NAUTICAL DEPTH DETERMINATION THROUGH DEFINITION OF FLUID MUD CHARACTERISTICS

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Introduction

Stema Systems: geophysical and hydrographical sub-bottom specialist

- Safe navigation harbors -> dredging
- Ensure security for vessels
- Nautical depth
- Reducing dredging costs and better for eco-system
- **Fluid mud: hard to determine nautical depth**

With the goal of safe navigation in mind, how can the presence of fluid mud be optimally measured for the determination of the nautical depth?

Introduction

- Fluid mud: non newtonian fluid
- Density + Yield stress
- Survey: EBP system + RheoTune
- Monitoring and mapping fluid mud
- Case study: Port of Rotterdam

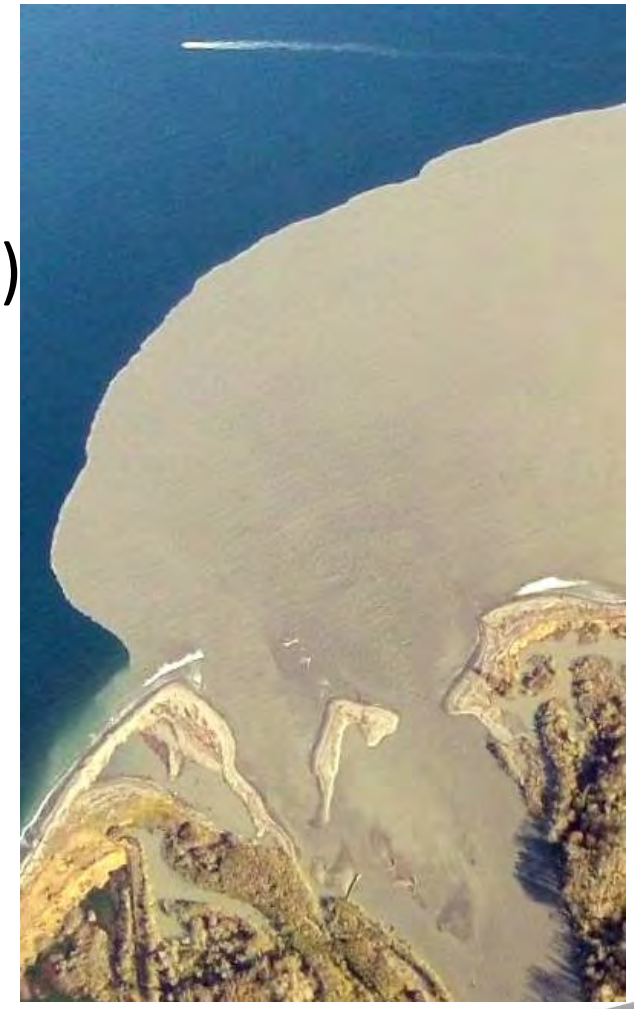
Background

Fluid mud:

- Small particles in suspension
- No interconnected matrix (mobility)
- Microbial slimes: internal friction
- Thixotropy and shear thinning

How fluid mud arises:

- Present in near bottom layers
- Local sediment source
- Dredging: particles disjoin



Fluid mud, Coichin India

Background

Density:

- Dominantly used to measure nautical depth
- Fluid mud has higher density than water
- 1200 g/l, depending on area or client (PIANC, 2014)

Yield stress:

- Determines the breaking force of the fluid mud's resistance against the ship
- Determine to know whether fluid mud is navigable or not (Wurpts 2005)
- 70 – 100 Pa determined as limit (Jam)

Background

The RheoTune -> **Tuning Fork principle**:

- One leg starts vibrating
- Based on the material and resonance,
- The other leg starts vibration based on the natural frequency
- Frequency and amplitude are measured
- Density increases: frequency decreases
- Yield stress increases: amplitude decreases

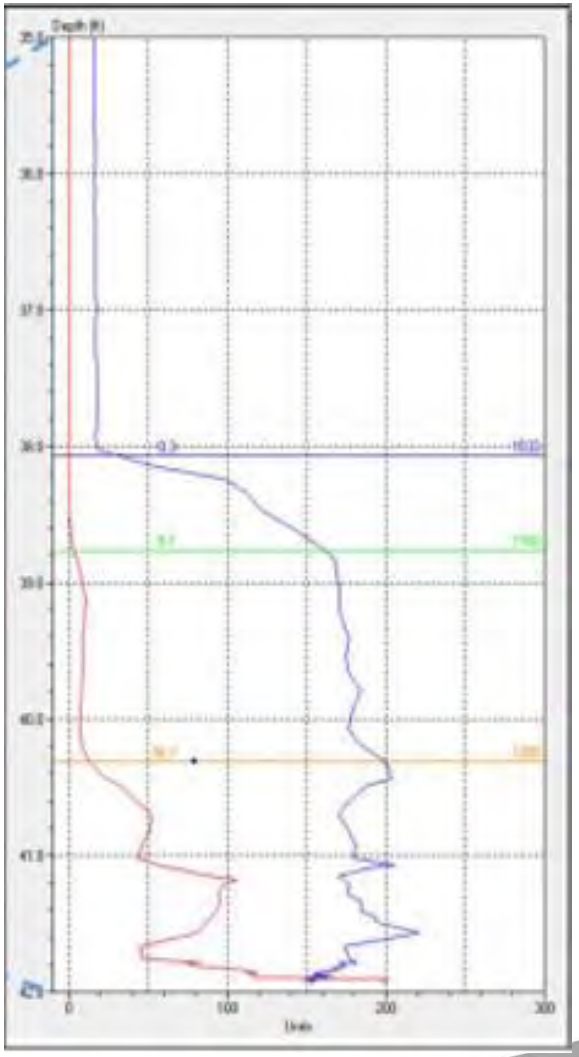
Calibration + database

Method

- Survey system
- Enhanced bottom profiler (EBP)
- Transducers + USB-A/D card
- Analog from digital:
- Insight in entire fluid mud column
- RheoTune

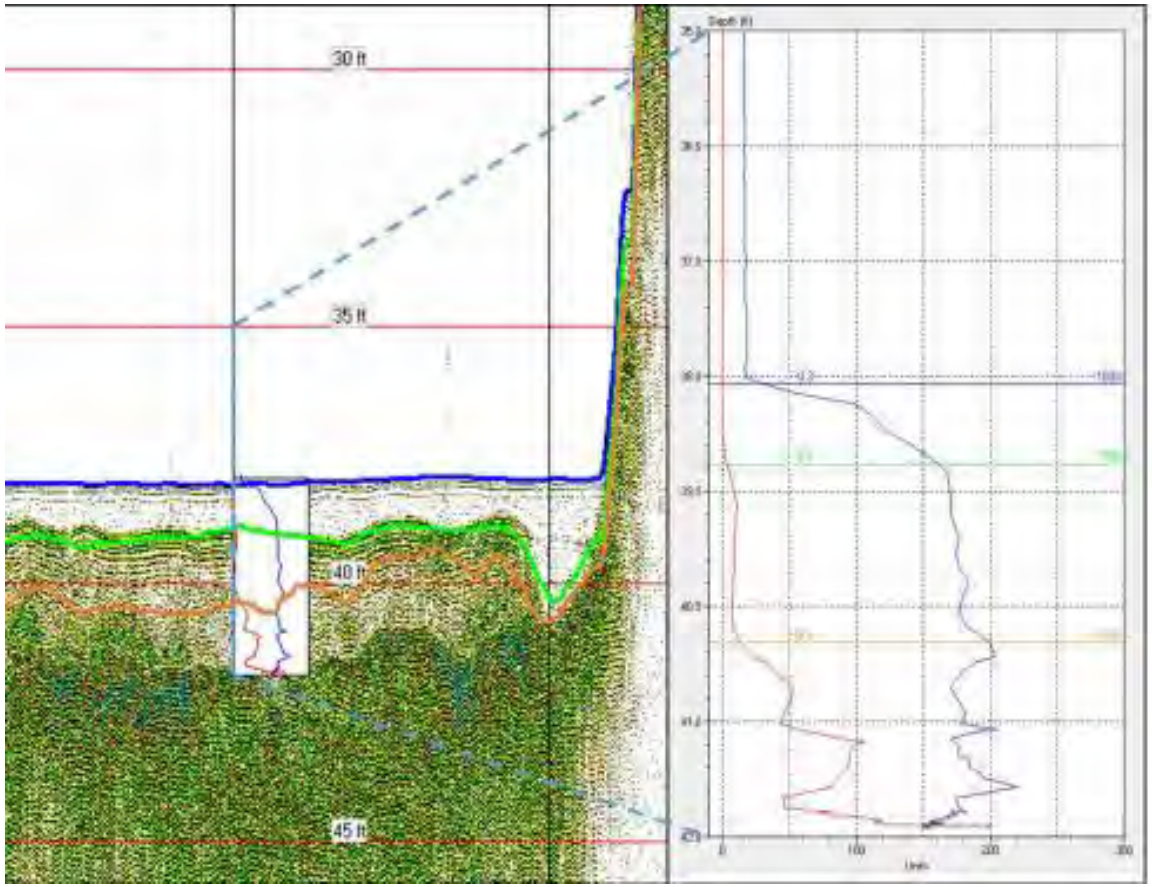
Method

- Rheotune measurements -> density + yield stress graphs
- Mark levels for density and yield stress
- Including **critical density level**
- Implement RheoTune measurements in seismic data

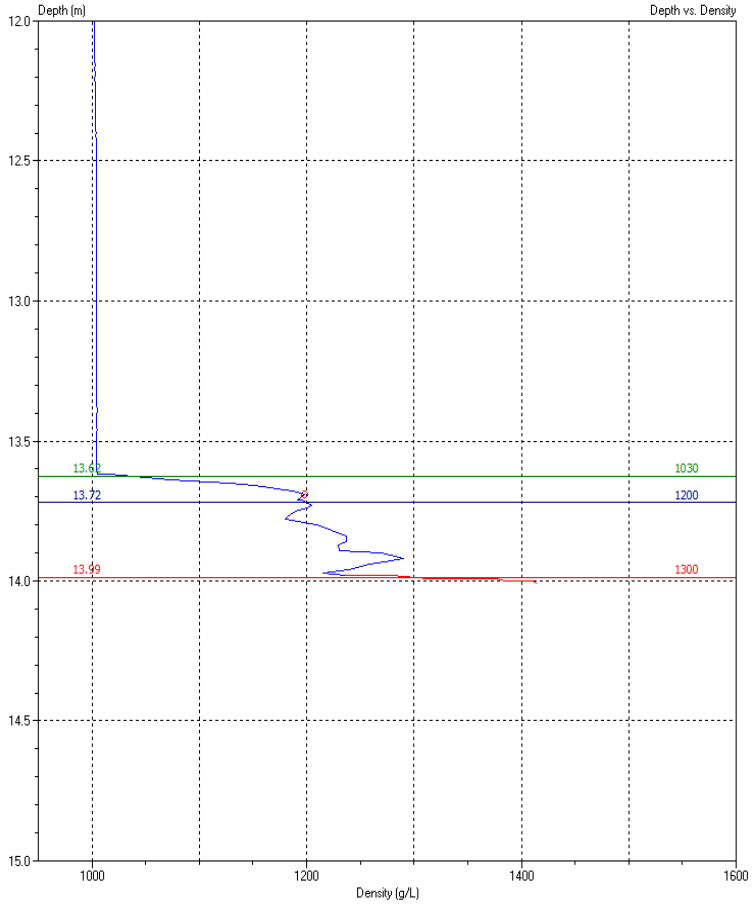


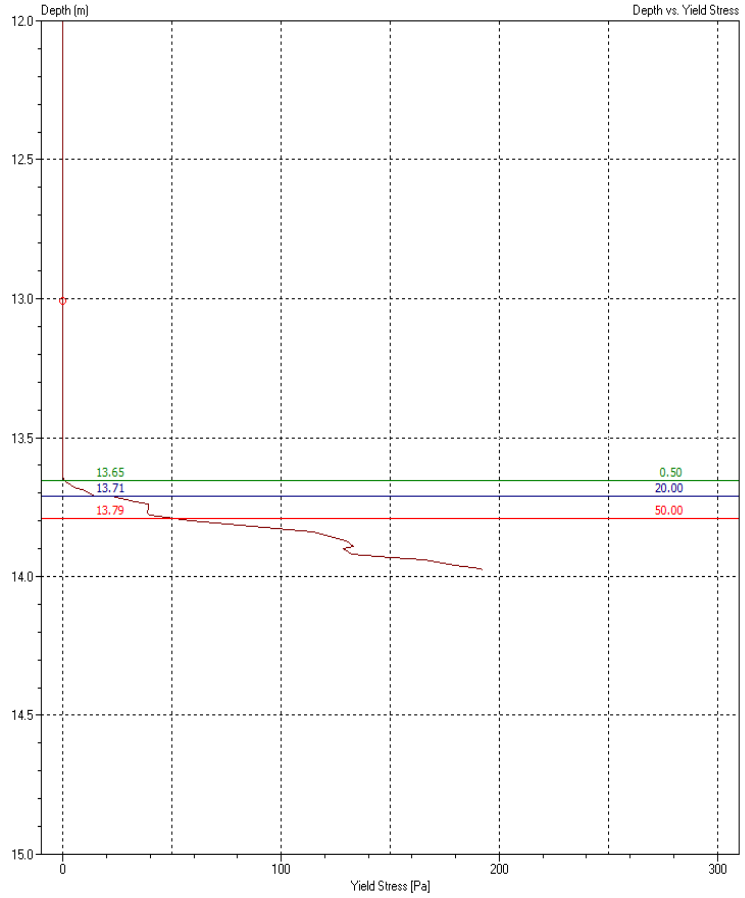
Method

- Seismic data: Silas2D
- Insert Rheotune measurments
- **Interpolate critical density level**

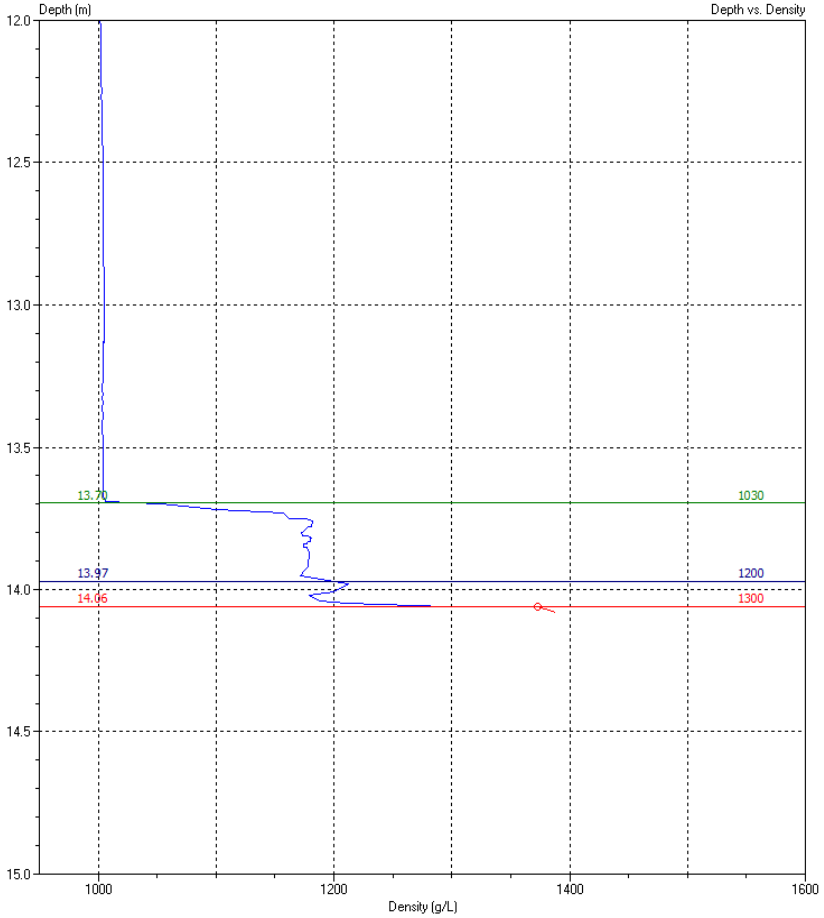


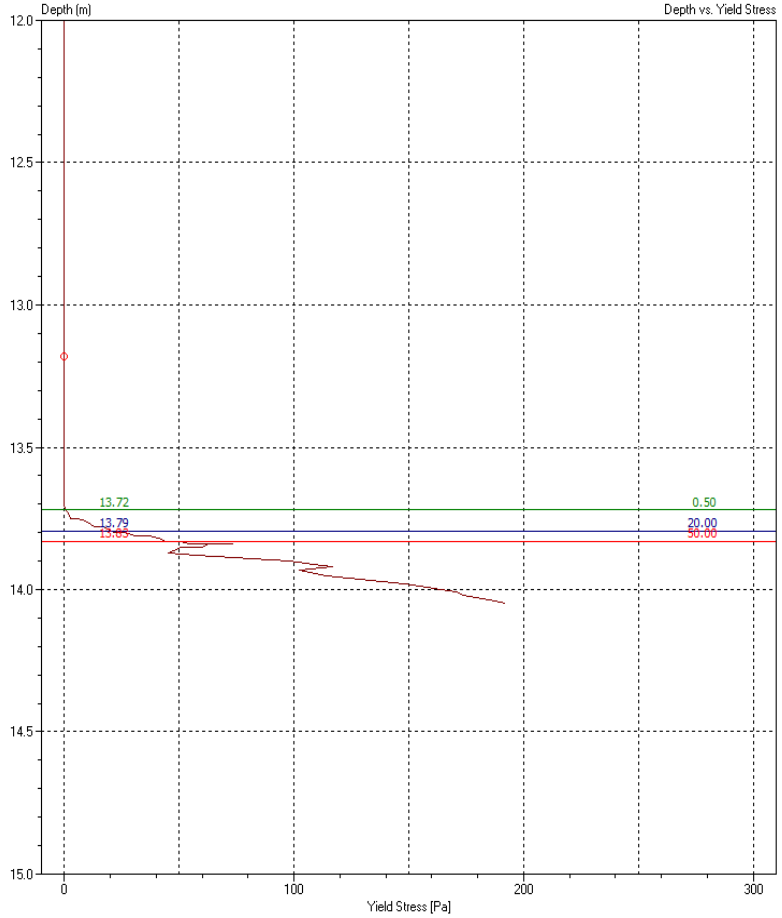
Results


Depth (m)
Depth vs. Density
12.0
12.5
13.0
13.5
14.0
14.5
15.0
13.62
13.72
13.99
1030
1200
1300
1000
1200
1400
1600
Density (g/L)

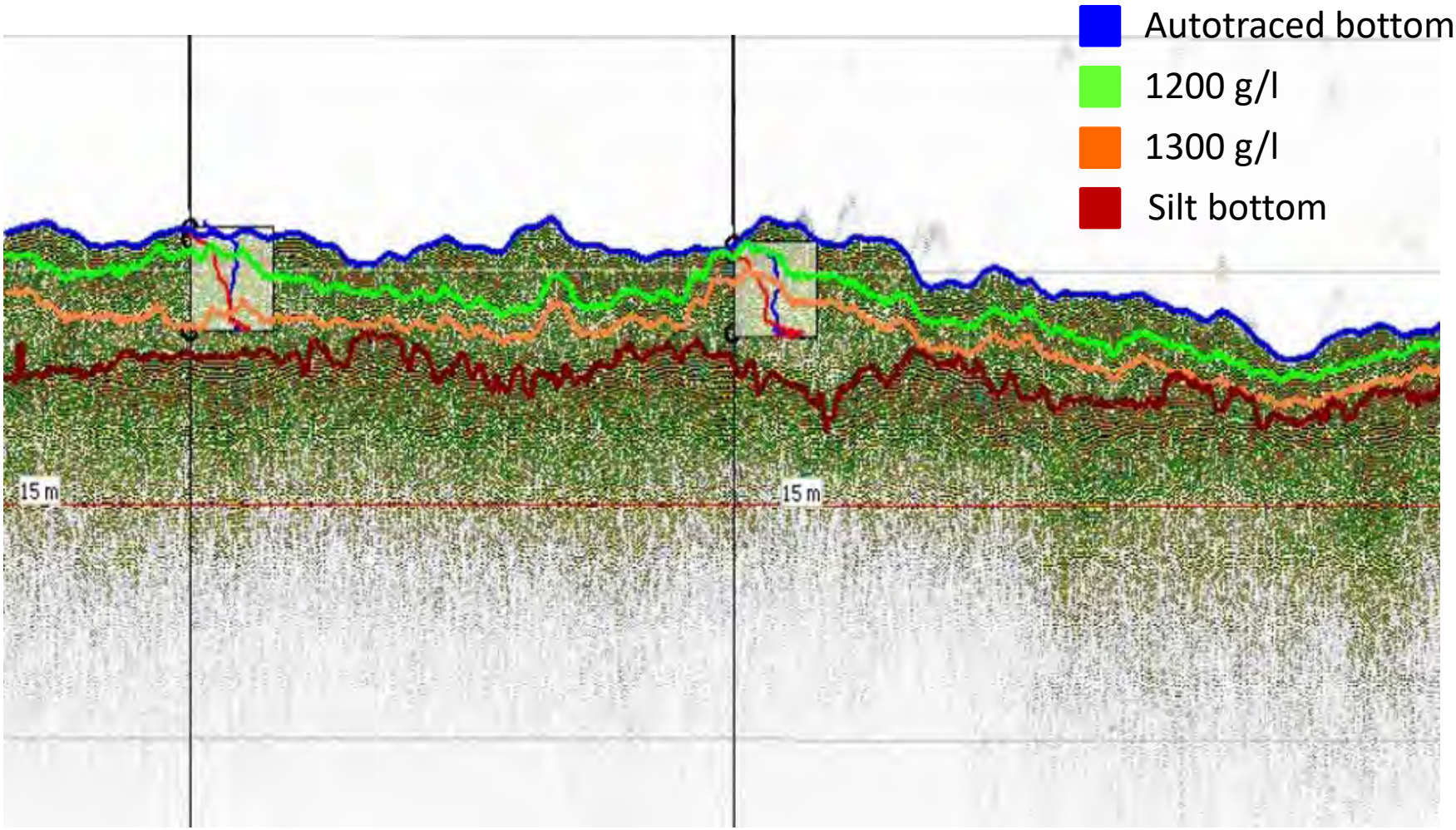

Depth (m)
Depth vs. Yield Stress
12.0
12.5
13.0
13.5
14.0
14.5
15.0
13.65
13.71
13.79
0.50
20.00
50.00
0
100
200
300
Yield Stress [Pa]

Results

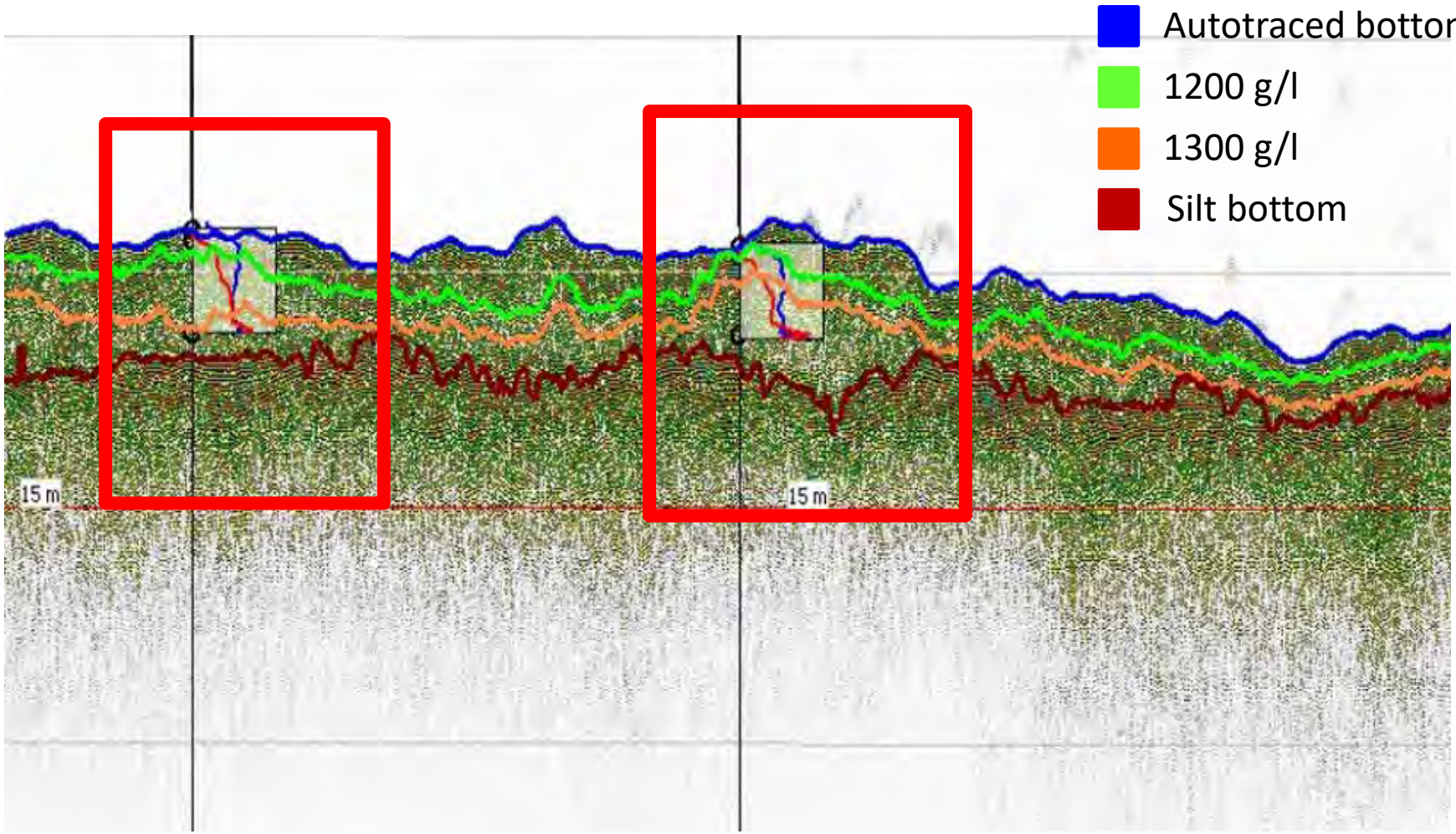

Depth (m)
Depth vs. Density
12.0
12.5
13.0
13.5
14.0
14.5
15.0
13.70
13.97
14.06
1030
1200
1300
1000
1200
1400
1600
Density (g/L)


Depth (m)
Depth vs. Yield Stress
12.0
12.5
13.0
13.5
14.0
14.5
15.0
13.72
13.79
13.83
0.50
20.00
30.00
0
100
200
300
Yield Stress [Pa]

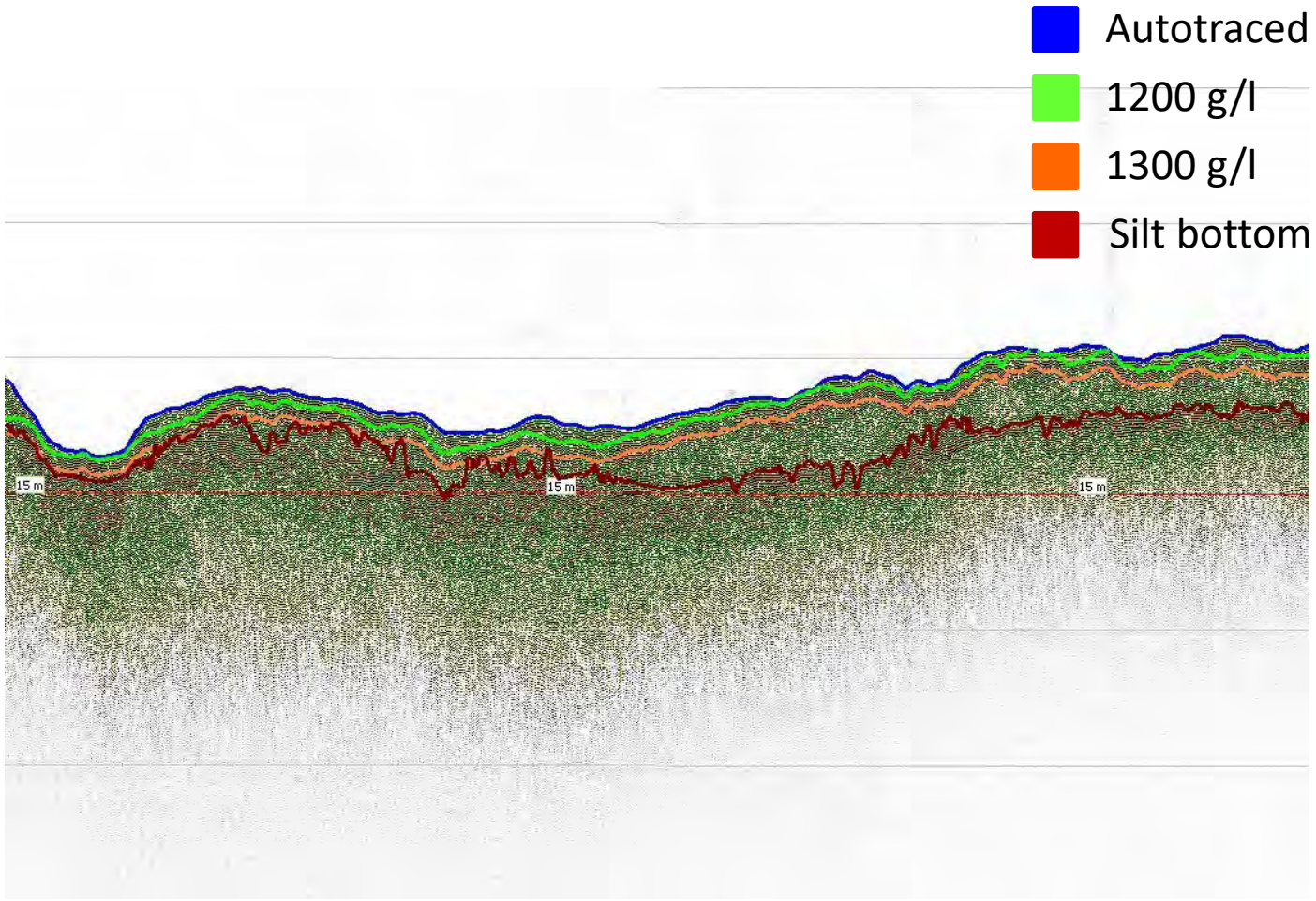
Results



Results

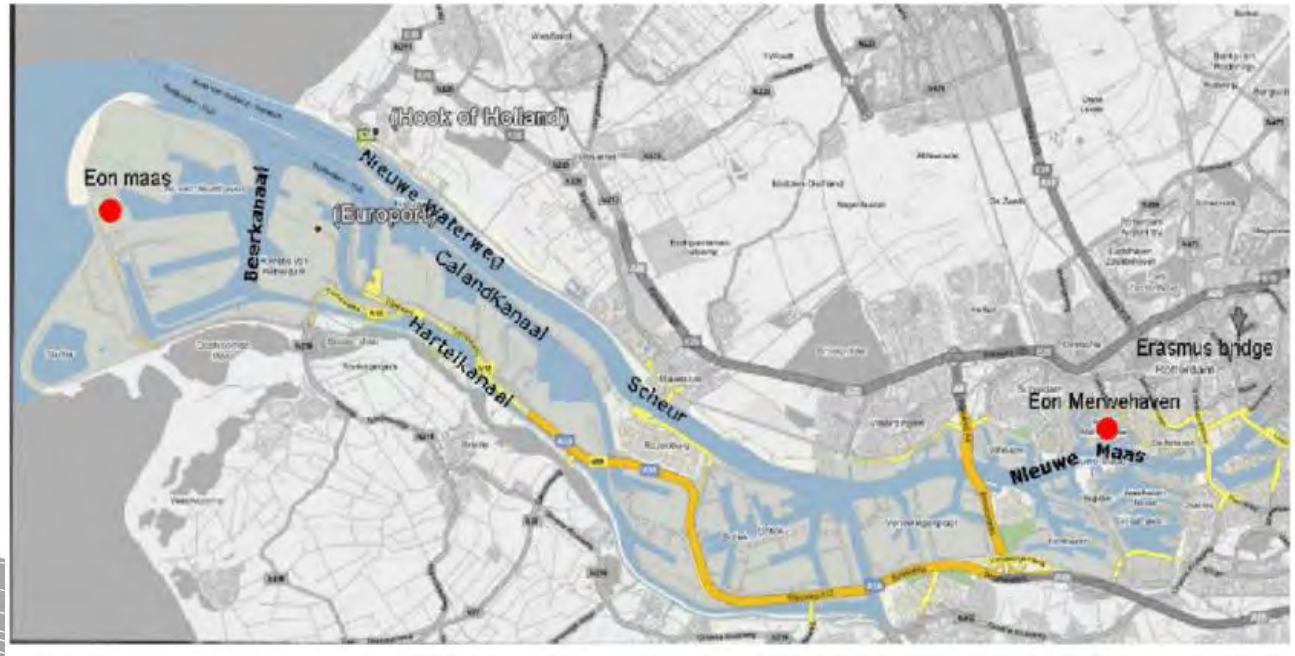


Results



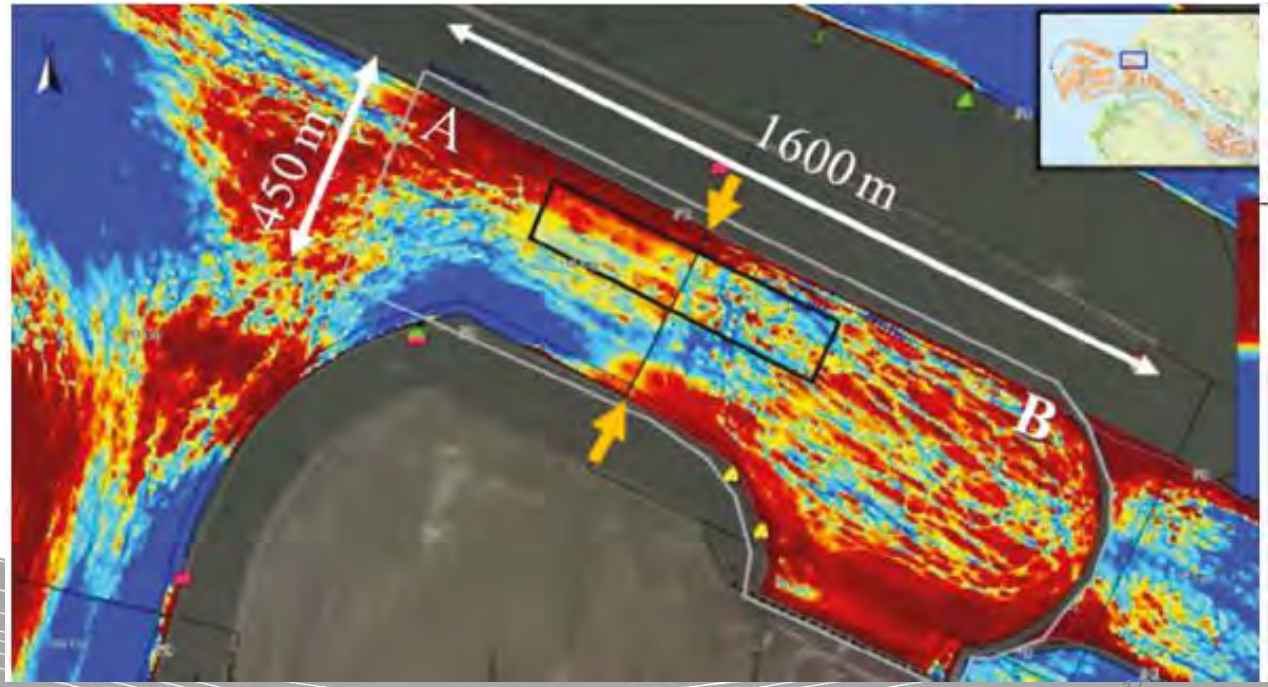
Case study: Port of Rotterdam

- Looking for most efficient dredging method
- Monitoring fluid mud at Port of Rotterdam
- Survey with EBP system and Rheotune
- Parallel lines together with cross lines sailed
- On cross points: Rheotune measurements were made



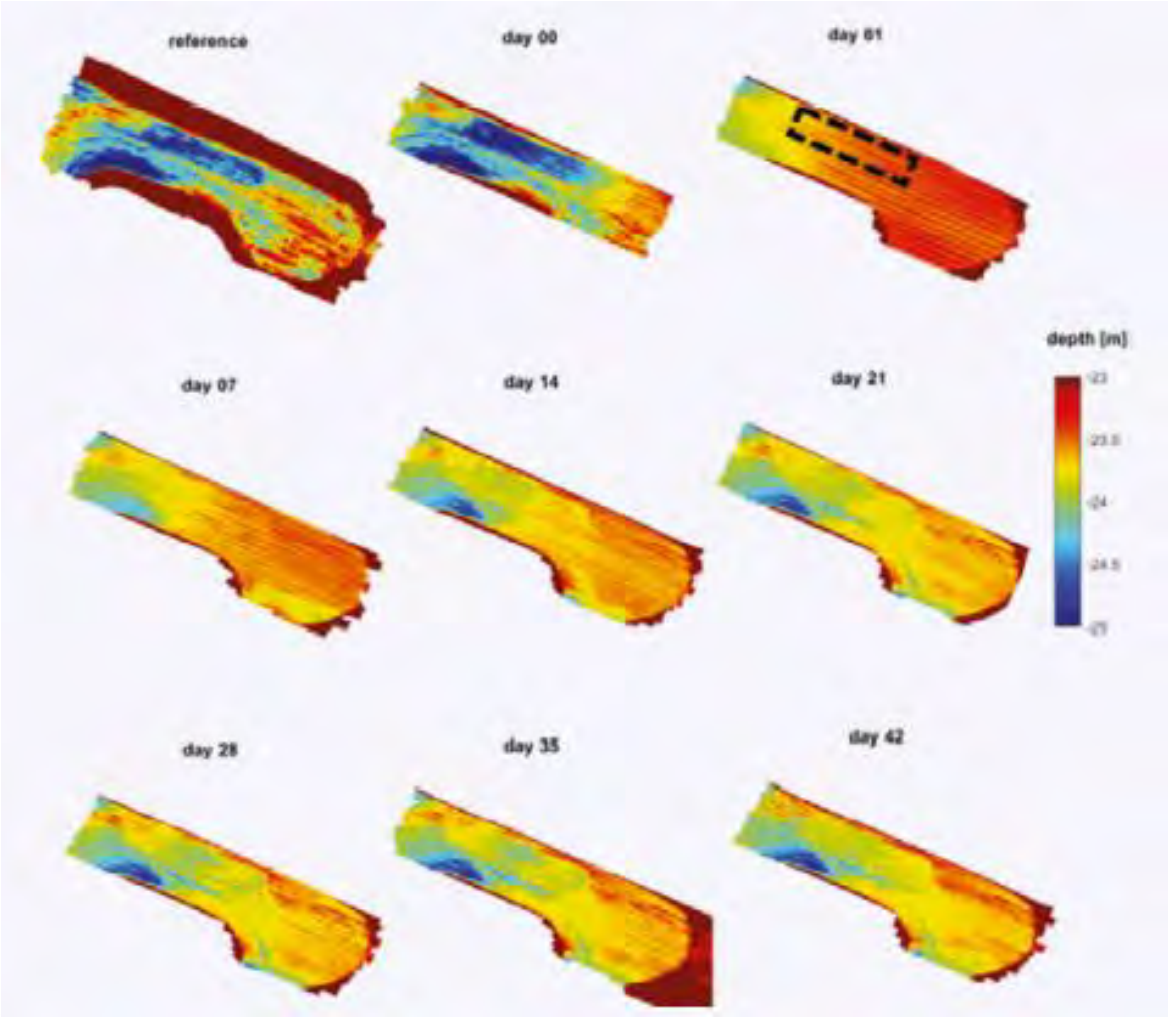
Port of Rotterdam

- Water Injection Dredging
- Top layer: more fluid, homogenous, lower yield stress
- Top layers will be transported by natural currents
- Sediment trap for fluid mud
- After WID monitor campagne of several weeks was held



Retrieved from Kiricheck et al., 2020

Result: Sediment trap



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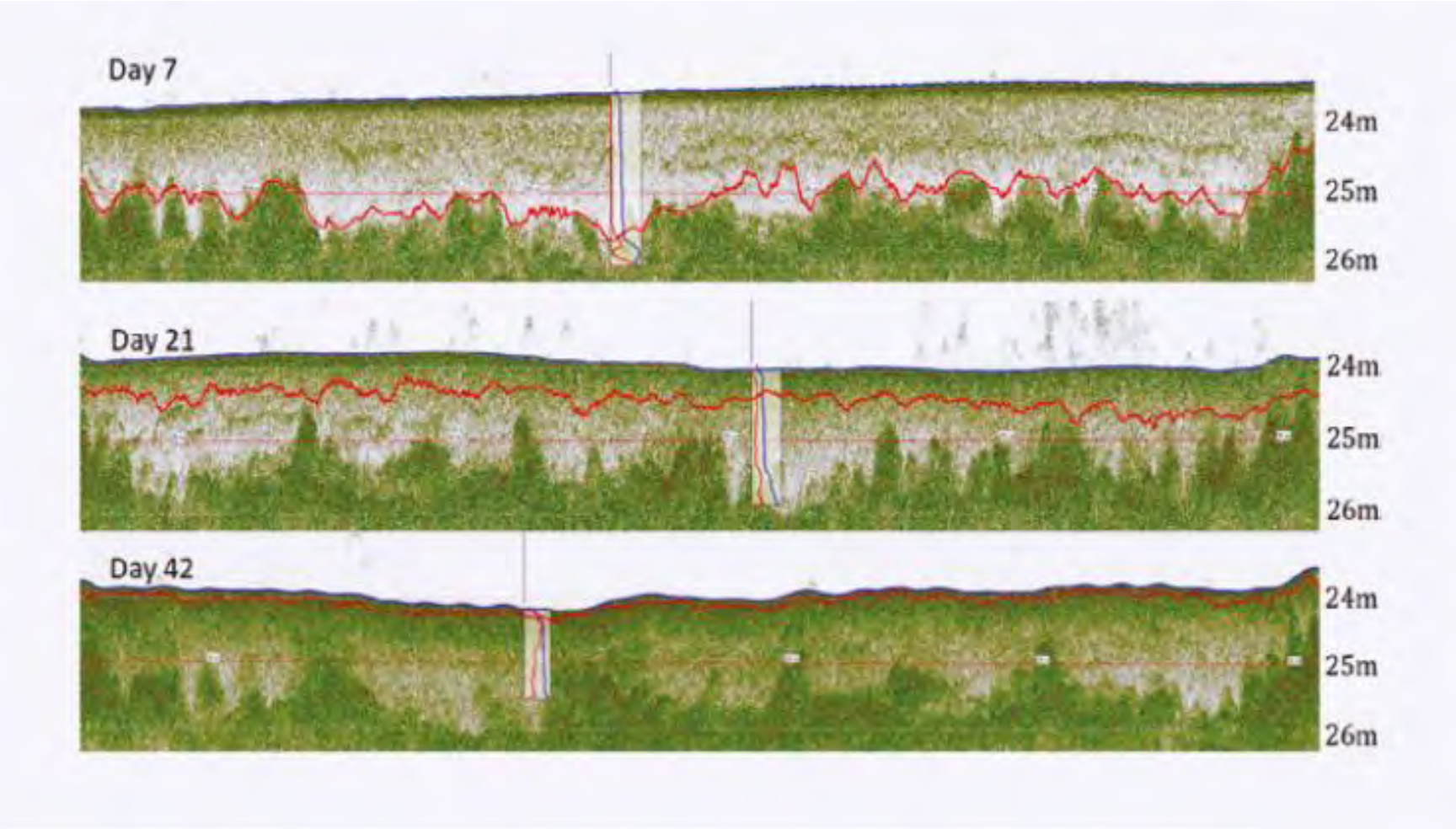
Result: Sediment trap



Retrieved from Kiricheck et al., 2020

Discussion

- Density level can be measured and interpolated across seismic data
- Yield stress also important for fluid mud
- Nautical depth can be determination through the definition of fluid mud charactersitics
- Nautical depth can be monitored and visualized
- Stema Systems is working on a solution to interpolate yield stress

Discussion

Port of Rotterdam:

- EBP and RheoTune: development of fluid mud layers and used to prove concept of WID
- Fluid mud becomes more homogenous
- Reducing dredging costs and CO2 emissions
- RheoTune and EBP -> important tool for solutions to sub-bottom problems

Conclusion

With the goal of safe navigation in mind, how can the presence of fluid mud be optimally measured for the determination of the nautical depth?

- RheoTune with tuning fork principle
- Critical density level can be interpolated on seismic data
- Port of Rotterdam: monitoring and visualization of fluid mud
- Applicable to dredging methods and fluid mud surveys
- **RheoTune and EBP system; important tool for effective solutions to sub-bottom problems**

Thank you for your attention!
Any question?