### The Sand Engine a 'Building with Nature' pilot

### Deltares

Delft Delft University of Technology

#### arjen.luijendijk@deltares.nl

# Outline

- 1. Motivation
- 2. Design & Construction
- 3. Monitoring and first results
- 4. Is it transferable?















# 1. Motivation





# 1. Motivation

at meters	8-0
-12-7	9-10
-7-6	10-12
4-1	12.14
- A - A	54-18
4-3	10-18
-5-2,5	19-20
25-2	20-28
-2-1.5	25-30
1.5-1	30-38
-1-4,5	35-40
-0.5-0	40-45
0-0.5	45-50
0.5-1	50.40
5-5.5	60.72
1.6-2	70-80
2.2,6	80-90
2,5-3	90-100
3-3,5	100-125
3.5-4	125-130
44.5	190-175
4,5-5	175-200
5-6	200-250
6-7	250-300
7.4	300-350



# Safety against flooding







### Holland Coast: Policy context

### Shortage of natural sediment

**Consequence: Structural erosion** 



### Solution: Nourishments

### Increase in nourished volumes

Dynamic preservation of the 1990 coastline

### Sand volumes:

- Since 1990: 6 mln m3/yr
- Since 2001: 12 mln m3/yr

### Prospect future: 40-85 mln m<sup>3</sup>/yr!

Tendency towards larger-scale nourishments Uncertainties on environmental effects Need for space (nature & recreation)





### 2. Design & construction



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



### 2. Design & construction

A

Suction hopper:Pumping ashoreBottom dumping

Rainbowing











### **Ambitions Sand Engine**

- Enhanced safety against flooding
- Cheaper per m<sup>3</sup> compared to traditional nourishments
- Longer period between consecutive nourishments
- Ecologically interesting intermediate stages
- Recreation potential
- Wider dune area  $\rightarrow$  increased freshwater reserve





### Evolution 2011 - 2016

#### www.flickr.com









#### www.flickr.com













### 'Living lab' for studying processes & species



# Morphological Evolution





### Morphological Evolution

Bodemligging Zandmotor, survey August 2011



### **Observations:** Recreation and Nature



EcoShape

### Hindcasts and forecasts



EcoShape

- Matches well with observations
- 1.5 mln m<sup>3</sup> was eroded

3000

е

d

# Findings from morphological modelling

- Erosion  $\sim \sum E$  of storm
- Wave directions are not relevant for the erosion
- Conditions with  $H_s > 1.5$  m are relevant

EcoShape

Total erosion of top 12 wave events → ~60% of the 1<sup>st</sup> yr erosion

Inter-tidal area is the main source for aeolian transports

Sediment sorting important...

Evolution for the next 20 years (Stive et al., 2013)



### Interdisciplinary research

### 15 Phds & 6 postdocs



## Interdisciplinary research

### 15 Phds & 6 postdocs



Marine ecology

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

• Governance

## Interdisciplinary research

### 15 Phds & 6 postdocs



Marine ecology

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

## Product: Integral landscaping toolbox



EcoShape

### Is this concept feasible elsewhere?

Lima, Peru (artist impression)

### Is this concept feasible elsewhere?



### Next Sand Motor in the Wadden Sea?





# Questions?