Short-term quantitative analysis of submarine bedform movement in the Sylt Outer Reef, North Sea

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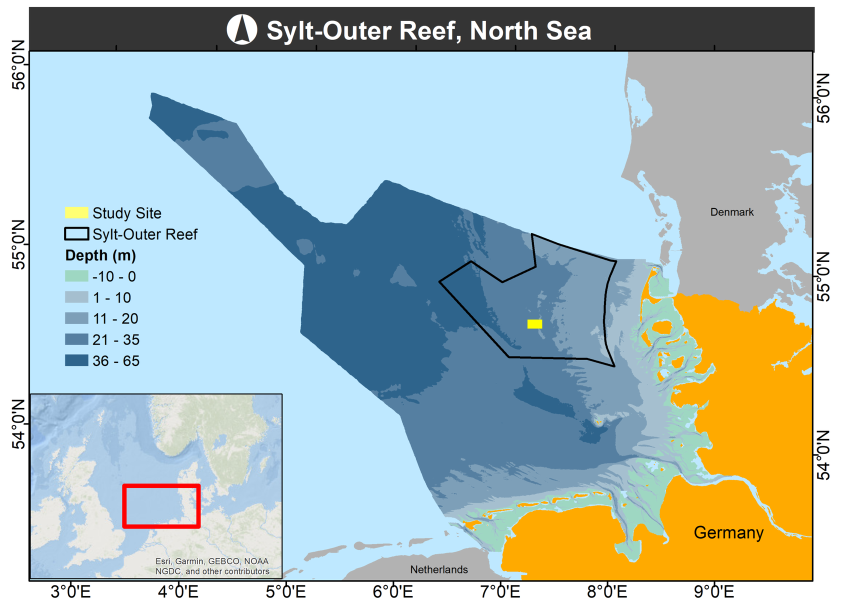
STUDY AREA



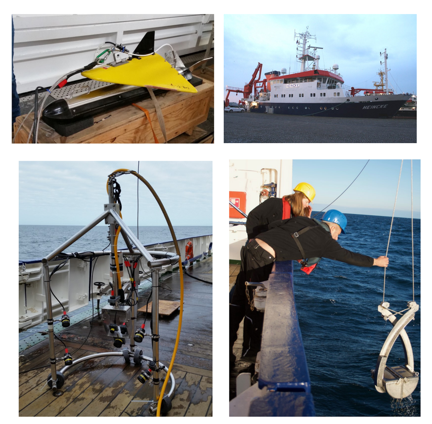
The sanbank habitat is located ~50km from the island of Sylt and within the water depth of 25-45 m. The area is characterized by patches of coarse sediments and gravel which originated from the post-glacial sorting processes.

- Located in the southeastern part of the North Sea (7° 20'00" E 54°55'00" N) with a total area of 5,314 km^2 ,the Sylt Outer Reef Special Area of Conservation (SAC) was Included in the European Commision's list of Sites of Community Importance for the Atlantic biogeographical region based on the main distribution ranges of harbour porpoises and the presence of sandbank and reef habitat types [a]
- Habitat types in Sylt Outer Reef include Sandbanks (87km^2) and Reefs (154 km^2). Sandbank habitats ranges from fine sand to coarse sand and gravel [a]
- A small sandbank habitat of 10.5 km^2 inside the SAR has been selected to monitor the sediment distribution pattern

METHODOLOGY

List of offshore surveys, devices, and data used for this study

Cruise Number	Date	Data Type	Device	Settings Used	Area Size/ Number of Sample
HE 501	16 Nov 2017	Side-scan Backscatter	Edgetech 4200	300 kHz, 150m range	10.5 km²
		Bathymetry	Kongsberg EM710	60-70 kHz, 110° opening angle	10.5 km²
HE 505	19-20 Mar 2018	Side-scan Backscatter	Edgetech 4200	300 kHz, 150 m range	10.5 km²
		Bathymetry	Kongsberg EM710	60-70 kHz, 120° opening angle	10.5 km²
HE 400	18 May 2013	Grain size	Van Veen Grab	HELCOM Standard	2
HE 436	17 Nov 2014	Grain size	Van Veen Grab	HELCOM Standard	7
HE 501	16 Nov 2017	Grain size	Van Veen Grab	HELCOM Standard	4
HE 436	17 Nov 2014	Video	Kongsberg oe14-106/197		
HE 501	16 Nov 2017	Video	Kongsberg Color Zoom Camera, GOPRO 3+ Black		
HE 505	19-20 Mar 2018	Video	Kongsberg Color Zoom Camera, GOPRO 3+ Black		



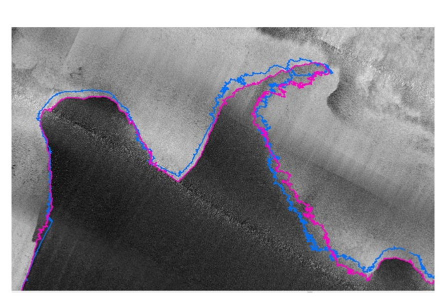
Clockwise: Photo of Edgetech 4200 Sidescan sonar, FS Heincke, Kongsberg Color Zoom camera , and Van Veen Grab Sampler

STEPS OF ACOUSTIC DATA PROCESSING

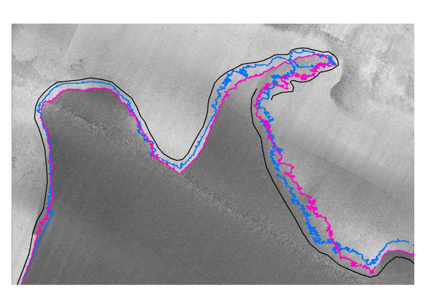
1. Multibeam data was process in QPS Fledermaus to create a Digital Terrain Model (DTM) of the study area
2. Side-scan data was processed in QPS FMGT where backscatter values are corrected from absorption loss using the model of absorption coefficient by Francois and Garrison (1982).
3. Angle-varying gain was normalized using the „Adaptive" algorithm with window size of 600 pings.
4. Final mosaic pixels were blended with "no nadir 25%" overlap, the dB values were cropped at ±3σ , logarithmically mapped to 8-bit scale, and gridded to 0.25 m resolution.
5. The DTM derived from multibeam data was used to georeference the final backscatter mosaics.

THE DSAS WORKFLOW—STEPS IN QUANTIFYING BEDFORM BOUNDARY

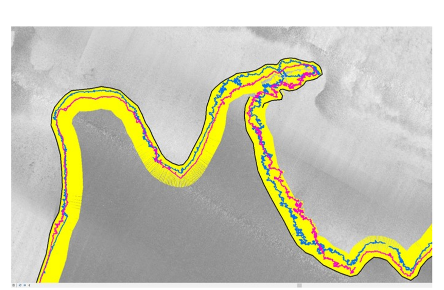
The Digital Shoreline Analysis System (DSAS) is an add-in tool in ArcGIS developed by USGS. It has been used globally to monitor changes along the coastiline. Below is the workflow in utilizing DSAS for bedform boundary monitoring.



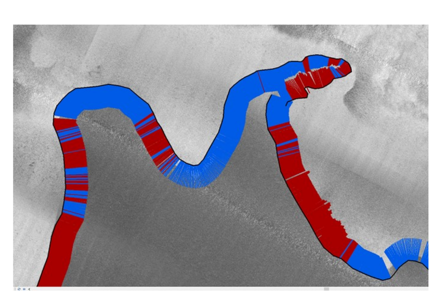
1. Define the boundary lines. Mosaics from Nov 2017 and Mar 2018 were segmented using OBIA of e-Cognition to extract bedform boundaries.



2. Create a baseline for casting the transects that are to be used for measuring boundary movement. Ensure that the baseline include all the boundary line on one side



3. Cast transects to be used for quantification. Length of transects is based on the farthest distance of the boundary from the baseline.



4. Run the change calculation and visualize the results spatially .

A method from shoreline change analysis is applicable to monitor oscillations of submarine bedforms. Monitoring the oscillation of sorted **bedform boundaries can infer the direction of sediment transport** in a submarine sandbank habitat.

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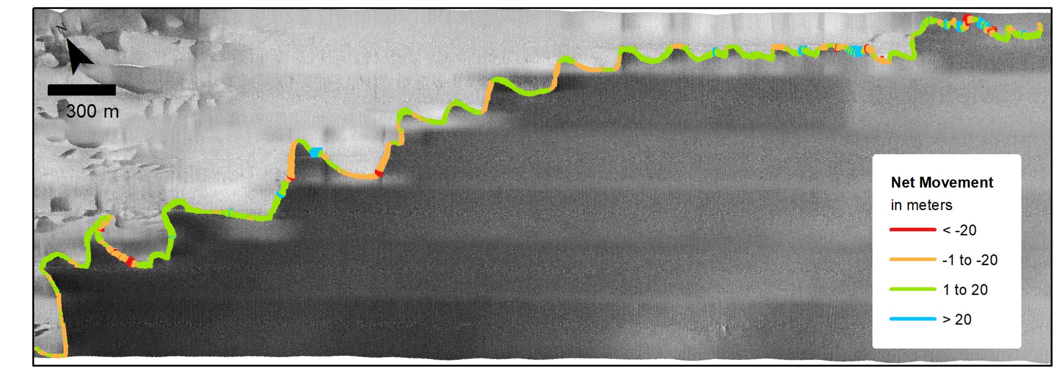
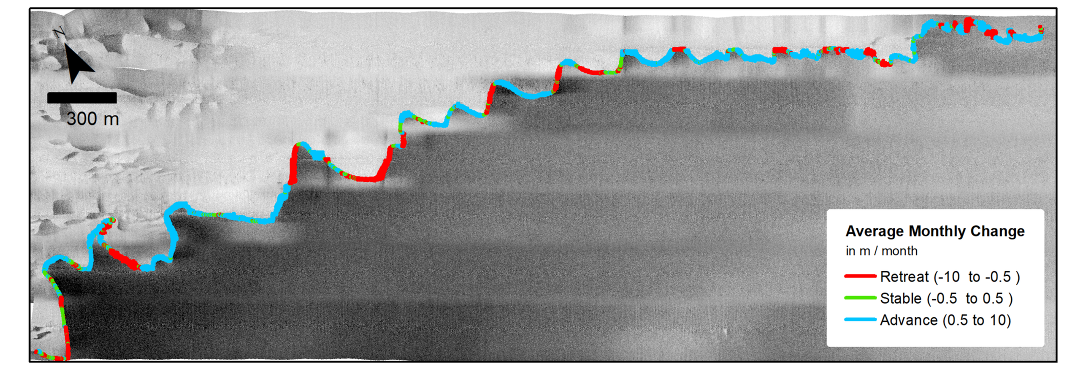
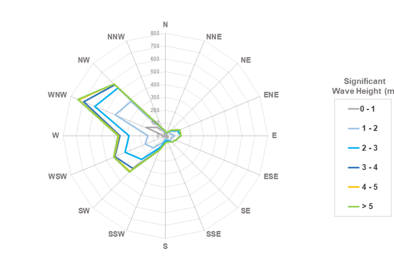
RESULTS

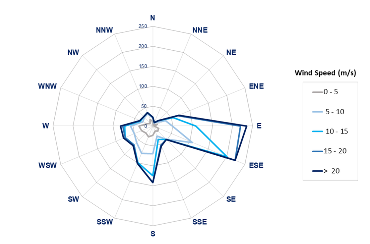


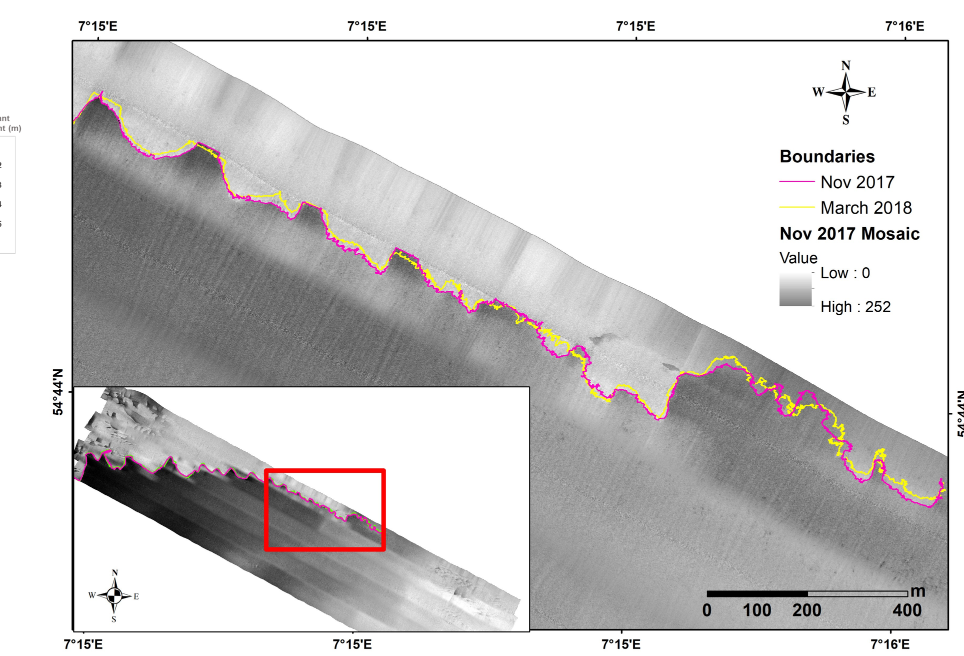


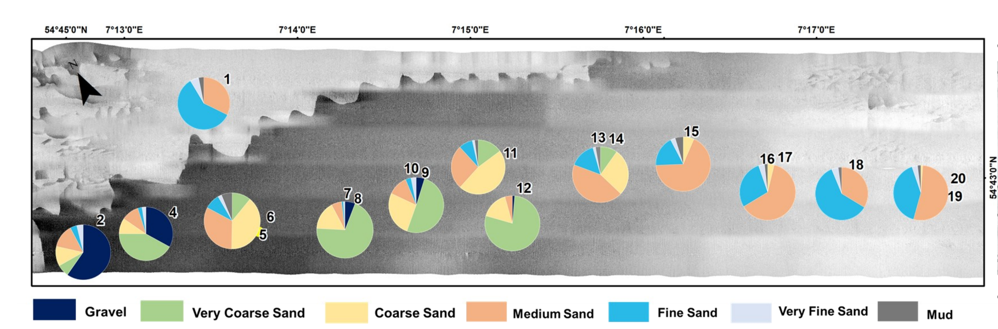
- The oldest backscatter mosaic (2017) was used as reference to determine the pattern and orientation of movement. Hence, it is advance if the new boundary (2018) move forward, and retreat if it moved backwards from the old boundary.
- The bedform movement calculation shows an overall advance movement of the boundaries with a rate of ~ 0.63m/month within a period of four months. Maximum boundary advance is 38 m while maximum retreat is –40 m. Hence, boundaries seem to fluctuate by ±40 m on west-northwest direction.
- The direction of boundary fluctuation is similar to the main heading of waves and wind direction in the study area

- The direction of boundary fluctuation is similar to the main heading of waves and wind direction in the study area —west-northwest.
- The average wave height from Nov 2017 to Mar 2018 is 2.03m and average wind speed is 5.33 m/s [b]

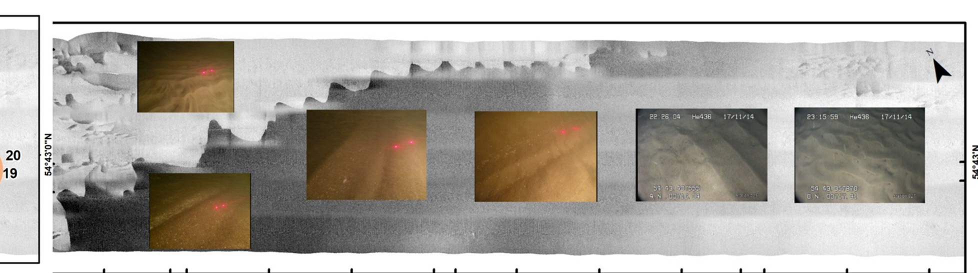








Grab samples show that grain-size distribution is mainly composed of gravel and coarse sand on the western portion, and becomes finer towards the east. Sediments in the area are believed to be winnowed lag deposits from the post-glacial sorting process.



Underwater footage revealed that there are varying scale of bedforms in the sandbank habitat. From small symmetrical straight ripples with wavelength of 50cm and height of 20-30cm to small linguoid ripples with 10cm wavelength and 2-3 cm high.

SUMMARY

- The Digital Shoreline Analysis System (DSAS) tool for shoreline change monitoring, is applicable to quantify the movement of bedform boundaries
- Results change analysis show that the direction of oscillation or fluctuation of the boundaries are comparable to the main heading of waves and winds.
- The submarine sorted bedform boundaries were observed to fluctuate on the direction pattern of wave and wind, instead of actually moving from one location to another.

REFERENCES:
[a] Federal Agency for Nature Conservation (BfN). Conservation objectives for the Sylt Outer Reef SCI (DE 1209-301) in the German North Sea EEZ. January 2008
[b] BMWi (Bundesministerium fuer Wirtschaft und Energie, Federal Ministry for Economic Affairs and Energy) and PTJ (Projekttraeger Juelich, project executing organization). FINO Project. April 2019.
Francois R. E., Garrison G. R., "Sound absorption based on ocean measurements: Part I:Pure water and magnesium sulfate contributions", Journal of the Acoustical Society of America, 72(3), 896-907, 1982.

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