Assessment of the design and behaviour of nourishments in the North Sea Region: Towards A NSR Guideline for Nourishments

Coastal Dynamics Conference 2017, Helsingør - Denmark

Rinse Wilmink - Rijkswaterstaat - The Netherlands
Quirijn Lodder – Rijkswaterstaat – The Netherlands
Per Sørensen – Danish Coastal Authority - Denmark
EU Interreg Building with Nature

Aim: To make coasts, estuaries and catchments of the North Sea Region more adaptable and resilient to the effects of climate change.
Partners in Interreg NSR Building with Nature
Coastal Work Package - Resilient coastal laboratories

By using:
+ Using an existing evidence base
+ Share knowledge and coastal data
+ A shared assessment methodology

We assess:
+ the effectiveness of nourishments given local conditions

To come up with:
+ An NSR Guideline for nourishments
Belgium to Skagen (DK): Primarily sandy coastline.
Examples of morphological development of (shoreface) nourishments in the North Sea region

+ Netherlands
+ Denmark
+ (Germany)
Morphological behaviour, Zandvoort NL
Longshore Cross-shore 2002

Height
irt MSL

60

Longshore

65

70

75

Km

1.5

1

0.5

0

-0.5

-10
300m Cross Shore
100 - 300m Long Shore
Morphological behaviour, Eierland Texel, Netherlands
Cross-shore

Seabed level of the Texel shoreface at 1999

Longshore

29 km 1.5 1 0.5 0

1999
Seabed level of the Texel shoreface at 2000

Cross-shore

Longshore

21 km

2000
Cross-shore

Seabed level of the Texel shoreface at 2001

Longshore

29 km

2001
Cross-shore

Seabed level of the Texel shoreface at 2002

Longshore

29 km

2002
Cross-shore

Seabed level of the Texel shoreface at 2003

Longshore

Distance [m] NAP [m]

km 21 1.5 1 0.5 0 29 2003
Cross-shore

Seabed level of the Texel shoreface at 2006

Longshore

29 km 1.5 1 0.5 0

2006
Seabed level of the Texel shoreface at 2007

Cross-shore
Seabed level of the Texel shoreface at 2009

500 m Cross Shore
500 – 1000 m Long Shore

29
km
21
km
1.5
1
0.5
0

2009
Morphological behaviour, Camperduin, Netherlands
Cross-shore
Seabed level of the Noord-Holland shoreface at 2000

Longshore

33 km

30

23

1.5 1 0.5 0

Distance from RSP [m]

2000
Cross-shore
Seabed level of the Noord-Holland shoreface at 2001

Distance [m] RSP [m] km
-1500 -1250 -1000 -750 -500 -250 0 250 500
1.5 1 0.5 0

Longshore

2001
Cross-shore
Seabed level of the Noord-Holland shoreface at 2002

Longshore

km

1.5
1
0.5
0
-0.5
-1
-1.5

Distance from RSP [m]
Cross-shore
Seabed level of the Noord-Holland shoreface at 2003
Cross-shore
Seabed level of the Noord-Holland shoreface at 2004
Cross-shore Seabed level of the Noord-Holland shoreface at 2005

Longshore

30 33 km

1.5 1 0.5 0

2005
Cross-shore
Seabed level of the Noord-Holland shoreface at 2007

Longshore

km
33
30
1.5
1
0.5
0

2007
Cross-shore
Seabed level of the Noord-Holland shoreface at 2015
+ Blue circles, primarily Cross-Shore migration

+ Green circles, primarily Cross- and Long Shore migration
<table>
<thead>
<tr>
<th>Original cross-shore bar behaviour</th>
<th>Original alongshore or no bar behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
</tr>
<tr>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Diagram" /></td>
</tr>
<tr>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

- **Zone of decay**
- **No zone of decay**
Bar behaviour

Cross-shore
Alongshore
No bar migration

Zandvoort
Callantsoog
Noord-Texel
Morphological behaviour, Skodbjerge Denmark
Conclusion

+ Seemingly different morphological behaviour of nourishments
+ But is there an overall system?

 Probably due to:

+ Local Coastal Dynamics (forcing, coastal state, geology etc.)
+ Design of Nourishments
### General Nourishment Designs NSR

<table>
<thead>
<tr>
<th>Nourishment location w.r.t. erosion spot</th>
<th>Beach nourishment</th>
<th>Shoreface nourishment</th>
<th>Total volume (Mm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DCA (Denmark, central North Sea coast)</td>
<td>beach nourishment</td>
<td>seaward offshore bar volume of breaker bar</td>
<td>Erosion Trend * Lifespan</td>
</tr>
<tr>
<td>Erosion hotspot</td>
<td>± 150-200 m$^3$/m + 4m MSL Natural slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. LKN.SH (Germany)</td>
<td>Erosion hotspot or damage driven</td>
<td>seaward offshore bar volume of breaker bar</td>
<td>Erosion Trend * Lifespan. Max around 150 m$^3$/m</td>
</tr>
<tr>
<td>150 m$^3$/m Natural slope: 1/10 ± 1 - 1.5 Mm3 - 400 Mm3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. NLWKN (Germany)</td>
<td>Erosion hotspot &amp; Dune safety</td>
<td>None</td>
<td>Reference height and slope 0.4-0.6 Mm3</td>
</tr>
<tr>
<td>300-400 M3/m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. RWS (Netherlands)</td>
<td>Erosion hotspot</td>
<td>-5m MSL seaward offshore bar volume of breaker bar</td>
<td>Erosion Trend * Lifespan. Max around 300 m$^3$/m</td>
</tr>
<tr>
<td>150-250 m$^3$/m + 3-3.5m MSL slope 1/20 - 1/30, 200-250 Mm3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. MDK (Belgium)</td>
<td>Erosion hotspot</td>
<td>Only 1 Connecting to the beach</td>
<td>Erosion Trend * Lifespan</td>
</tr>
<tr>
<td>+ 4.67m MSL (storm level) With berm on seawall Slope: 1/25 till 1/35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. LST (Sweden)</td>
<td>Erosion hotspot</td>
<td>Not yet done</td>
<td>Erosion Trend * Lifespan</td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Co-analysis

Try to quantify and understand the observed behavioural differences

+ Volume developments
+ LWM, HWM, Dunefoot
+ Bar dynamics

Using the same tools for the whole region
Results up to now

+ Overview of current Nourishment Practice in North Sea Region
+ Data overview of available Bathymetrical, Hydrological and Meteo Data
+ Conceptual model for Dutch Shoreface nourishments
+ MorphAn coastal transects database BE-Skagen
## Outlook

### Work Package 3 Brief Gantt chart

<table>
<thead>
<tr>
<th>Product</th>
<th>Task</th>
<th>Description</th>
<th>Beneficiary</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>T1</td>
<td>Work plan WP 3</td>
<td>All</td>
<td>2016</td>
</tr>
<tr>
<td>P2</td>
<td></td>
<td>Comparison current practice and coastal characteristics</td>
<td>All</td>
<td>2017</td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td>Factsheet data</td>
<td>All</td>
<td>2018</td>
</tr>
<tr>
<td>P4</td>
<td>T6</td>
<td>Shared methodology co-analyses</td>
<td>All</td>
<td>2019</td>
</tr>
<tr>
<td>P5</td>
<td></td>
<td>National Analyses</td>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>T2</td>
<td></td>
<td>Dutch North Sea coast nourishments</td>
<td>RWS</td>
<td>Dec</td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td>Danish North Sea coast</td>
<td>DCA</td>
<td>Dec</td>
</tr>
<tr>
<td>T4</td>
<td></td>
<td>East Frisian Island</td>
<td>NLWKN</td>
<td>Dec</td>
</tr>
<tr>
<td>T5</td>
<td></td>
<td>Sylt shoreface nourishment</td>
<td>LKN.SH</td>
<td></td>
</tr>
<tr>
<td>T7</td>
<td></td>
<td>Swedish coastal retreat prevention (Grannian)</td>
<td>LS</td>
<td></td>
</tr>
<tr>
<td>P6</td>
<td>T6</td>
<td>Co-analysis of national analyses</td>
<td>MDK</td>
<td></td>
</tr>
<tr>
<td>P8</td>
<td>T10</td>
<td>Evidence base and guidance</td>
<td>All IHE CWSS</td>
<td>Dec</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finalization and preparation final event</td>
<td></td>
<td>Jun</td>
</tr>
</tbody>
</table>
Thank you for your attention

Rinse.Wilmink@rws.nl
Quirijn.Lodder@rws.nl
PSO@kyst.dk
Bar behaviour

Cross-shore

Alongshore

No bar migration

Zandvoort  Callantsoog  Noord-Texel
The image shows a cross-shore profile with a longshore component, indicating directional wave energy. The area is marked as North Sea Region Zandvoort, Netherlands (NL), and the data is from 2009. The scale shows distance in kilometers (km) with a scale range from 0 to 70 km, and the cross-shore profile indicates various contours possibly related to sediment transport or water depth, with a color gradient representing different values.
+ Blue circles, primarily Cross-Shore migration

+ Green circles, primarily Cross and Long Shore migration
### Original cross-shore bar behaviour

<table>
<thead>
<tr>
<th>Sea</th>
<th>Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### Zone of decay

- ![Diagram](#)
- ![Diagram](#)
- ![Diagram](#)

#### Original alongshore or no bar behaviour

<table>
<thead>
<tr>
<th>Sea</th>
<th>Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Diagram" /></td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>

#### No zone of decay

- ![Diagram](#)
<table>
<thead>
<tr>
<th>Project partner</th>
<th>Flood risk reduction goal</th>
<th>Policy goals (criteria)</th>
<th>Compensate erosion goal</th>
<th>NBS/BwN in policy</th>
<th>Nourishment type (Beach / shoreface)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DCA (Denmark, central North Sea coast)</td>
<td>Yes</td>
<td>( P(f) : \frac{1}{100}, ) exceptional ( P(f) : \frac{1}{1000} ) (Hold the line)</td>
<td>Yes*</td>
<td>Yes</td>
<td>Both</td>
</tr>
<tr>
<td>2. LKN.SH (Germany)</td>
<td>Yes</td>
<td>(Hold the line)</td>
<td>Partly</td>
<td>Yes</td>
<td>Both</td>
</tr>
<tr>
<td>3. NLWKN (Germany)</td>
<td>Yes</td>
<td>Protect other functions (Hold the line and dune safety)</td>
<td>No</td>
<td>Yes</td>
<td>Beach</td>
</tr>
<tr>
<td>4. RWS (Netherlands)</td>
<td>Yes</td>
<td>1) ( P(f) : \frac{1}{300} ) up to ( P(f) : \frac{1}{100,000} ) 2) Protect coastal functions (Hold the line)</td>
<td>Yes</td>
<td>Yes</td>
<td>Both</td>
</tr>
<tr>
<td>3. MDK (Belgium)</td>
<td>Yes</td>
<td>1) ( P(f) : \frac{1}{1000} ) 2) No fatal casualties allowed (Hold the line)</td>
<td>No</td>
<td>Yes</td>
<td>Beach and experimental shoreface</td>
</tr>
<tr>
<td>3. LST (Sweden)</td>
<td>No</td>
<td>Shoreline protection (Building prohibited within range coastal zone)</td>
<td>No*</td>
<td>No</td>
<td>Beach and experimental shoreface</td>
</tr>
</tbody>
</table>
Shoreface nourishment
## Design Parameters

<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
<th>Year</th>
<th>Position (km-km)</th>
<th>Volume (Mm³)</th>
<th>Volume per m (m³/m)</th>
<th>D50 Nourished (µm)</th>
<th>Placement depth (m i.r.t. MSL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>Zandvoort 1</td>
<td>2004</td>
<td>62.75 - 67.75</td>
<td>2.2</td>
<td>440</td>
<td>250 – 300</td>
<td>-4</td>
</tr>
<tr>
<td>NL</td>
<td>Bloemendaal</td>
<td>2008</td>
<td>61 – 63</td>
<td>1.0</td>
<td>500</td>
<td>250 – 300</td>
<td>-5</td>
</tr>
<tr>
<td>NL</td>
<td>Zandvoort 2</td>
<td>2008</td>
<td>67.75 - 70.25</td>
<td>0.5</td>
<td>200</td>
<td>250 – 300</td>
<td>-5</td>
</tr>
<tr>
<td>DK</td>
<td>Sdr. Holmsland Tange</td>
<td>2010</td>
<td>11.6 - 21.0</td>
<td>7.7</td>
<td>57</td>
<td>300 – 400</td>
<td>-5</td>
</tr>
<tr>
<td>Dk</td>
<td>Skodbjerge North</td>
<td>2011</td>
<td>17.2 - 18.0</td>
<td>0.3</td>
<td>400</td>
<td>300 – 400</td>
<td>-5</td>
</tr>
<tr>
<td>DK</td>
<td>Skodbjerge South</td>
<td>2011</td>
<td>13.8 - 14.6</td>
<td>0.3</td>
<td>400</td>
<td>300 - 400</td>
<td>-5</td>
</tr>
</tbody>
</table>