Hamburg Port Authority

Project

Nautical Depth

Introduction and first results within the Project “Nautical Depth” in Hamburg

11th International SedNet Conference in Dubrovnik, Croatia, 3rd -5th April 2019

Nino Ohle, Ulrich Schmekel

Definition of Nautical Depth

PIANC (1997):

"The nautical depth is the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability and manoeuverability."

Detection of a safe nautical depth requires spatial multi beam soundings

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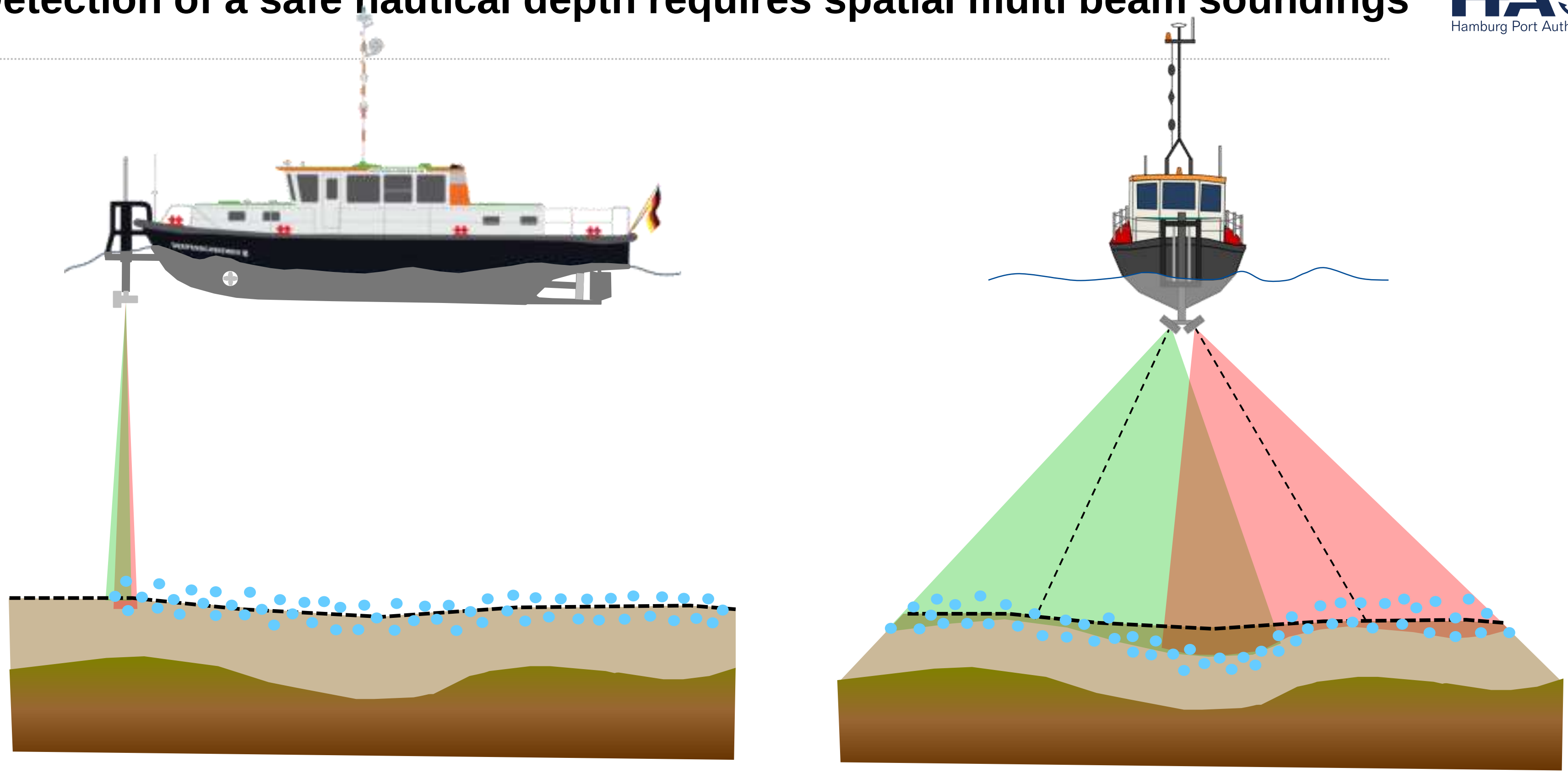
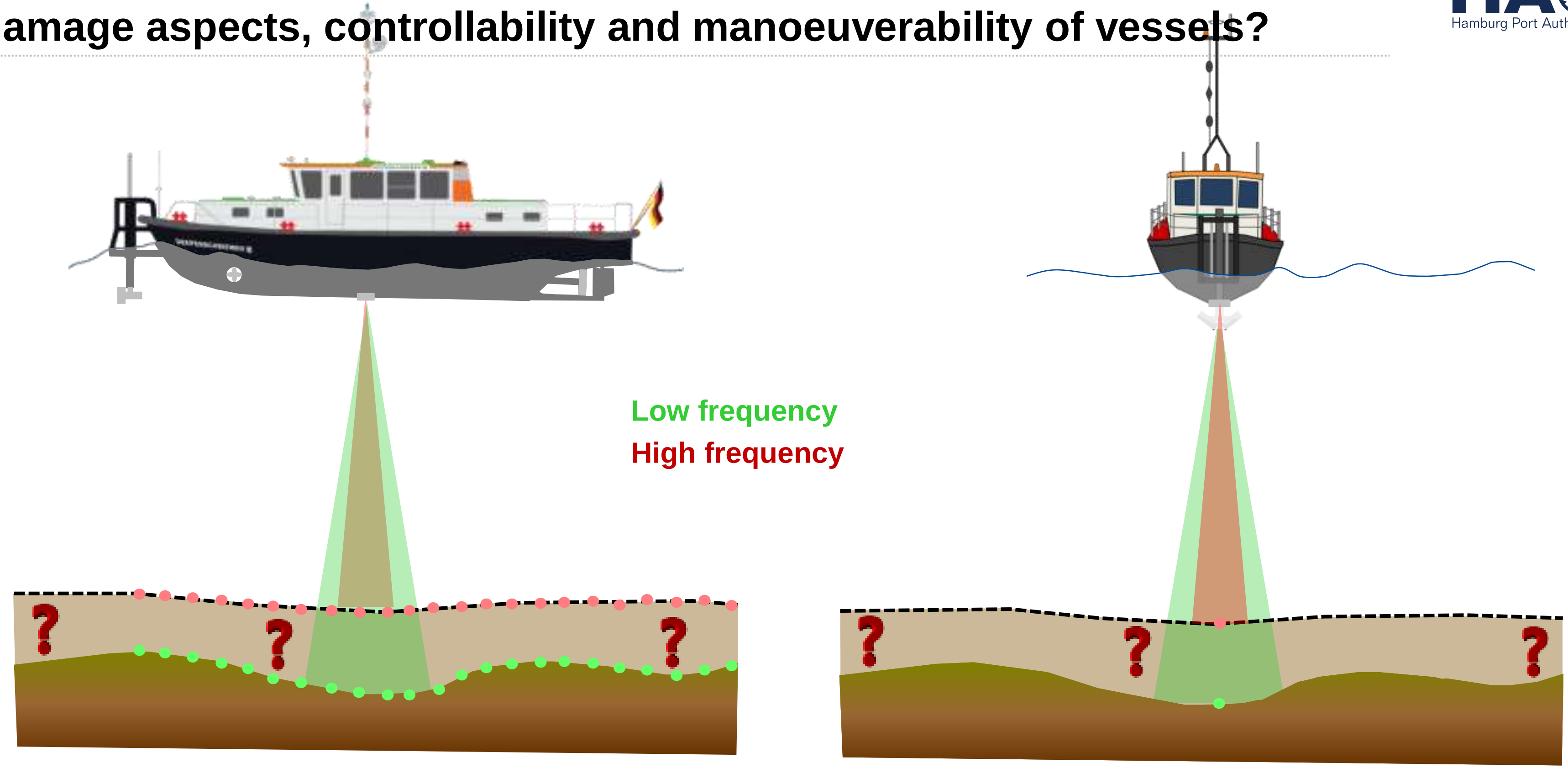
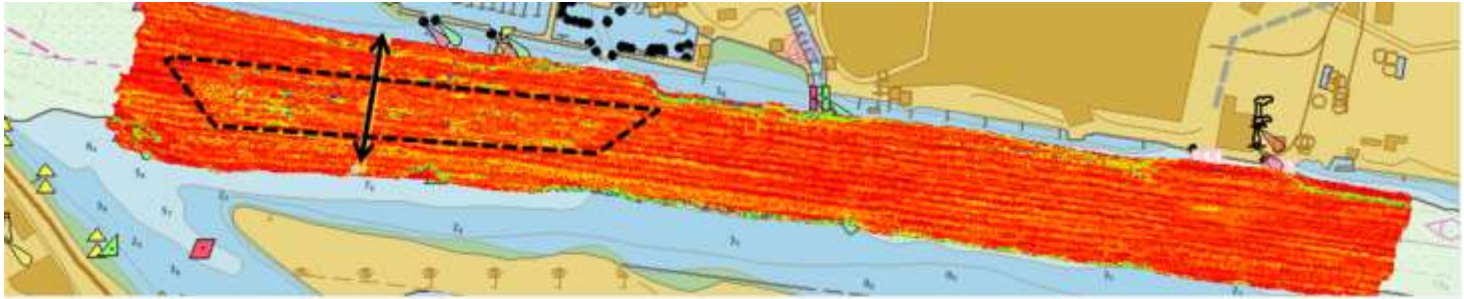
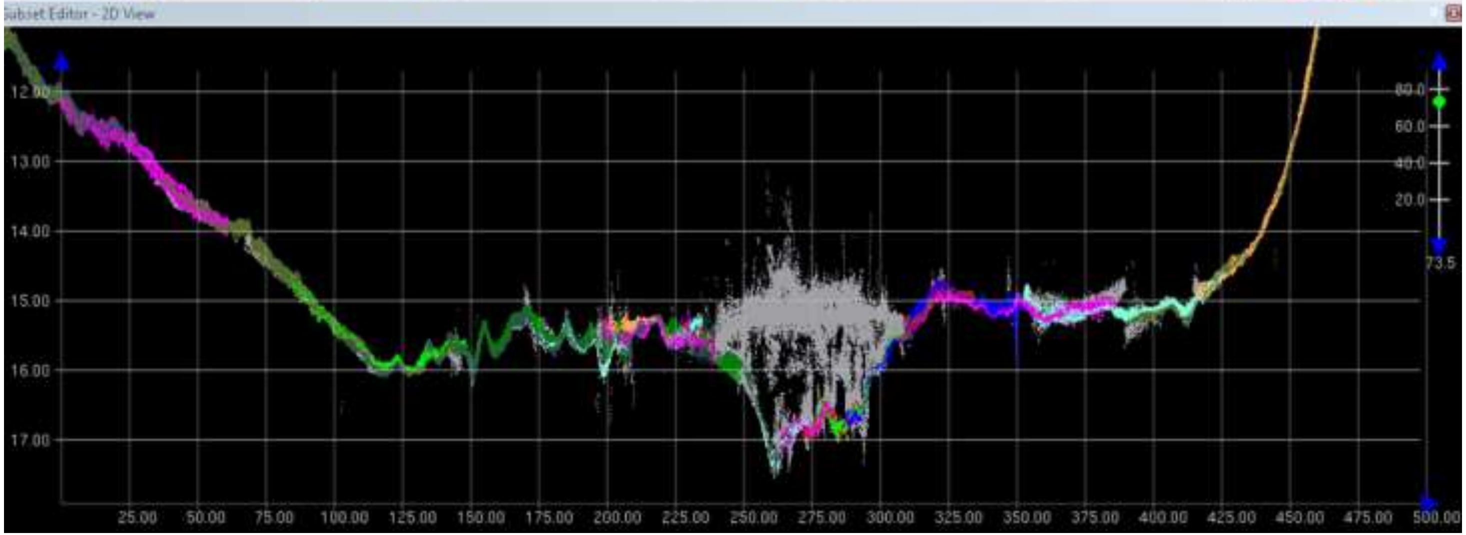


What is the best description of the sea/river bed, which is safe regarding damage aspects, controllability and manoeuverability of vessels?

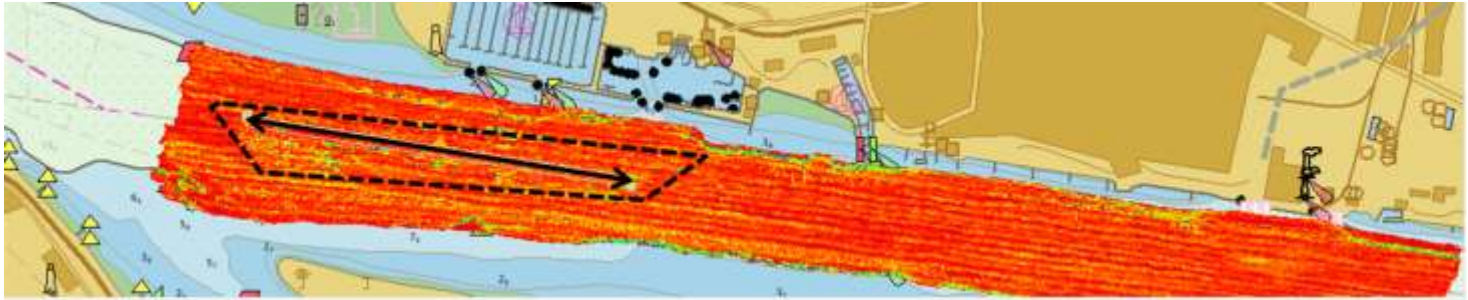


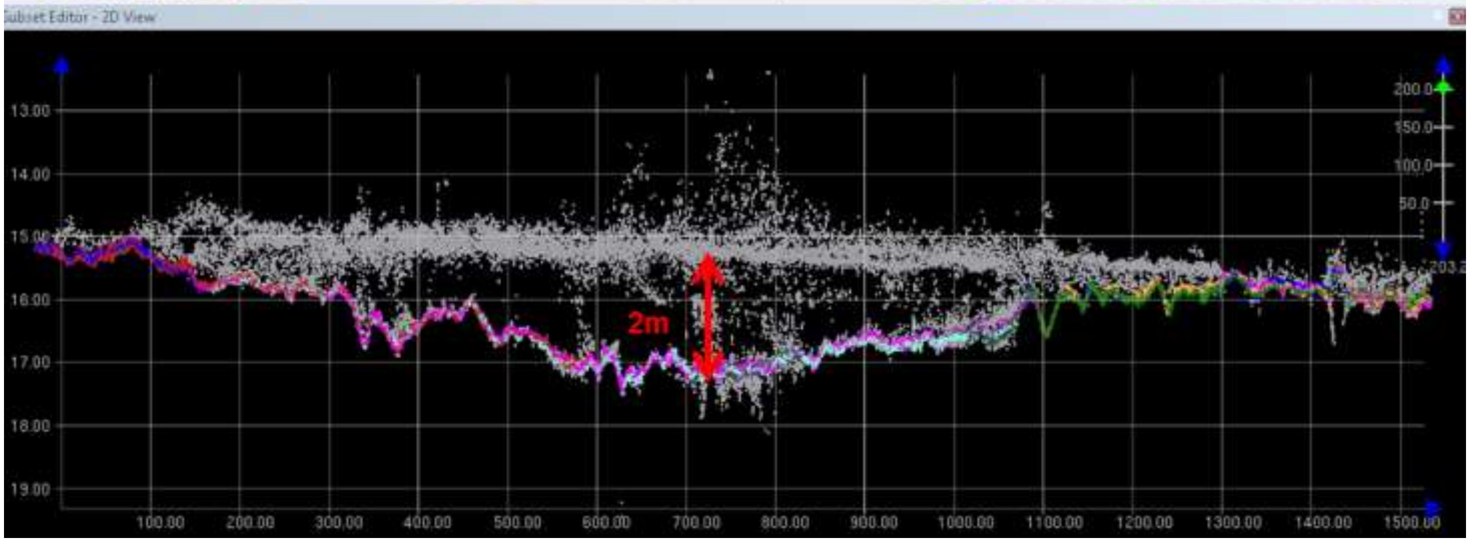
Detection of the river bottom in hydro-acoustical challenging areas





Detection of the river bottom in hydro-acoustical challenging areas





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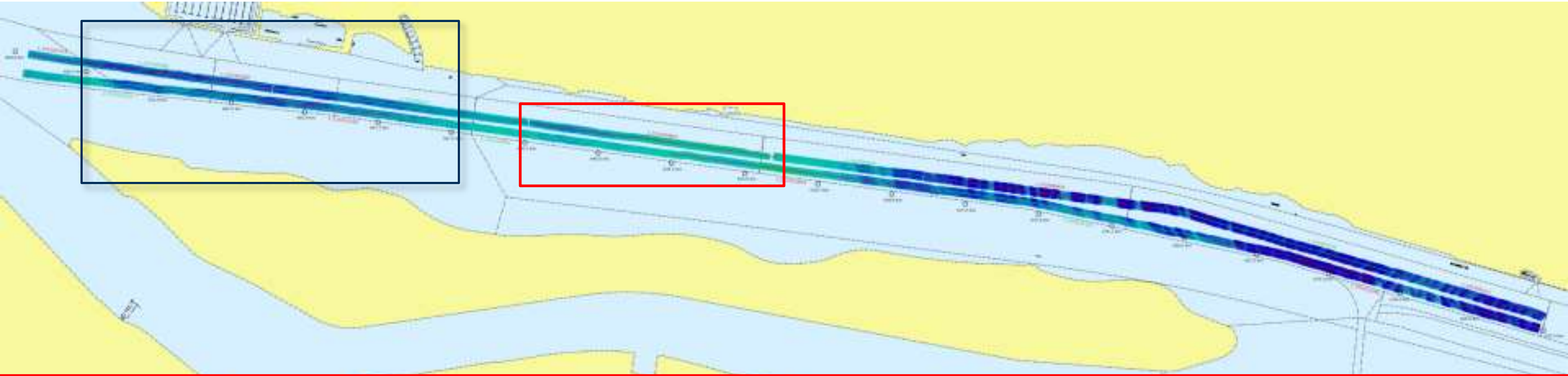

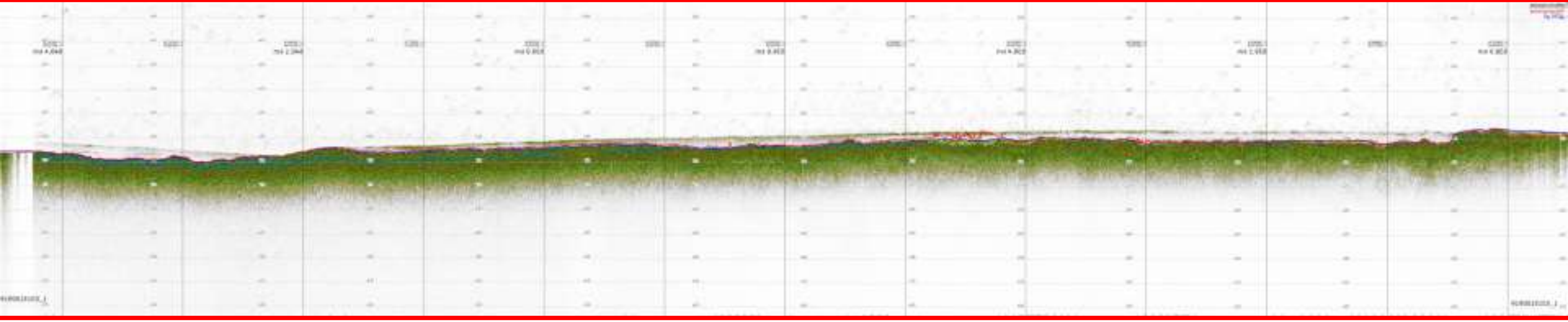

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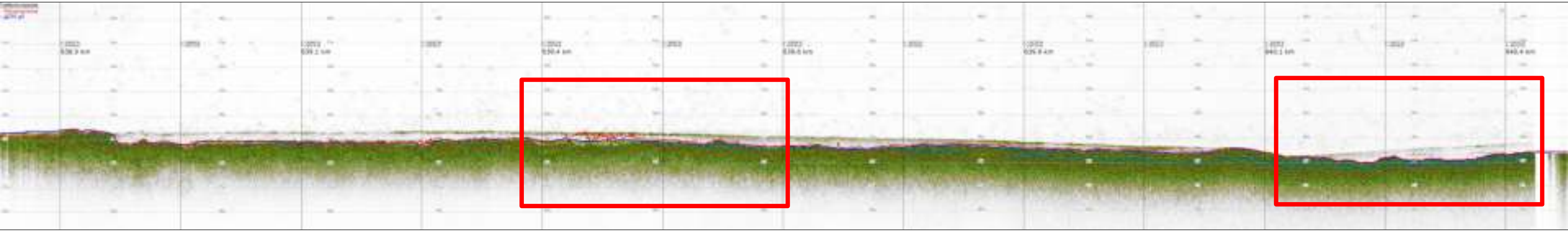
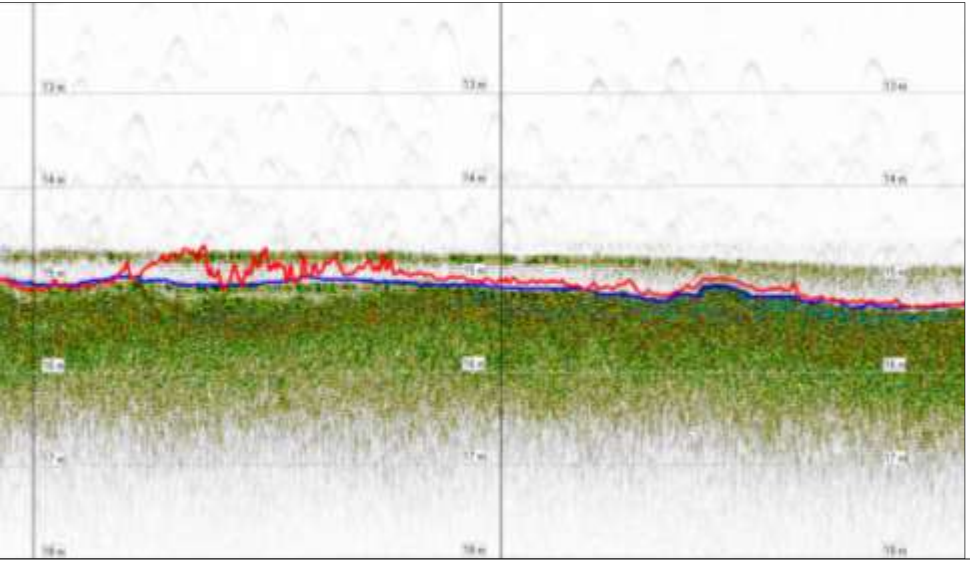
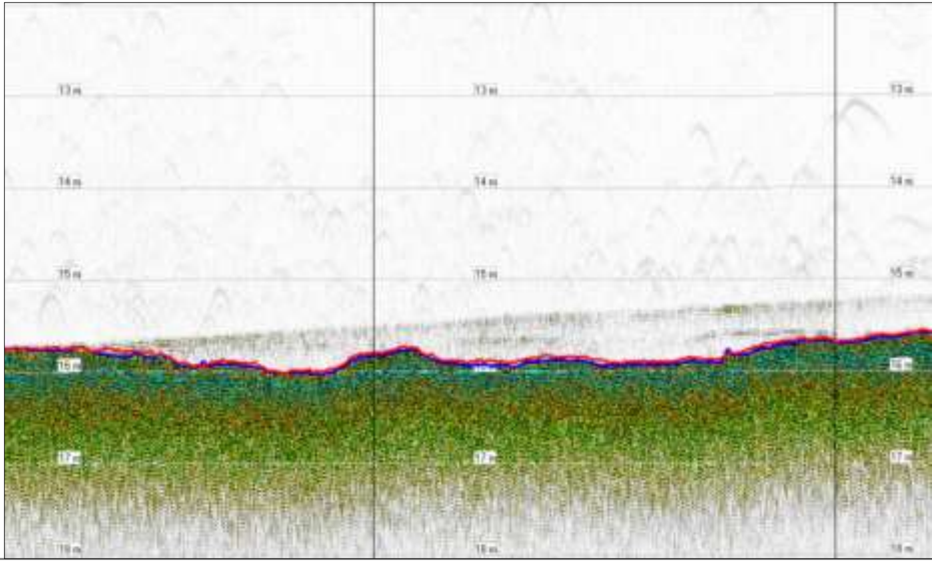
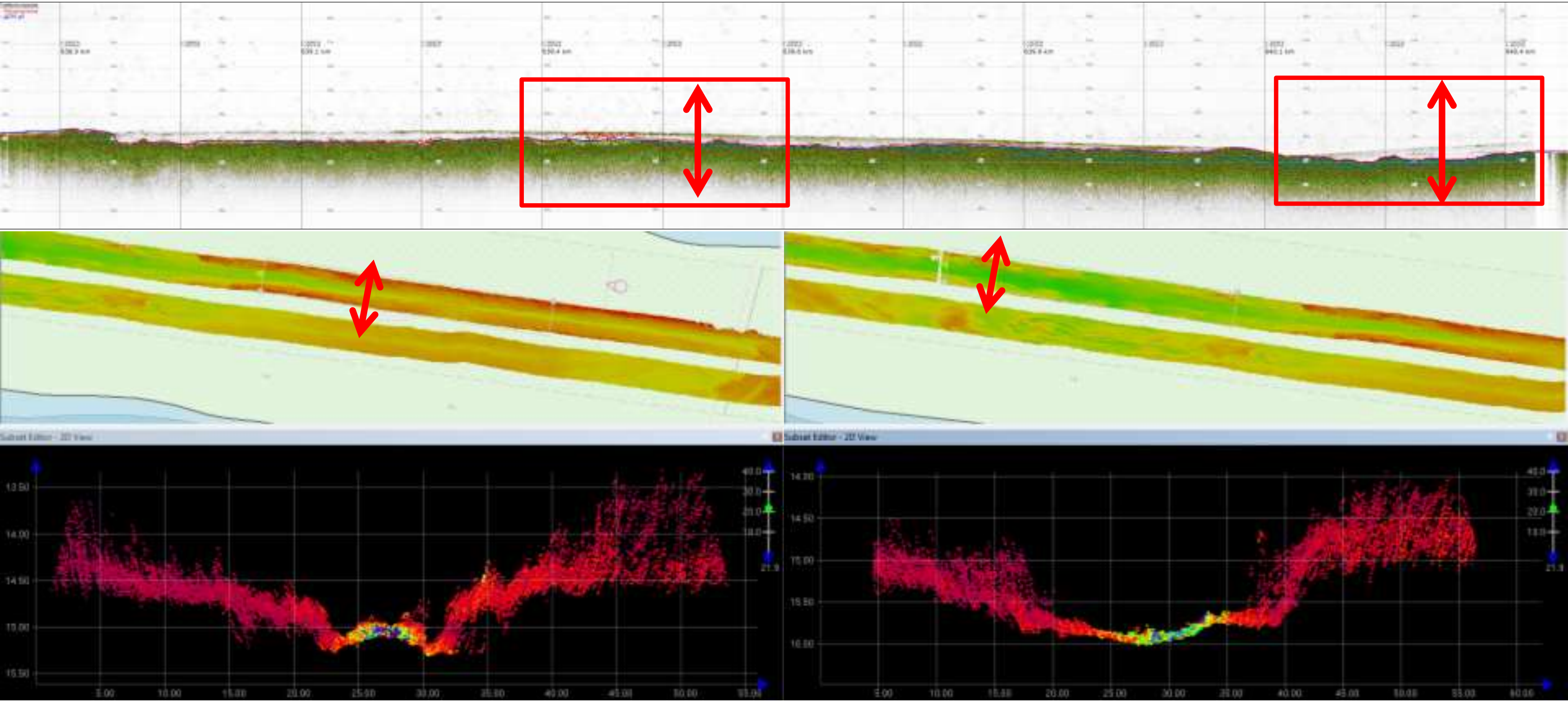


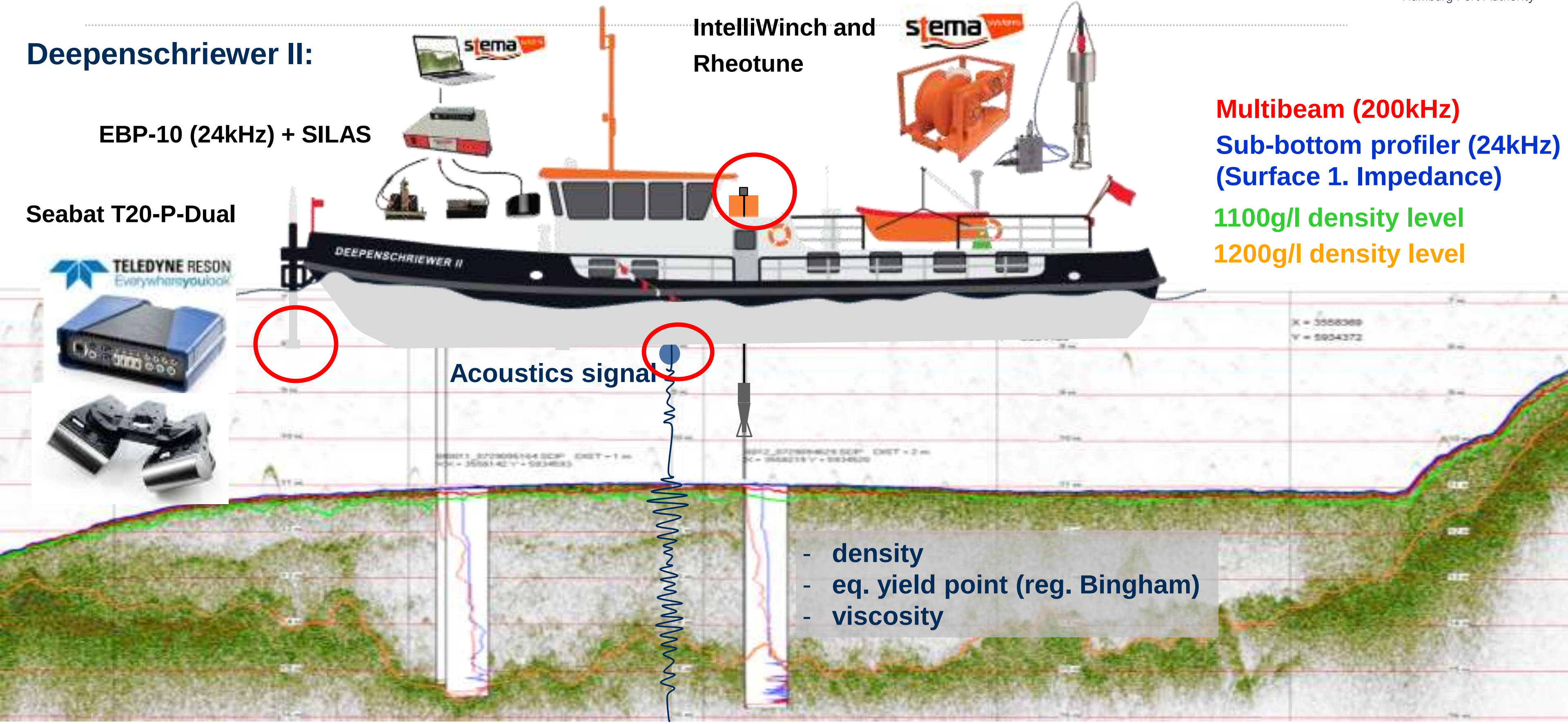




Detection of the river bottom in hydro-acoustical challenging areas



Additional measurements for optimizing dredging works and monitoring



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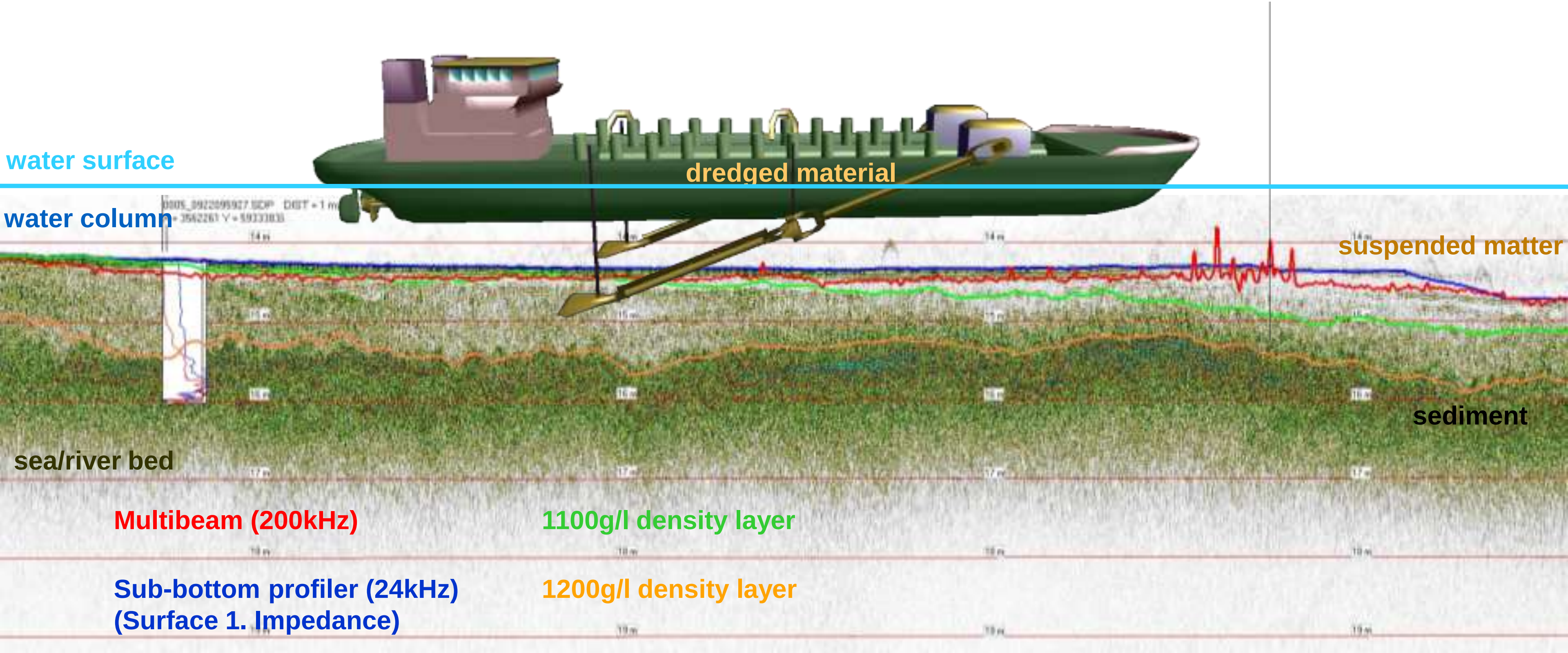
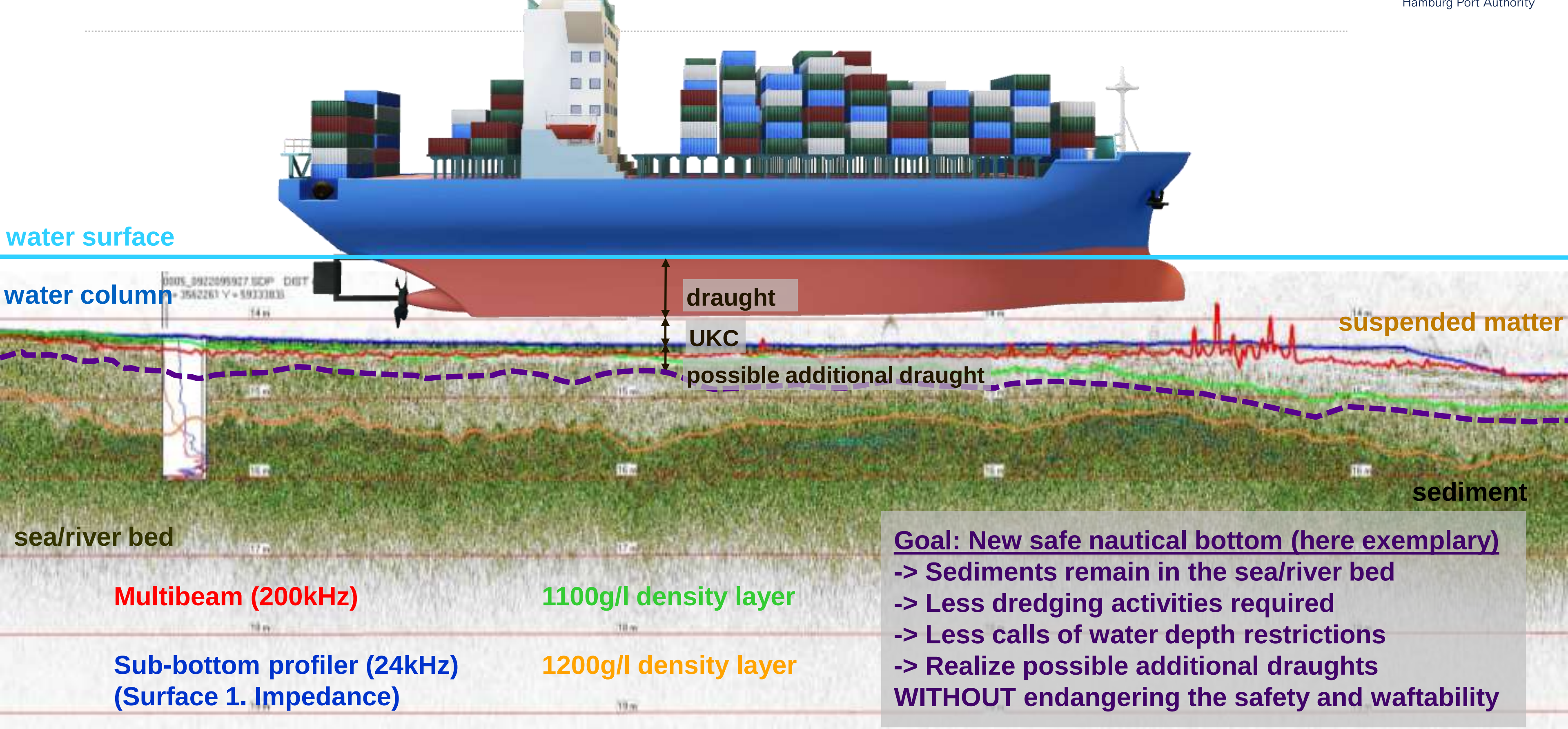


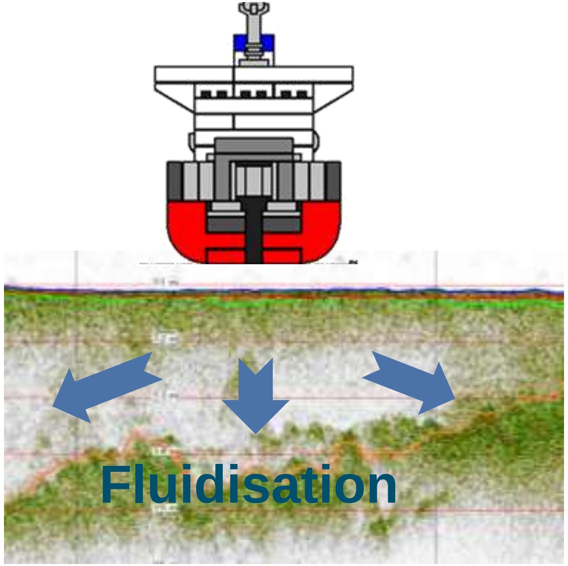
Overview sketch for a safe nautical bottom

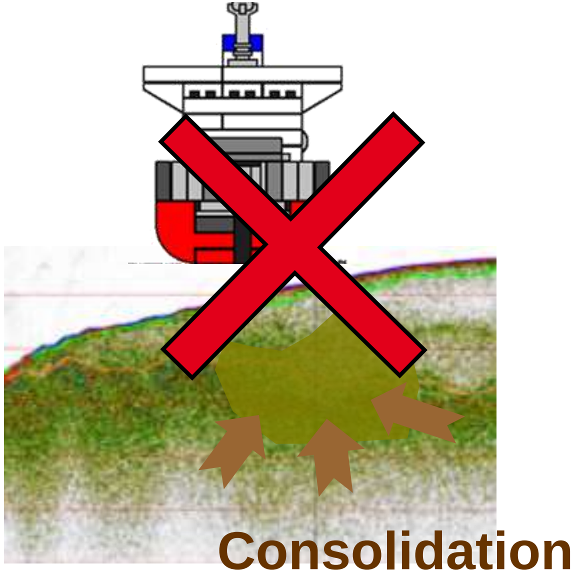


Goal: New safe nautical bottom (here exemplary)
-> Sediments remain in the sea/river bed
-> Less dredging activities required
-> Less calls of water depth restrictions
-> Realize possible additional draughts
WITHOUT endangering the safety and waftability

Investigations regarding nautical depth issues in detail

- Starting stakeholder management processes - first results:
  - Insurance status of the ports should be regarded:
    Keep the “Safe Port”, “Safe Berth” status, do not get a “ NAABSA“ (Not Always Afloat, But Safe Aground) port
  - @ Berths: Ship has to be always afloat -> then everything is safe
  - There are no overlapping regulations known, which may hinder the project aims at all

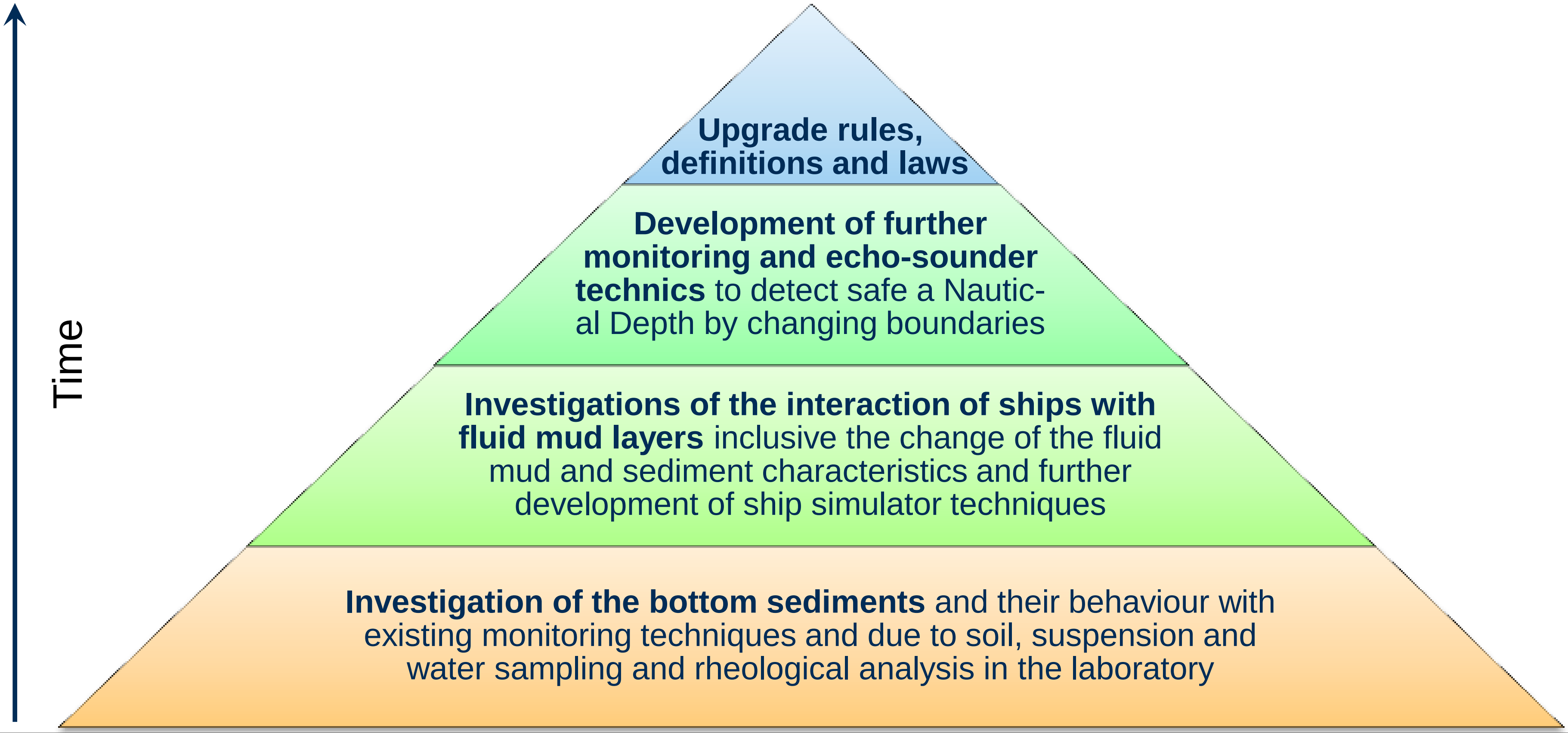




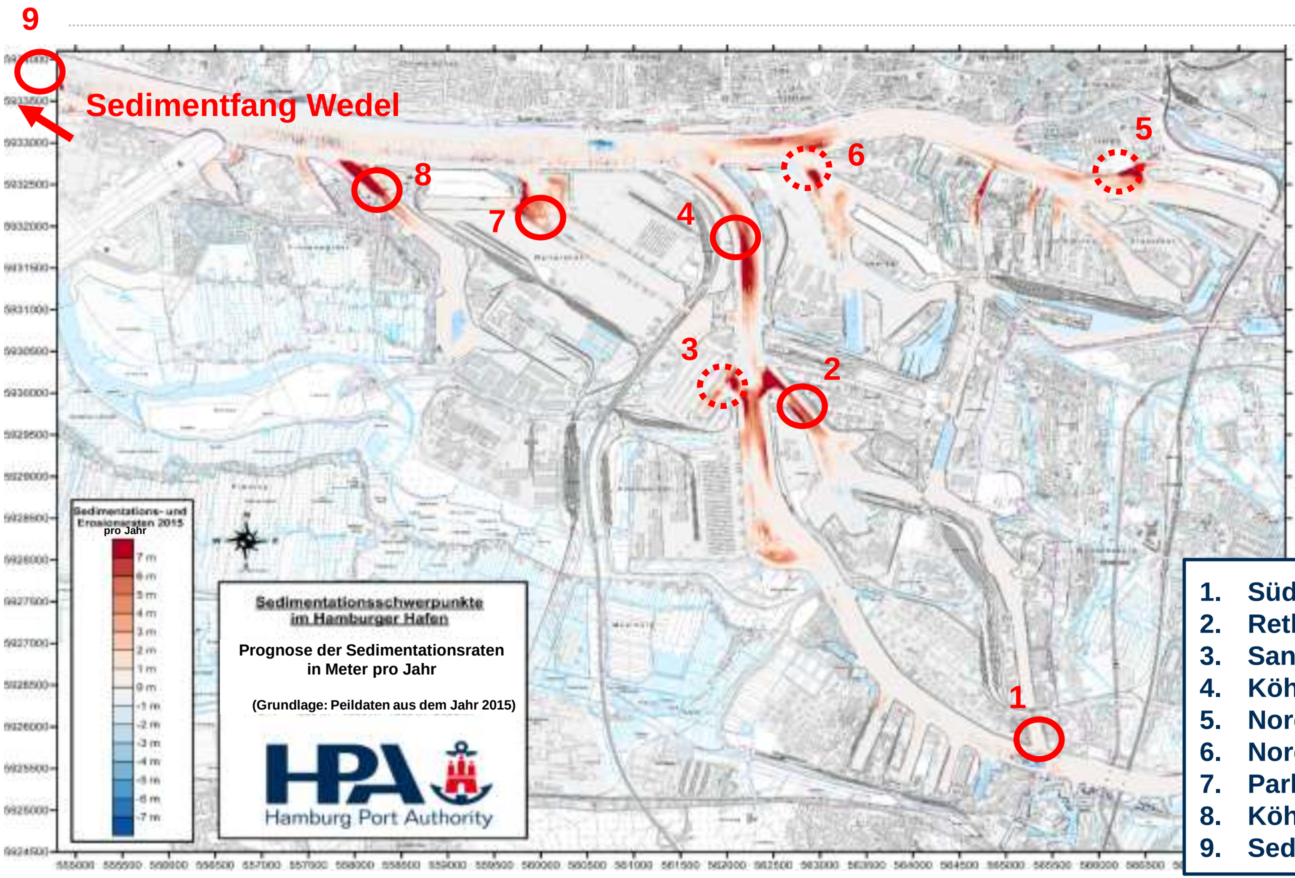
Memorandum of Understandings / Cooperation Frameworks

- **Existing cooperation with**:
  - **Port of Rotterdam**
    - Moving vessels
    - Joint venture with existing research and development projects
  - **Antwerp Port Authority**
    - Moored vessels at berths
    - Adaption of maintained berth depth
  - **International Research and Development Institutions**
    - Delft University of Technology (MudNet in progress)
    - Flanders Hydraulics Research (planned investigations regarding sediment conditioning and consolidation times of sediments)
    - Hamburg University of Technology (Investigations on moving and moored vessels in progress)
- **Existing and planned contracts and cooperation with local partners**:
  - National Research and Development Institutions (RDI)
  - Small and Medium-sized Enterprises (SME)

Necessary steps for the introduction of a safe Nautical Depth



Monitoring Campaign 2018 / 2019



- **KW17** 23.04. - 27.04.2018 **#0**
- **KW23** 04.06. - 08.06.2018 **#1**
- **KW26** 25.06. - 29.06.2018 **#2**
- **KW32** 06.08. - 10.08.2018 **#3**
- **KW38** 17.09. - 21.09.2018 **#4**
- **KW45**: 05.11.- 09.11.2018 **#5**

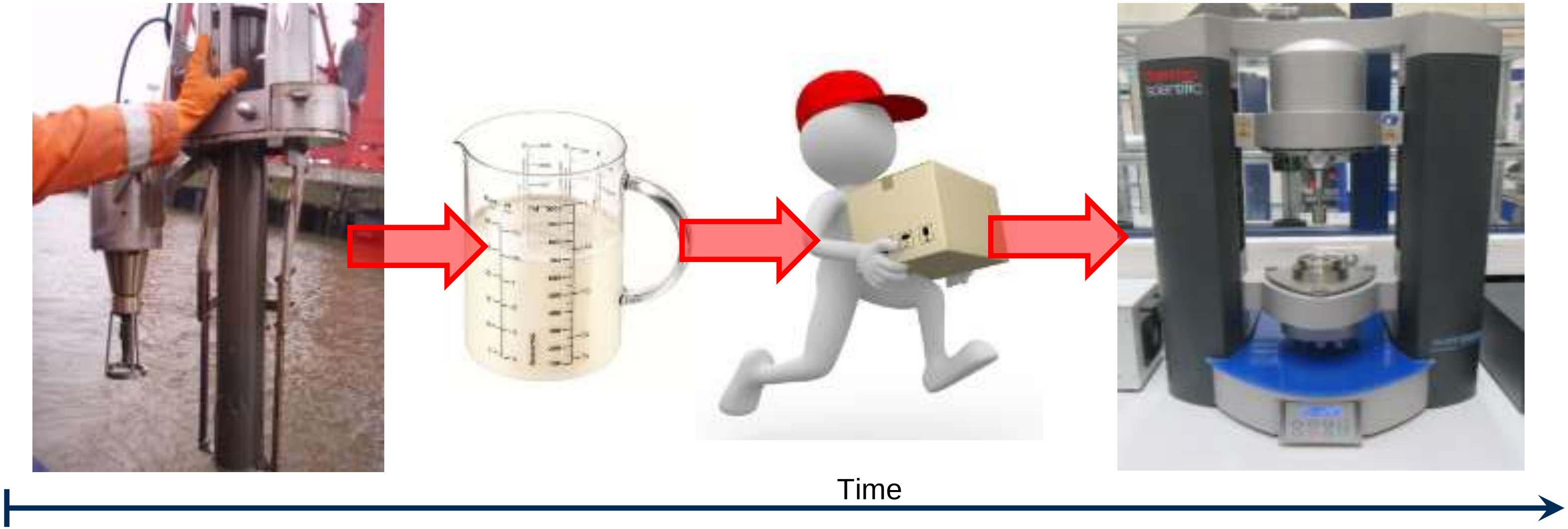
- **KW12** 15.03. - 20.03.2019 **#6**
- **KW19** 05.05. - 08.05.2019 **#7**
- **KW23** 04.06. - 06.06.2019 **#8**
- **KW27** 02.07. - 04.07.2019 **#9**
- **KW33** 13.08. - 15.08.2019 **#10**
- **KW39** 24.09. - 26.09.2019 **#11**
- **KW45** 05.11. - 07.11.2019 **#12**

1. **Süderelbe Vorhafen zur Reihererstieg Schleuse**
2. **Rethe Bereich Blatt 2 und 3**
3. **Sandauhafen LP3 und Unterhaltungsrinne**
4. **Köhlbrand in Höhe KS5**
5. **Norderelbe Strandhafen / Chicagokai**
6. **Norderelbe Höhe Einfahrt Vorhafen**
7. **Parkhafen Predhölkai LP 6**
8. **Köhlfleethafen LP N/S**
9. **Sedimentfang Wedel**

Monitoring Campaign 2018

Laboratory Tests

- **Rheological parameters*: yield stress, viscosity, etc***
- Dry density, wet **density, water content, ignition loss**
- **Grainsize distribution** with and without organic matter

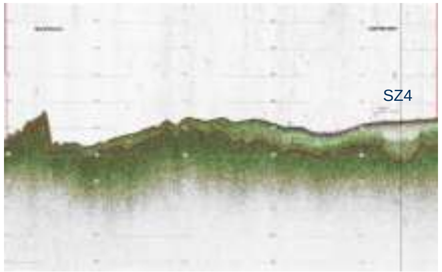


Comparison of in-situ & laboratory data: Sandauhafen

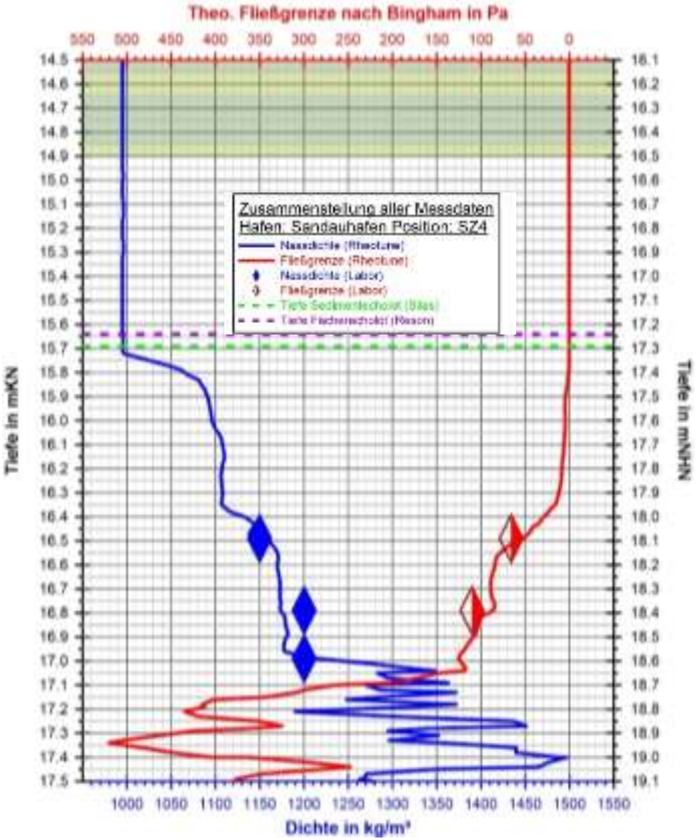
- **Comparison between:**
  - Rheotune device and
  - Rheological investigation in the laboratory

- **Laboratory should be reference:**
  - Rheotune device
    - → fine fit of density and equivalent yield point (reg. Bingham)

- **Data get unreliable in deeper areas:**
  - consolidated bottom layers



Sandauhafen (SZ4)

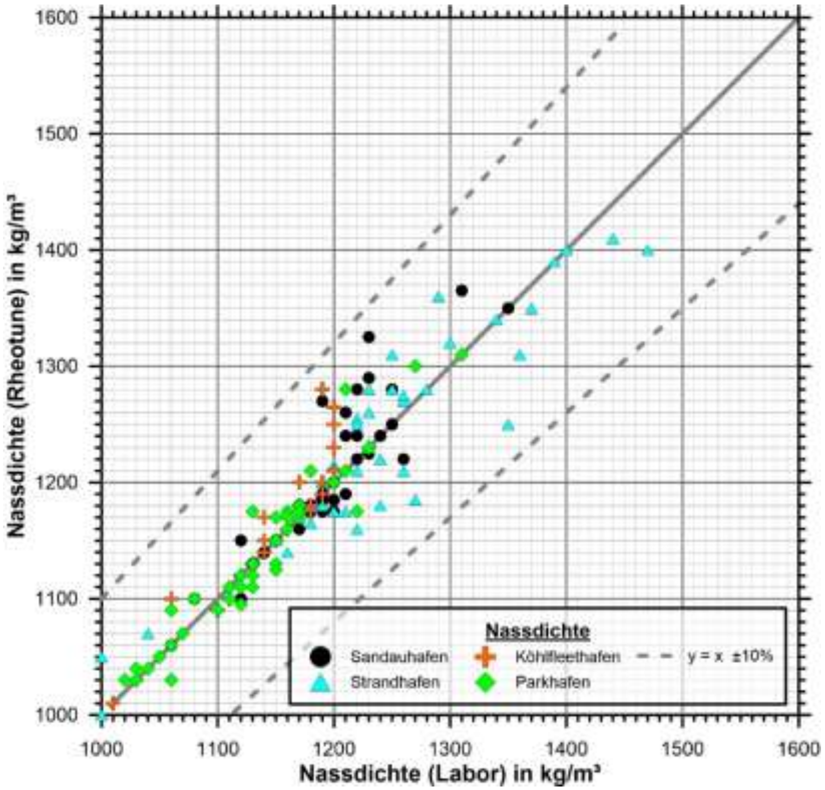


Sandauhafen (SZ4)

Comparison of in-situ & laboratory data: Density

- **Comparison of all investigation areas**

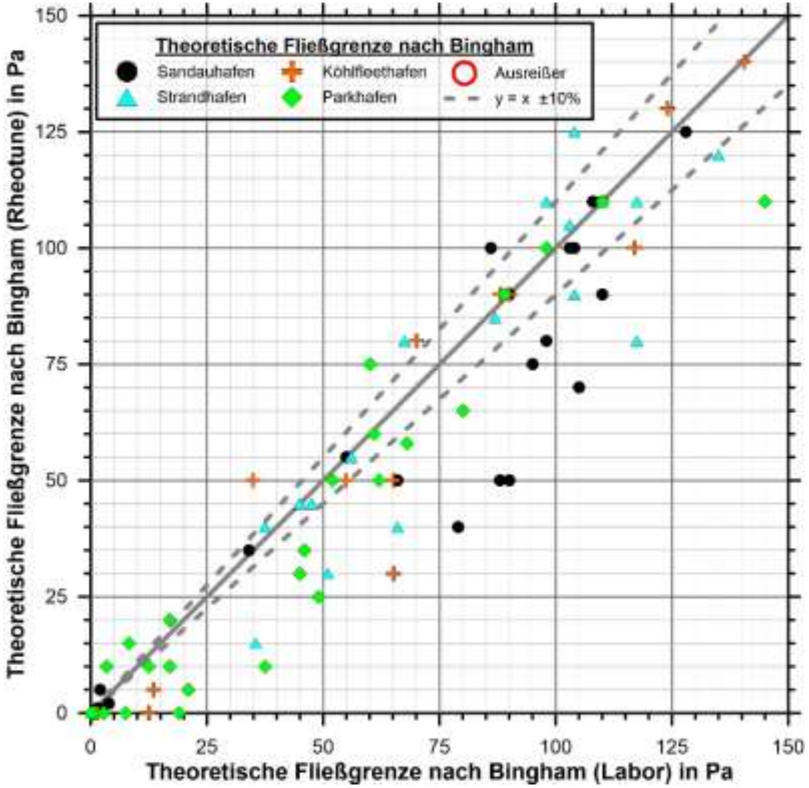
  → Rheotune measurements
  and laboratory data fits
  within a tolerance area
  of 10 %!



Comparison of in-situ & laboratory data: Eq. yield point (reg. Bingham)

- **Comparison of all investigation areas**
  up to 150 Pa eq. yield point (reg. Bingham)

  → higher scatter
  → bad calibration of Rheotune device
  in fluid mud areas
  → world-wide calibration of the Rheotune
  Enhancement due to direct calibration
  of the rheotune with Hamburg silt



Theoretische Fließgrenze bis 150 Pa im Vergleich zur Rheotune und im Labor

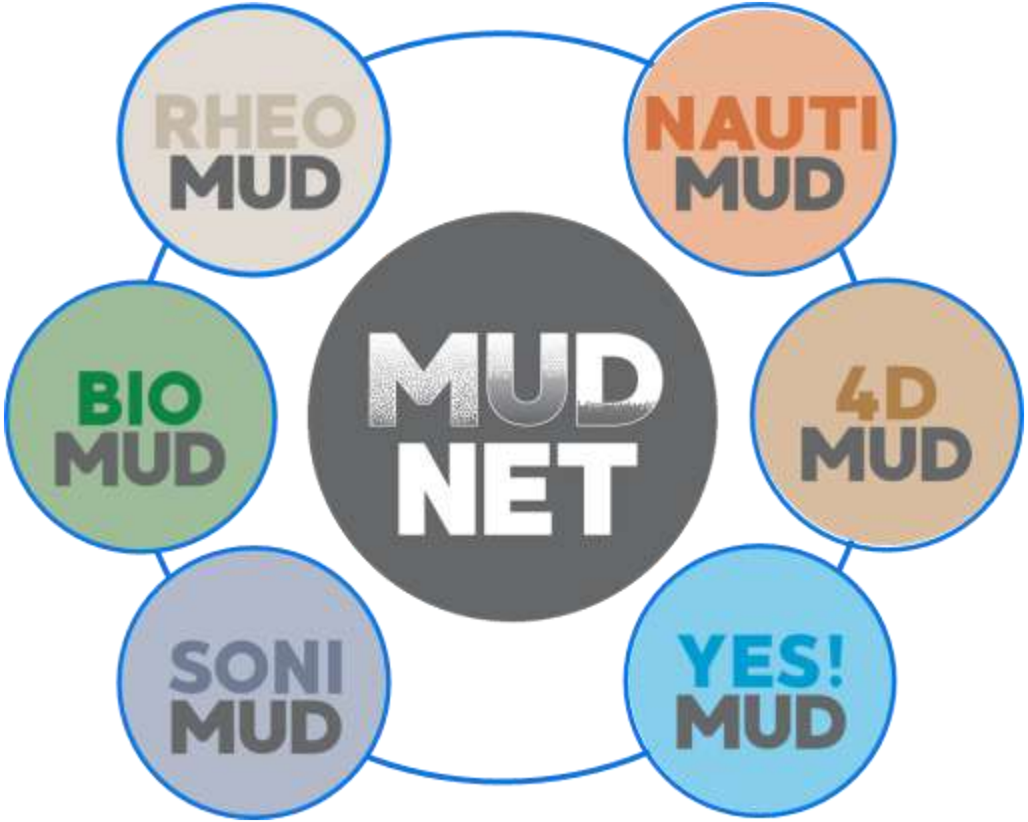
MUDNET Network

Hamburg Port Authority

Port of Rotterdam

TUDelft Delft University of Technology

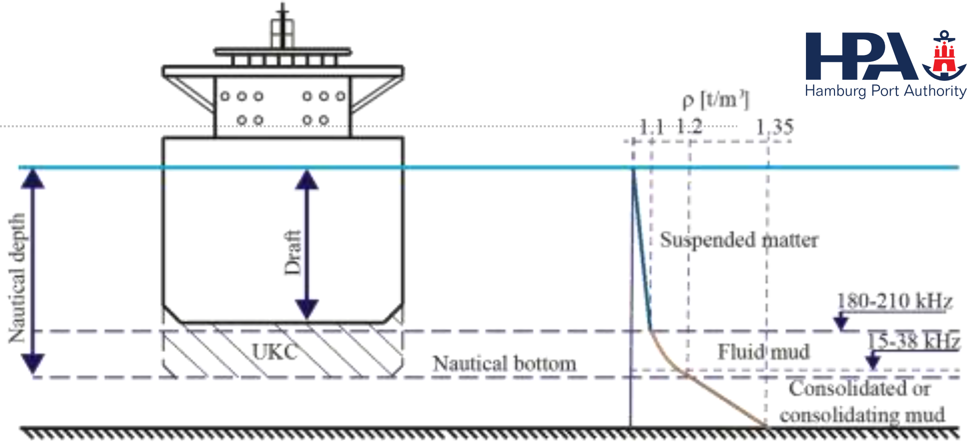
Hamburg Port Authority



See also:

http://www.mudnet.eu

research questions



1) Comparison of different sampling methods during monitoring campaign and of different mud samples by means of physico-chemical analysis -> **Quantitative and qualitative characterization of mud of different port areas**

2) Investigations of the **boundary conditions for different fluid mud behaviour**.

3) **Cross reference** and investigations in the **basic physical, biological and geo-chemistry processes** (see next slides for BIOMUD)

4) **Understanding the consolidation / settling behaviour** of mud from different port location.

5) Rheological analysis of mud using samples and definition of **boundary conditions** which influence fluid mud and which should be operationally **measured to predict changes in the nautical depth concept.**

6) **Theoretical modelling of consolidation** and **prediction of rheological properties** of mud **in time**.

What do we find in Hamburg?

chocolate drink

Fluid Mud (FM)

(density < 1.2 kg/L)

yoghurt

Pre-Consolidated (PS)

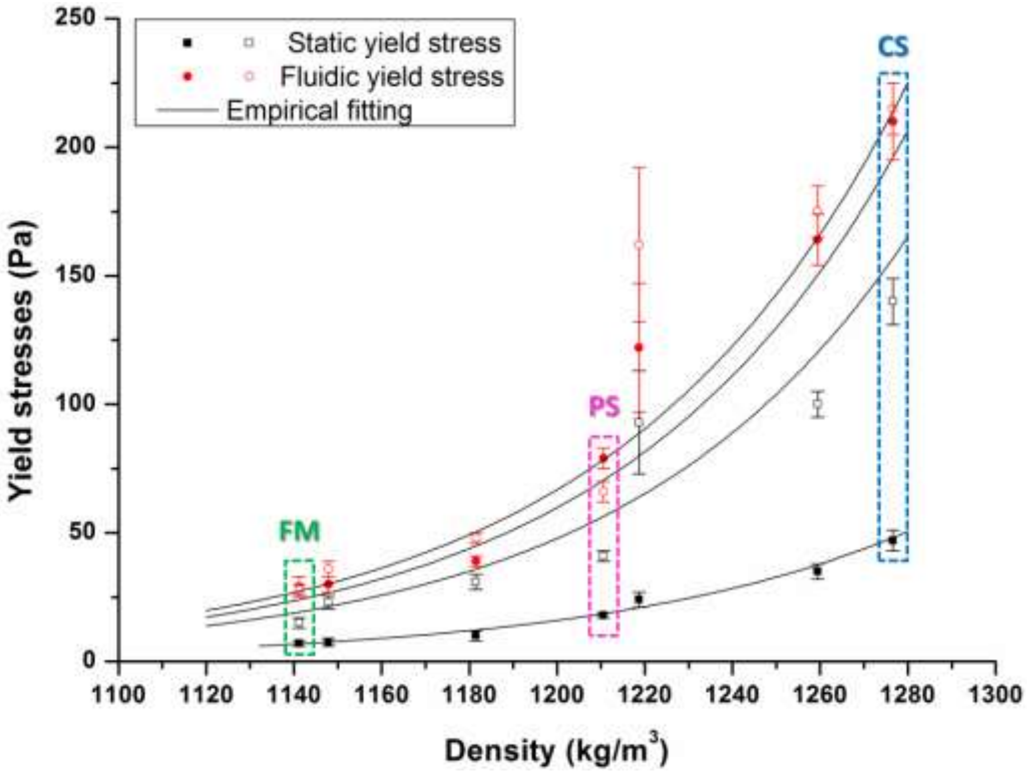
(density < 1.3 kg/L)

pudding

Consolidated (CS)

(density < 1.3 kg/L)

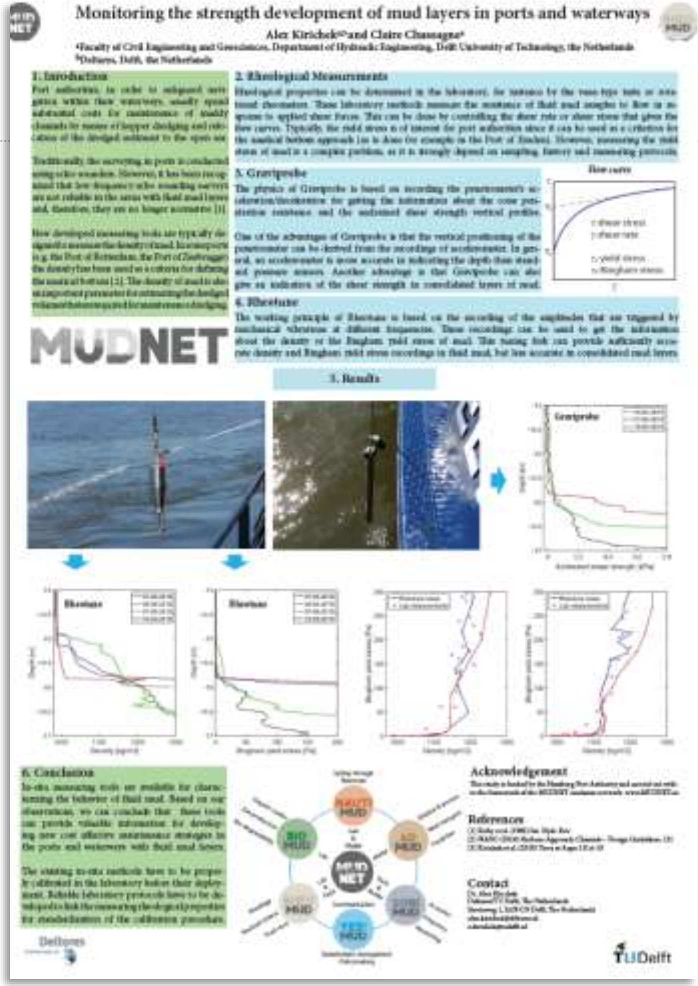
First Conclusions / Characterisations of the mud in Hamburg

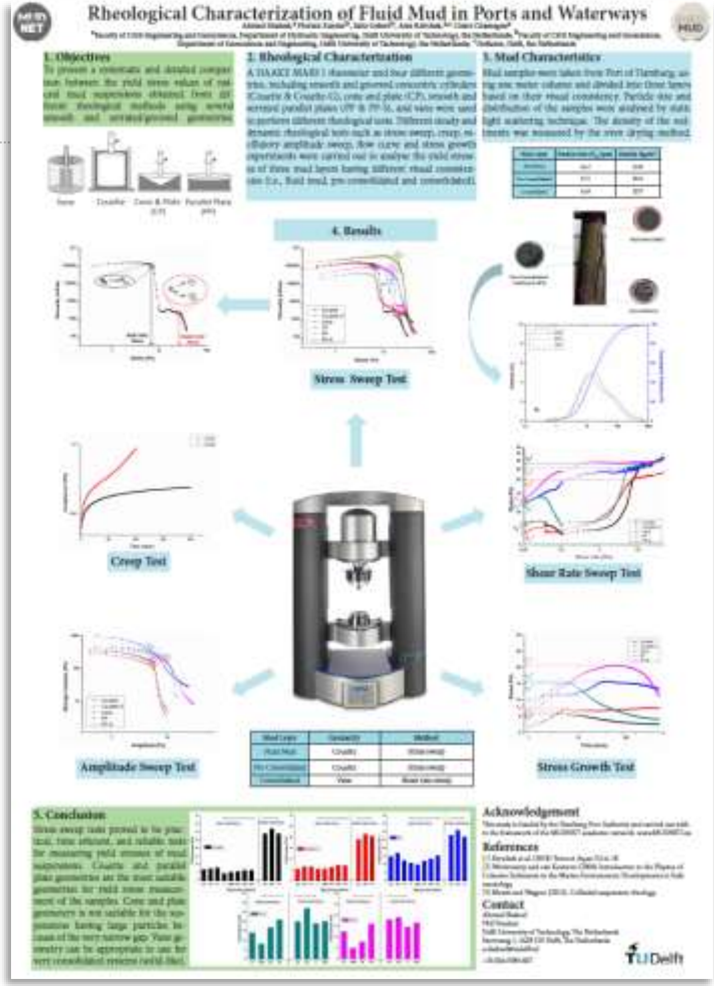


$$\sigma_{yield} = \sigma_0 \, e^{\rho/\rho_0}$$

$$\rho = \frac{\text{mass water} + \text{mass solids}}{\text{volume water} + \text{volume solids}} = \phi_s \rho_s + (1 - \phi_s)\rho_w$$

Posters


Monitoring the strength development of mud layers in ports and waterways
1. Introduction
2. Rheological Measurements
MUDNET
Acknowledgement
References
Contact

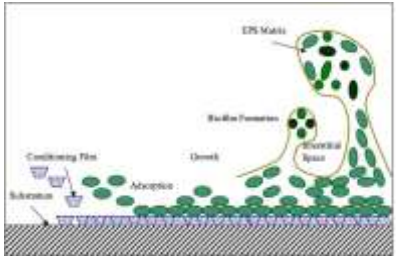

Rheological Characterization of Fluid Mud in Ports and Waterways
1. Objectives
2. Rheological Characterization
3. Mud Characteristics
4. Results
Stress Sweep Test
Creep Test
Shear Rate Sweep Test
Amplitude Sweep Test
Stress Growth Test
5. Conclusion
Acknowledgement
References
Contact

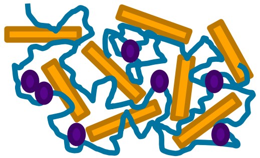
BIO MUD

research questions

1) What is the relationship between **organic matter (OM) lability** and the physicochemical properties of OM and sediments?
2) What is the **spatiality** of the biogeochemical properties in the harbor area (locations)?
3) What is the **temporal variability** of biogeochemical properties (season)?
4) What is the effect of OM lability on the processes of flocculation, sedimentation and consolidation within the four-layer system of SPM, FM, PS and CS (**depth**)?

On the definition:
What is fluid mud?
Why is there fluid mud?
Where it develops?
Which are the drivers?





Polymers = slime that are originates from micro-organisms and that have a density comparable to water; a fluid-mud layer must be in an **aerobic state** so that the bacterial (micro-organisms) cultures have the continuing ability to produce this slime.
The slime also significantly reduces the internal friction between clay particles.

Laboratory analyses

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1) Organic matter degradation

- Anaerobic conditions (gas production: CH_4, CO_2)
- Aerobic conditions (respiration: CO_2)
- Longest duration so far: 250 days
- Standard evaluation after 21 and 100 days
- Unit: mg C/g TOC, giving C-quality of OM

2) OM physical and chemical properties

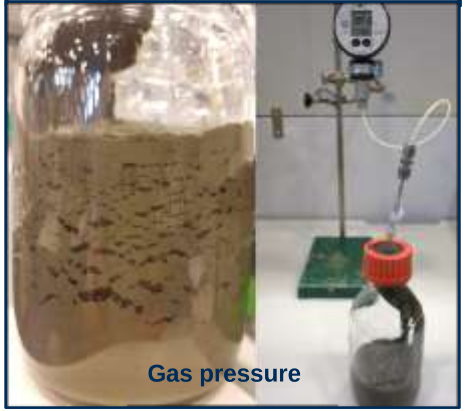
- Physical: density fractionation; TOC, TN, $\delta^{13}C$ in density fractions
- Chemical: humic acids, fulvic acids

3) Microbiology

- Microbial biomass
- Community composition (DNA)
- Extrapolymeric substances (EPS, “slimes”)

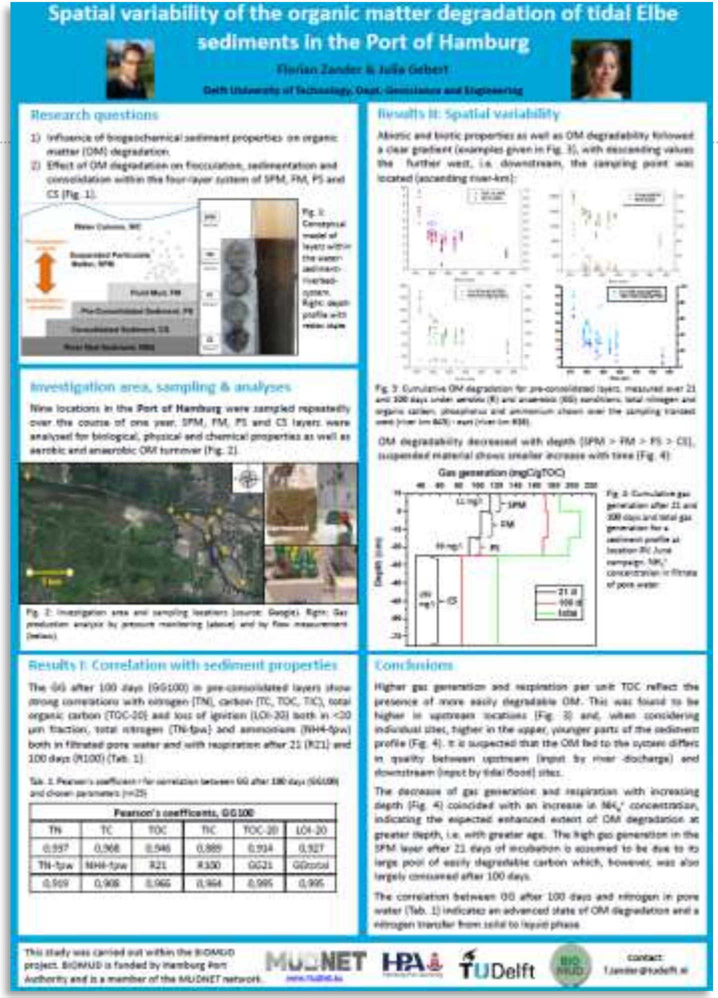
4) Standard sediment properties

- Standard solids physics & chemistry + redox potential
- Standard pore water chemistry + DOM

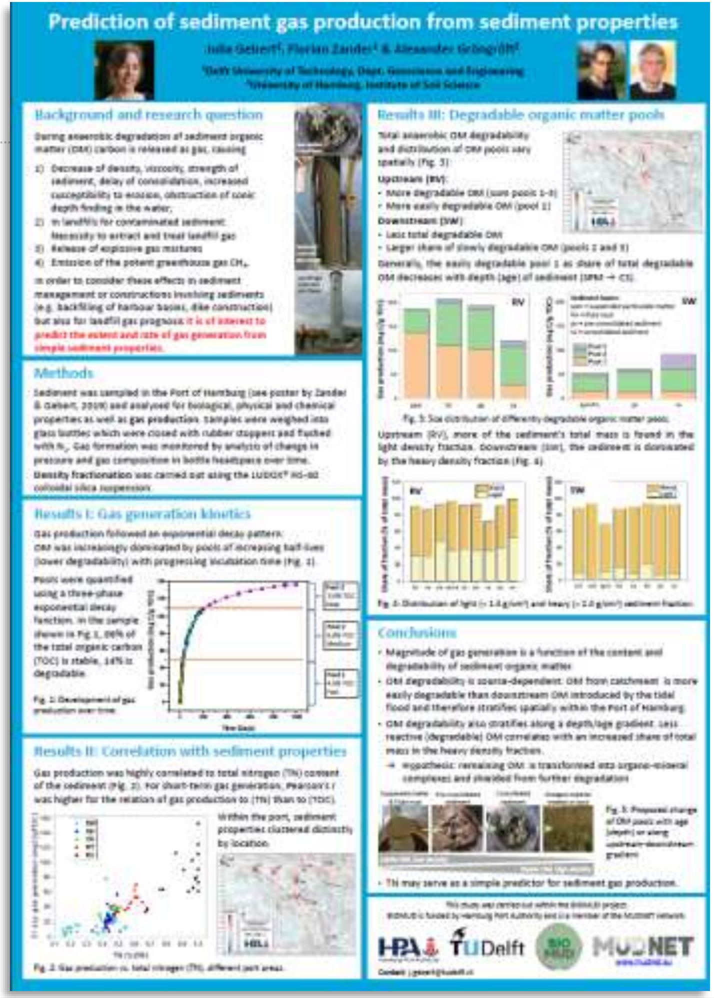


BIO MUD

Posters



Spatial variability of the organic matter degradation of tidal Elbe sediments in the Port of Hamburg
Florian Zander & Julia Gebert
Delft University of Technology, Dept. Geoscience and Engineering
Research questions
Results II: Spatial variability
Investigation area, sampling & analyses
Results I: Correlation with sediment properties
Conclusions



Prediction of sediment gas production from sediment properties
Background and research question
Results III: Degradable organic matter pools
Methods
Results I: Gas generation kinetics
Results II: Correlation with sediment properties
Conclusions

Thank you for your Attention !

Is it Gold, Waste or just Mud ?

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