Sediment management in the Tidal Elbe
Optimization of relocation strategies

Magdeburger Gewässerschutzseminar
„Die Elbe und ihre Sedimente“
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Dredging sections in charge of the Waterways and Shipping Offices Hamburg und Cuxhaven

- 17 dredging sections (Elbe-km 638.9 - Elbe-km 748.0)
- amount of dredged material (navigation channel): approx. 12 Mio. m³/a hopper capacity and 1 Mio. m³/a water injection (WI) dredging
- costs at last around 45 Mio. €/a
- noteworthy dredged silt volumes (with adherent pollutants) in BA1, BA3 and BA12 (in average 4 Mio. m³/a fine sandy silt); in other sections predominantly sandy bed material to be dredged
Morphological structures in the navigation channel

Elbe-km 639 to 643

- Medium sandy dunes
  - (isolated shallows, preferred charge of WI-dredgers)

- Sandy ripples
  - (dune height: 2 to 3 meters)

- Fine sandy silt
  - (plane sedimentation / large-area shallows, in general charge of hopper dredgers)

Elbe-km 639 to 643
Morphological structures in the river channel

- medium sandy dunes in the navigation channel / fairway
- silty fine-sand / fine-sandy silt in boundary areas

Elbe-km 681,3 – 684,0 (relief shading by surveying data)
Dredging and relocation strategies - medium-sandy sections of the navigation channel

- direction of residual bed load transport can be determined by surveying data (dune tracking resp. bed form tracking)
- compared to suspended load transport lower loads and very much lower residual transport rates
- assumption for „inner estuary“: charge of WI-dredgers senseful, alternativ charge of hopper dredgers and - as far as possible - near-by relocation

residual transport of bed load, Elbe-km 638 - 689

(Qrefa-Sander, WSA Hamburg 2011)
Dredging and relocation strategies - (medium-)sandy sections of the navigation channel

no topic in this presentation: morphodynamics in the mouth of the Elbe estuary (dynamic transport processes not comparable with processes in the „inner estuary“, shifting of banks and branches can lead to unexpected rise in dredging amount, predication of morphological chances is a complex task)
Suspended load transport in the Tidal Elbe, turbidity zone of the Tidal Elbe

loads calculated by suspended sediment measurements using ADCP

(BAW, 2006; Weilbeer et al., 2012)

Q = 330 – 350 m³/s

37.000 t / ebb tide
29.000 t / flood tide
72.000 t / ebb tide
72.000 t / flood tide
12.000 t / ebb tide
20.000 t / flood tide

turbidity zone of the Tidal Elbe, pictured by surface-near suspended matter concentrations
(Source: ARGE Elbe)
• silting up of tidal floodings, isolation of sediment spaces (e.g. by lost of floodings due to flood dyking), repeated upgrading of the navigation channel etc. have reinforced the tendency to silting up in the upper reaches of the Tidal Elbe.
Morphological evolution of the Tidal Elbe and resulting effects on the turbidity zone

- silting up of tidal floodings, isolation of sediment spaces (e.g. by lost of floodings due to flood dyking), repeated upgrading of the navigation channel etc. have reinforced the tendency to silting up in the upper reaches of the Tidal Elbe
- effects on the turbiditiy zone can only be estimated by model simulation (no resp. only unsatisfying nature measurements before 2006)

Source: Hindcast studies on different historical states with a 3-d hydro-morphodynamical model
(Weilbeer and Paesler, 2008)
Dredging and relocation strategies - fine-sandy silty sections of the navigation channel (I)

- direction of residual suspended load transport can only be determined by nature measurements and simulation (hydro- and morphodynamic models)
- herefrom it is known, that upstream Elbe-km 677 high residual transport rates towards Hamburg are common ("tidal pumping")
- answer for "inner estuary": basically relocation downstream, only charge of hopper dredgers + longer transport distances senseful (no near-by relocation)

transport distances by changed relocation strategy of WSV up to 47 km

Q = 180 m³/s

disposal area 686/690

about 4 Mio. m³/a total dredging volume (WSA HH)
Dredging and relocation strategies - fine-sandy silty sections of the navigation channel (II)

- furthermore it is known, that residual transport upstream is lower at high headwater discharge (less „tidal pumping“)

- accordant effects could also be shown for the disposal area 686/690 (simulation of erosion and drifting of fine sediments; BAW / Weilbeer et al. 2012)
• furthermore it is known, that residual transport upstream is lower at high headwater discharge (less „tidal pumping“)

• accordant effects could also be shown for the disposal area 686/690 (simulation of erosion and drifting of fine sediments; *BAW / Weilbeer et al. 2012*)

• this knowledge is used in dredging of an in 2008 build „sediment trap“ at Elbe-km 641,8 – 643,8 (dredging in months with normally high headwater discharge)

10-years series (2001/2010) of mean monthly discharge Neu Darchau (Elbe km 536.4)
Outlook: Further optimisation of the changed relocation strategy (fine material)

- Currently ecological evaluation of further relocation strategies for fine sediment by the Federal Institute of Hydrology (BfG)
- One focal point is the influence of different relocation strategies on the pollution of sediments
- Study shall identify knowledge gap and main issues for further research

Potential relocation sites for silty + fine-sandy dredged material (WSV + HPA)

Distance dredging to relocation area ↔ costs?

Upstream or downstream transport of sediments (esp. silt to fine-sand)? rates?

Effects and distribution of pollutants?
More information …

• optimisation of relocation strategies is only one topic in the River Engineering and Sediment Management Concept (RESMC) of HPA and WSV for the Tidal Elbe

• presentation could can only give some flashlights on topics / activities regarding relocation strategies

• some more information on RESMC with a focus on contamination of Tidal Elbe sediments will be given by Axel Netzband („Sediment Management for the Port of Hamburg“)

• several aspects of monitoring programs / long-term measurements will be discussed on field trip „measuring station Seemannshöft“
Thank you for paying attention!