Building/Working/Designing with Nature: the Sand Engine experience

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With contributions from:

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and many others!

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

EcoShape

Kansen voor West
G4P4

13. FZK-Kolloquium am 15.02.2018

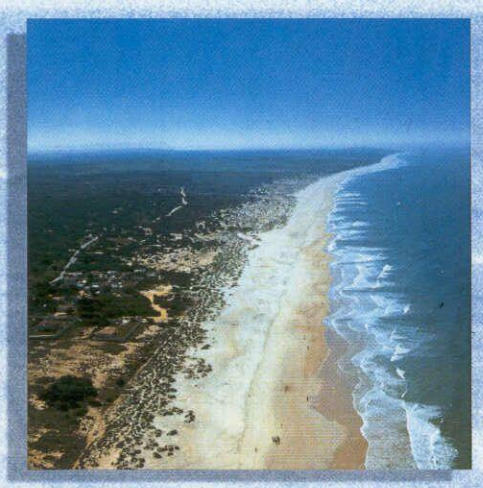
Building/Working/Designing with Nature (BwN, WwN, DwN)

My personal definition: BwN = integrating natural system elements in "engineered" environments"

- NEW? Hmmm … not really: see e.g. 1000 years of Wadden Sea reclamations
- NEW! Yes, regarding scale and technology
- First promoting discipline: landscaping

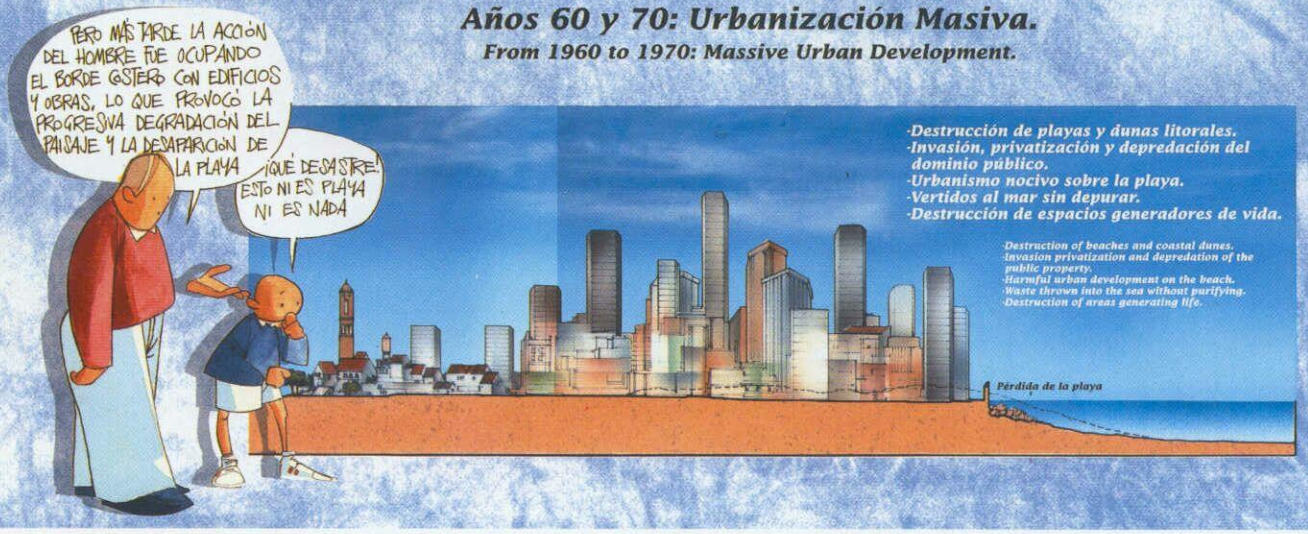
Años 40 y 50: Situación Original.

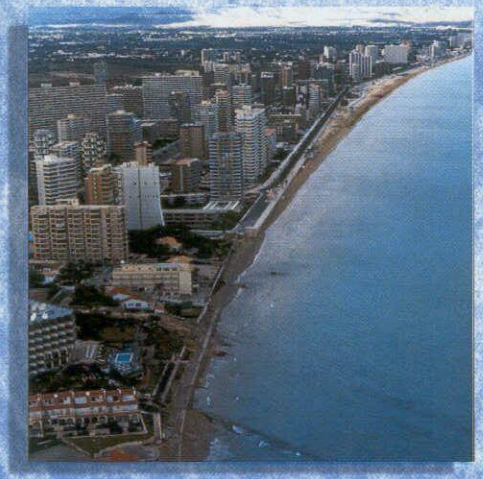
From 1940 to 1950: Original Situation.



Años 60 y 70: Urbanización Masiva.

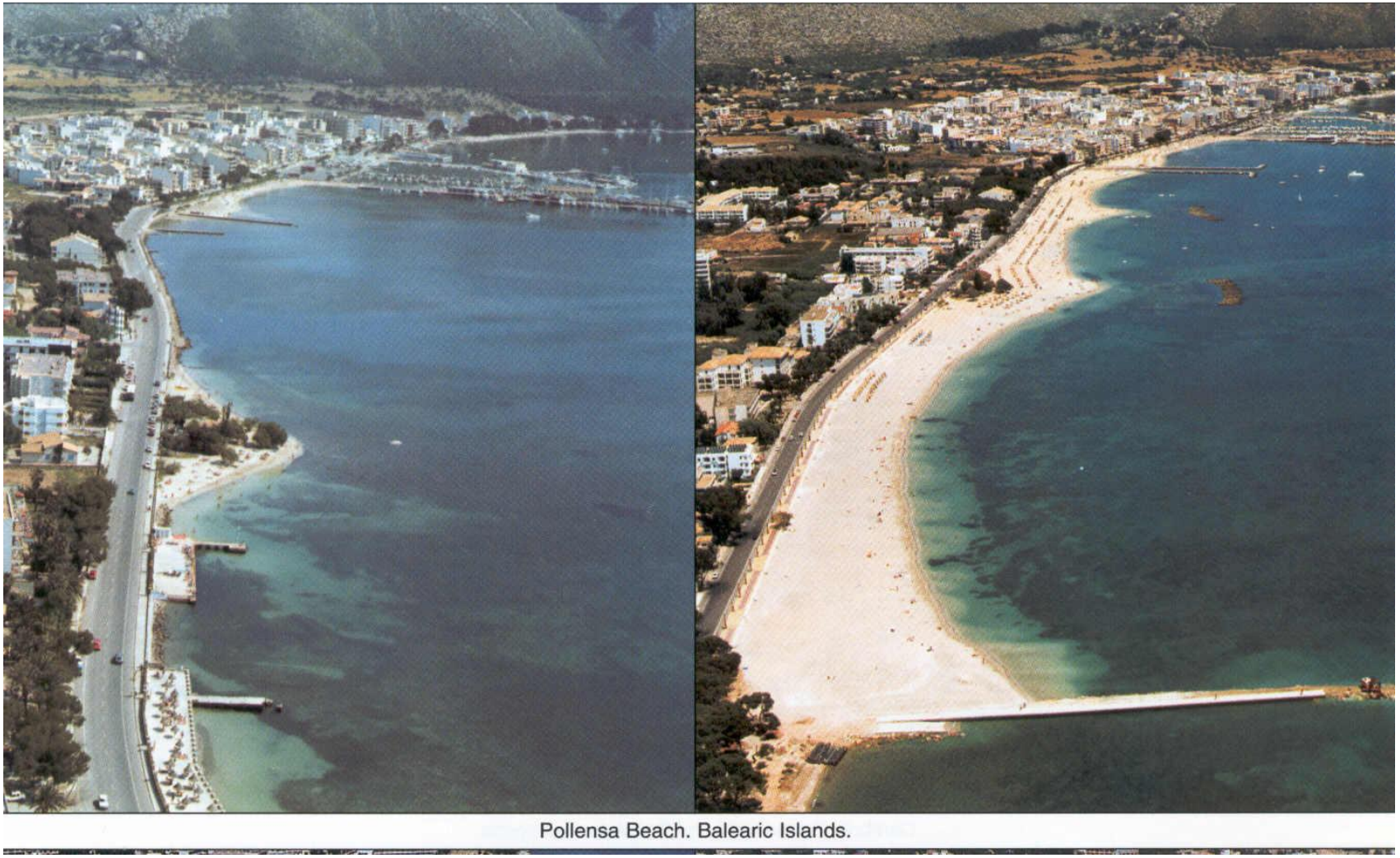
From 1960 to 1970: Massive Urban Development.





URBANIZACION DE LA COSTA.
URBAN DEVELOPMENT OF THE COAST.

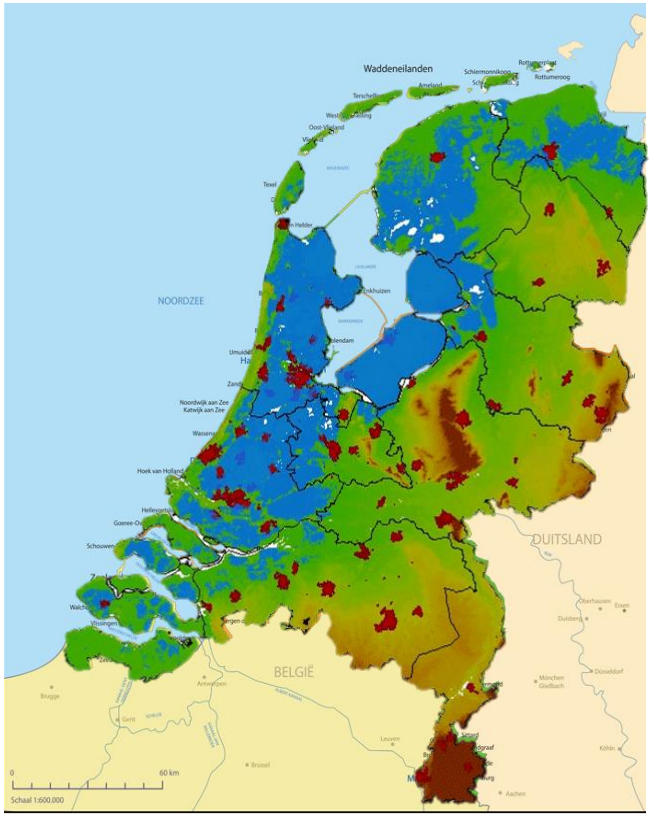
OPCIONES DE ACTUACION.
OPTIONS OF ACTIONS.



Pollensa Beach. Balearic Islands.

The Dutch Coast

'coastal squeeze'

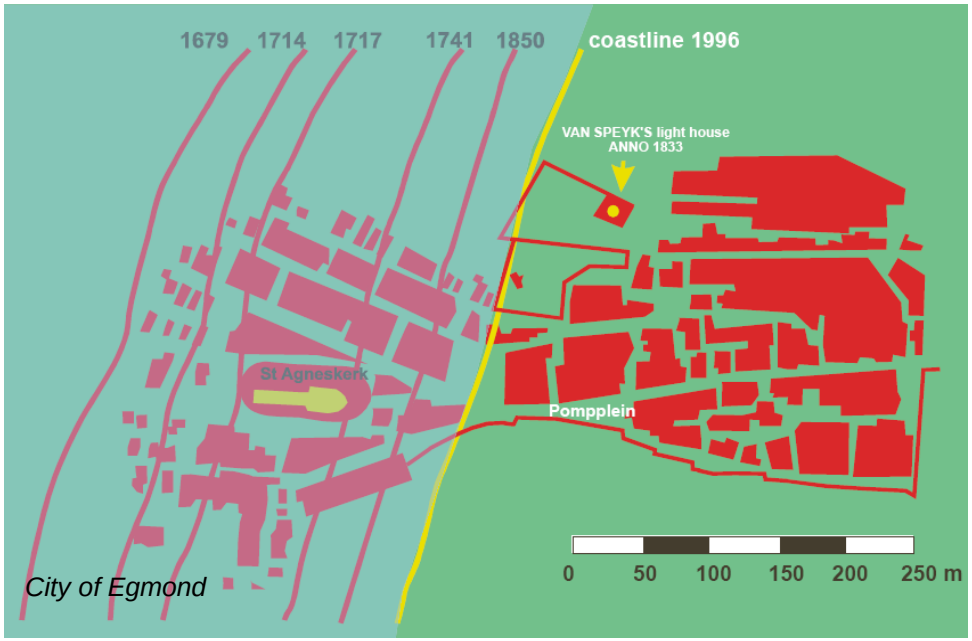


Historic perspective

Shortage of natural sediment

Consequence: Structural erosion

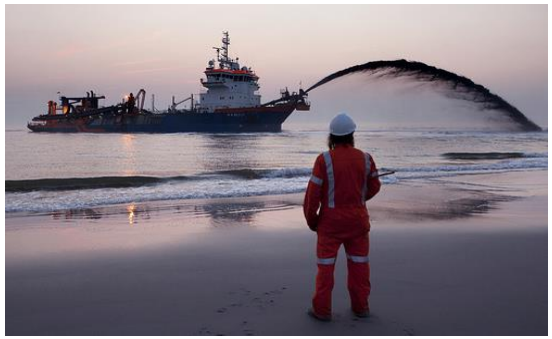
Solution: ??



Traditional 'hard' solutions
Solution 1.0

‘Soft solutions

Nourishments



Development of nourishment strategy

since the nourishments were used as main mitigation measure

Increase in volume

Annual added sand volumes:

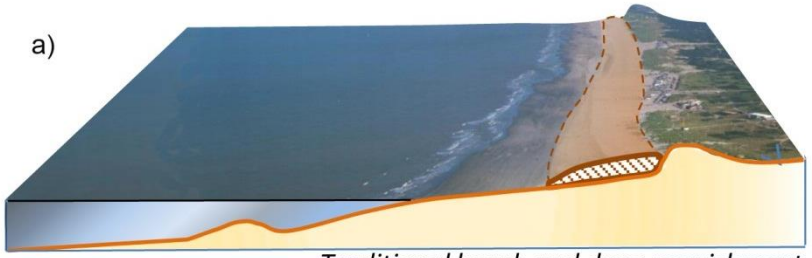
- Since 1990: 6 mln m^3/yr
- Since 2001: 12 mln m^3/yr

Prospect future : 40-85 mln m^3/yr !!

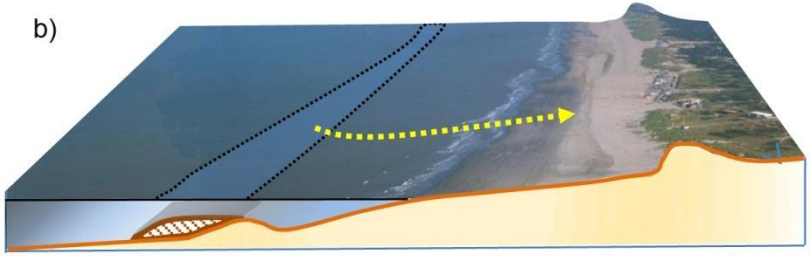
Example of town of Ter Heijde:
Nourishments in years

1986-1993-1995-1997-2001-2003
-2004-2005-2009-2011

Change in design

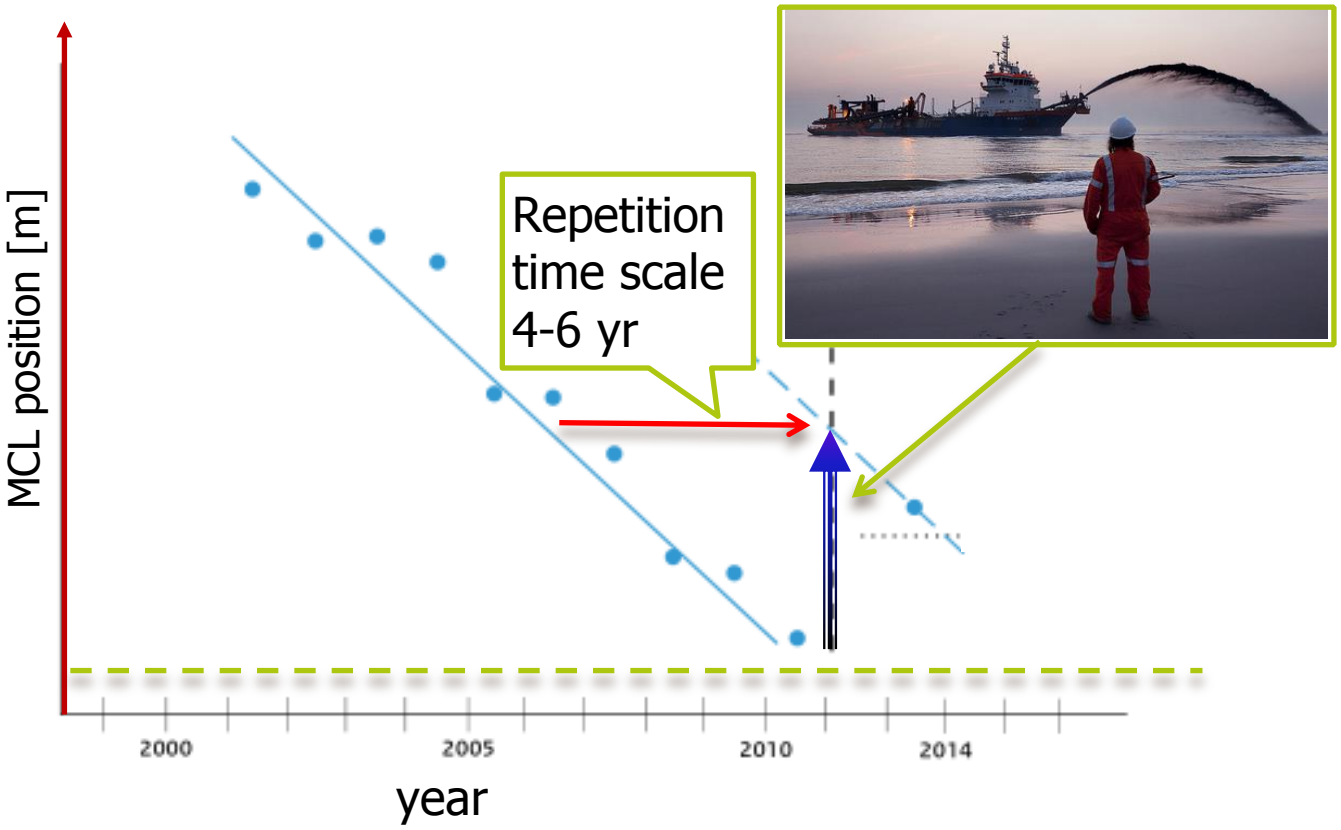


Traditional beach and dune nourishment



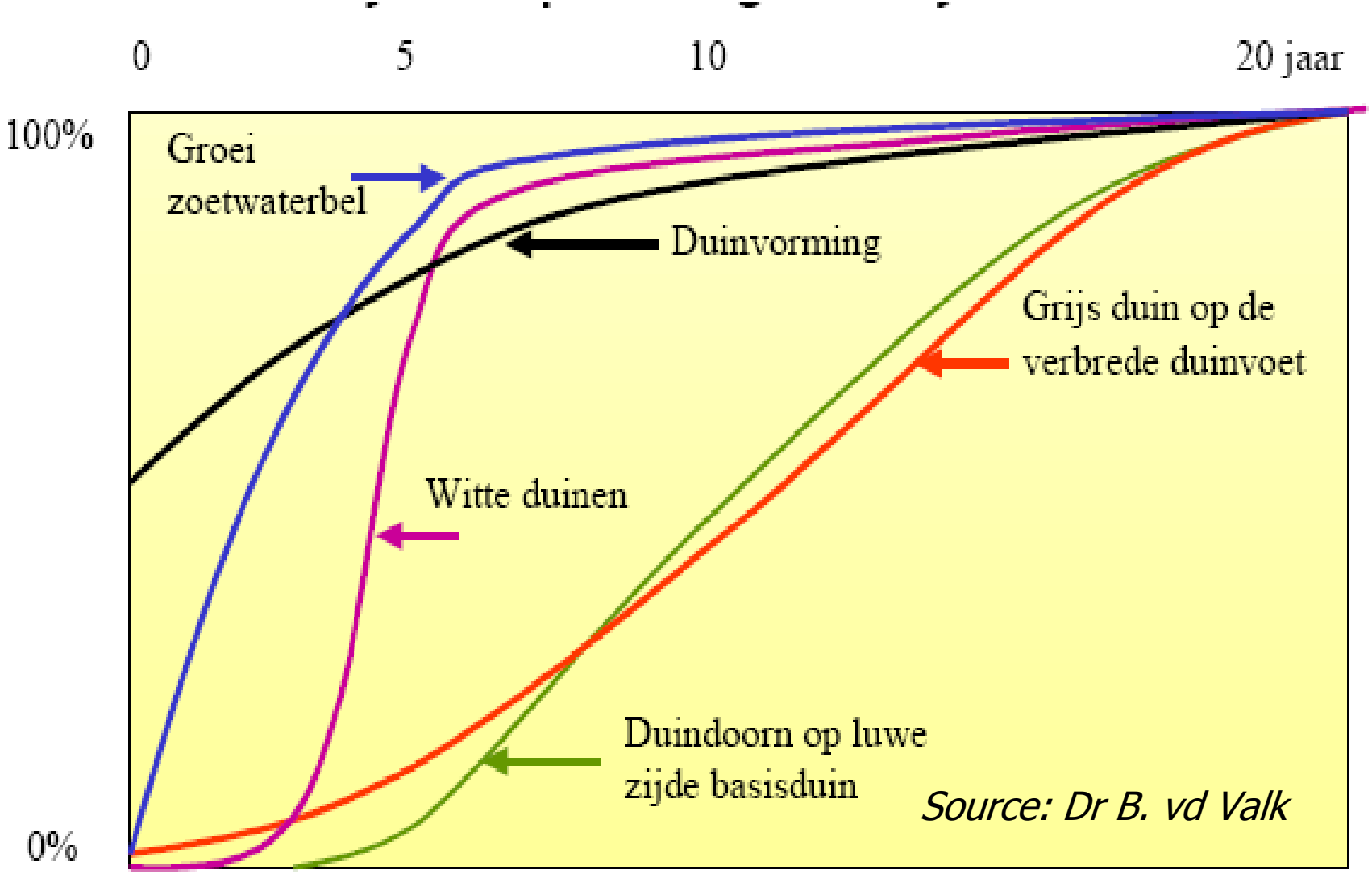
Shoreface nourishment

‘Soft’ protection strategy



Intervention (nourishment) when the momentary coastline (MCL) starts to move landward of a defined threshold

Spanjaards Duin: ontwikkeling 2008-2018



Deltares

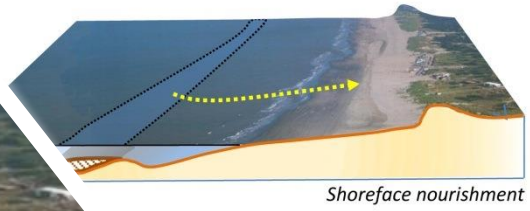
The use of natural forces in our advance

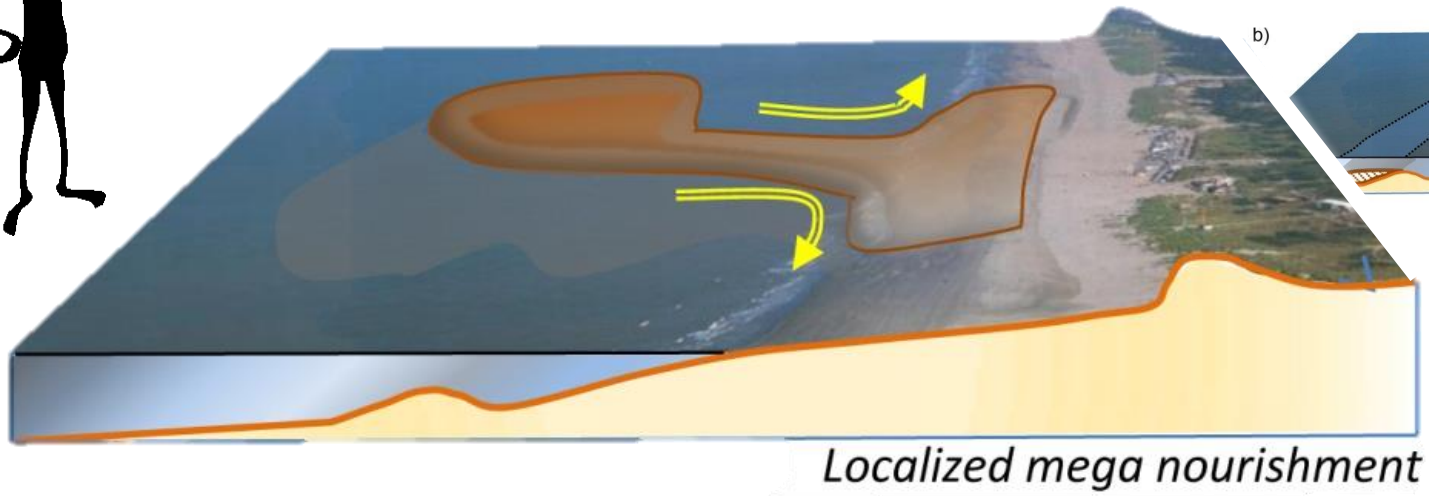
building with nature?

cannot we let nature do part of the work ...

while creating new new opportunities for itself?

1. Tendency towards larger-scale nourishments
2. Extra functions nourishments (nature, surfing)
3. Can we have nature do part of the work?
4. Increasing the intervention interval





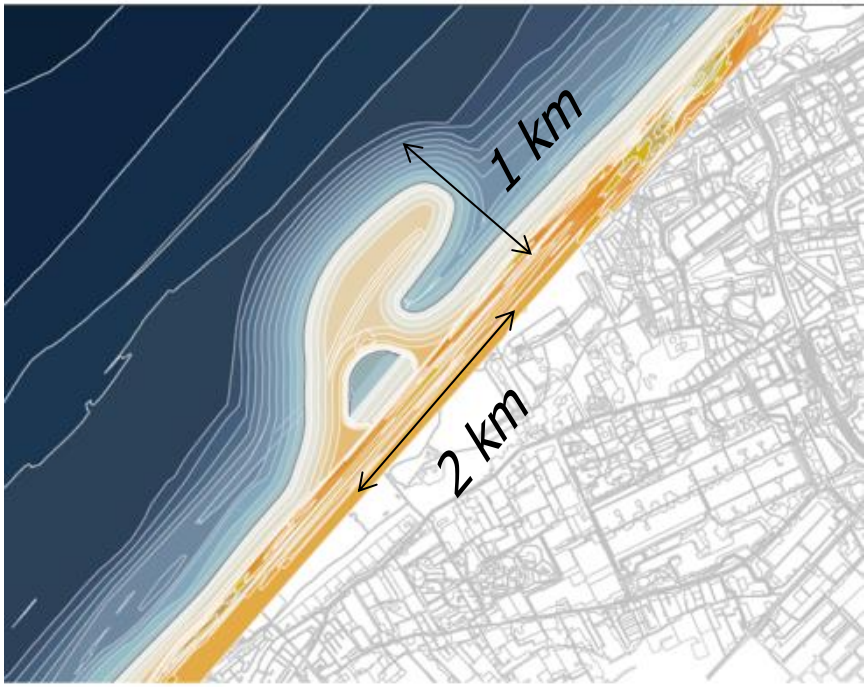
The Sand Engine!

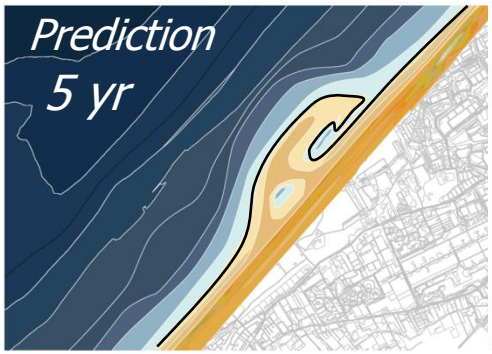
Objectives:

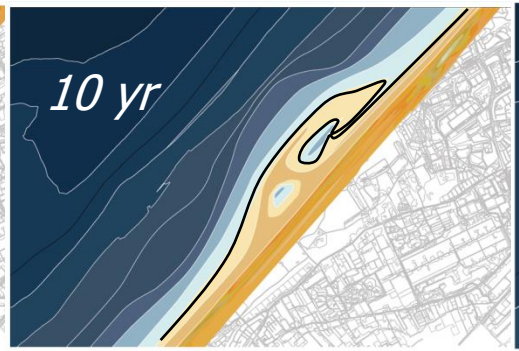
1. *Extra Safety*
2. *Nature area / 'Quality of living'*
3. *Innovation*

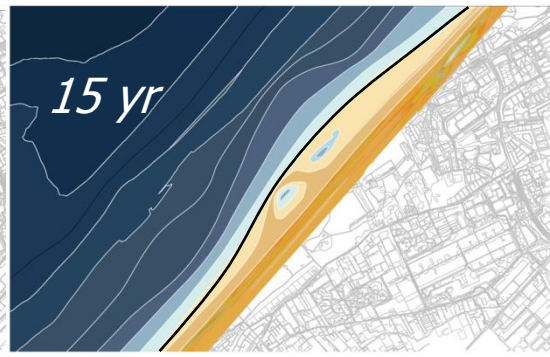
Peninsula alone 17.23 million m3

Envisioned lifetime 10-20 yrs









Construction, ~ 3 months

Constructed peninsula

Aerial photo Sept. 2011, 2 months after completion

Aerial photo Oct. 2011, after 3 mnths

Aerial photo Jan. 2012, after 6 mnths

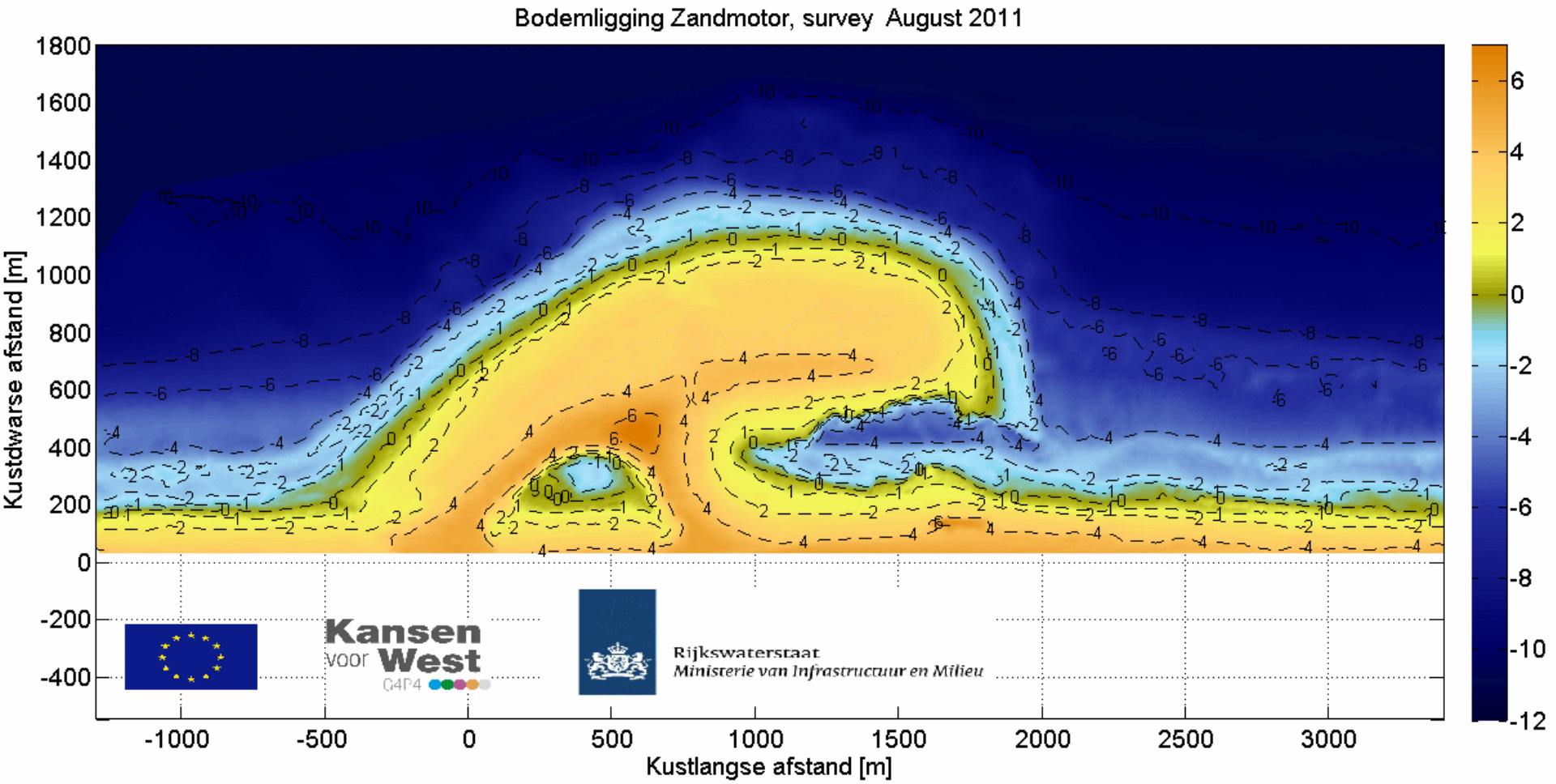
Aerial photo July. 2012, after 1 yr

Aerial photo July. 2013, after 2 yrs

Monitoring the Zandmotor

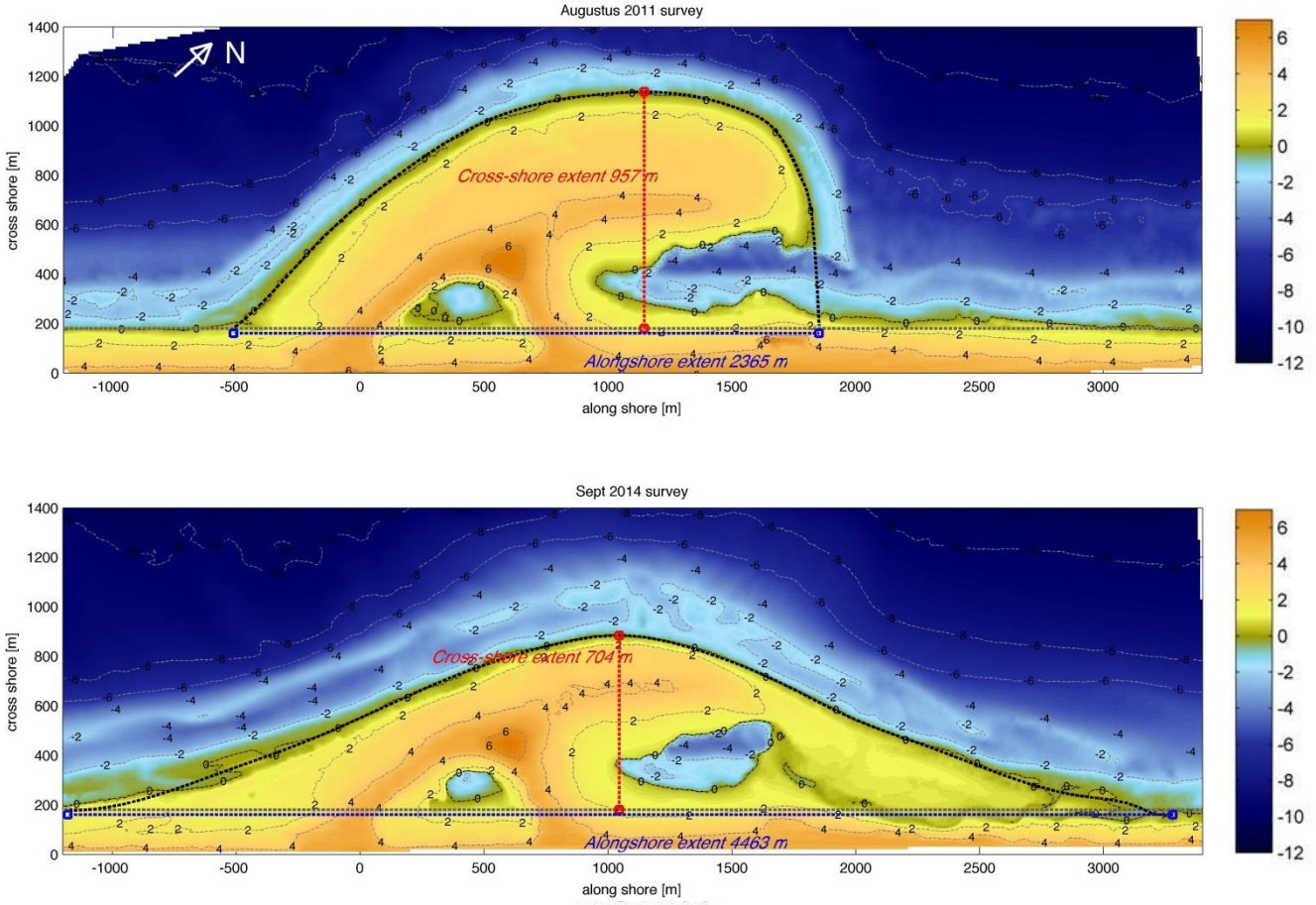
Topography

Animation surveys

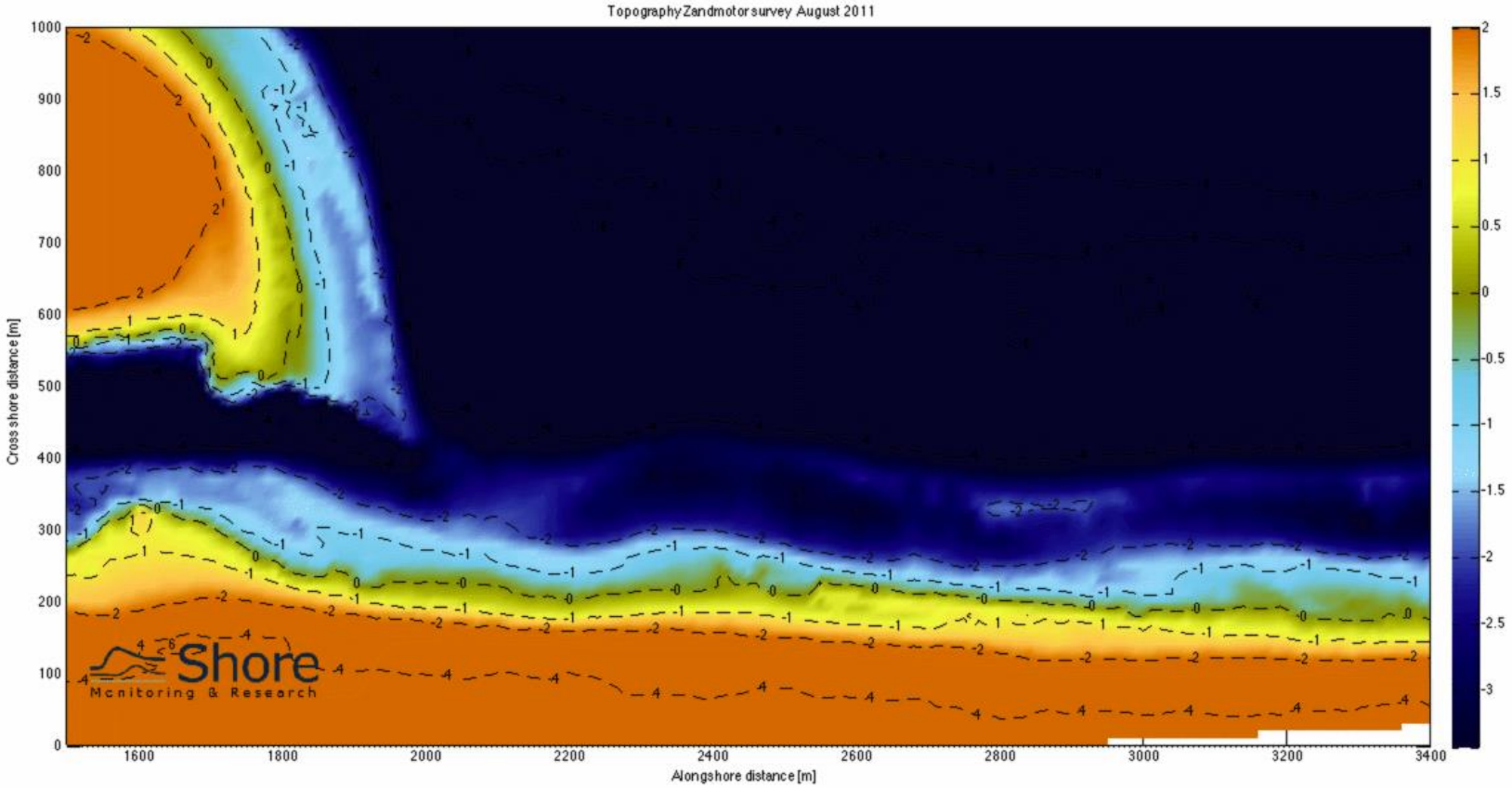


Morphology: General observations

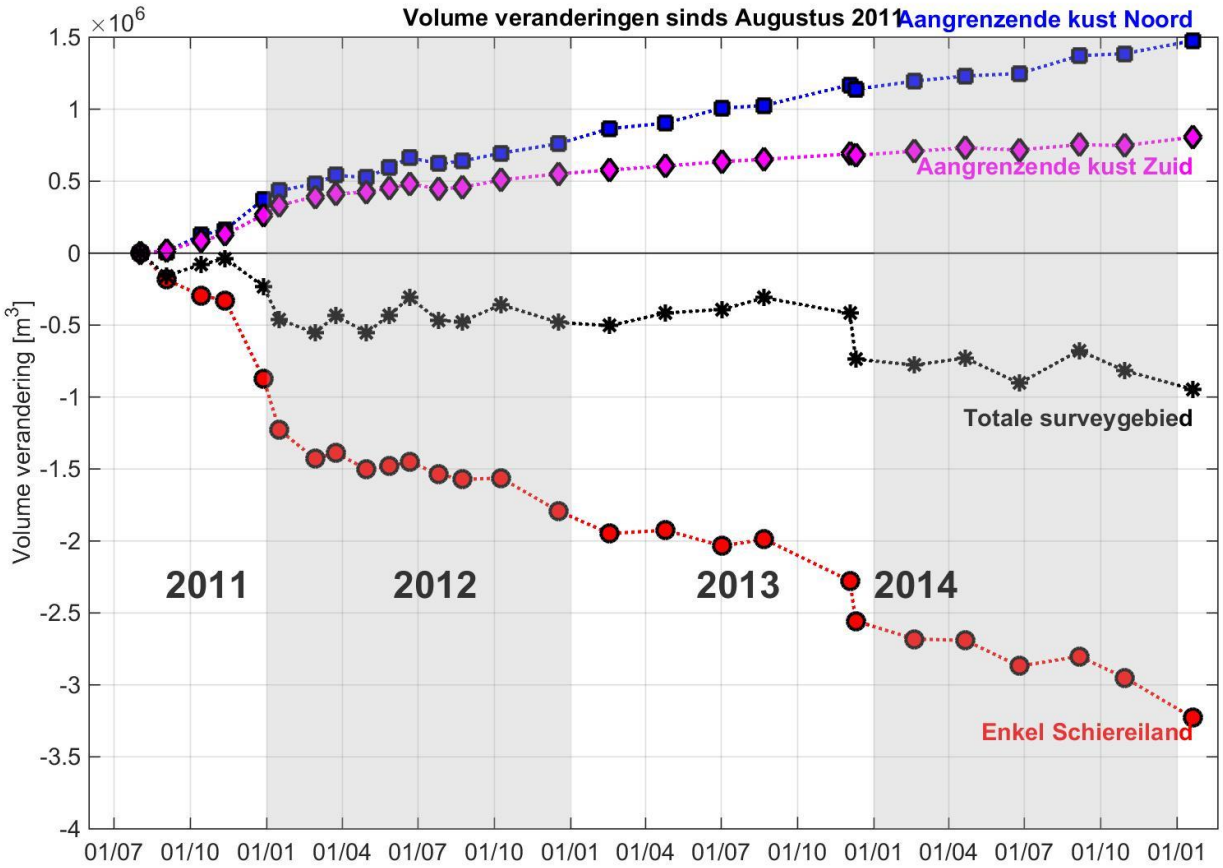
- Erosion seaward side ('tip')
- Elongation alongshore of ~ 2km
- Sedimentation southern end
- Spit and channel formation near lagoon
- Symmetry

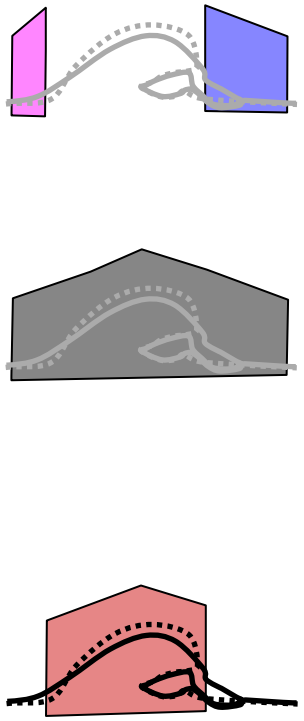


Spit and channel formation near lagoon



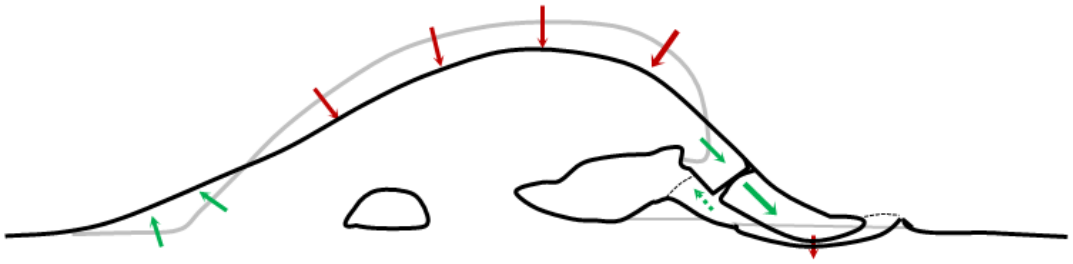
Volume change





Morphology observations

- It is feeding!
- Rapid change in the outline (within the first months)
- Quickly turning into almost diffusion case (skewed normal distribution)
- Feeding primarily during the energetic months, mild months show mostly cross shore change



Building with Nature

= Unexpected dynamics

> More uncertainty >>> **Monitoring, Data & Research essential**

Multi disciplinary pilot and monitoring

Nature Coast

BUILDING WITH NATURE

STW Enabling new technology

Results after 3 years of research

The Hague, 14 Sept 2016

Rijkswaterstaat Ministerie van Infrastructuur en Milieu

EcoShape

provincie ZUID HOLLAND

Kansen voor West G4P4

STW Nieuwe technologie mogelijk maken

Outline

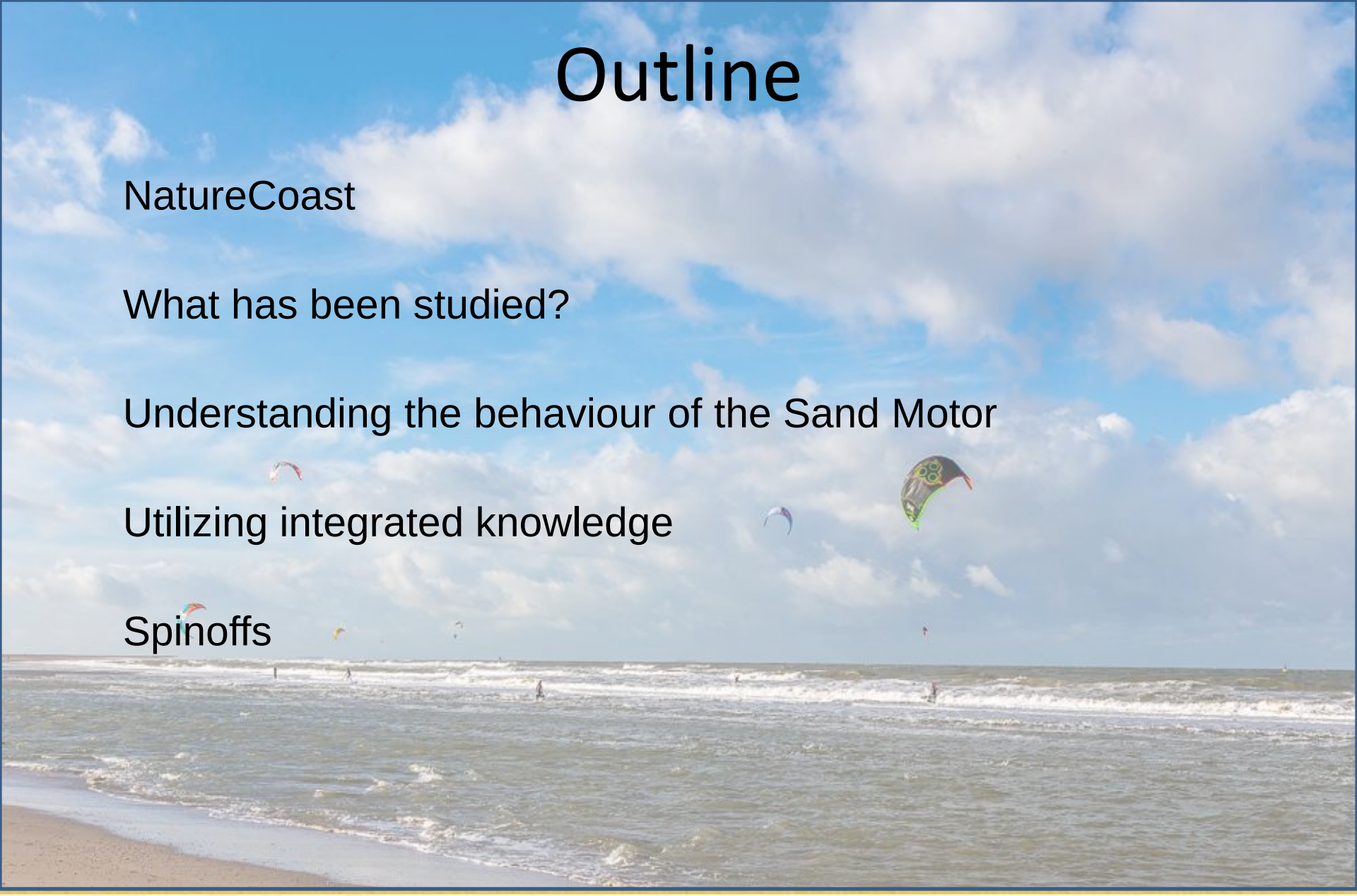
NatureCoast

What has been studied?

Understanding the behaviour of the Sand Motor

Utilizing integrated knowledge

Spinoffs



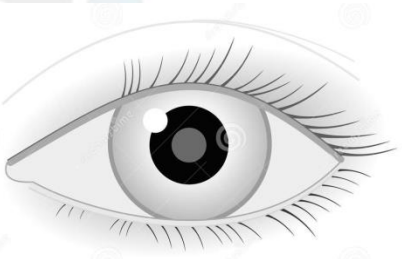
Motivation for interdisciplinary research

- Large signal to noise ratio
- Multi-functionality requires interdisciplinary science
- End-user involvement in definition of research questions

NatureCoast Research Program

- Interdisciplinary research project
- Funded by STW – Dutch Science Foundation (5.5 mln €)
- 6 universities, 12 PhDs + 3 postdocs
- Strong involvement of end-users
- Builds on MEP, EFRO and NEMO (3 PhDs)
- International collaboration with universities (MegaPex)

Monitor → *Understand* → *Create*



TU Delft · NIOZ · Universiteit Utrecht · UNIVERSITEIT TWENTE. · VU Vrije Universiteit Amsterdam · WAGENINGEN UR For quality of life · Building with Nature

End-users

Nature Coast
BUILDING WITH NATURE


Morphology
Dune formation
try
Hydrology
Terrestrial
Ecology
Swimmer safety
Governance

Province South Holland key figure

- Ministry invited provinces for integrated ideas
- Province of ZH was Initiator
- Opportunity-oriented instead of problem-oriented
- Convincing all stakeholders

Nature Coast
BUILDING WITH NATURE

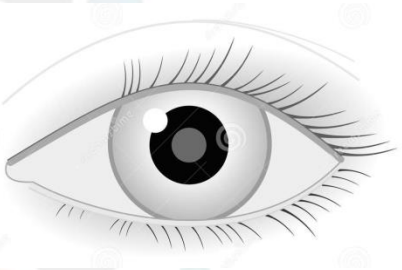
What was unexpected?

- Dunes need more time to develop and lower growth rates
- Vegetation needs more time to develop
- Intertidal area is main sand source for aeolian transport
- Channel breach cycle is longer than expected (5 years)
- Steep slopes and erosional pits in channel
- Cliff formation
- Liquefaction / quick sand

Utilizing Integrated Knowledge

1. Through Ecosystem Services in Design
2. Develop integrated tools for quantification
3. Verification through international cases
4. Exploring governance setting

Monitor



Understand

Create

Nature Coast
BUILDING WITH NATURE

Alexander van Oudenhoven
Post-doc at Leiden University

Consequences of Sand Motor design to human well-being

- Shape (hook, island, parallel)
- Extent, height, orientation
- Grain size of material
- Other (chemical) properties
- (Permanent) infrastructure
- Management (raking, etc.)

Erosion Prevention

Coastal Protection

Recreation

Fresh water provision

Habitat provision

Inspiration for culture, art & design

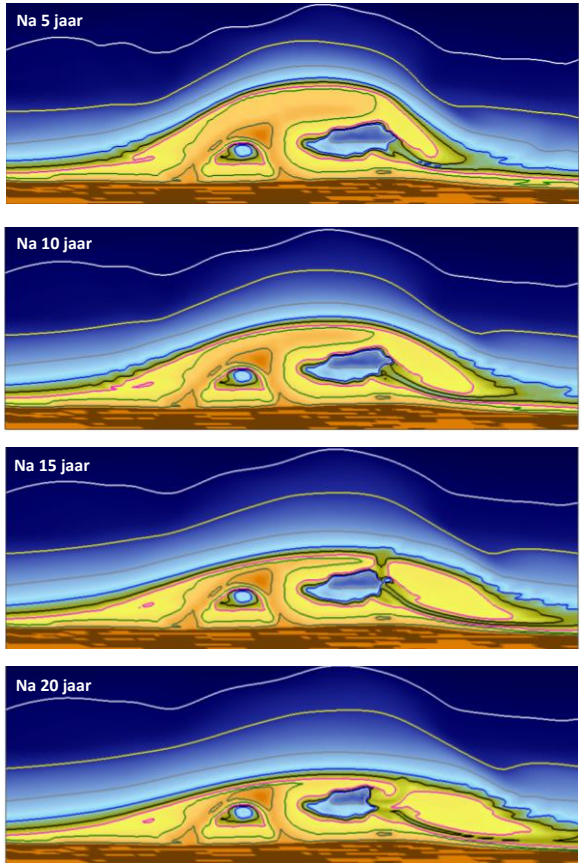
and others..

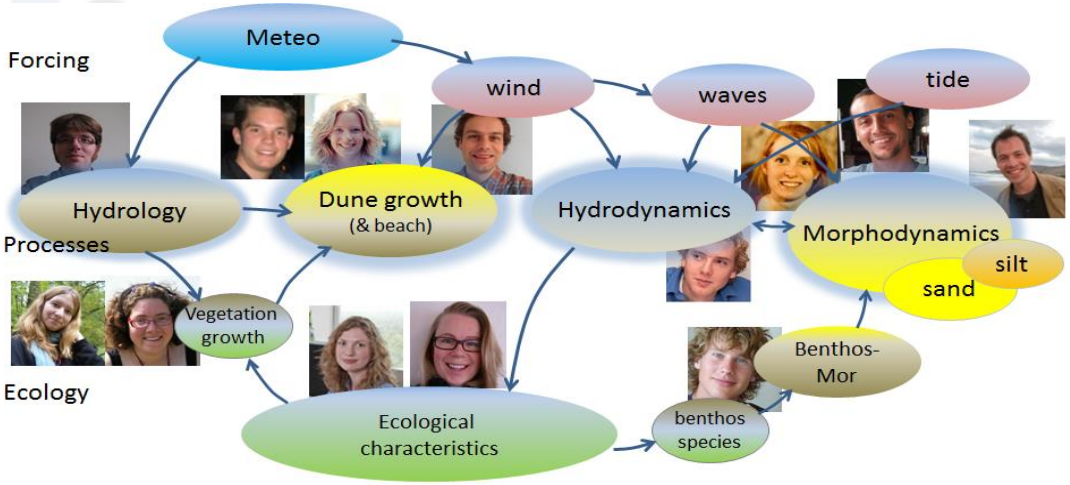
Nature Coast
BUILDING WITH NATURE

Arjen Luijendijk
Post-doc at Delft Univ of Technology / Deltares

Integrated tools for ESS quantification

- Long-term predictions with coupled models
- Combining aeolian transports, morphology, groundwater and vegetation, habitat development
- Input for quantification of Ecosystem Services





Nature Coast
BUILDING WITH NATURE



Cases / applications

Nature Coast
BUILDING WITH NATURE

Vera Vikolainen
Post-doc at Twente University

Viability of sandy solutions in different governance settings

- Norfolk, UK
- Barriers and opportunities
  in the governance context

Spinoffs

- Active involvement of end-users
- Innovative measuring techniques:
  - –WaveDroid
  - –Drone
  - –Jetski (Shore)

XB-radar

- Integrated models (open-source)
- Data Management System
- MOOC → BwN in educational programs
- OpenData

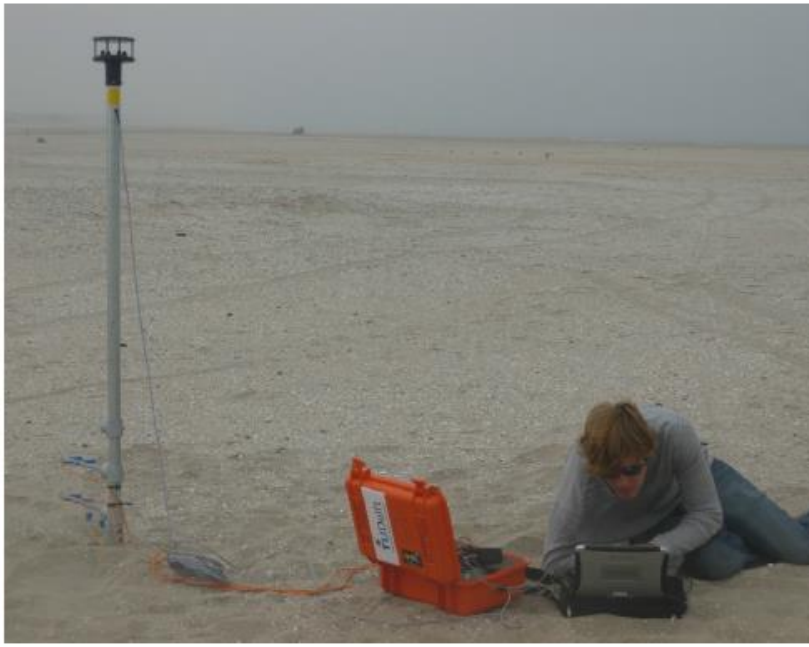
Nature Coast
BUILDING WITH NATURE

Field Experiments

MEGAPEX 2014

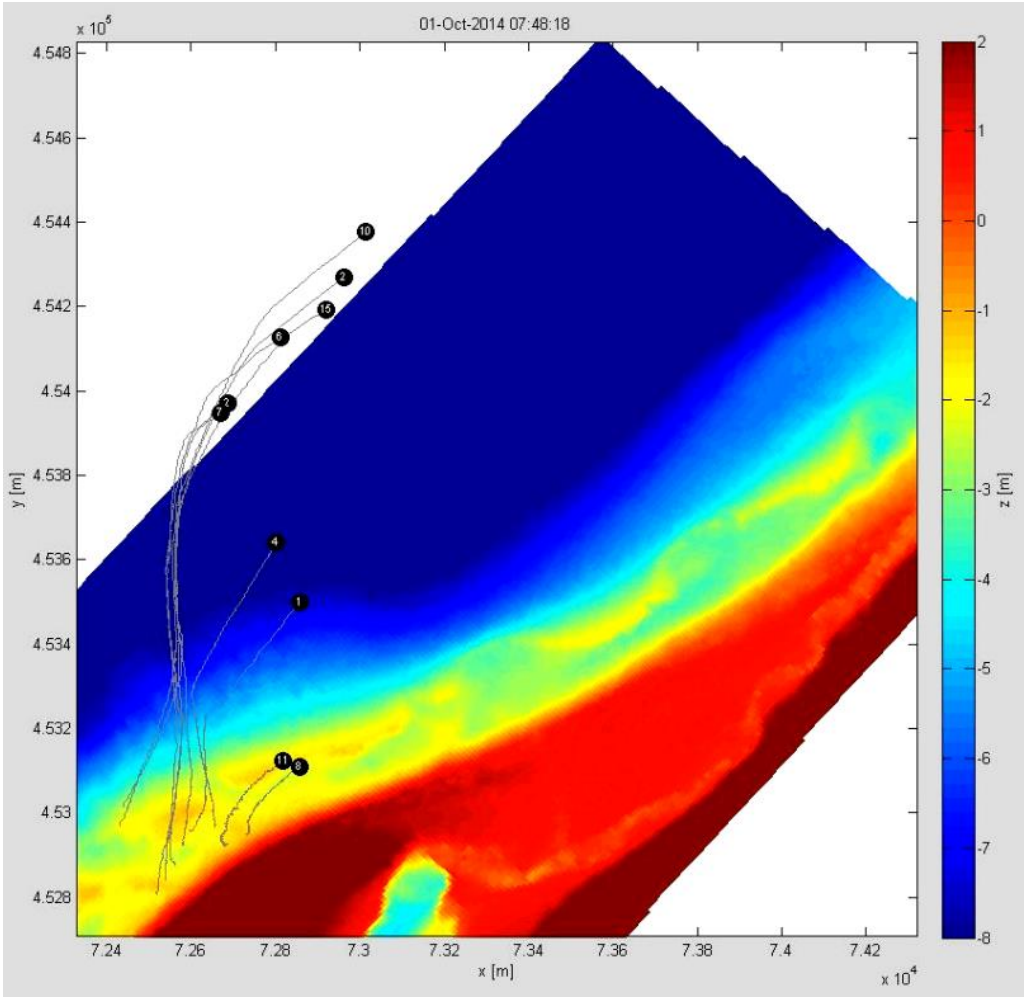
Beach & Dunes

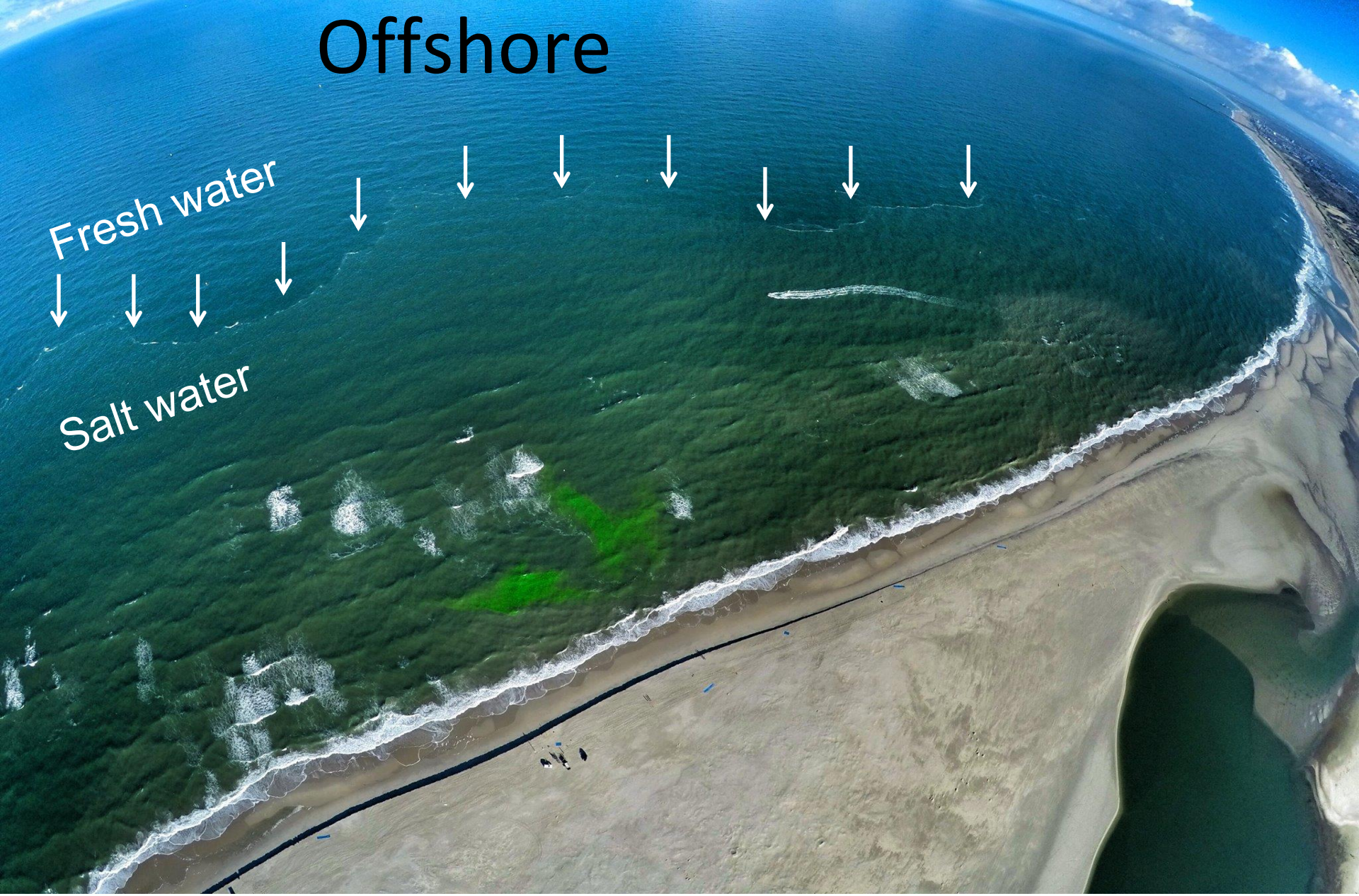
Sediment transport measurements across the beach

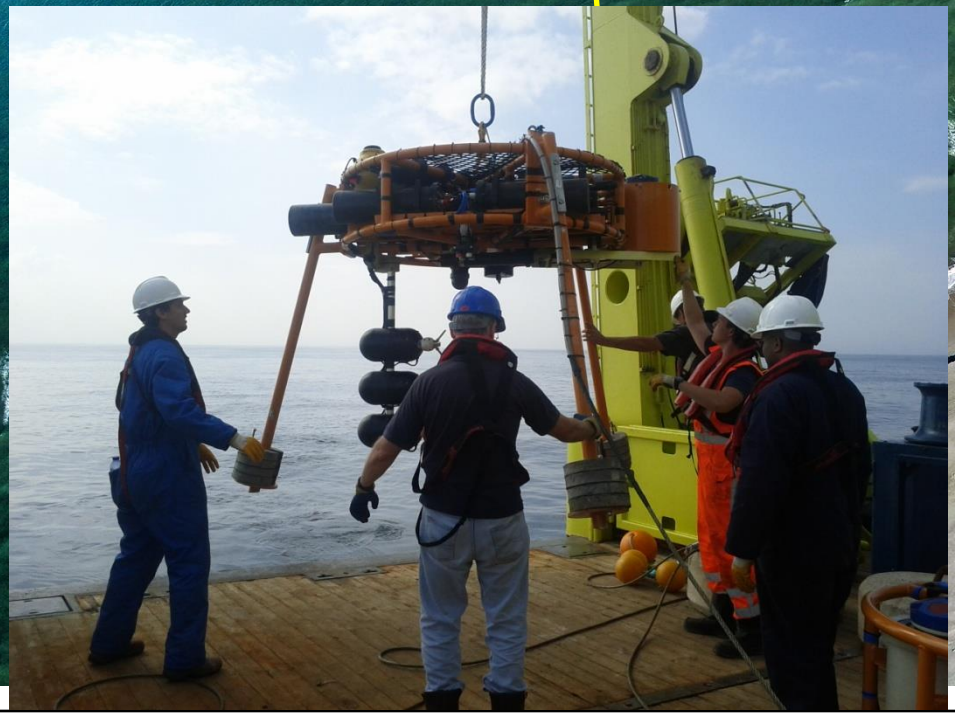


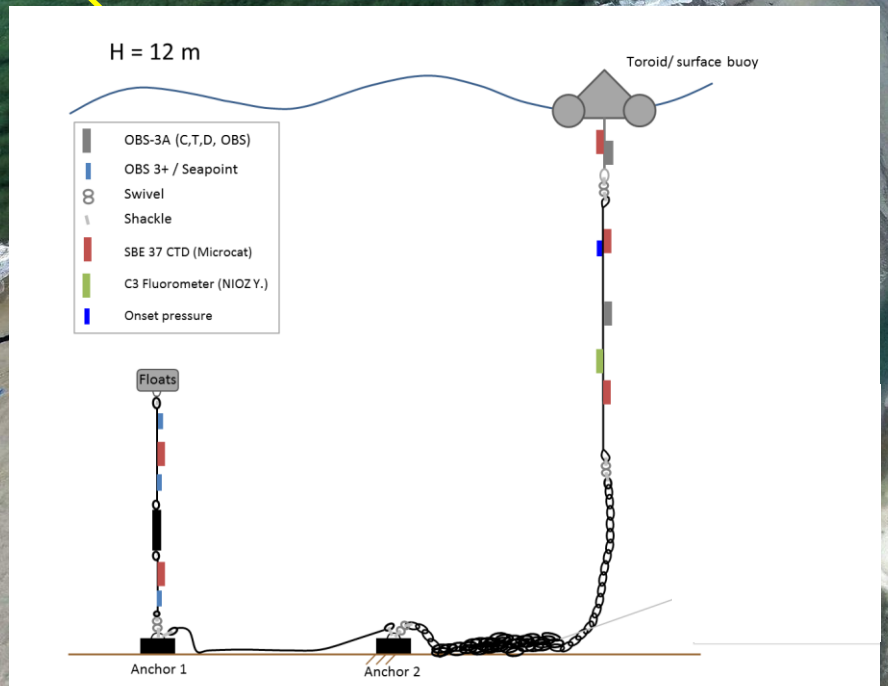
Drifter flow measurements

Free floating buoys with GPS




Offshore
Fresh water
Salt water

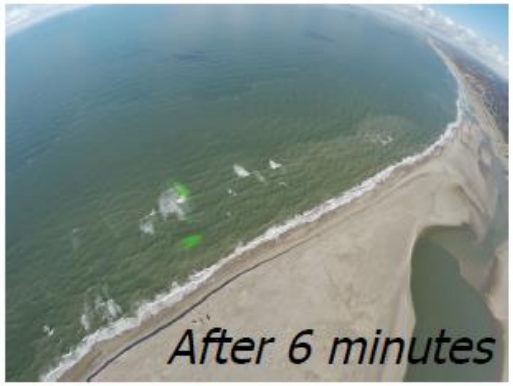


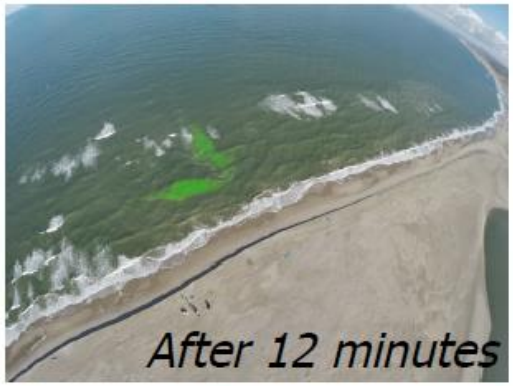

H = 12 m
Toroid/ surface buoy
OBS-3A (C,T,D, OBS)
OBS 3+ / Seapoint
Swivel
Shackle
SBE 37 CTD (Microcat)
C3 Fluorometer (NIOZ Y.)
Onset pressure
Floats
Anchor 1
Anchor 2

Dye & drone measurements

Measure currents near the coast

Dye & drone measurements



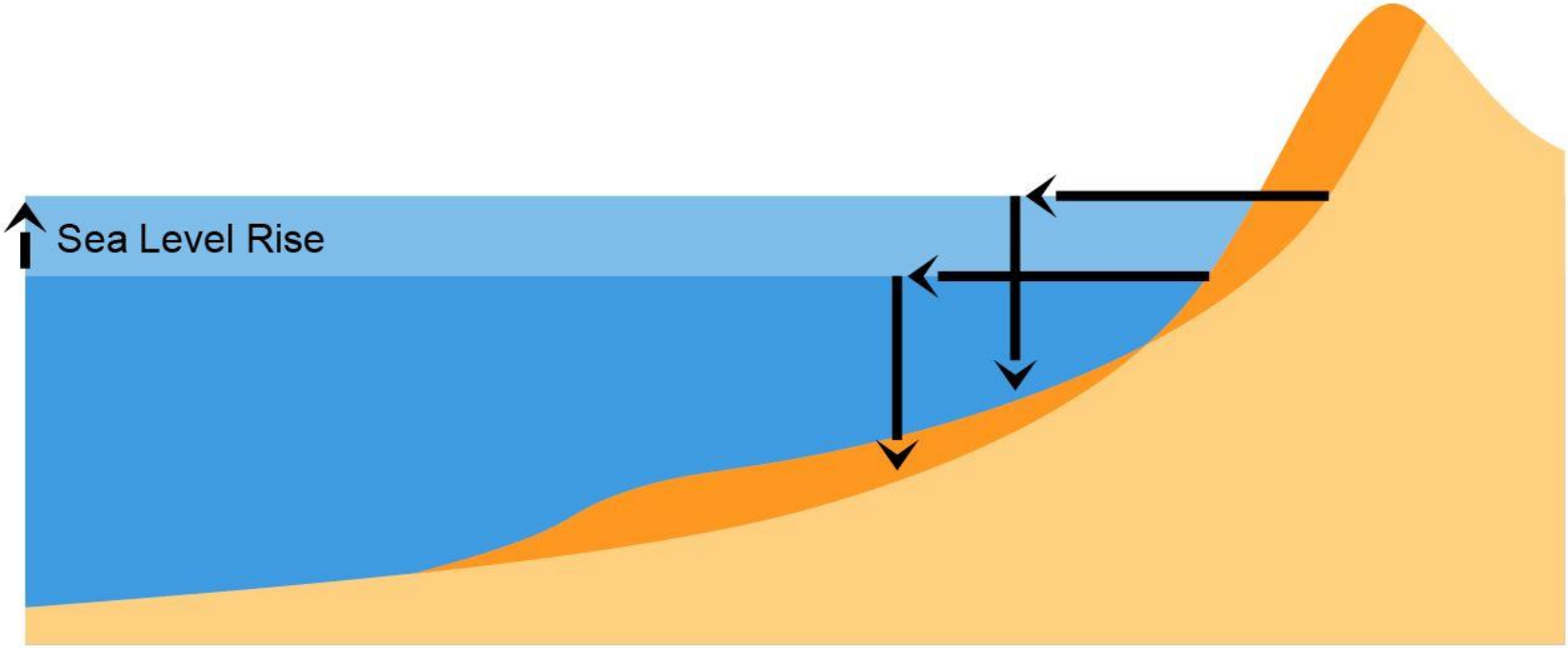


Global challenge

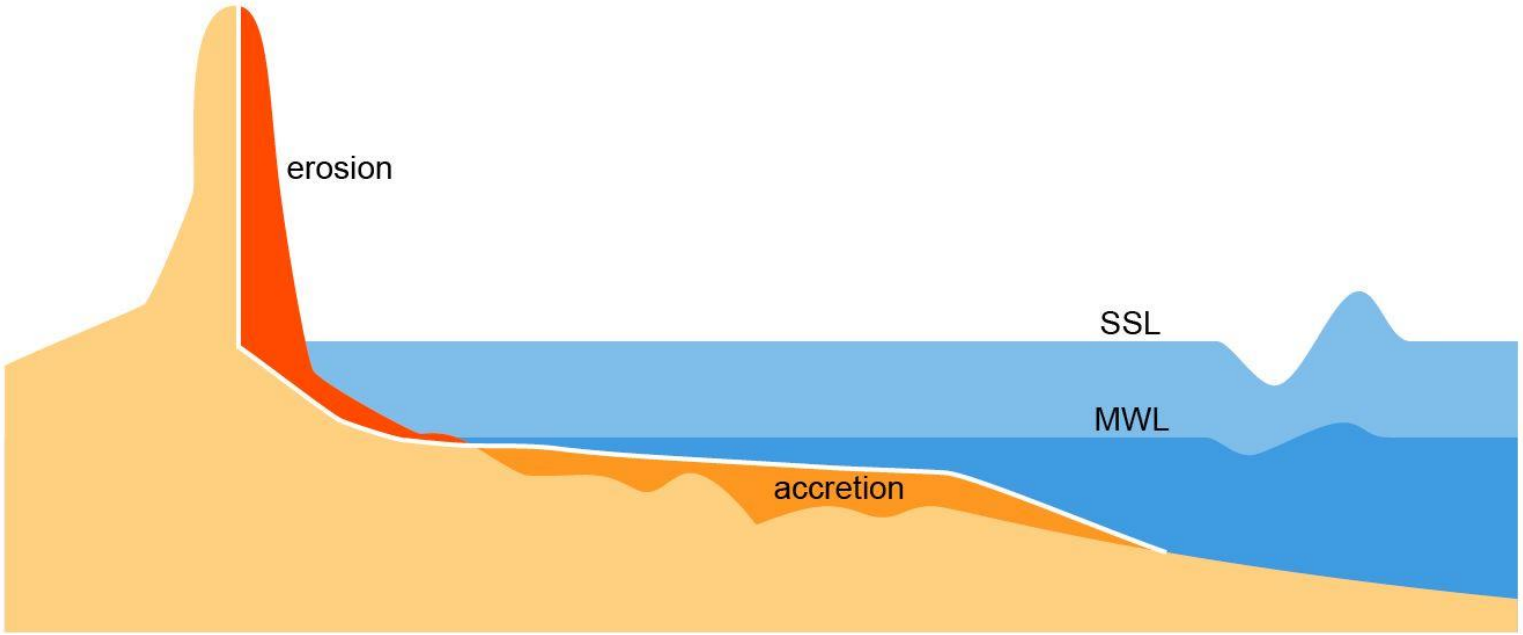
- Impact of Sea Level Rise (SLR) on coastal systems: beach/dune/barrier coasts, salt marshes and mangroves, deltas/estuaries/lagoons
- Impact of Weather Pattern changes on coasts: extreme events, structural wind direction changes
- Impact of Weather Pattern changes on river catchments: rainfall and drought changes

NB: in all cases we need to consider climate change drivers AND non climate change drivers, e.g. coastal squeeze

Sea level rise causes coastal retreat: 3 mm slr/yr gives a retreat of 30 cm/yr without compensation



Fringing habitats need space to breath (besides absorbing the impact of sea level rise)



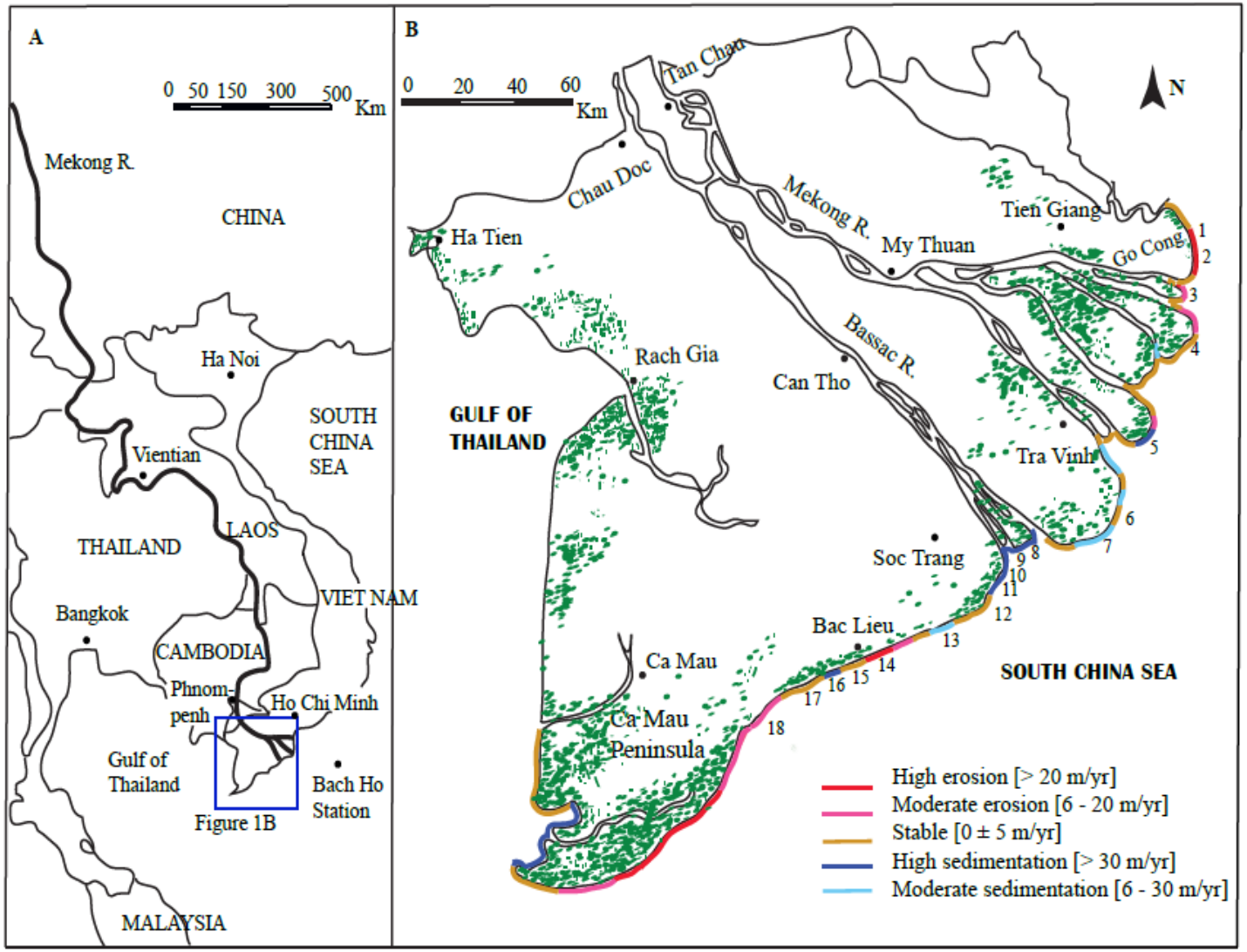
At least as important to cope with slr is to prevent Coastal Squeeze

Fringing coastal habitats suffer from squeeze:

- Dune, beach and beach barrier habitats
- Salt marsh habitats
- Mangrove habitats

- A classic example of beach and dune squeeze: Spain
- Mangrove squeeze in the Mekong delta

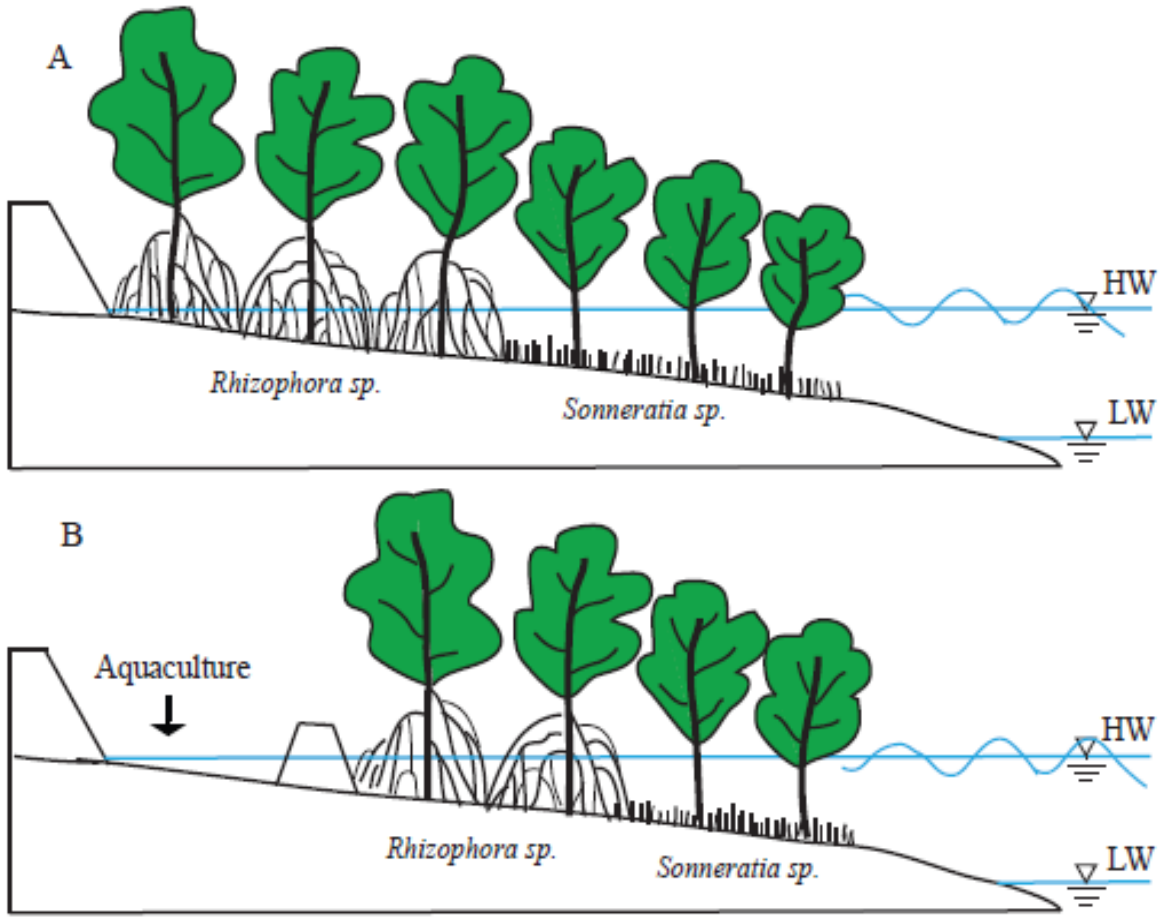
Coastal mangrove squeeze in the Mekong delta



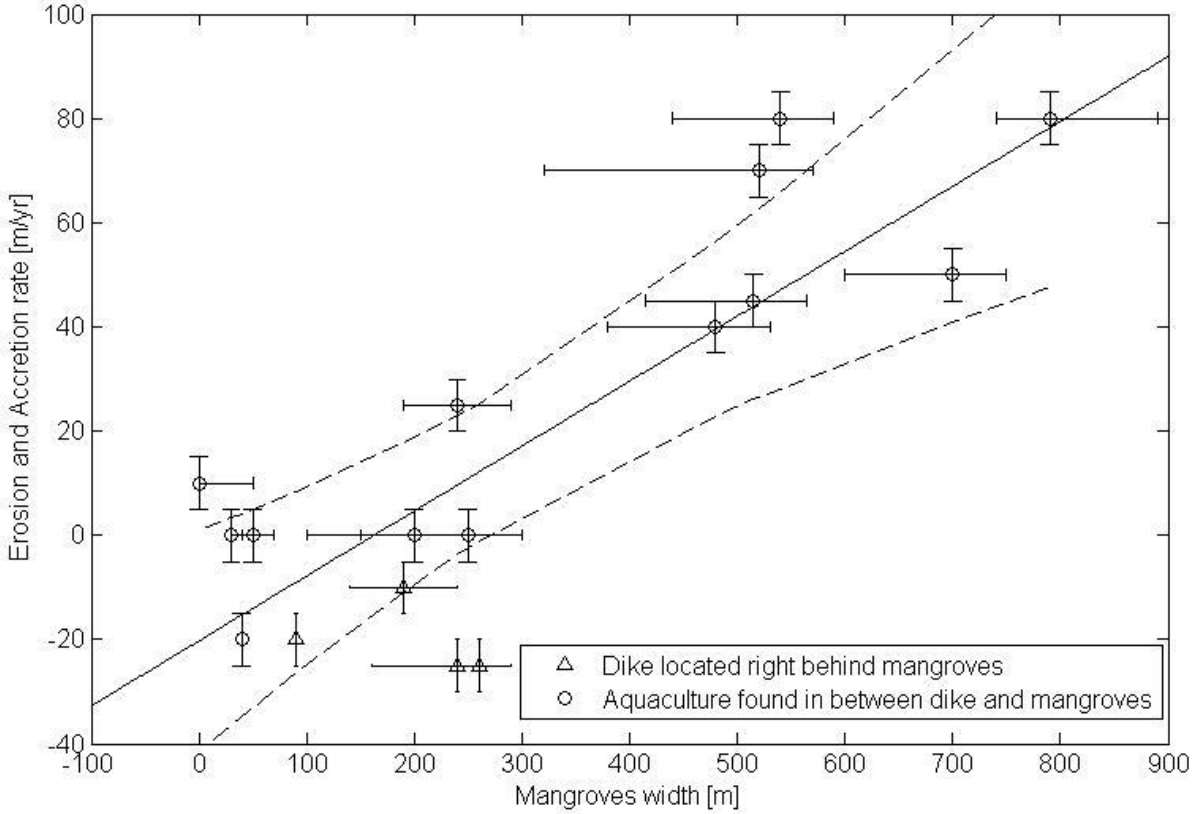
Soc Trang Province

Endangered dyke in Soc Trang Province

Abundant sea dike construction



For locations where sediment source is not restricted




2006
Fish farm
2010
Extented
Extented
Fish farm

Squeeze hypothesis

When either the primary or the secondary dike is too close to the non-vegetated foreshore, erosion is usually occurring and the health of the mangrove forest is under stress

COASTAL SQUEEZE

- Fringing habitats need space to 'operate'
- 'Operate' means:
  - Absorb extreme events
  - Allow for cyclic rejuvenation
  - Absorb relative sea level rise
- The habitat needs space so

Nourish or retreat?

- Sediment availability is not trivial
- Is retreat an option to resolve this?
- Technically: YES
- Politically: ???

Thank you

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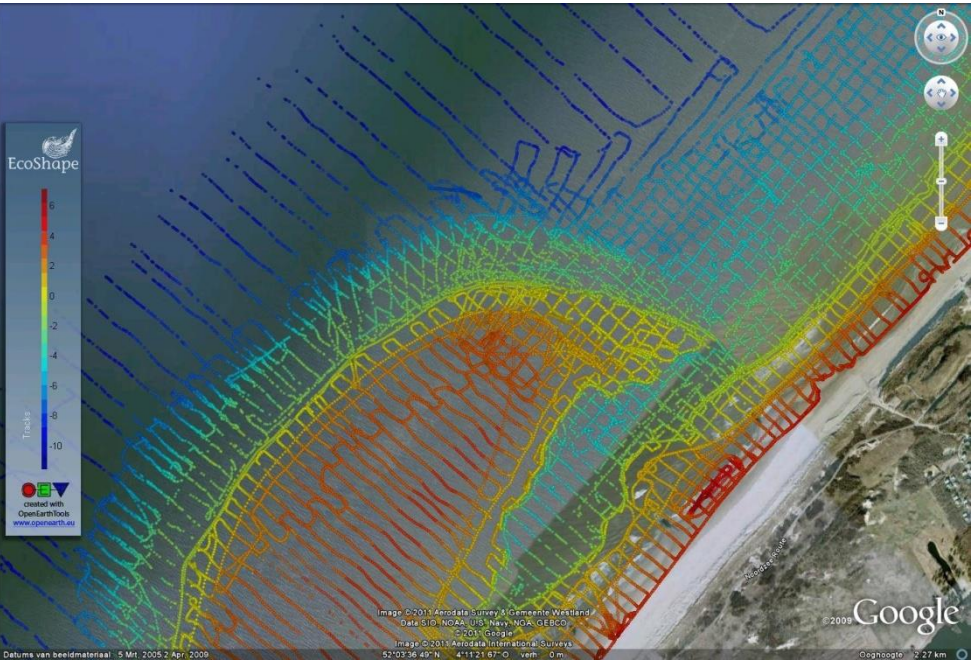
@WaterTUDelft

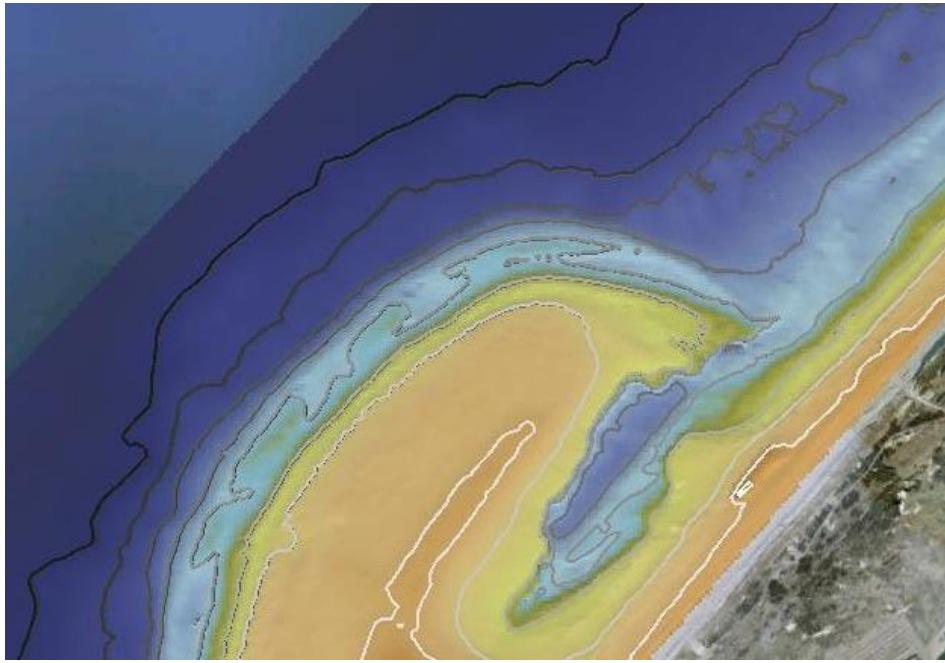
Building with Nature

=
Unexpected dynamics

Combining surveys

Topography maps





In conclusion: Squeezing of land-water and water-water transitions needs our attention

- Beside coastal also in rivers along the fringing banks, or upstream and downstream of dams
- Also in estuaries along the banks or due to damming separating fresh and salt water bodies