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

IMPLICATIONS OF CONSOLIDATION ON BARRIER BEACH STABILITY

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A cross-shore model of barrier island migration over a compressible substrate

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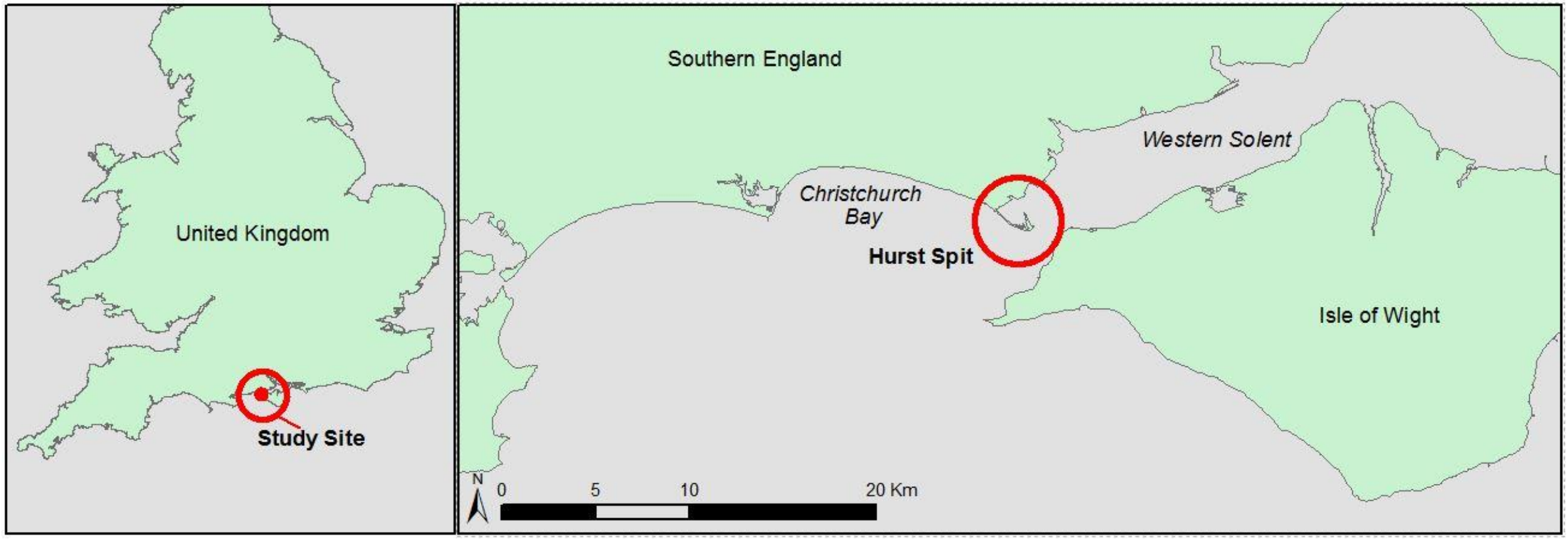
ABSTRACT

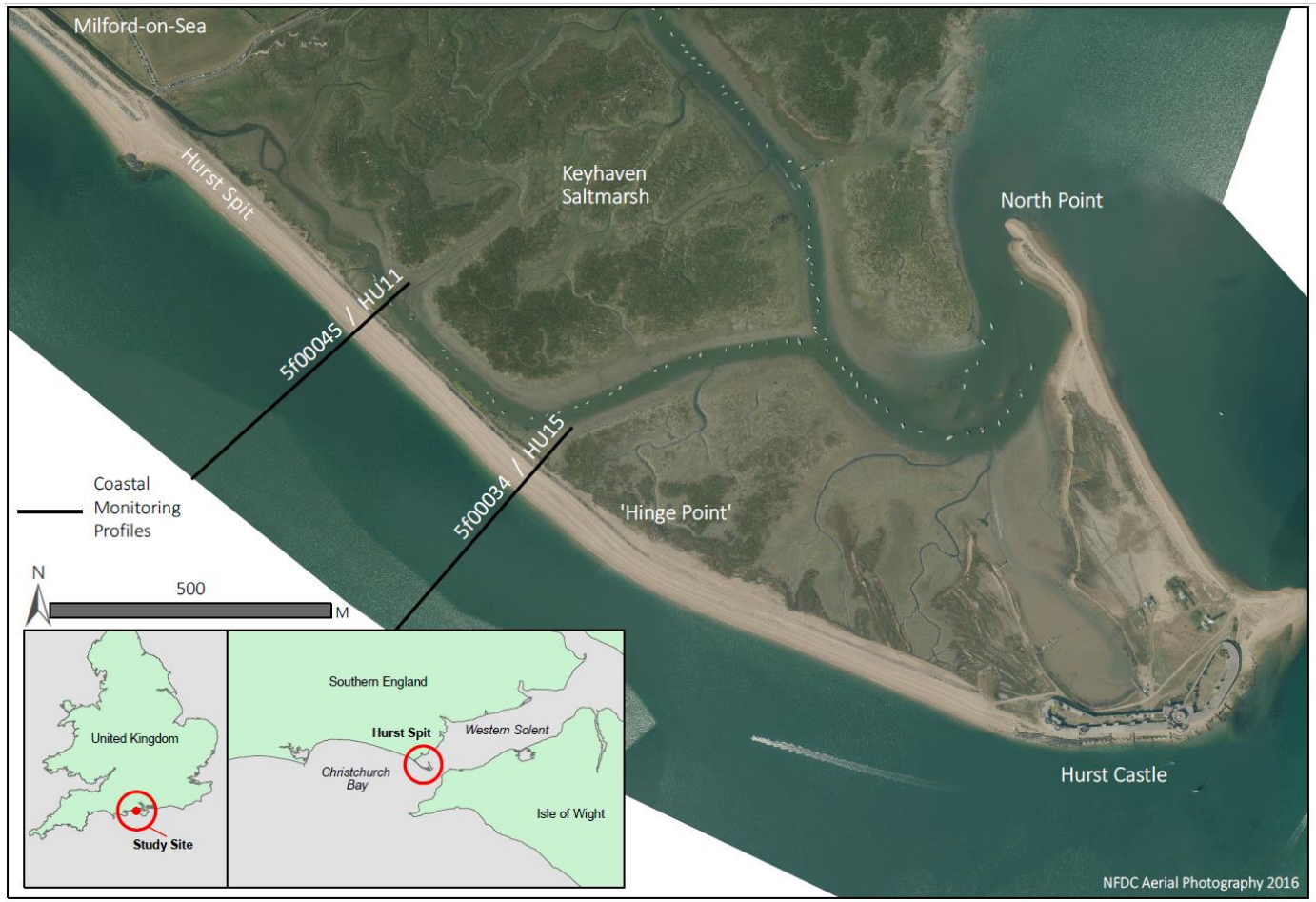
Barrier islands that overlie a compressible substrate, such as islands in deltaic environments or those that overlay mud or peat deposits, load and consolidate the underlying subsurface. Through time, the elevation and aerial extent of these islands are reduced, making them more susceptible to future inundation and overwash. Sand washed over the island and onto back-barrier marsh or into the bay or estuary begins the consolidation process on a previously non-loaded substrate, with time-dependent consolidation as a function of the magnitude of the load, duration of load, and characteristics of the substrate. The result is an increase in the overwash, migration, breaching, and segmentation of these islands.

Hurst Spit, Hampshire, UK



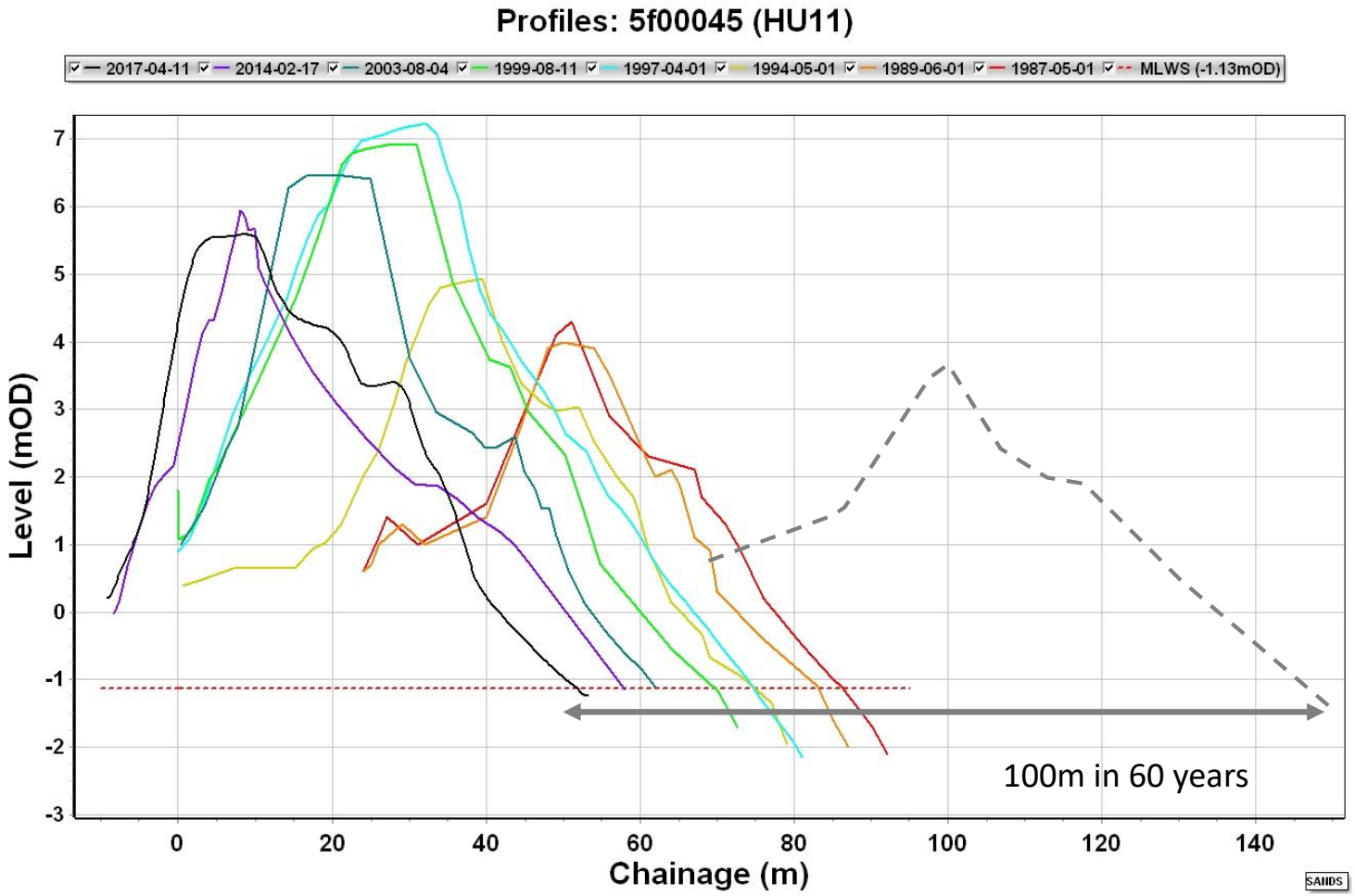
Hurst Spit, Key Characteristics

- Coarse-grained – shingle (pebble) beach
- Steep beach slopes – typical 10 degree slopes
- Rapid erosion -- big changes in extreme events
- Overlies the marsh deposits found to landward – typical transgressive situation
- Marsh deposits consolidate and also “fail” (load exceeds bearing capacity)
- Retreating beach leads to rapid change in loads due to steep slopes
- Declining beach volumes due to failing sediment supplies
- Major breach in December 1989
- First nourishment in 1996 (300,000 m^3)
- Erosion slowed but volume loss continues
- Second nourishment in 2020 (?)
- Consolidation influences natural morphodynamics and nourishment design



Hurst Spit: 1946 and 2016 shorelines

Hurst Spit – Typical cross-sectional changes



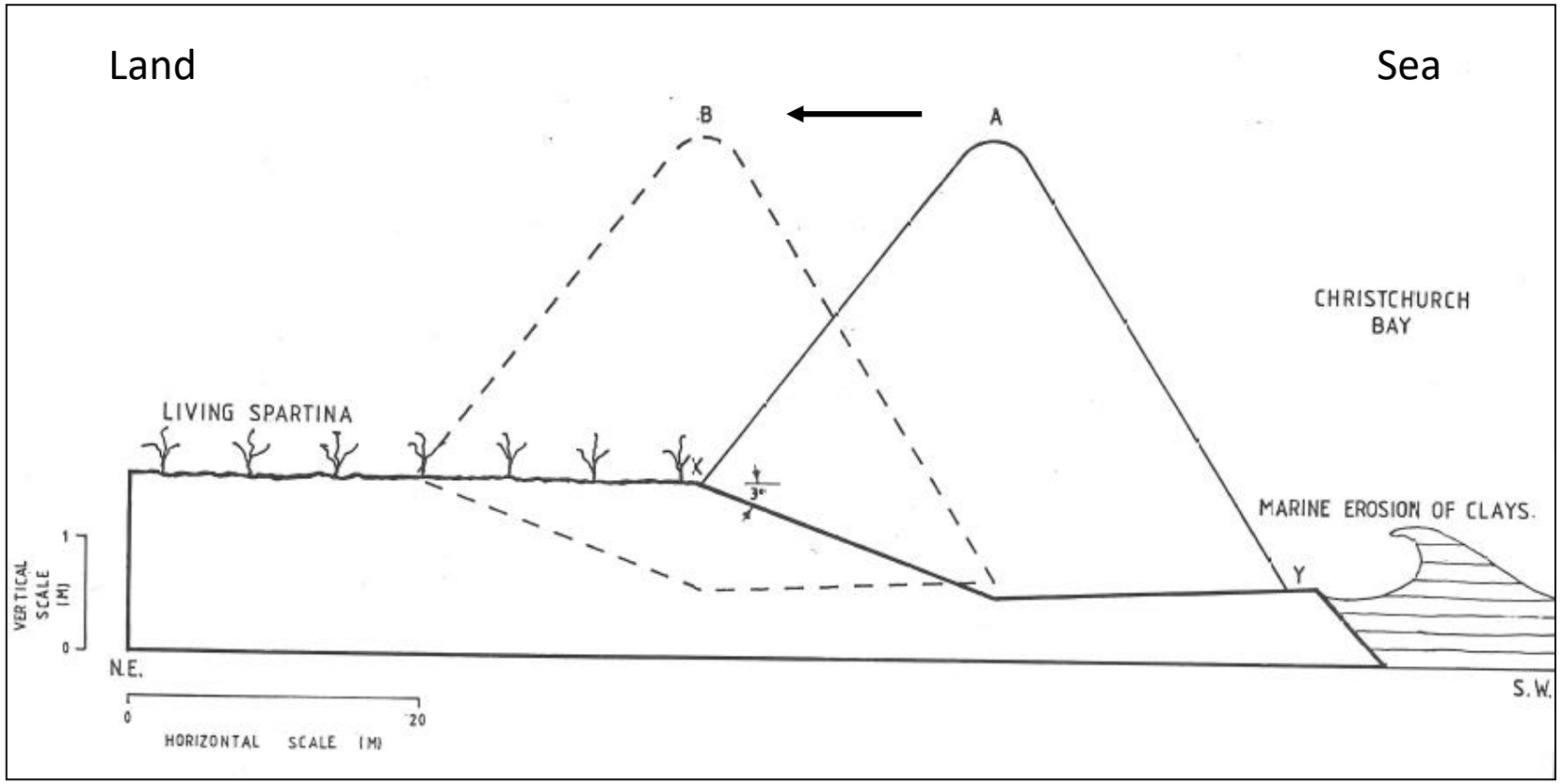
Nourishment in 1996 raised beach volume and elevation, but volume loss and shoreline retreat continued

Marsh deposits – seaward side of Hurst Spit (1980s)

Hurst Spit, UK, March 1979

1-m difference in elevation of the marsh surface across the barrier over 10 years

Schematic cross-section through Hurst Spit, including the beach/marsh substrate interface (from Nicholls, 1985)



Hurst Spit Nourishment 1996

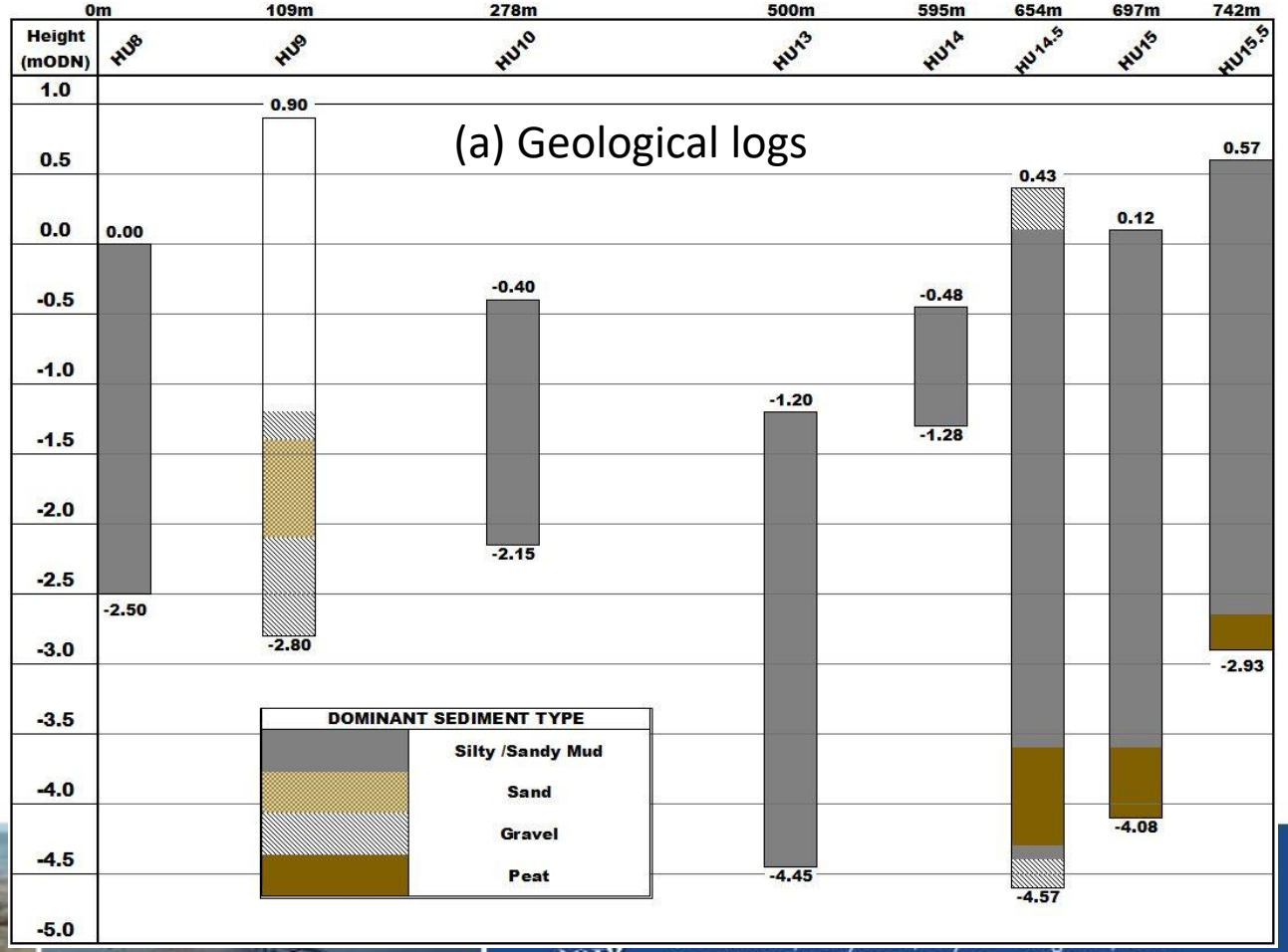
Recharge of 300,000m^3 -- almost doubled the volume of the pre-scheme Spit, raised the crest height to between 5 and 7 m OD, and increased the crest width.

Methods

- Geological sampling and geotechnical testing
- Morphodynamic analysis using XBEACH-G
- Consolidation calculations and measurements for the nourishment

Geology and Geotechnical Analysis

Sample sites, lithology and oedometer tests



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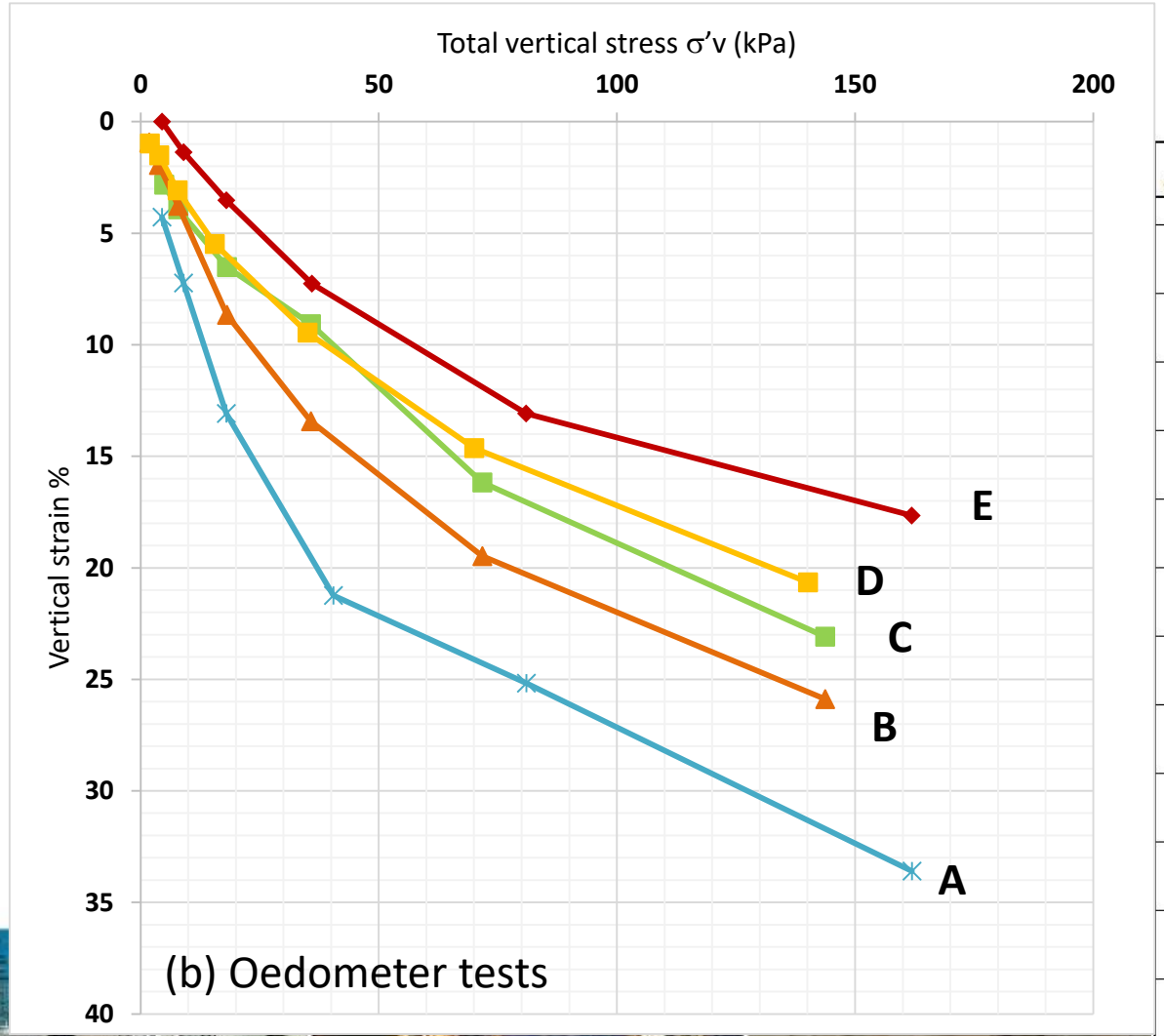
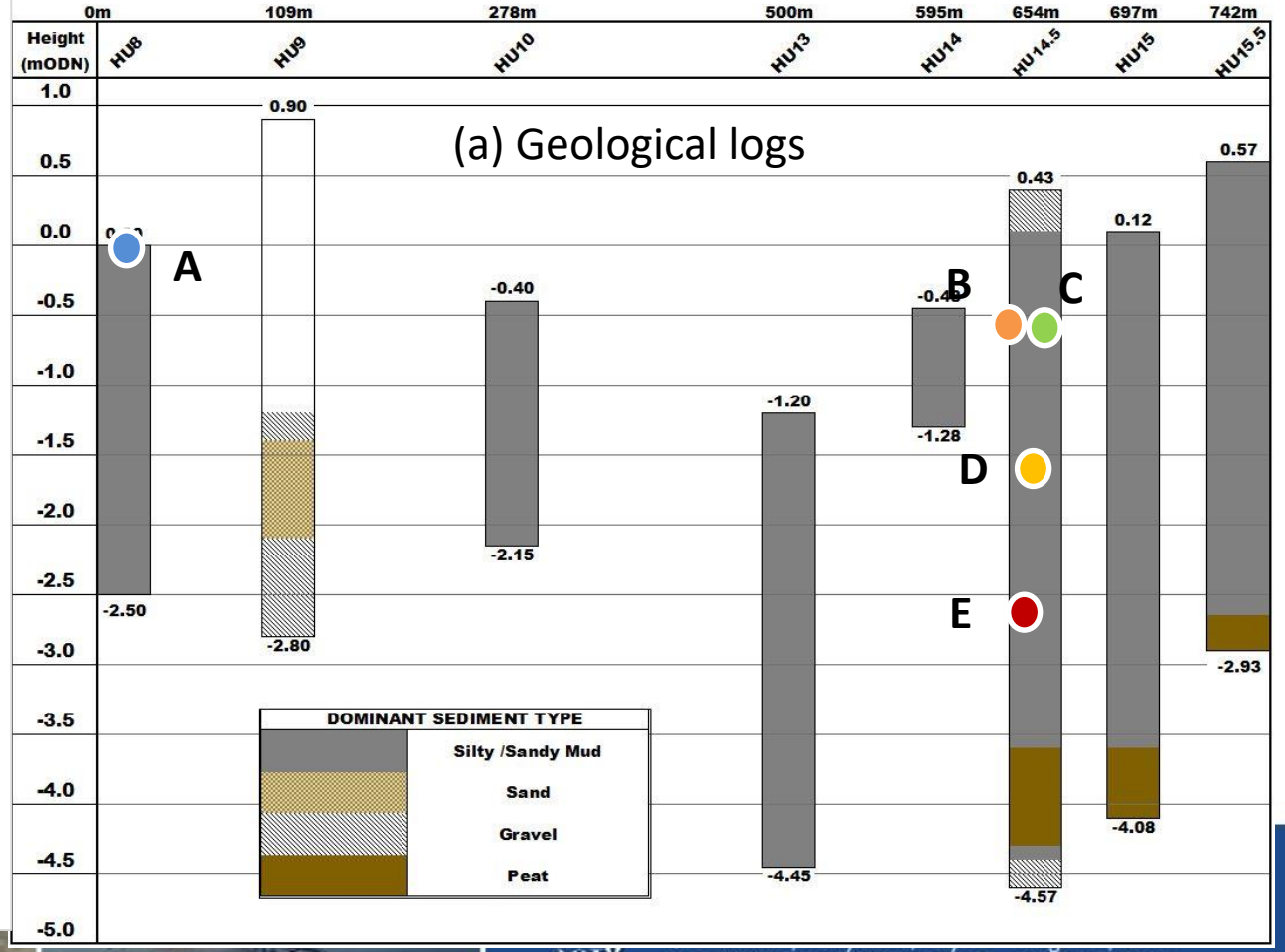
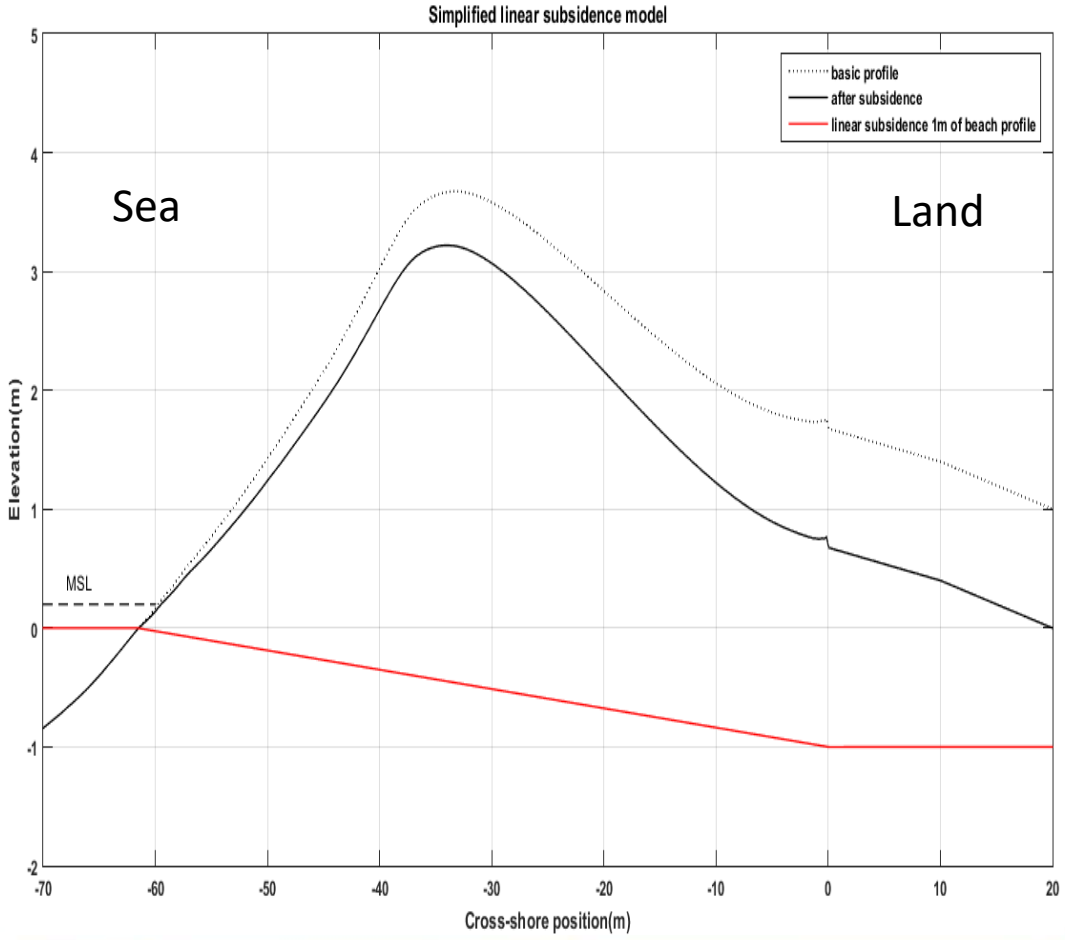




Morphodynamics Using XBeach-G

Zeng, 2016. Unpublished MSc Thesis

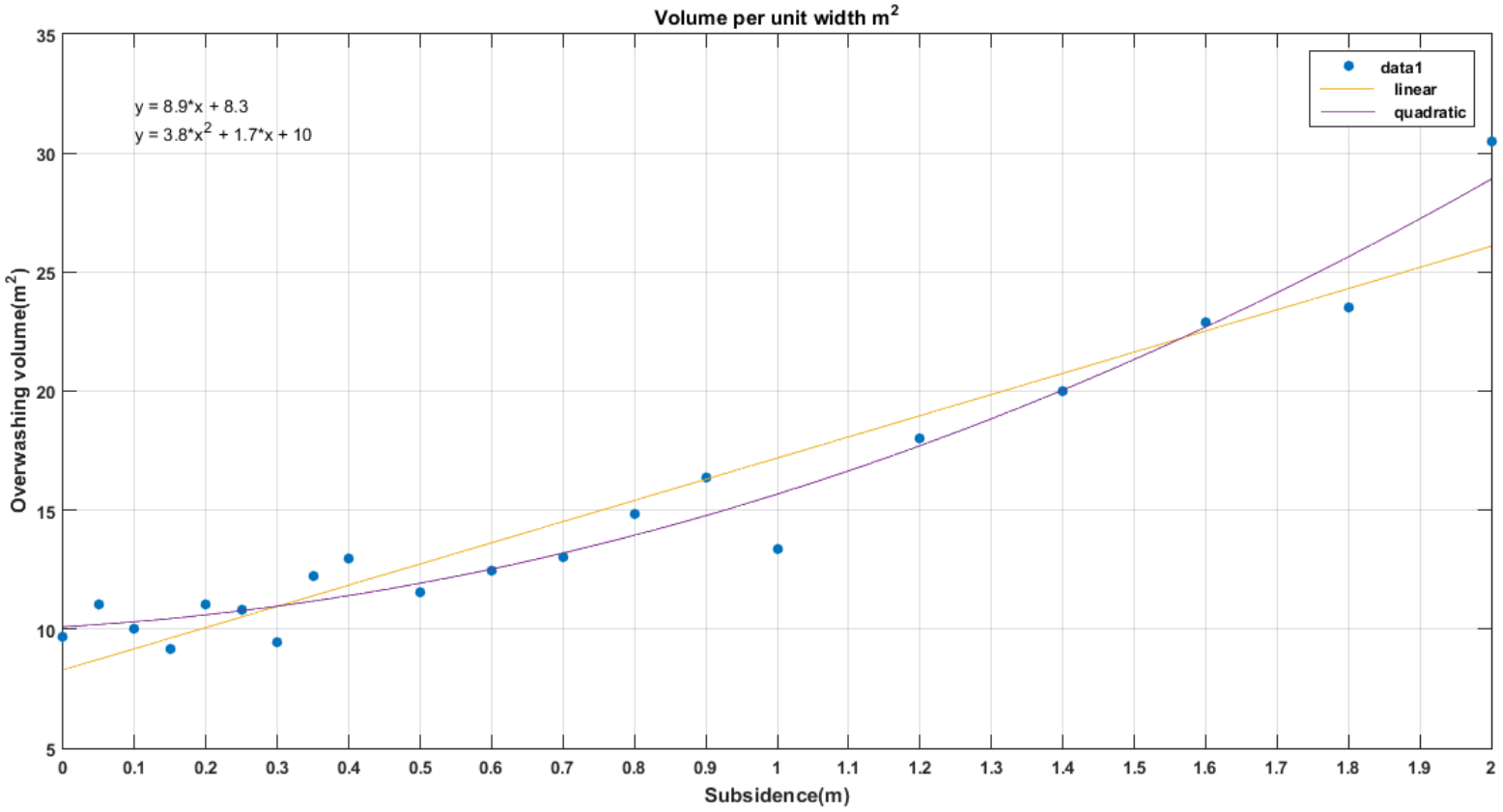


Model Set-Up

- Pre- and post subsidence barrier
- Linear subsidence model
- Maximum subsidence in saltmarsh layer on backshore.
- Zero subsidence at foreshore.
- Range of subsidence depths analyzed

X-Beach-G Model Results

Zeng, 2016. Unpublished MSc Thesis



Increased subsidence leads to increased probability of overwashing, and increased volumes of overwashed material. ($R^2 > 0.91$; $p < 0.001$)

Hurst Spit, UK, March 1979

Exposed marsh has a morphodynamic function increasing wave dissipation and reducing run-up
(and at the same time is rapidly removed)

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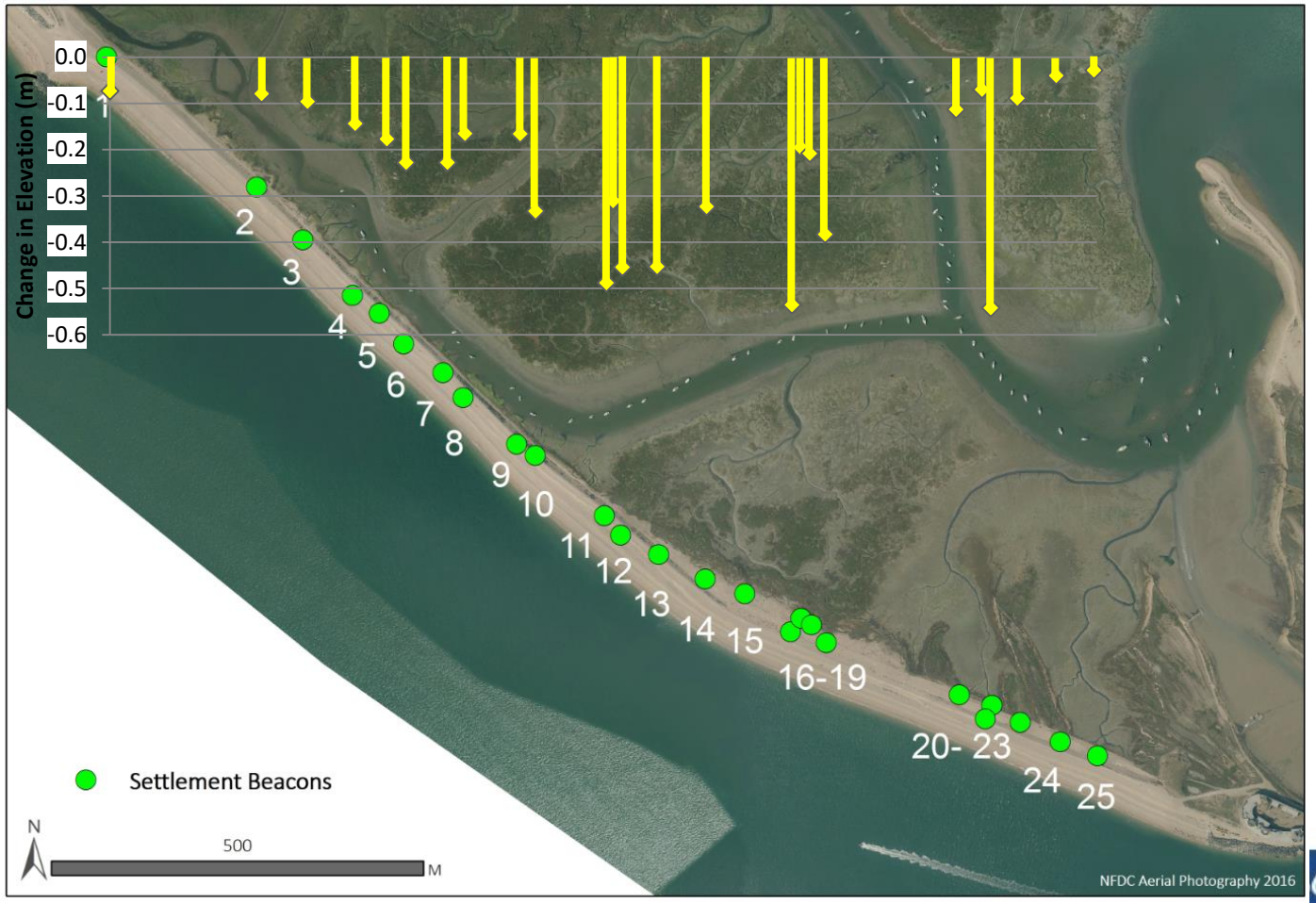
Consolidation and Beach Nourishment

Settlement Beacons Due to Nourishment Load

Change in elevation: 1996 to 1999 (three years)

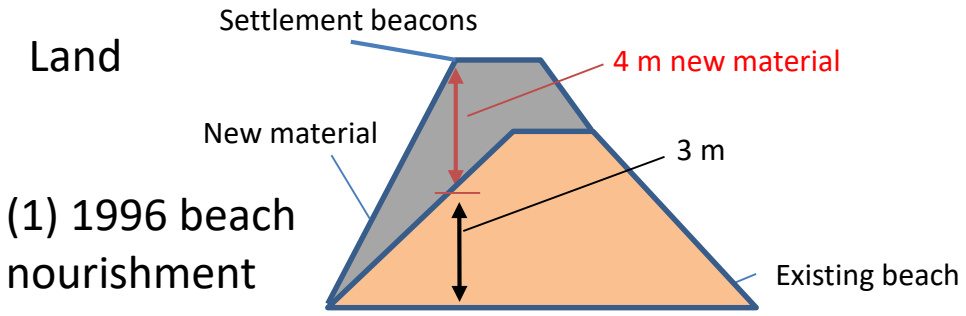




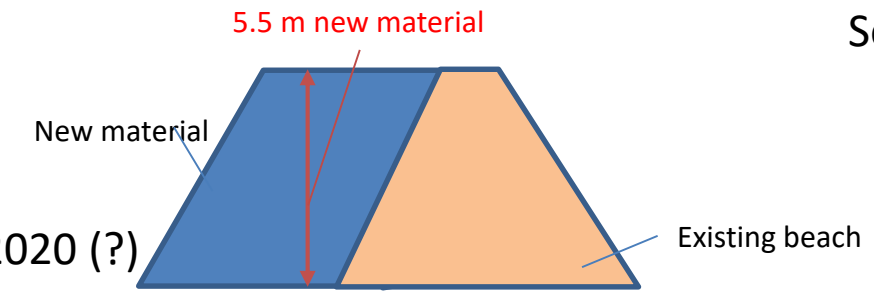

Consolidation calculations

Using oedometer data, and assuming 4 m depth of sediment

	Total settlement	Time to 90% consolidation	Time to 50% consolidation
(1) 1996 beach nourishment	240 mm	~5 years	1.25 years
(2) Proposed nourishment 2020 (?)	460 mm	~5 years	1.12 years



(1) 1996 beach nourishment



(2) Proposed nourishment 2020 (?)

Implications

- Consolidation influences the morphodynamics of Hurst Spit.
- Consolidation also influences beach nourishment design at Hurst Spit – more material is required.
- (Sudden load can lead to bearing failure).
- Further analysis to support the design of the next nourishment at Hurst is in progress.
- More broadly, rapidly retreating shingle beaches are of special interest due to steep slopes and hence large change in loads.
- Further investigation is required on consolidation (and other geotechnical processes) on barrier beaches, including nourishment.
- Is guidance for coastal engineers required on when and how to include consolidation and related issues in management and design on barrier beaches?

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