

# Decadal evolution of an intensely nourished coast

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**Flanders**  
State of the Art

## Content

1. Belgian coast, Ostend area
2. Evolution between 2000 and 2022
3. Morphological analysis – volumes nourished, erosion rates; long term trends, storm impact
4. **Hard protection -> Soft protection -> Nature based Solution**
5. Conclusions and future evolution



## Belgian coast

Moderate wave climate  $H_s \sim 1.0$  m

Macrotidal up to 5.0 m at spring tide

Grain size increasing from west to east following nourishments intensity

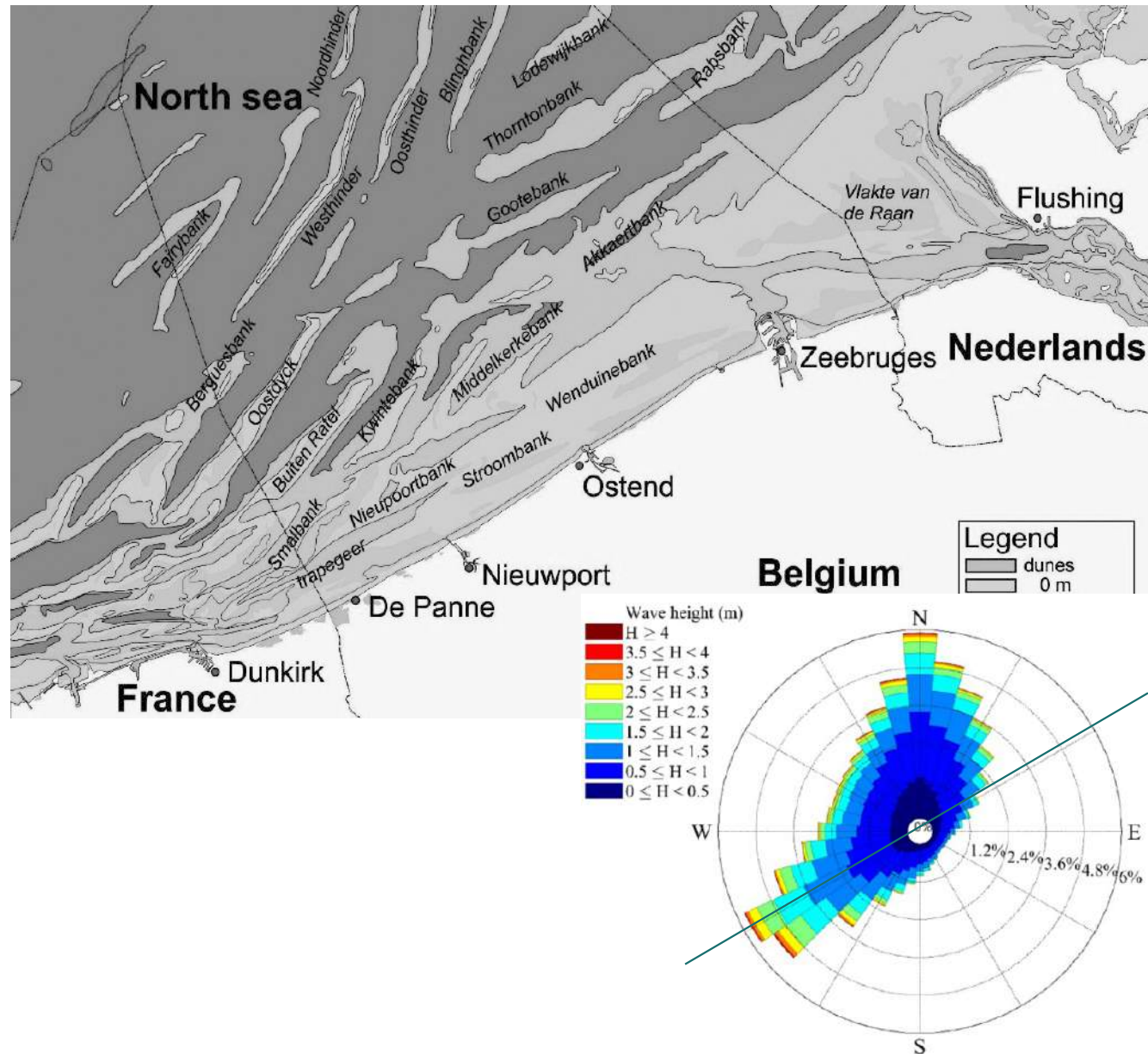
Complex system of gullies and banks

Intensely exploited 65 km length, three harbors, tourism, residential area, fishing

Continuous dredging to maintain navigation

Continuous nourishments to increase protection against storms

$\sim 0.75$  mil.  $m^3$ /year



## Protection against flooding

*Soft engineering as much as possible and complemented by 'hard' measures where is necessary.*

Coastal risk and vulnerability assessment framework for improving adaptive capacity implemented in the Master Plan for Coastal Safety in 2011

Describing needed measures to be taken for an adequate protection of the coastline and the adjacent low-laying polders against a storm surge with a return period of 1,000 years

Overtopping less than 1 l/m/s

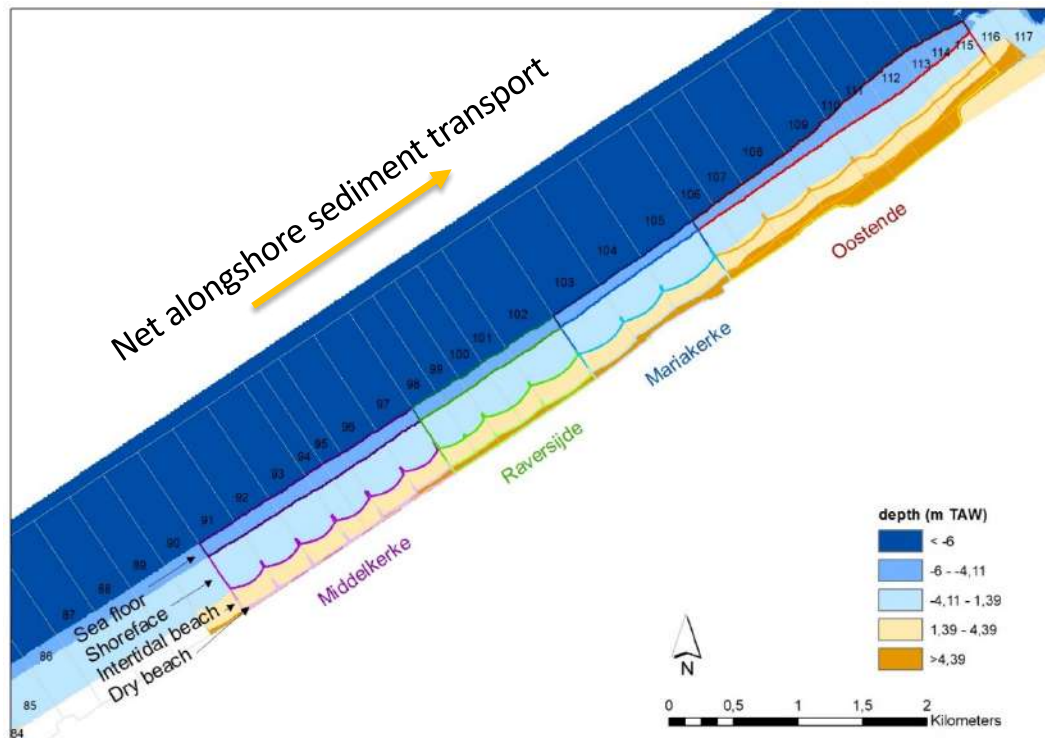
Re-assessing every 6 years and after extreme storms



# Ostend – Middelkerke beach

Intensive use; touristic and residential

Approximately 9 km length



Evolution of the Ostend – Middelkerke beach during last two decades



# Ostend harbor extension

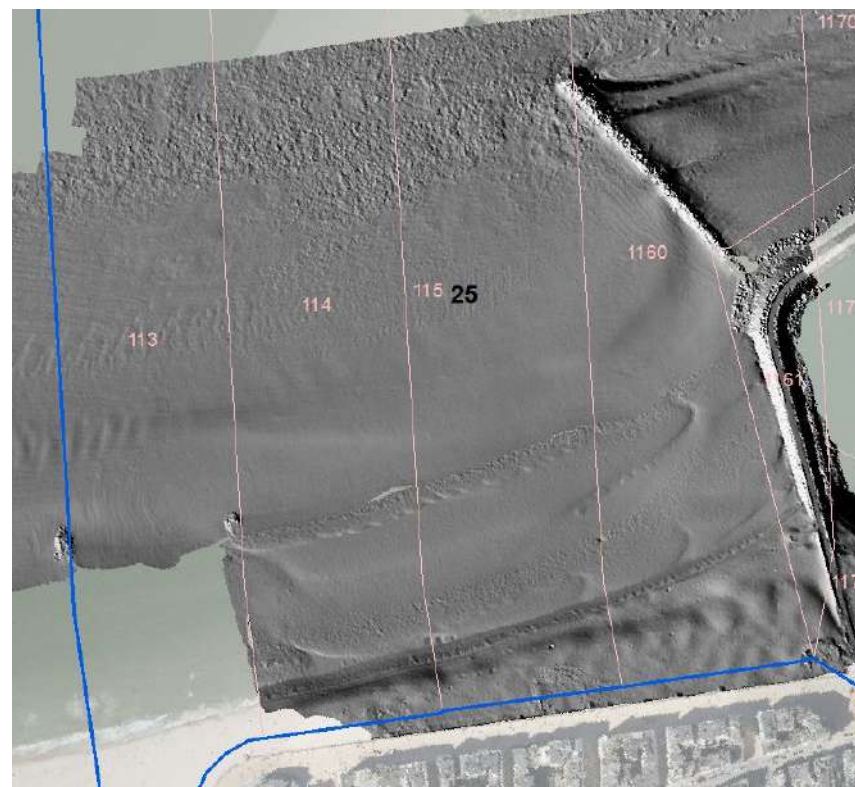


Submerged breakwater built to prevent sedimentation of the harbor channel access

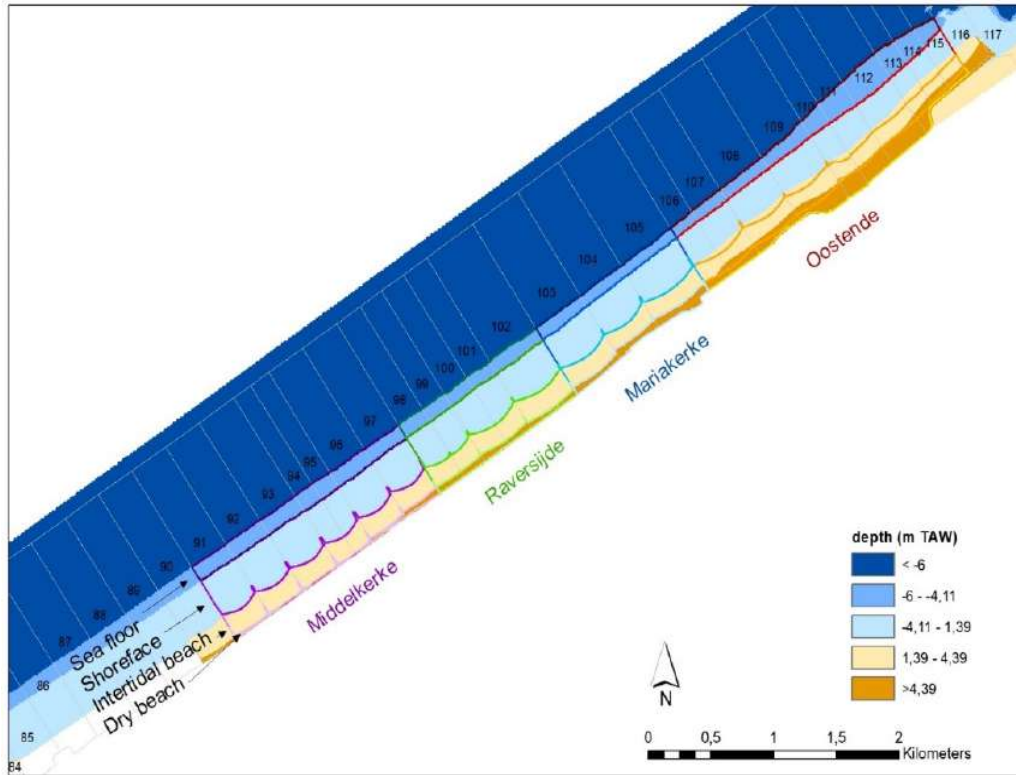


Enhance sedimentation and creation of complex patterns of channel and bars

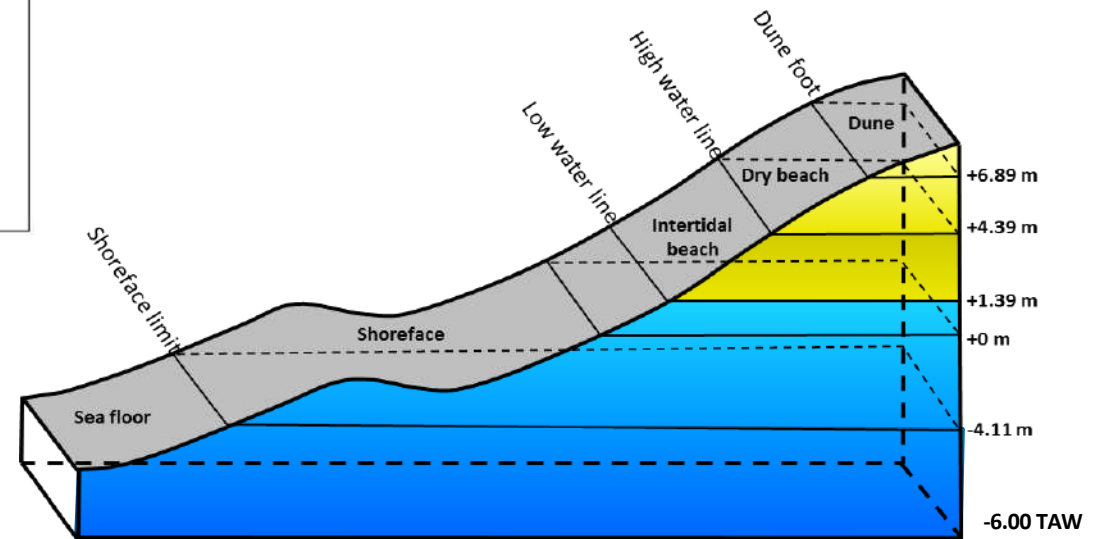
Tide induced currents play important role







## Coastal divisions Along- and cross-shore



Intensely nourished: over 4.0 mil. m<sup>3</sup> in 22 years  
in area Ostend Middelkerke

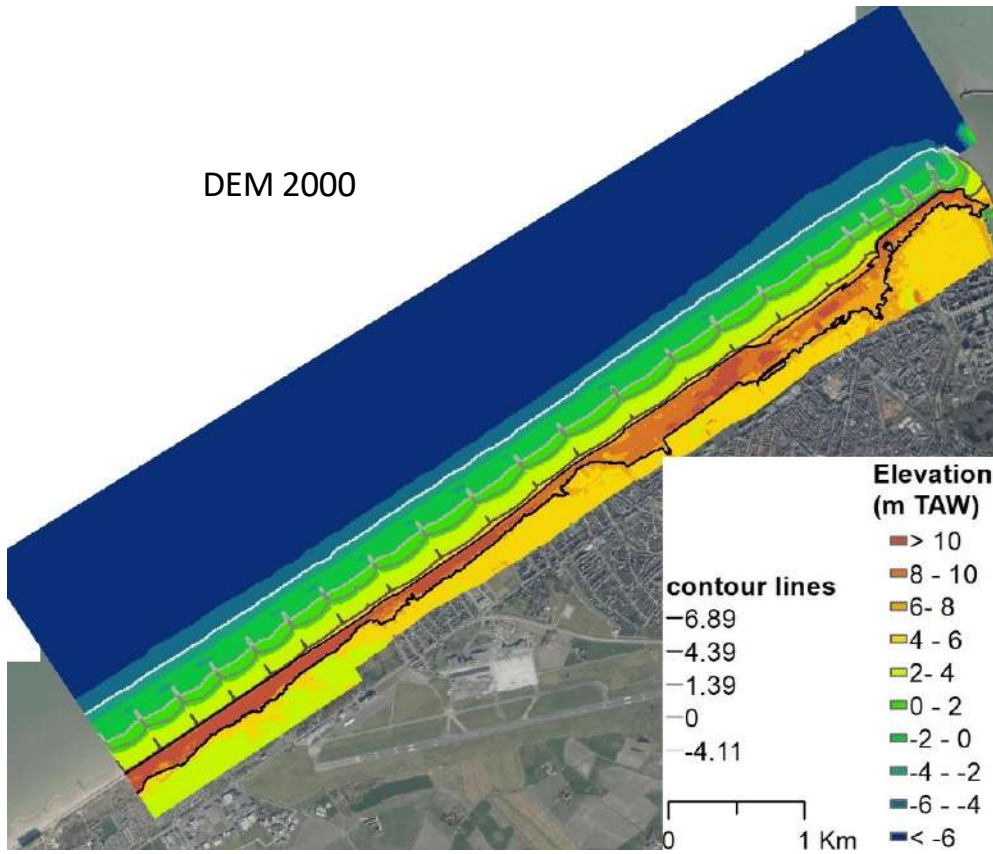
Majority of the volumes after 2013

Beach morphology influenced by works

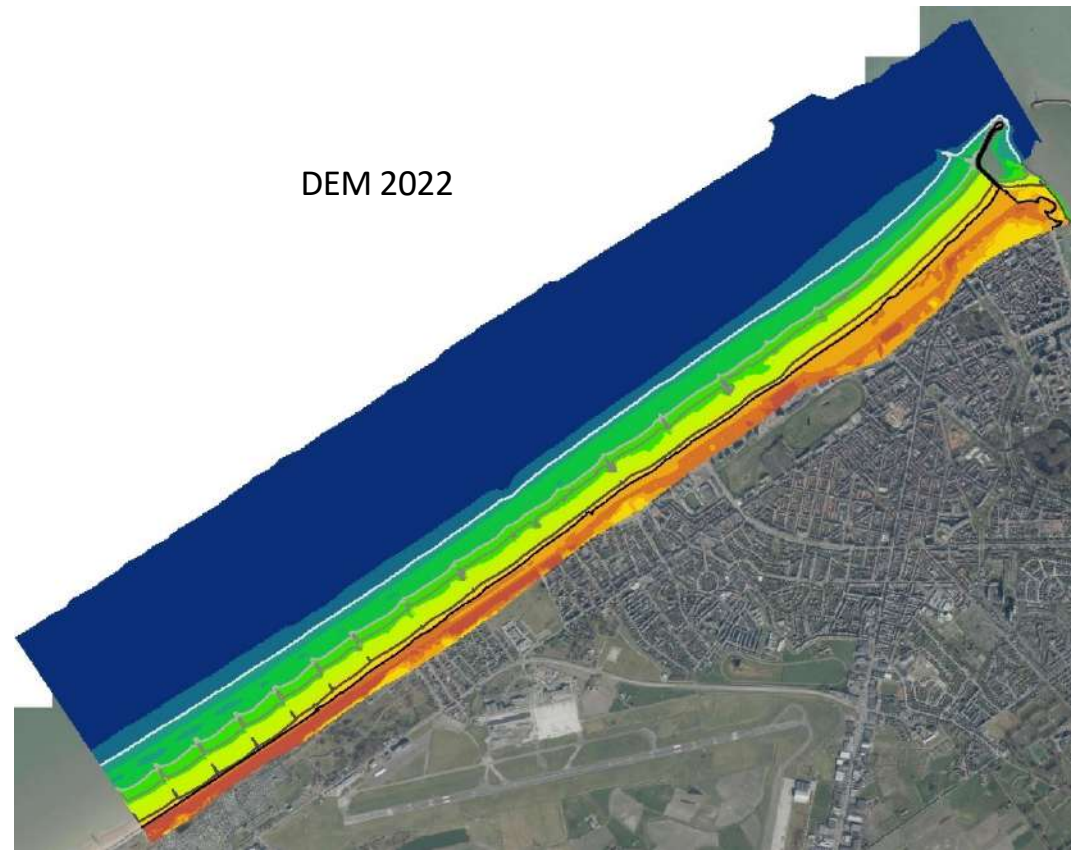


# Digital Elevation Models – combined topography and bathymetry

DEM 2000

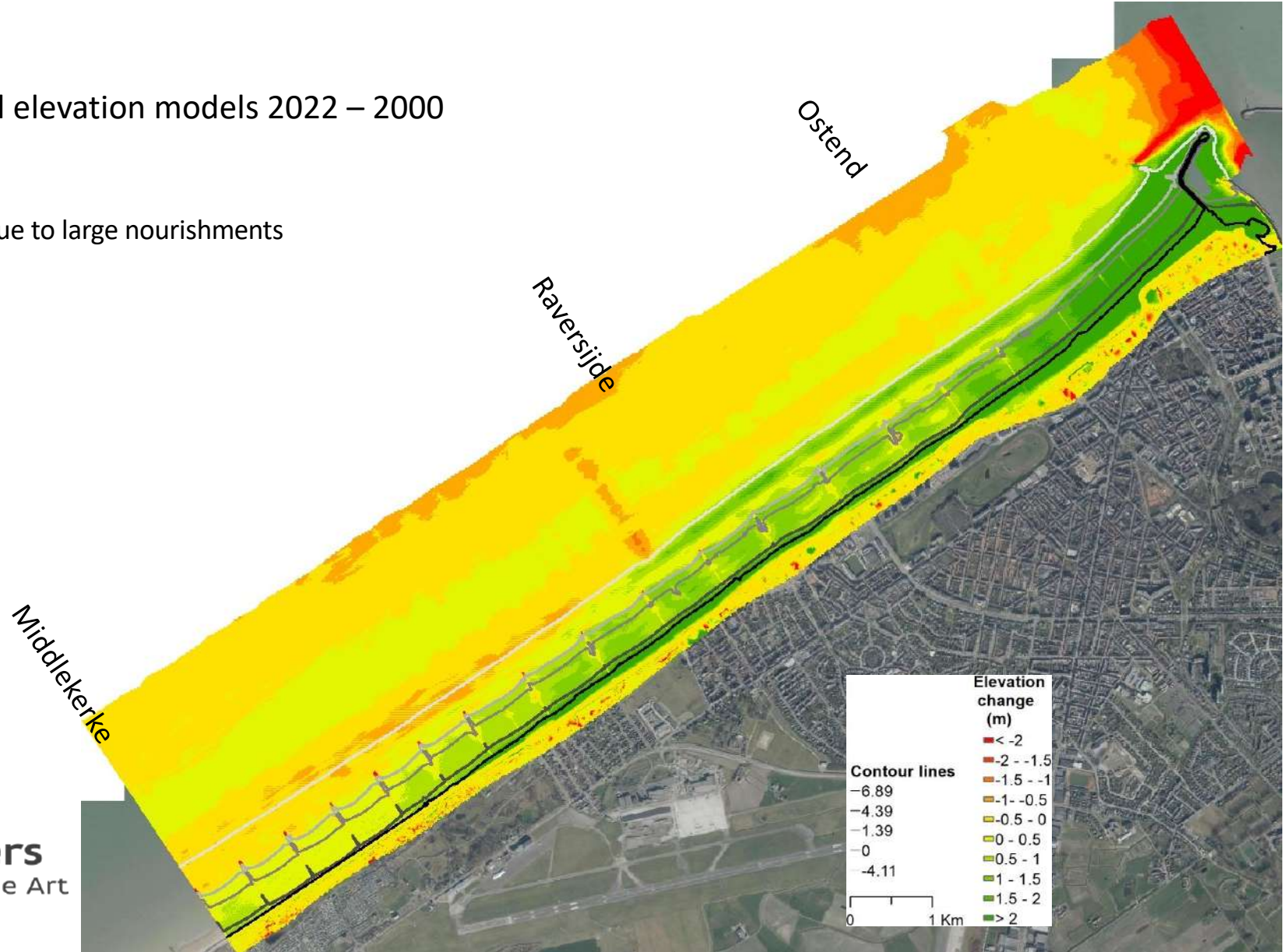


DEM 2022

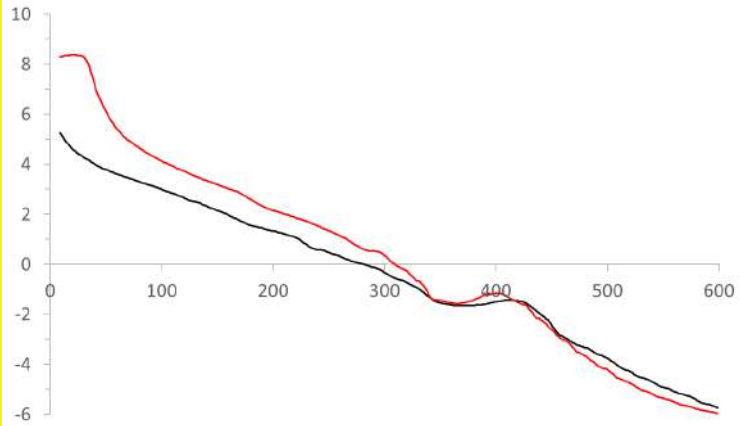


# Difference of digital elevation models 2022 – 2000

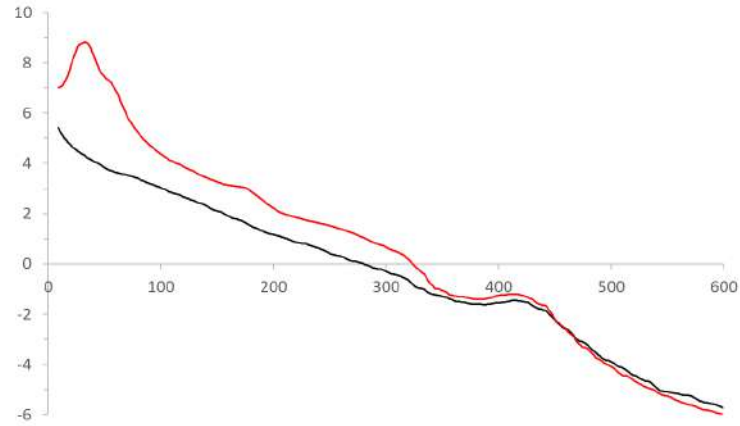
General accumulation due to large nourishments



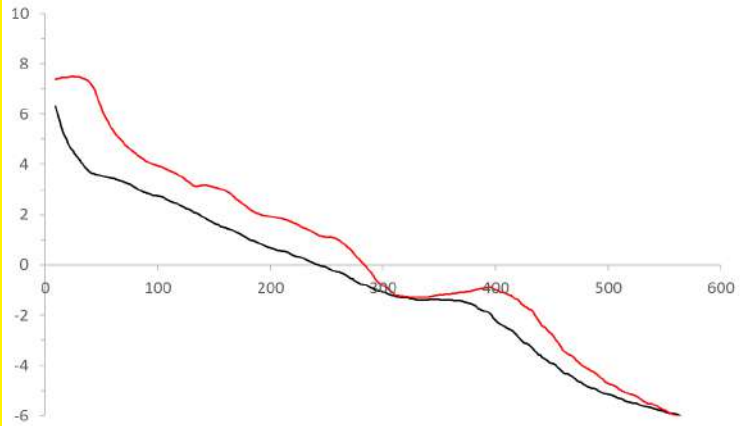
Profile 1



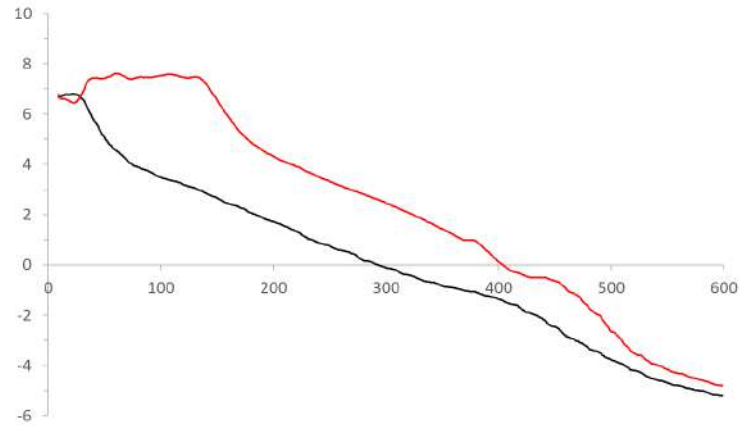
Profile 2



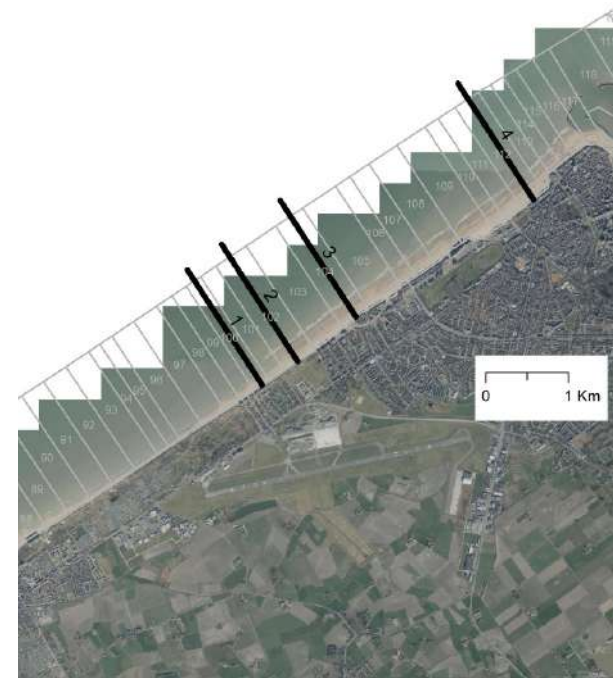
Profile 3



Profile 4



## Active beach profiles



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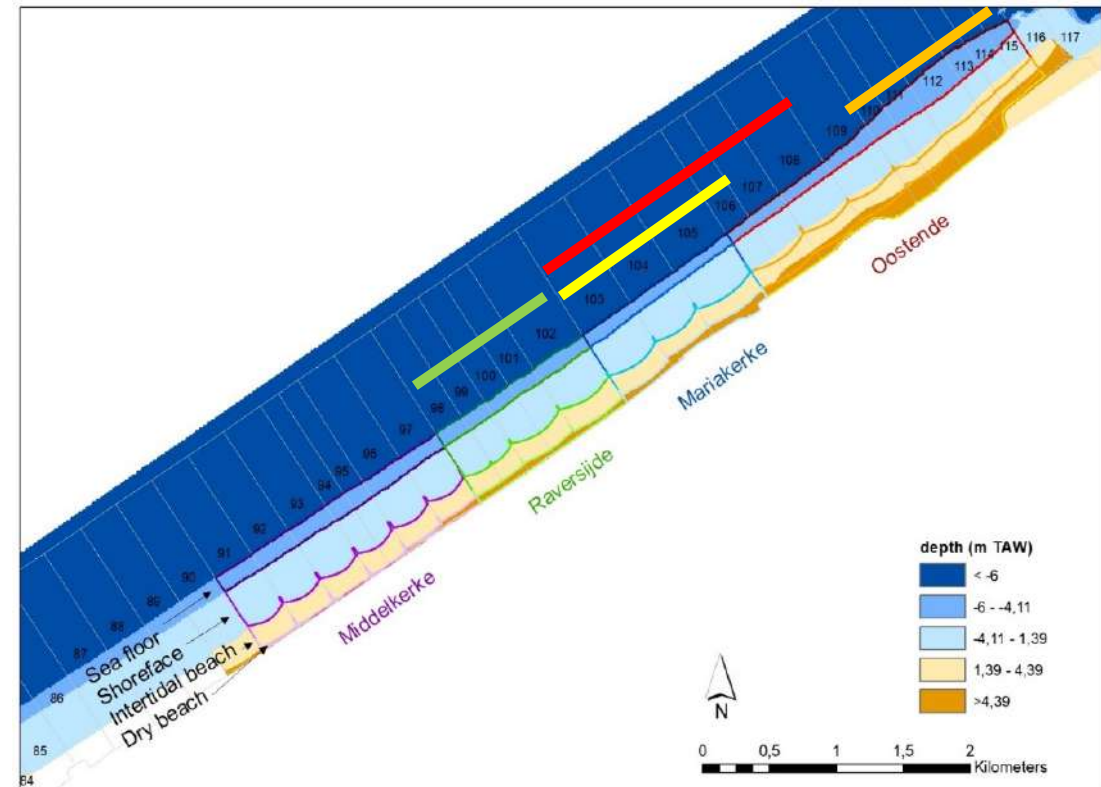
## Beach vs shoreface nourishment experiment 2013 - 2017

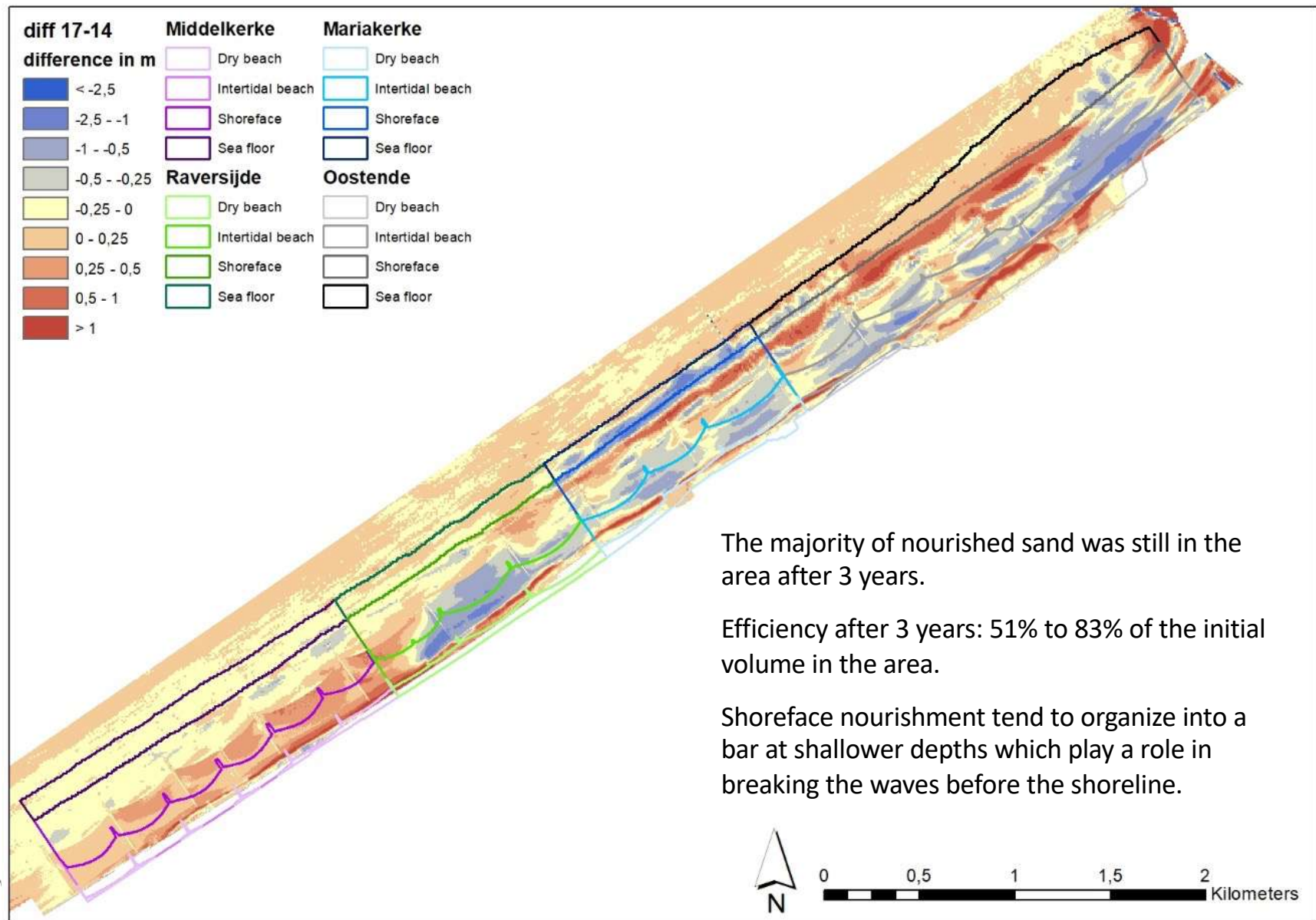
Investigate the efficiency of shoreface nourishment vs beach nourishments

2.2 mil m<sup>3</sup> deployed in 2013-2014

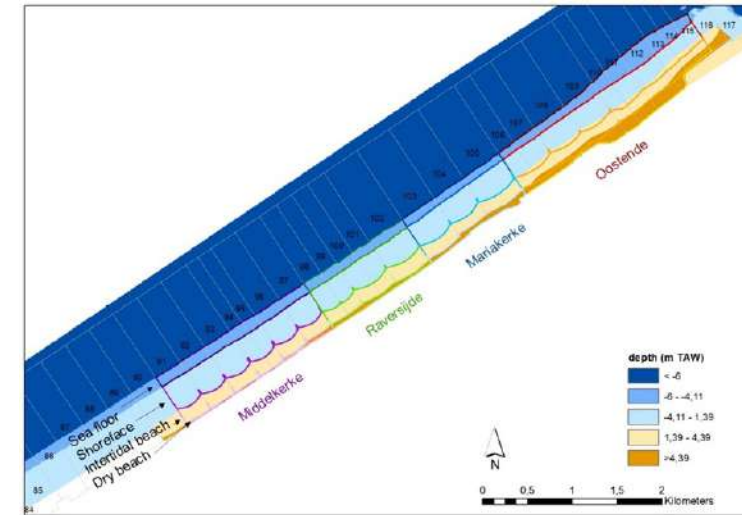
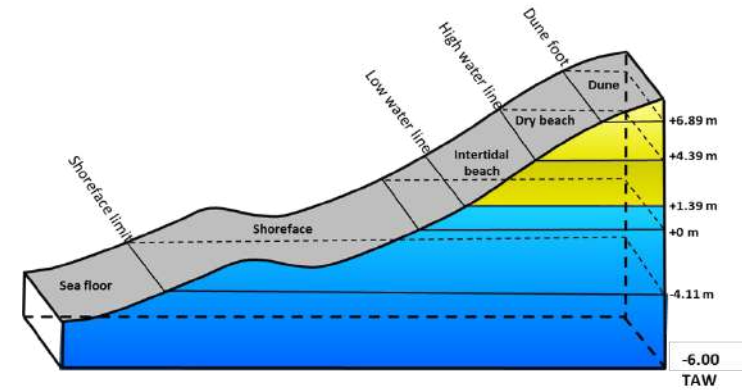
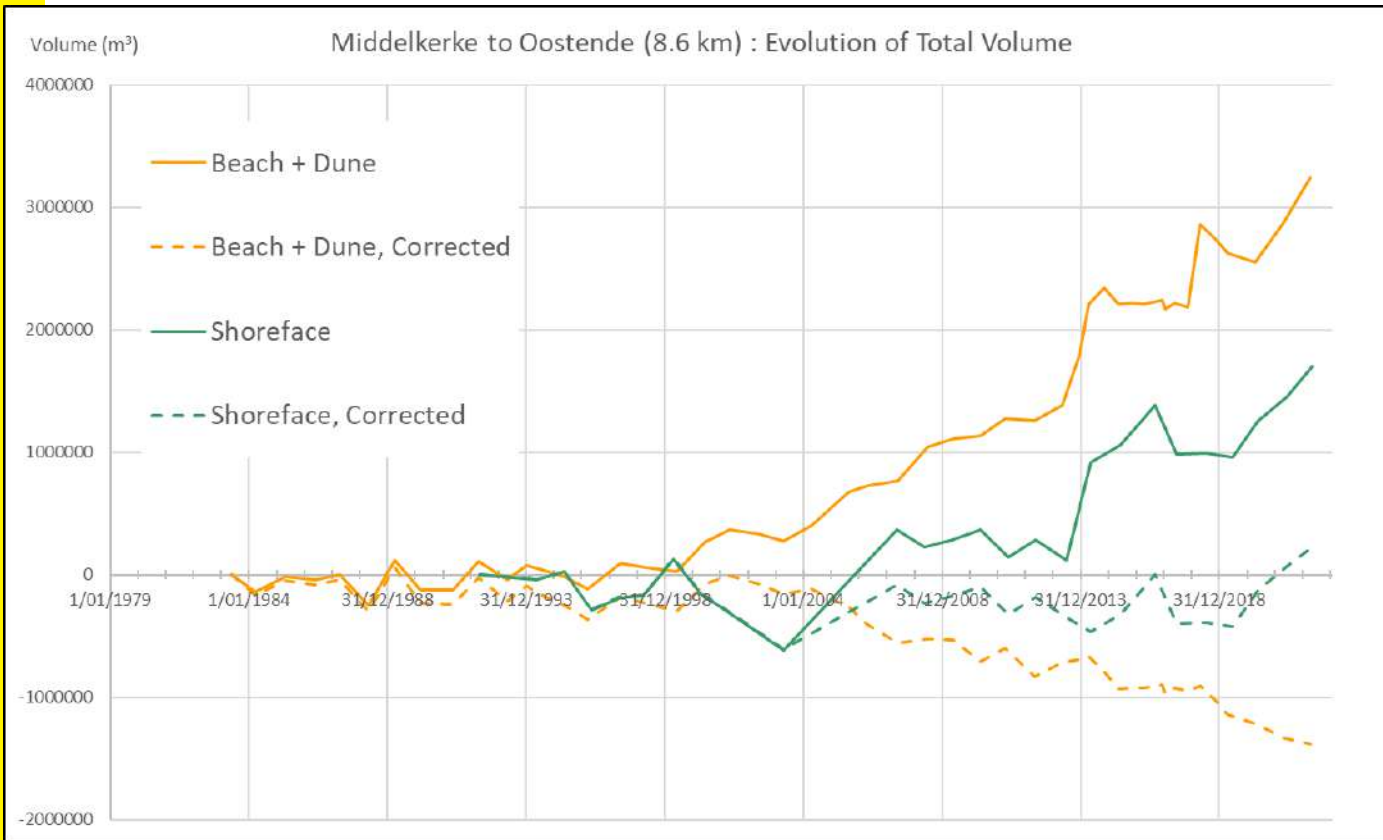
0.74 mil m<sup>3</sup> deployed in 2018

Date	Sections	Beach	Shoreface
Oct 2013 - Feb 2014	102-106	nourishment (681 200 m <sup>3</sup> )	
	109-115	nourishment (822 200 m <sup>3</sup> )	
Apr-May 2014	102-108		nourishment (303 800 m <sup>3</sup> )
Apr-Jun 2014	74-89*	nourishment (968 800 m <sup>3</sup> )	
Jun 2014	97-102	nourishment (190 900 m <sup>3</sup> )	
2015	82-87*	nourishment (118 900 m <sup>3</sup> )	
Feb-Mar 2018	105-109	nourishment (315 381 m <sup>3</sup> )	
Feb-Mar 2018	110-116	nourishment (424 631 m <sup>3</sup> )	





# Volume evolution last 40 years





# Nature based Solutions

Dune for dike project – pilot site for MANABAS EU Interreg project

Protect, sustainably manage and restore natural ecosystem that address societal challenges and help build coastal resilience.

Pilot study with artificial vegetated dune system implemented in front of an artificial dyke in 2021

Successful after 2 years providing an important coastal protection, a more natural appearance and greater ecological and socio-economic values.

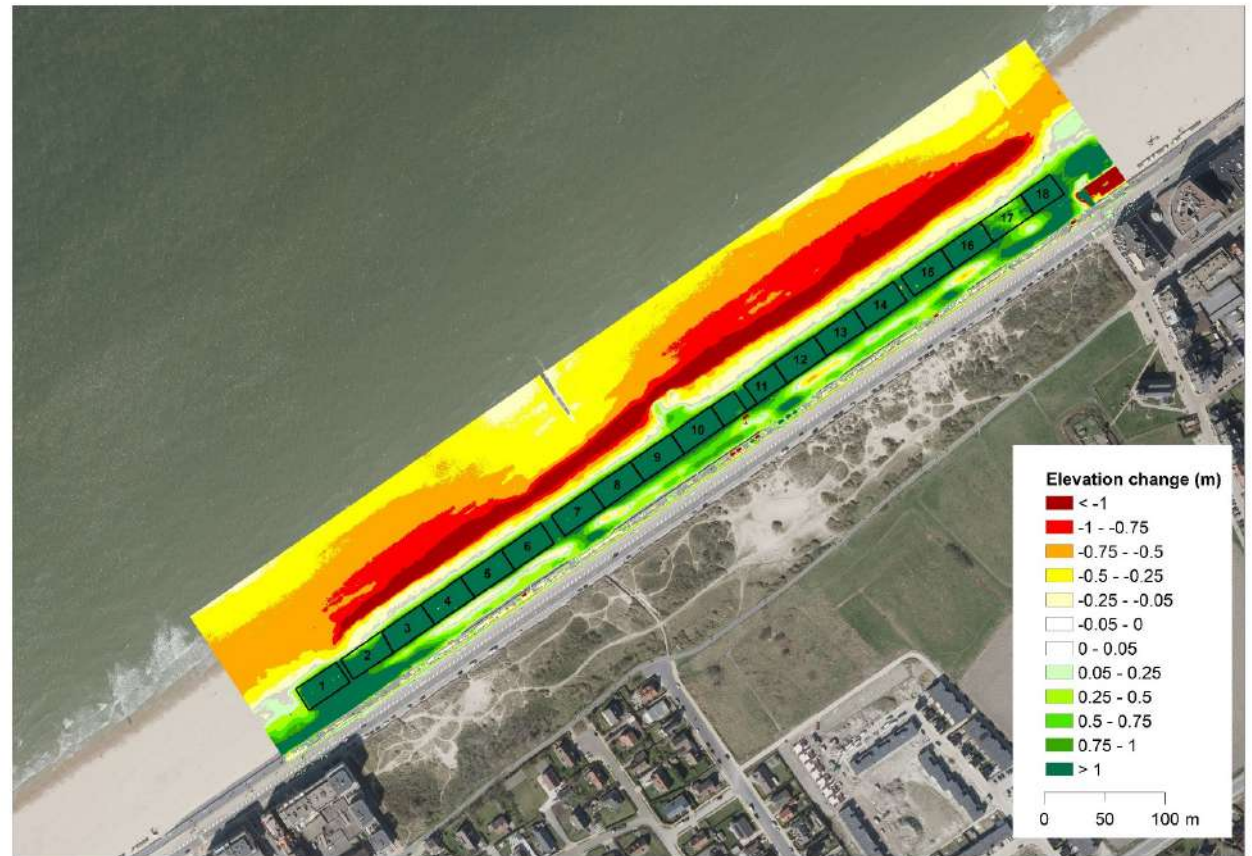


# Nature based Solutions – dune for dike Raversijde



2021 start project

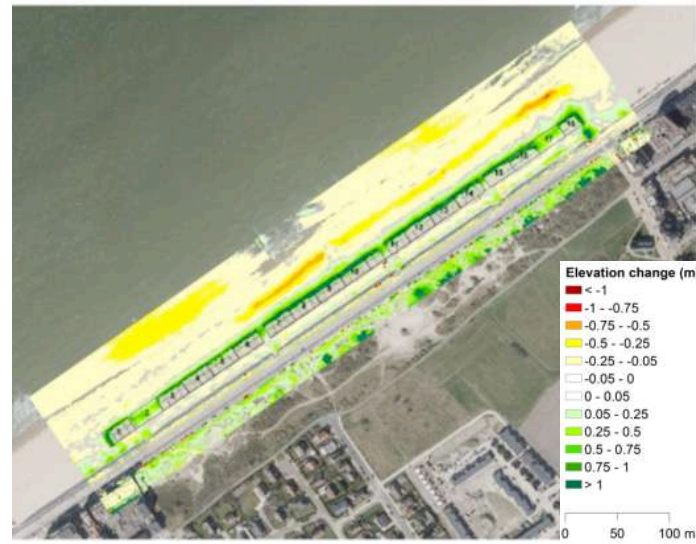
2023 two years after



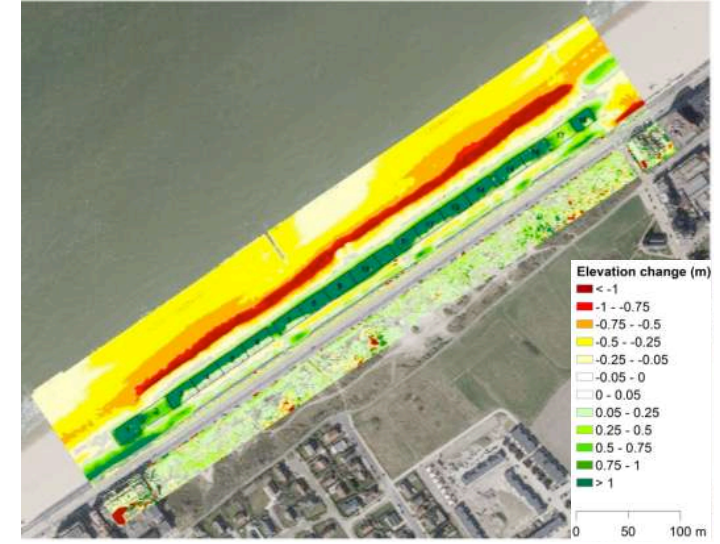
A) T0-T3: 2.8m



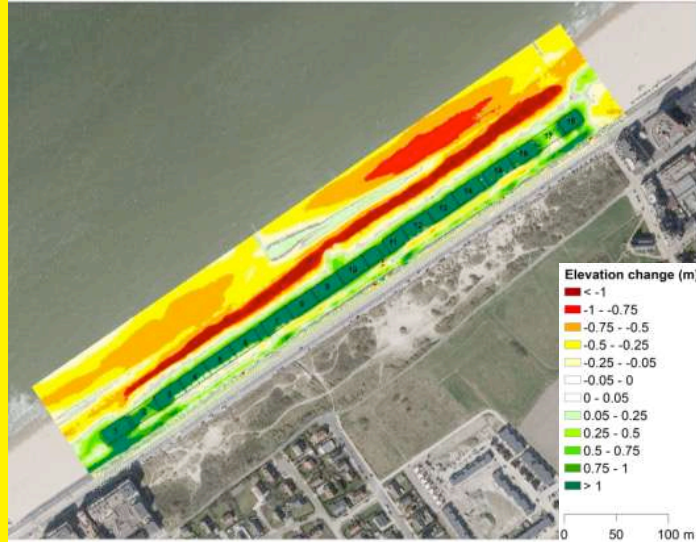
B) T0-T4: 5.3m



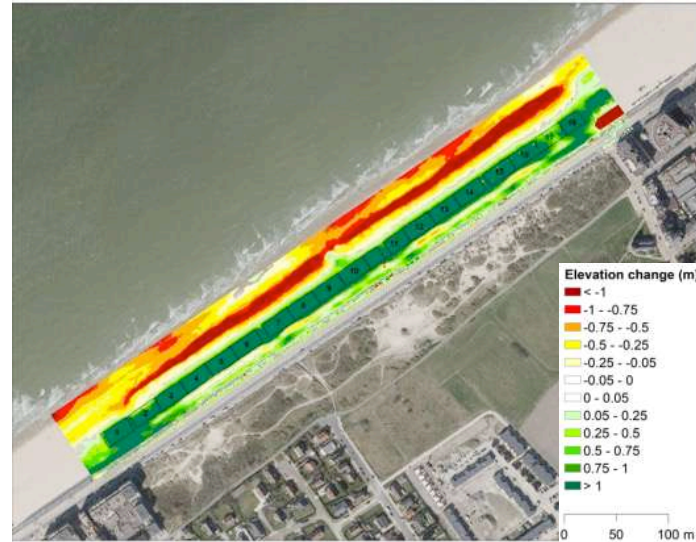
C) T0-T10: 11.7m



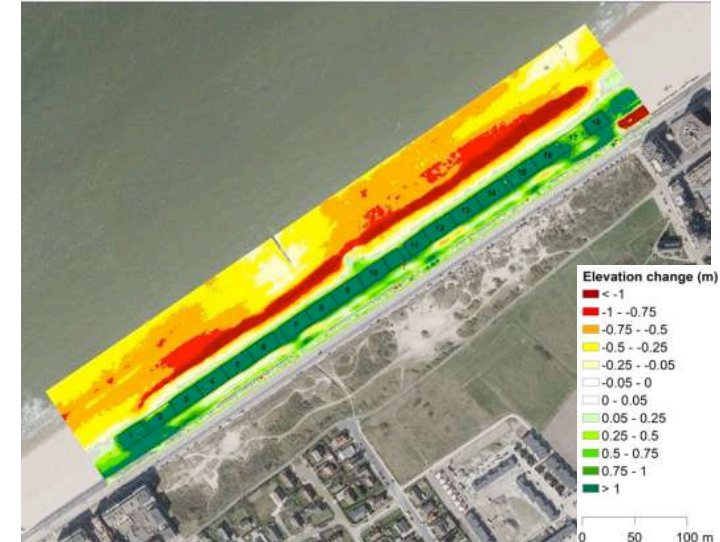
D) T0-T14: 1y5.4m

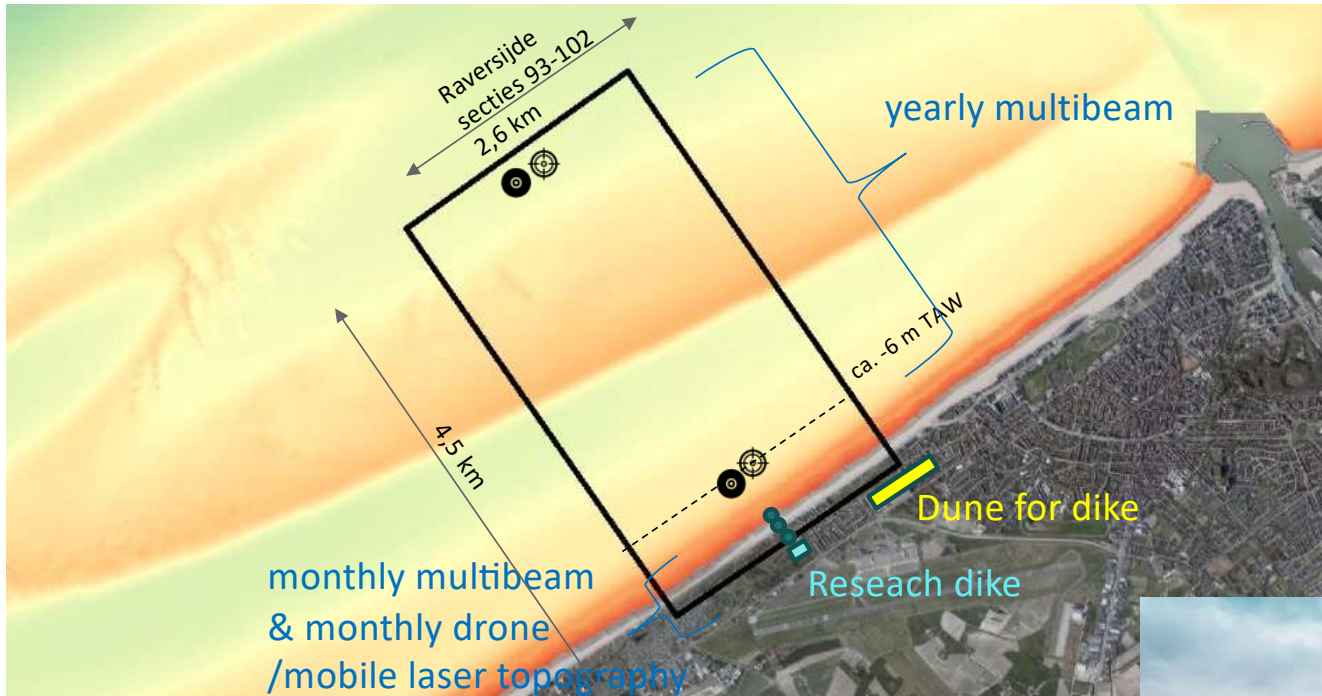


E) T0-T16: 1y9.8m



F) T0-T18: 1y11.3m





# LIVING LAB RAVERSIJDE

Research dike: overtopping measurements

- bottom frame with ADCP and pressure sensor
- wave bouy
- intertidal poles (current meter, pressure sensor, ASM bed level)



## Conclusions

Ostend coast is a management success, in only two decades it evolved from no beach at high tide to robust coast able not just to defend the city behind, but to provide ecological and social services.

The large volumes of nourished sand stayed in the active beach due to both natural setting (complex pattern of channels and throughs) and human interventions (harbor extension, maintenance).

The new situation comes with challenges, swimmers' safety, risk of sand bypassing into the navigational channel.

## Future developments

Dune for dike experiment is ongoing, but the support for dune growth ( e.g. grass plantation, wooden fences) will diminish. Applied for three other sites – NbS are growing at Belgian coast.

Living Lab Raversijde will provide valuable data on active beach evolution and vulnerability to extreme events.

