Adam Corbridge and Duncan Hawley

'Holding the line': a case study of the physical geography and coastal management of the Fylde coast

Adam and Duncan highlight how careful study of physical geography has influenced the revision of coastal defences on the Fylde Coast.

'Holding the line' (HTL) is a phrase used in coastal management to describe a policy and strategy of keeping the coastline in its present position and stopping the sea from encroaching where it is not wanted.

On vulnerable stretches of coastline where HTL is important coastal management is a matter of understanding the specific locational processes at work (the coastal dynamics) and how different coastal defence options will respond to the physical conditions. Before deciding what defences to build, engineers study and model the range of wave and tidal conditions and how different defences will behave to predict how they will affect the natural processes along the coast (the coastal feedback loop). This is important because choosing the wrong coastal defence option can change the coastal dynamics and work against HTL. Recent work on the Fylde coast provides a useful illustration of this link between physical geography and coastal defence design.

What is at stake on the Fylde coast?

The Fylde peninsula is a low-lying coastal plain in north-west England bounded by the Irish Sea to the west, the River Wyre and its estuary to the east, Morecambe Bay to the north and the Ribble estuary to the south. Fleetwood sits at the northern tip of the shoreline, which extends southwards through Blackpool and on to Lytham at the mouth of the Ribble (Figure 1).

Managed by Blackpool and Wyre Borough Councils, the Fylde coast is probably best known as a tourist destination, with the famed Blackpool beach having a long history as a seaside leisure resource. The beaches along the entire 17.5km length of the Fylde coast are an important draw for tourists, with significant benefits for the local economy. Keeping the beaches in good order is important for retaining their sandy appeal.

Directly inland from the shoreline is a low-lying coastal plain less than 10m above sea level. When storms hit the coast more than 16,000 homes and much commercial property here are at risk from flooding. The area has been severely flooded twice in the last 100 years, and over the next 100 years the sea level is expected to rise by 60cm, making it important to update the sea defences on the Fylde coast in order to 'hold the line'.

The physical geography of the Fylde coast

a. Landforms

The coast is dominated by wide sandy beaches made up of two to four intertidal sand bars and troughs which migrate across the beach to the coastline. Each is up to 2m in height and depth, with ridges and runnels oriented slightly oblique to the coastline, and periodically intersected by cross-beach channels (Figure 2).

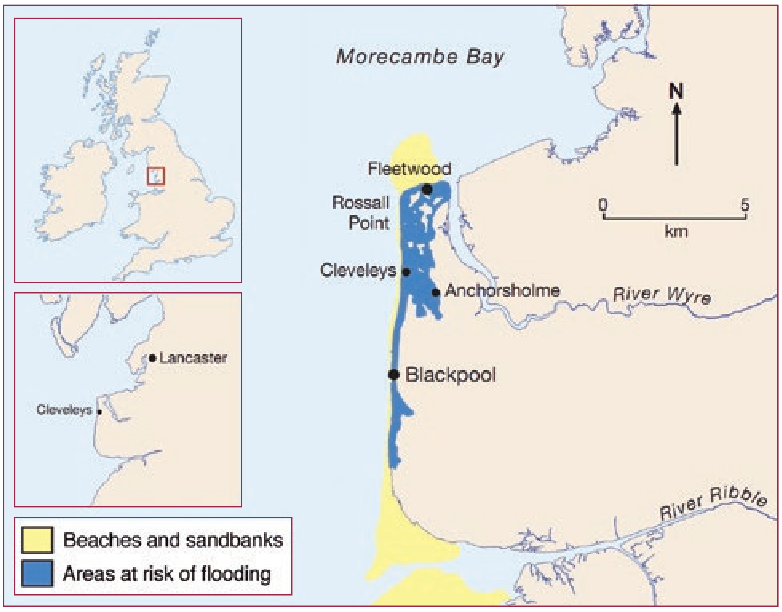

Figure 1: Location of the Fylde coast.

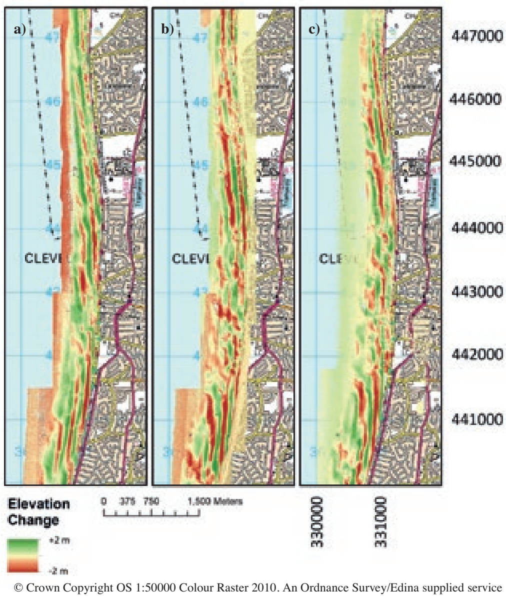

Figure 2: Lidar map showing the changing pattern of linear bars and troughs on the beach at Cleveleys: a) 1999-2009, b) 2009-2010, c) 2010-2011. **Source:** Adapted from: Miles *et al.* (2012).

Northwards from Blackpool up to Fleetwood the proportion of shingle on the beaches increases. At the northern end of the peninsula, at Rossall Point, the sediment builds into a sand and gravel spit with a backshore sand dunes system. The sediment extends out north into Morecambe Bay as a tidal muddy sand flat off Fleetwood.

b. Wind direction

Wind directions vary along the Fylde coast, so there is no dominant prevailing wind direction (Figure 3). Westerly onshore winds blowing approximately perpendicular to the coastline account for just under one third, while north-westerly and south-easterly winds (which blow offshore) each account for one sixth of the winds along the Fylde coast.

c. Waves

Waves arriving at the coast are determined by the strength, direction and fetch of winds; accordingly the Fylde coast waves generally arrive from the west, although wave direction demonstrates a great deal of variability (Figure 4). Due to the sheltering effects of Ireland to the west, Wales to the south and the Isle of Man to the northwest, the maximum fetch is about 375km, resulting in relatively low mean wave heights of 0.6–1.5m. These are short-period waves, averaging between three and eight seconds between each wave and putting relatively small volumes of water onto the beach as they break. Wave heights can reach up to 3.0m during more energetic periods (about 5 % frequency). Storm waves over 3.0m in height are not common (less than 1 % frequency).

d. Tidal flows – flood and ebb

Along the coastline there is a spring tidal range of about 8m. The flood tide brings in water from the south, which pours north along the coast into Morecambe Bay. The ebb tide flows south and west out into the Irish Sea so the return tide is weaker, resulting in a northward residual tidal flow at a rate of 0.4–0.8 m/s. The stronger northward tidal current is an important driver of sediment movement.

e. Sediment budget, sediment drift and sediment mobility

The Fylde coast forms a sediment sub-cell (a closed system of sediment inputs and output) and at this scale sediment movement is in two directions. South of Blackpool the drift is southerly, while to the north there is net sediment transport along the coast towards Fleetwood. Modelling indicated a negative sediment budget towards Cleveleys, attributed to the lack of sediment supply from the south due to the long history of coastal protection at Blackpool's Golden Mile and increased northerly transport of material. Around Blackpool, the northerly rate of sediment transport is 25,000m3 per year increasing to approximately 134,000m3 per year near Rossall Point.

At littoral zone scale, during energetic conditions breaking waves form on the top of the sand bar ridges and shift sediment from the ridges into the runnels, which moves the ridges slowly towards the coastline. In turn, this sediment is moved longshore northwards in the runnels and through the intersecting channels by the tidal and wave-induced currents.

The process that drifts sediment along the Fylde coast is complex and does not conform readily to the 'standard' model of longshore drift.

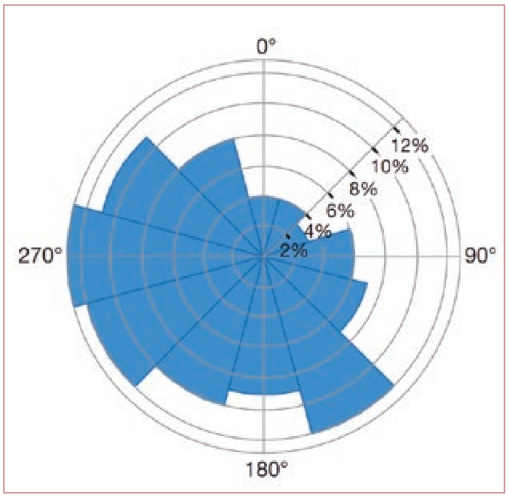

Figure 3: Cleveleys wind frequencey rose. **Source:** Global Wind Atlas (https://globalwindatlas.info/)

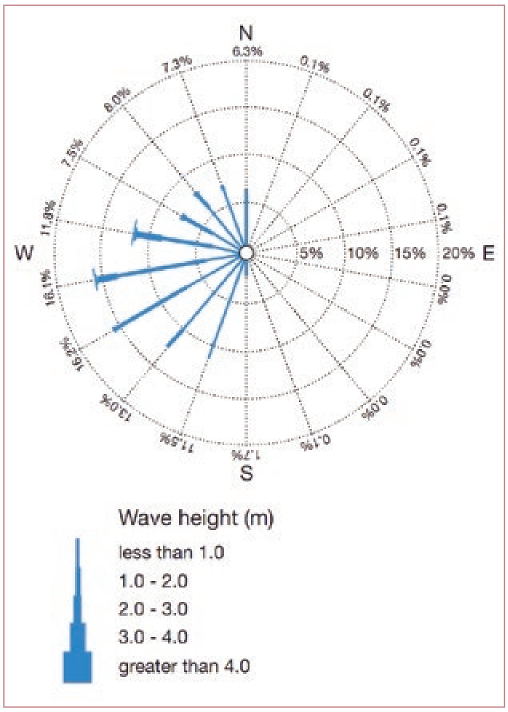

Figure 4: Inshore wave rose for the Fylde coast. **Source:** (H.R. Wallingford (2001).

Coastal defences in the past

'Hard engineering' has defended much of the Fylde coast for over 100 years. The previous update of sea defences northwards from Blackpool, in the 1980s, generally consisted of curved concrete sea walls (revetments) and wooden groynes along stretches of the beach. The curved sea walls were intended to reflect wave energy and the groynes to slow the northward drift of sand and shingle. Unfortunately, these strategies haven't worked as intended. High wave energy crashing into a curved sea wall scours at its base as it is reflected, taking beach material out to sea. This process is exaggerated on the Fylde coast where the ebb tide has a westward current away from the coastline, carrying sediment offshore.

Wooden groynes also exaggerate beach erosion, particularly when the dominant wave direction is perpendicular to the shore, as on the Fylde coast. As water contained between groynes piles up it causes strong compensating flows seaward along the structures, leading to erosion of the beach and sand loss to deep water. This unnatural lowering of the beach level by erosion is not helpful, in three interconnected ways. First, as waves scour underneath the sea wall it begins to sink and break up, undermining the sea defences, so in storm conditions larger waves can overtop the sea wall. Second, a lower beach means wave energy impacts more directly on coastal defences, resulting in higher rates of erosion. Third, there is less beach for visitors, and since the finer sand has been swept away what is left has a much higher proportion of coarser gravel and shingle, which makes the beach less appealing.

How have the new defences been designed to respond to the physical geography of the Fylde coast?

Understanding what is causing the lowering of a beach, and how unnatural erosion can be minimised or eliminated, requires careful consideration of the tidal currents and waves that shift the sediment along the beach. A beach that holds its sediment creates shallower water resulting in waves losing some of their energy as they approach the coastline. Defences designed to work with natural processes in ways that build up a beach provide added protection to the coast: not just 'holding the line', but extending it.

In the north of the peninsula, where the altitude is only a few metres above sea level, the coastal defences built in the 1980s have been replaced by major schemes, at Cleveleys (completed 2010) Anchorsholme (2017), and Rossall (2018) (Figure 5).

Figure 5: Coastal defences in construction at Rossall, 2017. **Photo:** © Wyre Council/Balfour Beatty Civil Engineering Ltd.

a. Stepped revetments

Blackpool rebuilt its Golden Mile sea front in the central area between the south and north piers in 2011. The curved concrete sea wall was replaced with a long, stepped revetment stretching down to the beach. The steps are designed to appeal to visitors as a place to sit and look over the beach or out to sea. However, their structural function is to dissipate wave energy as they approach at high water and in storm conditions. Further north on the peninsula, stepped revetments constructed well above the high-water level, and designed to look elegant, replace old upper wall defences.

b. Rock armour

On the northern defences a 50m-wide apron of huge rock boulders, each weighing 3–7 tonnes, has been placed at the base of the stepped revetment between the mean high-water level and the beach. These are designed to dissipate wave energy by turbulent flow through the spaces between the boulders during periods of high waver energy, limit abrasive action below high tide and prevent removal of sediment by reducing scouring at the base of the defences.

c. Rock groynes

Huge boulders were also used to build rock groynes at 100–130m intervals, each extending 75 metres across the beach (longer than the old wooden groynes they replaced). The design is ideally suited to the low-angle oblique drift conditions found on the Fylde coast as the rock groynes do not interrupt the pattern of wave and tidal currents that shift the sediment on to the nearshore but trap it between groynes on the foreshore. Their porous properties minimise any backwash scour, significantly slowing the rate of sediment erosion from the beach. The net effect is that the beach builds as a low-gradient sloping shelf that is practically parallel to the shoreline, adding extra protection to the defences.

Summary

Where stakes are high HTL is usually the preferred approach to coastal management. Study of the particular physical conditions and coastal dynamics at a specific location gives insight into how the processes conform to or vary from standard models, allowing the design of coastal defences to accommodate and complement the real physical system as observed so the HTL strategy is more likely to succeed. | **TG**

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References

Miles, A., Ilic, S. James, M. and Whyatt, D. (2012) 'Morphological Variability of Cleveleys Beach, UK at Multiannual Timescales based on Airborne LiDAR Data', *GIS Research UK*.

Wallingford, H. R. (2001). 'Sediment transport and the effects of sand extraction, Fylde Shoreline, Lancashire'. Stage 3: Modelling Phase II Report EX4352.

Resources

All websites last accessed 20/03/2020.

Visit Cleveleys, Visit Fleetwood and Live Blackpool websites have much information and images on the coastal defence schemes and the seafront, including archive images of flooding:

www.visitcleveleys.co.uk/environment/coast-watchers

www.visitfleetwood.info/about/seafront/rossall-coastal-defence-scheme

www.liveblackpool.info/about/seafront/anchorsholme-coast-protection-scheme

Video drone flying north over Rossall beach showing construction of the new sea defences: https://youtu.be/sDAP2jDya3E