on Sediment Properties: A Case Study in the Seaport Emden

Fatemeh Chamanmotlagh[1], Dr. Julia Gebert[2], Dr. Alex Kirichek[1]

1 Department of Hydraulic Engineering, Delft University of Technology, Delft, the Netherlands

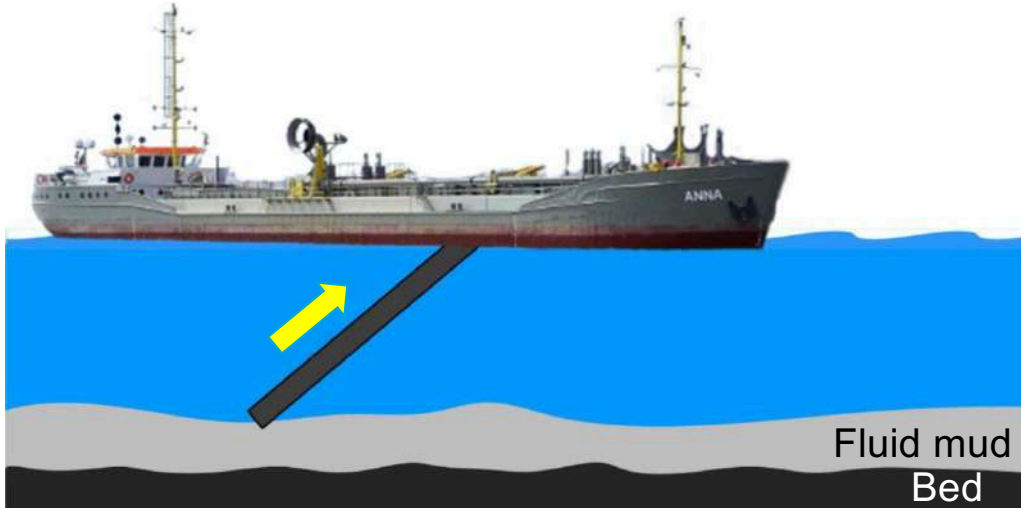
2 Department of Geosciences & Engineering, Delft University of Technology, Delft, the Netherlands

TU Delft

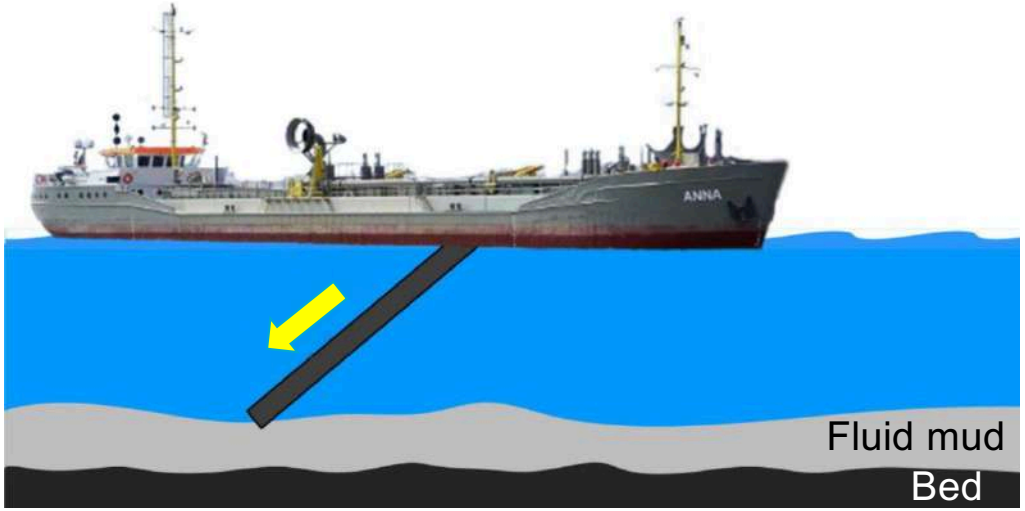
Niedersachsen Ports

Introduction

- Objective: Monitor the changes in sediment properties due to recirculation to optimise port maintenance (cost efficiency and environmentally friendly)
- Maintenance dredging for safe navigation in ports
- Innovative solutions for minimizing regular maintenance dredging's high cost
- Port of Emden utilized **recirculation** since 1988.
  - The annual costs reduced from € 13.5 million in 1988 to € 1.2 million in 2004 (R. Wurpts, "15 Years Experience with Fluid Mud: Definition of the Nautical Bottom with Rheological Parameters)



a) Collecting sediments by hopper dredger



b) Releasing the sediments into the ports area

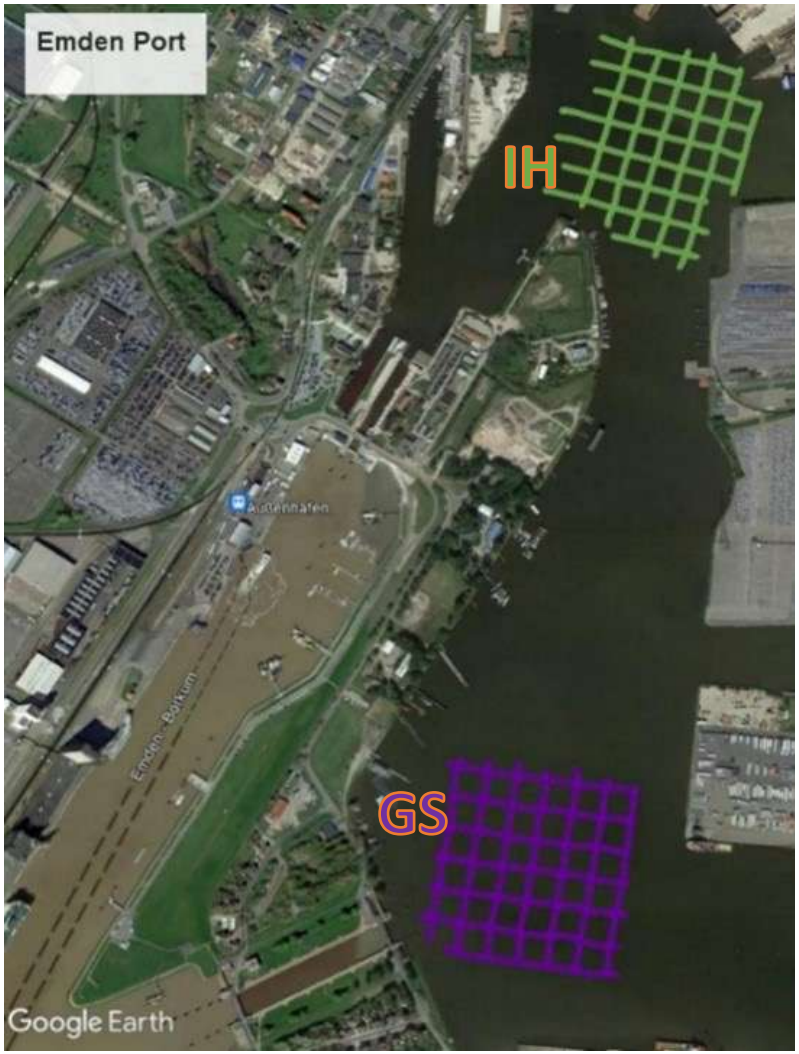
Introduction

- Recirculation ⟶ Weaken the materials strength by decreasing fluid mud yield stress and density
- **Nautical bottom** concept when navigating through fluid mud
  - Level at which vessels can safely navigate
  - Density of fluid mud (1.15 – 1.20 g/ml)
  - Yield stress of fluid mud (50 – 100 Pa)

TU Delft

Methodology: Field Surveys

- Field data on effects of recirculation on fluid mud before and after recirculation in the port of Emden.
- Six field surveys conducted in the two monitoring locations (Große Seeschleuse and Industriehafen) from July 2022 to July 2023.
- Samples from 5 points, three different depths (9 ,10, and 11 m) per point.
- Dredge continuously

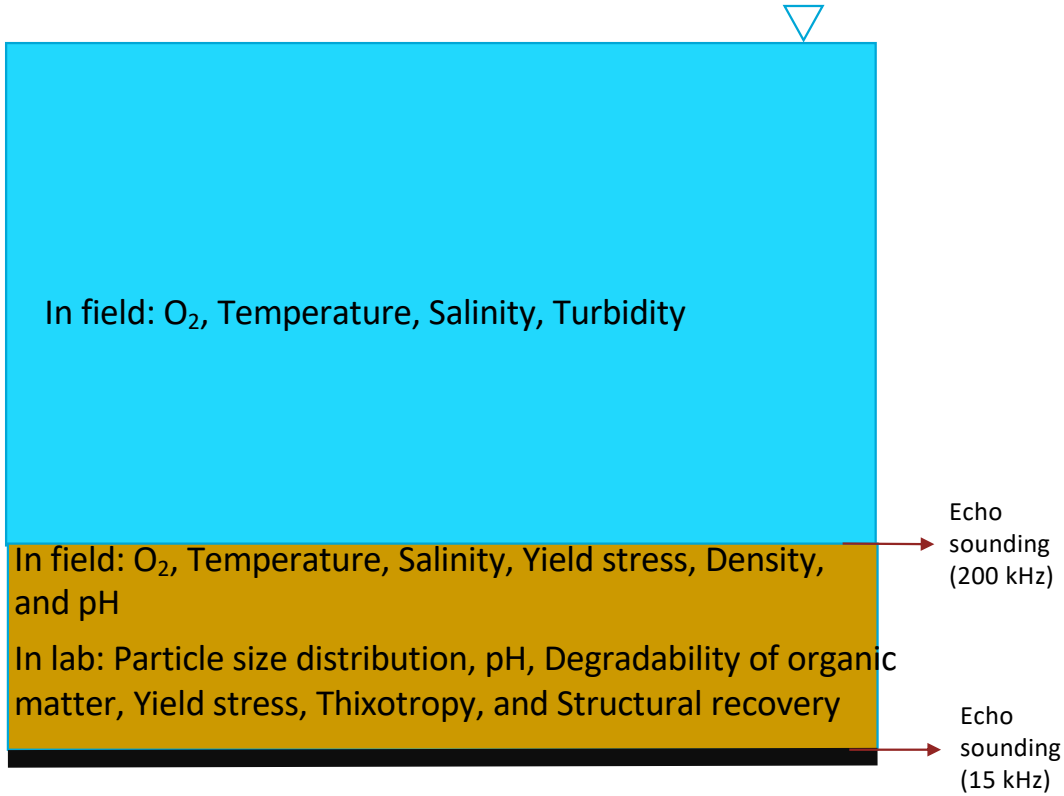


Port of Emden monitoring lines, the lines intersections are the measuring points.

Methodology: Field Surveys

Field measurements
• **Density** • **Lutocline** • **Yield stress,** • **Fluid mud layer thickness.** • pH • Salinity • Turbidity • **Oxygen saturation**

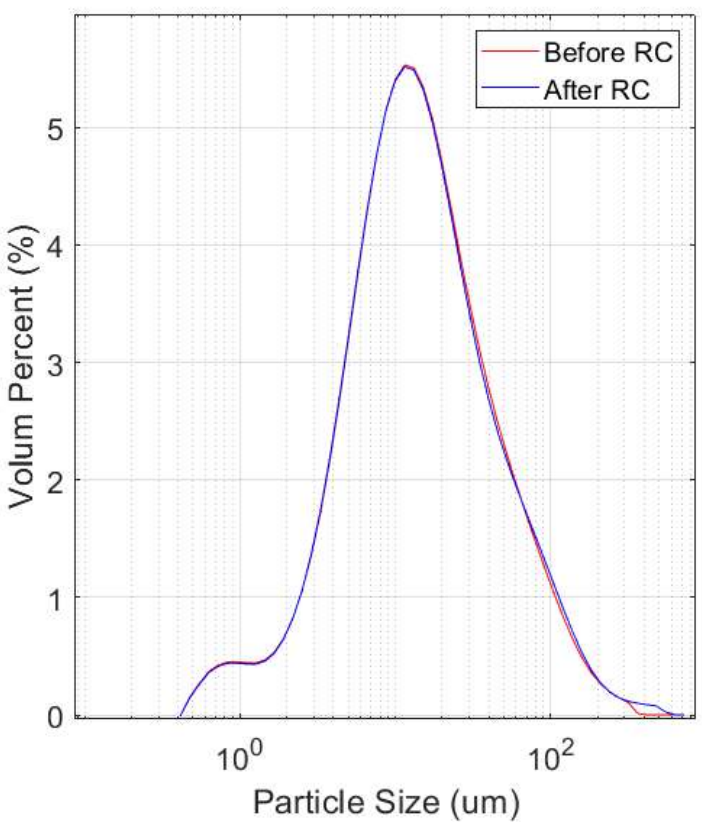
Laboratory experiments
• Yield stress • Density • Dynamic viscosity • Structural recovery • **Particle size distribution** • pH • **Organic matter degradation rate**



Results: Particle Size Distribution

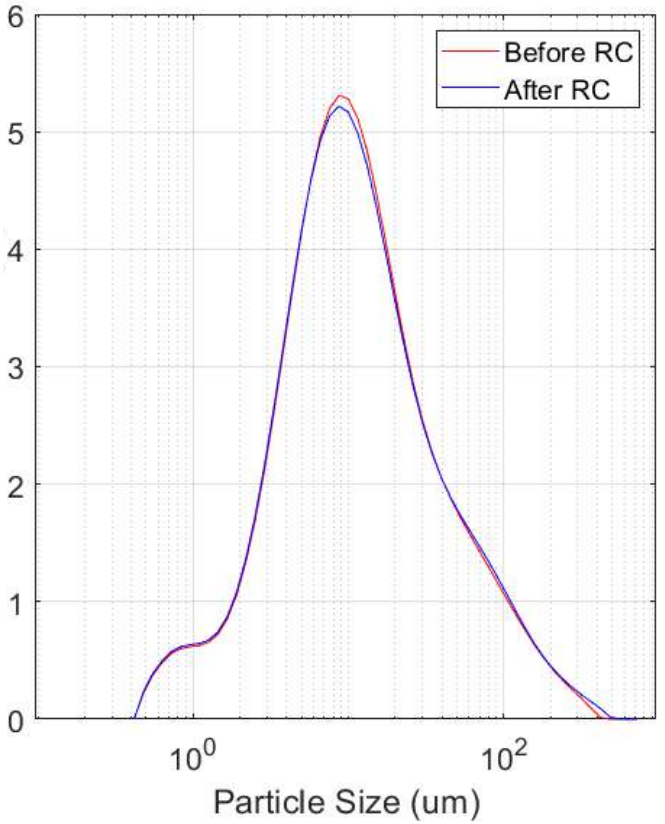
- There is no change in particle size distribution before and after recirculation
- Dominated by silt fraction

GS



d50 = 12.5 um
d90 = 55.2 um

IH

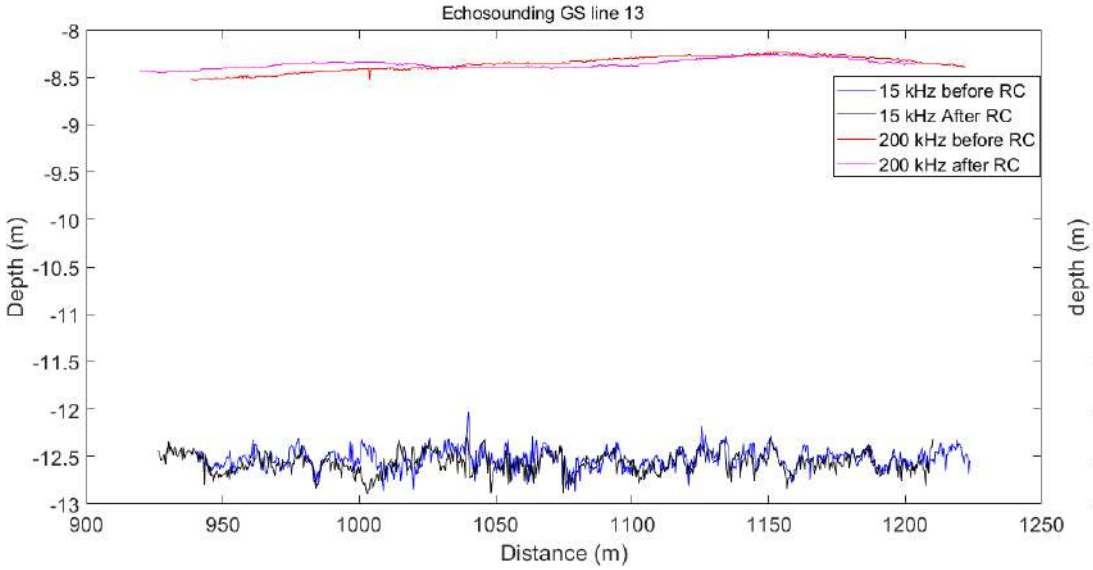


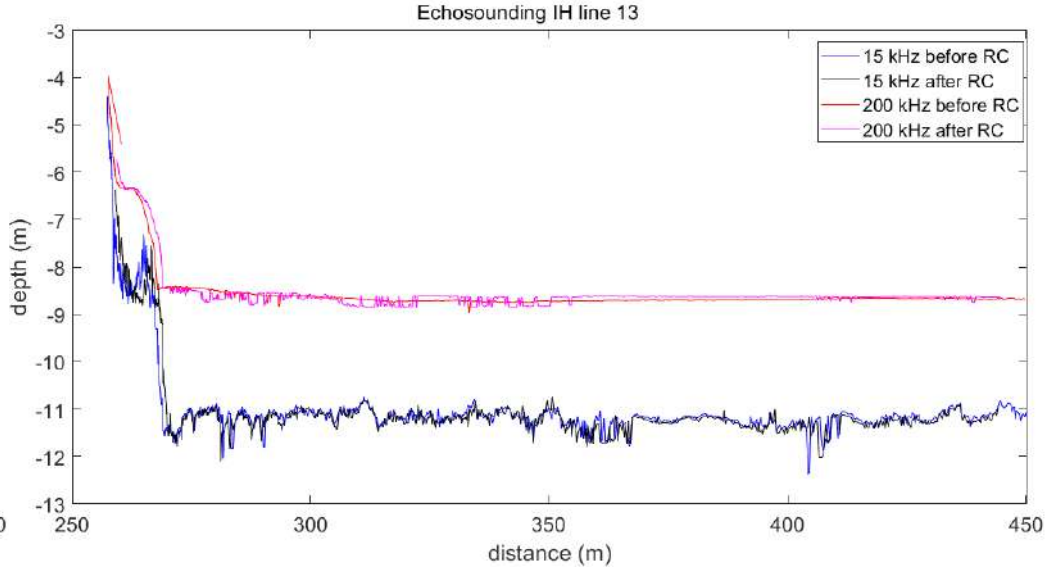
d50 = 9.7 um
d90 = 56.2 um

Thickness of Fluid Mud Layer

Thickness of the fluid mud layer remains consistent before and after recirculation

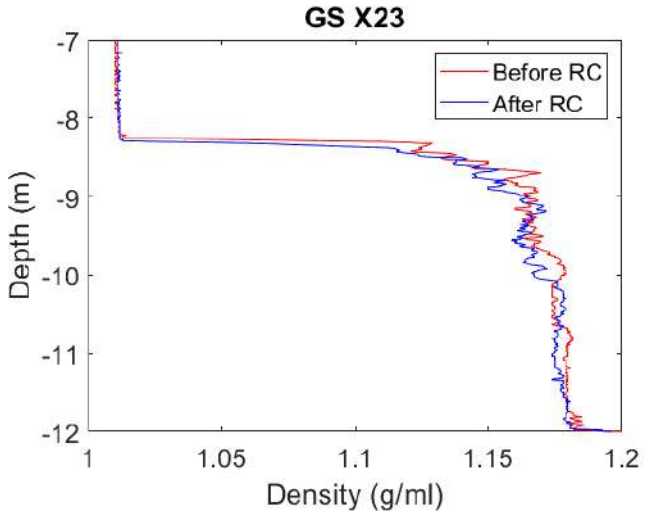
- 3.5 to 4.5 m in GS location
- 2.5 to 3.5 m in IH location

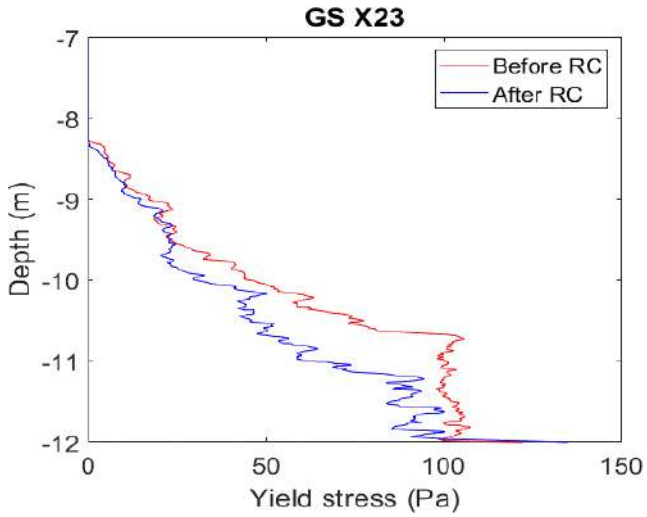




Results: Field Surveys Density and Yield

- Density and yield stress profiles were measured before and after the recirculation
  - Density and yield stress increased with increasing depth
  - Pre- and post-recirculation density changes ranged from 1% to 3%
  - Yield stress changes before and after recirculation, ranging from 10% to 40%

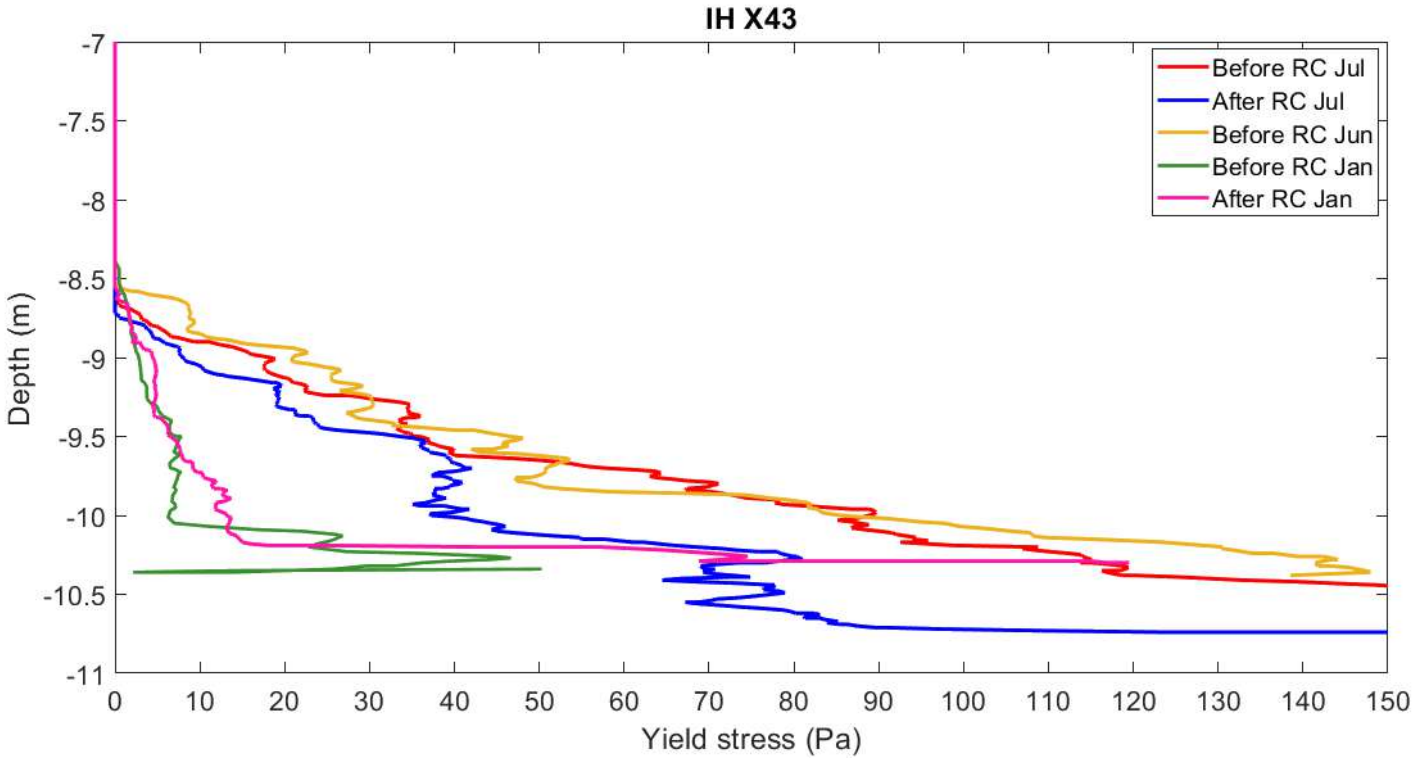




TU Delft

Comparison of Yield Stress

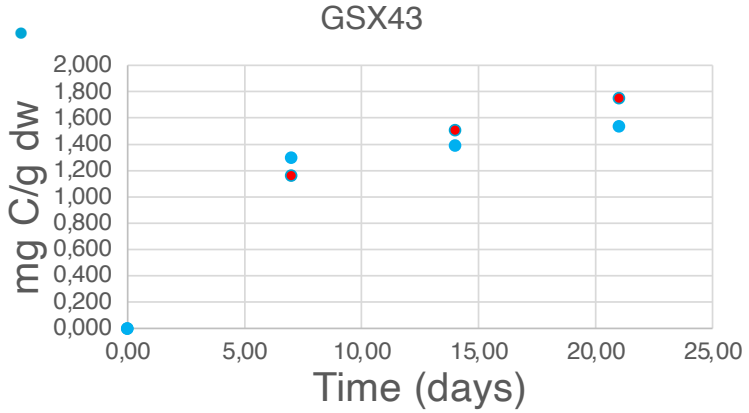
- The yield stress in July survey was more than previous surveys.
- Before recirculation, in depth of 10 m, the yield stress in Jan. survey is 82% less than Jul. survey.



Results: Organic Matter Degradation and Oxygen Saturation

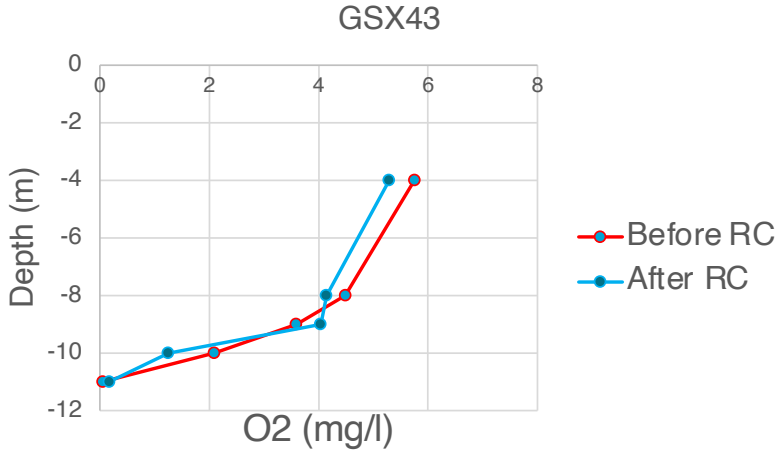
❑ Organic matter degradation

- In a few samples collected after dredging, the aerobic carbon release is lower than before dredging. Presumably dredging enhances organic matter decay, leaving a more degraded material



❑ Oxygen saturation

- Oxygen decreased with depth
- Low Oxygen in fluid mud

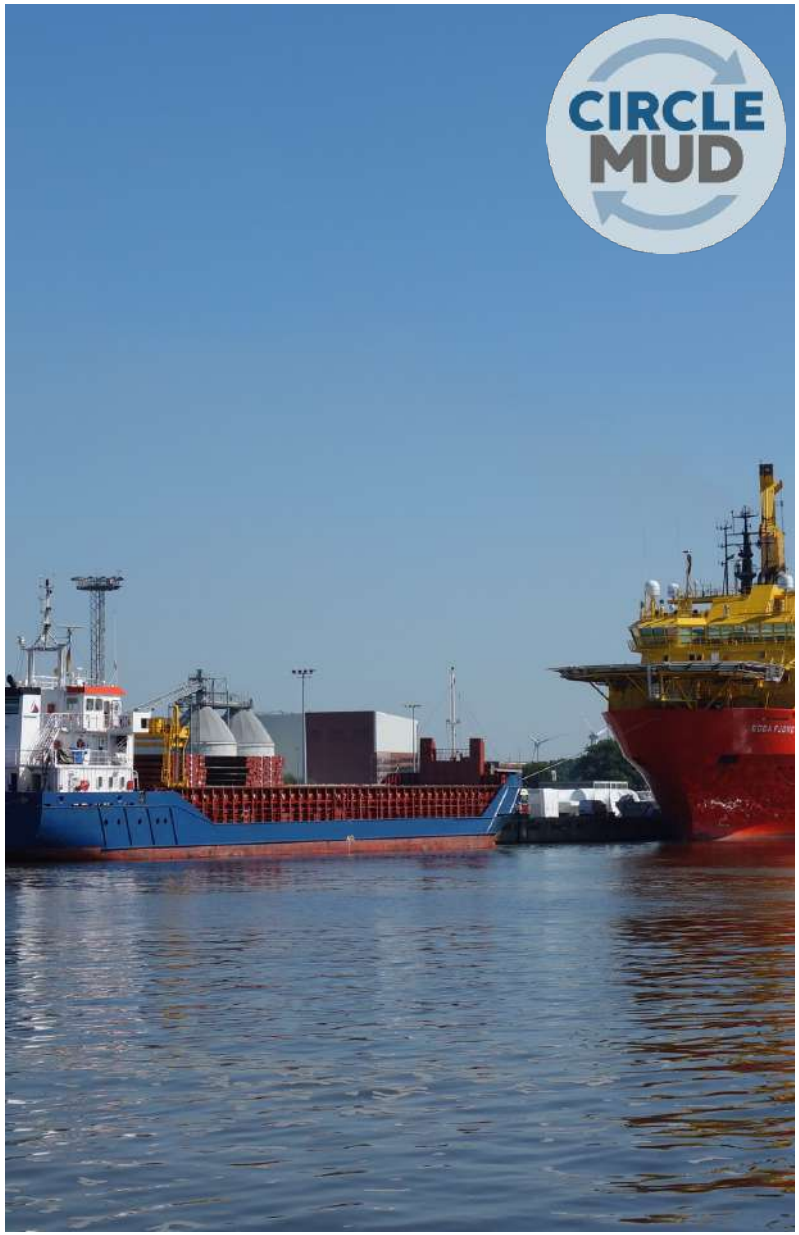


Red and blue symbols indicate organic matter degradation before and after recirculation, respectively.

Conclusion

- Recirculation maintain the desired conditions in Port of Emden (yield stress< 50 – 100 Pa, density<1.15-1.20 mg/l).
- Density was not significantly different before and after recirculation.
- After recirculation, the yield stress changes.
- Low saturation of oxygen in fluid mud was observed. The oxygen saturation did not change in response to recirculation.

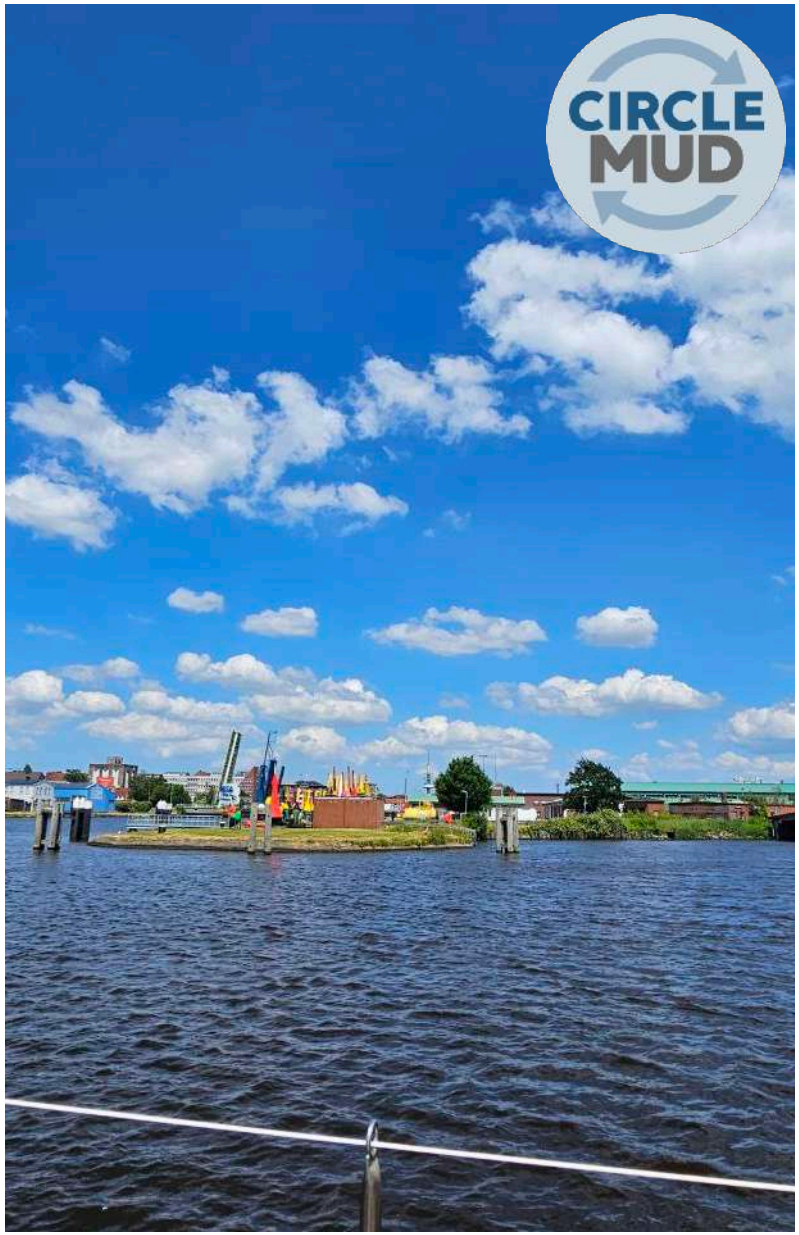
TU Delft



Future Works

- Compare the effects of recirculation on sediment to other conditioning techniques (water injection dredging and bed leveling) in order to optimize maintenance costs and environmental impacts.

- Investigate fluid mud oxygen saturation as a factor in optimizing dredging efficiency.



TU Delft

Questions and Contact

Thank you for you attention

Fatemeh Chamanmotlagh

F.C.Chamanmotlagh@tudelft.nl

TU Delft