BAW
Federal Waterways Engineering and Research Institute

Competence for waterways

Morphological changes and drainage capacity of the Eider estuary

Motivation and relevance

After the reduction of the catchment area and the construction of a weir 30 km landwards in 1936 (*Nordfeld*, Fig. 1) a high level of sedimentation started in the Eider estuary (70 mm/yr). The cross-sectional areas of the tidal eider reduced by 90%. In 1972 a storm surge barrier (Fig. 4) was built in order to protect the hinterland and to control sedimentation. Based on over hundred historical digital terrain models (DTMs), we now investigate how the morphology of the estuary has changed during the last 50 years. We try to estimate the influence of these changes on drainage capacity.

Eider estuary

- North Sea
- Catchment: 2072 km²
- Length: 110 km
- Mesotidal
- Since 1972 divided into Outer and Tidal Eider by a storm surge barrier (Fig.4)

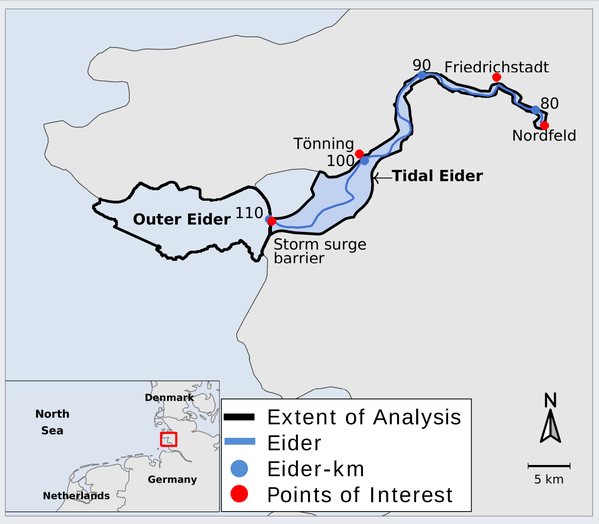

Fig.1: Map of Eider estuary

Methods

a. Assemble DTMs for selected years.

b. Calculate water volume and sedimentation rate for the assembled DTMs.

c. Generate along-estuary sections along the thalwegs and calculate the mean height.

d. Generate cross-estuary sections (Fig. 2) and calculate the hydraulic radius (R_{hyd}). It provides a rough estimate of the drainage capacity of a channel.

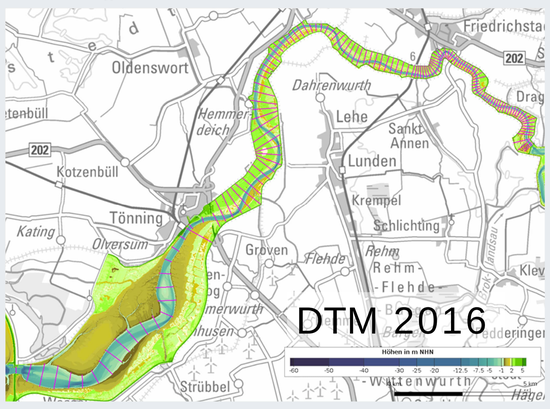

Fig. 2: Cross profiles

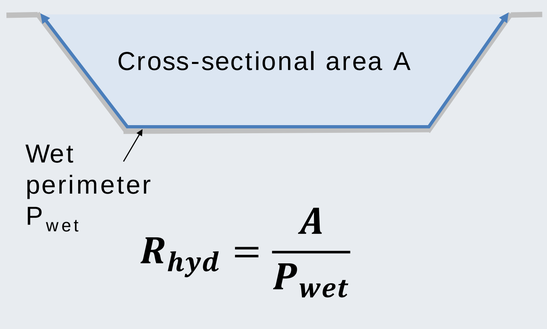

Fig. 3: Hydraulic Radius

Results

- Despite the construction of the barrier, the Eider still shows high morphological activity (Fig. 5).
- The sedimentation rate of the Outer Eider is four times higher than those of the Tidal Eider. It reduced to 4 mm/yr (Tab. 1).
- Between 1980 and 1996 the Tidal Eider became 0.7 m deeper (Tab. 2). The hydraulic radius increased (Tab. 3). Since 1996 the mean height and the hydraulic radius stayed constant. The system reached an equilibrium state.

Fig. 4: Aerial photograph of the storm surge barrier of the Eider

Twenty years after the construction of the Eider barrier the inner estuary reached an equilibrium state

Report: Morphologische Veränderung der Außen- und Tideeider (2023)

Tab. 1: Sedimentation of the Outer and Tidal Eider

	Outer Eider	Tidal Eider	
number	36	36	year
volume of water in 1980	317.1	63.2	Mill. m³
volume of water in 2016	286.8	59.3	Mill. m³
area	53.4	28.9	km²
annual volume change	0.84	0.11	Mill. m³/yr
sedimentation rate	16	4	mm/yr

Tab.2: Mean height of the along-estuary sections

DTM	mean height (m NHN)
1980	-4.8
1996	-5.5
2005	-5.6
2016	-5.4

Tab.3: Mean R_{hyd} calculated for the cross-estuary sections

DTM	R_{hyd} (m) reference horizon 0 m NHN
1980	2.8
1996	3.1
2005	3.1
2016	3.1

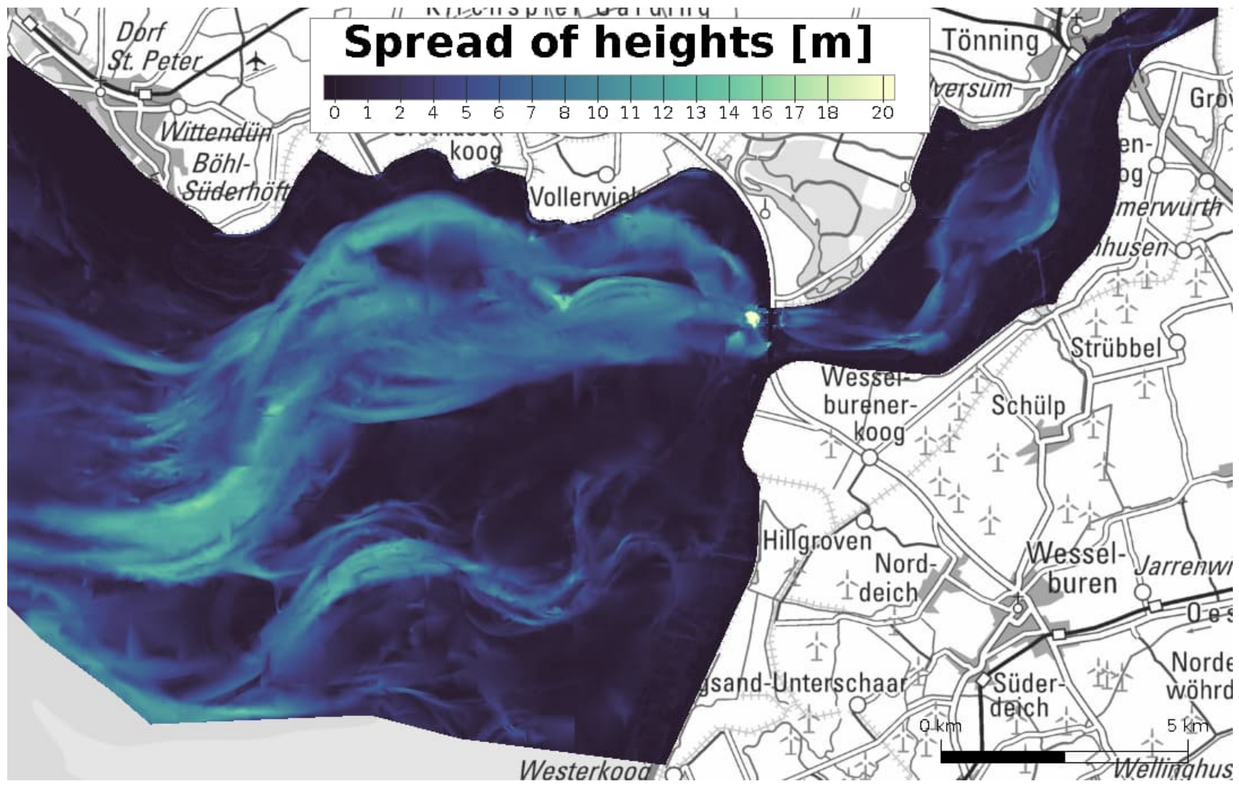

Fig. 5: Spread of heights in the DTMs since 1972

IAHR 2023 | Elke Siegmann, Janina Freund, Frank Kösters – E-Mail: elke.siegmann@baw.de