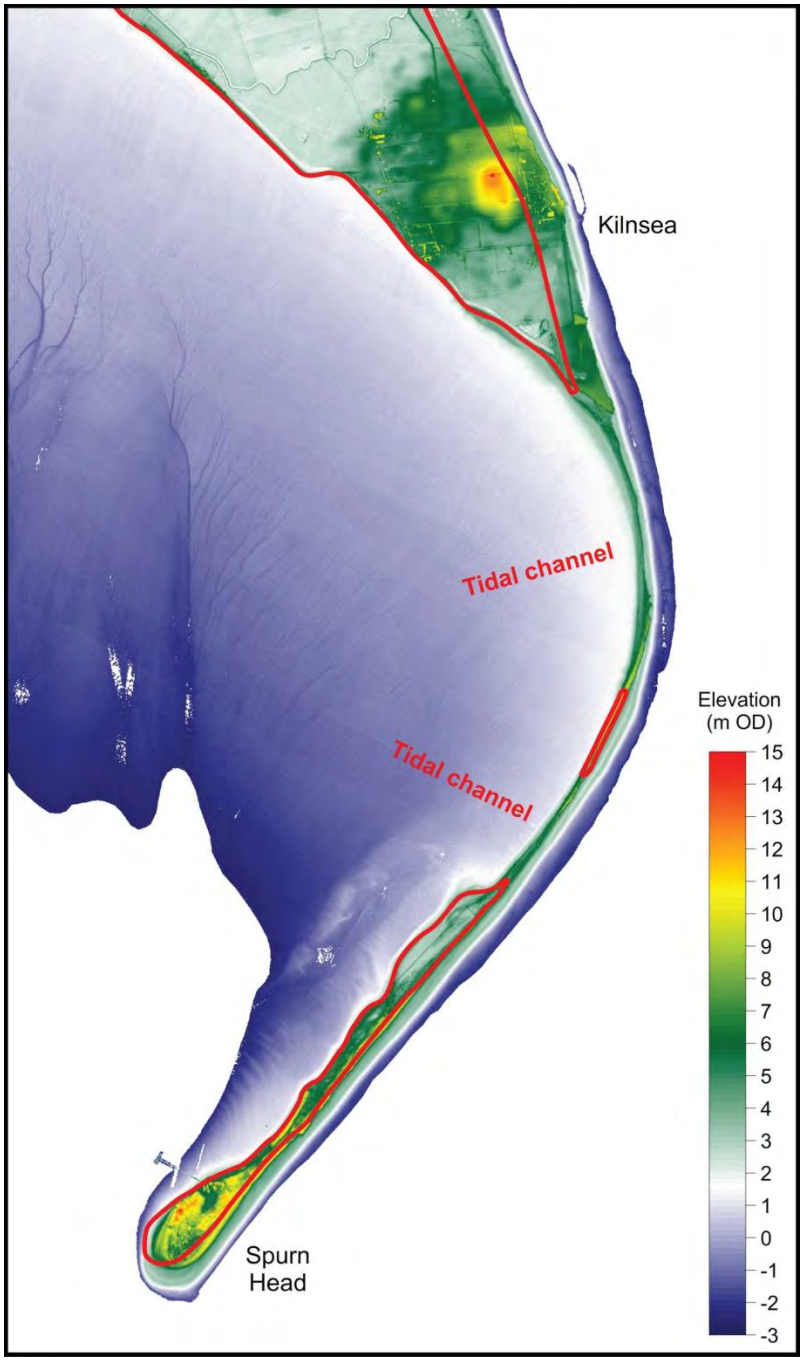
The likely future evolution of Spurn Peninsula

c. 2050



The likely future evolution of Spurn Peninsula

c. 2100



Conclusions

- Over the entire 52 km of the Holderness coastline, 153 million cubic metres of sediment has been eroded since 1852
- The till cliffs are largely composed of mud and fine sand, and as a consequence <10% of the sediment is retained in the beach/nearshore system to provide protection from future erosion
- The coastline is subjected to a strong tidal and wave-induced southerly littoral drift. This is unlikely to change in the future.
- Defended sections of coast at Bridlington, Hornsea, Withernsea and Easington will continue to act as hard points, which locally continue to reduce rates of erosion.

Conclusions

- Erosion at Kilnsea since 1953 has been very rapid partly due to the abandonment of the sea defences.
- In the next 50 to 100 years, continued recession at Kilnsea will produce an unsustainable curve in the neck of Spurn Peninsula.
- Tidal channels are likely to develop, with Spurn Head once again becoming an island, as happened in the 1850s.
- Periodic elongation of a spit feature at Kilnsea may occur, while the area between Kilnsea and Spurn Head will probably exhibit a series of migrating banks and channels.
- This process would be speeded up by a significant acceleration in the rate of sea level rise.

Uncertainties and requirements for further work

- Morphology and sediment transport in the nearshore zone are presently poorly understood.
- The origin of the gravel and medium and coarse sand which comprise the Spurn Peninsula is poorly understood (possibly relict glacial deposits in the immediate vicinity, with relatively minor contributions from Holderness)
- The threshold conditions for breaching of the spit are poorly understood and need further investigation.
- The effects of a breach on the tidal and sediment regimes of the Humber Estuary require further evaluation.