Estimating ship-induced sediment transport in confined waters

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Background

- Dredging and disposing of accumulated sediments from waterways are expensive tasks for federal authorities.
- Physical transport processes and the impact of passing ships on these processes are not fully explored yet.
- Moving ships have an influence on the turbidity by resuspending sediments which can then be transported by prevailing currents, but:
- **How large is the ship-induced proportion of the totally transported sediment volume in a waterway?**

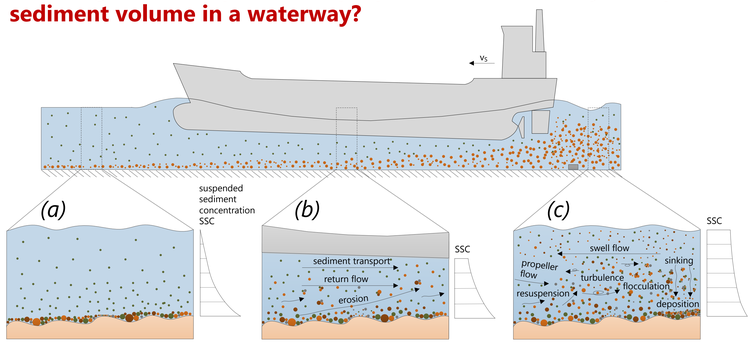

Fig. 1: *Flow and turbidity regime before (a), during (b), and after (c) a passing ship in confined waters.*

Kiel Canal field campaign

- Three probes at the canal bed (turbidity, pressure, 3D flow velocity; see example in Fig. 4), recording for 8 days.
- AIS recorder at a nearby bridge (length, width, draft, speed/curse over ground, position, ship identifier).
- ADCP flow/SSC profiles (ship-based).

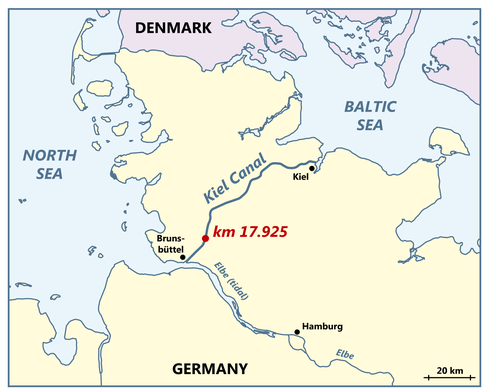

Fig. 2: *Map of the Kiel Canal.*

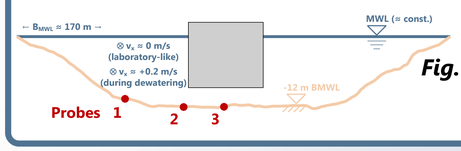

Fig. 3: *Cross-section at km 17.925, probe locations and exemplary vessel.*

Estimating the ship-induced proportion

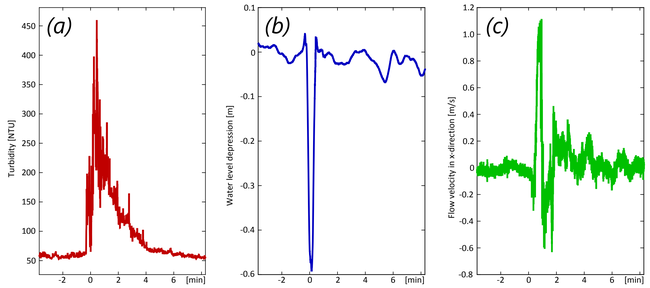

Fig. 4: *Ship-induced turbidity (a), water level depression (b), and flow velocity (c) at one exemplary passage.*

1. Approximating a 2D turbidity distribution for each time step by extrapolating discrete turbidity data recorded with the probes (see Fig. 5). Validation using ADCP SSC profiles.
2. Estimating the transported volume by linking the 2D turbidity distributions with corresponding flow velocities for each time step and summing up all time steps (see Fig. 6).

→ Recorded data yield the transported sediment volume due to "natural" currents (mainly dewatering) including the ship-induced volume (A).

3. Removing all ship-induced signals from turbidity and flow data using smoothing techniques.

→ Smoothed data yield the "naturally" transported sediment volume (B). The ship-induced volume results from the volume difference (A-B).

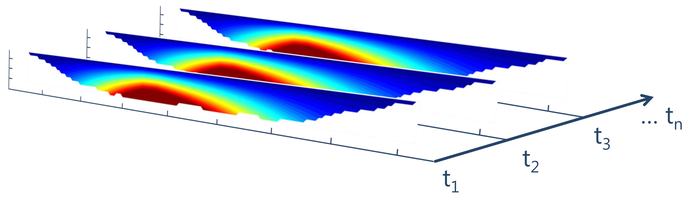

Fig. 5: *Schematic illustration of the transport simulation with extrapolated turbidity distributions for each time step.*

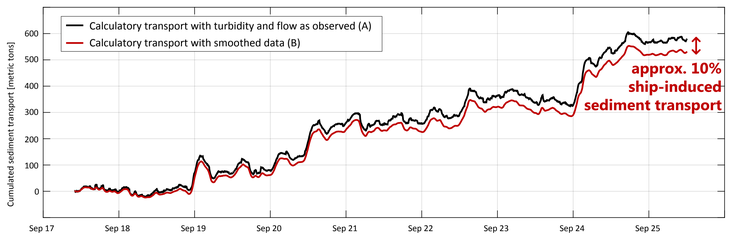

Fig. 6: *Cumulated sediment transport, calculated with observed and smoothed data using the full record (8 days).*

Elbe field campaign and preliminary results

- Six probes at the canal bed (same setup as for the Kiel Canal campaign), recording for 16 days (see Fig. 7).
- Estimation of the ship-induced proportion of the totally transported sediment volume similar to the Kiel Canal method.

→ Tidal currents are the major cause of sediment resuspension and transportation. Preliminary result: the ship-induced proportion is <2%.

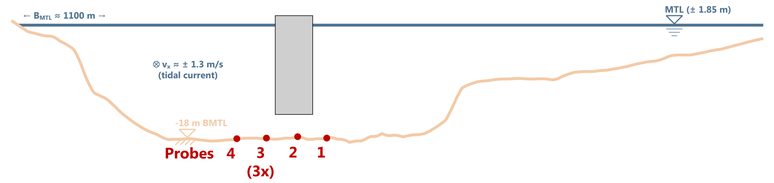

Fig. 7: *Field campaign cross-section in the Elbe river at km 646.8, probe locations and exemplary vessel.*

Take-home messages

- **A proportion of about 10% of the entirely transported sediment can be attributed to ship-induced resuspension under laboratory-like conditions in the Kiel Canal.**
- **Especially tidal but also discharge flows in the Elbe river dominate the transport regime. The ship-induced proportion of the totally transported sediment volume is <2%.**

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