THESEUS: Investigations on Artificial Sandbanks in the Mouth of the Elbe Estuary for Mitigation of Tidal Energy

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The THESEUS Project

Coastal areas are vital economic hubs in terms of settlement, industry, agriculture, trade and tourism to mention some key sectors. There are already many coastal problems including erosion, flood risk and long-term habitat deterioration. As economies continue to develop the asset base at risk will grow, while accelerating climate change will increase the likelihood of damaging extreme events, as well as accelerate habitat decline. Existing coastal management and defence approaches are not well tuned to these challenges as they assume a static situation.

THESEUS will develop a systematic approach to delivering both a low-risk coast for human use and healthy habitats for evolving coastal zones subject to multiple change factors.

THESEUS activities will be carried out within a multidisciplinary framework using 8 study sites across Europe (Fig. 1). The study sites typify the most vulnerable coastal environments such as deltas, estuaries and wetlands, where many large cities and industrial areas are located.

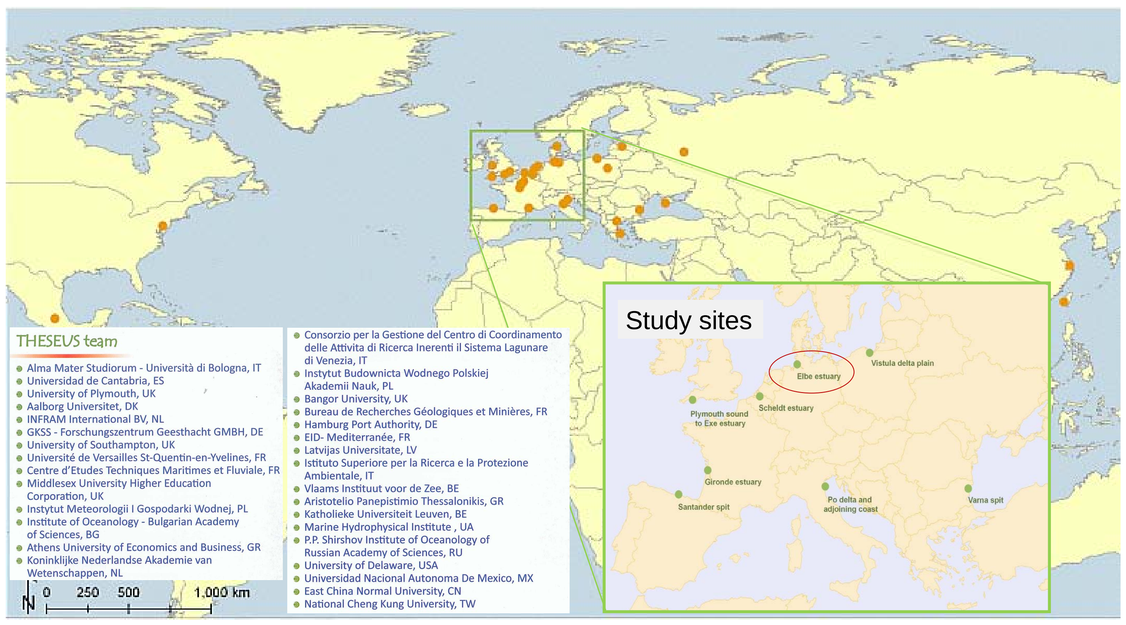

Figure 1: Partners and study sites in the EU-Project THESEUS (www.theseusproject.eu)

The Elbe Study Site

The Elbe Estuary is the artery of the whole region and functions as an important federal waterway. About four million people live in the metropolitan region of Hamburg in an area of approximately 19.000 km². However, the influence of the Tidal Elbe River extends far beyond this area. The Port of Hamburg is an international hub. It is the largest port in Germany and the second largest in Europe. Together with the other Elbe seaports of Lower Saxony and Schleswig-Holstein the Port of Hamburg is the biggest employer of Northern Germany and as such is indispensably linked to the economic development of Hamburg, Schleswig-Holstein, Lower Saxony and beyond.

Reduction of Tidal Energy by Artificial Sandbanks

Scientific results and the observations of the people in this region unfortunately indicate an unfavourable hydro morphological evolution of this essential artery. In a natural estuary the meandering channels and varying bed forms tend to damp down tidal energy but man-made changes together with evolutionary processes have removed this ability so that the flood tide comes in with more tidal energy.

The generation of offshore sandbanks represents one option to reduce the incoming tidal energy. The efficiency and stability of such sandbanks is analysed by means of the high resolution 2d hydro dynamic model *TRIM* (*Cheng, R.T., Casulli, V., and Gartner, J. W.*; Tidal, residual, intertidal mudflat *TRIM* model with applications to San Francisco Bay; Estuarine, Coastal Shelf Science, Vol. 36, pp. 235-280).

The model for the Elbe Estuary is a rectangular grid with a spatial resolution of 50m, which allows the investigation of the effects of the coastal structures in the mouth of the Elbe on the currents and water levels in the inner estuary, e.g. the port of Hamburg.

All numerical simulations are carried out under various scenarios and boundary conditions, including storm surge conditions and climate change options.

Figure 2 shows the bathymetry in the model area for today's situation and with three scenarios of artificial sandbanks in the mouth of the Elbe Estuary. Furthermore locations of gauges and monitoring measurements are indicated. These measurements are carried out due to licensing requirements and the last fairway deepening. At these stations water levels, current velocities, turbidity and conductivity are measured. Due to navigational restrictions different layouts e.g. pile or buoy constructions for measurements are chosen. In all cases *Aanderaa RCM 9* or *SEAGUARD* measuring platforms are used. The results of the numerical simulations of the reference situation were calibrated and validated with data of these monitoring measurements. The time domain of the simulations is the year of 2006.

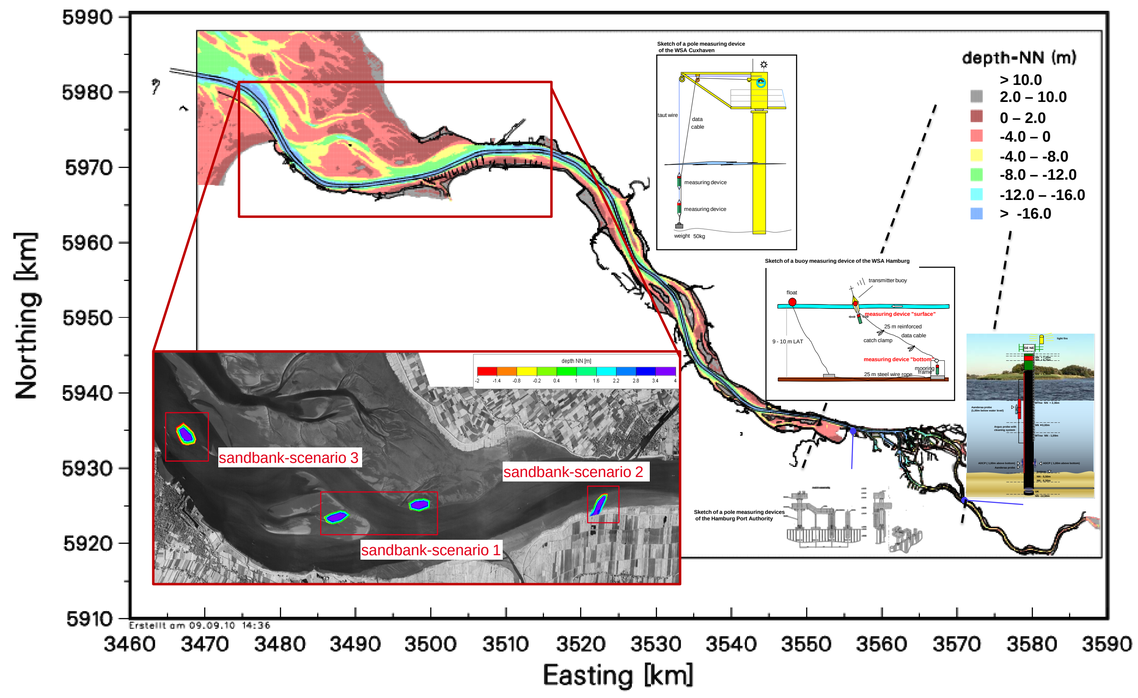

Figure 2: Bathymetry and positions of investigated sandbanks

Investigations and First Results

In a first step numerical simulations were done for the reference situation 2006 and for the sandbank scenario 1, which consists of 2 sandbanks on both sides of the Medemrinne. For the evaluation of the model results 2 of the 12 monitoring stations are used. Station D4 is situated near the city of Glückstadt and the Rhinplatte, station D1 is located at the island of Hanskalbsand close to the entrance of the Hamburg Port. Figure 3 shows the calculated differences between the sandbank scenario 1 and the reference situation at D1 for water level (left panel) and currents (right panel). In general positive values give an increase in water level or flood and residual current velocity for the sandbank scenario in comparison to the reference situation. While an increase in the magnitude of the ebb current velocity results in a lower (negative) value in the diagram.

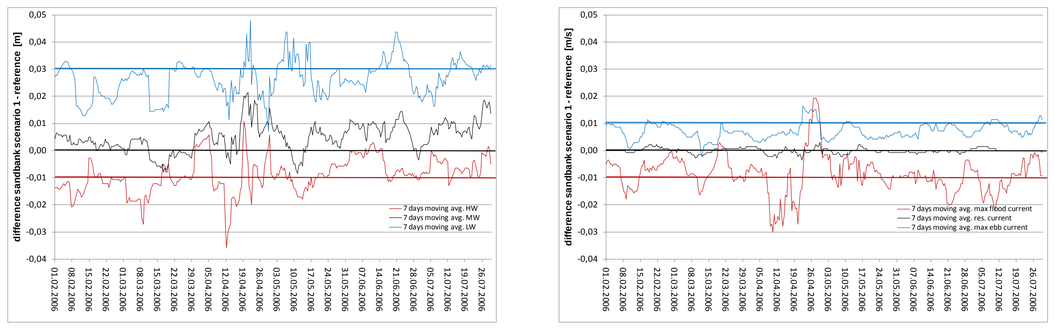

Figure 3: Difference of water level (left) and current velocity (right) at monitoring station D1

The overall average effects of scenario 1 at station D1 are:

- 1 cm decrease of high water level
- no change of mean water level
- 3 cm increase of low water level
- 1 cm/s increase in maximum flood and ebb current velocities
- no change in residual currents

The overall average effects of scenario 1 at station D4 are similar to the results of station D1 but less pronounced, due to the more down-estuary position (Fig. 4)

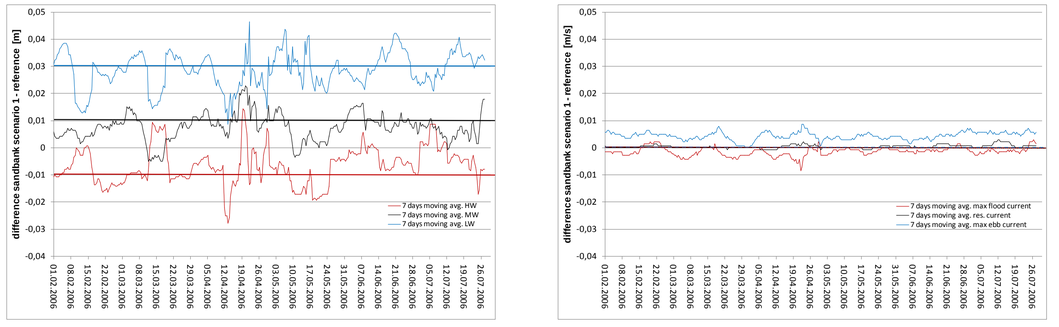

Figure 4: Difference of water level (left) and current velocity (right) at monitoring station D4

Outlook

The results of scenario 1 will be analysed in relation to flood risk in other part of the port and estuary. Furthermore the effectiveness of the other sandbank scenarios (Fig. 2) will be investigated. In the final step the effects of the IPCC climate change scenario A1B will be taken into account. The overall results will contribute to the THESEUS aims to develop innovative risk mitigation options and tools for coastal defence planning strategies.

Acknowledgement:
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