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

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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.

Natural protection of the coast: beaches and dunes. Balanced systems. High environmental value of the environment.

Años 60 y 70: Urbanización Masiva.

Destruction of beaches and coastal dunes. Invasion, privatization and degradation of the public domain. Harmful urban development on the beach. Wastes thrown into the sea without purifying. Destruction of areas generating life.

URBANIZACION DE LA COSTA.
URBAN DEVELOPMENT OF THE COAST.
**Opción 1: Solución Rígida**
Option 1: Rigid Solution

**Defensa artificial de la costa:** muros, escurillas, espinas.
- Altos costes de mantenimiento y reparación:
- Edificaciones junto al mar
- Efectos negativos en la costa adyacente.
- No se recupera el escenario natural.
- Escasas perspectivas de futuro.

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**Opción 2: Solución Blanda**
Option 2: Soft Solution

**Defensa artificial de la costa:** aportación de arena.
- Altos costes de mantenimiento y reparación:
- Alimentación periódica
- Edificaciones junto al mar
- Recuperación parcial del escenario natural.
- Eficacia a medio plazo.

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**Opciones de actuación.**
**Options of actions.**
The Dutch Coast
’coastal squeeze’
Historic perspective

Shortage of natural sediment

Consequence: Structural erosion

Solution: ??
Traditional ‘hard’ solutions
Solution 1.0

Galveston, TX
‘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


*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

Repetition time scale 4-6 yr
Spanjaards Duin: ontwikkeling 2008-2018

Source: Dr B. vd Valk
The use of natural forces in our advance

**building with nature?**

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

while creating 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

15-03-2011

18-04-2011

17-05-2011

14-06-2011
Constructed peninsula
Aerial photo Sept. 2011, 2 months after completion
Aerial photo Oct. 2011, after 3 mnths
Aerial photo Jan. 2012, after 6 months
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

Volume veranderingen sinds Augustus 2011

Aangrenzende kust Noord
Aangrenzende kust Zuid
Totale surveygebied
Enkel Schiereiland
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

Benthos

Morphology

Recreation
Swimmer safety

Nature

Science/Innovation
Results after 3 years of research

The Hague, 14 Sept 2016
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)
End-users
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
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
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..
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
Cases / applications

Map showing locations such as Lima, Durban, Jamaica, S-Sweden, UK, Da Nang, and Bali.
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
  - XB-radar
  - Drone
  - Jetski (Shore)
- Integrated models (open-source)
- Data Management System
- MOOC → BwN in educational programs
- OpenData
Beach & Dunes

Sediment transport measurements across the beach
Drifter flow measurements

Free floating buoys with GPS
Offshore

Fresh water

Salt water
Dye & drone measurements

Measure currents near the coast
Dye & drone measurements

begin
After 6 minutes
After 12 minutes
After 18 minutes
After 28 minutes
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 breathe (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
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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Building with Nature

= Unexpected dynamics

High tide

Low tide
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