Building with Nature

EcoShape

The Sand Engine

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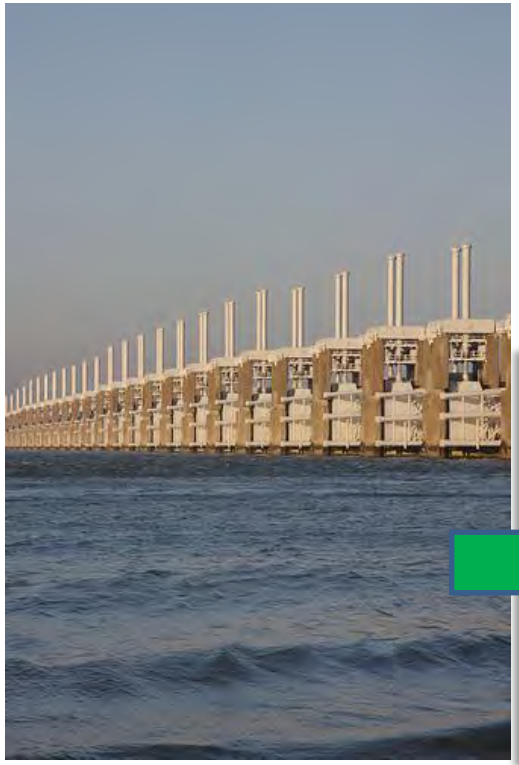
Deltares
Enabling Delta Life
Delft Hydr

TU Delft
Delft University of Technology

Paradigm shift in Delta Infrastructure

EcoShape

- From: Building ***in*** Nature
- Via: Building ***of*** Nature
- To: Building ***with*** Nature

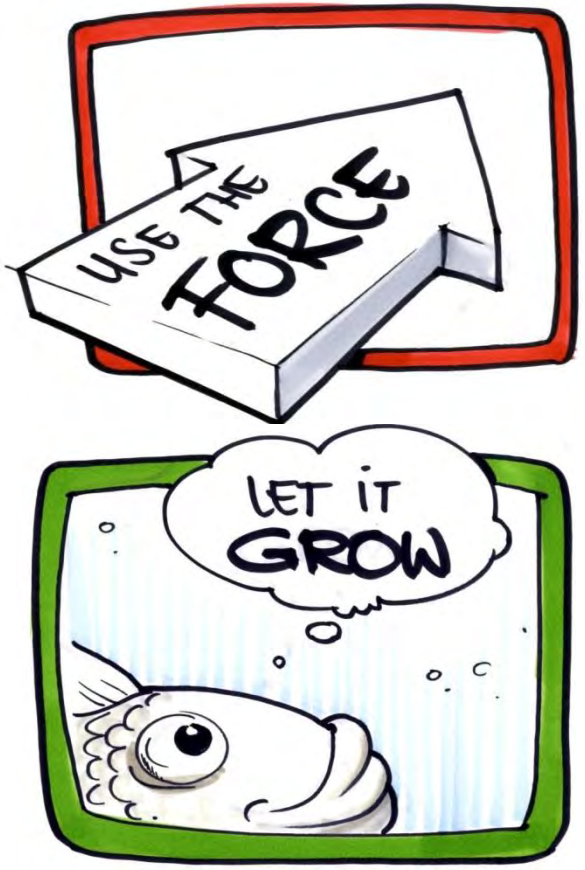


- Eastern Scheldt storm surge barrier (1986)
- Maasvlakte 2 Rotterdam port extension (2008)
- Sand Engine (2011)

The heart of the matter

Building with Nature, a design process that :

- Integrates nature and development goals
- Uses natural processes
- Creates added value for nature and society



Building with Nature solutions

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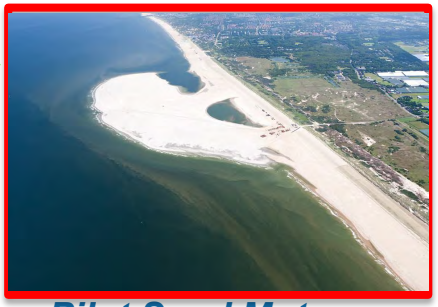
soft solutions

hard solutions

Temperate

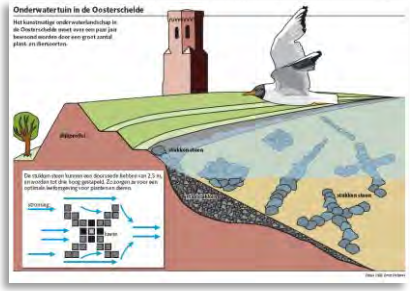
Tropical



Pilot Sand Motor
Delfland Coast

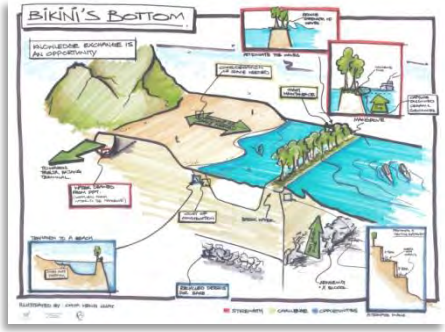
IJsselmeer
foreshore nourishment

ES: oyster reefs
as shore protection



Eastern Scheldt
Underwater garden

Coastal protection
Sea grass



BwN design Singapore
Labrador Park

Coastal protection
Mangroves

Singapore
'rich levee'

focus on ecosystem functioning

focus on infrastructure development

Sand Engine Delfland

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

EcoShape

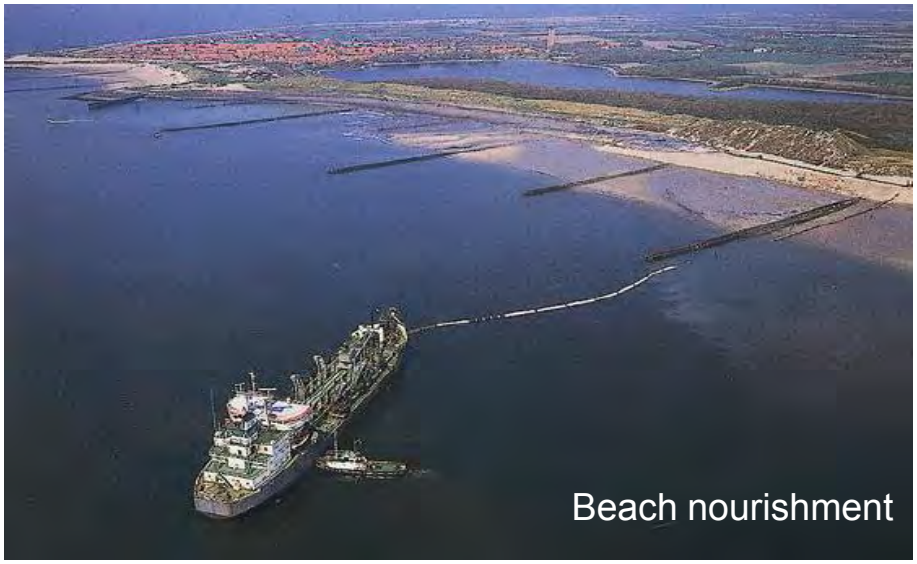
provincie ZUID HOLLAND

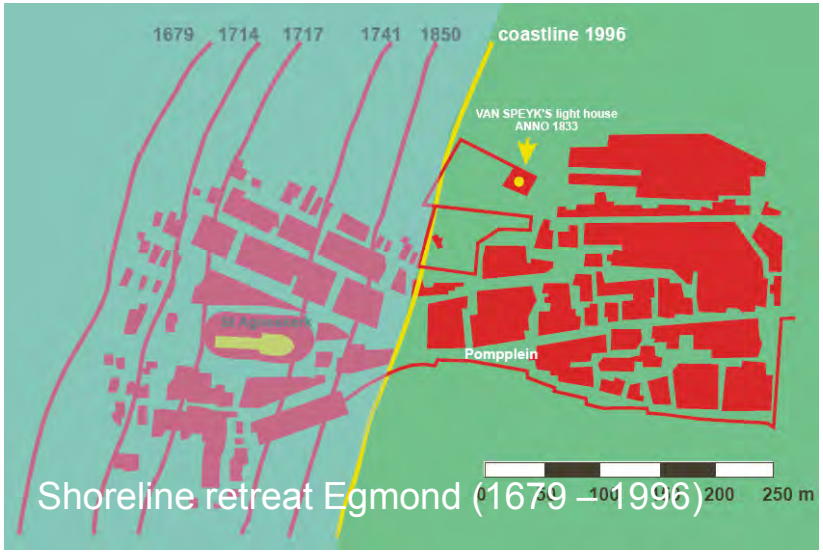
Kansen voor West
G4P4

STW
Nieuwe technologie mogelijk maken

NL Coastline

- Decrease of natural sediment supply owing to
  - Sea level rise
  - Human interventions
- Consequence: Structural erosion
- Solution: Nourishments


Beach nourishment



Shoreline retreat Egmond (1679 – 1996)

Anticipating Climate Change effects

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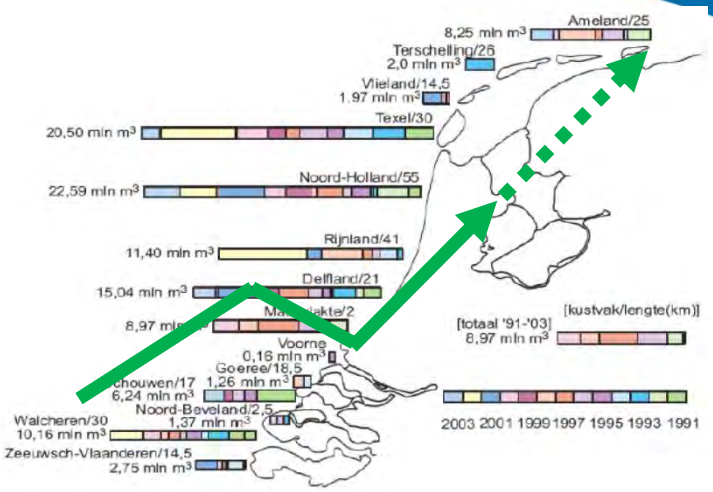
Dynamic preservation of the 1990 coastline

Sand volumes:

- Since 1990: 6 mln m^3/yr
- Since 2001: 12 mln m^3/yr



Prospect future since 2008:

Tendency towards larger-scale nourishments

Uncertainties on environmental effects

Need for space (nature & recreation)

Challenge for Province

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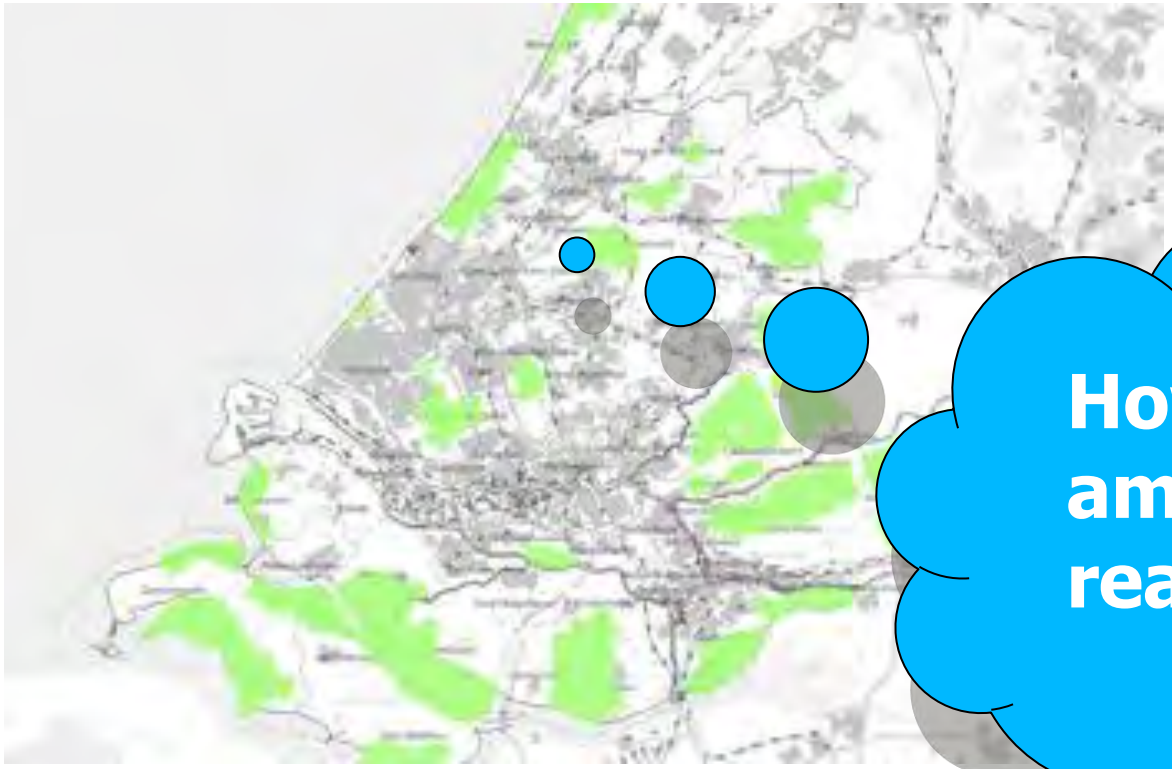
Shortage on natural recreation areas



How can ambitions by realised?

Challenge for the Ministry of Public Works

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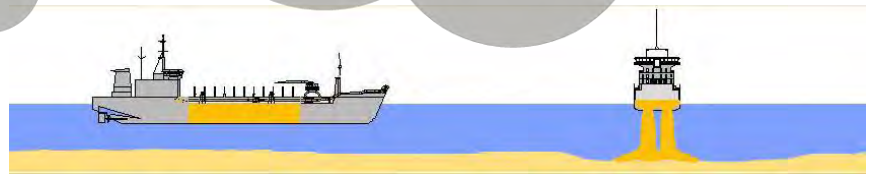
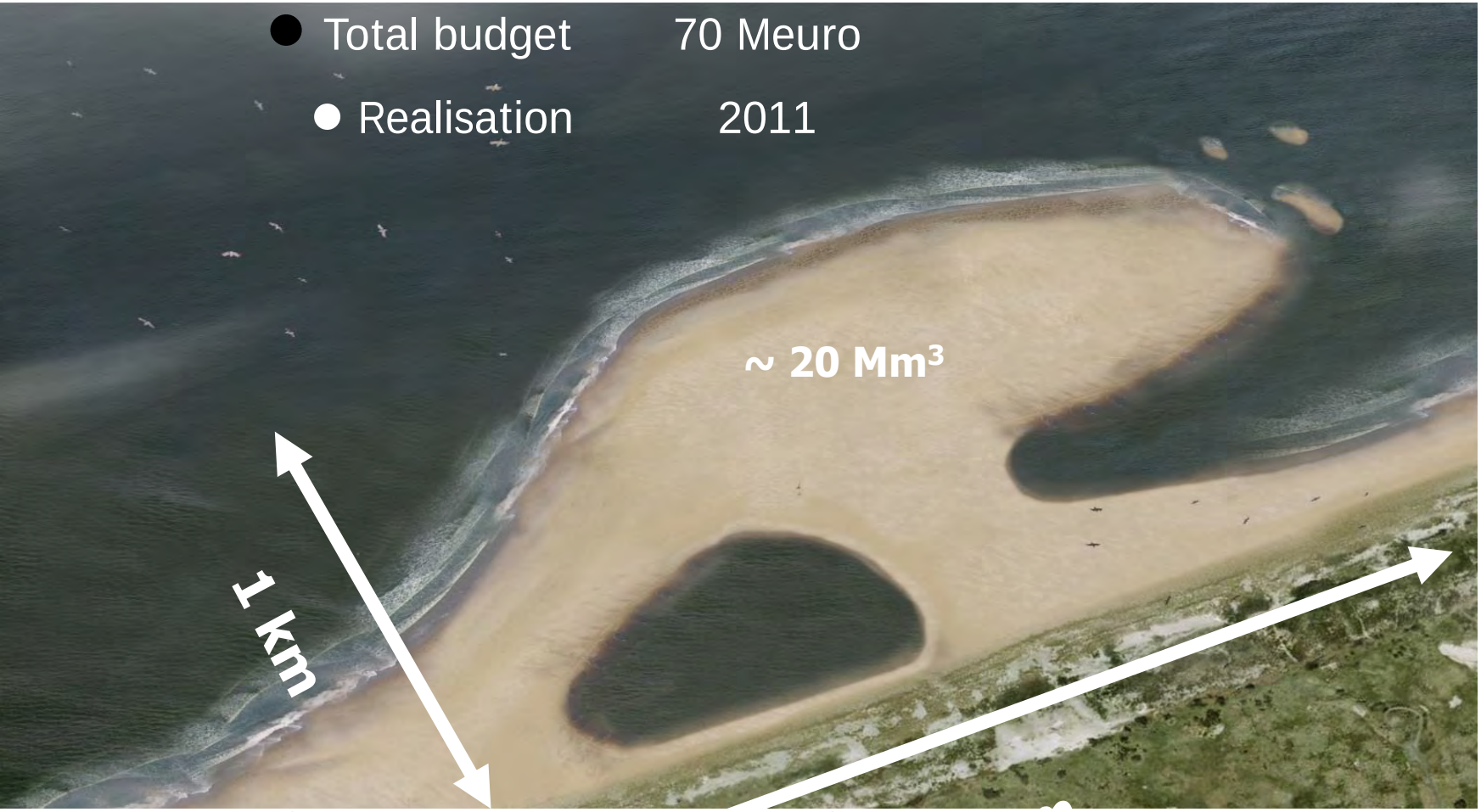
- Trad
  sin

- Sho
  since 1990's

Let's try a pilot that combines the wishes of different stakeholders



Pilot Sand Motor



- Reduce frequency, upscaling of volumes
- Surplus of sand, distribution by tide, wind and waves

Evolution 2011 - 2017

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What makes the Sand Motor unique?

Large volume
scale,
emerged,
concentrated at one location
combination of functions (safety, recreation, nature, & knowledge development),
walkable (no island),
dynamic

February 2016

photos: Rijkswaterstaat; Joop van Houdt

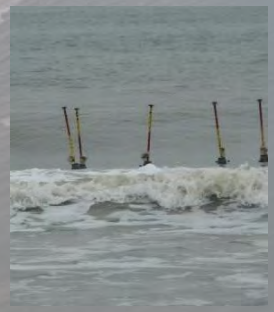
Services of the Sand Motor

Extensive monitoring campaign…

BEACH




SURF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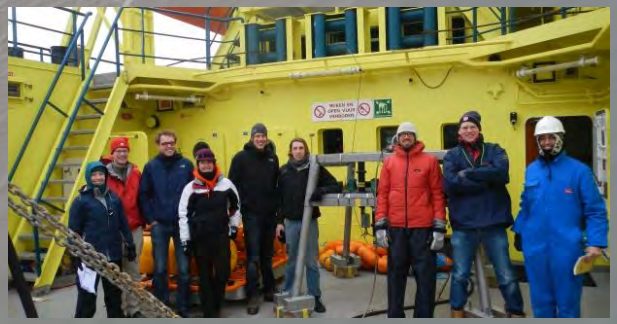
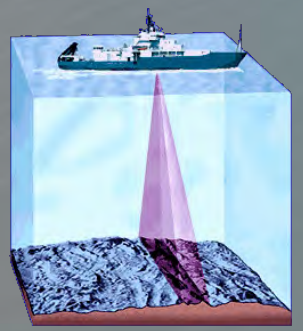
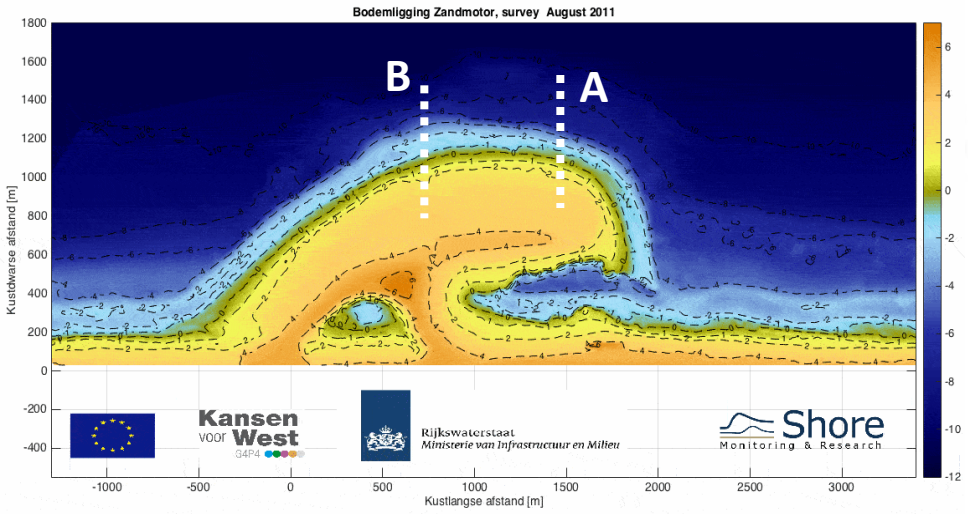
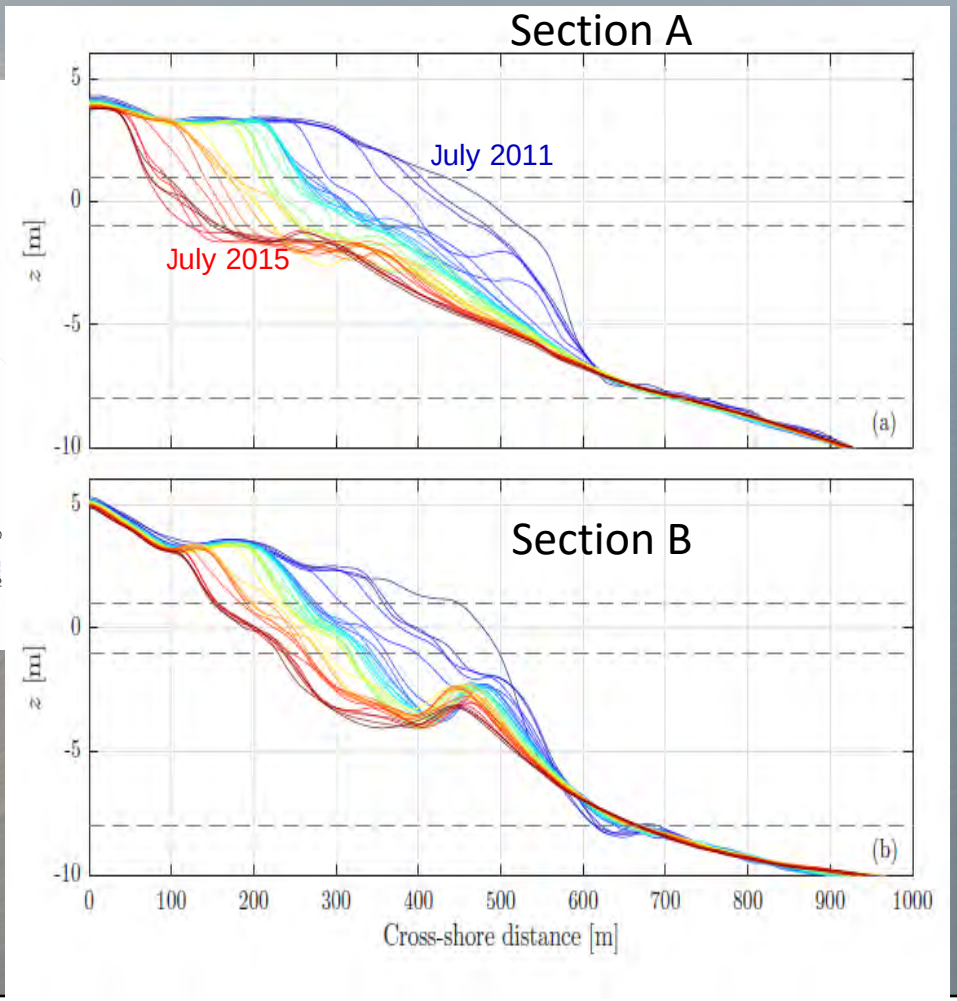



Evolution morphology



Source: Shore Monitoring



Source: Rutten et al. in press, Earth Surface Processes and Landforms.

Ecological monitoring

Macrobenthos:

Fish

Birds

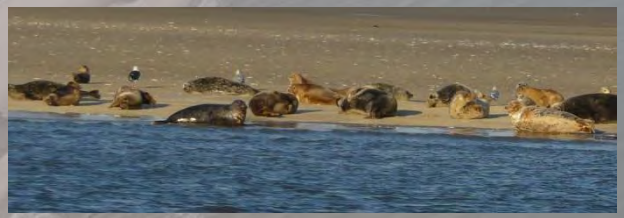
Sea mammals

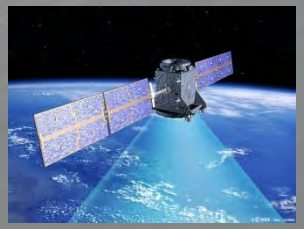
Vegetation

Insects

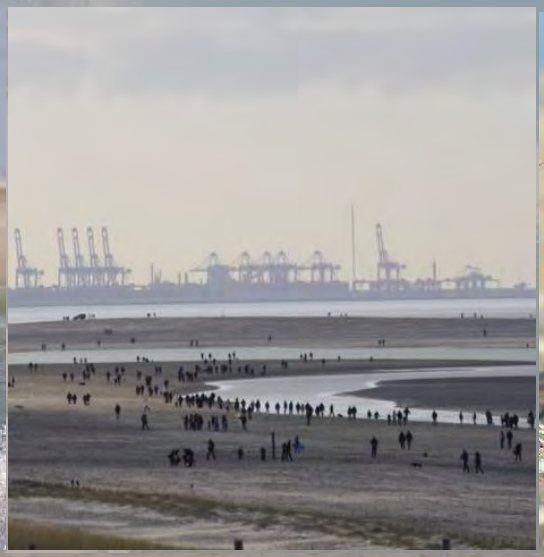




Recreation and Nature go hand-in-hand



Interdisciplinary research on Complex Landscape Evolution

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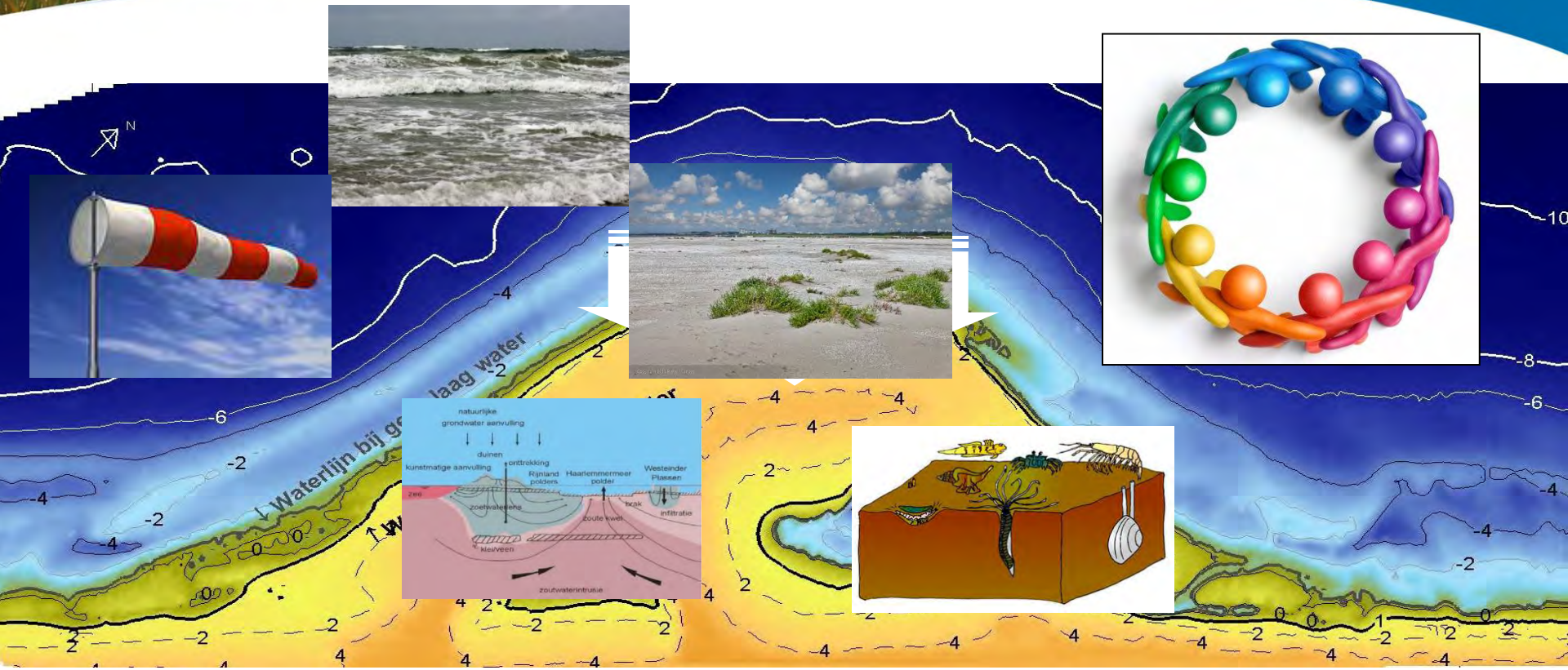

- Coastal Safety
- Dune formation
- Hydrology and geochemistry
- Marine ecology
- Terrestrial ecology
- Governance

Some interdisciplinary findings

after 5 years

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- Tidal currents increase the area of sediment sorting around a sandy intervention; this influences habitat areas and fish.
- The elevation, fresh water lens, and governance are important factors for growth of vegetation and dunes on emerged sandy developments.
- Bed composition of the dredged material influences dune formation.
- Explaining behaviour of a BwN pilot demands simultaneous, multi-disciplinary measurements.

WIP: Integrated morphodynamic model
for the dry beach and subaerial

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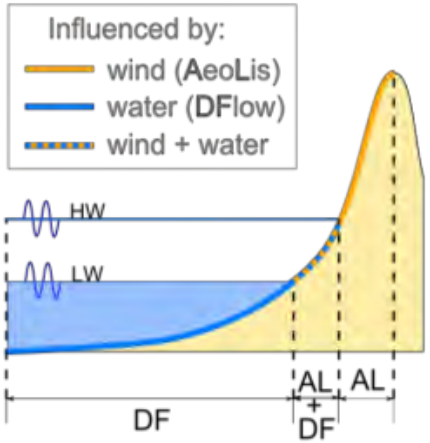
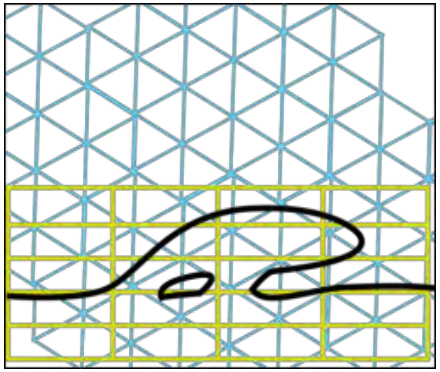
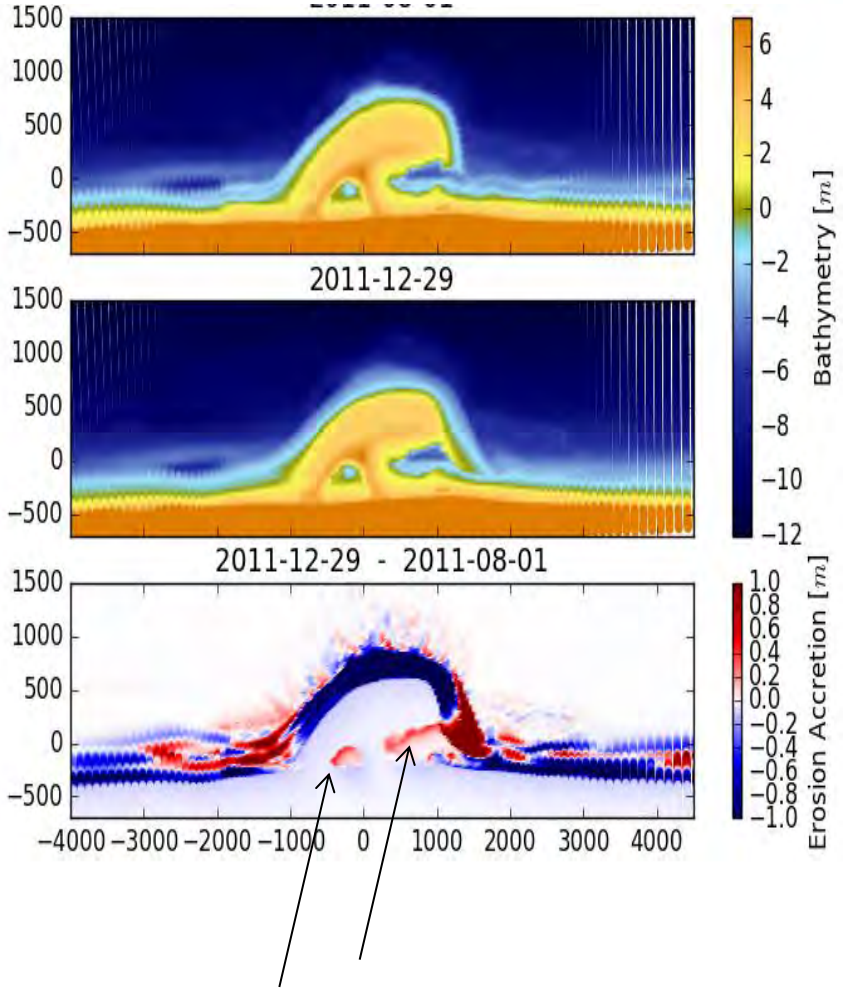
- Intertidal area is resolved by Delft3D and AeoLiS model
- Deposition of dune lake and lagoon is now incorporated in the morphological simulation.







Arjen Luijendijk, Bas Hoonhout, Rufus Velhorst and Sierd de Vries, Coastal Dynamics, 2017

Examples of other Dutch nourishments

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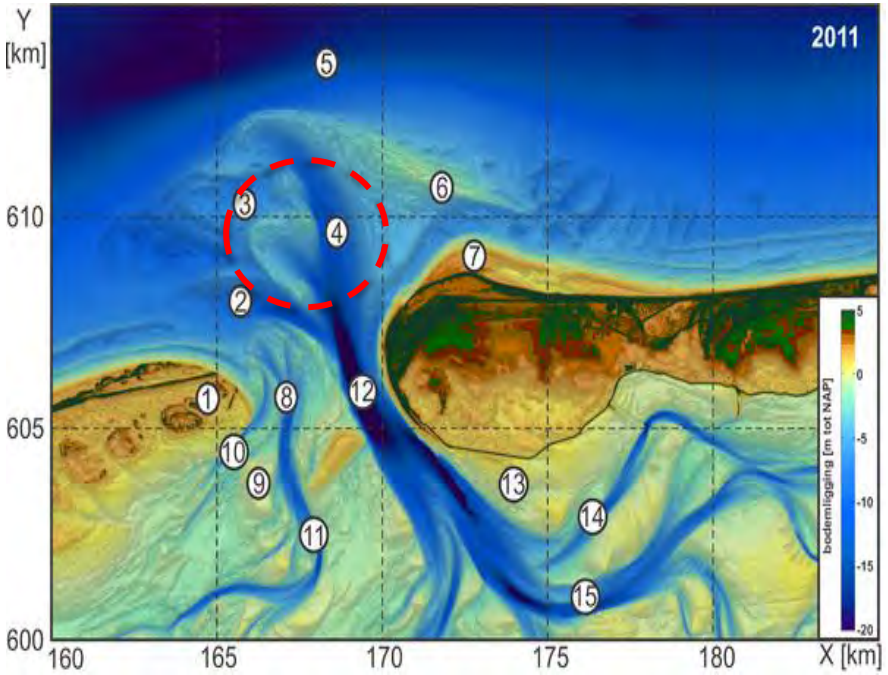
Constructed in 2015: Petten sea defence

30 mln m^3 + maintenance requirement
Located near Petten

Planned for 2018: Pilot experiment in Amelander Inlet

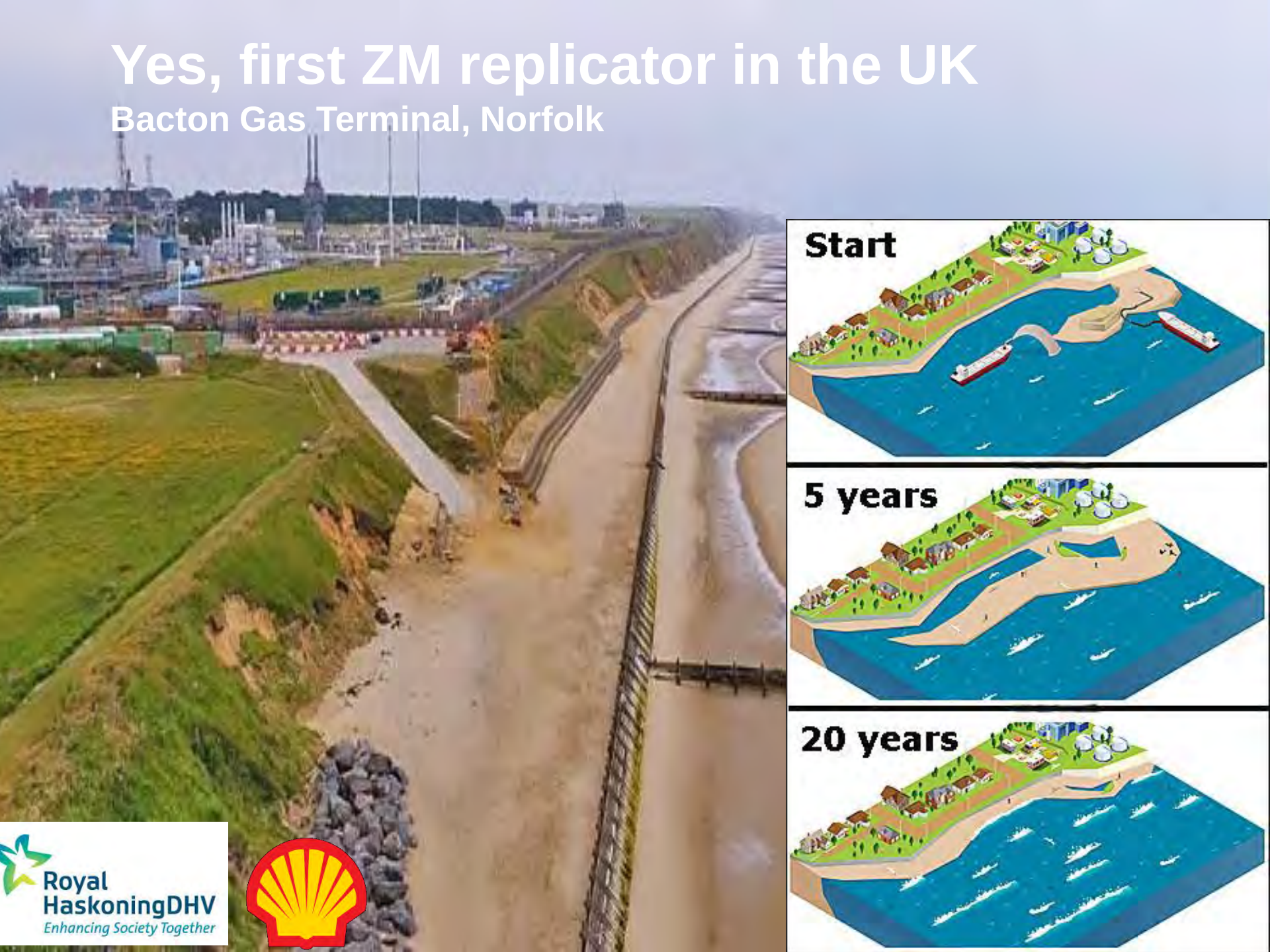


About 8 – 10 mln m^3
Located at outer delta

Is the ZM concept transferable to other locations?

Yes, first ZM replicator in the UK

Bacton Gas Terminal, Norfolk



Royal HaskoningDHV
Enhancing Society Together

Building with Nature

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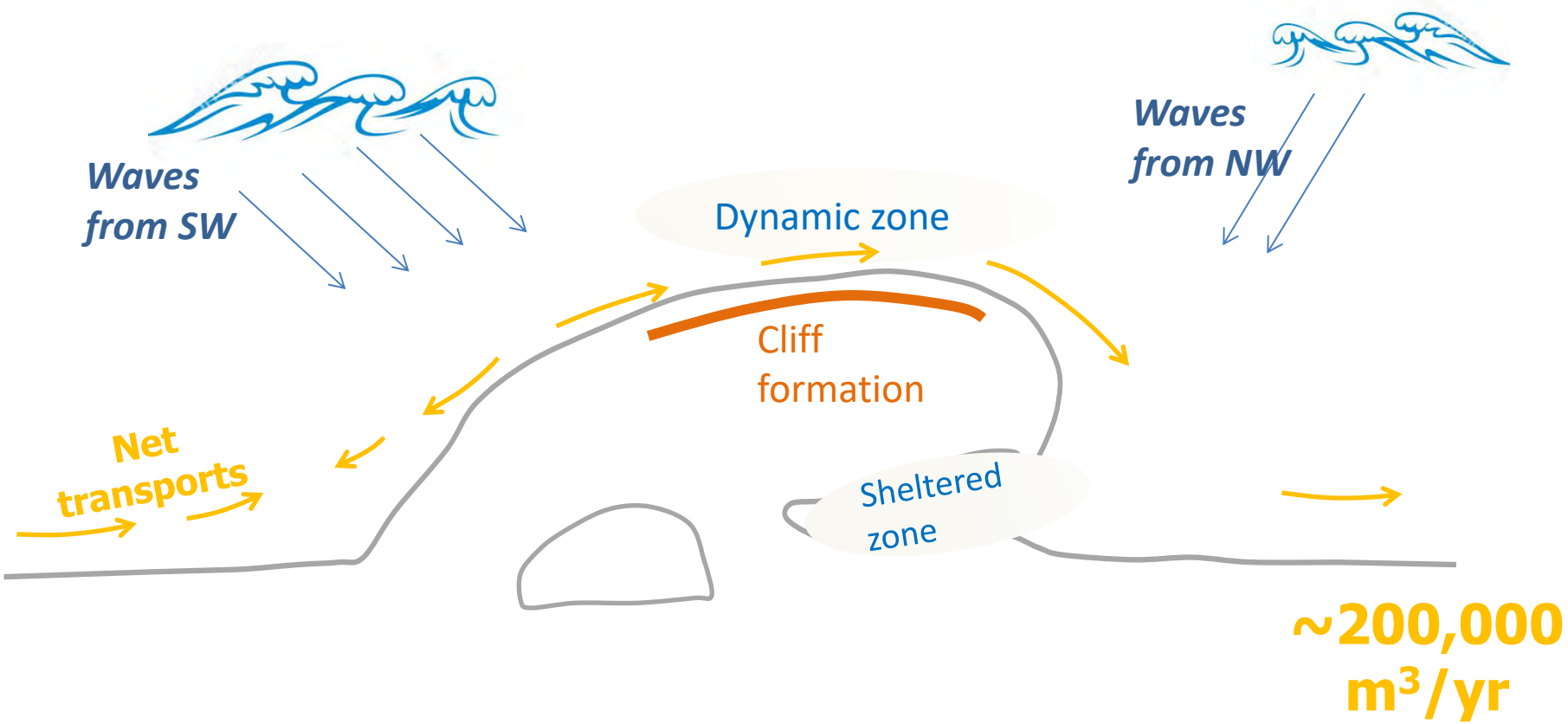
Extra slides

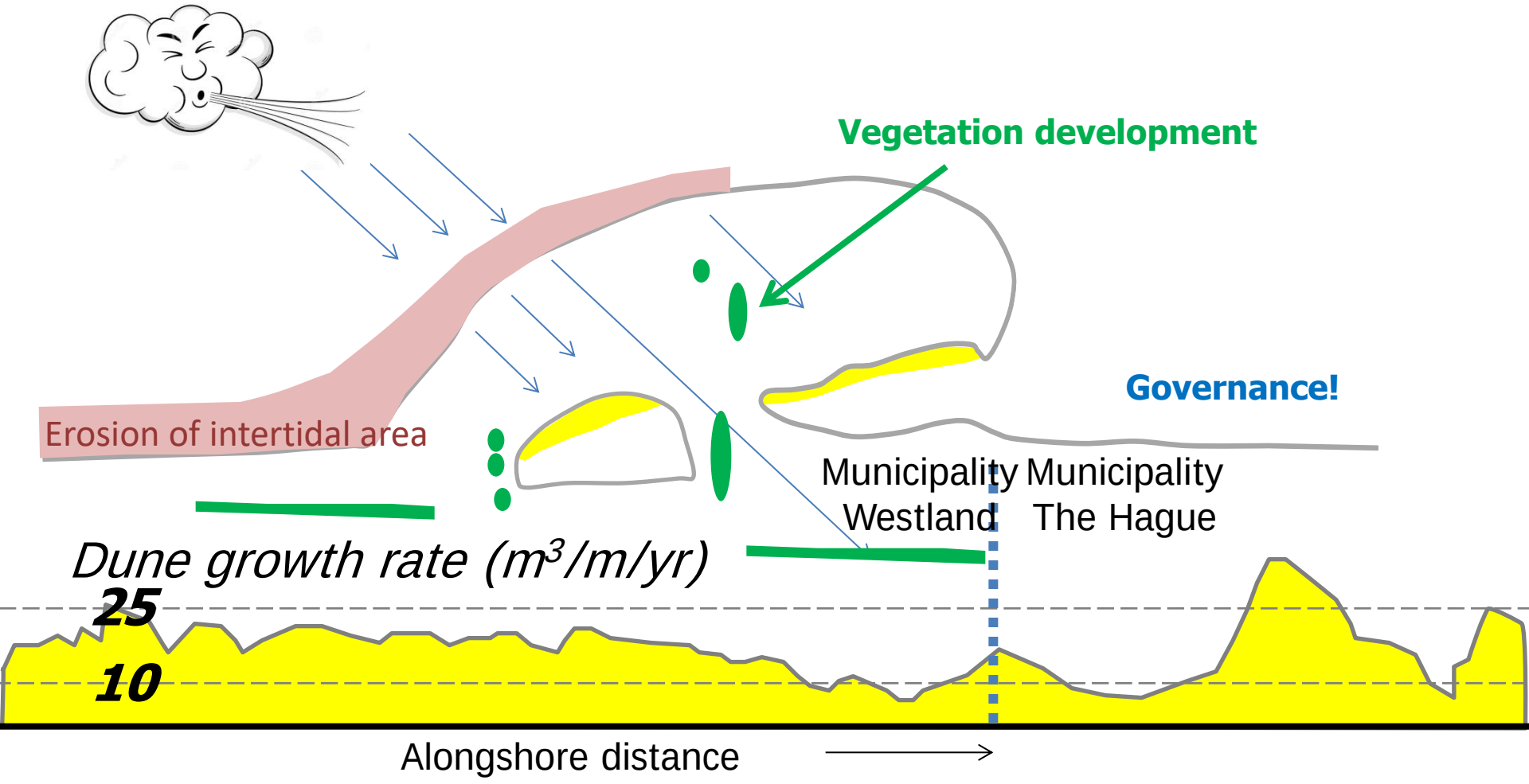
Understanding its behaviour

Forcing type: **Waves** Tide



Understanding its behaviour

Forcing type: Waves **Wind** Tide



Understanding its behaviour

Forcing type: Waves Wind **Tide**

t
deeper water

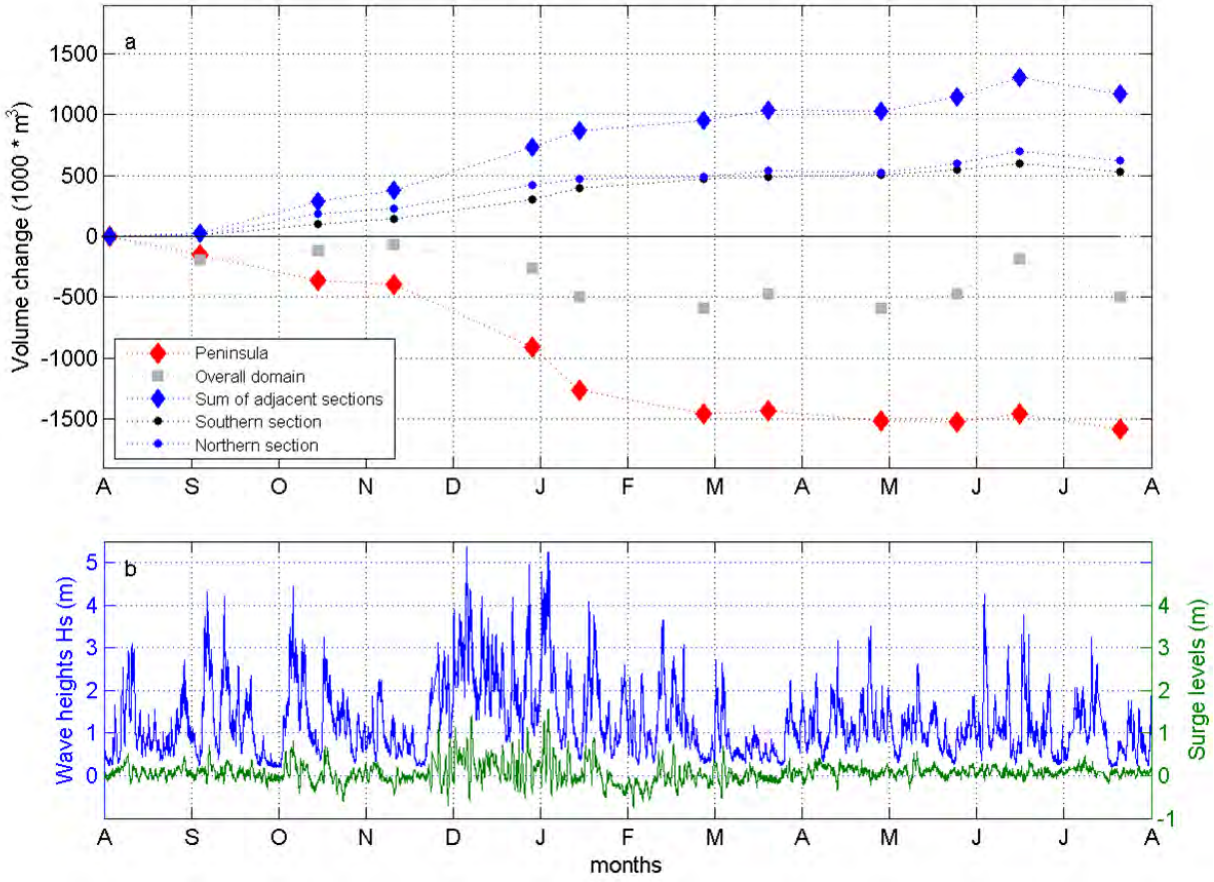
Tidal currents

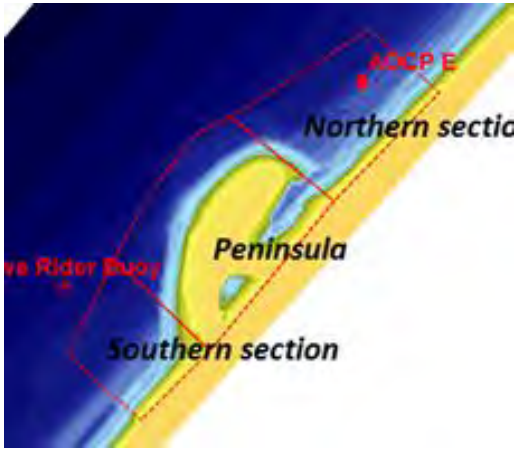
2016 Coastline

Goal: Identify the processes governing the first year evolution

Modelling the evolution of the ZM

First year volume changes

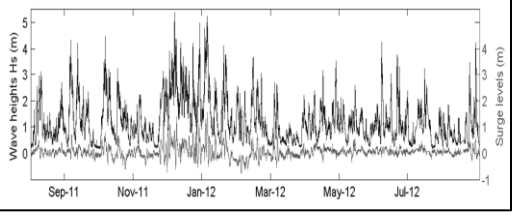




Brute-force hindcast for 1 year

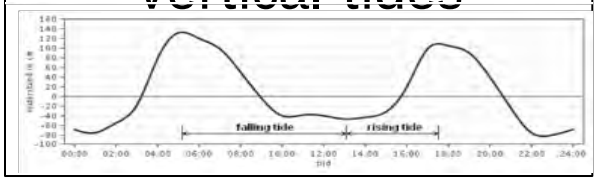
Model application

Wind

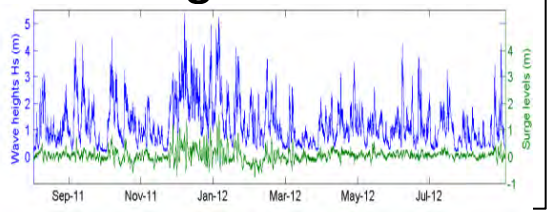


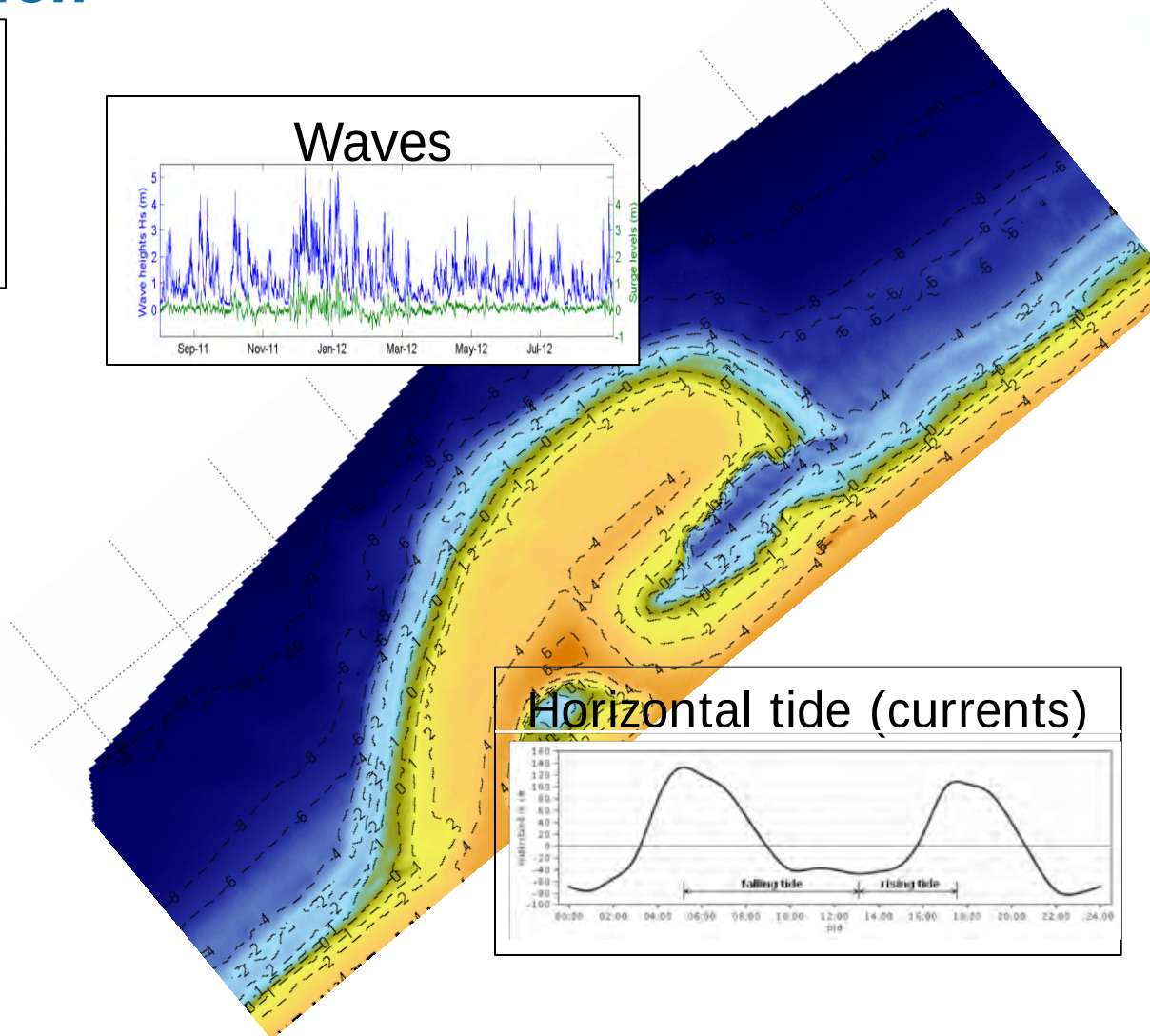
Waves

Vertical tides

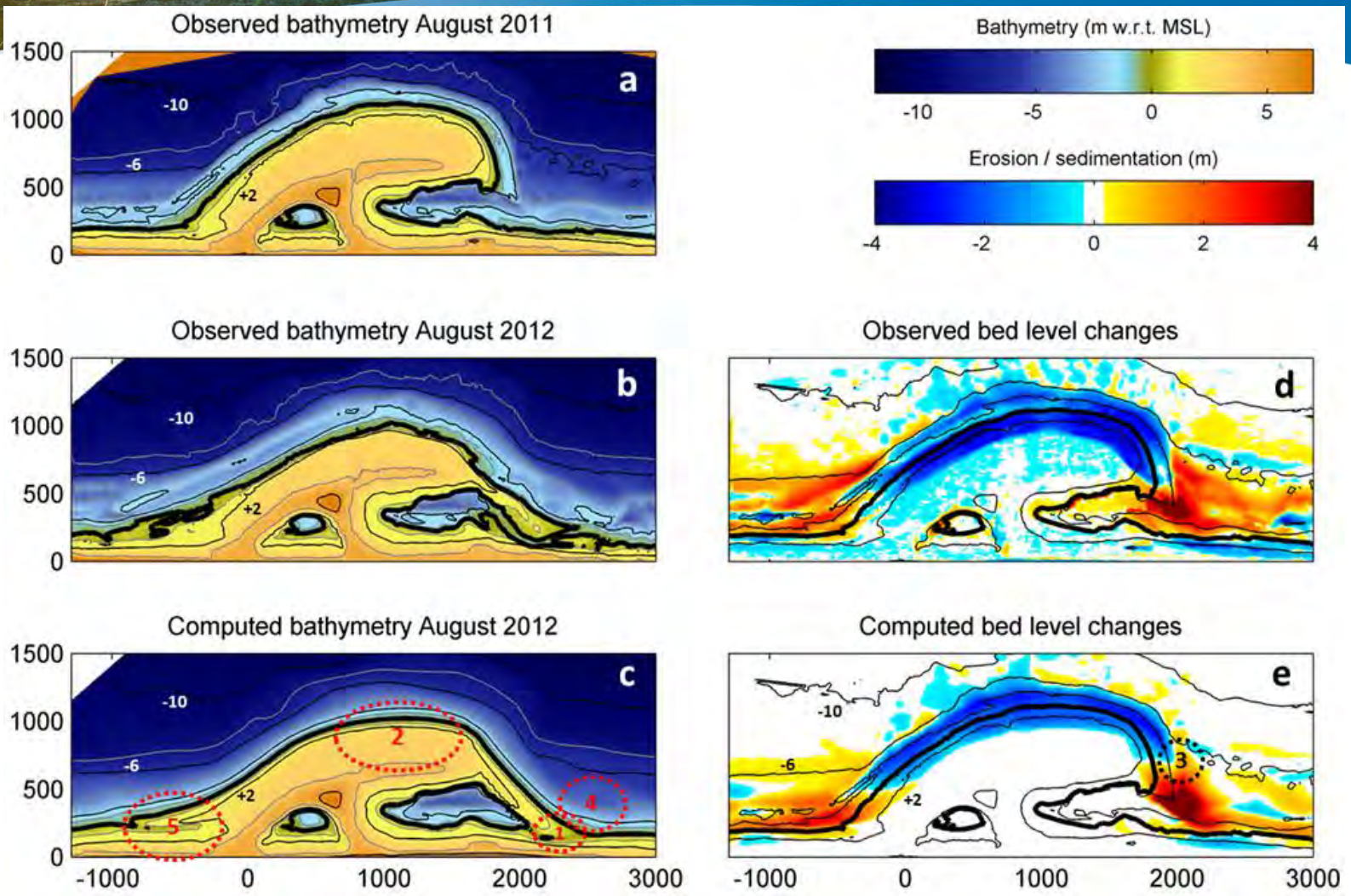


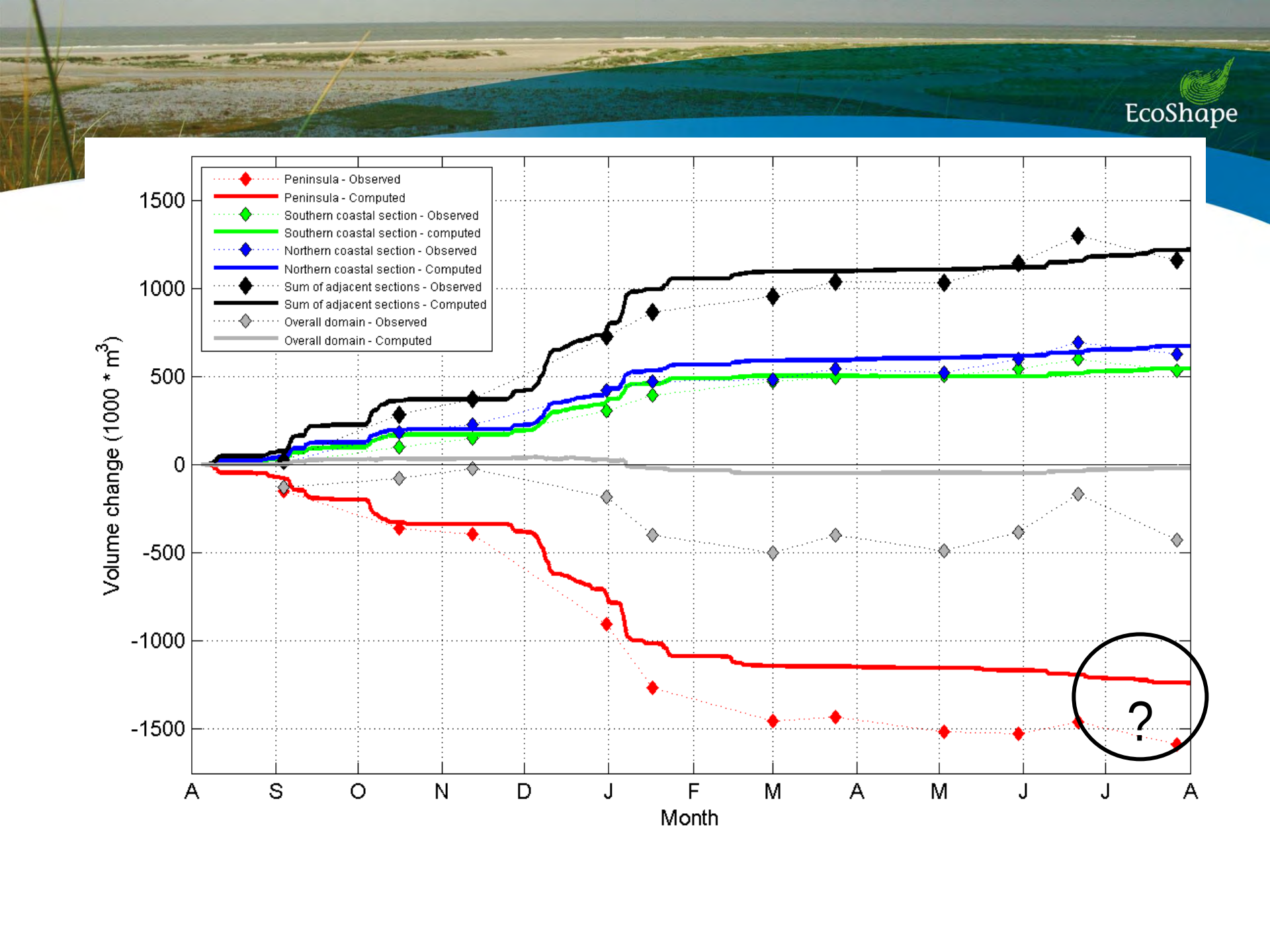
Surge levels



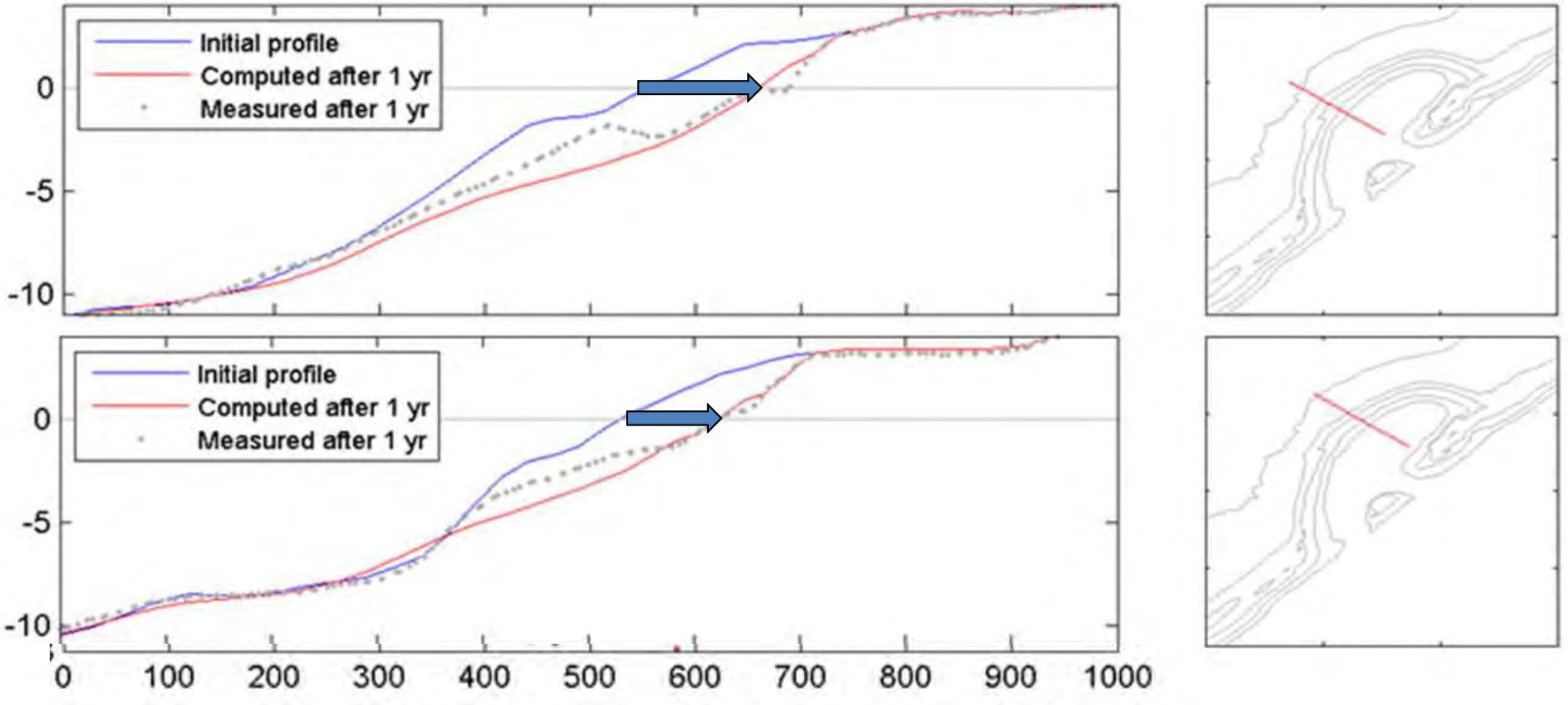


Horizontal tide (currents)


Observed bathymetry August 2011
a
-10
-6
+2
1500
1000
500
0
Bathymetry (m w.r.t. MSL)
-10
-5
0
5
Erosion / sedimentation (m)
-4
-2
0
2
4
Observed bathymetry August 2012
b
-10
-6
+2
Observed bed level changes
d
Computed bathymetry August 2012
c
-10
-6
+2
1
2
3
4
5
Computed bed level changes
e
-10
-6
+2
-1000
0
1000
2000
3000


Peninsula - Observed
Peninsula - Computed
Southern coastal section - Observed
Southern coastal section - computed
Northern coastal section - Observed
Northern coastal section - Computed
Sum of adjacent sections - Observed
Sum of adjacent sections - Computed
Overall domain - Observed
Overall domain - Computed
Volume change (1000 * m3)
1500
1000
500
0
-500
-1000
-1500
A
S
O
N
D
J
F
M
A
M
J
J
A
Month
?

Morphological modelling



Decadal prediction with calibrated model