ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018

The State of the Art and Science of Coastal Engineering

Modelling Rapid Coastal Catch-Up After Defence Removal Along The Soft Cliff Coast Of Happisburgh, UK

British Geological Survey
Expert | Impartial | Innovative

Dr Andres Payo, Dr Andrew Barkwith, Dr Michael A. Ellis

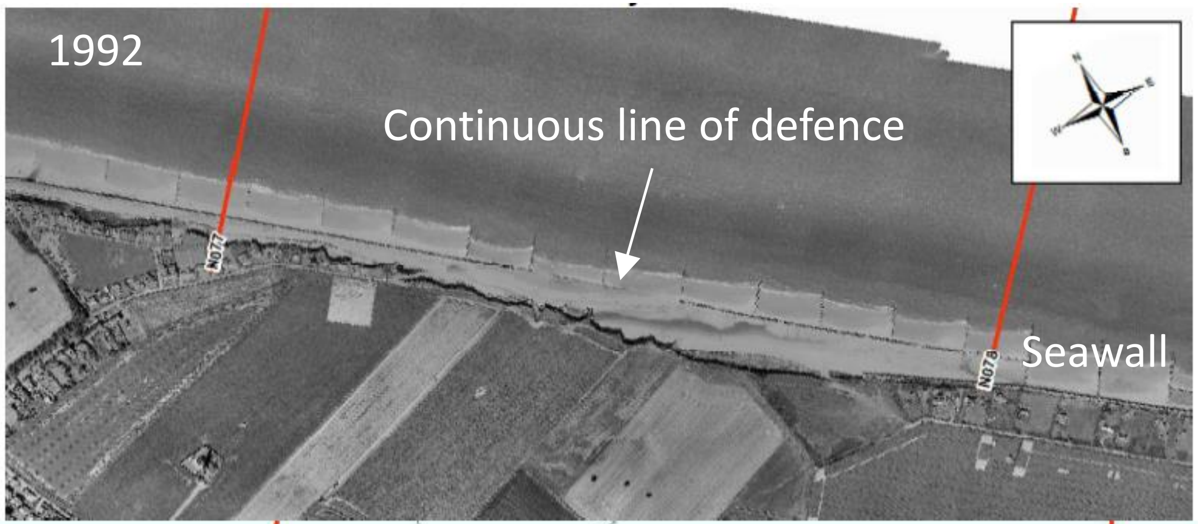
British Geological Survey

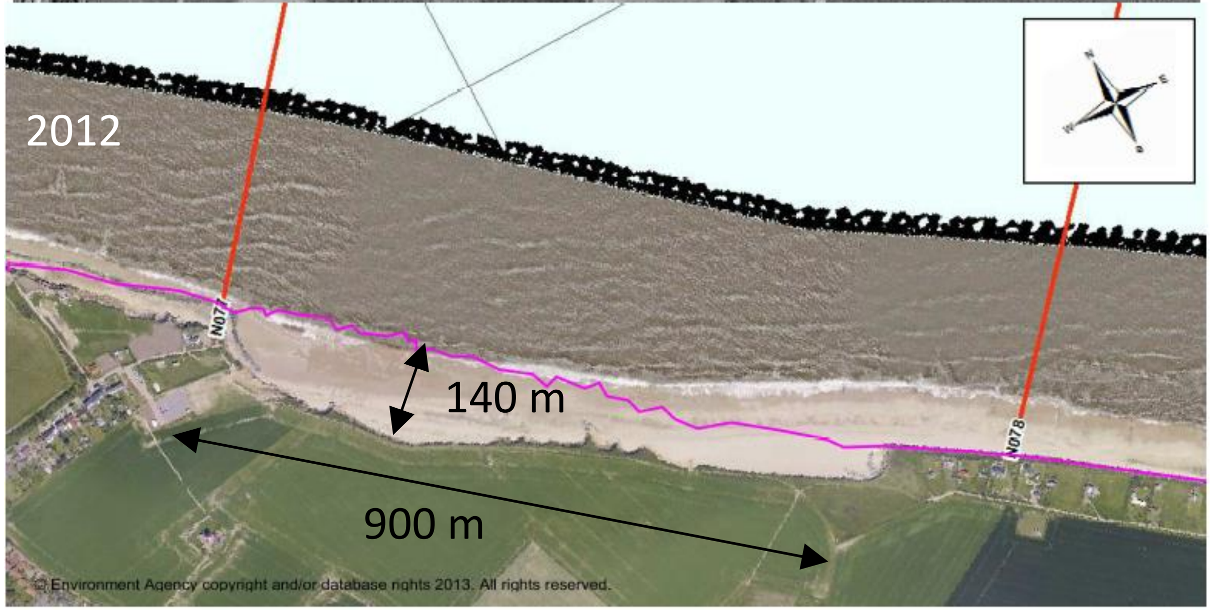
Dr Mike Walkden

WSP Group




Our aim is to better understand the drivers of the quick coastal erosion after defence removal in Happisburgh (East coast UK)





1960s line of defence was designed to reduce cliff erosion rather than entirely prevent it

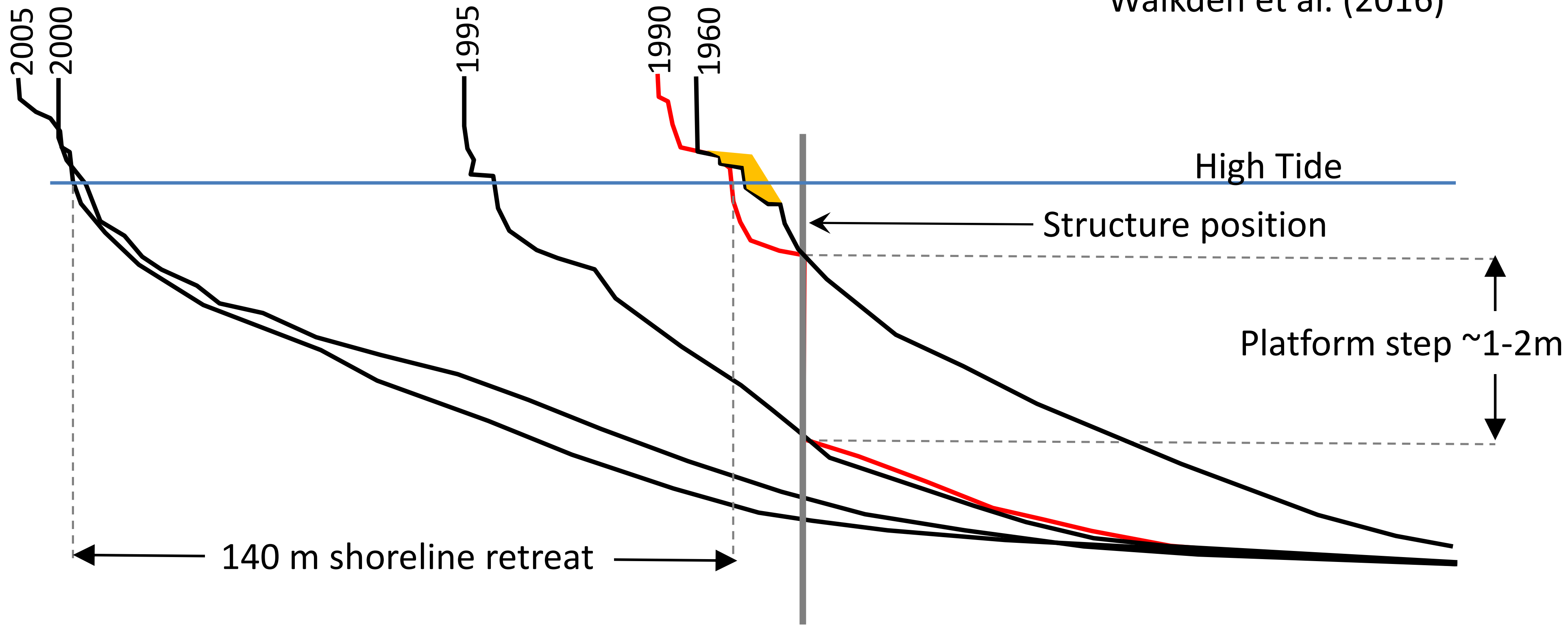
1993 a line of defence section was removed after failure leaving the soft cliff unprotected

Outline

1. Current explanation suggest an un-even platform lowering as main driver of change
2. We tried a non intrusive survey method to search for evidences of platform lowering
3. We show here for first time that beach thickness is non uniform alongshore
4. Successfully simulated four years of landscape and subsurface change
5. Lessons learnt and next steps

Current explanation assumes an un-even platform lowering in-front and behind the line of defence drives the rapid erosion after defence removal

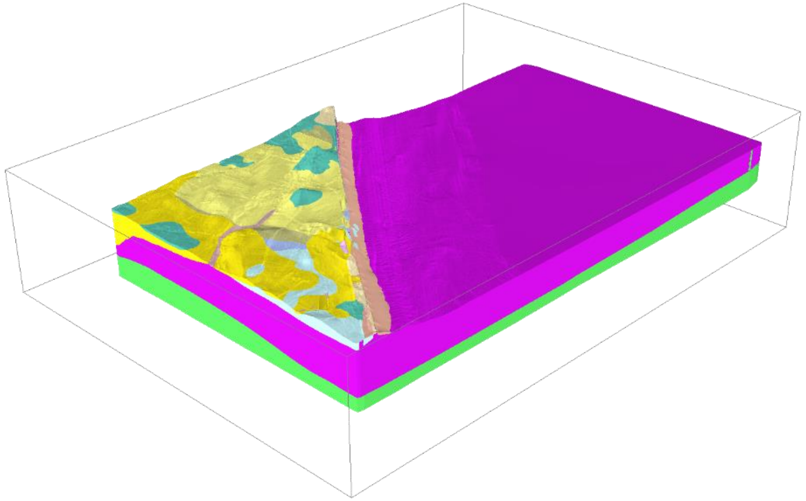
Walkden et al. (2016)

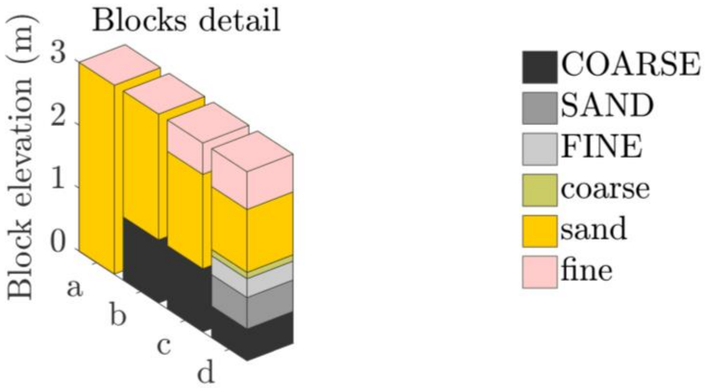


The net shoreline retreat is found to be very sensitive to **beach volumes** and ca four times larger than expected retreat if no structure were built

Previous analysis were limited by the lack of data of beach volume and evidences of un-even platform lowering

Tried a non intrusive survey method to search for any evidences of platform lowering



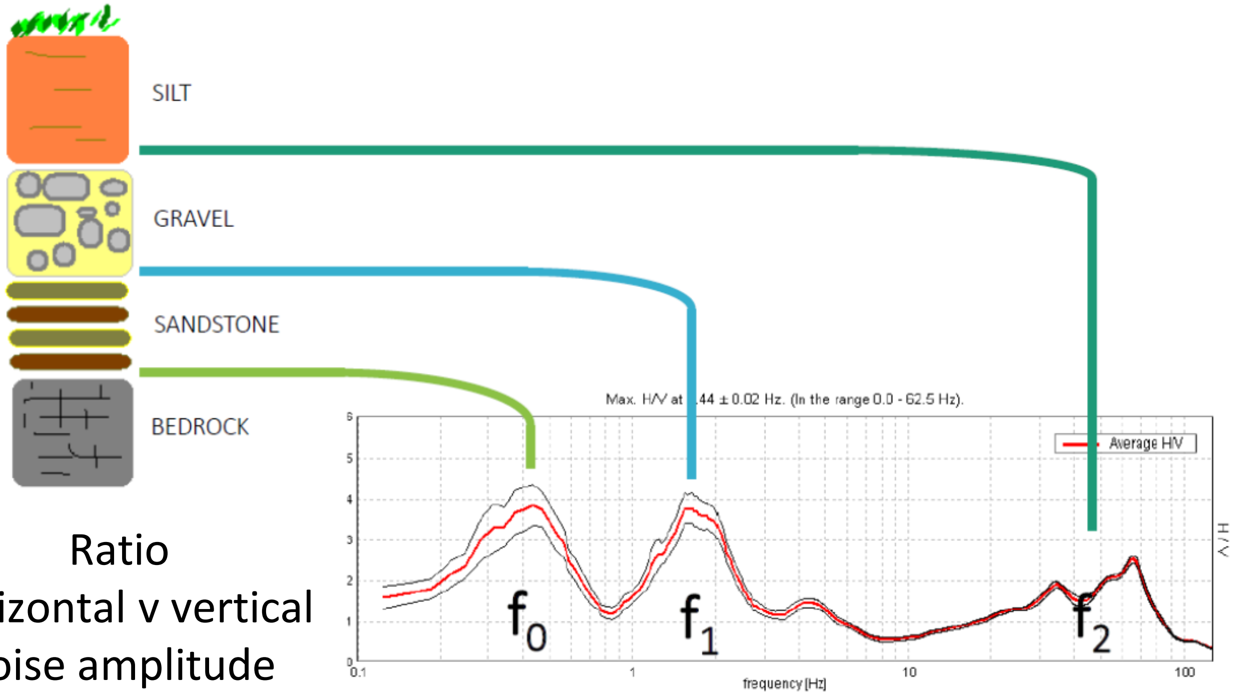


Hypothesized that a better representation of the subsurface might allows us to simulate the observed erosion

A passive seismic survey was conducted to search for any evidence of platform lowering and estimation of beach volume

ICCE 2018

This survey method allows us to estimate the thickness of the different lithologies in the subsurface

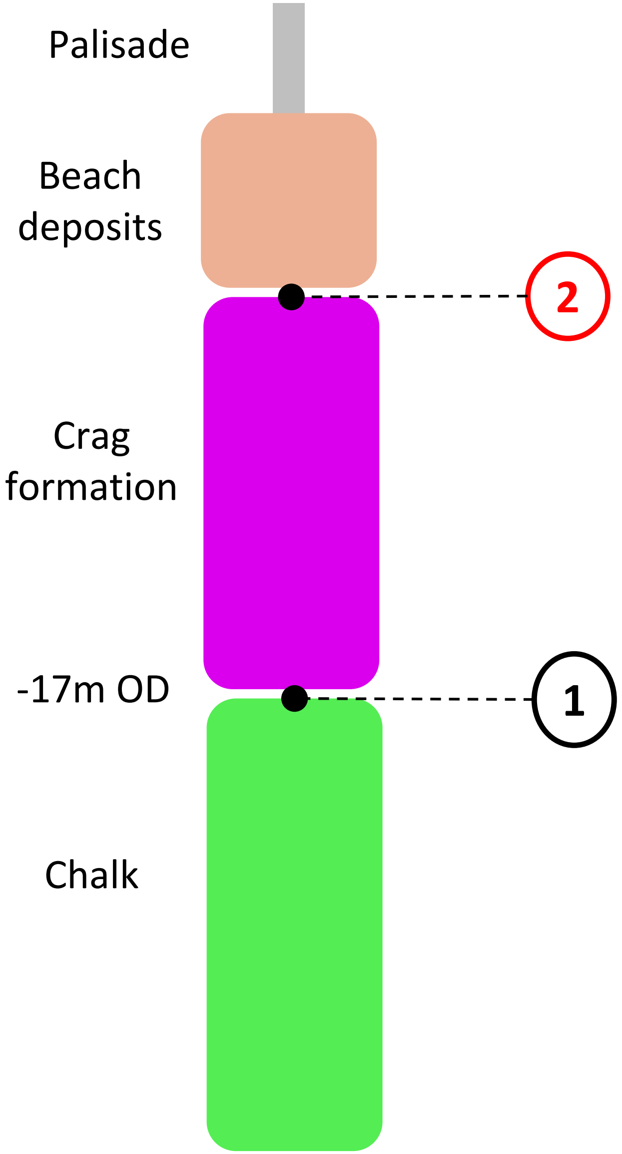


Ratio
Horizontal v vertical
noise amplitude

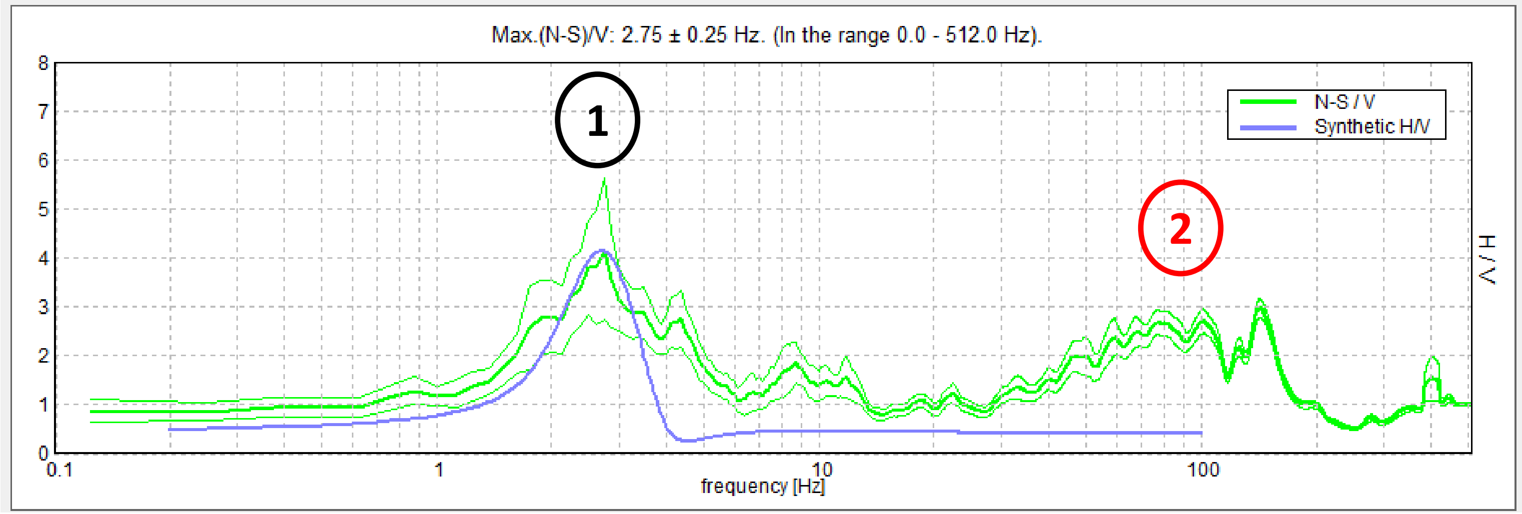
Frequency →

~Depth ←

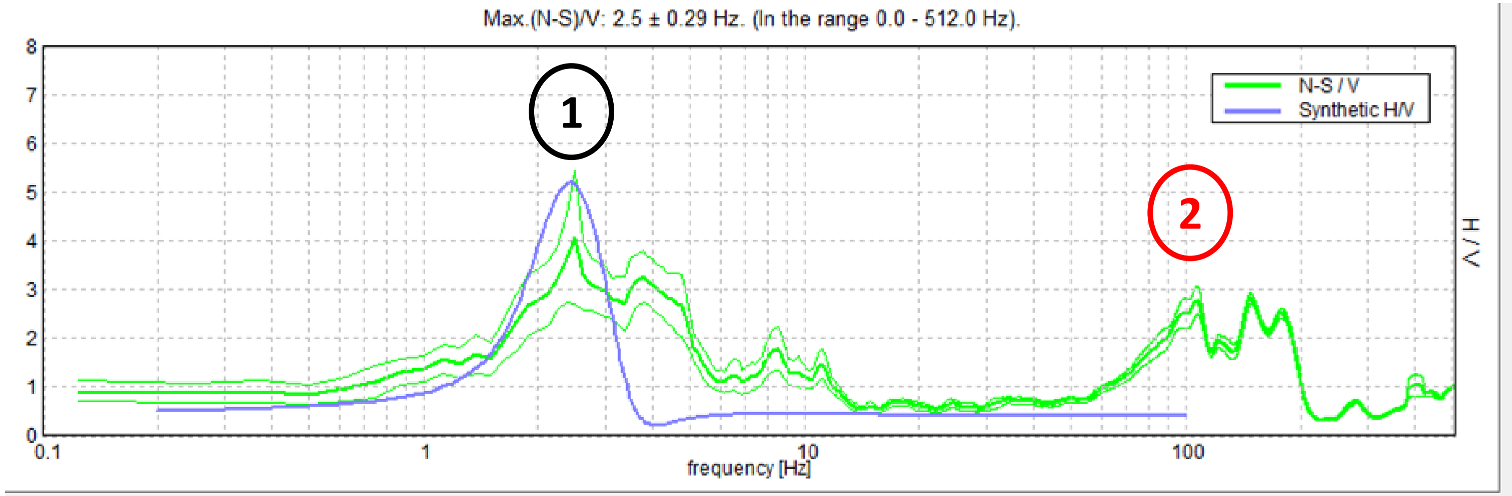
We can see beach deposits transition to crag formation at depths O(1-10m) but peak is not sharp enough to see the un-even lowering



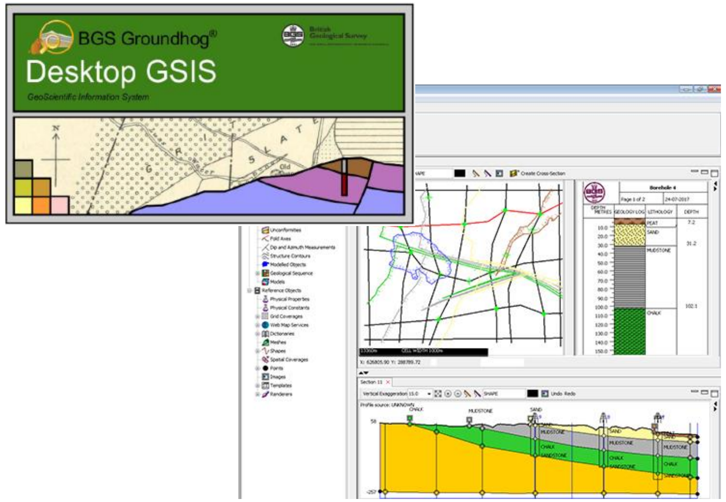
Behind the palisade



In front of the palisade

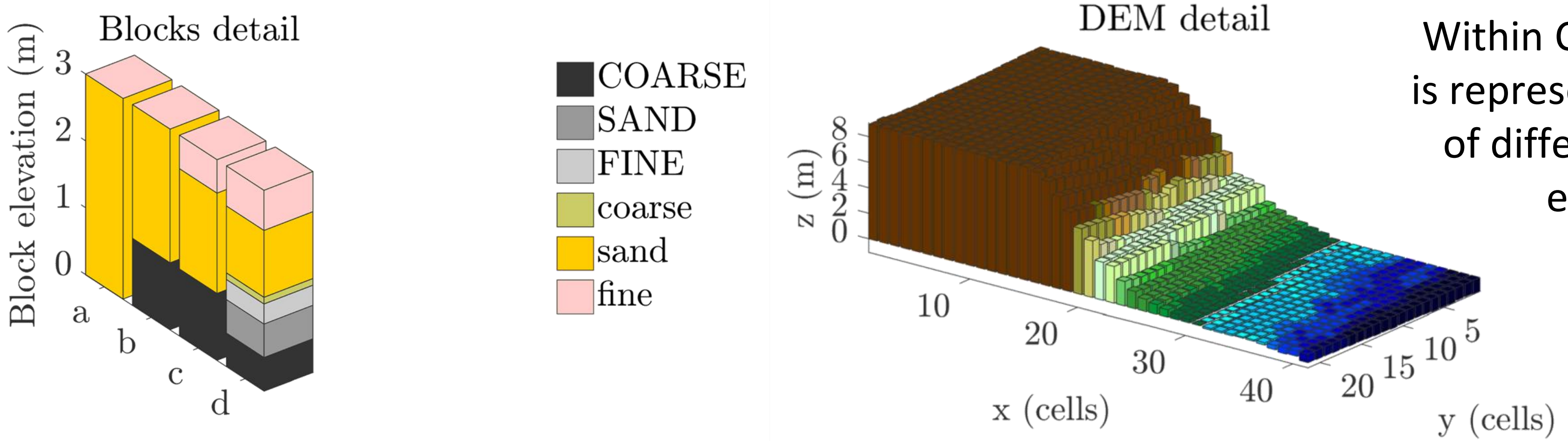


We hypothesized that a better representation of the transportable and source material might provide further insights to explain the observed coastal erosion



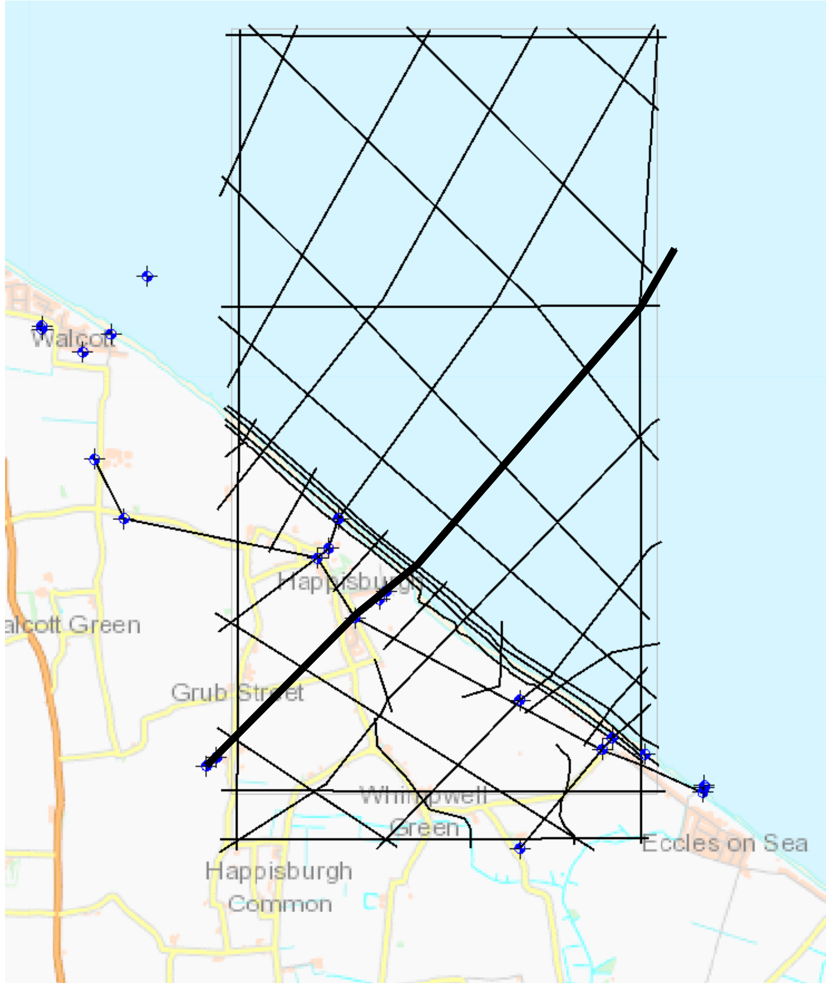
Free to use under UK's Open Government Licence

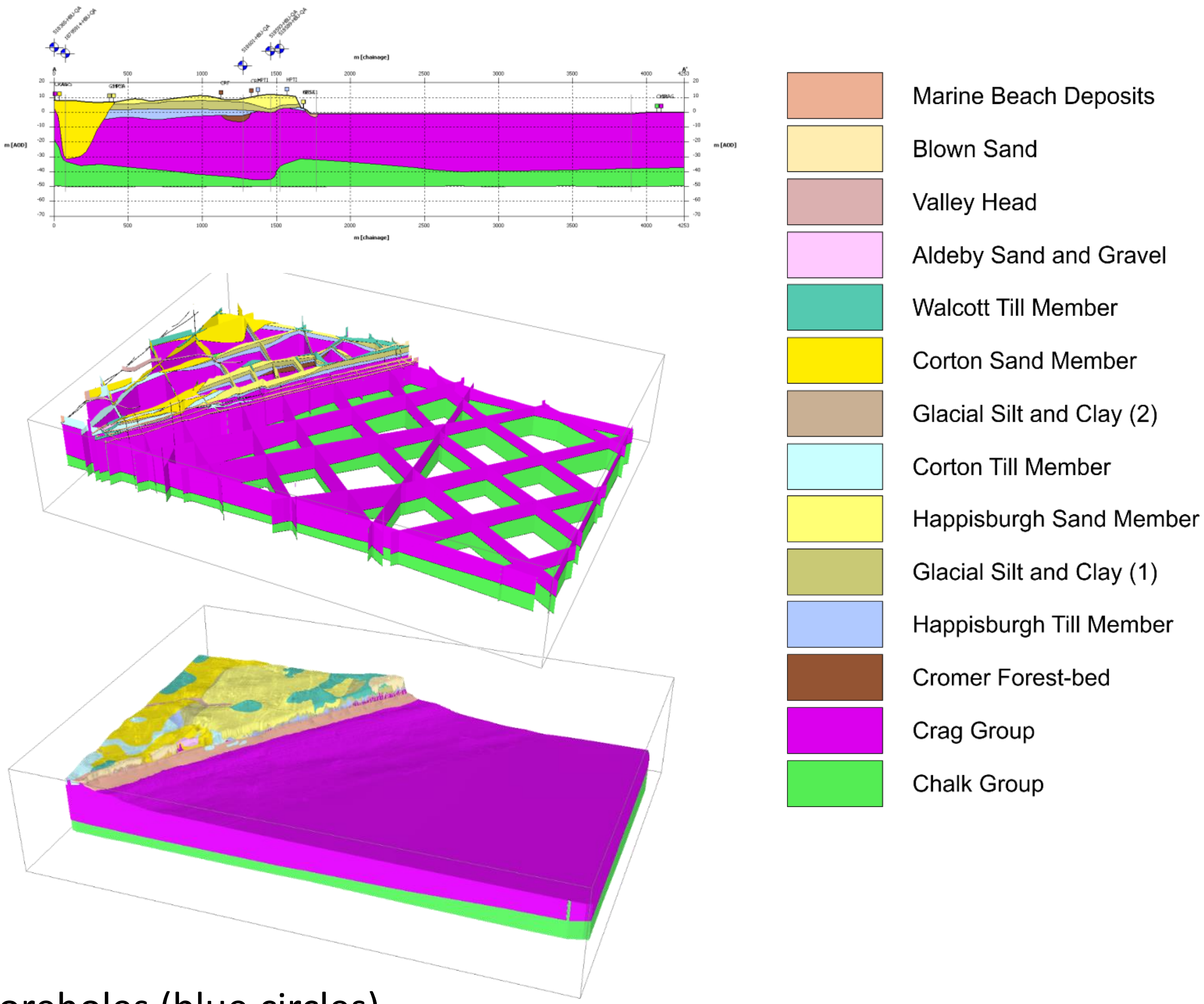
- *Boreholes logs*
- *Digital sections*
- *Interpolated 3D digital model*
- New! *Exported to* ***4D CoastalME thickness layers***
  Payo et al. (2017, GMD)



Within CoastalME topography is represented as square blocks of different thicknesses and evolves on time.

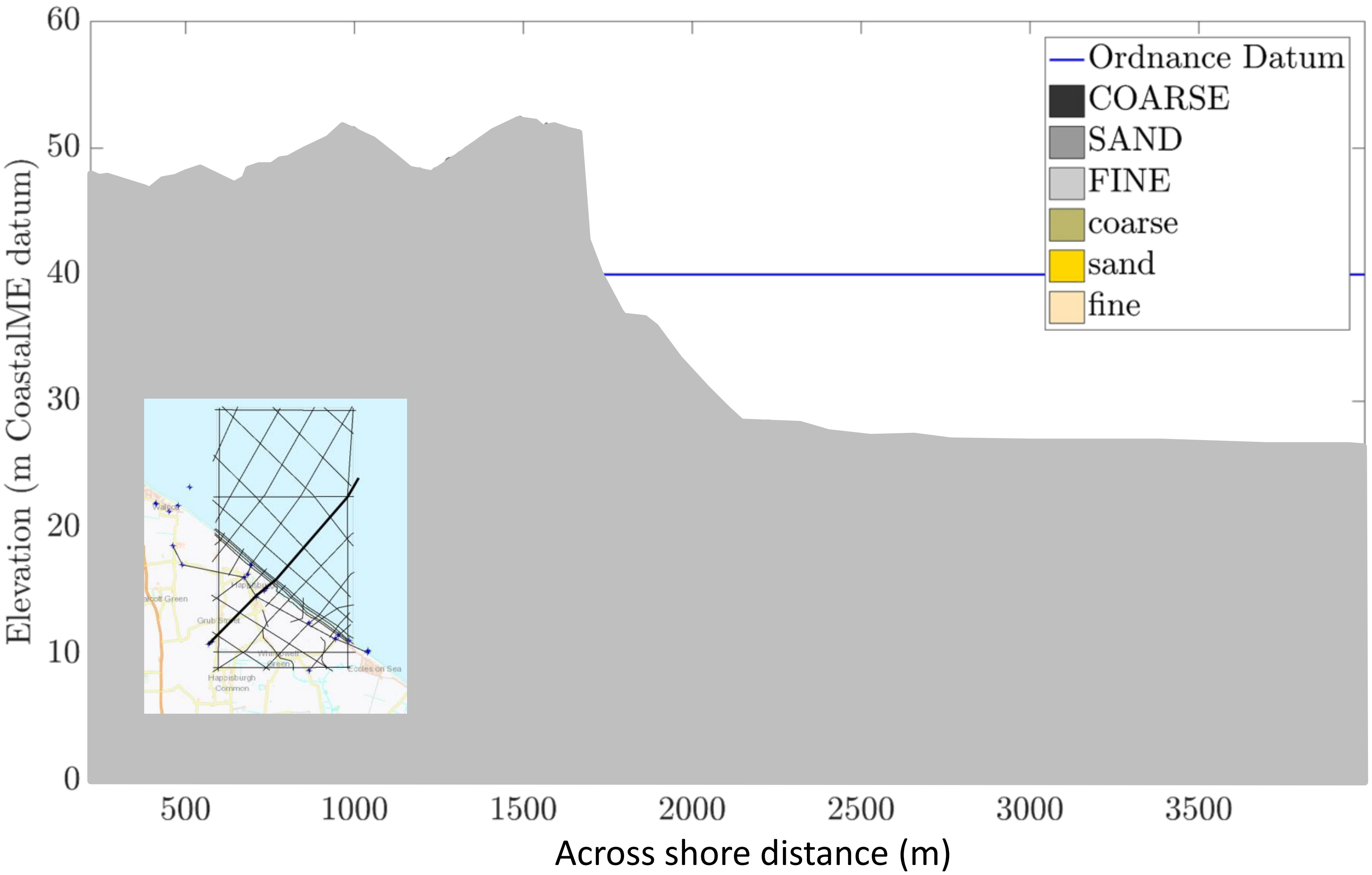
From boreholes and cross-sections interpretations we have generated a 3D model of the subsurface

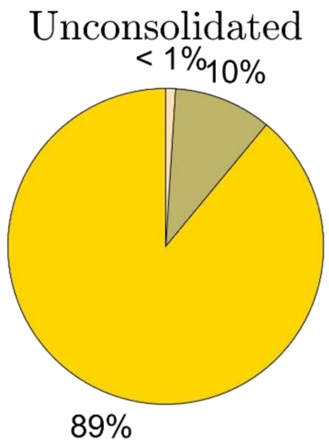


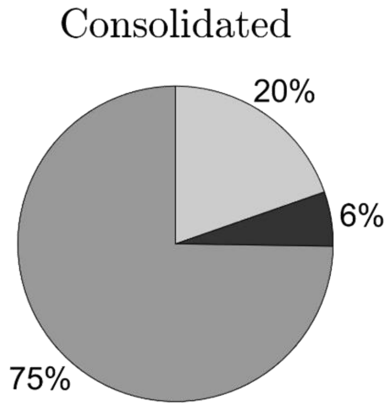


Location of the cross-sections (black lines) and boreholes (blue circles) used to build the 3D subsurface model of Happisburgh

We have created a thickness model with the estimated amount of gravel, sand and fine material on each lithology

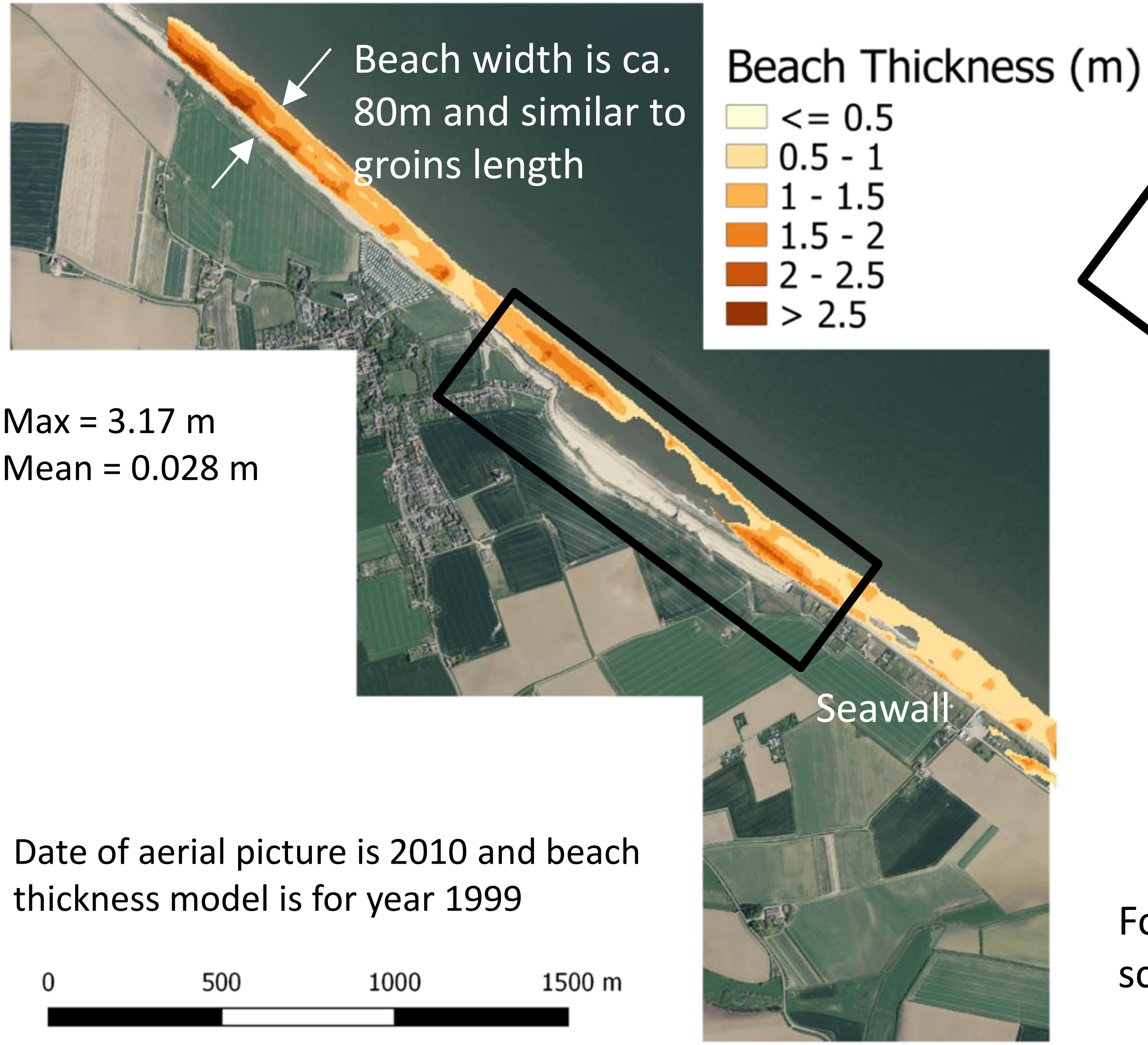






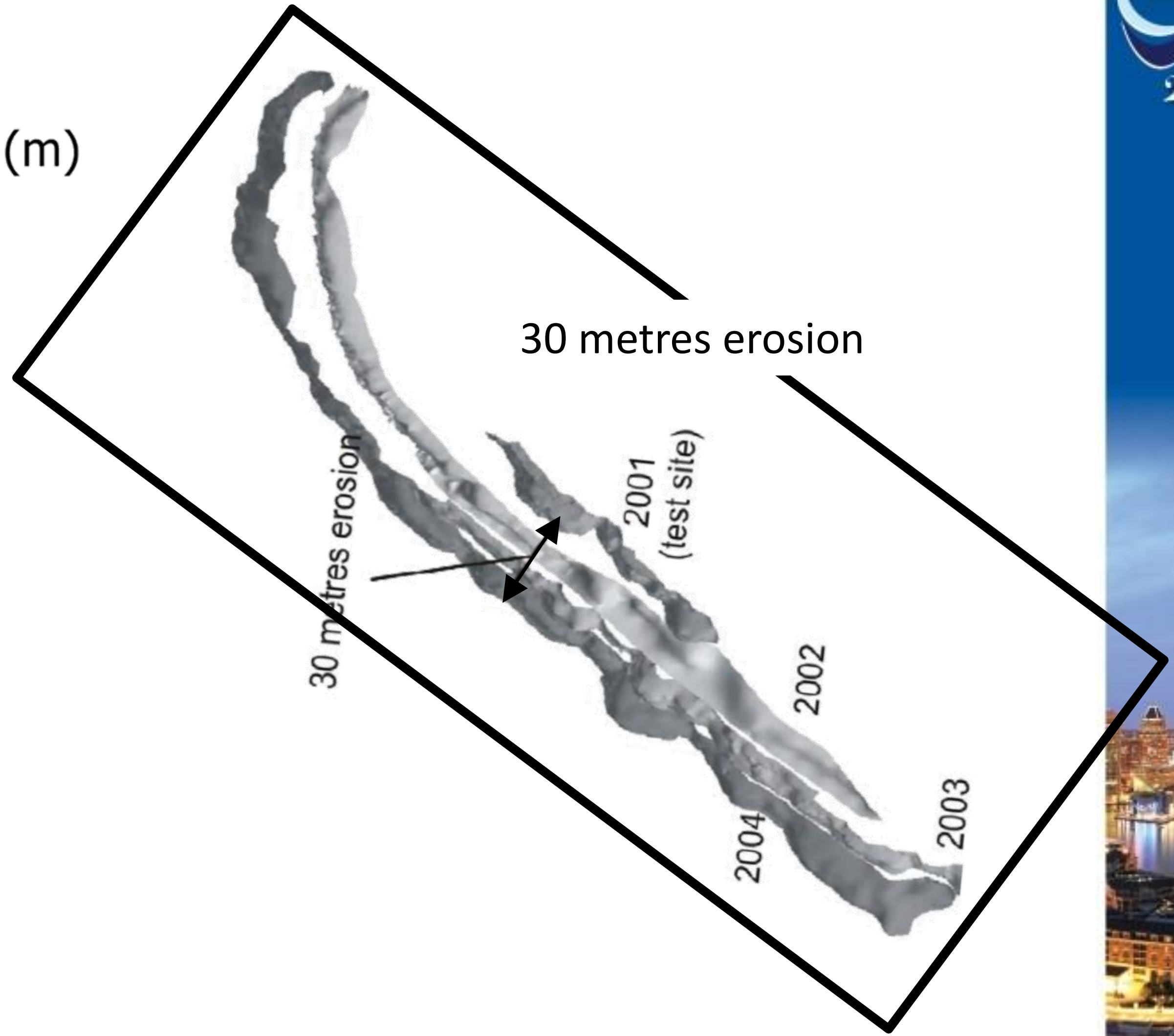
Example of exported thickness model across a section in the middle of the study area

Beach thickness is minimum along the unprotected coastal stretch



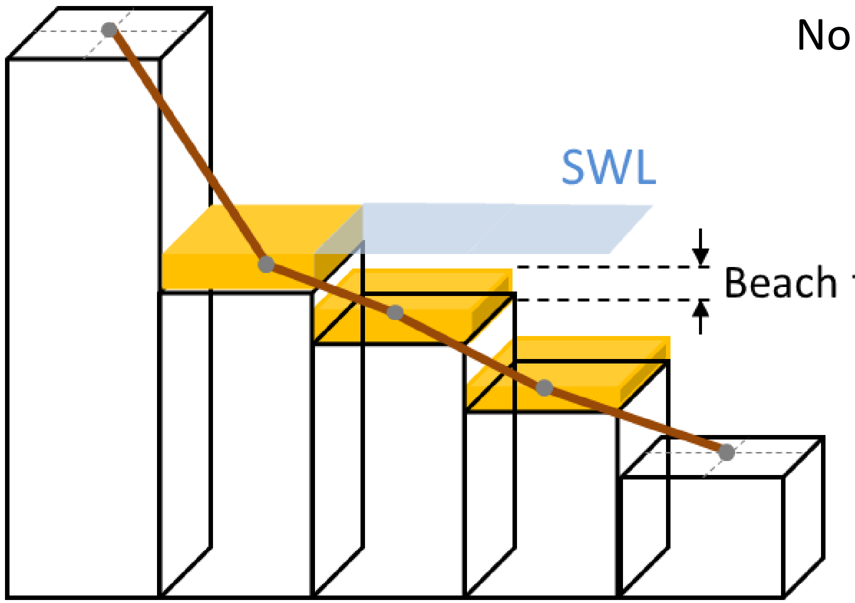
Max = 3.17 m
Mean = 0.028 m

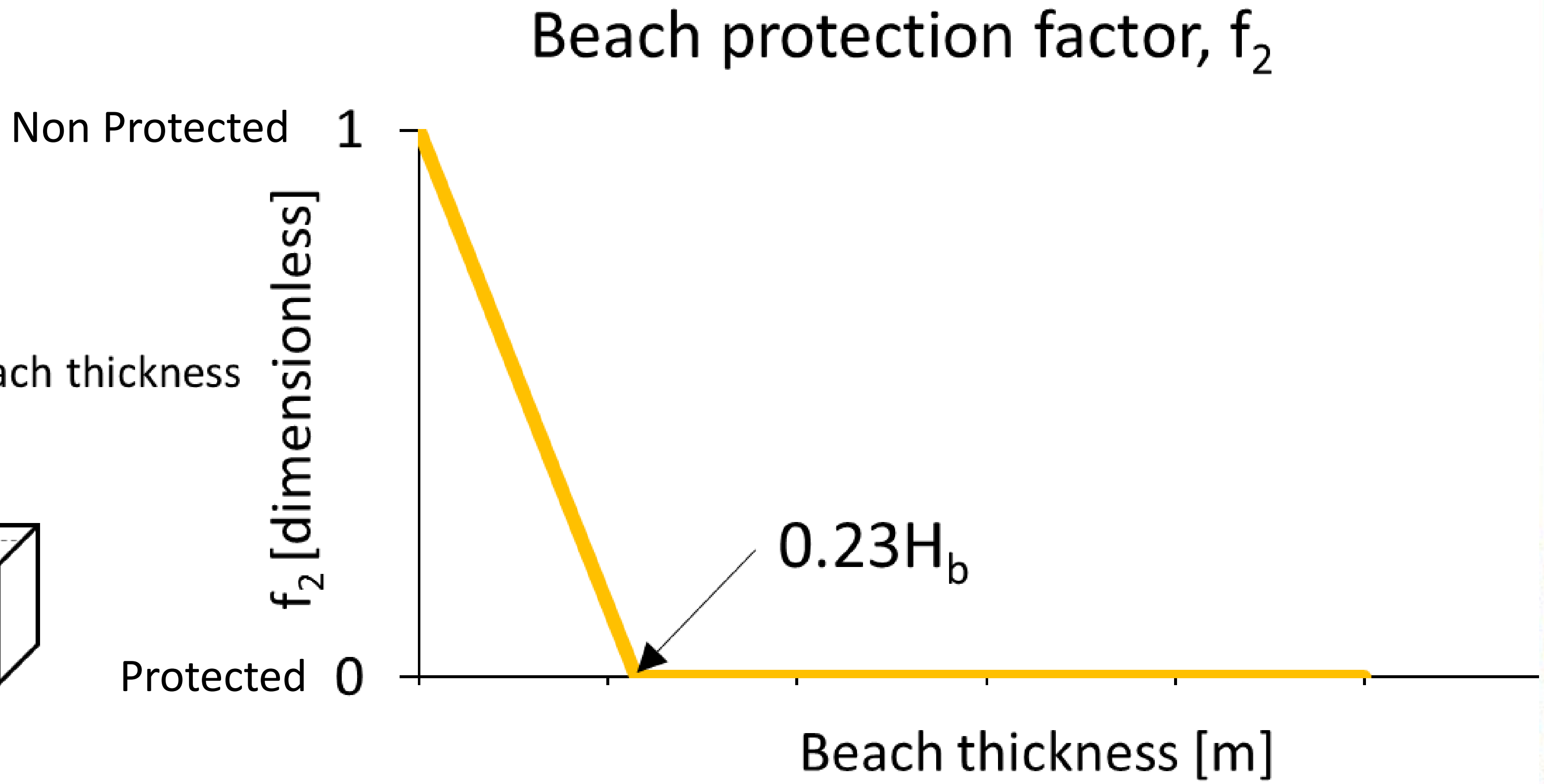
Date of aerial picture is 2010 and beach thickness model is for year 1999



Four unprotected cliff surfaces as recorded by cliff scans between 2001 and 2004 (Poulton et al., 2006)

Assuming that alongshore sediment transport gradients drives beach volume changes we have simulated 4 years of observed coastal erosion





Beach and shore platform interaction simulated as in SCAPE (Walkden & Hall, 2011)

As a first approximation wave energy dissipation behind palisade simulated by an increase on the energy dissipation due to bottom friction

In our simulations:

- Cliff backwearing = f(Resistance, wave energy at cliff toe)
- Platform lowering and alongshore sediment transport is proportional to wave height at breaking

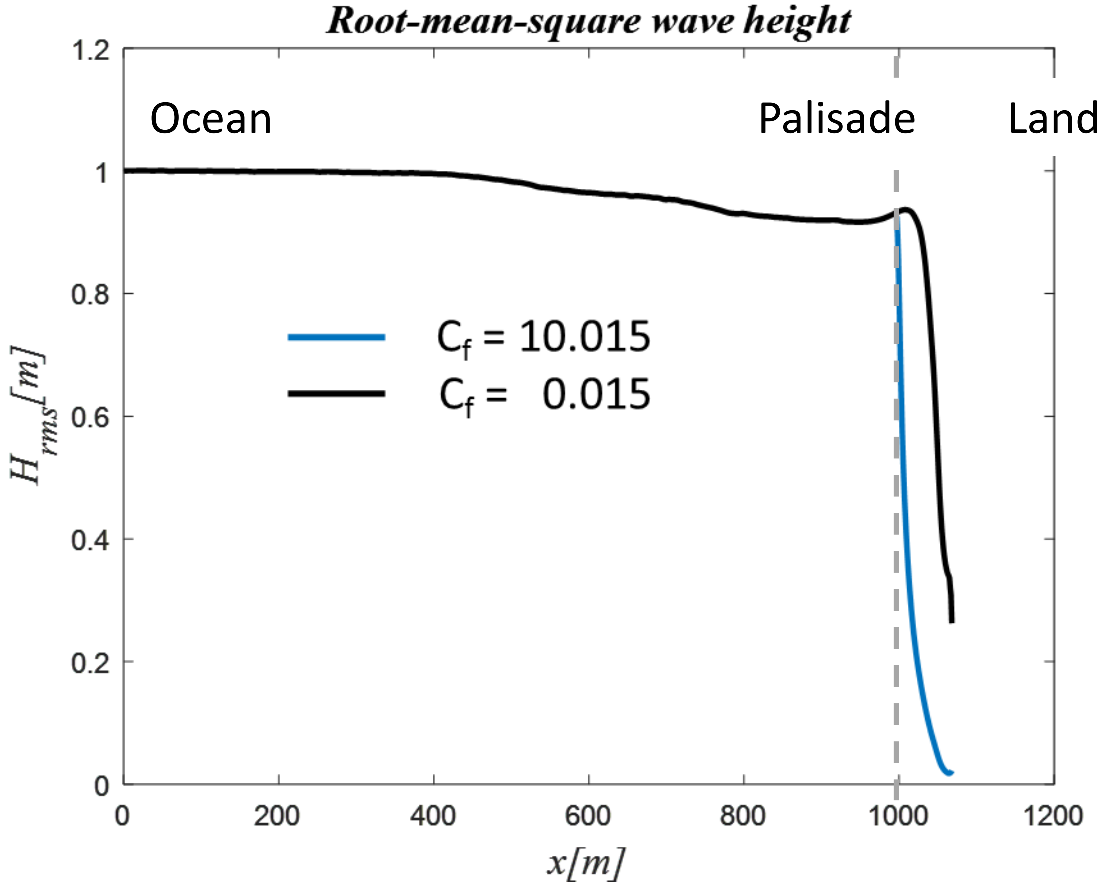
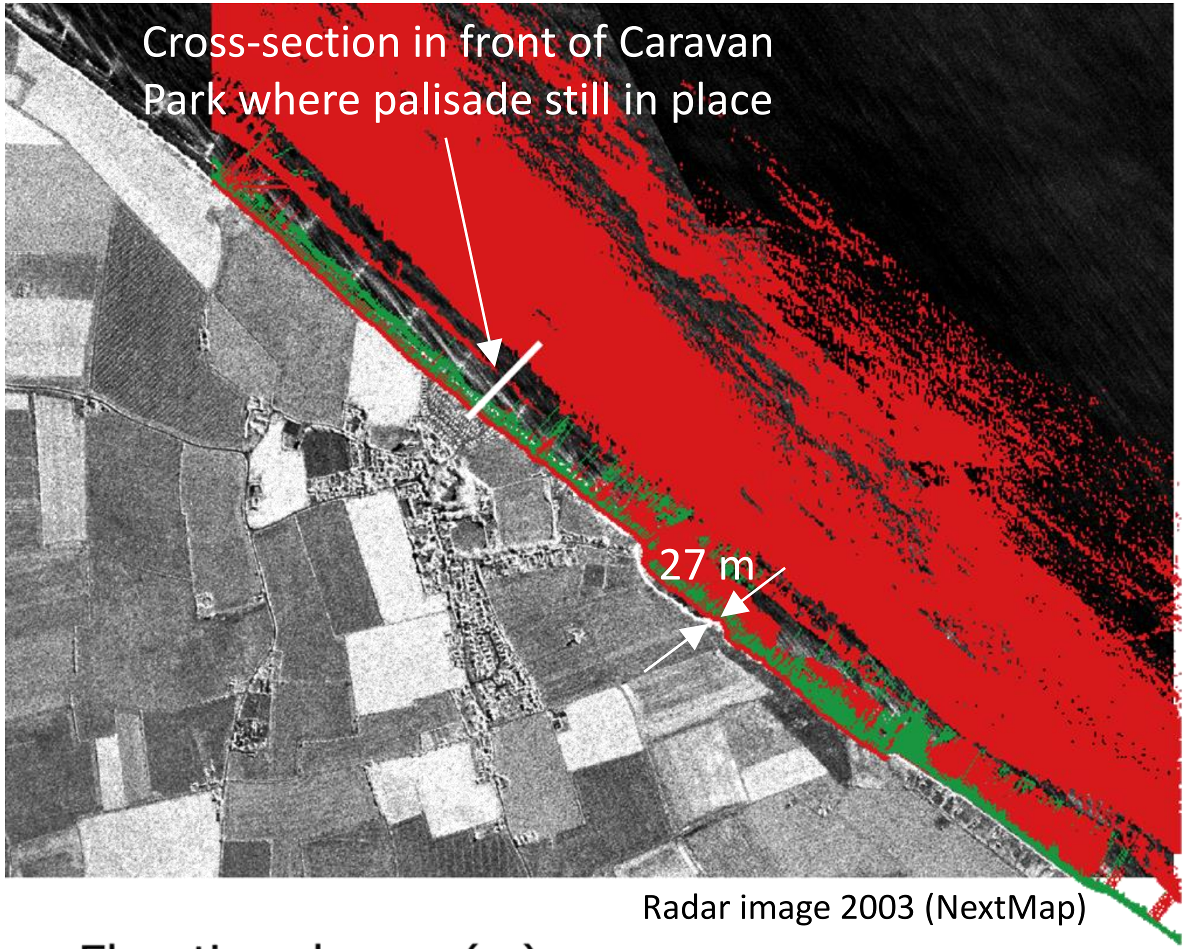
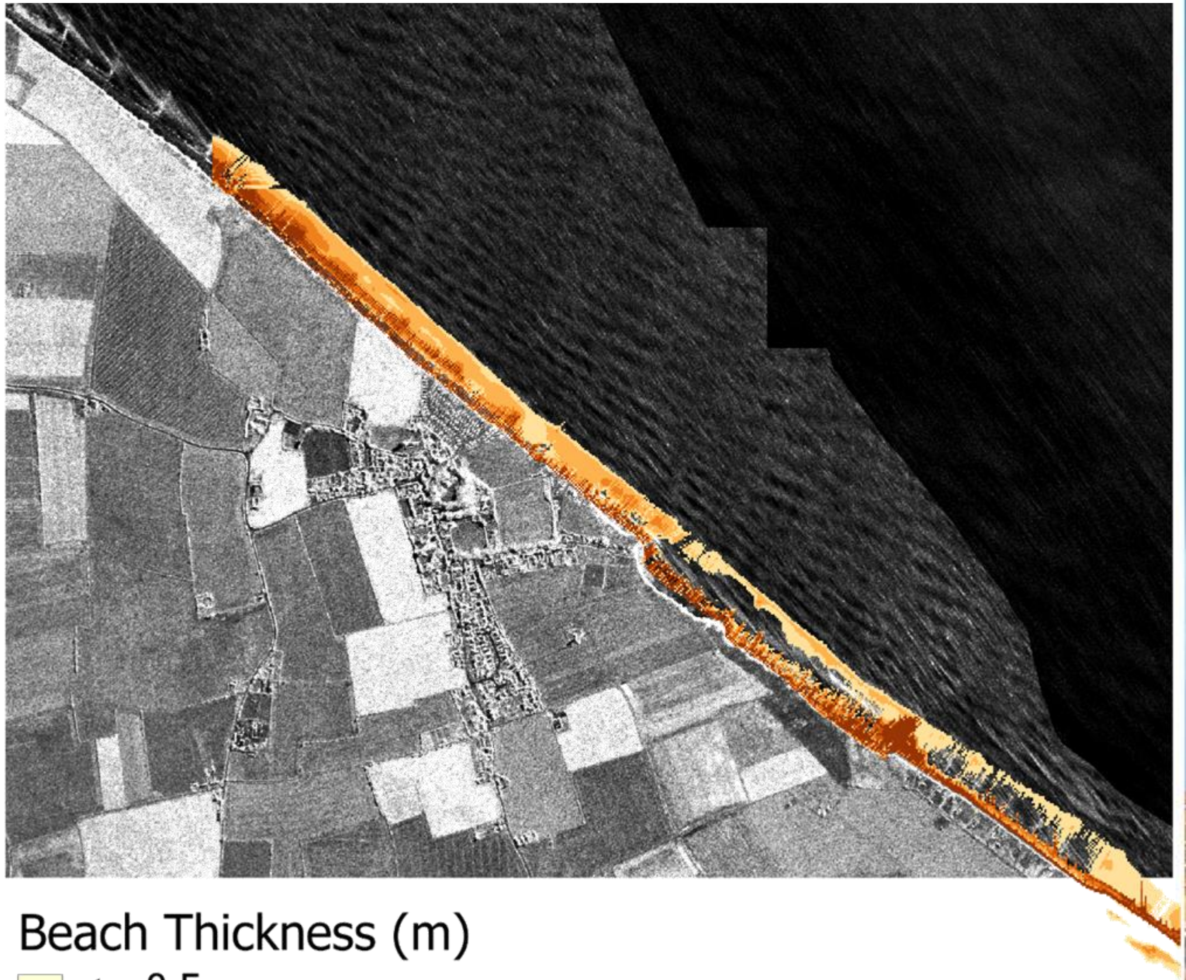


Illustration of simulated wave height variation across a profile using CSHORE model (Kobayashi et al. 2016) with (blue line) and without (black line) the enhanced friction factor (Cf) behind the palisade.

Simulation from 1999 to 2003 suggest that overall beach thickness has increased



Radar image 2003 (NextMap)



Elevation change (m)
- <= -0.01
- -0.01 - 0.01
- > 0.01

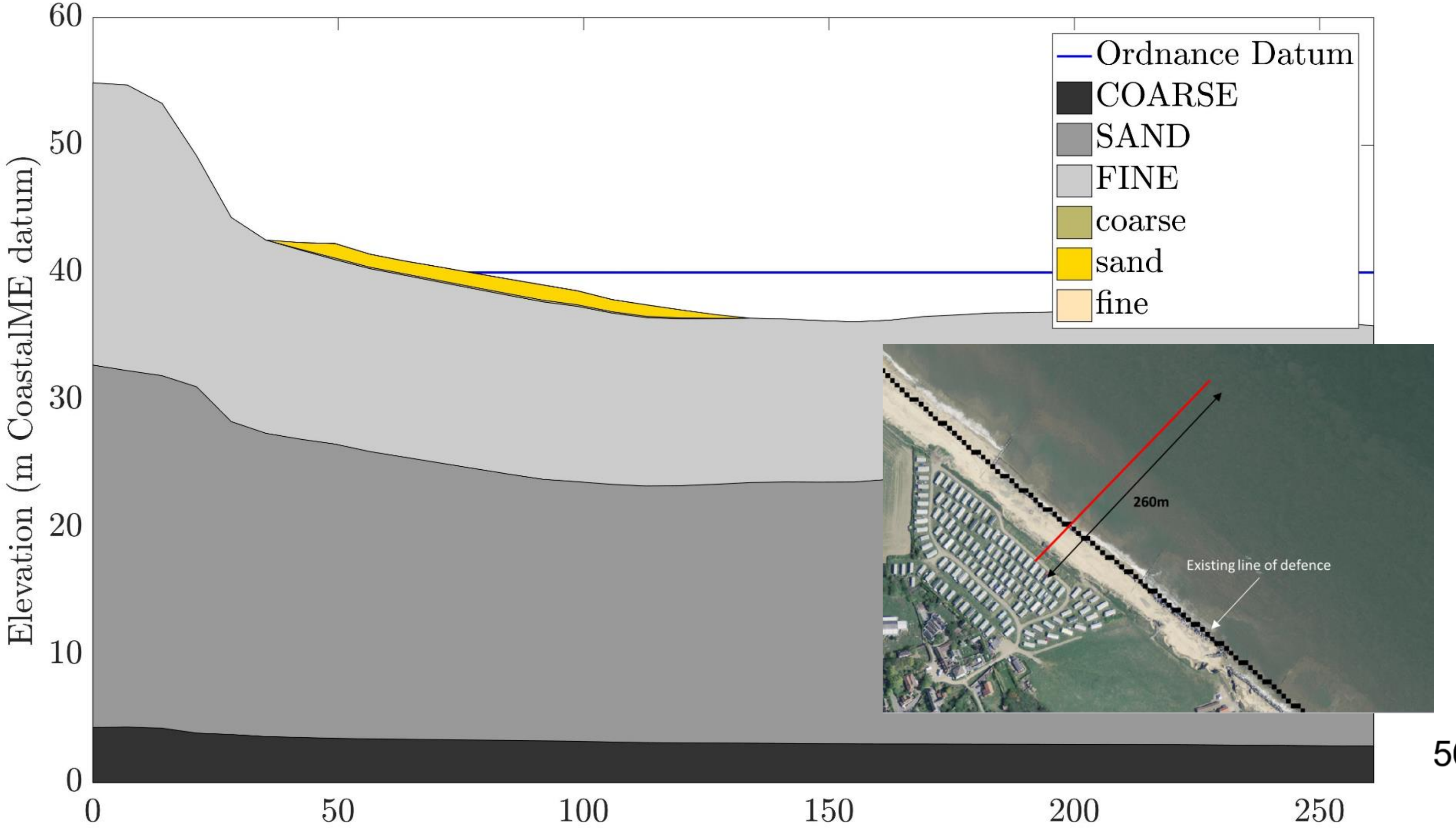
0 500 1000 1500 m

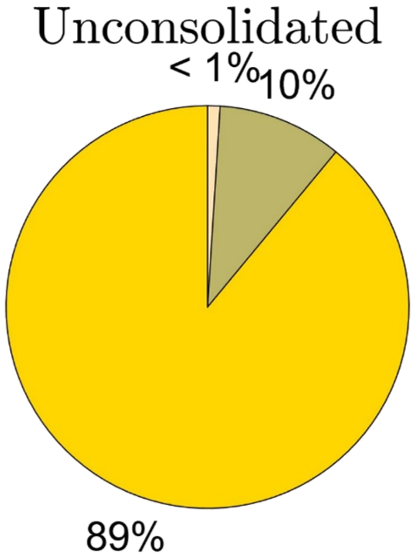
Beach Thickness (m)
- <= 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- > 2.5

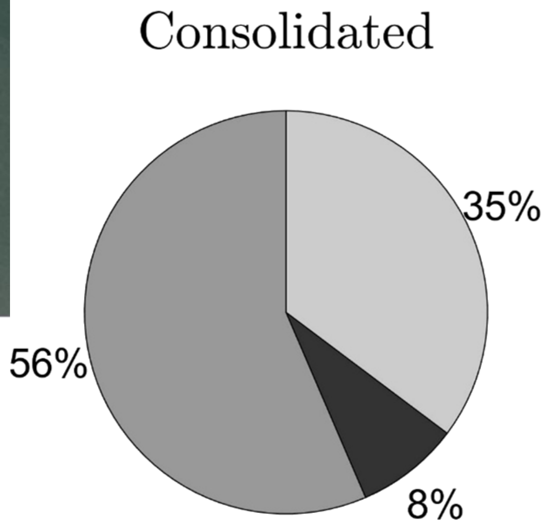
Year	Max	Mean
1999	3.17 m	0.028 m
2003	6.85 m	0.045 m

By evolving the thickness model we can estimate changes on beach volumes and sediment fraction composition

Initial profile and sediment fractions at a 260m long cross-section in-front of Caravan park where continuous line of defence remains

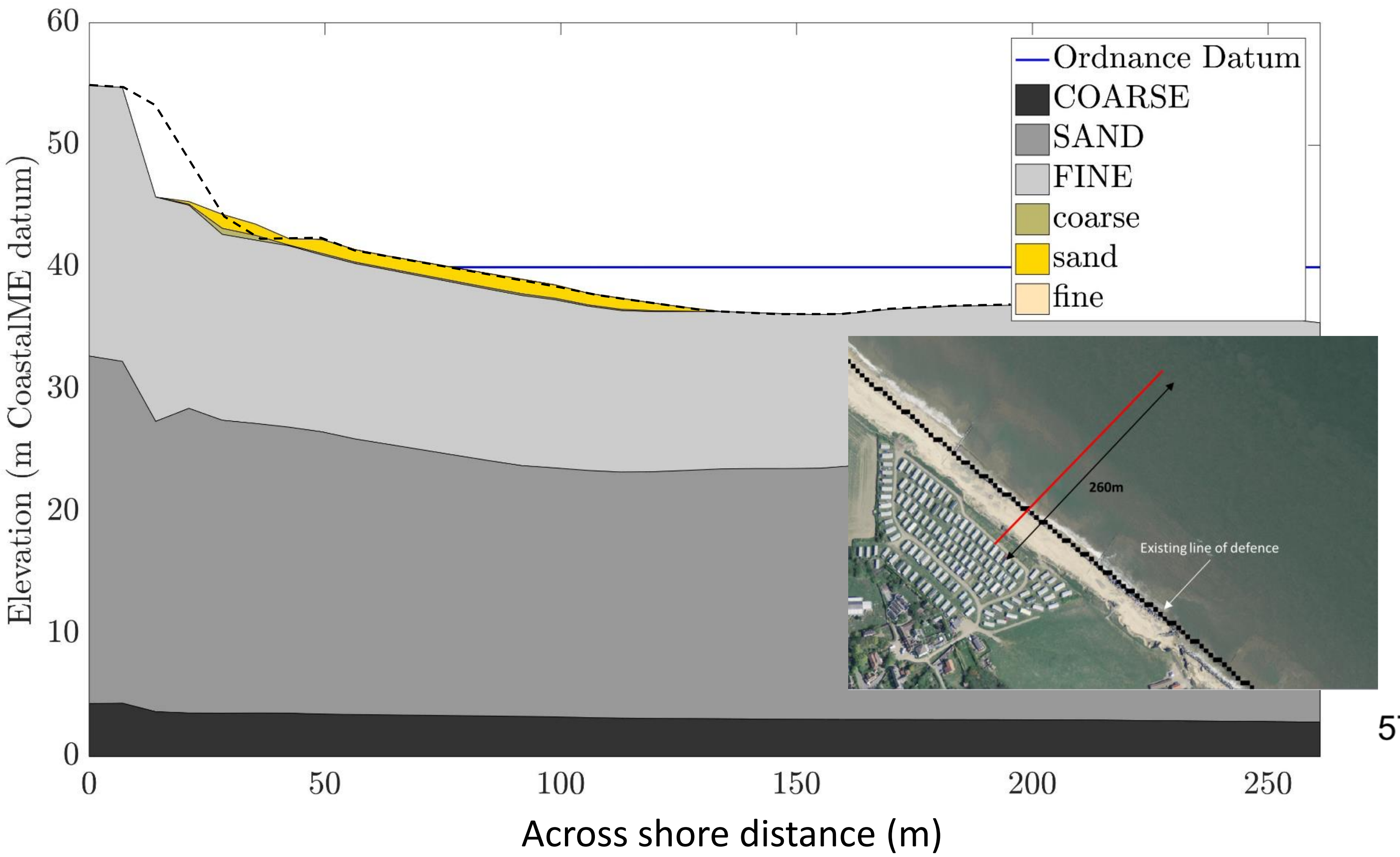


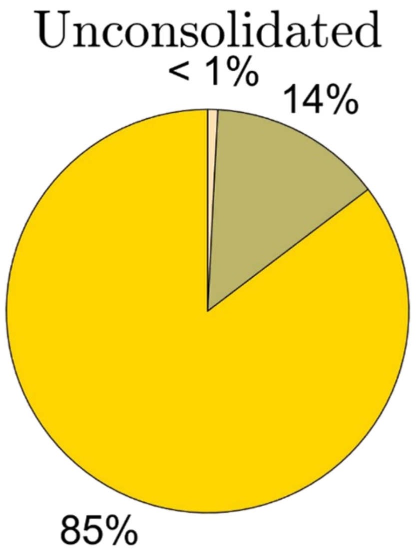


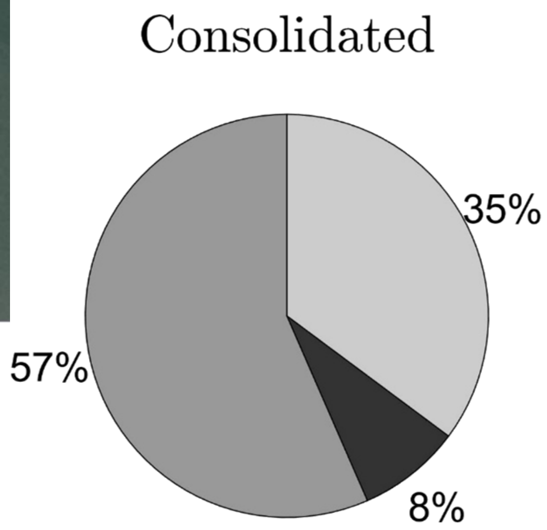


After four years unprotected cliffs has retreated ca. 30m and overall beach thickness has increased

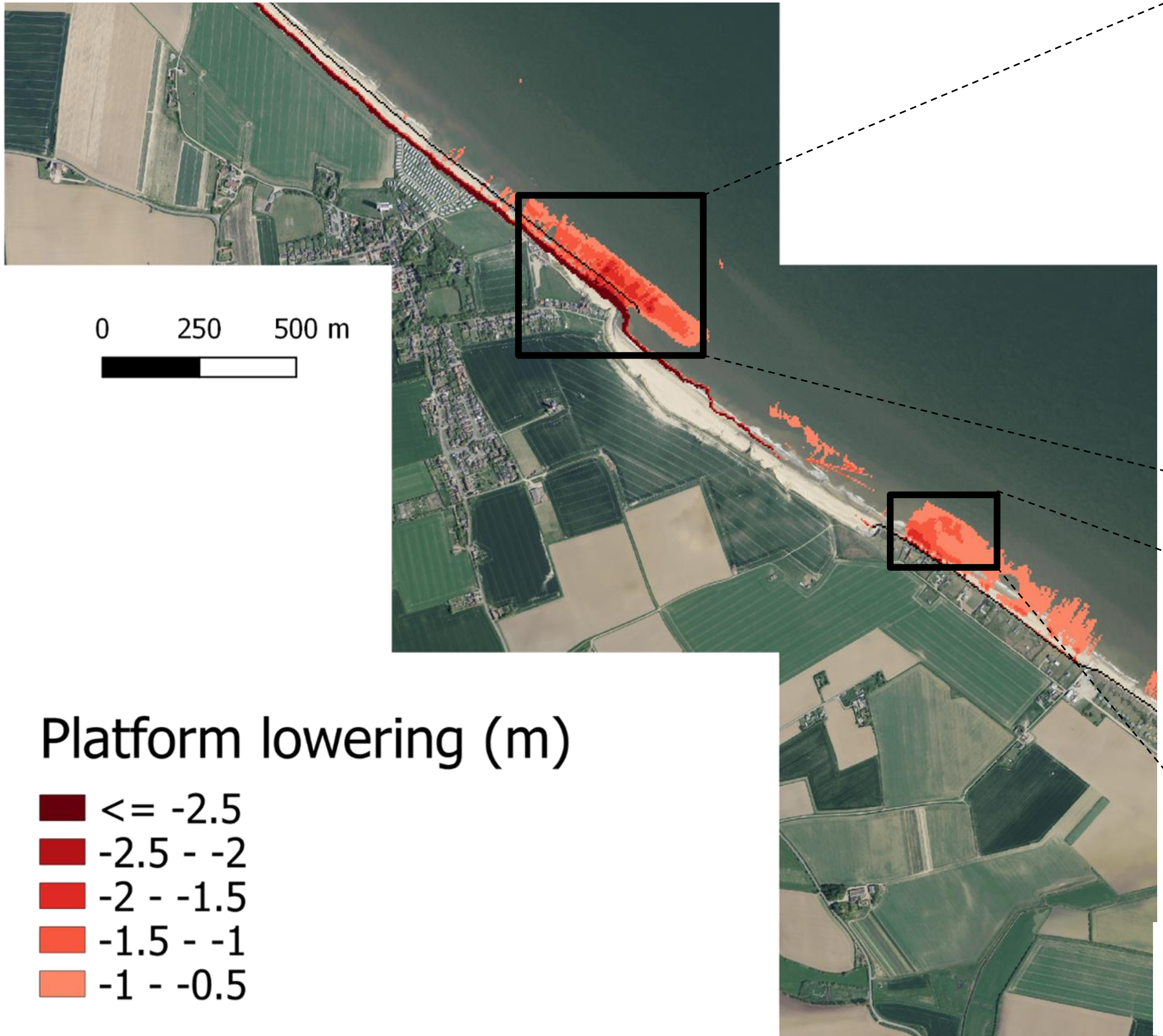
Final profile and sediment fractions. Dash line represent initial ground elevation.
Note the increase of the unconsolidated gravel fraction (from 10% to 14%).

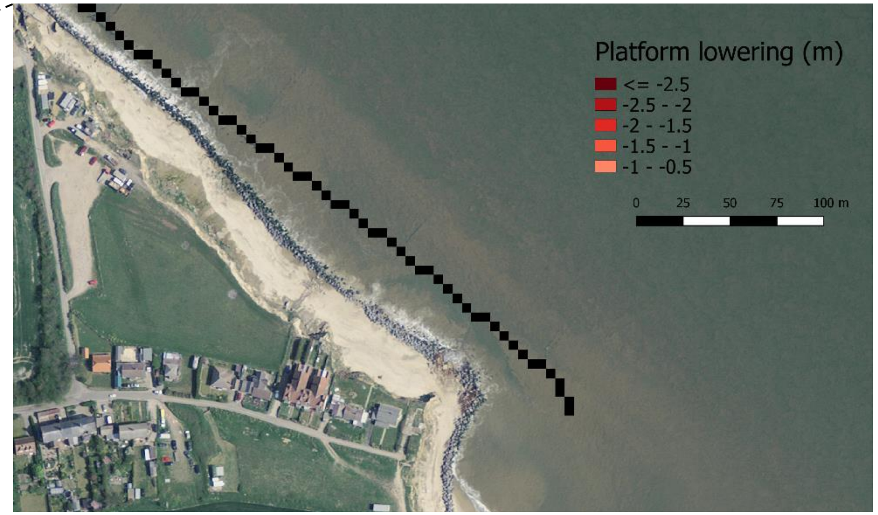






Simulation suggest un-even platform lowering on the order of 2m at locations were beach thickness remains low





Location of rubble breakwater coincides with area of maximum estimated platform lowering and observed cliff erosion

Simulated platform lowering suggest that sea wall foundation might be at risk of collapsing

Summary

1. Current explanation suggest an un-even platform lowering as main driver of change
2. Passive seismic survey method not appropriate at Happisburgh to measure platform lowering due to similar impedances of beach deposits and crag formation
3. 3D model of the subsurface reveals that beach thickness is minimum along the undefended coastline
4. CoastalME evolving from proof of concept to operational tool
5. Simulations suggest platform lowering is significant but our process understanding still limited

Thanks for your attention!

Collaborators:

David-Favis Mortlock, Oxford Univ.	CoastalME
Benjamin Woods, BGS	GroundHog
Holger Kessler, BGS	GroundHog
Jonathan Lee, BGS	Quaternary Geology
Nobuhisa Kobayashi, UDEL	CSHORE
Brad Johnson, USACE	CSHORE

BLUE Coast

Physical and biological dynamic coastal processes and their role in coastal recovery

..follow us and join in with the conversation at #bluecoastuk

www.bluecoastuk.org