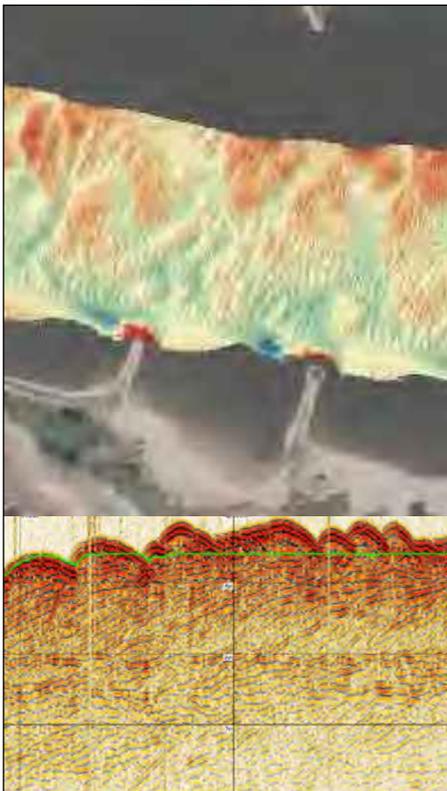


Proceedings of the 10th Workshop “Seabed Acoustics”, Presentation P09:

Dune preservation in the River Waal, Netherlands, using high-resolution sub-bottom profiling and multibeam echo sounding

Thaiënne van Dijk
Deltares, The Netherlands



10th November 2022

Dune preservation in the River Waal, NLds, using high-resolution sub-bottom profiling and multibeam echo sounding

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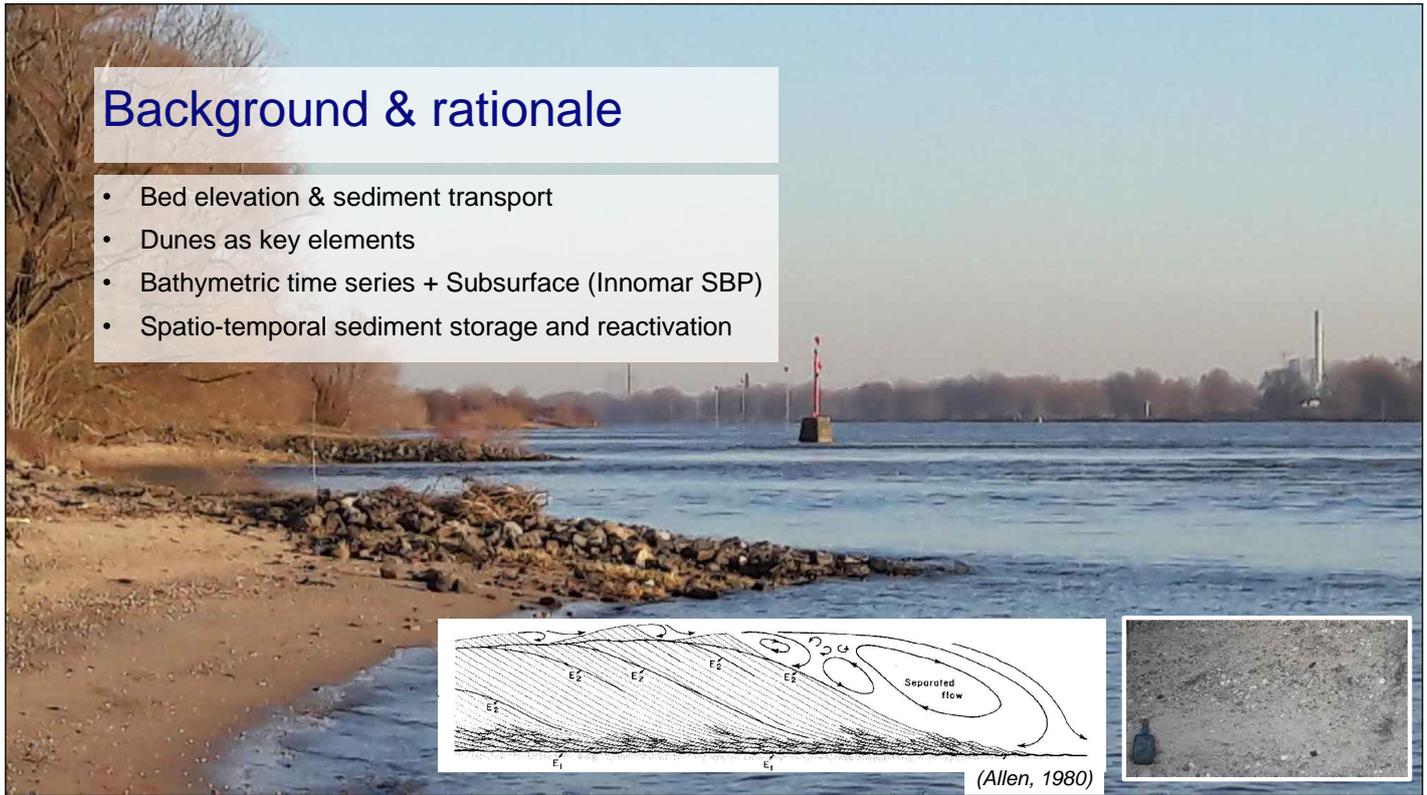
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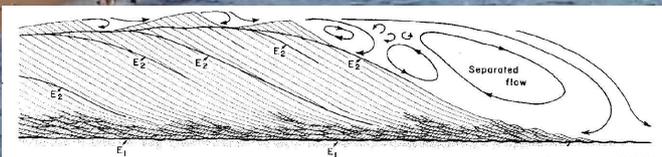


Rijkswaterstaat

Background & rationale

- Bed elevation & sediment transport
- Dunes as key elements
- Bathymetric time series + Subsurface (Innomar SBP)
- Spatio-temporal sediment storage and reactivation

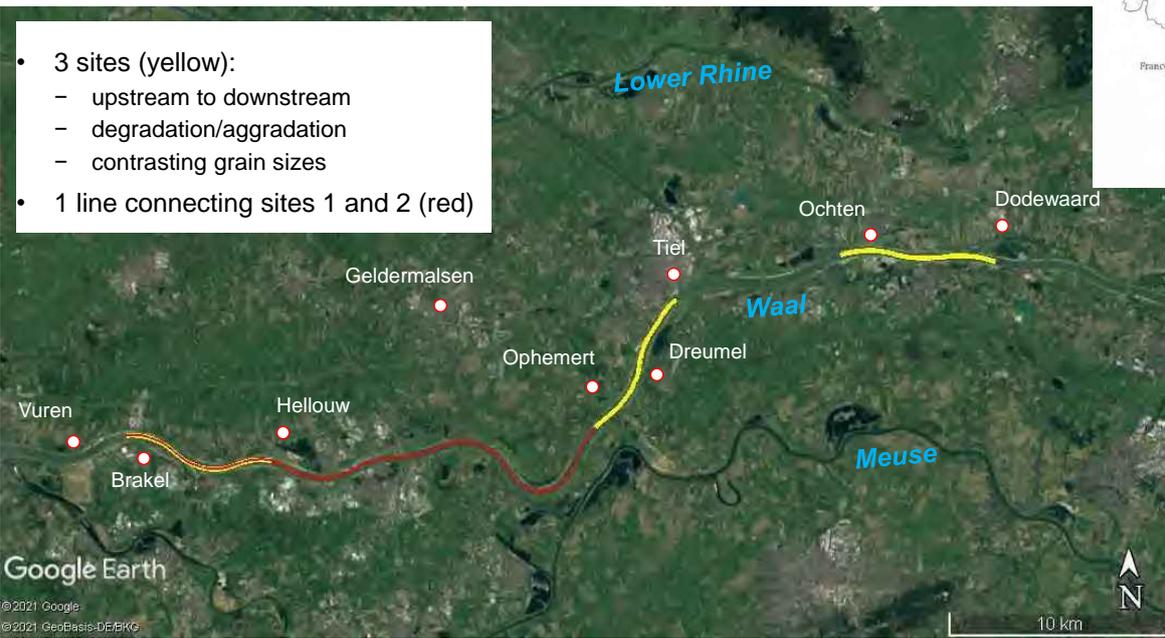





(Allen, 1980)

River Waal & Survey areas

- 3 sites (yellow):
 - upstream to downstream
 - degradation/aggradation
 - contrasting grain sizes
- 1 line connecting sites 1 and 2 (red)



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10 km

Seabed Acoustics 2022 - Innomar

3

Surveys: MBES bathy & bs, SBP (PES) & cores

- Per Area:
 - 4 survey lines, 7 km long
 - sailed upstream, max. 5 km/hr
 - **Simultaneous recordings of high-resolution MBES (bathy +BS) + SBP (PES); vibrocores**

- Repeat surveys, 'exact' overlap:
 - S1, S1R (area 1): 4 days after S1
 - S2 (all areas): 3 weeks after S1

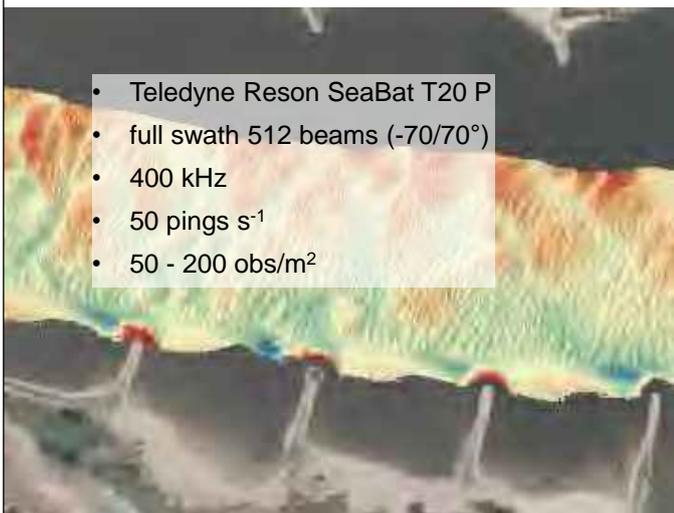
- MBES bathy time series (RWS):
 - 2-weekly MBES (2005 – present)
 - Bi-annual MBES (1999 – 2011)

- 18 Vibrocores

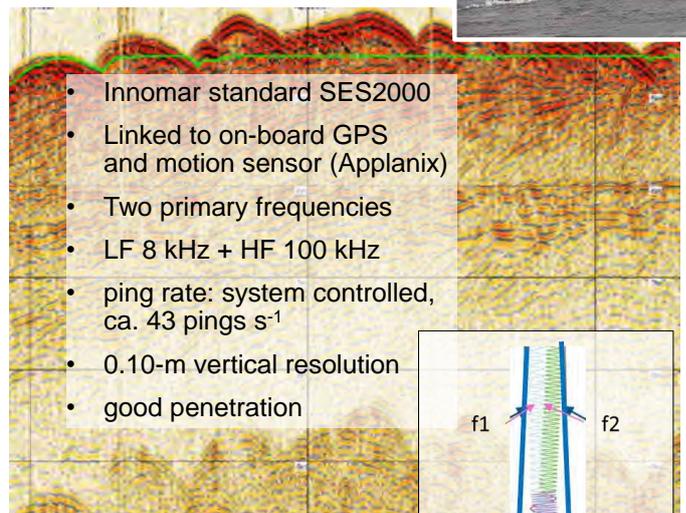
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MBES & PES, simultaneously

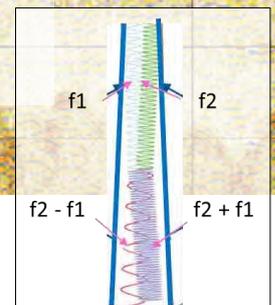
Van den Herik's Sprinter, equipped with RTK, GPS and motion sensor.



- Teledyne Reson SeaBat T20 P
- full swath 512 beams (-70/70°)
- 400 kHz
- 50 pings s⁻¹
- 50 - 200 obs/m²



- Innomar standard SES2000
- Linked to on-board GPS and motion sensor (Applanix)
- Two primary frequencies
- LF 8 kHz + HF 100 kHz
- ping rate: system controlled, ca. 43 pings s⁻¹
- 0.10-m vertical resolution
- good penetration



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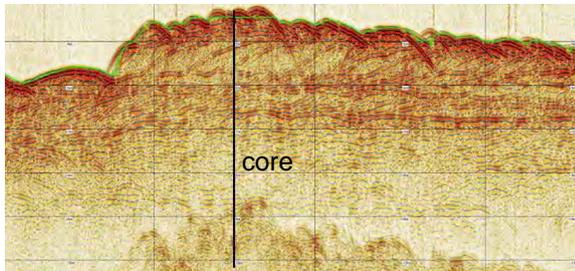


Rijkswaterstaat

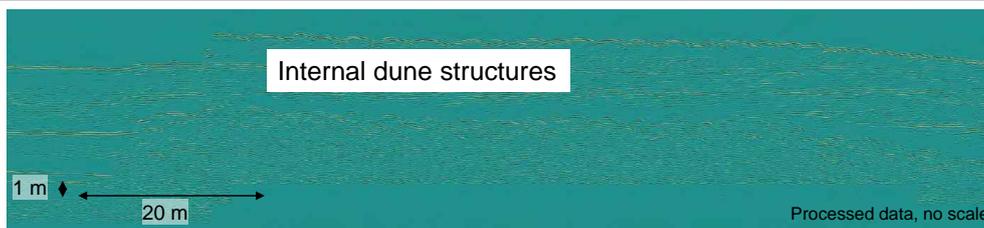
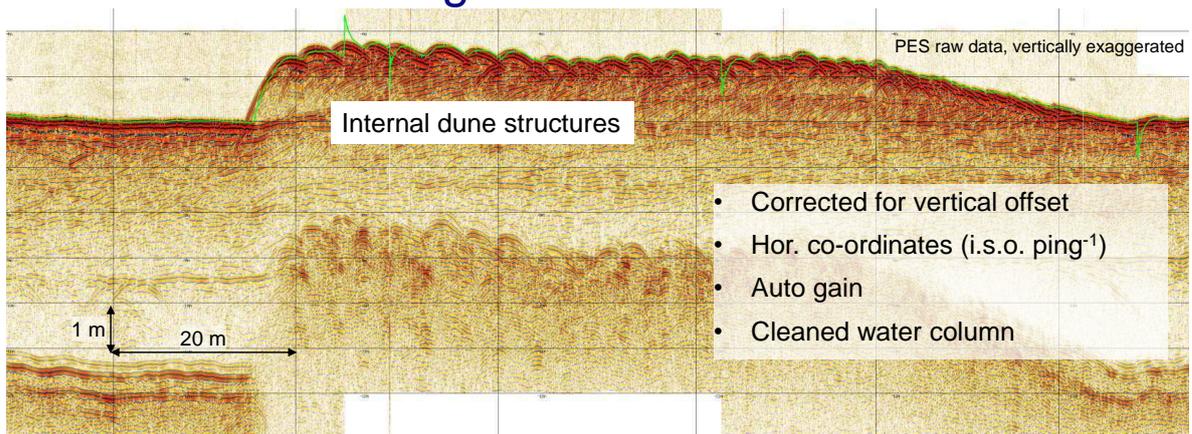
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Vibracores

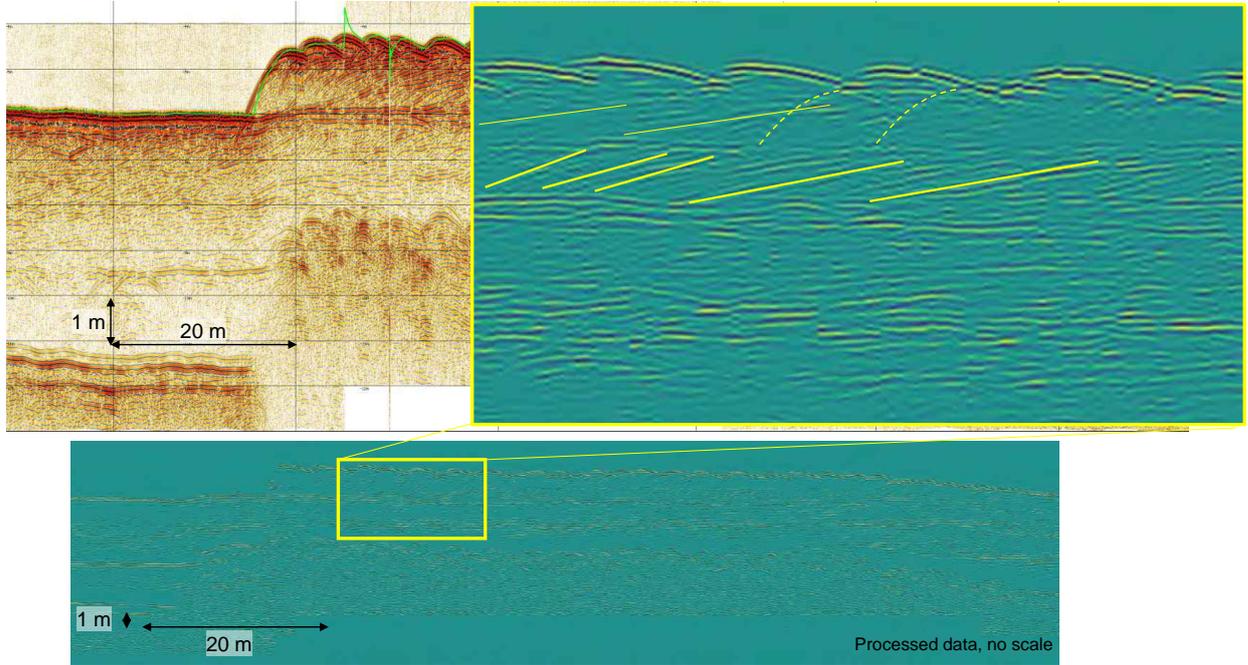
- 18 vibracores in total (3 areas)
- Core location based on PES-data Survey 1, adjusted to current morpho/structures of Survey 2 (same day),
- Acquired during Survey 2, one day after MBES/PES per area small vibracorer (Marine Sampling Holland) aboard work vessel (Europa)
- Penetration 5.9 m
- Recovery 3.9 – 5.5 m (rodding)
- Core descriptions
- Lacquer peels; subsampling grain size & **plastics** (U Birm'ham, UK)



PES Data Processing



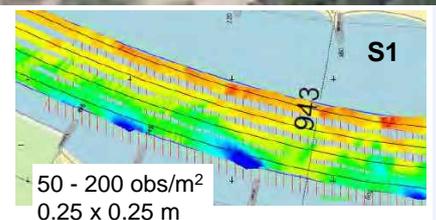
PES Data Processing



Preliminary Results: dune morphology

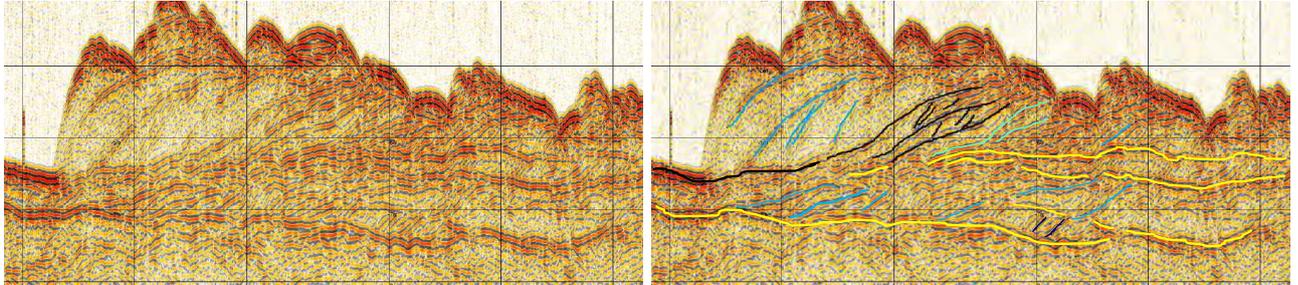


- Large dunes with superimposed small dunes



Preliminary Results: dune morphology and structures

Raw data, to be interpreted from processed data



- Large dunes with superimposed small dunes (bathymetry)
- Dune foresets; lee slopes with structure of smaller dunes migrating down slope
- Reactivation surfaces & horizontal erosional reflections at base of dunes
- Deeper structures below active dunes

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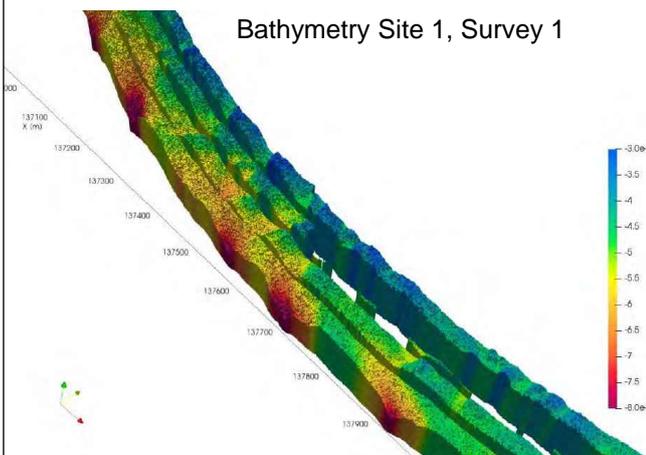
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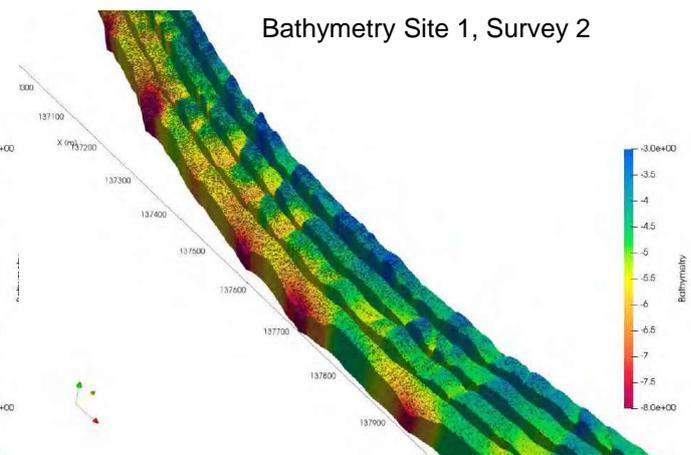
Rijkswaterstaat

Preliminary Results: time series

Bathymetry Site 1, Survey 1



Bathymetry Site 1, Survey 2



- Dune migration and changes in dune shape

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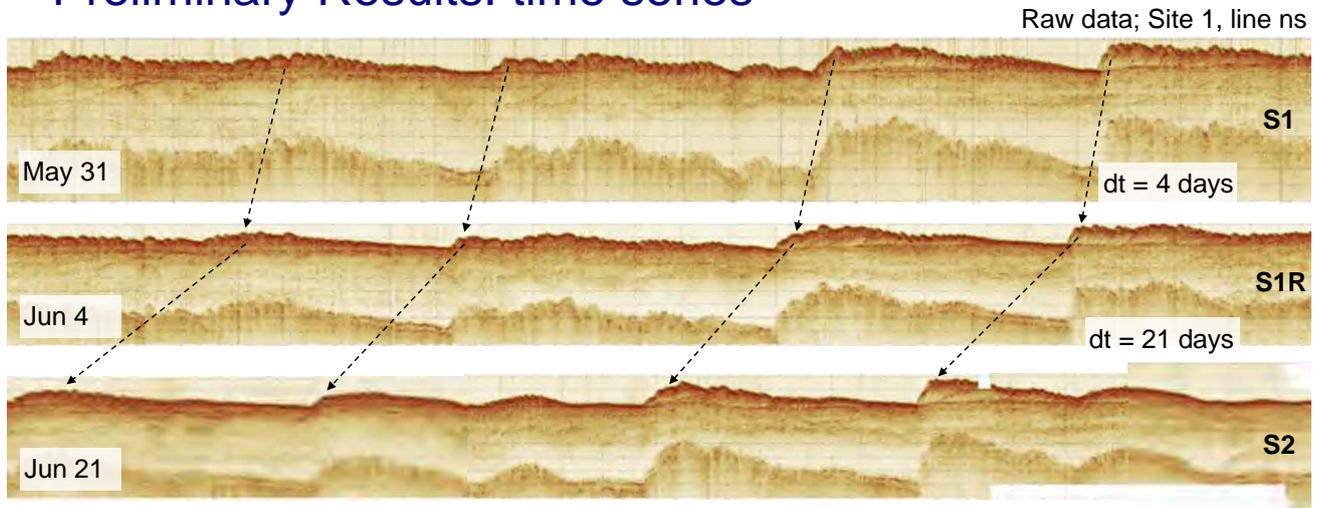


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Preliminary Results: time series



- Dune migration and changes in dune shape (bathymetry)
- Subsurface structures preserved or eroded by dune migration

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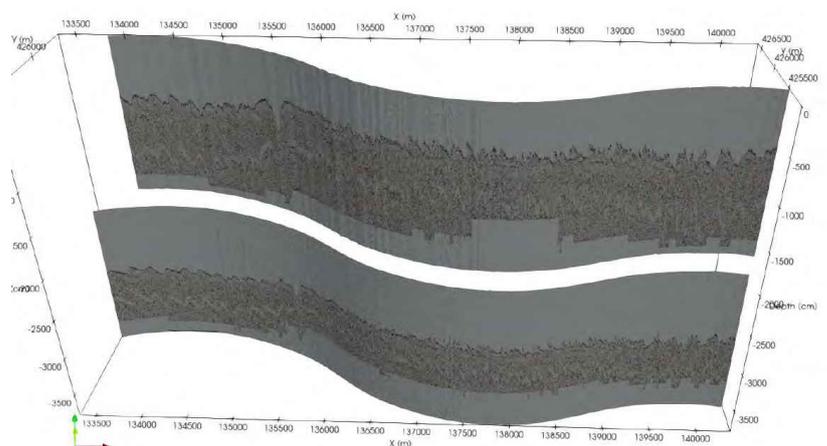


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Preliminary Results: time series

Georeferenced, 3D image of processed PES data, Site 1, Line N:

Note here: Surveys 1+2 (over time)



- Dune migration and changes in dune shape (bathymetry)
- Reconstruction of dune preservation in the subsurface, using 2-weekly bathymetric time series

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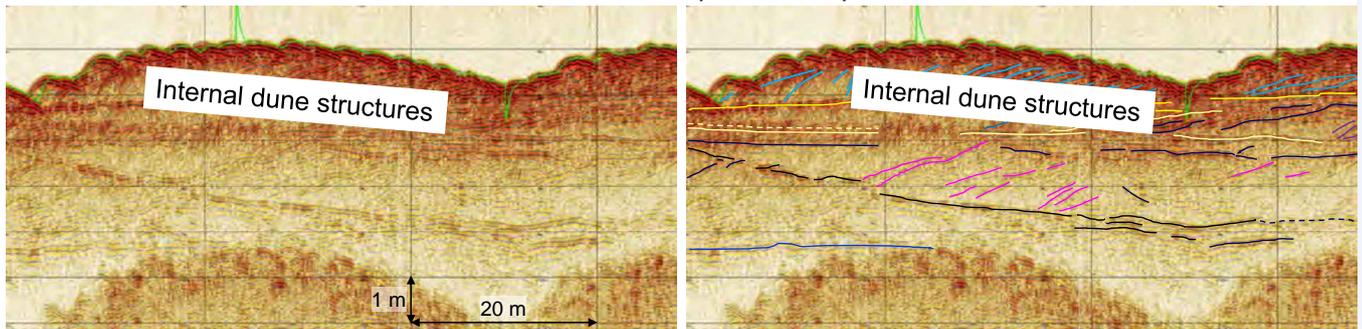


Rijkswaterstaat

Preliminary Results: around core 10

- Area 2, Survey 2 (22 June 2021), line ns

Raw data, to be interpreted from processed data



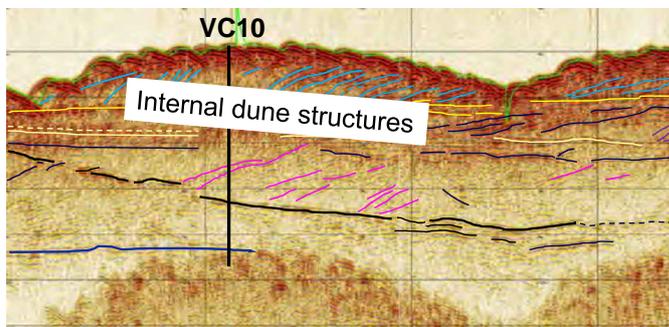
PES raw image (waylines: hor: 20 m; vert. 1 m)

- Large dunes with superimposed small dunes
- Lee sides
- Horizontal reflectors
- Deeper subsurface

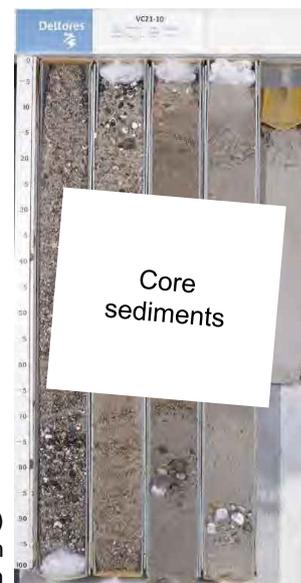
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Preliminary Results: around core 10

- Area 2, Survey 2 (22 June 2021), line ns; VC10



PES raw image (waylines: Hor: 20 m; Vert. 1 m)

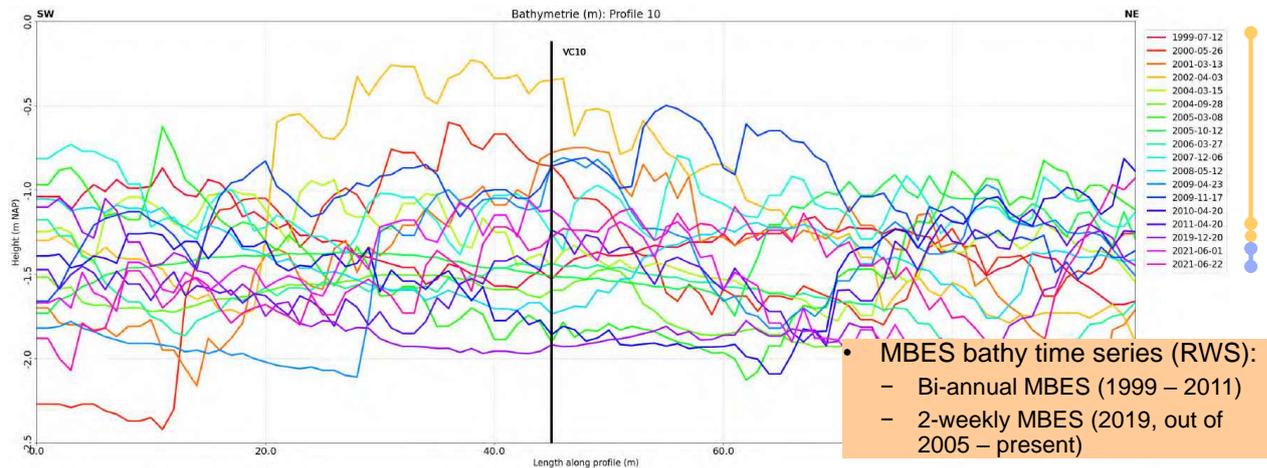


VC10 (23 June 2021)
Penetration 5.90 m
Recovery 4.75 m

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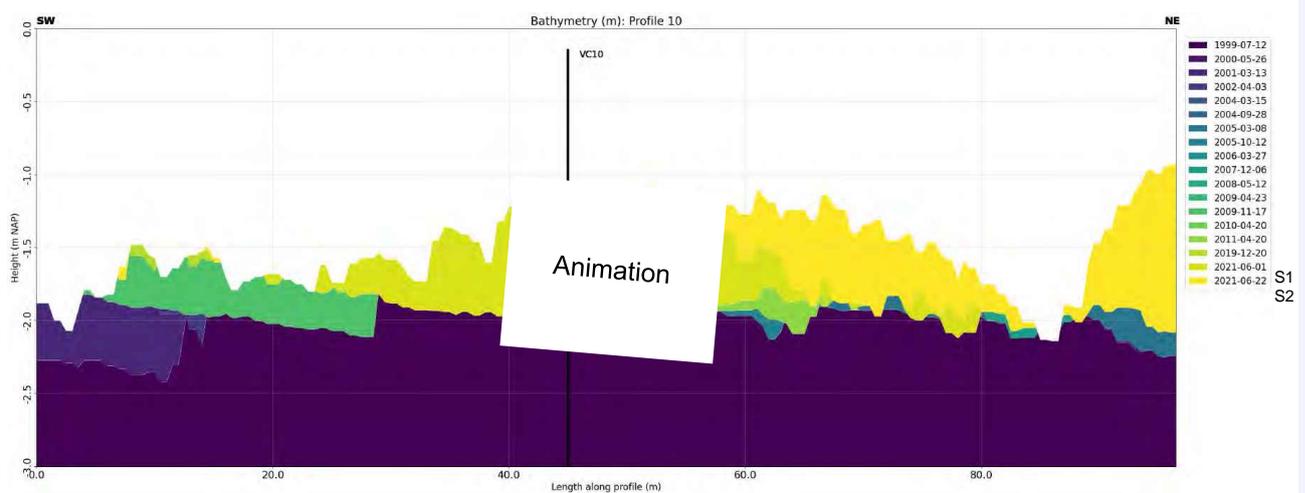
Preliminary Results: bathy time series around core 10

- all in same surface level range



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Preliminary Results: sediment preservation

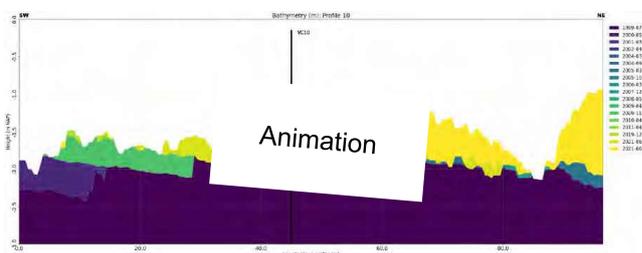


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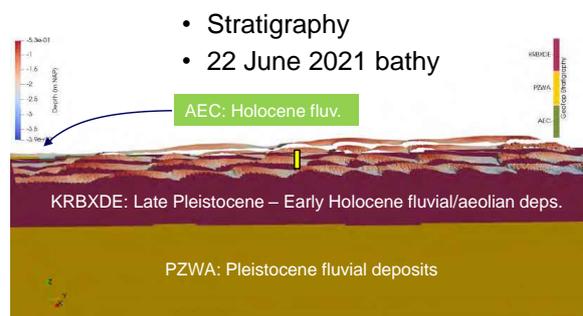
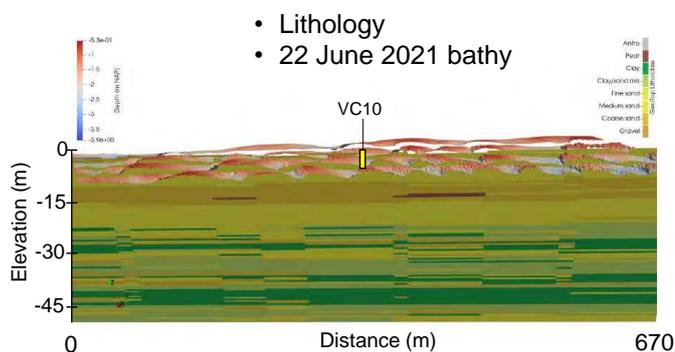
- In part degrading bed
- High temporal resolution of time series is crucial for interpretation

Stratigraphy

- Active dunes on pre-1999 surface
- Directly on Late Pleistocene to Early Holocene deposits

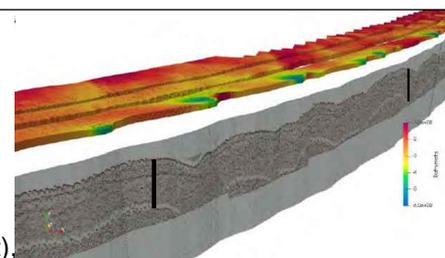


GeoTop Geological Model, TNO – Geological Survey of the Netherlands ([Subsurface models | DINOloket](#))



Future prospects

- Couple PES data to bathymetry and cores
 - (i) 2-weekly and bathymetry over the past 16 years (2005 - present)
 - (ii) bi-annual MBES time series (1999 - 2011)
 - (iii) older bathymetry (SBES, historical)
- Combination of high-resolution MBES + PES in time series:
 - **Dated** sedimentary structures with 2-weekly bathymetry,
 - Preservation of structures: previously in flume, now in **field record**
 - Link to **depositional events**

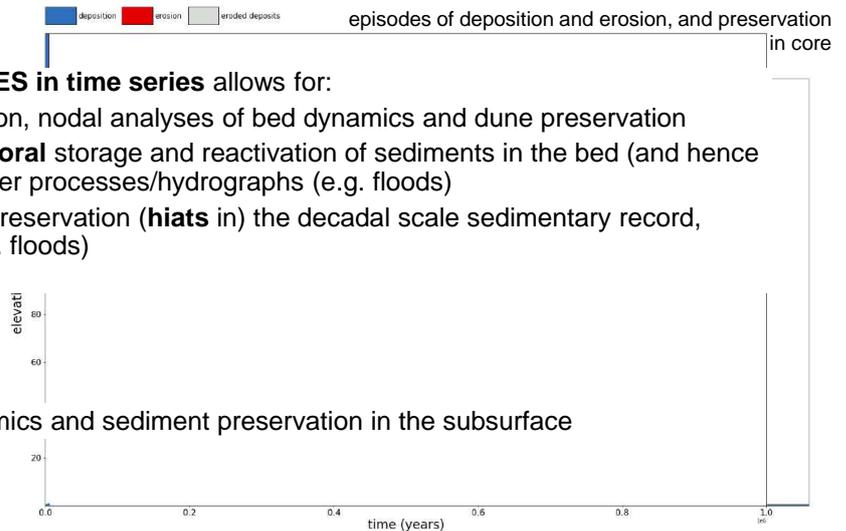


Future prospects

- **Unique 3D data set PES & MBES in time series** allows for:
 - High spatio-temporal resolution, nodal analyses of bed dynamics and dune preservation
 - Quantification of spatio-**temporal** storage and reactivation of sediments in the bed (and hence sediment fluxes), linked to river processes/hydrographs (e.g. floods)
 - Reconstruction of sediment preservation (**hiats** in) the decadal scale sedimentary record, linked to river processes (e.g. floods)

In 2D!

- 3D understanding of dune dynamics and sediment preservation in the subsurface



Elevation vs. time plot; animation by Zoltán Sylvester (2021, on Twitter <https://twitter.com/zzsylvester/status/1366854023773646856>) of Barrell's (1917) classical diagram.

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Acknowledgements & Feedback

- Funded by TKI programme of the Netherlands Enterprise Agency (RVO; Grant DEL107)
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- Others in the project: Erik Roos and Bram van der Kooij (Van den Herik).
- Poles and flange available from Delft University of Technology.
- Subcontractors:



Marine Sampling Holland (MSH), Netherlands
(vibrocoring, permits)



Dive- and Salvation company Europa, Netherlands
(work vessel, permits)



Innomar Technology GmbH, Germany
(PES hardware & software, support surveys & data interpretation)

We'd love your feedback! Thaienne.vanDijk@Deltares.nl

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Rijkswaterstaat

Backscatter-in-Flume project (BSiF)

- Comprehensive reference measurements in the **Delta Flume** (291 m long, 5 m wide, 9.5 m deep)



Backscatter-in-Flume project (BSiF)

- for building a reference data base (model) of angle- and frequency dependency for both bottom backscatter and in-water sediment plumes
 - 10 compartments with different sediment types
 - Effects of extra scatterers (shell/gravel/sea grass), bed roughness, layering, etc.
 - Series of sediment plumes of different grain sizes and concentrations
- Feasibility test proved that these measurements are feasible in the Delta Flume
- EU LIFE proposal; in search for co-funding

