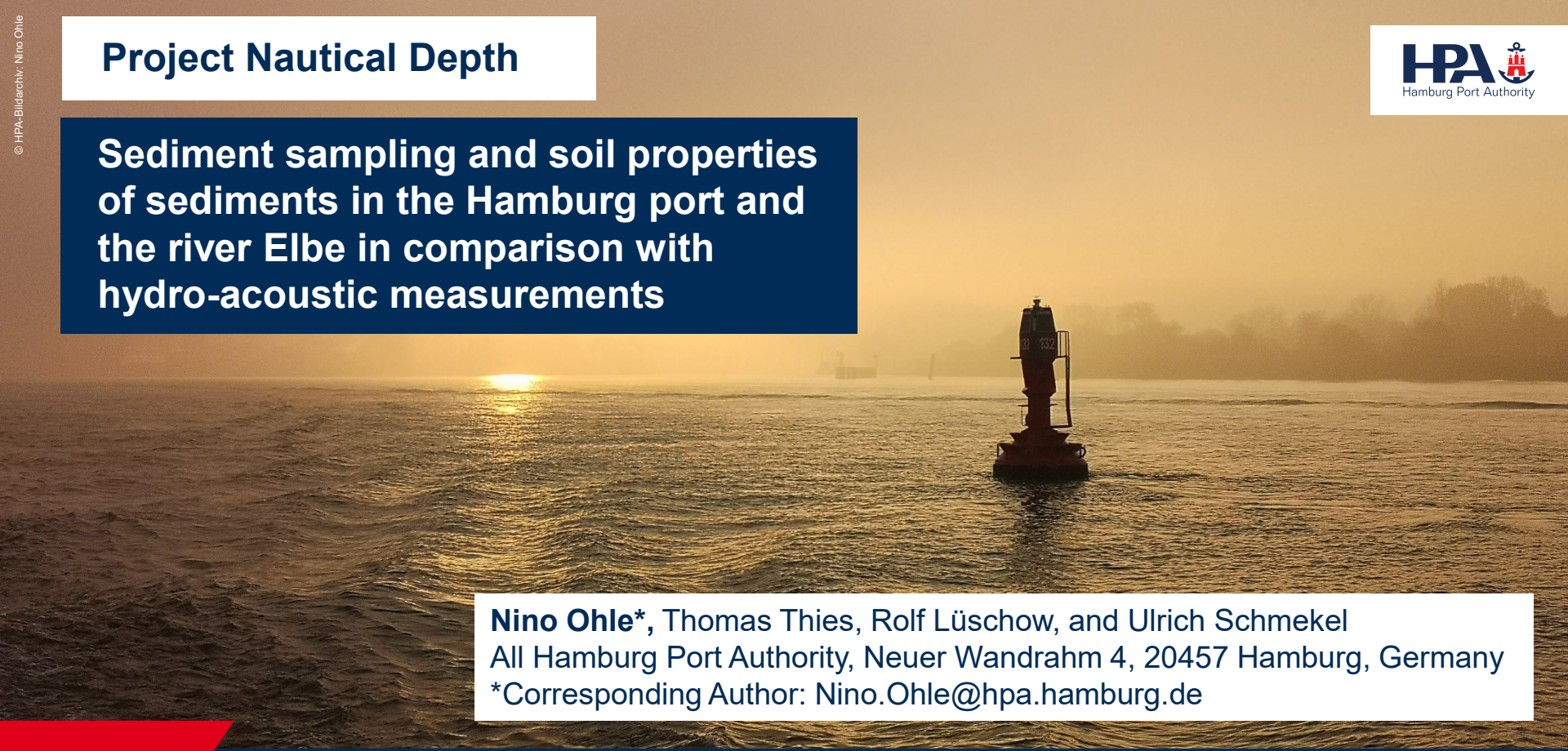
Project Nautical Depth

Sediment sampling and soil properties of sediments in the Hamburg port and the river Elbe in comparison with hydro-acoustic measurements



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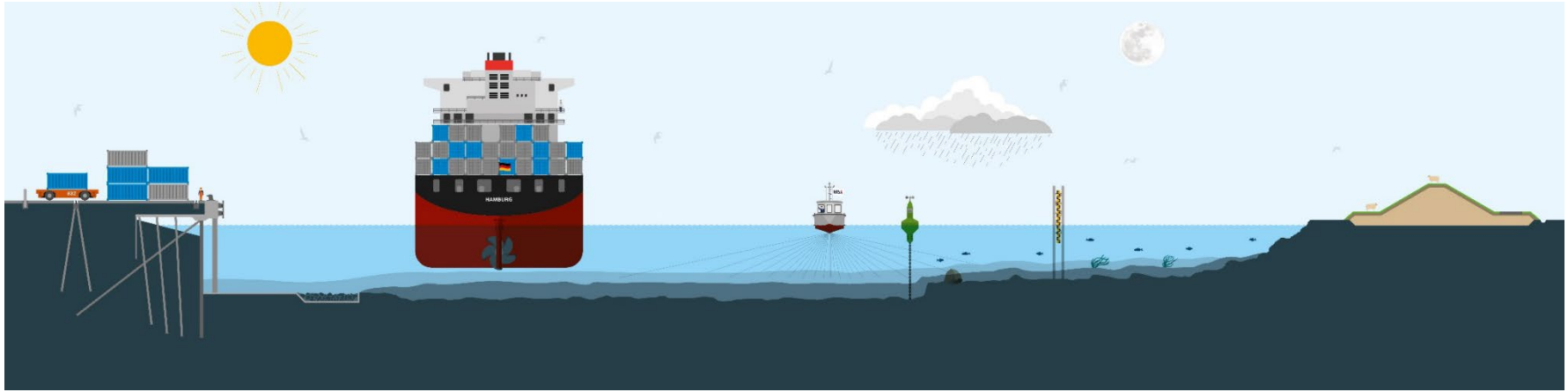
EGU General Assembly 2020, Session HS9.3
Measurements, monitoring and modelling of hydro-morphological processes in open-water environments

Background: Use of the Nautical Depth Term according to PIANC* (1997)



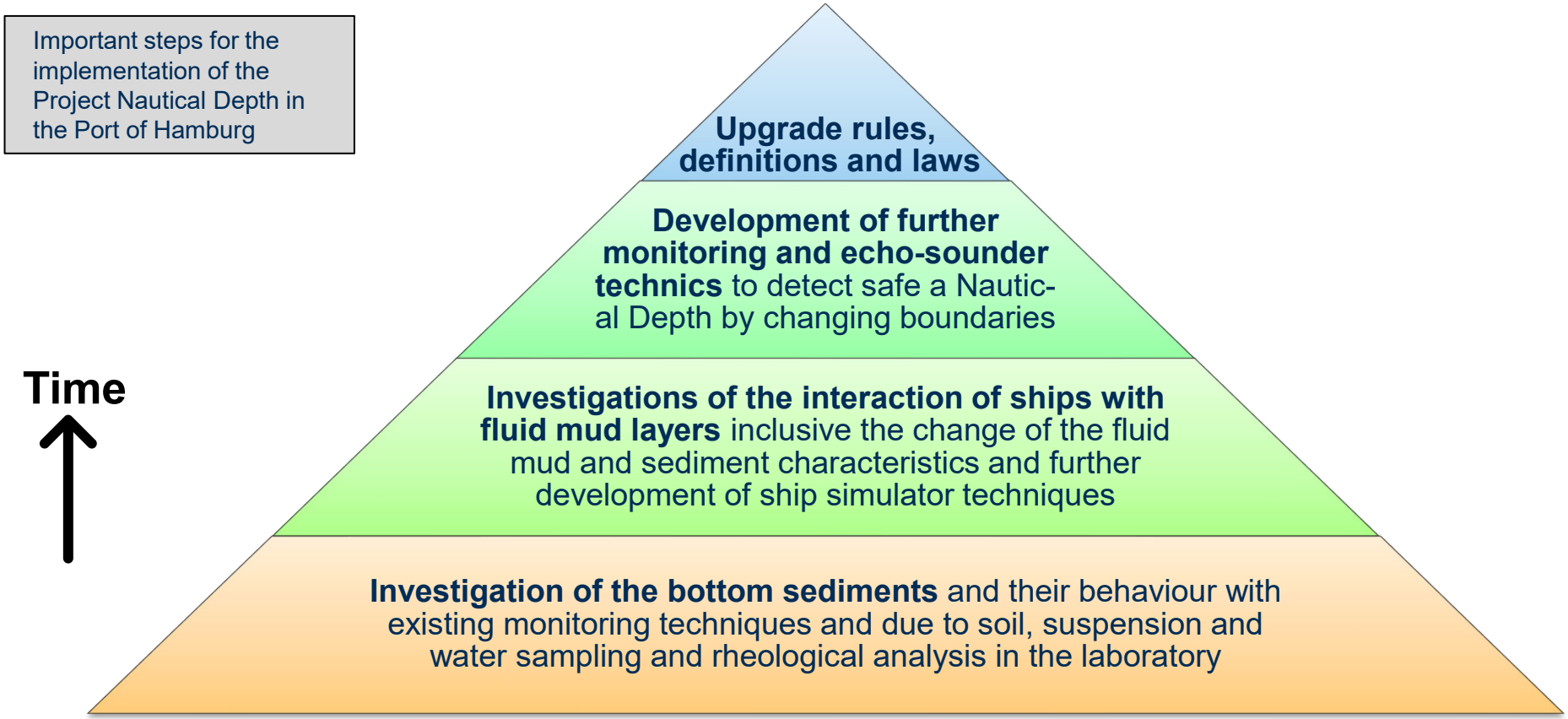
"The nautical depth is the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship's keel causes either damage or unacceptable effects on controllability and maneuverability."

*PIANC: Permanent International Association of Navigation Congresses

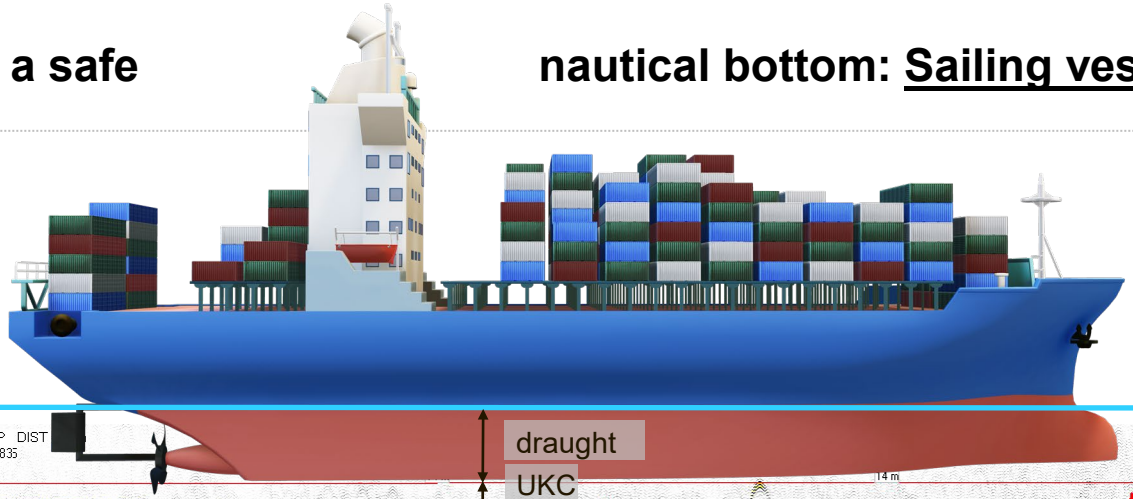
Background: Steps for introduction of a safe Nautical Depth in Hamburg

Hamburg Port Authority

Important steps for the implementation of the Project Nautical Depth in the Port of Hamburg



Goals: For a safe nautical bottom: Sailing vessel



water surface

water column

draught

UKC

possible additional draught

suspended matter

sediment

sea/river bed

Multibeam (200kHz)

1100g/l density layer

Sub-bottom profiler (24kHz)
(Surface 1. Impedance)

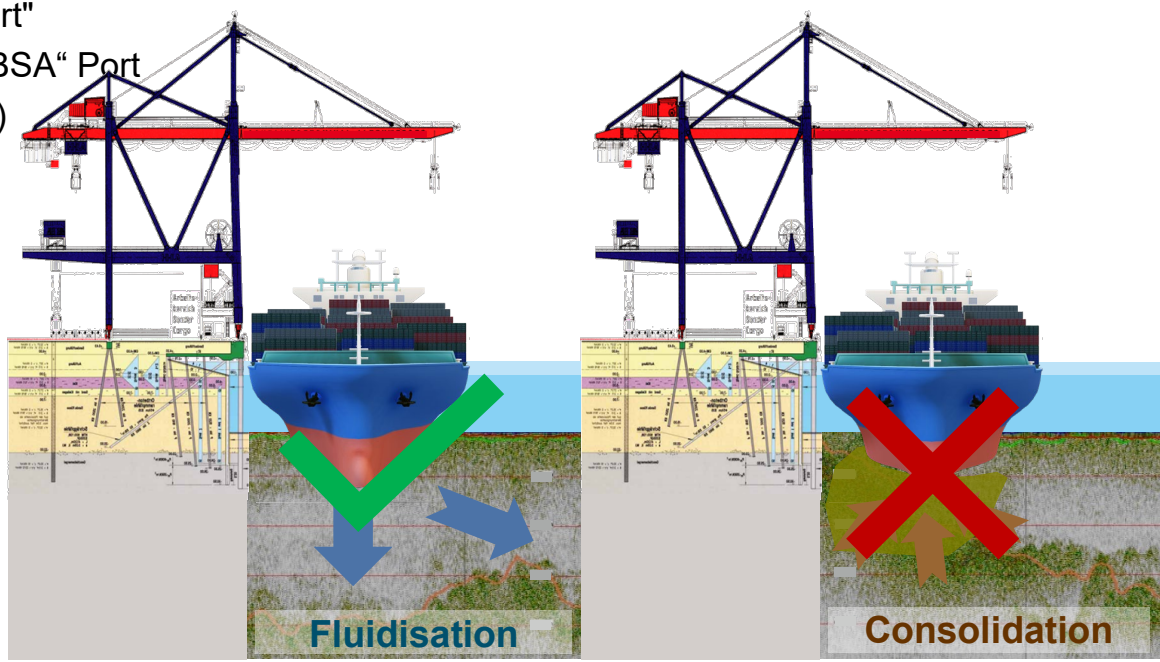
1200g/l density layer

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 ease of handling

Goals: For a safe nautical bottom: Moored Vessels

- Determination of limit values for "safe" penetration of ships in fluid mud layers during low water situations
- Results of initial interviews with stakeholders (BG Transport, Shipowners, Insurance):
  - Insurance status must be observed:
  - Hamburg has the status of a "Safe Port"
  - Hamburg should not become a “NAABSA“ Port
    (Not Always Afloat, But Safe Aground)

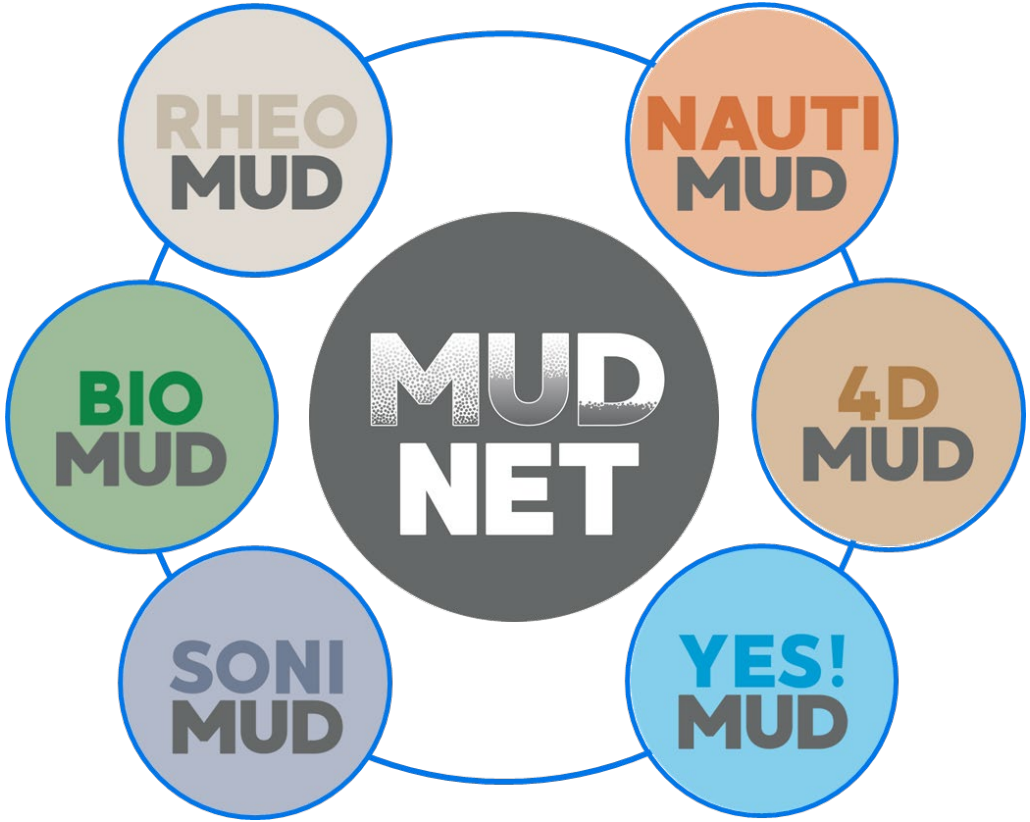
- For berths areas, this means:
- Ships have to swim all the times
  -> **The Archimedes Principle have to be observed!**
- The water cooling of ship machines have to be done via upper sea boxes!
- No other regulations known, which stand against the sinking of the ships in ground suspensions!



Port of Rotterdam

TU Delft Delft University of Technology

Hamburg Port Authority



See also:

http://www.mudnet.eu

Applied monitoring methods to describe the soil layers in Hamburg

Hamburg Port Authority

Monitoring devices of the Deepenschriewer II with systems for line detection of the sub-bottom (sub-bottom profiler) and devices of in-situ calibration (Rheotune):

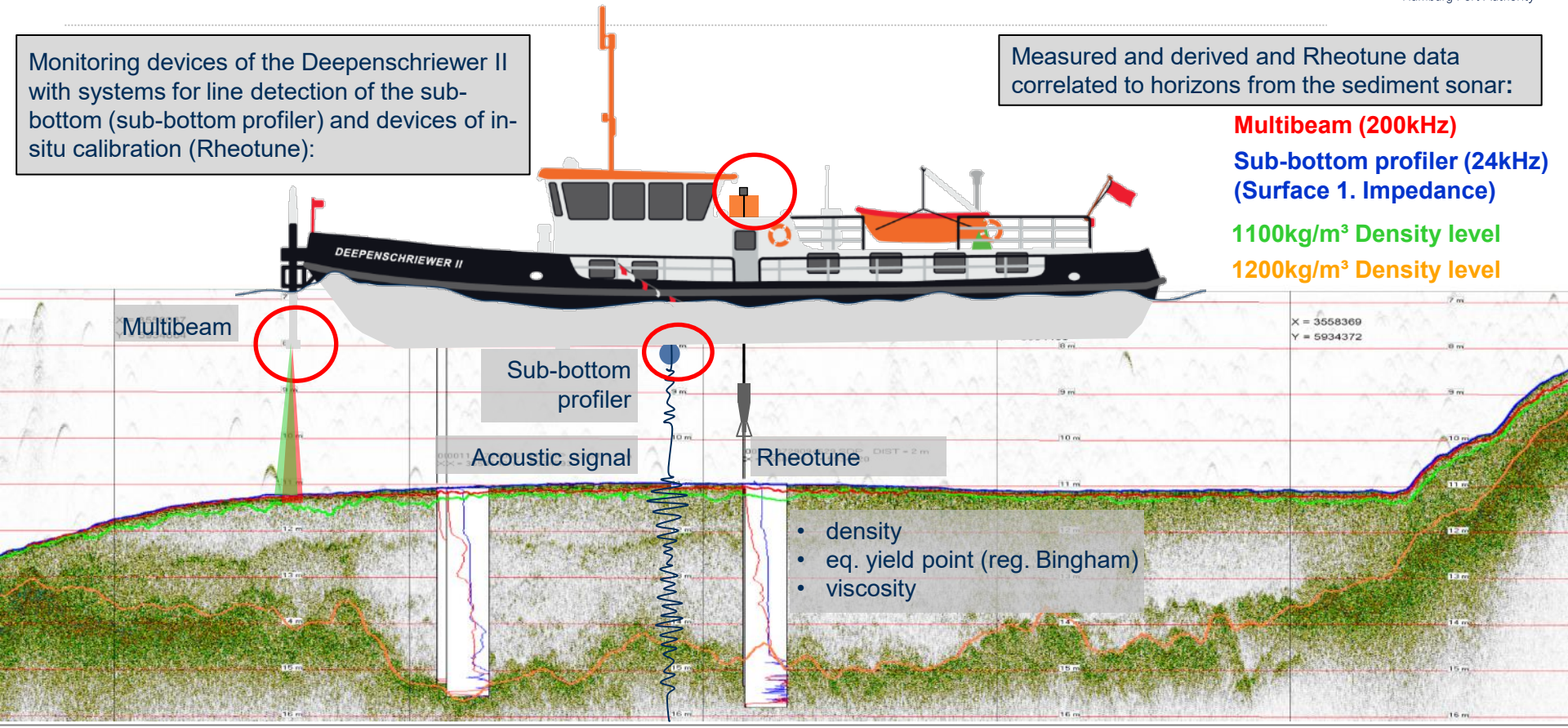
Measured and derived and Rheotune data correlated to horizons from the sediment sonar:

Multibeam (200kHz)

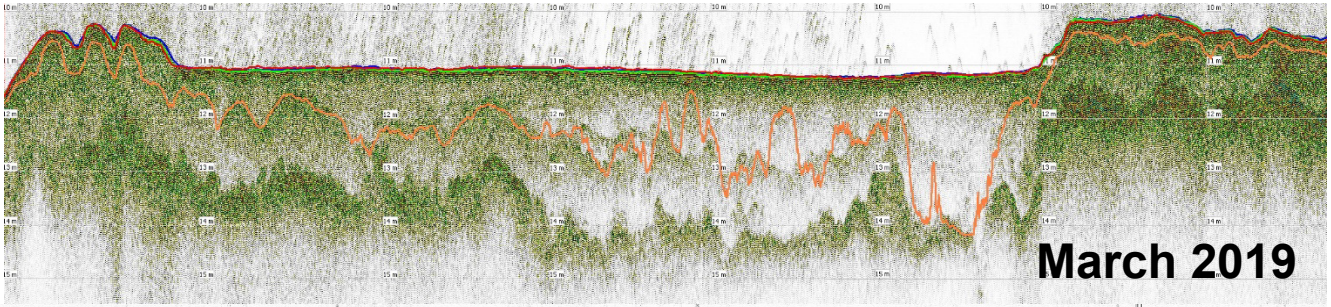
Sub-bottom profiler (24kHz) (Surface 1. Impedance)

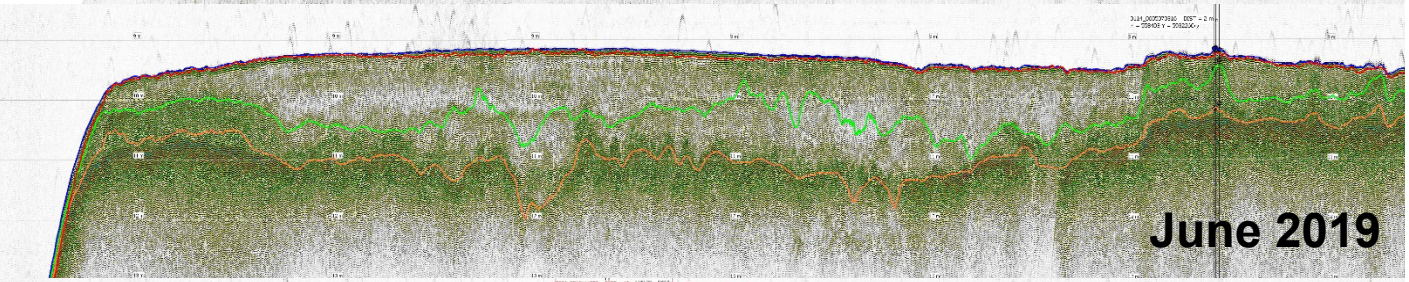
1100kg/m³ Density level

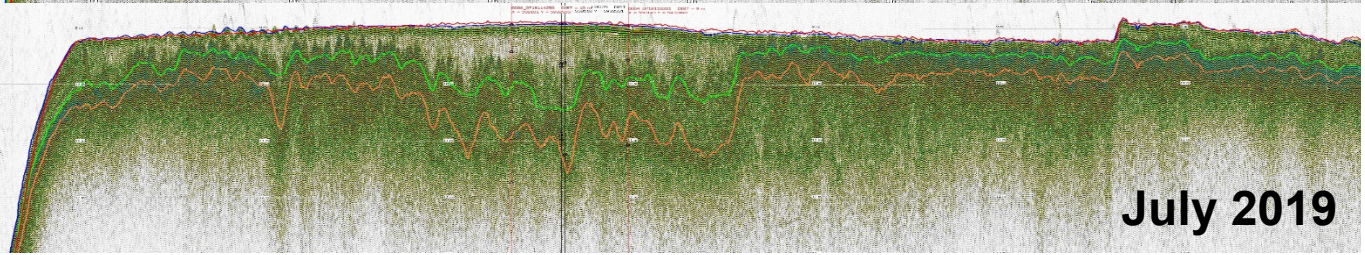
1200kg/m³ Density level

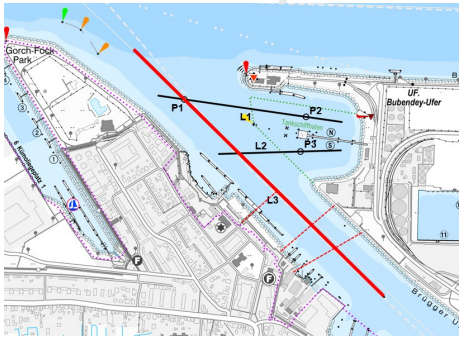


Detection of the parameters of a suspension layer in 4D



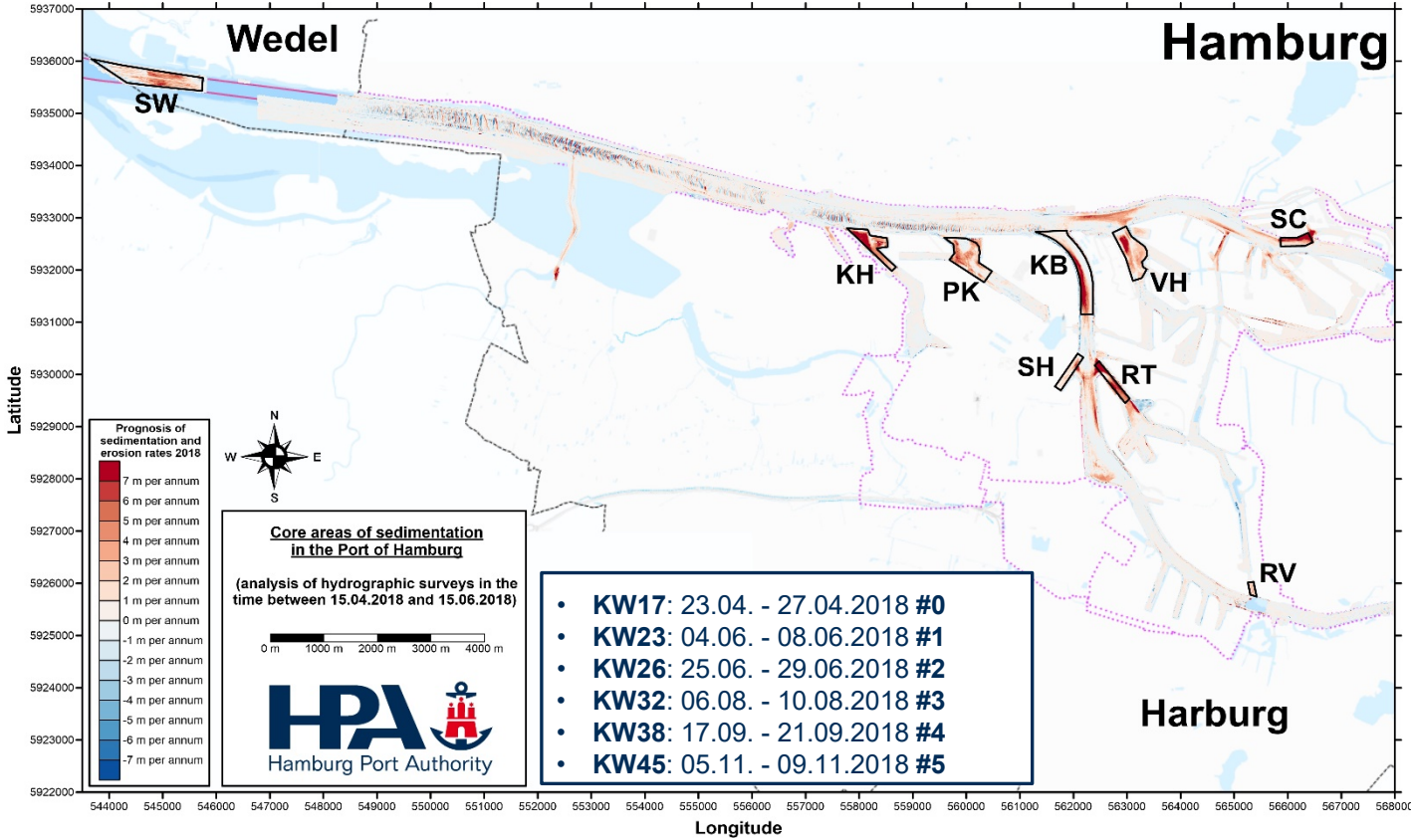






Density lines over time:
Changes in fluid mud layers in Köhlfleet Harbour over the time

Monitoring Campaigns 2018 / 2019 at the Hamburg port



- **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**

RV	**Süderelbe Vorhafen zur Reihererstieg Schleuse**
RT	**Rethe Bereich Blatt 2 und 3**
SH	**Sandauhafen LP3 und Unterhaltungsrinne**
KB	**Köhlbrand in Höhe KS5**
SC	**Norderelbe Strandhafen / Chicagokai**
VH	**Norderelbe Höhe Einfahrt Vorhafen**
PK	**Parkhafen Predhölkai LP 6**
KH	**Köhlfleethafen LP N/S**
SW	**Unterelbe Sedimentfang Wedel**

- **KW 12:** 18.03. - 20.03.2019 **#6**
- **KW 19:** 06.05. - 08.05.2019 **#7**
- **KW 23:** 04.06. - 06.06.2019 **#8**
- **KW 27:** 02.07. - 04.07.2019 **#9**
- **KW 33:** 13.08. - 15.08.2019 **#10**
- **KW 39:** 24.09. - 26.09.2019 **#11**
- **KW 45:** 05.11. - 07.11.2019 **#12**

Investigation of the sediments with different devices

Gravi-probe | BAW-Kernlot | Frahmlot 2018 ø10cm with/without Rheotune | Frahmlot 2019 ø15cm with/without Rheotune | Admodus USP pro

Impressions of sampling sediments of the bottom and further development and testing of in-situ monitoring instruments for the description of soil conditions

What sediments can be found in the Port of Hamburg?

Review

Areas that, according to the investigations, may still be safe to sail

Review

Areas that are certainly not easily navigable, but where - according to the investigations – a ship may still safely sink into fluid mud layers at the berth

Areas that will not be usable in the future for navigation purposes, but can be well maintained with hopper dredger

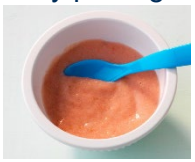
Bottom below the target depth, which is not maintained by default

Suspended Matter

Custard

Fluid Mud (FM)

Baby porridge



Pre-Consolidated (PS)

Pudding

Pre-Consolidated (PS) bis Consolidated (CS)

Semolina pudding

Consolidated (CS)

SPM

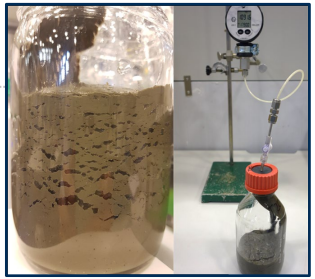
FM

PS

PS-CS

CS

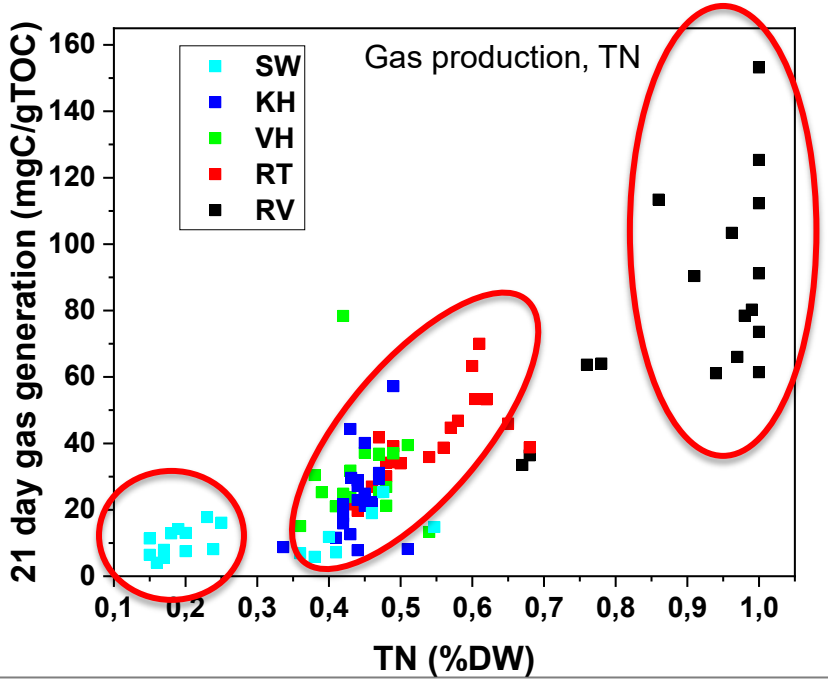
One challenge more …



- Gas production within the sediment layers …

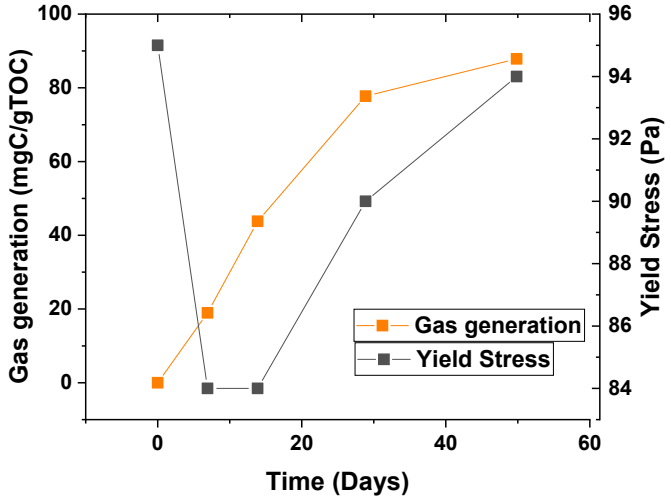
Clustered locations: High, medium, low

TN and gas production



Influence of gas production on yield stress and yield point

- Increase in gas generation and yield stress after 2nd measurement

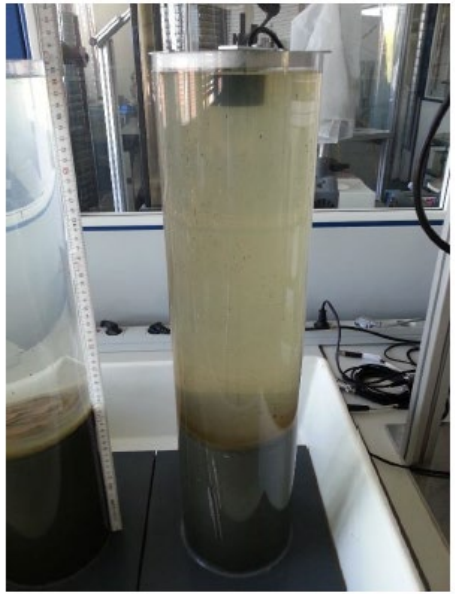


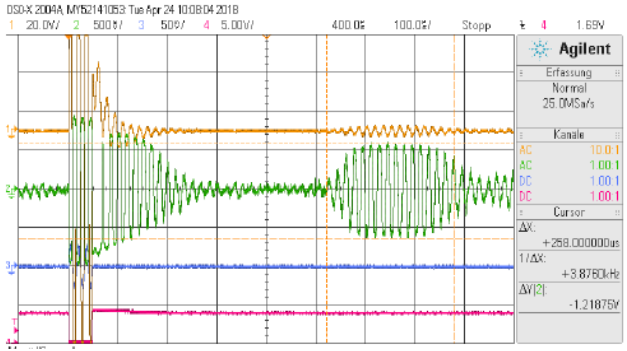
Partner: Fraunhofer Gesellschaft Institute for Biomedical Technics

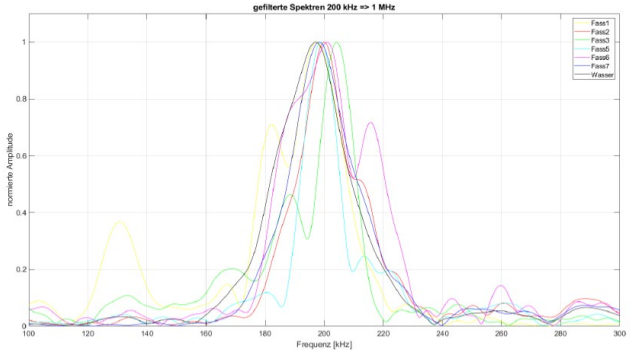
- Preliminary Laboratory Tests:

  Transmission and reflection measurements

https://www.ibmt.fraunhofer.de/de/ibmt-kernkompetenzen/ibmt-ultraschall/ibmt-sonar.html

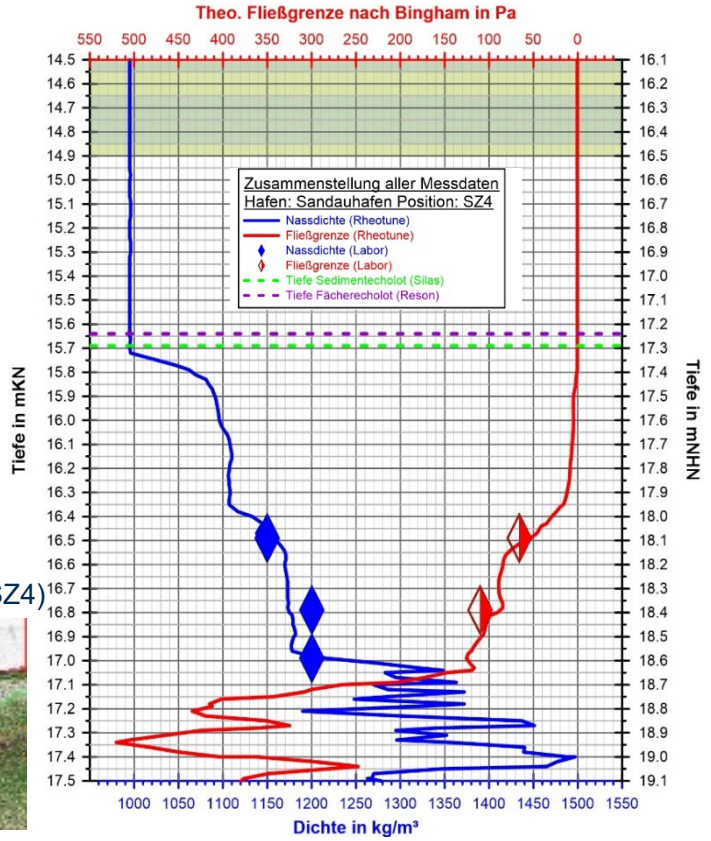




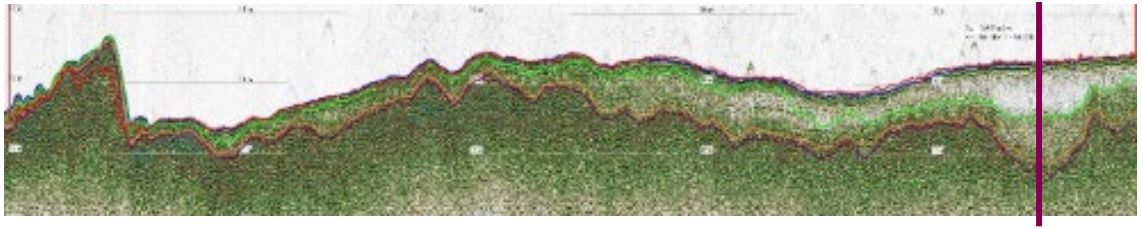


Partner: Stema Systems from the Netherlands (https://stema-systems.nl/)

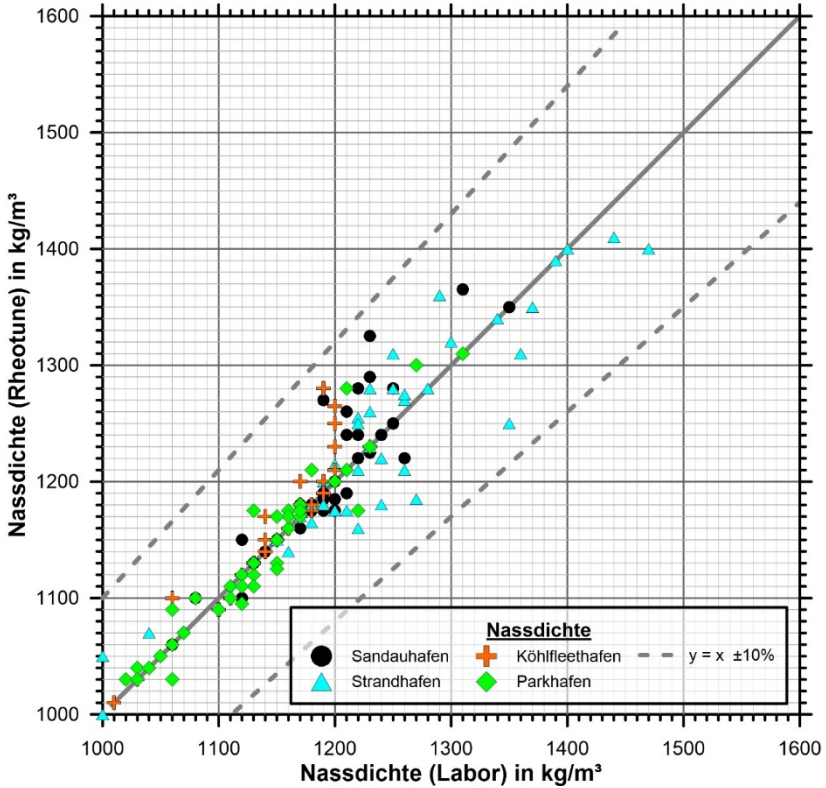
- Comparison of data at the Sandauhafen area:
- Measurements with Rheotune probe from Stema Systems and laboratory tests
- Laboratory values are considered as reference values here:
- Rheotune probe:
  => good calibration of density and yield point!
- Rheotune data become inaccurate the deeper it penetrates consolidated soil:
  => for the project Nautical Depth these are uninteresting areas!

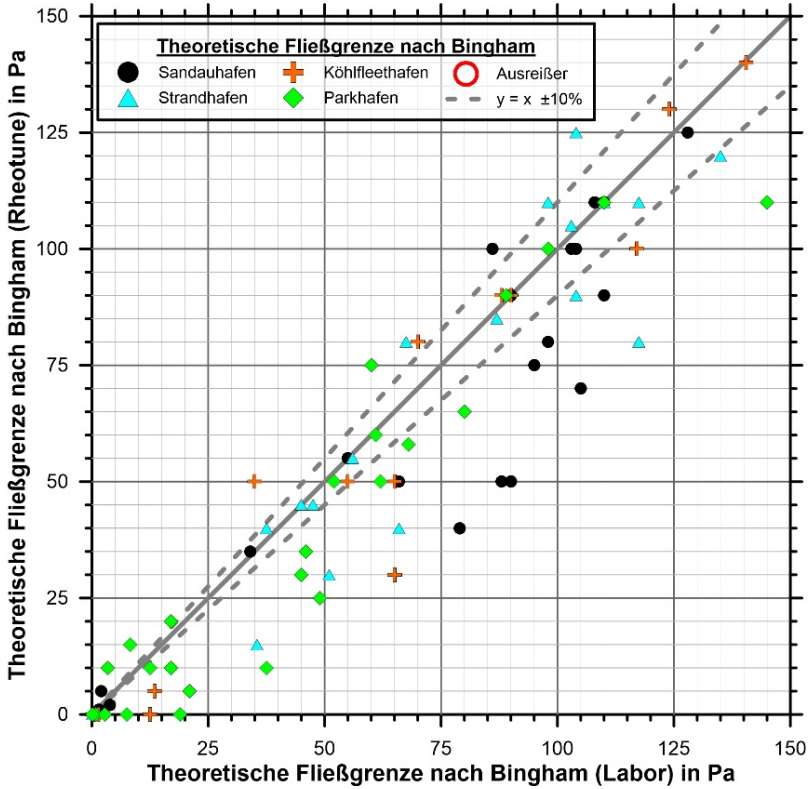


Sandauhafen (SZ4)



Comparison in-situ / laboratory measurements

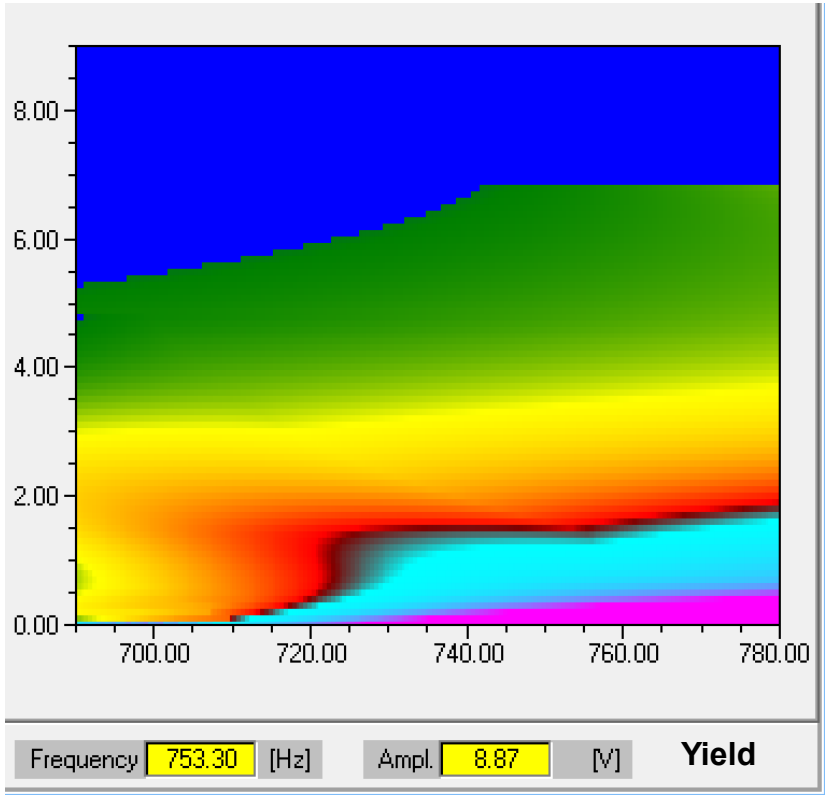


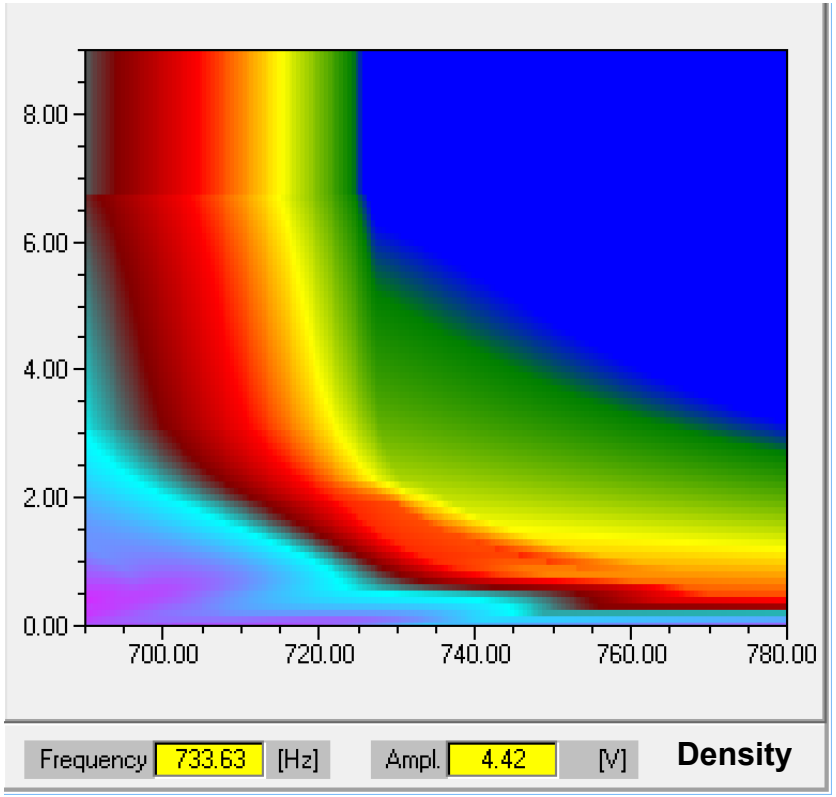


Rheotune Calibration: Worldwide Sediment Database

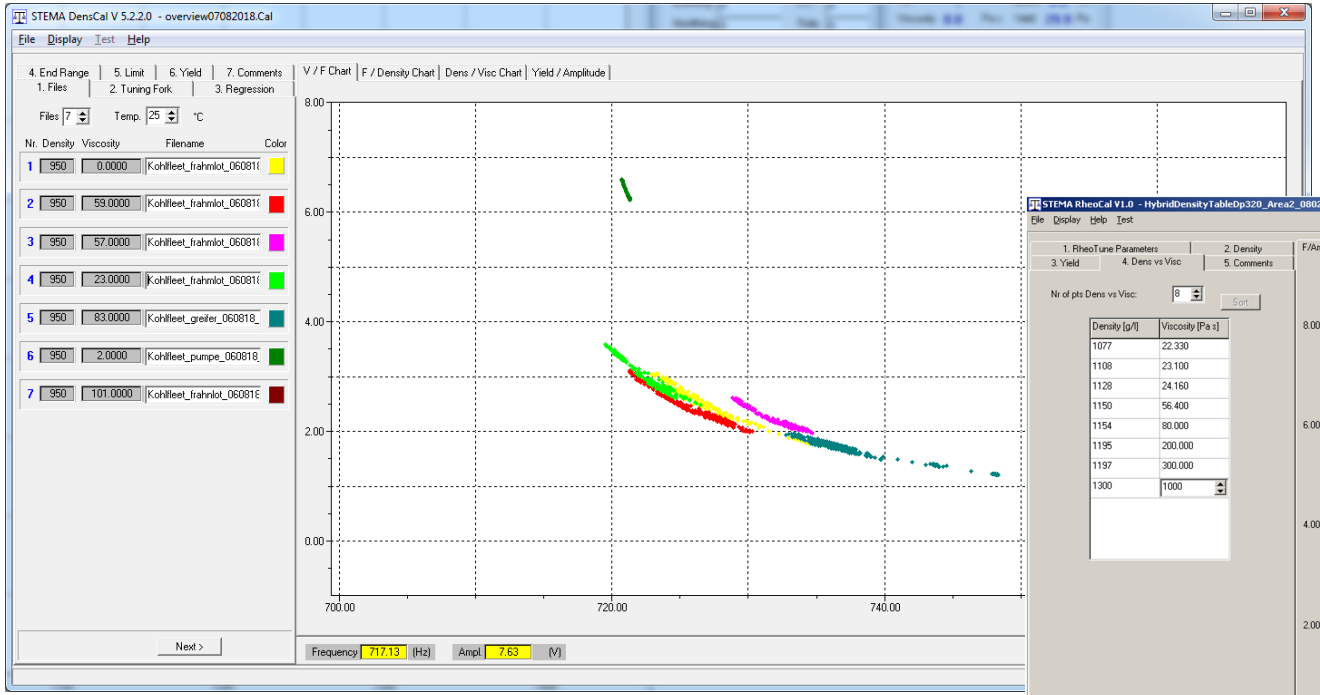
Hamburg Port Authority

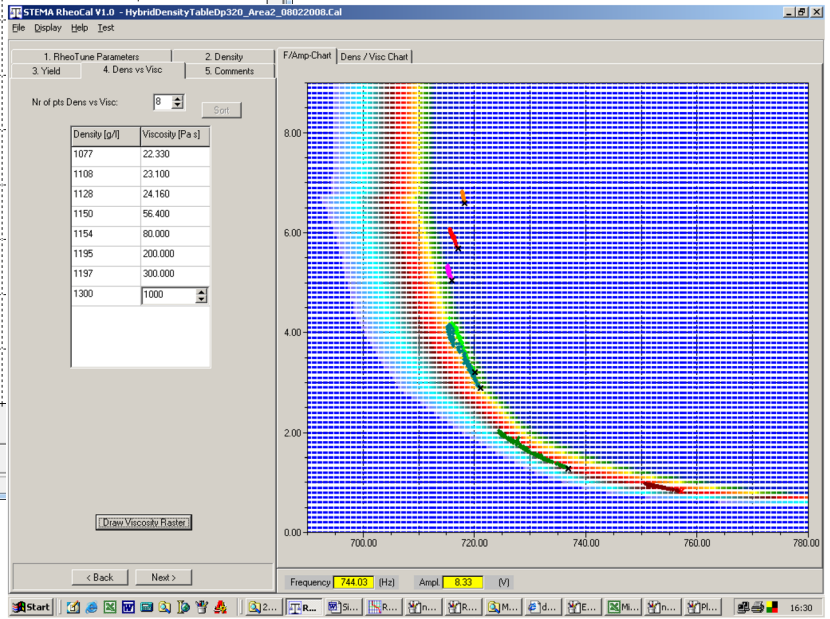
Worldwide Sediment Database





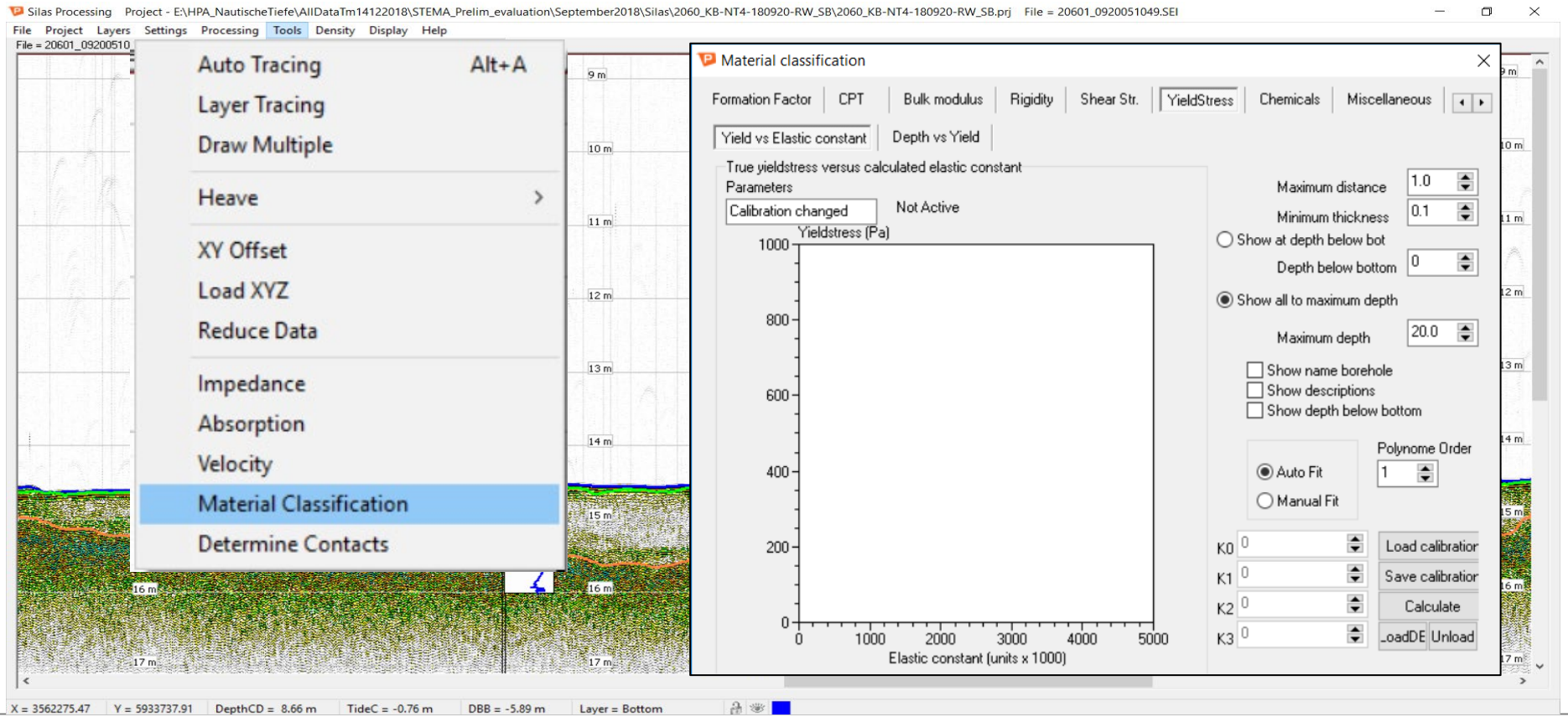
Rheotune Calibration with data from the Hamburg port





Rheotune responses of different mud samples in the Amplitude / Frequency plane

Implementation of Material characteristics within Stema Software in 2020



Conclusions

- Density and Yield surfaces in the Frequency and Amplitude space for acquired datasets plot to surfaces which are generally not biased:
  - This indicates that for each parameter (density, yield) the RheoTune RheoCal software can be adapted to generate a standardized database.
  - This database subsequently can be exchanged and filled with information from specific areas

- In general tests executed in 2018 and 2019 lead to following conclusions:
  - There is a correlation of Rheotune yield stress and yield stress of Brookfield viscosimeter. Later finetuning with database will be required.
  - There is a correspondence of results of Brookfield results with results of Thermo Haake Mars rheometer
  - Database for Hamburg should be provided and is now developed and filled with results of Thermo Haake Mars and Rheotune measurements.

Therefore acoustic measurements of density and viscosity respectively yield point will be available on a cross-section line by using a sub-bottom profiler, calibrated with point measurements with a Rheotune device as in-situ depth monitoring instrument and finally processed with SILAS post-processing software!


SALAHUDDIN
MAJURO