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Interreg North-West Europe SURICATES

European Regional Development Fund

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Port of Rotterdam

12th International SedNet Conference

Session 1 – Climate change and sediments

Seasonal changes in turbidity and bathymetry in the NWW

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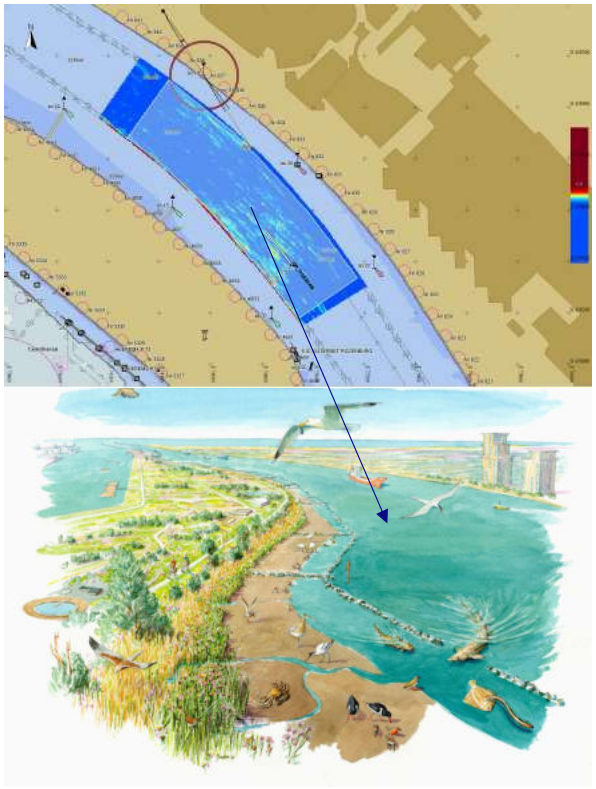
Introduction – SURICATES

SURICATES stands for Sediment Uses as Resources In Circular And Territorial EconomieS.

SURICATES aim is to increase sediment reuse for erosion and flood protection.



<u>Dutch Pilot: Sediment reallocation within Port of Rotterdam</u>

One such application is the reallocation of 580.000 m^3/ 200.00 tons sediment in the Nieuwe Waterweg (NWW) within the Port of Rotterdam.

The aim is to make a constructed wetland at the river bank more resilient by increasing the sedimentation.

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Sediment reallocation within Port of R'dam - assessment

The impact on the systems resilience has been assed by:

1. The change in **bathymetry** in the main shipping channel, is there extra siltation?
2. The **nourishment** of the constructed wetland, is sediment entrapped?
3. The **sedimentation balance**, is there an observed increase in the amount of fluvial sediments?
4. The **turbidity** in the channel, how is the sediment transported?

(greyed out: discussed in another session)

Seasonal change is a special topic: How does this impact the system resilience?

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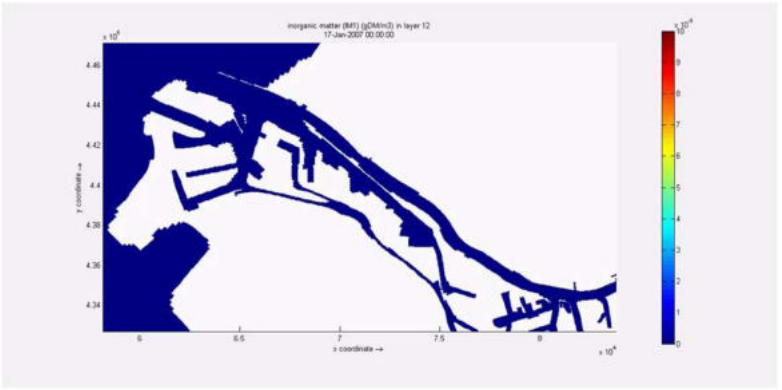
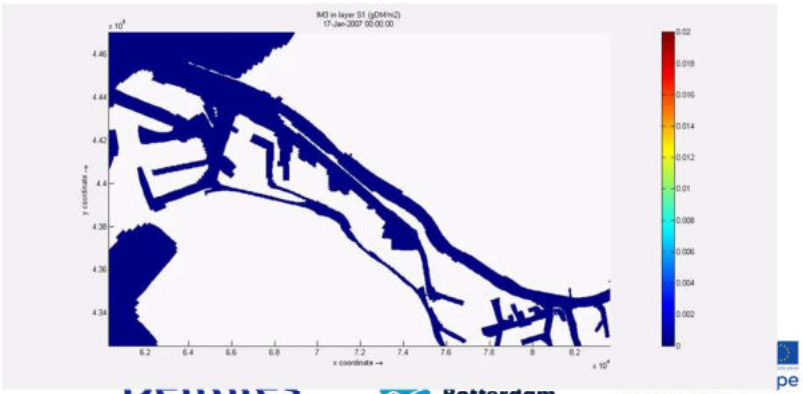
Sediment reallocation within Port of R’dam – site selection

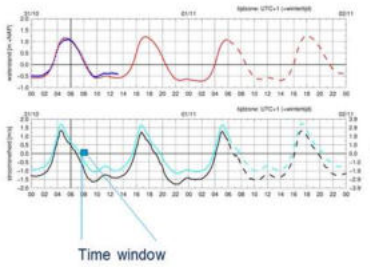
The sediment reallocation should not impact the to be dredged amount of sediments within the port.
Therefore a model study helped to define the reallocation site and tidal time window.

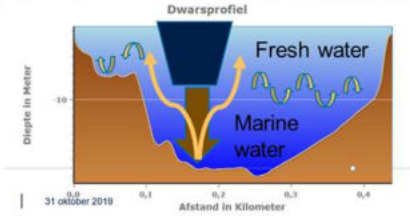




Time window: up to 1 hour after turning tide.

Based on operational tidal model Rotterdam





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Sediment reallocation within Port of R'dam - monitoring

The assessment of the impact of the sediment reallocation consisted of several monitoring techniques.

The focus here is on the monitoring of the bathymetry at the reallocation site and the suspended sediment concentration (SSC) downstream.

Main tools:

- *A good survey team*! Thanks Gerrit and Ed!
- Multibeam echosounder (bathymetry)
- Profiler with Optical Back Scatter (turbidity)
- Acoustic Doppler Current Profiler (flow)
  - with backscatter analyzer (turbidity)
- Niskin bottle (for lab grainsize analyses)
- Sediment grab sampler (bank sedimentation)

Short video impression of one reallocation event

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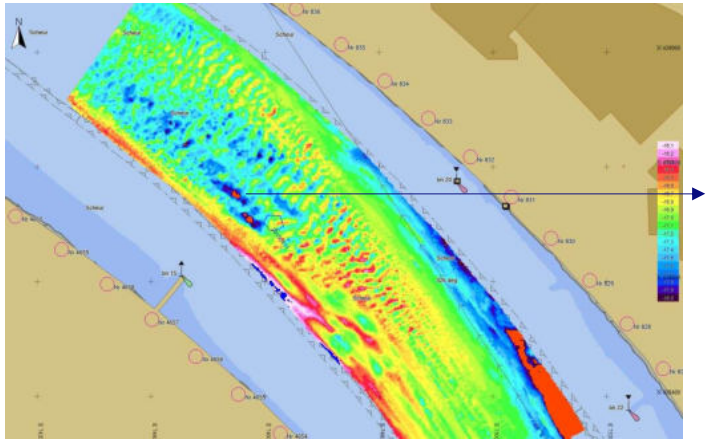
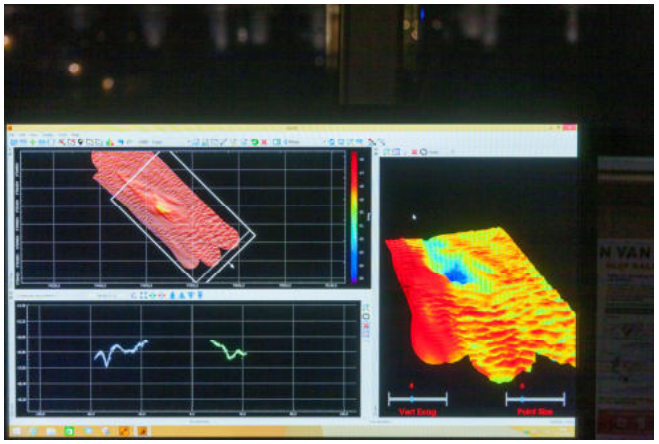
Sediment reallocation within Port of R'dam - bathymetry

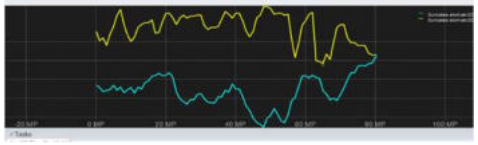
On site (channel) impact of reallocation

Multiple surveys at the site during the reallocation and a weekly multi beam surveys of the channel showed a decrease in the amount of sediment in the channel: The reallocation lead to erosion pits.





Bed level difference before and after reallocation by opening barge doors.



Question 1: On site impact reallocation on main shipping channel: *There is no extra siltation in the channel*

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Sediment reallocation within Port of R'dam - bathymetry

Wetland impact of reallocation

(Detailed results not for this session)

Conclusion:

Question 2: Bank nourishment: *The nourishment of the constructed wetland did not take place*

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Sediment reallocation within Port of R'dam - bathymetry

Downstream impact of reallocation - navigation channel

Pilot site

Based on surveying the bathymetry of the NWW:

- There was some siltation at the northern edge of the channel
  - Resulting in a 500 m shift of the reallocation area
- There was no siltation at the storm barrier location
  - This was the main concern, hampering the closing of the barrier
- The erosion pits filled up after the pilot, no other observed impacts in the navigation channel
  - overall there was no observed siltation in the navigation channel

Question 3: Sediment balance. *Bathymetry surveys showed no increase in the amount of sedimentation*

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Sediment reallocation within Port of R'dam – turbidity

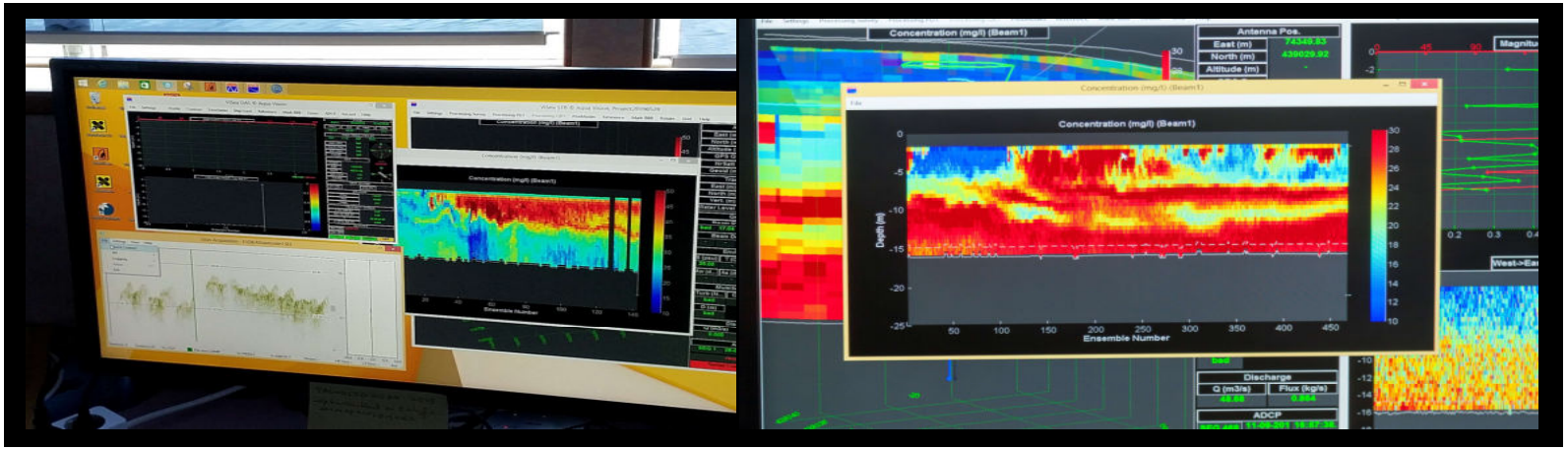
Turbidity during reallocation – on site

The reallocation had a direct impact on the turbidity at the reallocation site.

Depending on the reallocation method, the turbidity increased the most in the top fresh water layer (rainbowing) or in the bottom salt water layer (opening of barge doors).

ADCP backscatter snapshots

Reallocation by rainbowing *Reallocation by opening barge doors*



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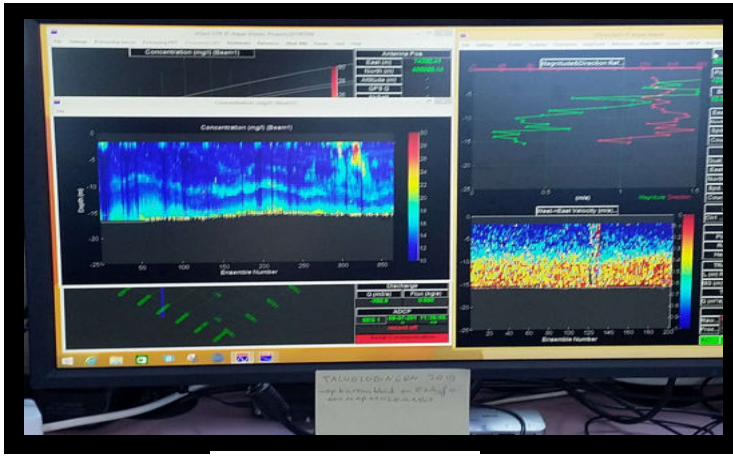
Sediment reallocation within Port of R’dam – turbidity

Turbidity during reallocation - downstream

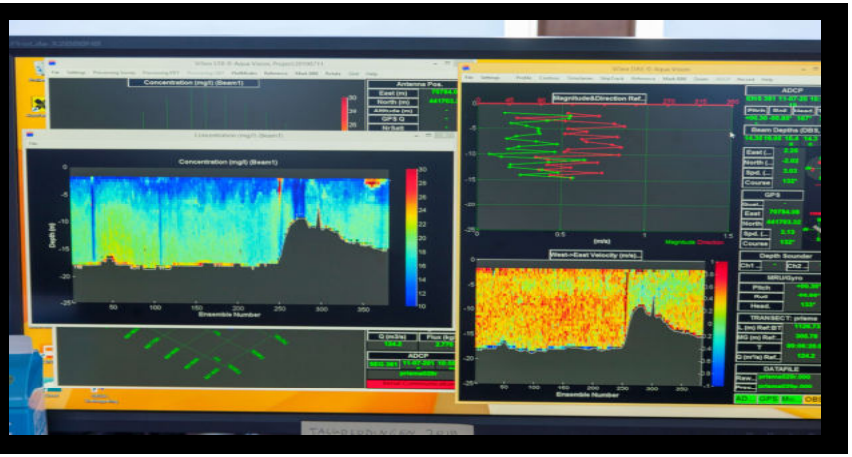
Outside the reallocation site the suspended sediment flume settled into the bottom layer.

ADCP backscatter snapshots

Turbidity 2 km downstream from site



Turbidity 4 km downstream of site



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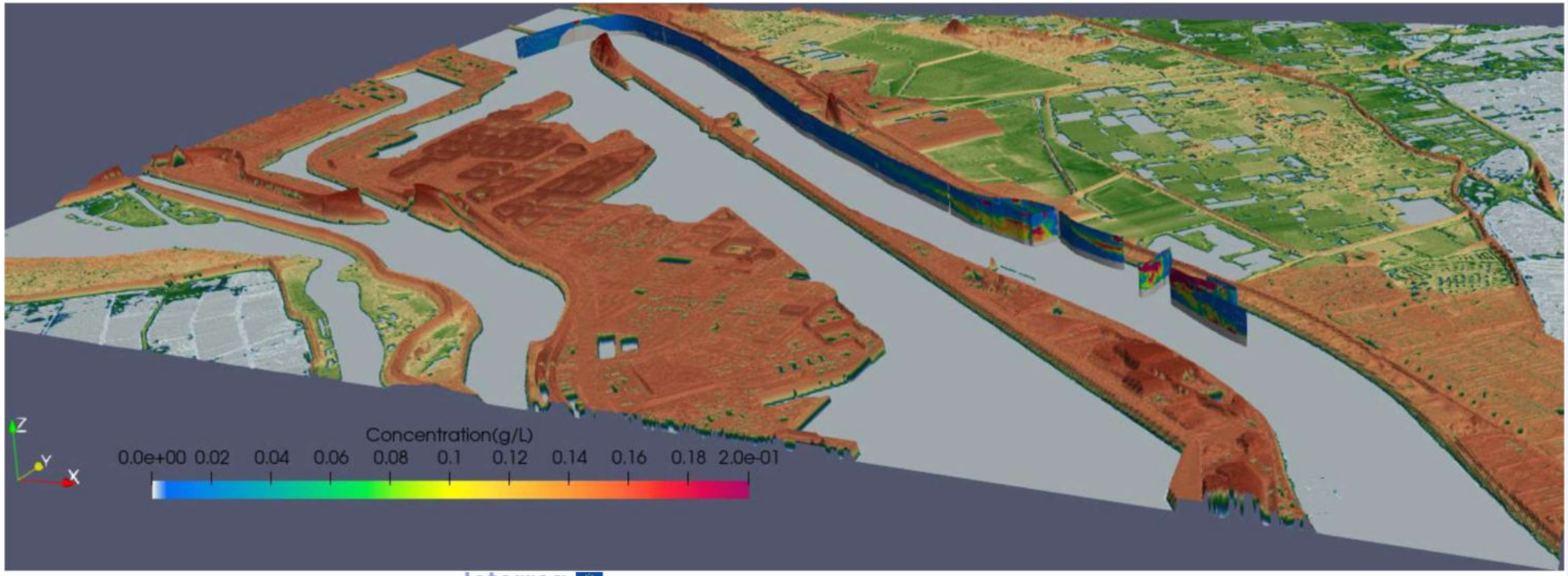
Sediment reallocation within Port of R'dam – turbidity

Turbidity during reallocation - downstream

ADCP backscatter constructed turbidity profiles – following the reallocation flume downstream



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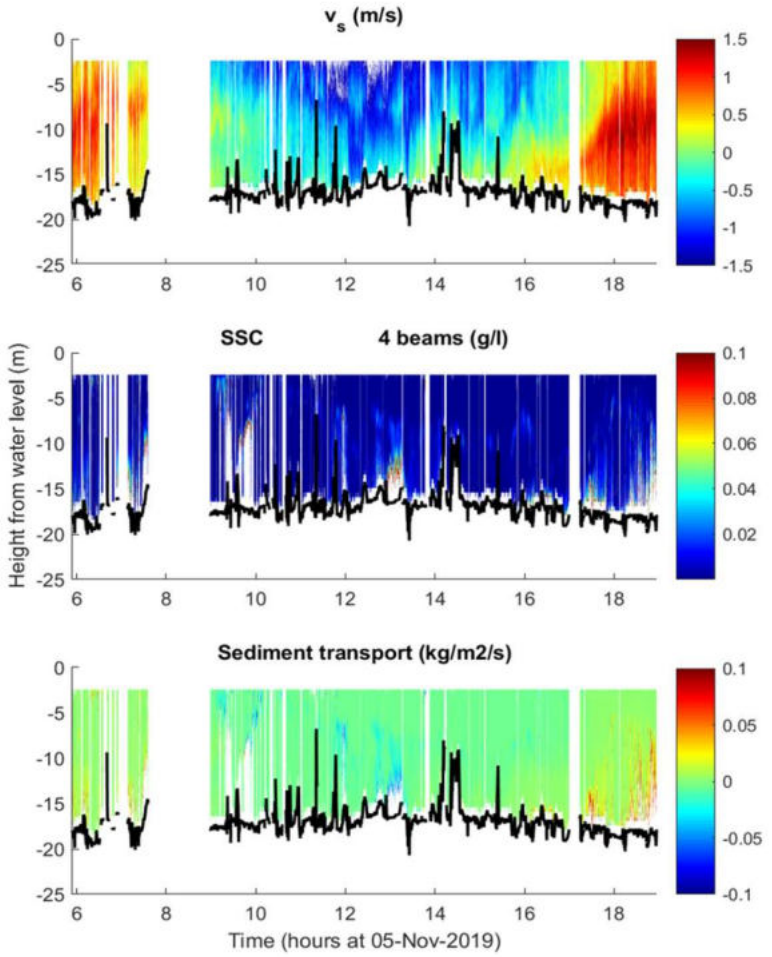
Sediment reallocation within Port of R'dam – turbidity

Turbidity during reallocation - downstream

Sediment transport mass balance, 13 hours campaign

- The flow velocity along the channel (top),
- The suspended sediment concentration (SSC) (middle), and
- The sediment transport per unit width (bottom).

The absolute sediment transport in the profile is highest when the ebb flow velocities are highest.



Question 4: Turbidity. *Sediment transport mostly takes places at the bottom (salt water layer) during outgoing tide. This is in accordance with the reference (T_0) situation.*

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Sediment reallocation within Port of R'dam – seasonal shifts

The overall system impact of the pilot (580.000 m^3 reallocated sediment in 9 months plus 3 months additional monitoring) is in line with the 'normal' system behavior. There is no additional channel sedimentation due to the reallocation and the impact of reallocation on turbidity is only near field (at and close to the site).

How about seasonal patterns?

Sampling during sun, rain and wind

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Sediment reallocation within Port of R'dam – seasonal shifts

Seasonal shifts in river bank sedimentation

Outside the navigation channel there was initially an increase in sedimentation (+ 1 m) on the northern bank. This was at the start of the pilot (May 2019).

Later (November 2019), when the pilot was still conducted, this 1m sediment layer on the northern bank was eroded and the southern bank had an increase in sedimentation (+ 1 m).

Grab sampling showed a seasonal shift in sedimentation/erosion outside the main navigation channel, this could not be contributed to the extra sediment in the reallocation area.

Almost empty vs. half full core sample

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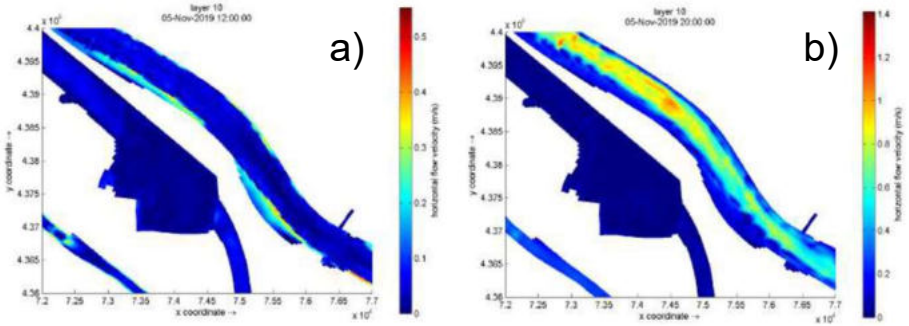
Sediment reallocation within Port of R'dam – seasonal shifts

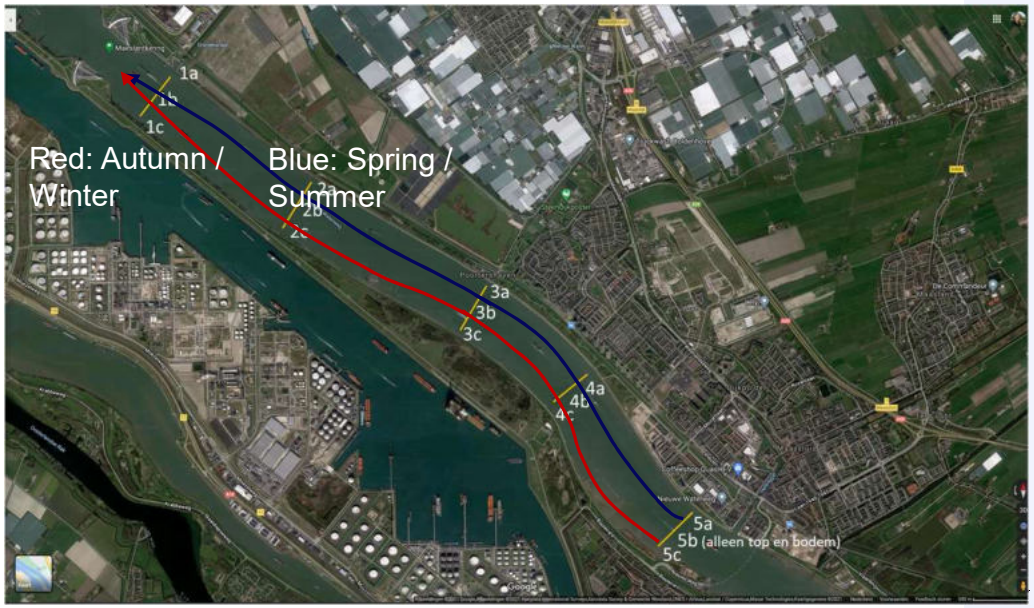
Seasonal shifts in turbidity

Can the shift in bank sedimentation be linked to changes in turbidity, using the reallocation flume as transport tracer? Yes, tracing the flume we observed:

- A north bank oriented pattern during spring/summer
- A south bank oriented pattern in the autumn/winter



Modeled flow velocity close to the bed in winter during ebb a) and flood b)



SSC Sample locations, colored lines are area's with high SSC

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Sediment reallocation within Port of R'dam – seasonal shifts

Seasonal shifts in turbidity and sedimentation – conclusions

While the regional pattern of sedimentation within the port, including the (minimal) contribution of the reallocation pilot, was predicted correctly by the simulation model, local effects were missed. These effects are seasonal dependent.

Sediment reallocation within Port of R’dam – questions

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