

Monitoring of suspended mater with H-ADCP devices and comparison with sedimentation rates and soil properties in the Köhlfleethafen harbour basin of the Hamburg port



***Presentation on the General Assembly 2023 of the European Geosciences Union (EGU) @ Austria Center Vienna (ACV)
Session HS9.3 Hydro-morphological processes in open water environments – measurement and monitoring techniques***

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Analysis of Consolidation Grades

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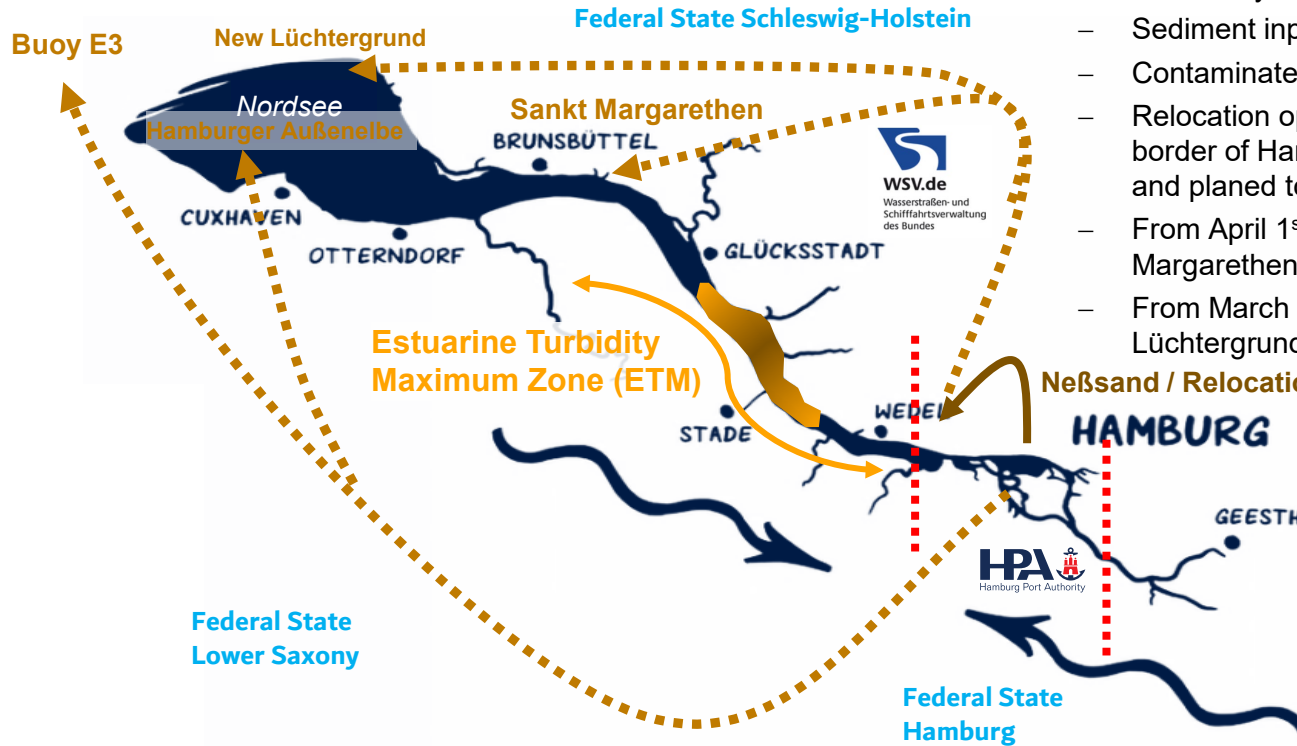
Comparison Sediment Flux and
Sedimentation Rate / Mass Dry Matter

Introduction

Background

01

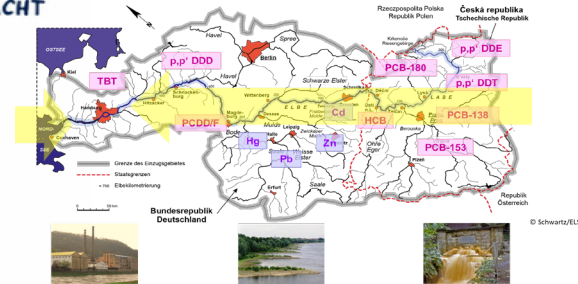
Boundary conditions of the HPA with regard to sediment management options



- Federal system / a lot of responsibilities and stakeholders
- Sediment input from upstream and downstream
- Contaminated sediments from upstream
- Relocation options within Hamburg at Neßsand (state border of Hamburg) and in the North Sea at Buoy E3 and planned to Hamburg Außenelbe
- From April 1st, 2021 also relocation at Sankt Margarethen possible (area of the federal agency)
- From March 15th, 2022 also relocation at New Lüchtergrund possible (area of the federal agency)

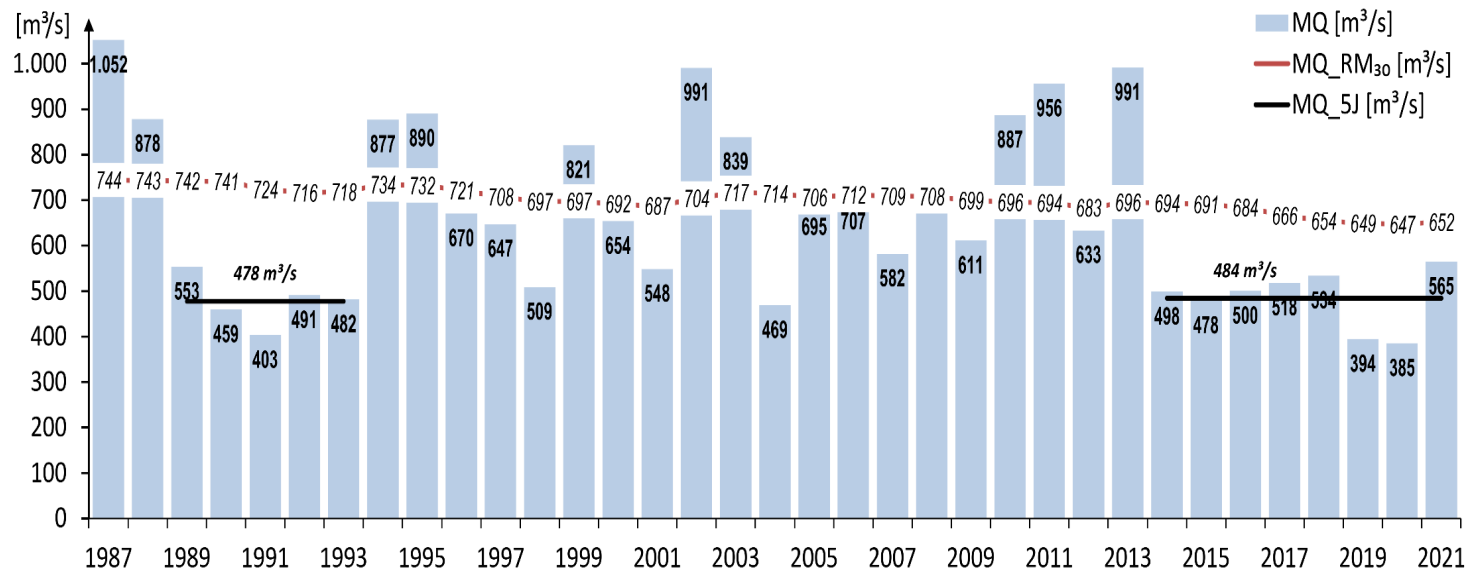
Neßsand / Relocation to border of Hamburg

Contaminated Sediment from the catchment area of the Elbe



Climate Change influences the dredging quantities in Hamburg

- Extremely low discharges (climate change) that have persisted for 8 years! This means that more sediment enters the port and not enough material can be relocated sustainably to buoy E3 for export.
- The result is increasing sediment accumulation in Hamburg!

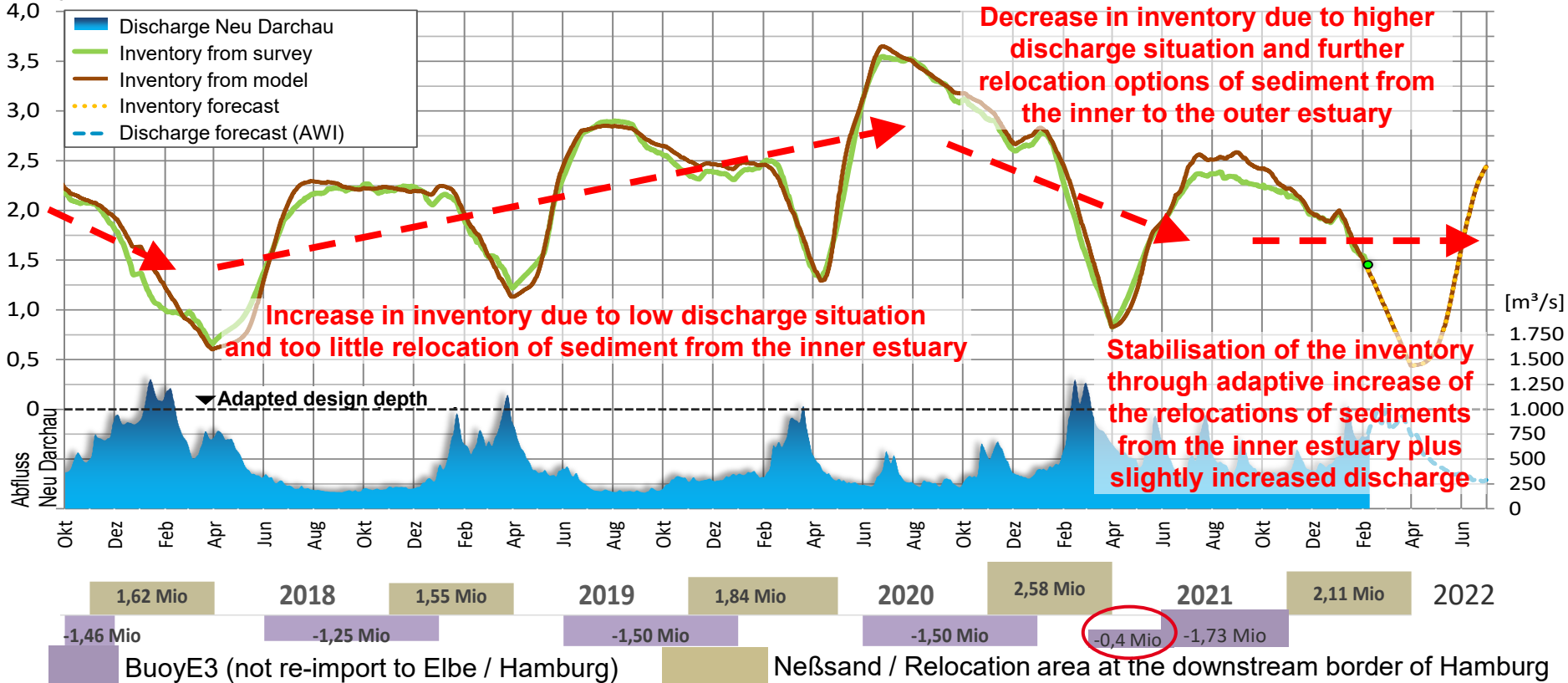


If the discharge drops from 700m³/s to 200m³/s, then the amount of sediments in HH is five times higher !

At discharges of 200 m³/s, the sedimentation rates are around 10,000 t/d!

Increasing sediment inventory in the harbour: Dredging circles due to higher sediment import and limited export to buoy E3

Mio. t dry matter



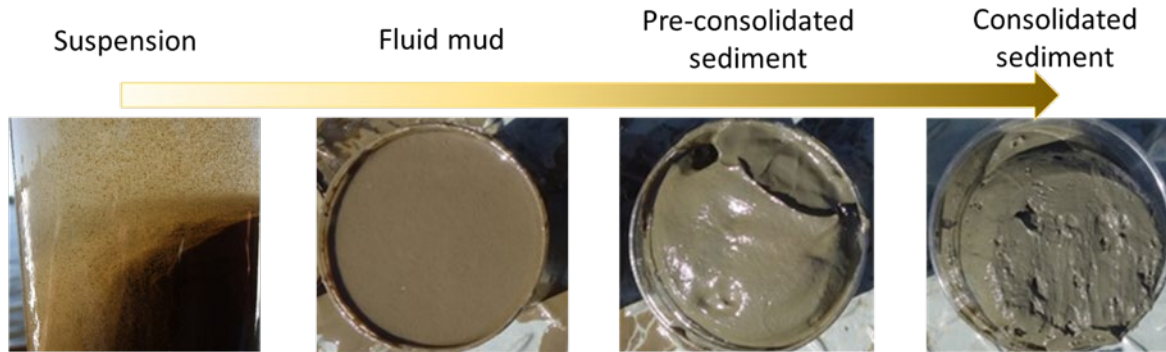
Sediment Properties

Boundary Conditions

02

- Aerobic or anaerobic decay depending on redox conditions
- Classification by organic matter pools with organic matter rates

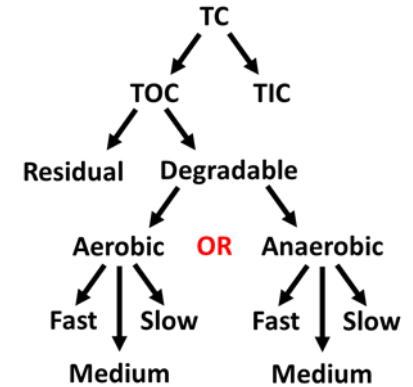
Organic matter metamorphosis in sediments



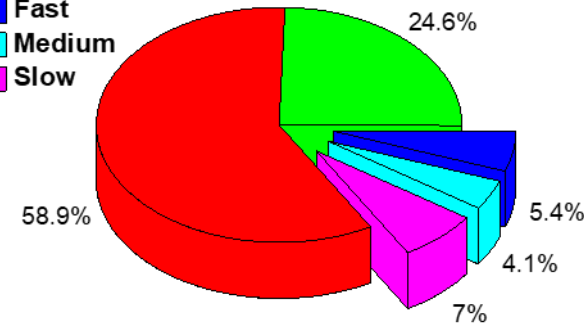
Labile SOM

Mineralisation • Transformation • Stabilisation in organo-mineral complexes

Stabile SOM



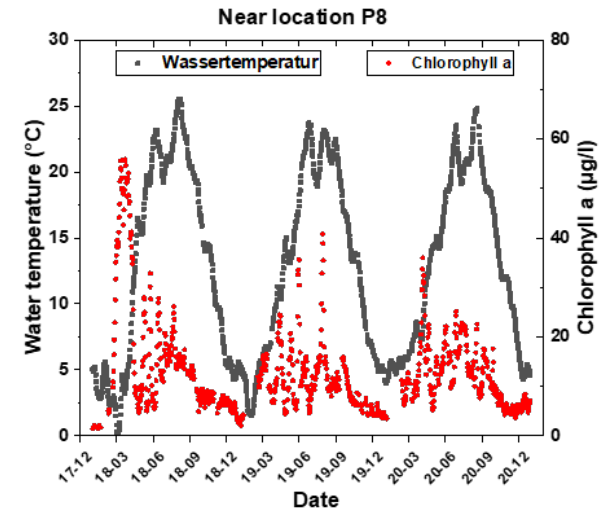
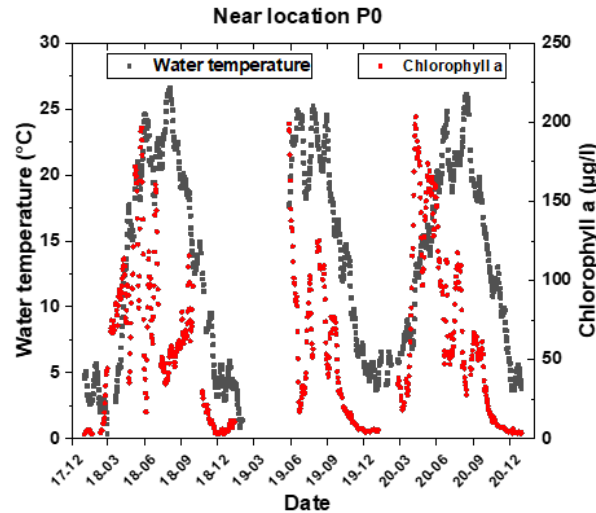
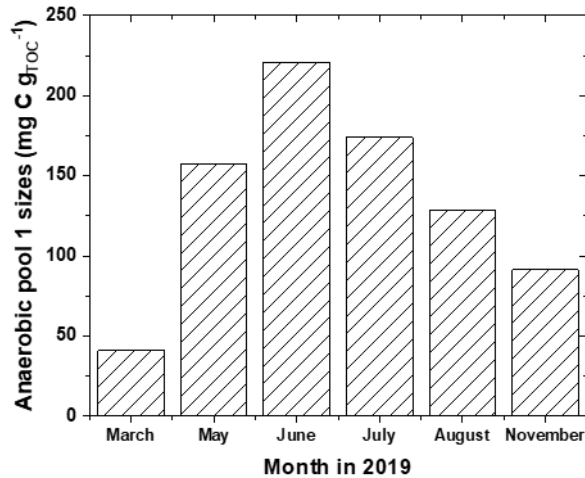
- Residual
- TIC
- Fast
- Medium
- Slow



More boundary conditions due to dependencies on temperature and seasonal effects (algae bloom and Chlorophyll)

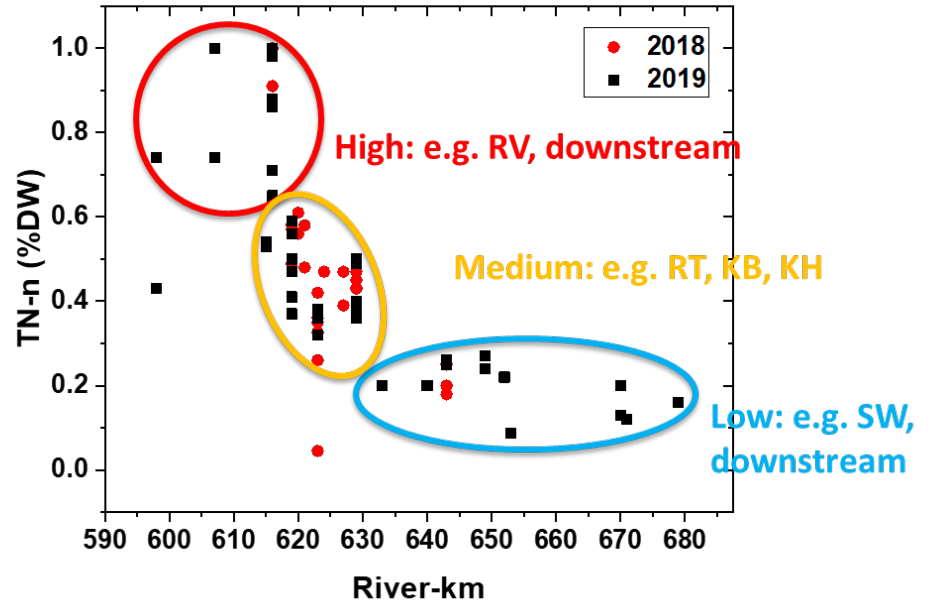
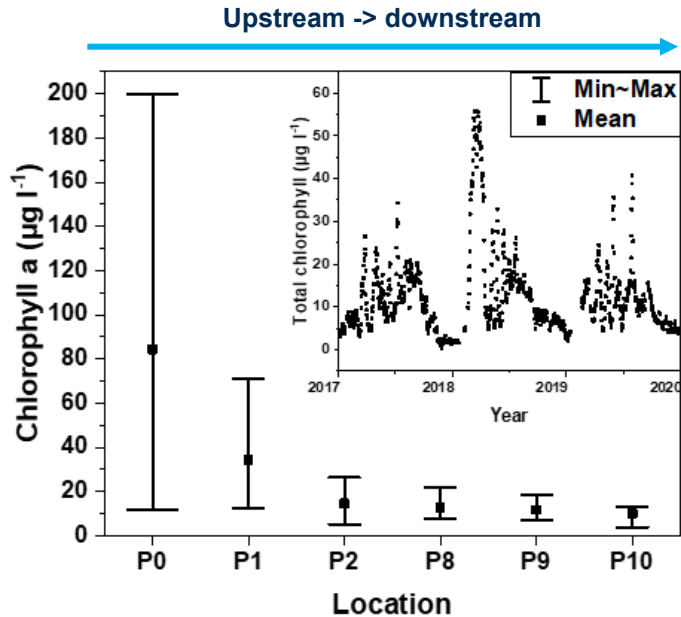
- Chlorophyll a as algal biomass indicator
- Clear temporal trends (summer winter)
- Temporal pattern explained by input of fresh, easily degradable OM from upstream in spring and early summer (phytoplankton)
- Light deficits in winter lead to lower net primary production (algal biomass)

Climate Change has an important impact!



Advantage: Cluster of biological parameters is possible

- Clustering of locations (upstream: RV, downstream: SW and other)
- Chlorophyll a, TOC, silicic acid, microbial biomass, O2 consumption and EPS decrease in direction downstream

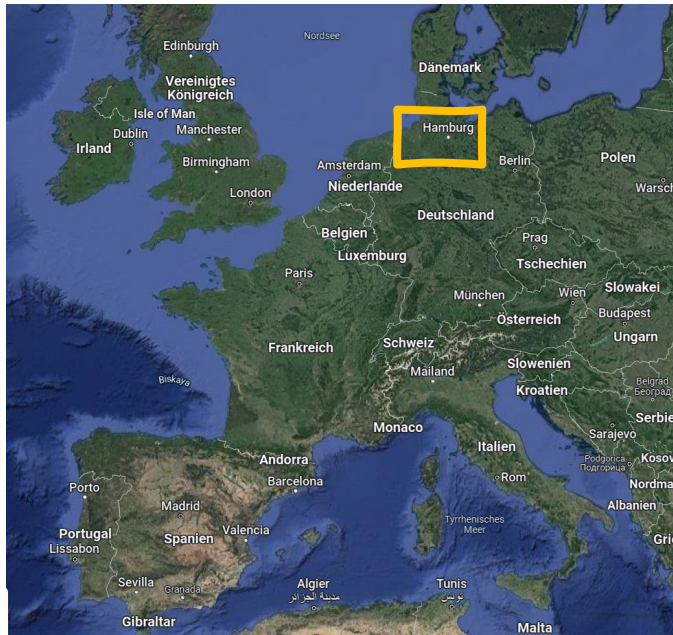


H-ADCP Monitoring Stations

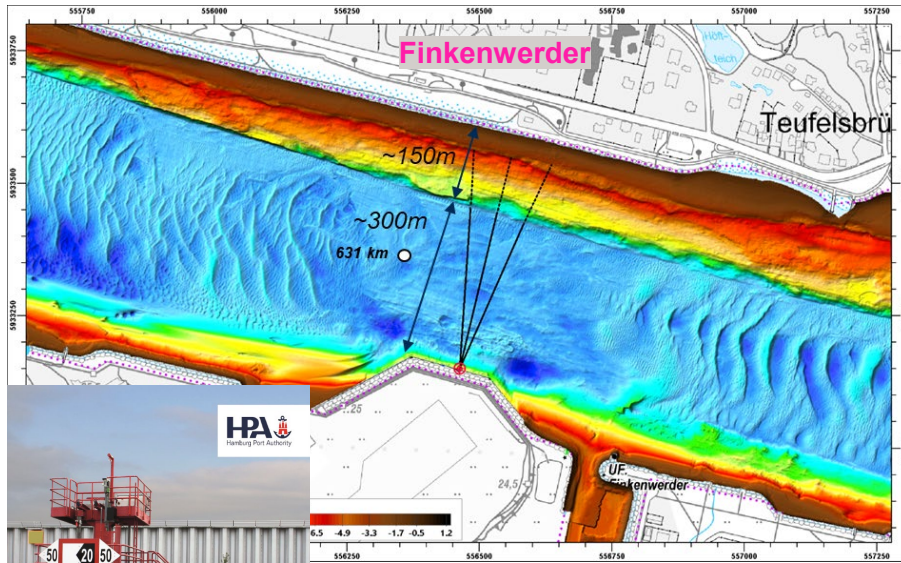
Technical and Analysis Background

03

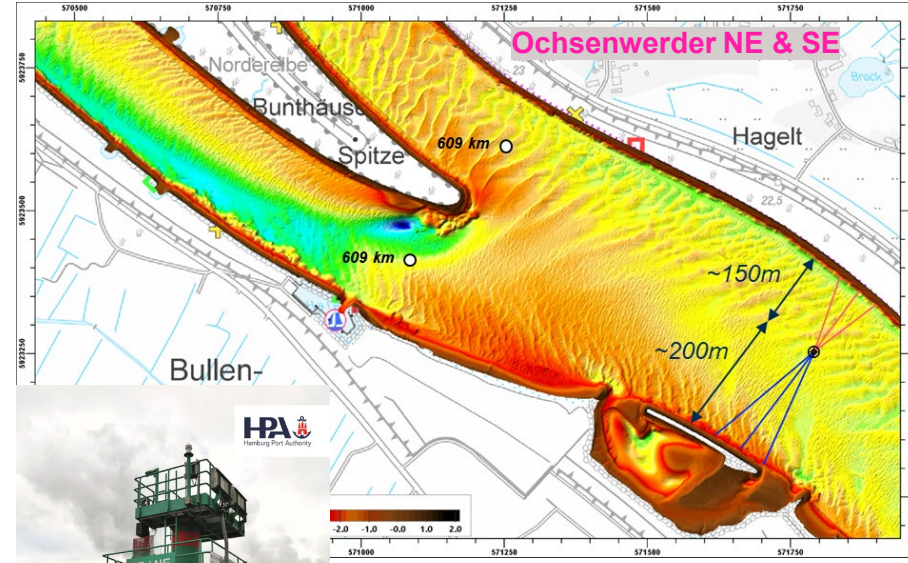
Monitoring of Suspended Matter with H-ADCP Devices



Monitoring Stations Overview



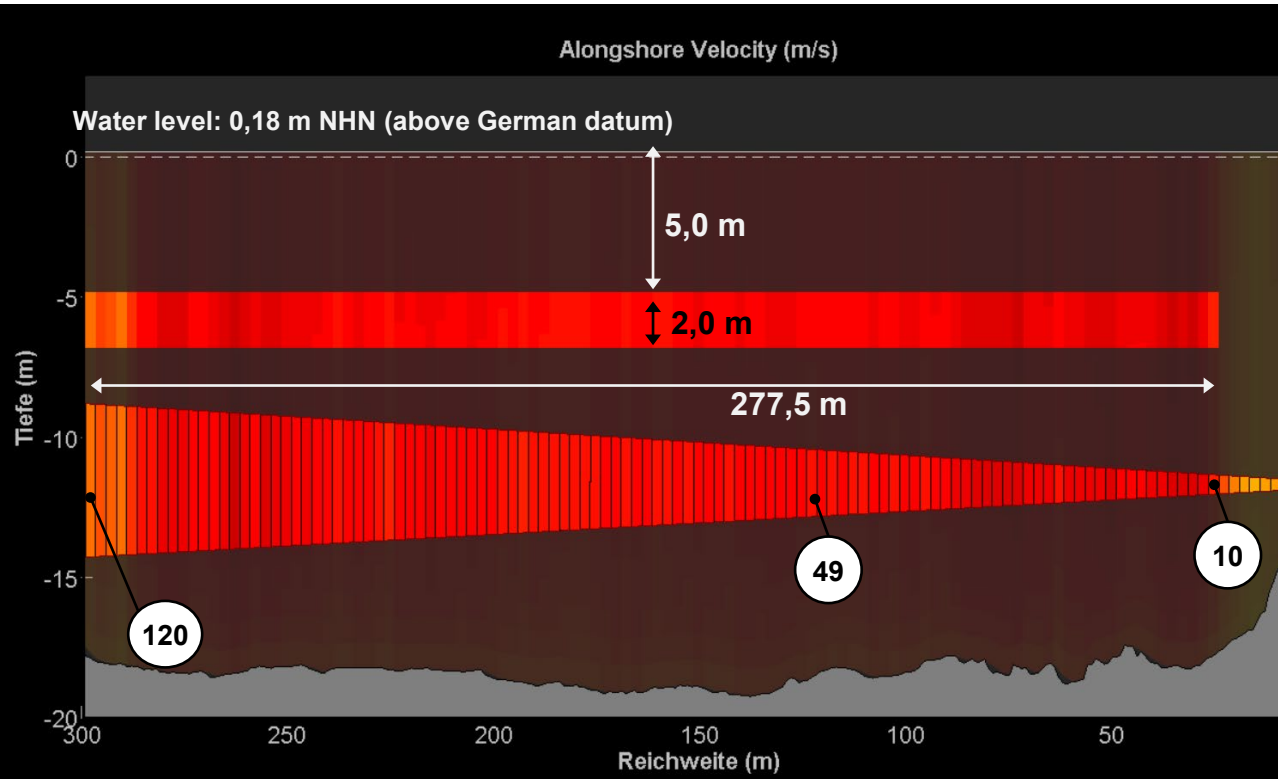
- 3 H-ADCP monitoring stations
- Data writings since 2011
- Direct measurements of flow and backscatter
- Derived parameters: Flow and suspended sediment concentration



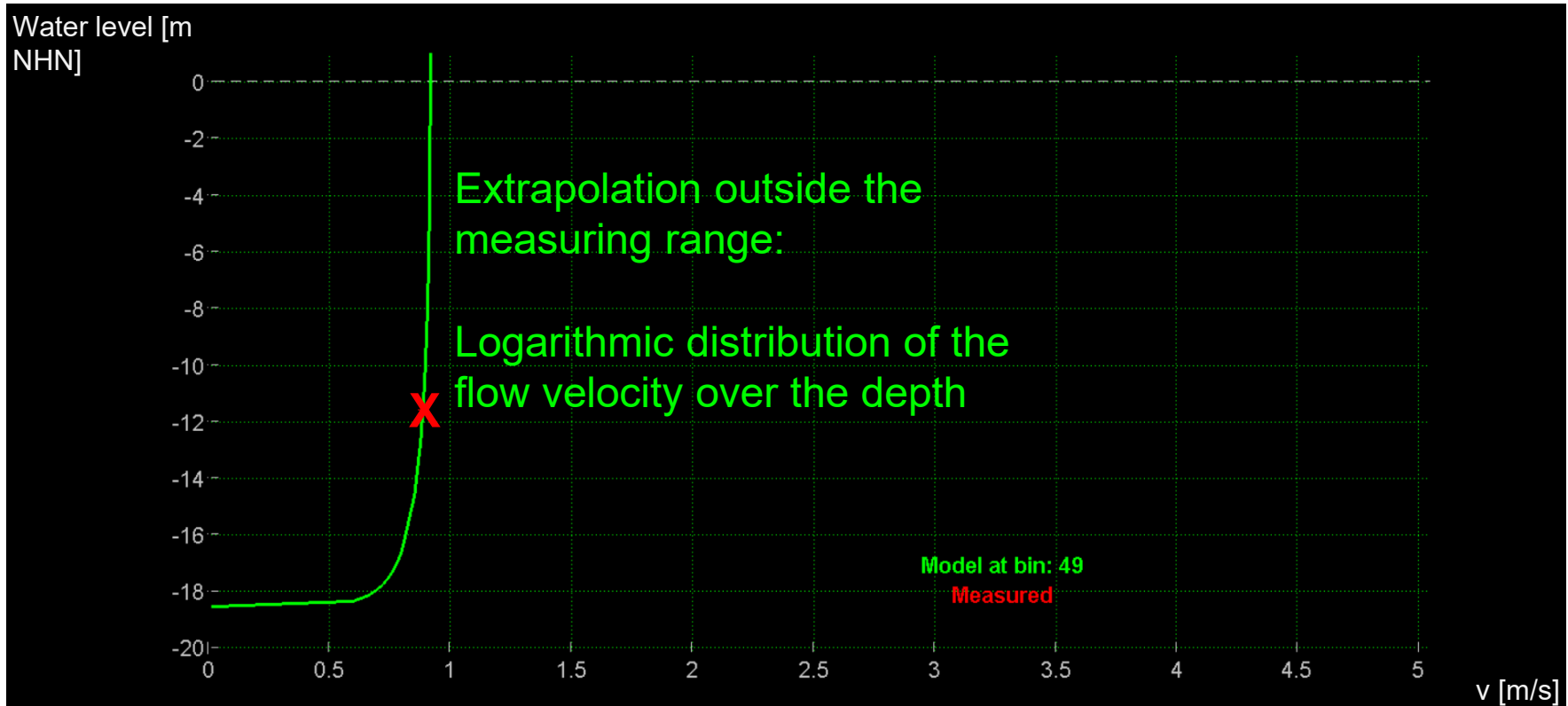
- Used Aqua-Vision Software: ViSea-H & PDT-H
- MATLAB Routine: Analysis and Validation of flow current and SSC Flux

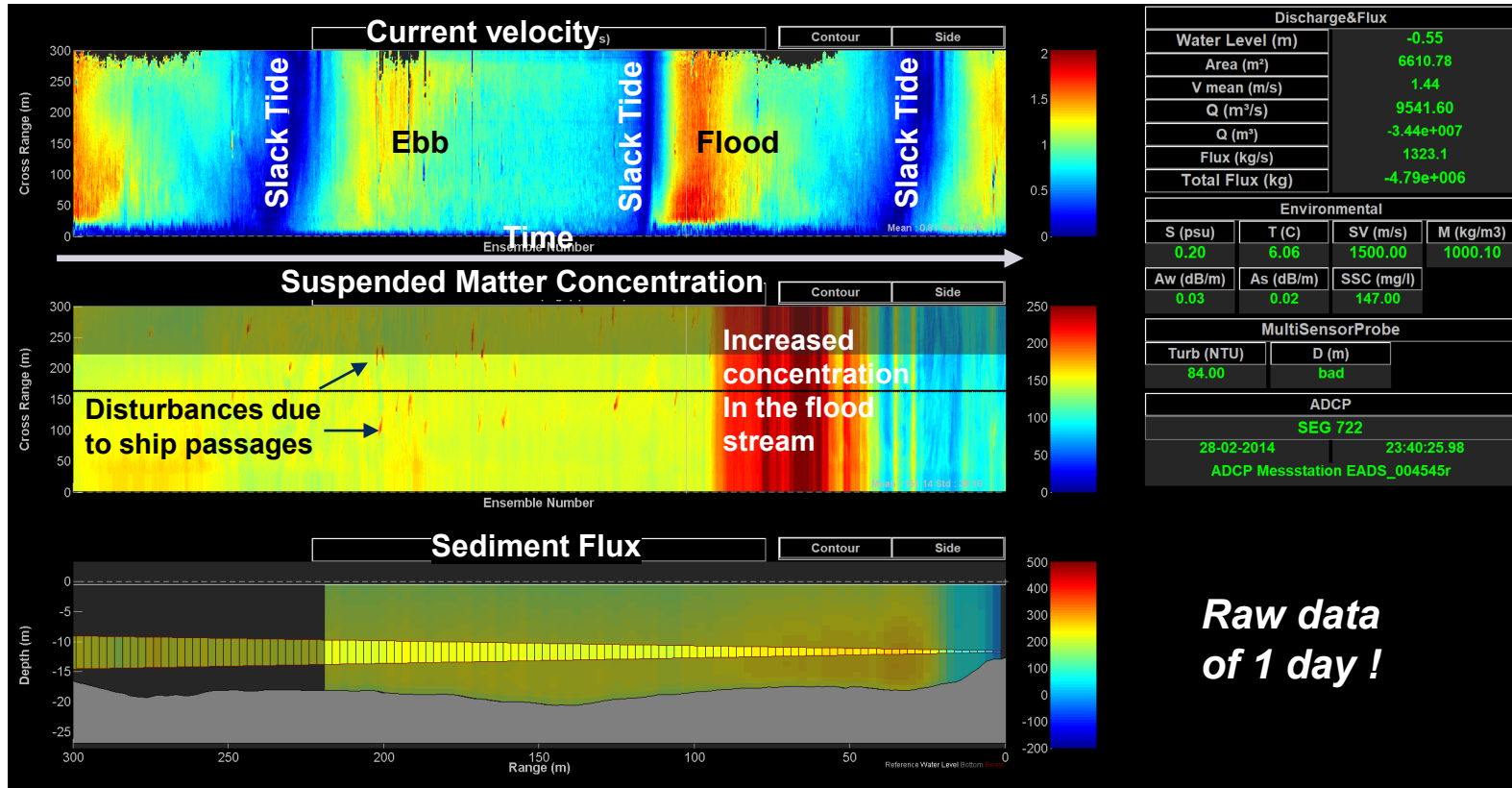
Monitoring Station Finkenwerder

24.02.2021 10:32 MEZ



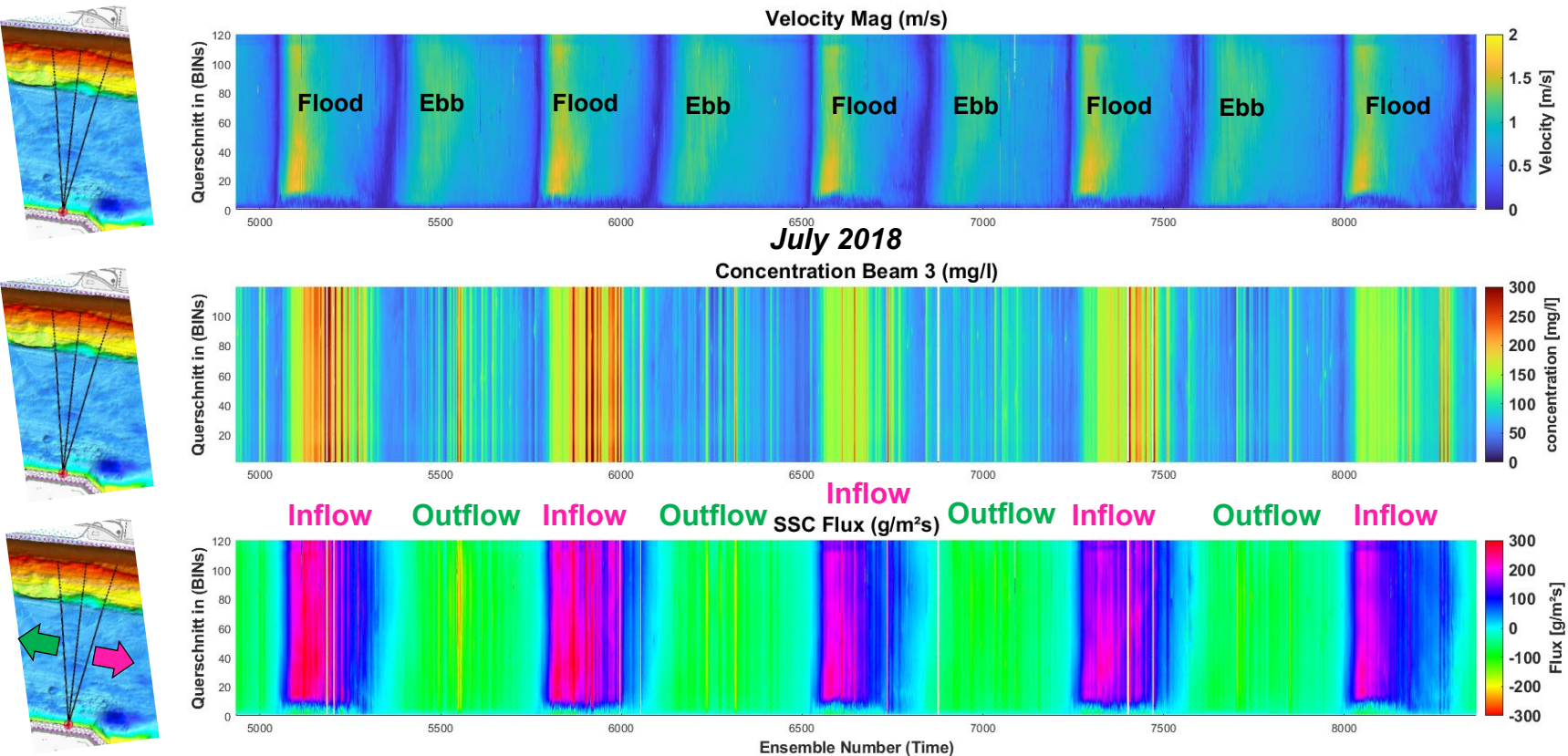
ADCP			
ENS 1172	24-02-2021	10:32:04.66	
Pitch	Roll	Peilung	Temp.
+00.04°	-00.21°	016°	03°C
Water Level			
Pressure (Pa)	118510		
Wasserstand (m)	0.18		
Gemessenes Profil			
Area (m ²)	5459.41		
V mean (m/s)	1.08		
Q (m ³ /s)	5899.25		
Total profile			
Area (m ²)	6920.83		
V mean (m/s)	1.08		
Q (m ³ /s)	7478.41		
TRANSECT: ADCP Messstation EADS_			
T	19:31:00.00		
Qtot (m ³)	-1.36e+008		
Datendatei			
Raw Data	ADCP Messstation		
Verarb. D...	EADS_20210224_000		
ADCP			



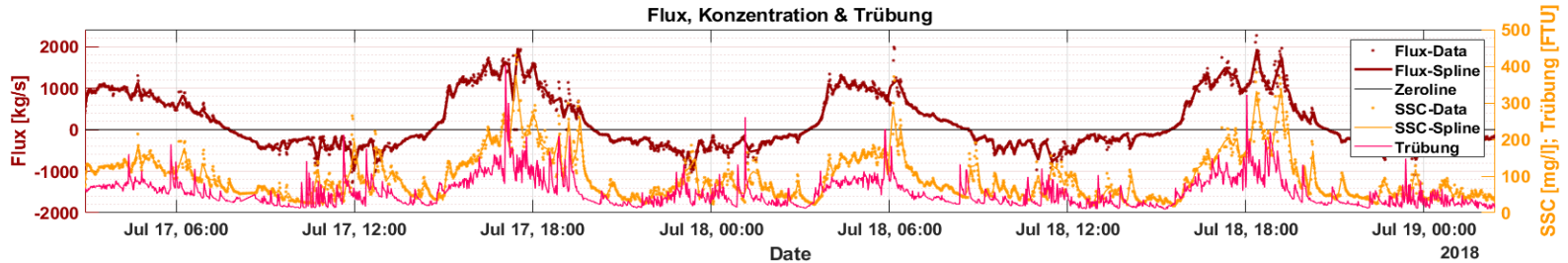
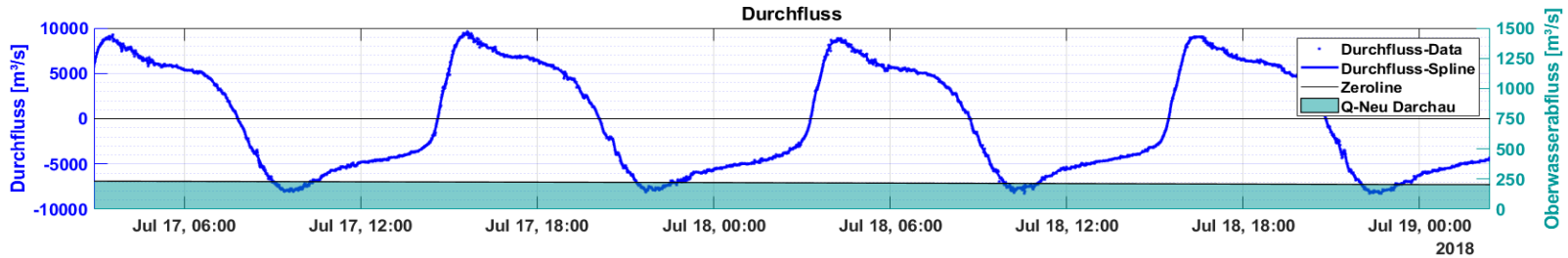
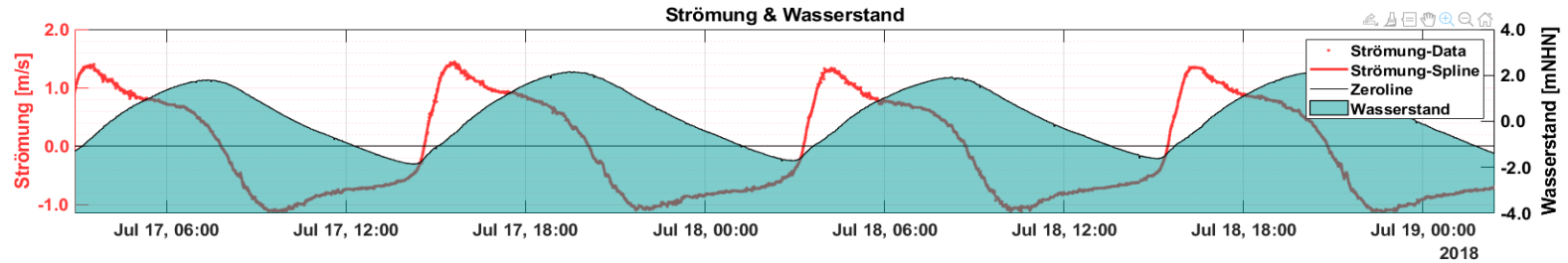


Raw data of 1 day !

Suspended matter concentration & flux calculation with H-ADCP data



Suspended matter concentration & flux calculation with H-ADCP data



Soundings with Sediment Profilers

Analysis of Consolidation Grades

04

Recording the parameters of a suspension layer in 2D

Deepenschriewer II:

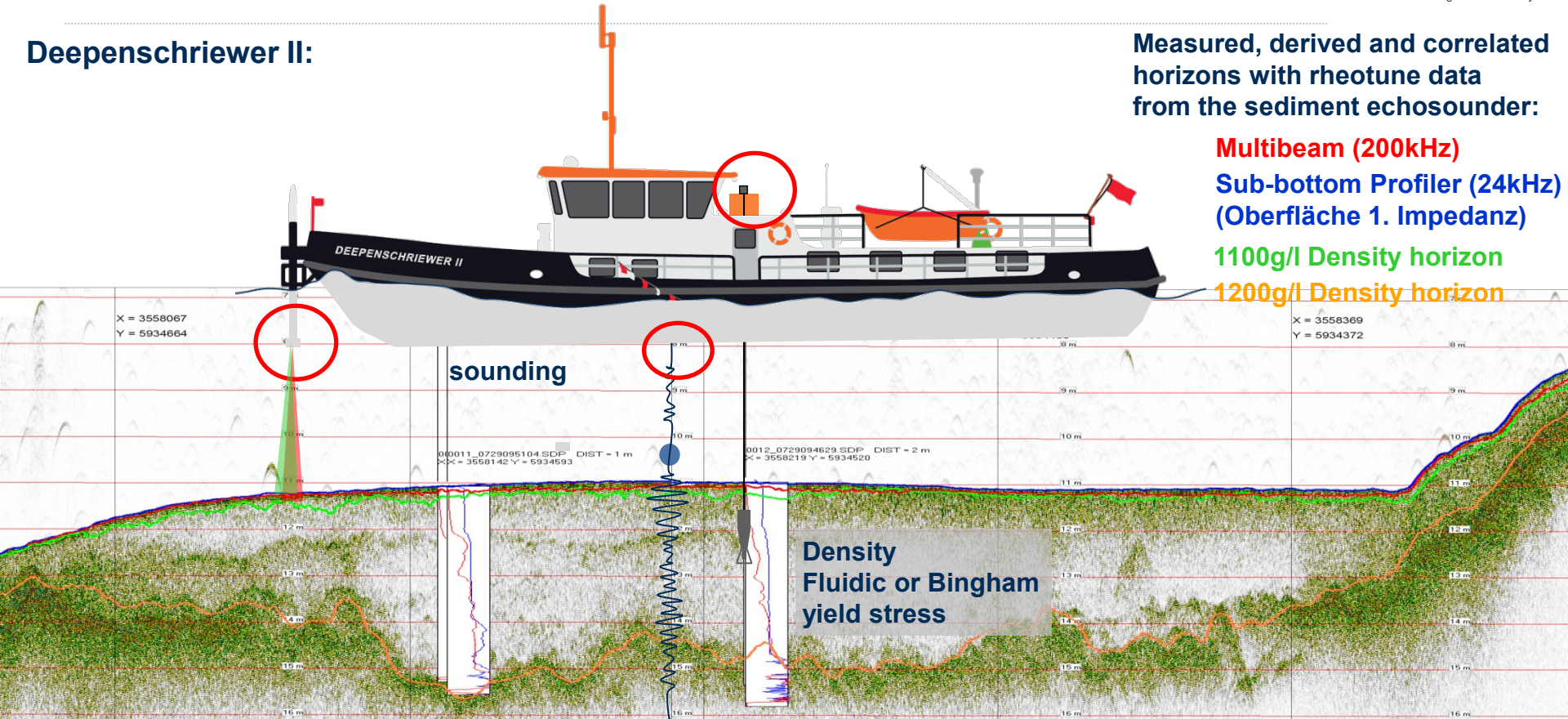
Measured, derived and correlated horizons with rheotune data from the sediment echosounder:

Multibeam (200kHz)

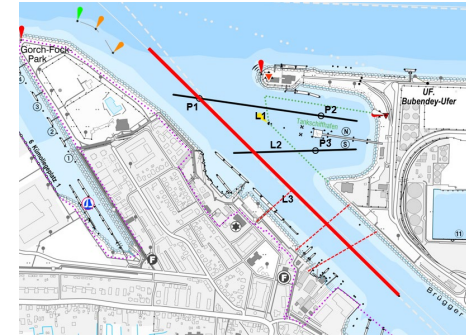
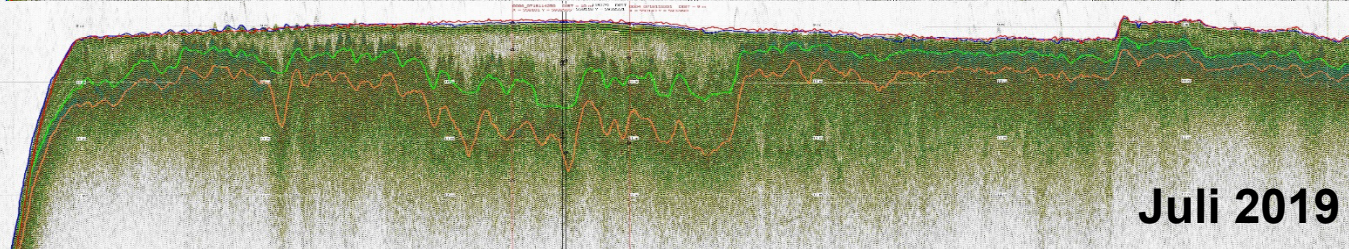
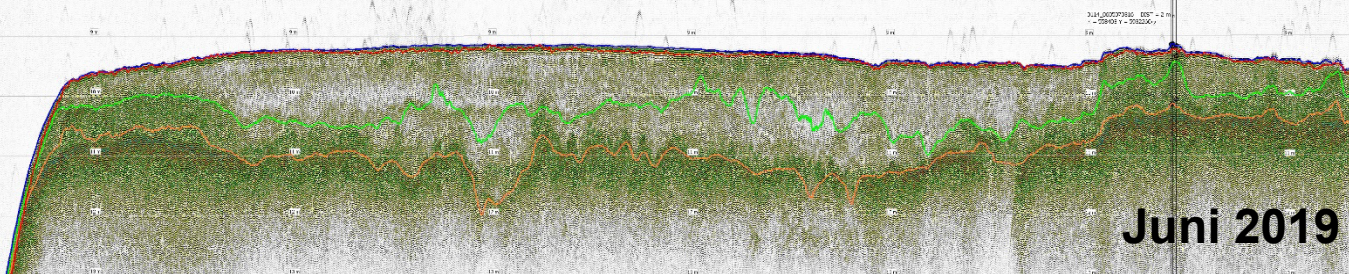
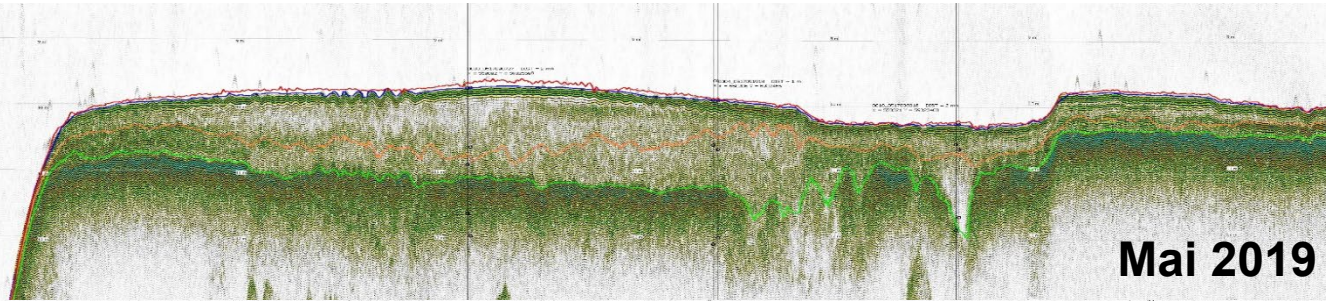
Sub-bottom Profiler (24kHz)
(Oberfläche 1. Impedanz)

1100g/l Density horizon

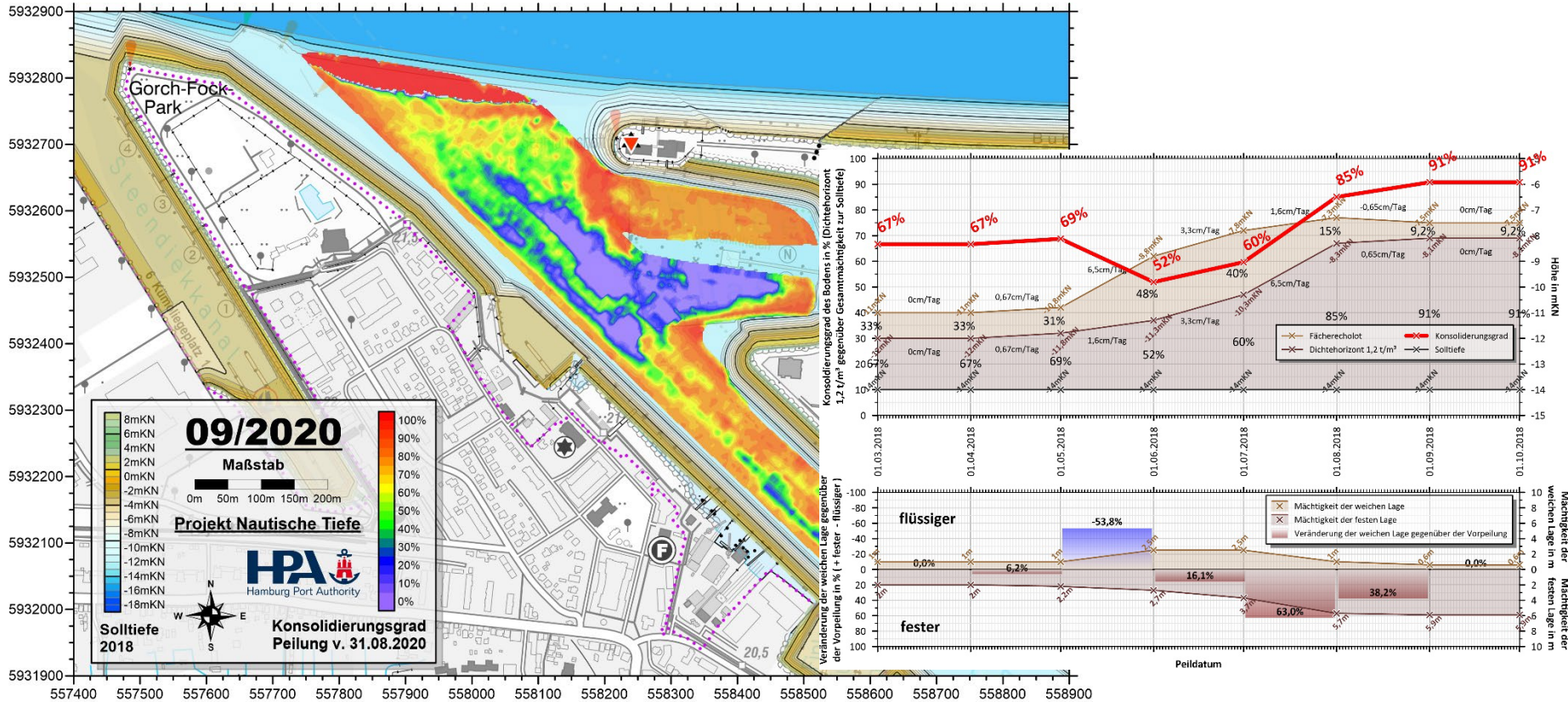
1200g/l Density horizon



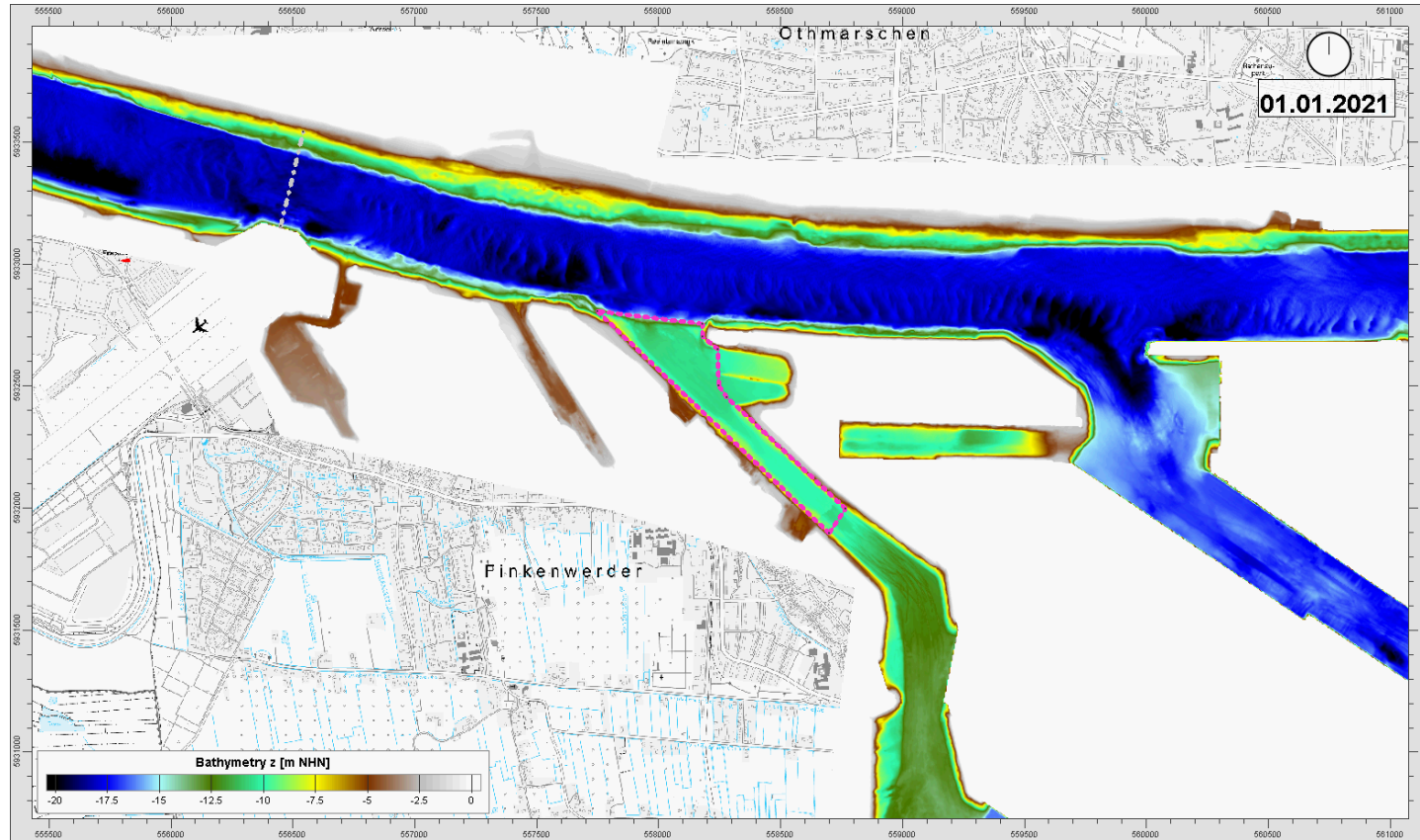
Recording the parameters of a suspension layer in 2D over the time



Calculation of Consolidation Grades



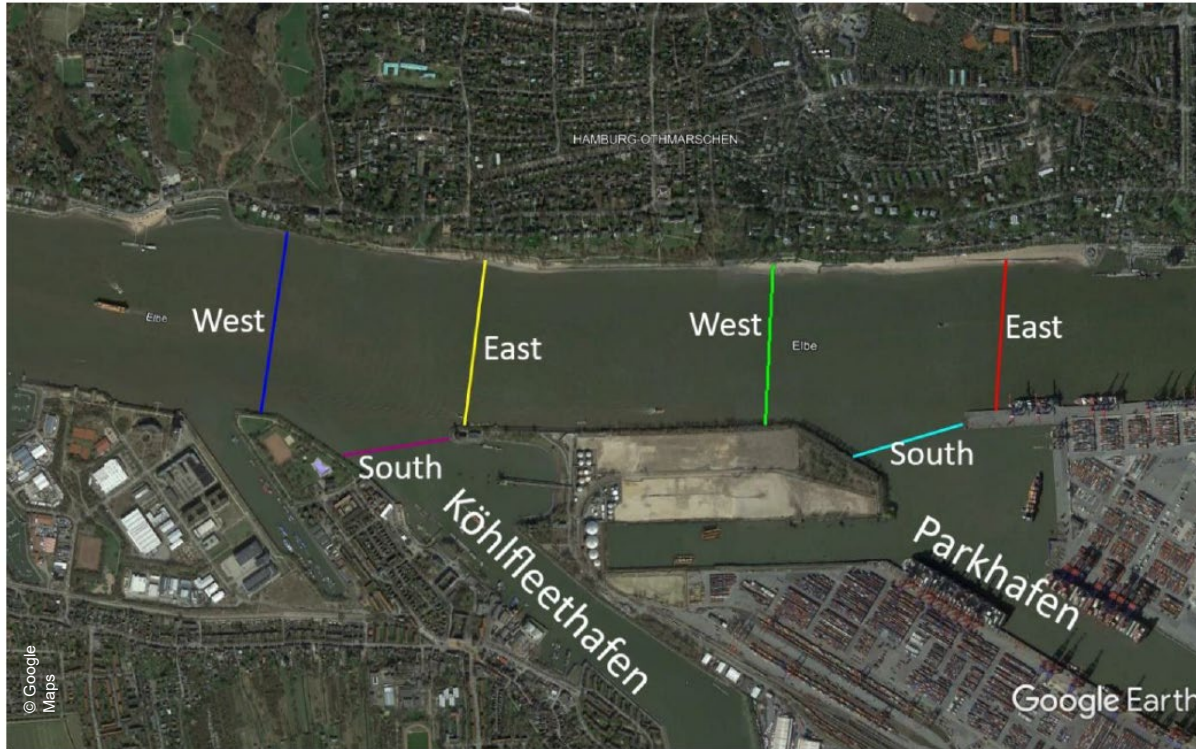
Changing Bathymetry 2021 / 2022 – Boundary Conditions for Calculations



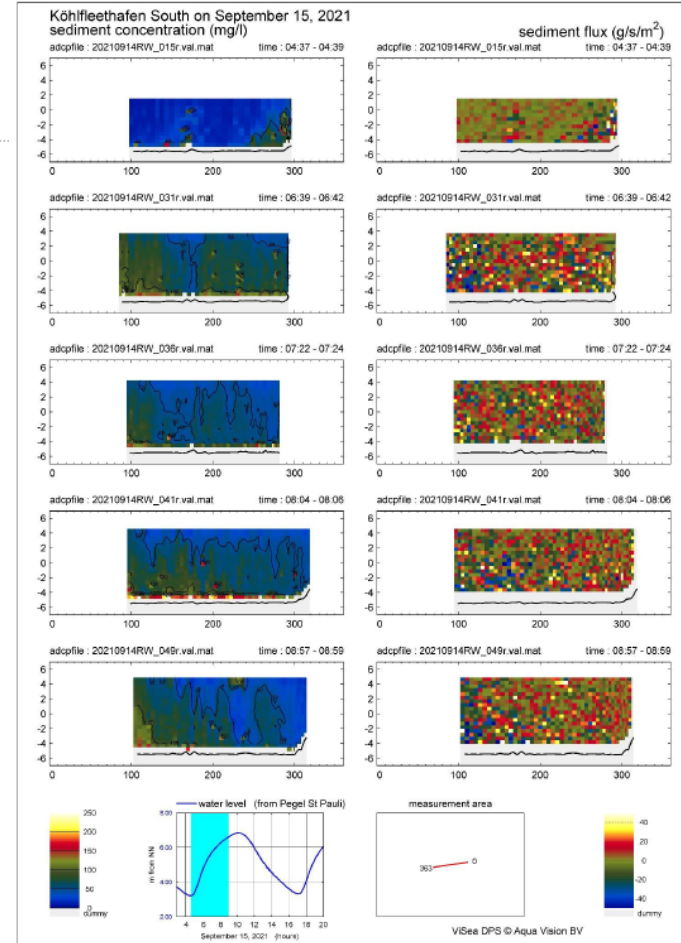
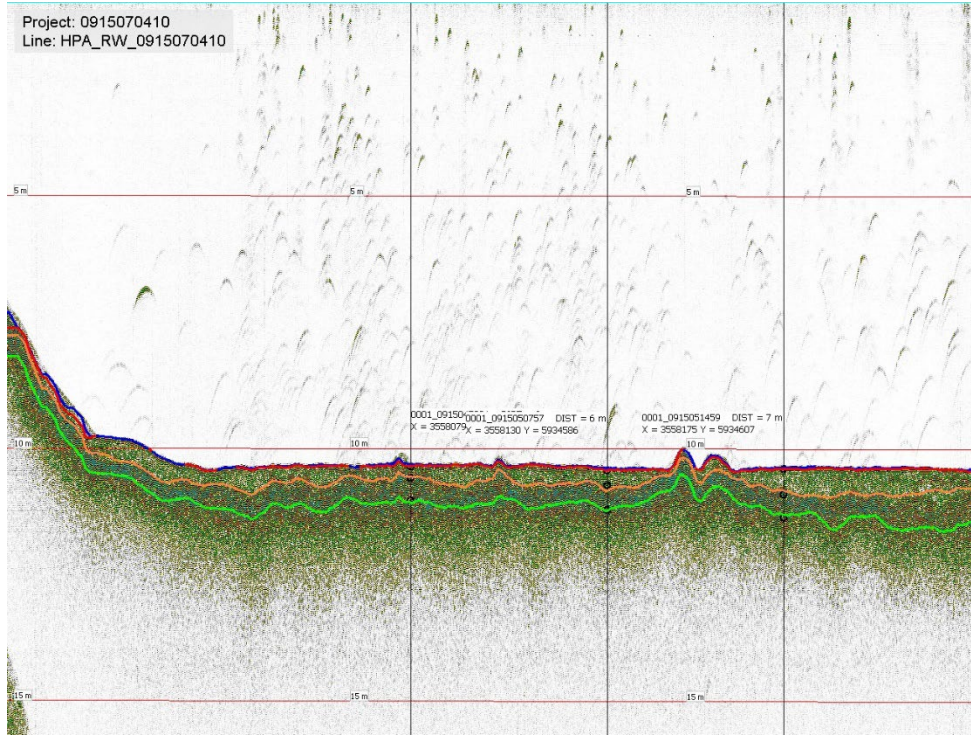
V-ADCP Plume Detection *Analysis of Sediment Flux Split-Up.*

05

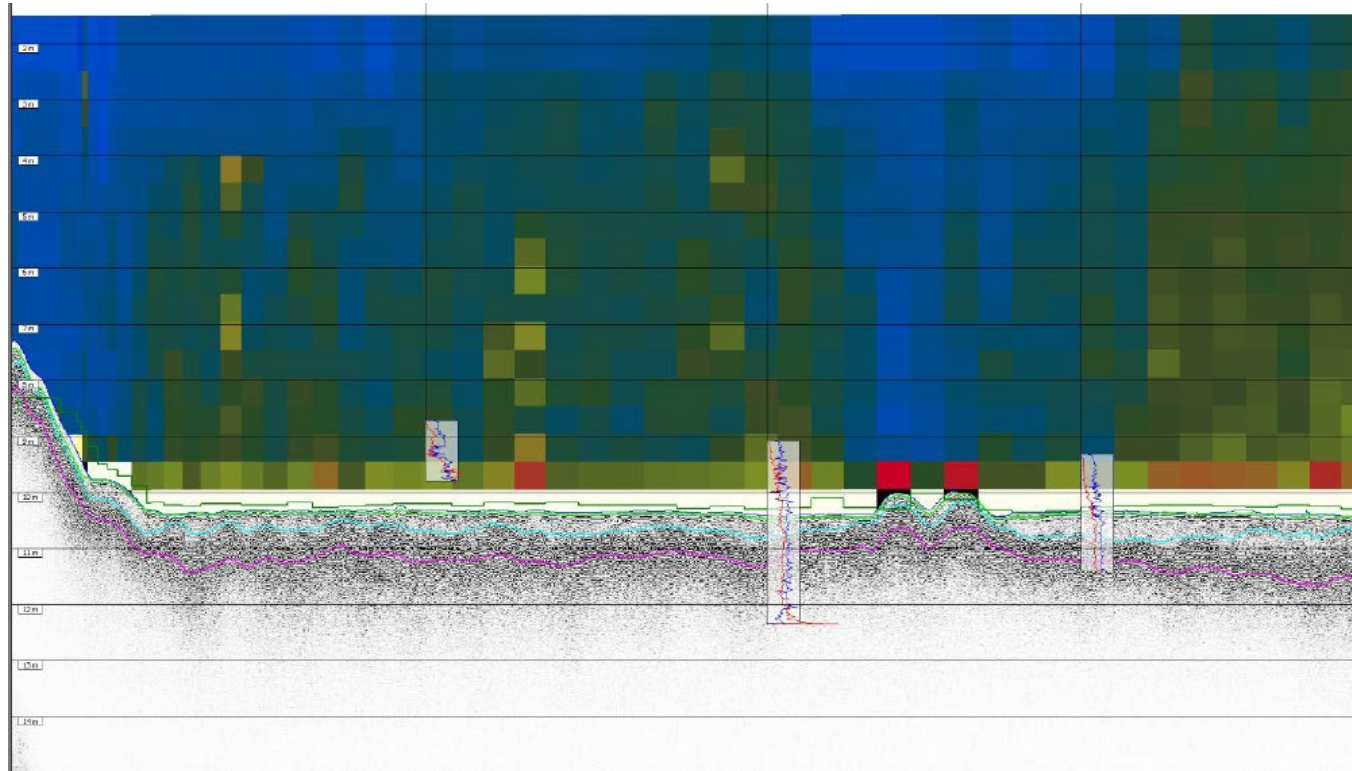
V-ADCP Plume Detection and Combination with Sediment Profilers for the Analysis of Sediment Flux Split-Up at Köhlfleet and Parkhafen



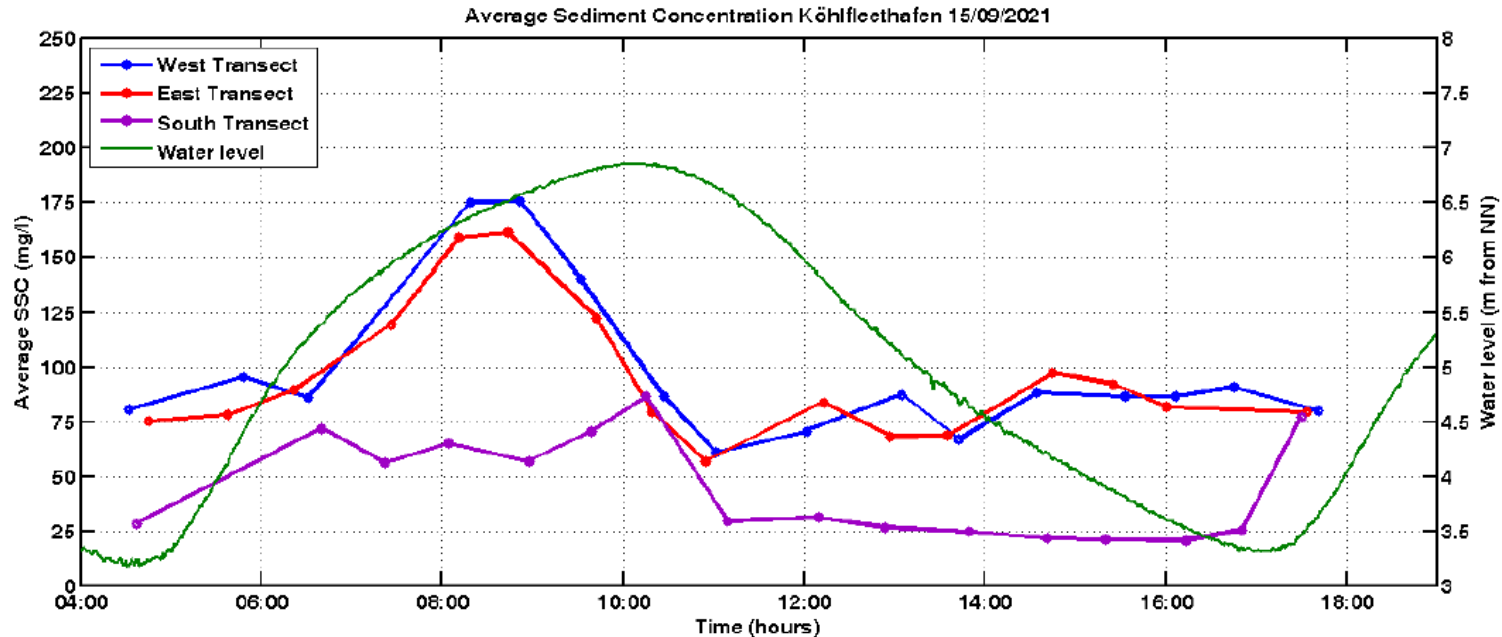
Combination of V-ADCP Plume Detection and Sediment Profiler (Silas)



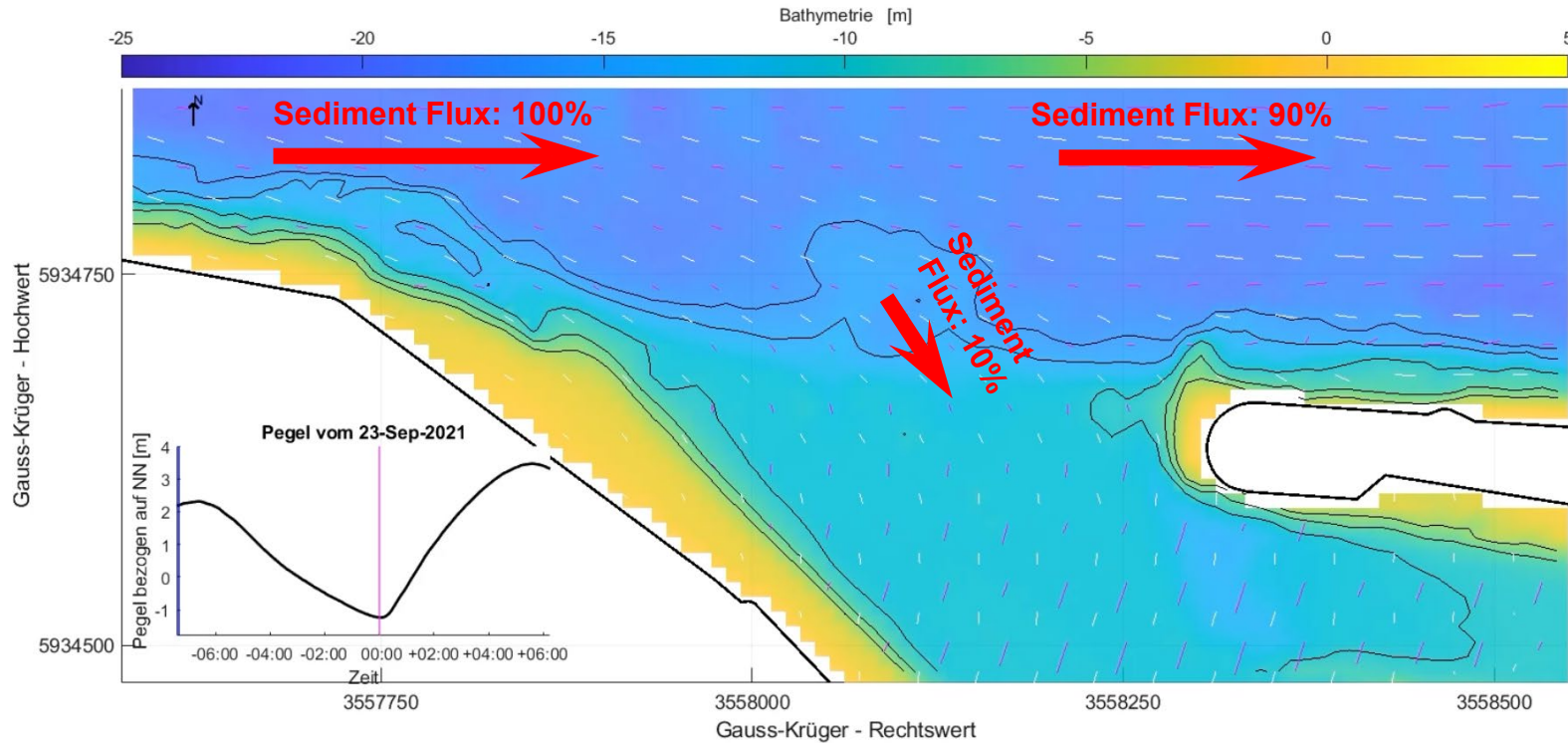
V-ADCP Plume Detection and Combination with Sediment Profilers for the Analysis of Sediment Flux Split-Up at Köhlfleet and Parkhafen



V-ADCP Plume Detection and Combination with Sediment Profilers for the Analysis of Sediment Flux Split-Up at Köhlfleet and Parkhafen



V-ADCP measurements: Analysis of flow patterns and eddies at the Köhlfleet within the layer $-7\text{m} > d > -10\text{m}$ layer (white) compared to the layer $-10\text{m} > d > -14\text{m}$ layer (pink)



Comparison Sediment Flux and Sedimentation Rate / Mass Dry Matter

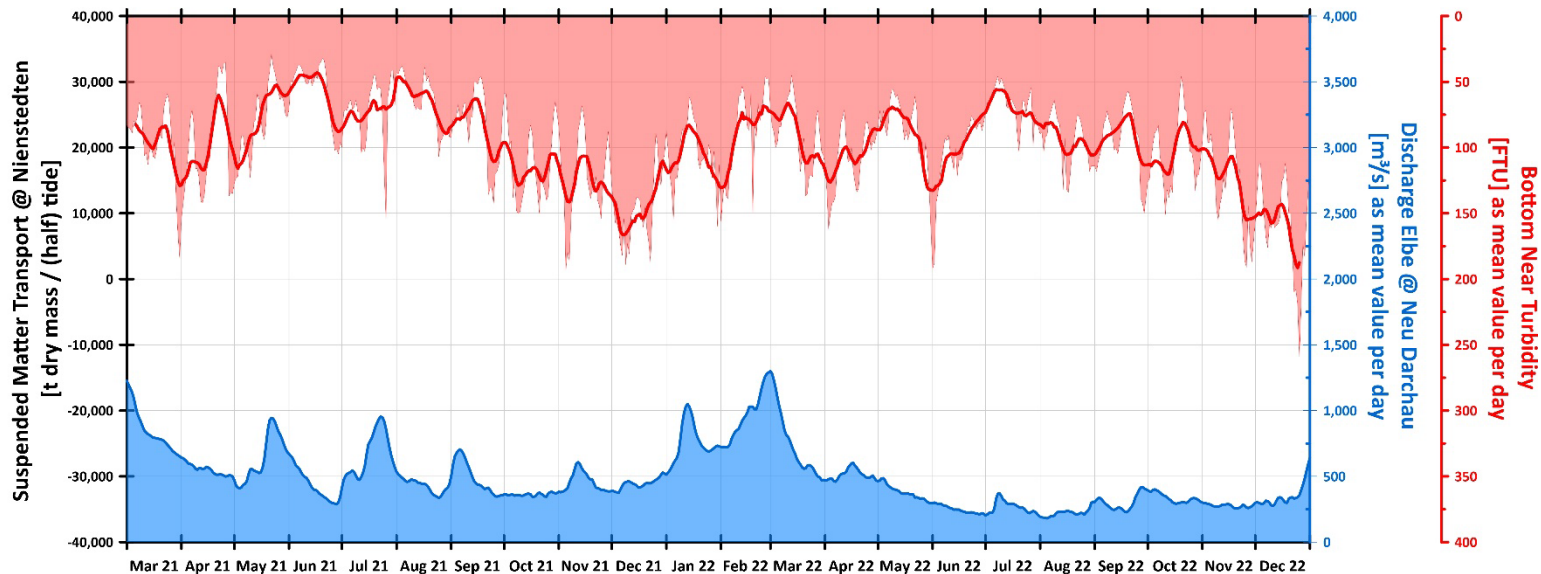
06

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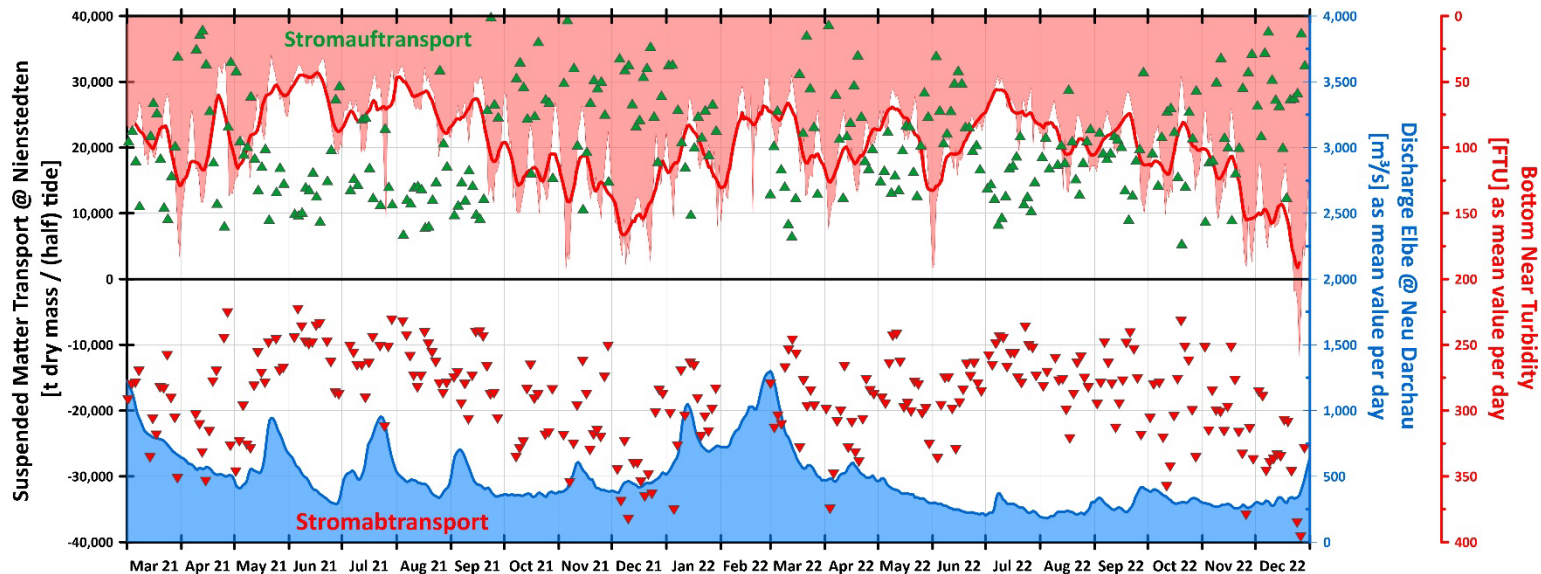
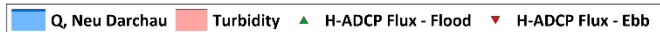
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler

Q, Neu Darchau Turbidity

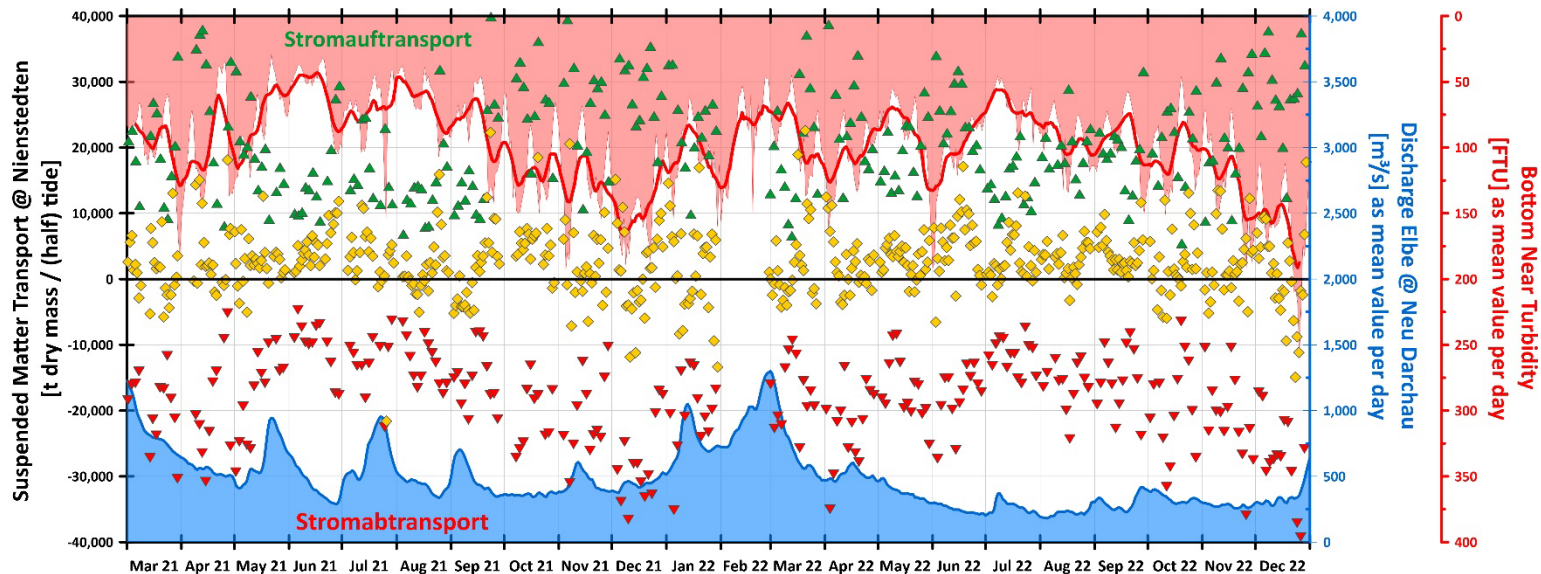
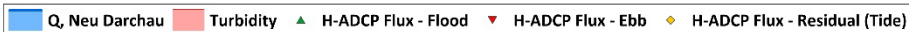
HPA
Hamburg Port Authority



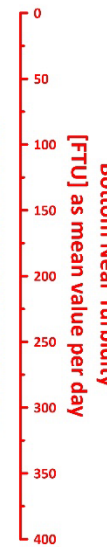
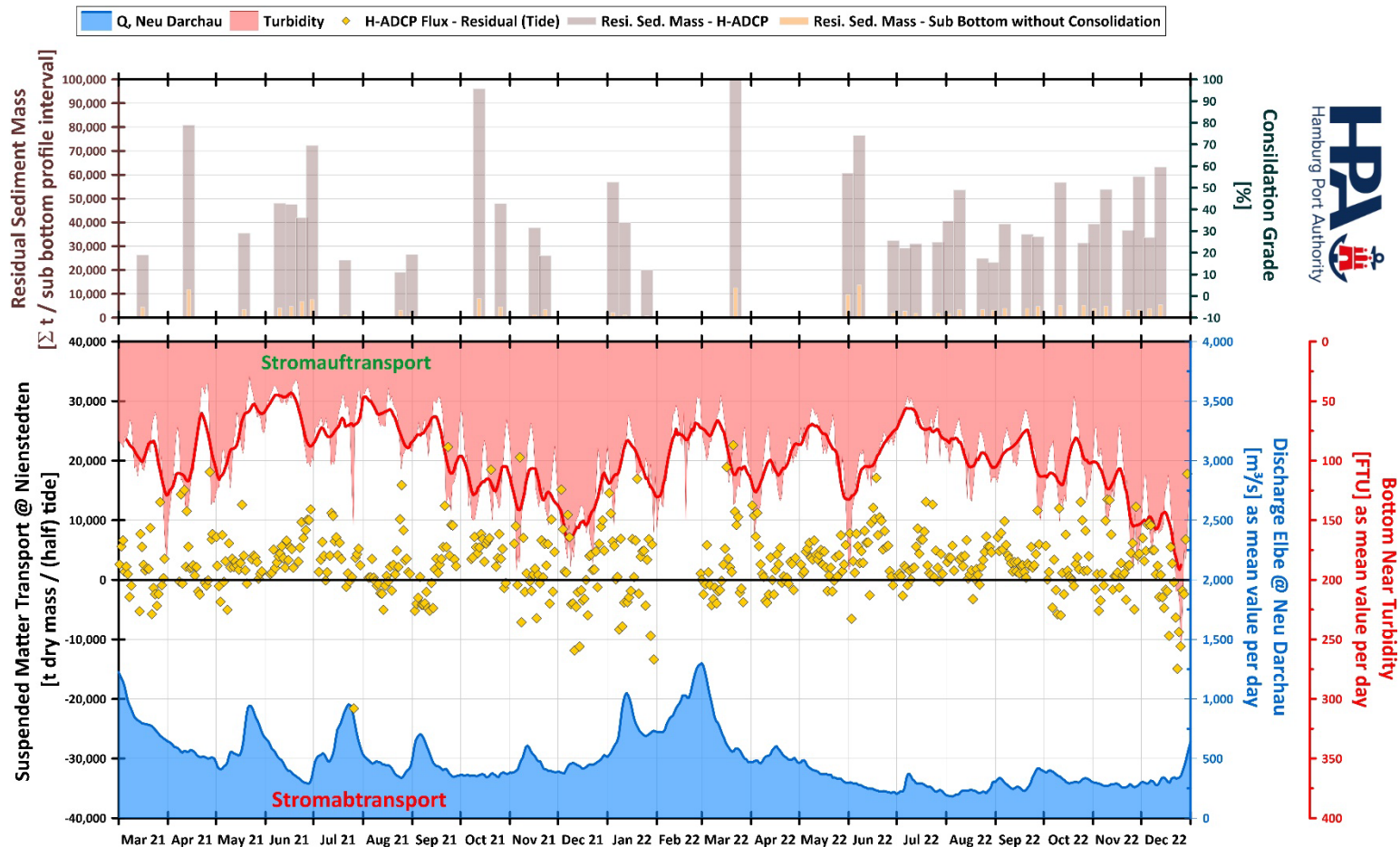
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



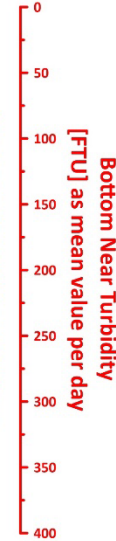
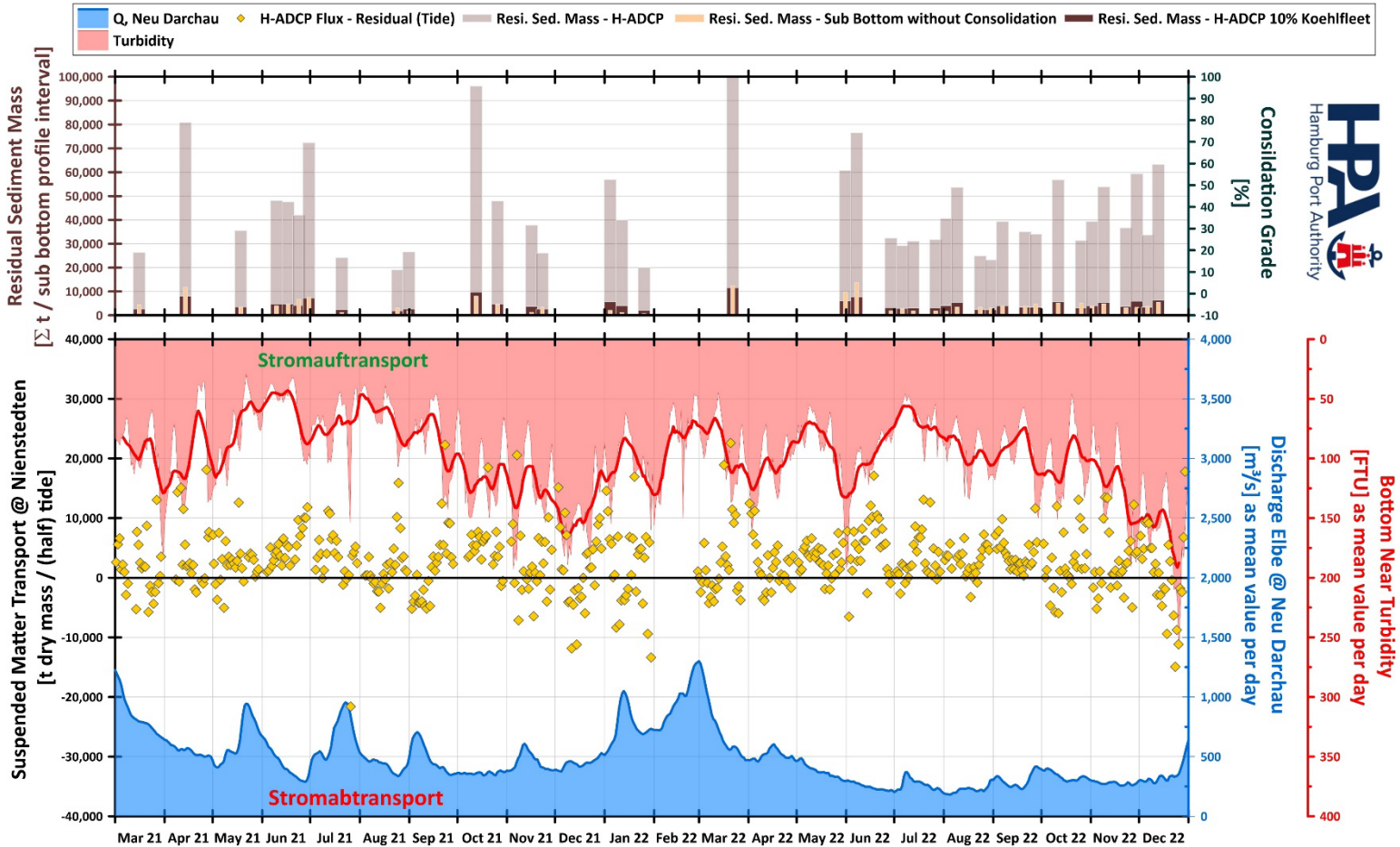
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



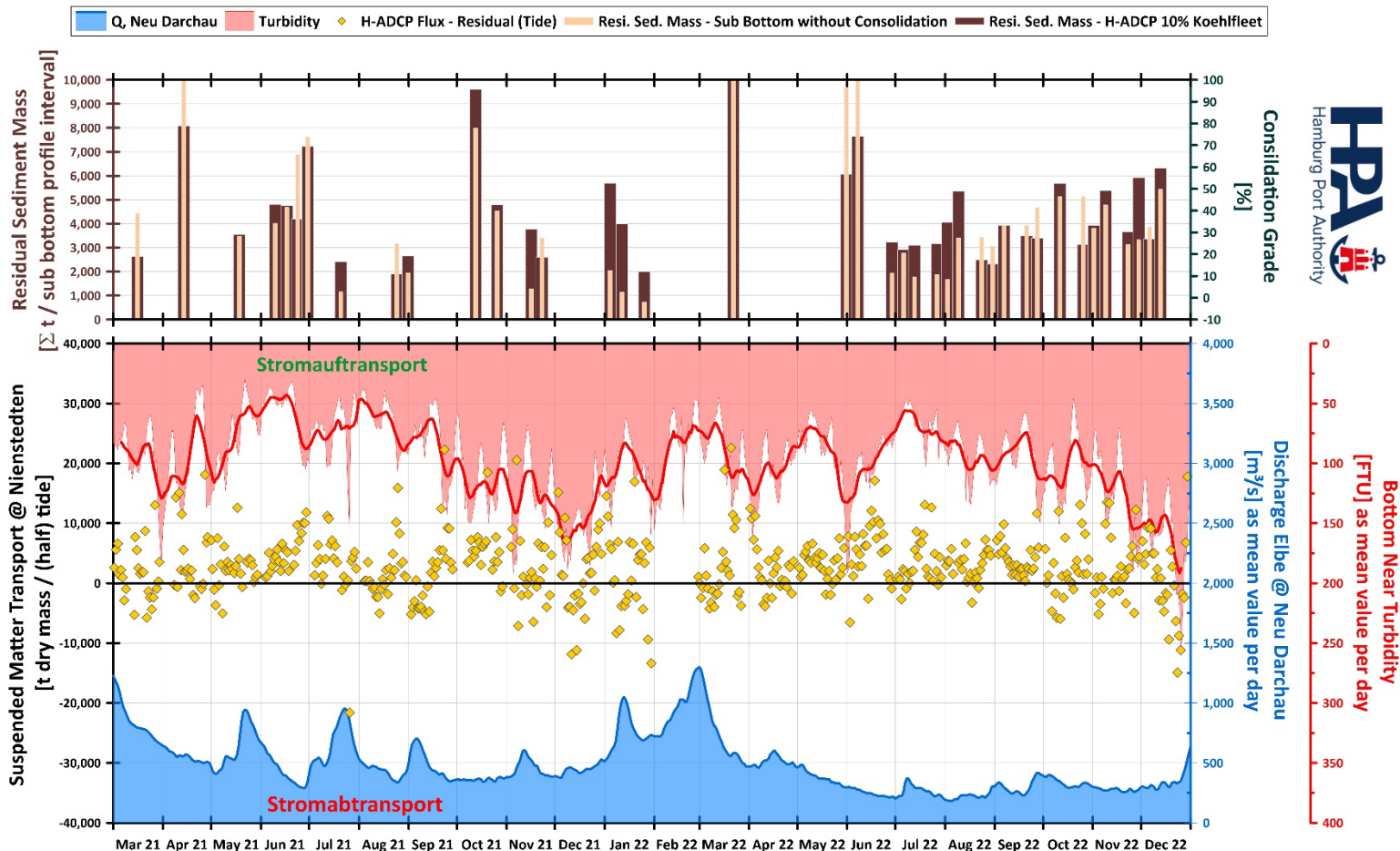
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



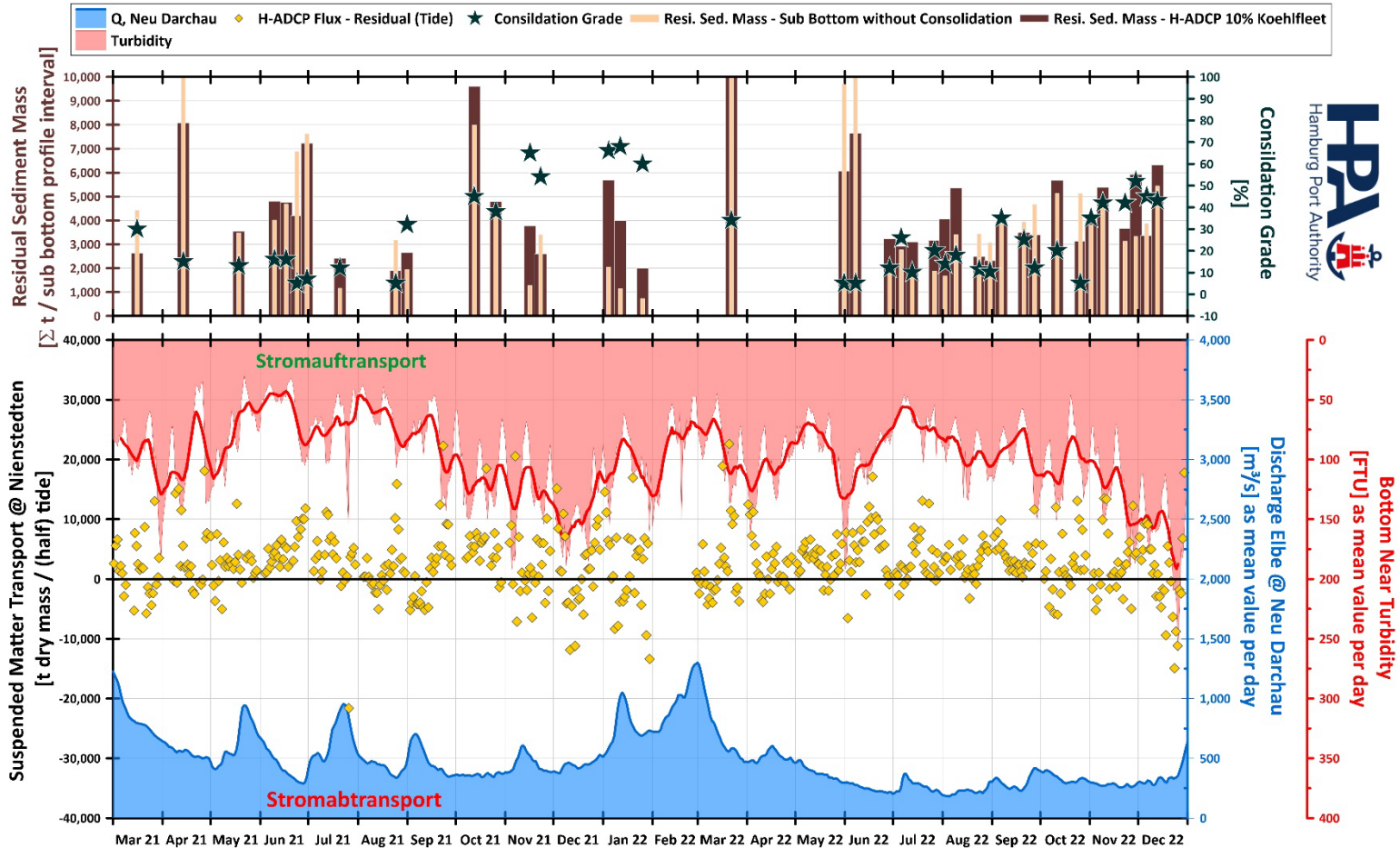
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



Discharge Elbe @ Neu Darchau [m^3/s] as mean value per day

Bottom Near Turbidity [FTU] as mean value per day

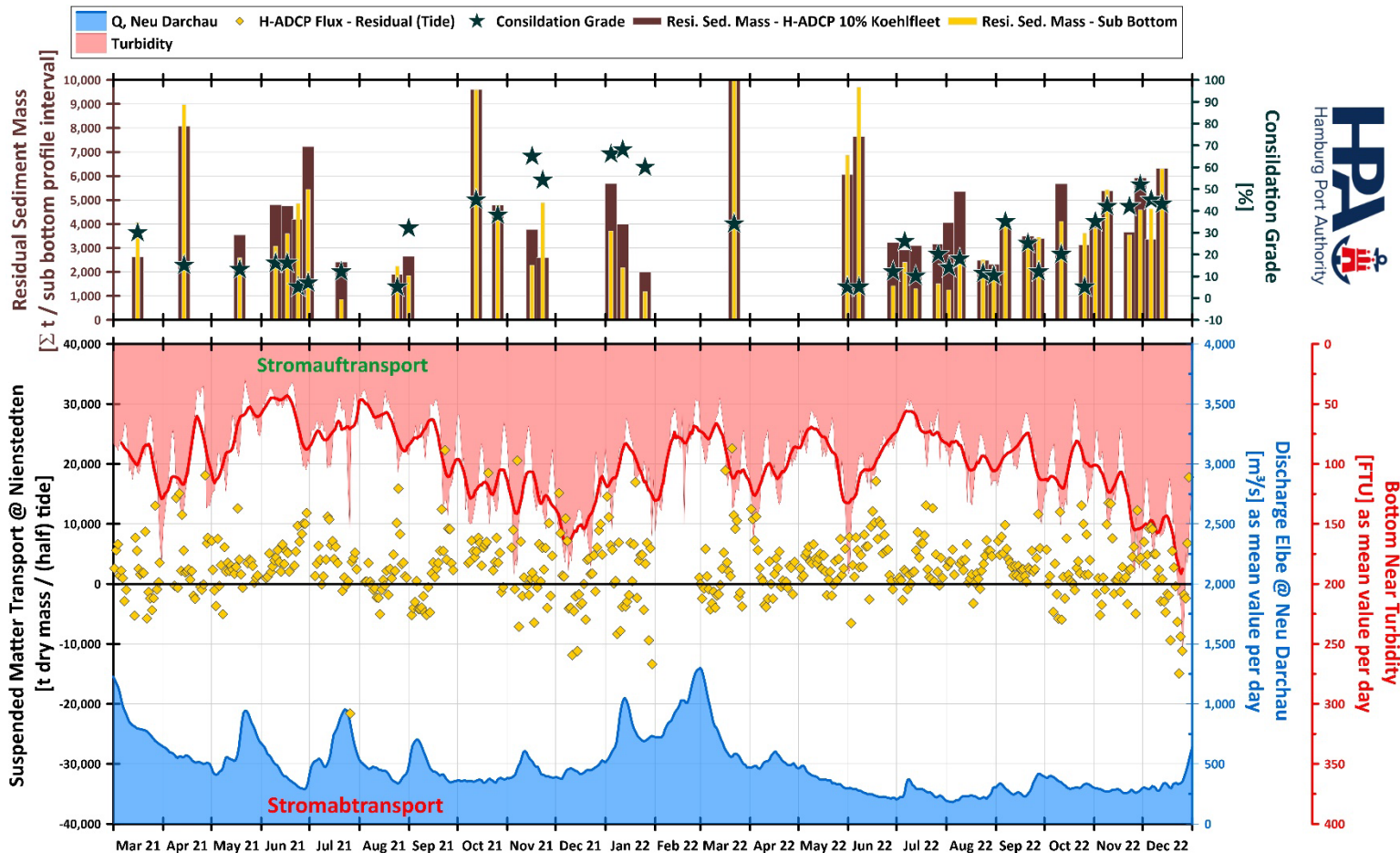
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



Discharge Elbe @ Neu Darchau [m³/s] as mean value per day

Bottom Near Turbidity [FTU] as mean value per day

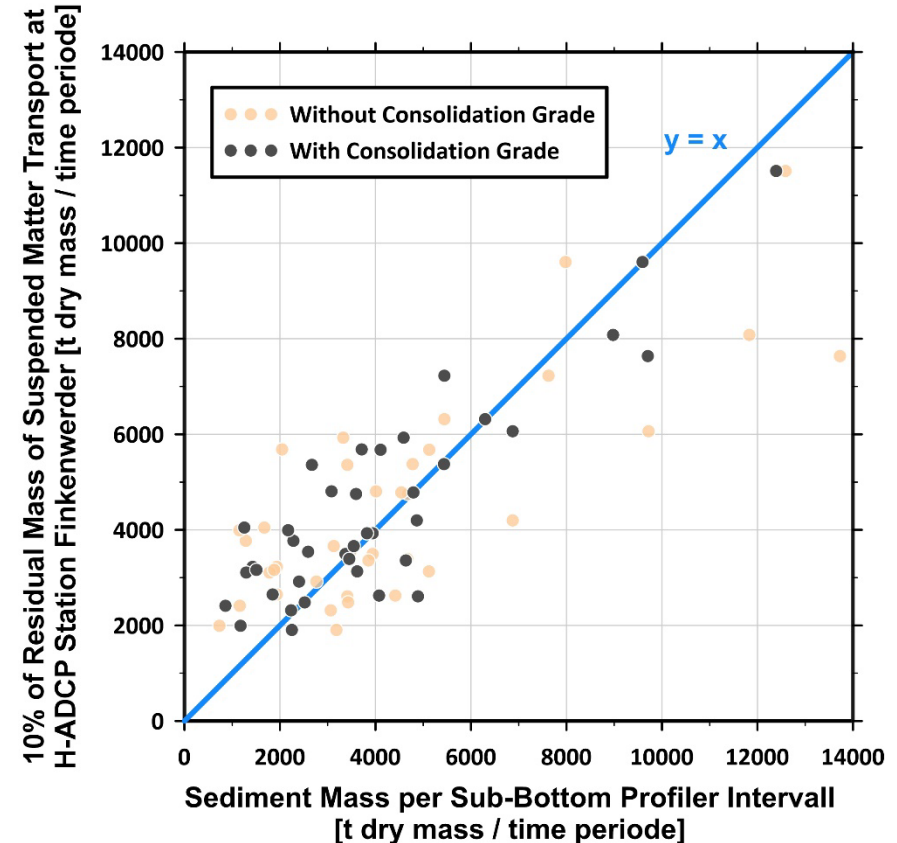
H-ADCP Suspended Matter Flux Transport and Sediment Mass from Sub Bottom Profiler



Discharge Elbe @ Neu Darchau [m^3/s] as mean value per day

Bottom Near Turbidity [FTU] as mean value per day

- Sediment Mass per Sub-Bottom Profiler Intervall with a represented area in the Köhlleet
- and
- 10% of Residual Mass of Suspended Matter Transport at H-ADCP Station Finkenwerder
- are well comparable!
- Use of the consolidation grade has a positive effect
- Not all comparisons fit well:
-> maybe change in the split-up of the sediment flux over the time



Thank you for your attention!

MUDNET

