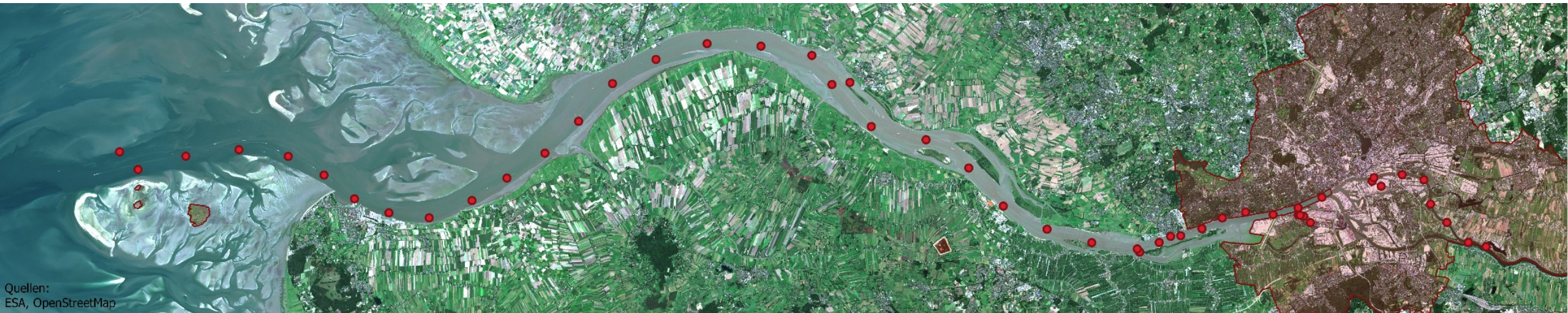
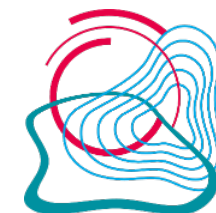


PELAGIC OXYGEN CONSUMPTION RATES IN THE ELBE ESTUARY, GERMANY: PROXIES AND SPATIAL PATTERNS



Justus van Beusekom, Dorothee Fehling, Sina Bold, Tina Sanders

EGU, 26.04.2021



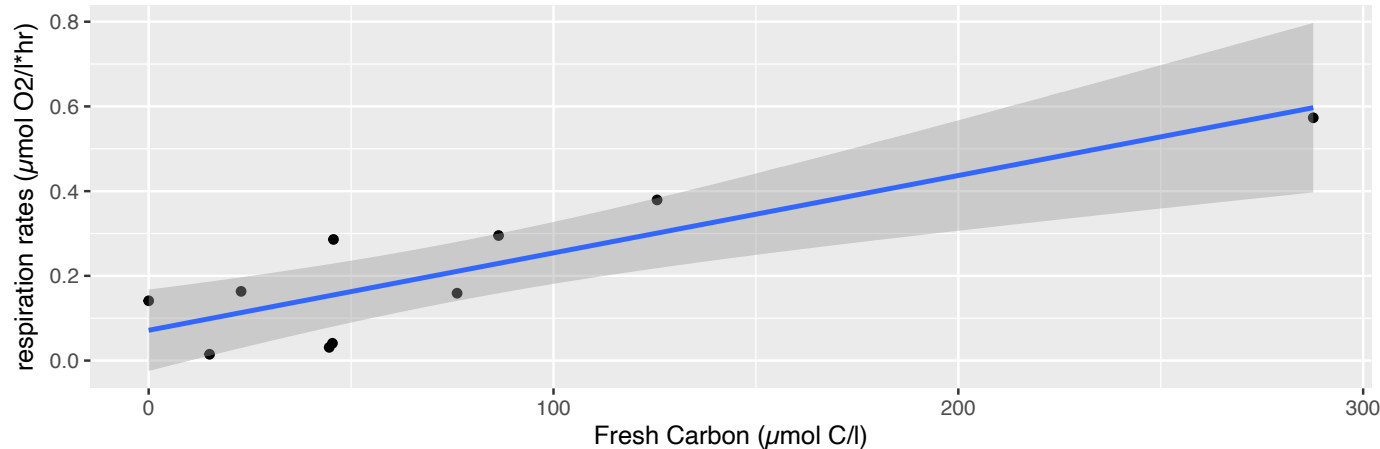
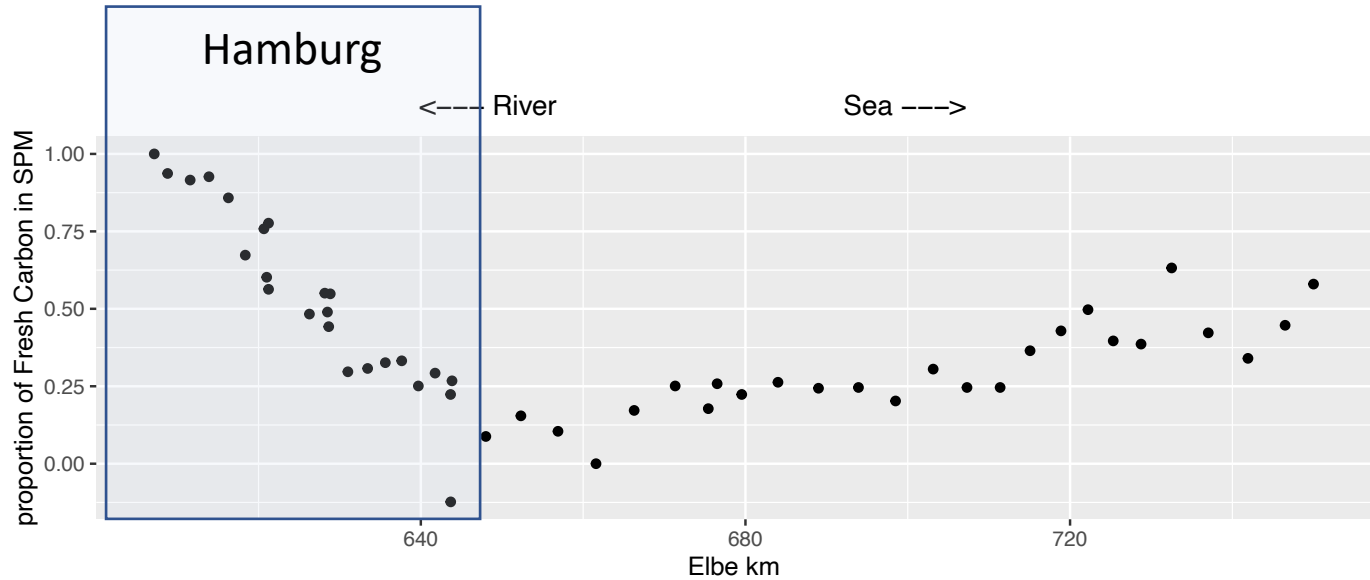
Helmholtz-Zentrum
hereon

OVERVIEW

- Long-term change in the Elbe
- Present problems with rapid decay of fresh riverine phytoplankton in the upper estuary
- Challenge: to characterize the degradability of organic matter
 - Differentiate between “fresh” and “recalcitrant” organic matter associated with SPM
 - Test of this method during a research cruise, September 2021

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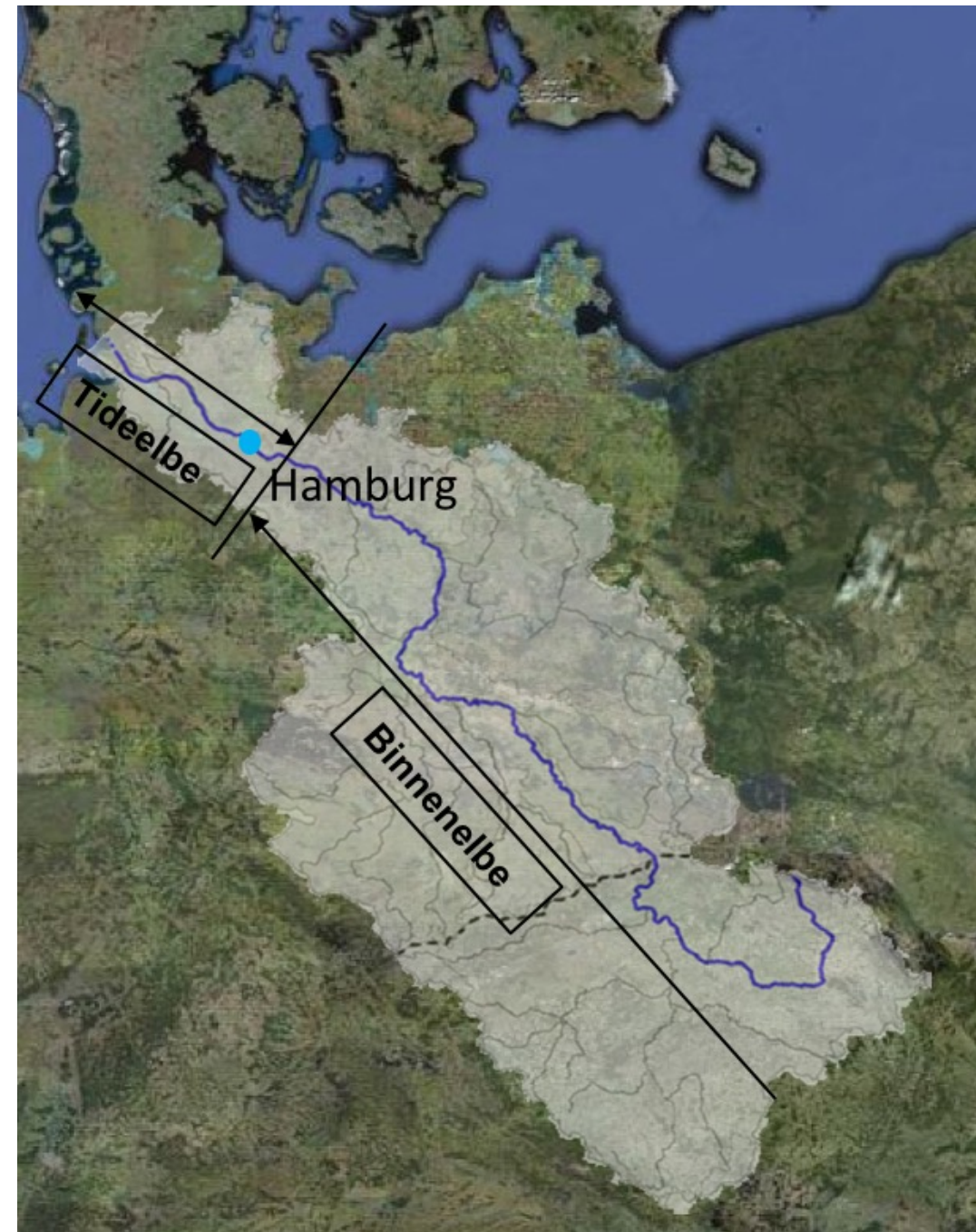
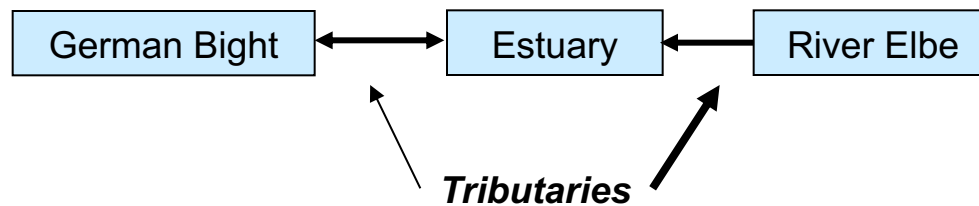


- We estimated „C_fresh“: carbon **NOT** associated with clays and silt.
- The estimate is based on the specific weight of phytoplankton: $\sim 20 \mu\text{mol/mg}$ and SPM with minimum C content $\sim 3 \mu\text{mol/mg}$
- „C_fresh“ is a good proxy for degradability
- The river is the major source of „C_fresh“ followed by the North Sea
- The estuary is a sink for SPM enriched with C

Elbe Estuary

Elbe catchment area

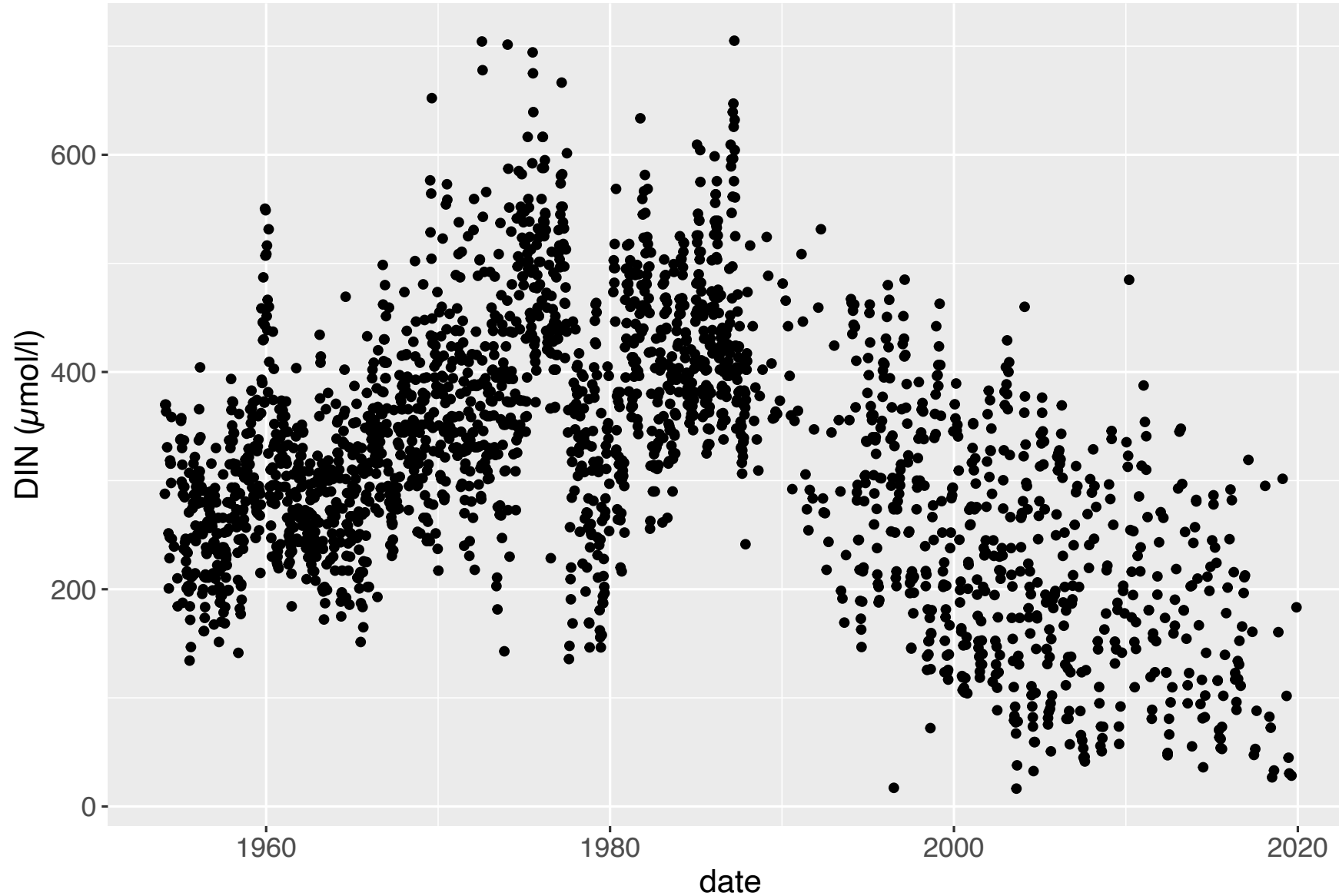
- 1.100 km river length
- 150.000 km² catchment
- ~24 Mio inhabitants
- International river area
- Discharge ~710 m³/s (150 – 4000 m³/s)



E.g. Boehlich & Strotmann, 2008

Long-term change at the last river station upstream of the estuary

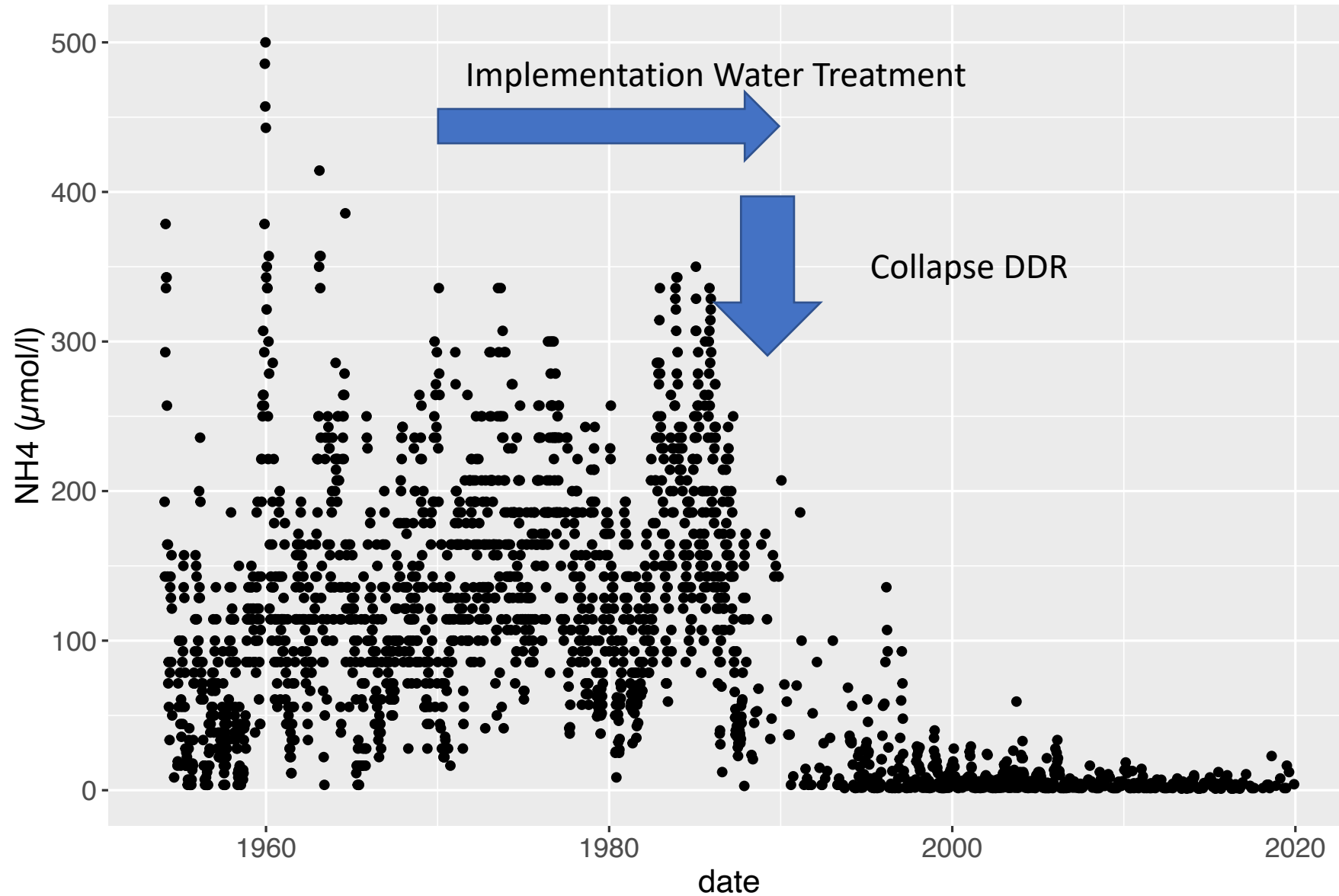
Geesthacht (Wehr) Dissolved Inorganic Nitrogen: Max in the 1970s and 1980s



Data: FGG-Elbe.de

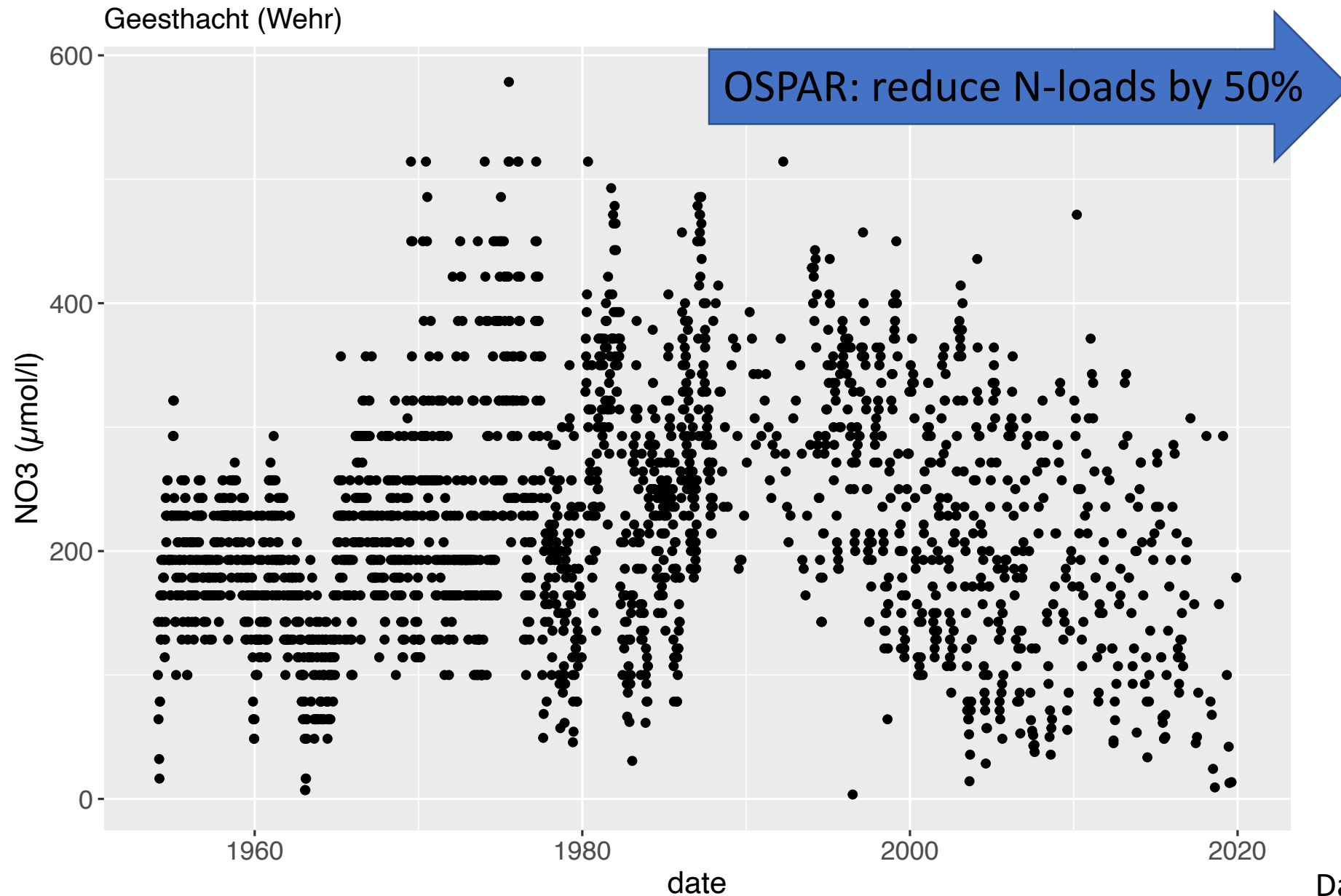
Long-term change at the last river station upstream of the estuary

Geesthacht (Wehr)



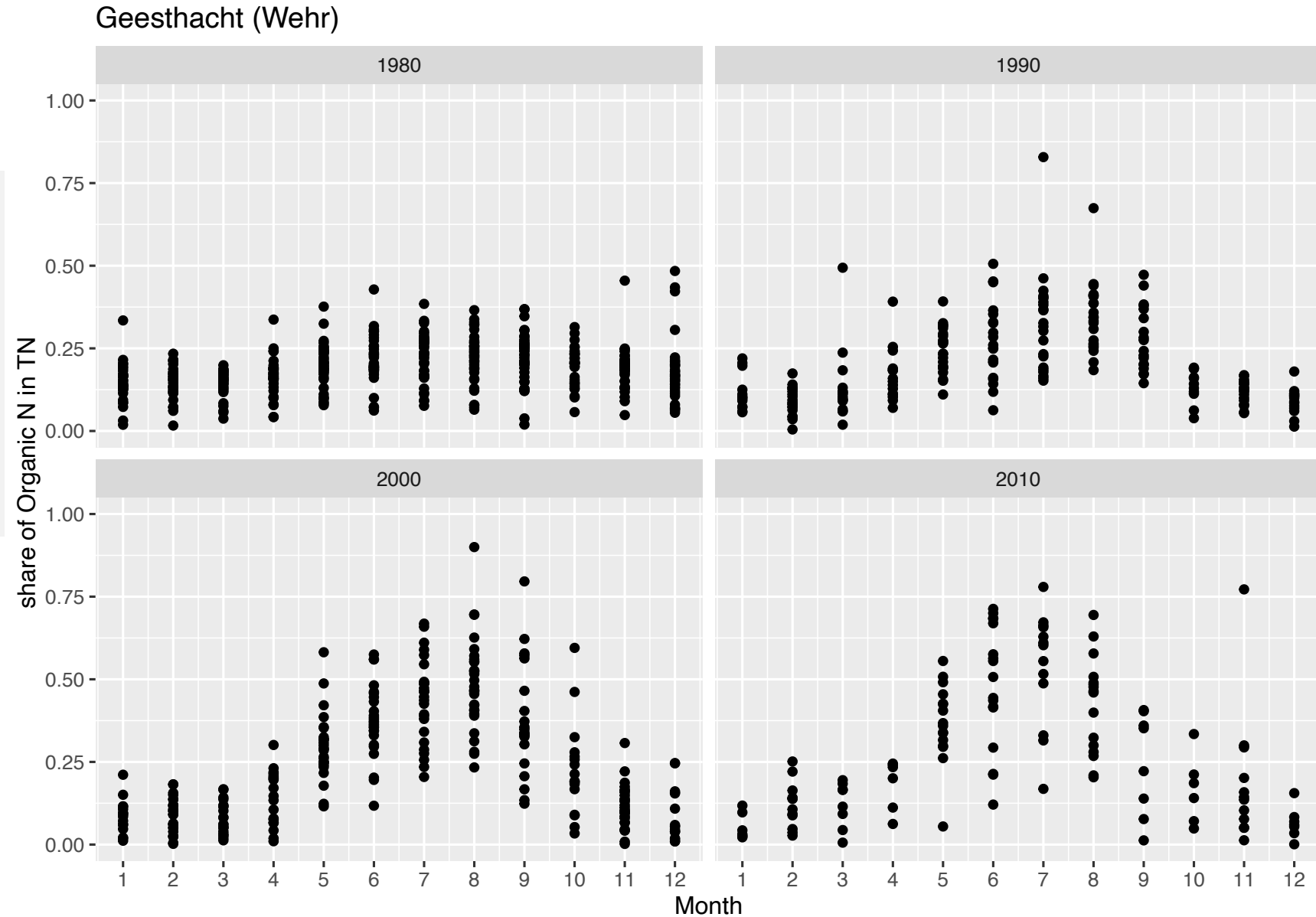
Data: FGG-Elbe.de

Long-term change at the last river station upstream of the estuary



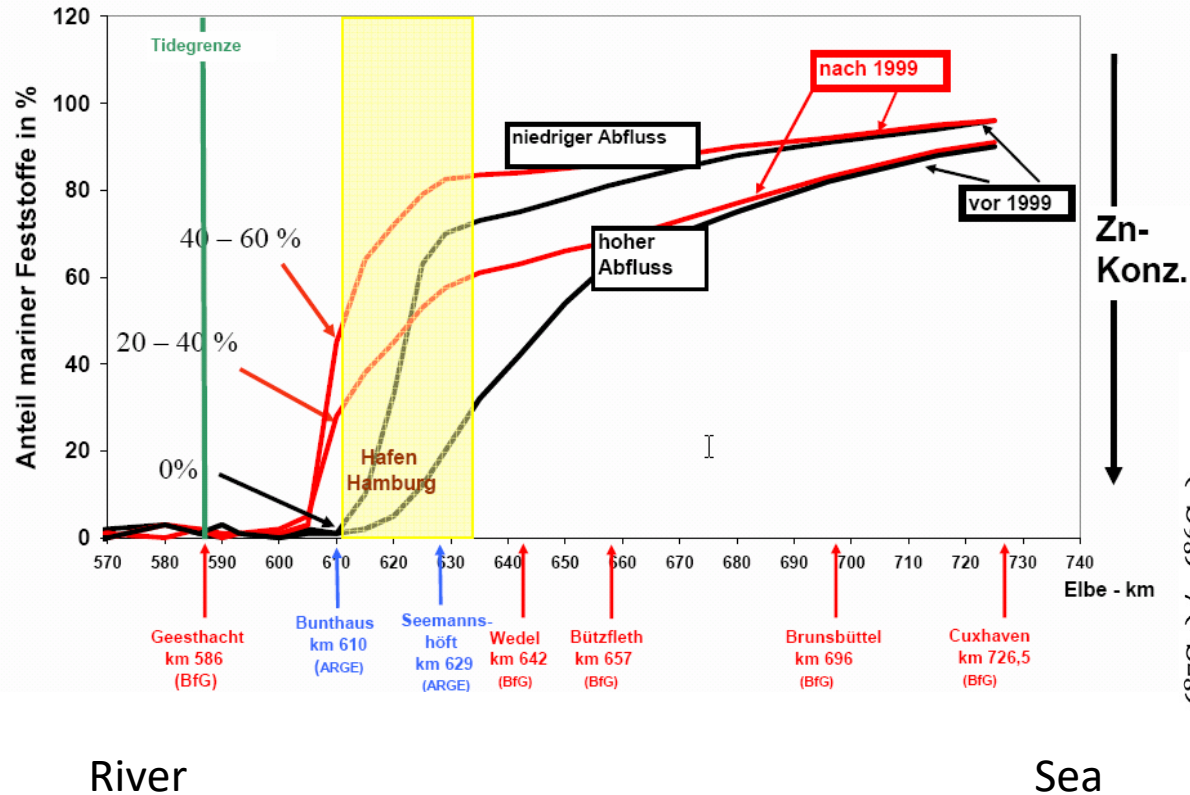
Increasing seasonal organic matter dynamics

A shift in organic matter
quality from
waste water (degraded)
to
Phytoplankton (fresh)

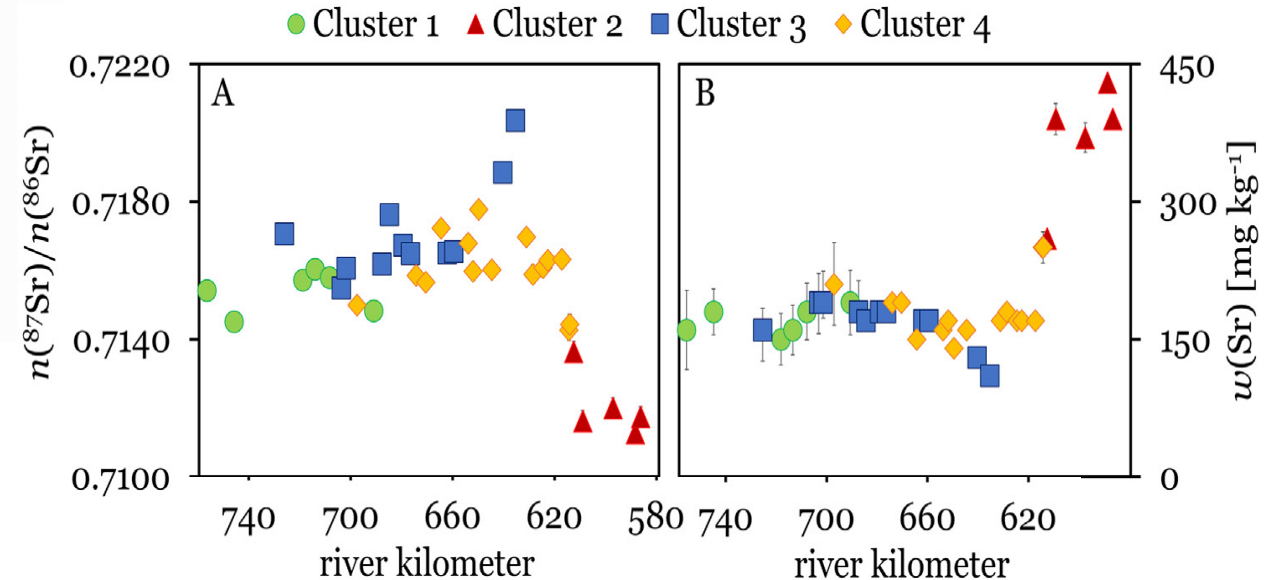
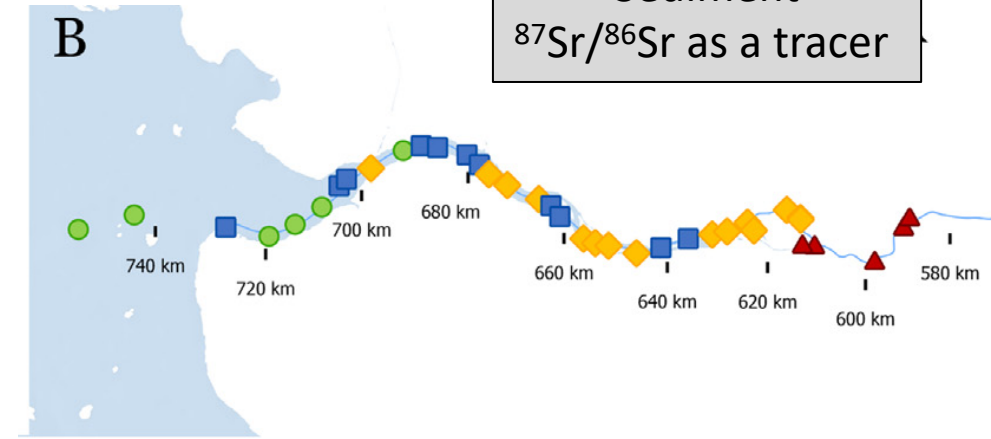


Increasing marine SPM in the freshwater part of the Elbe Estuary

SPM
Zn as a tracer



Sediment
 $^{87}\text{Sr}/^{86}\text{Sr}$ as a tracer



At present:
massive Elbe Phytoplankton blooms
collapse in the Hamburg Harbor area

Responsible for the decrease

- Transition shallow-deep
- Light limitation/Reduced growth
- FRRF measurements:
phytoplankton is in good shape (but..)
- Grazing of phytoplankton
- Sedimentation

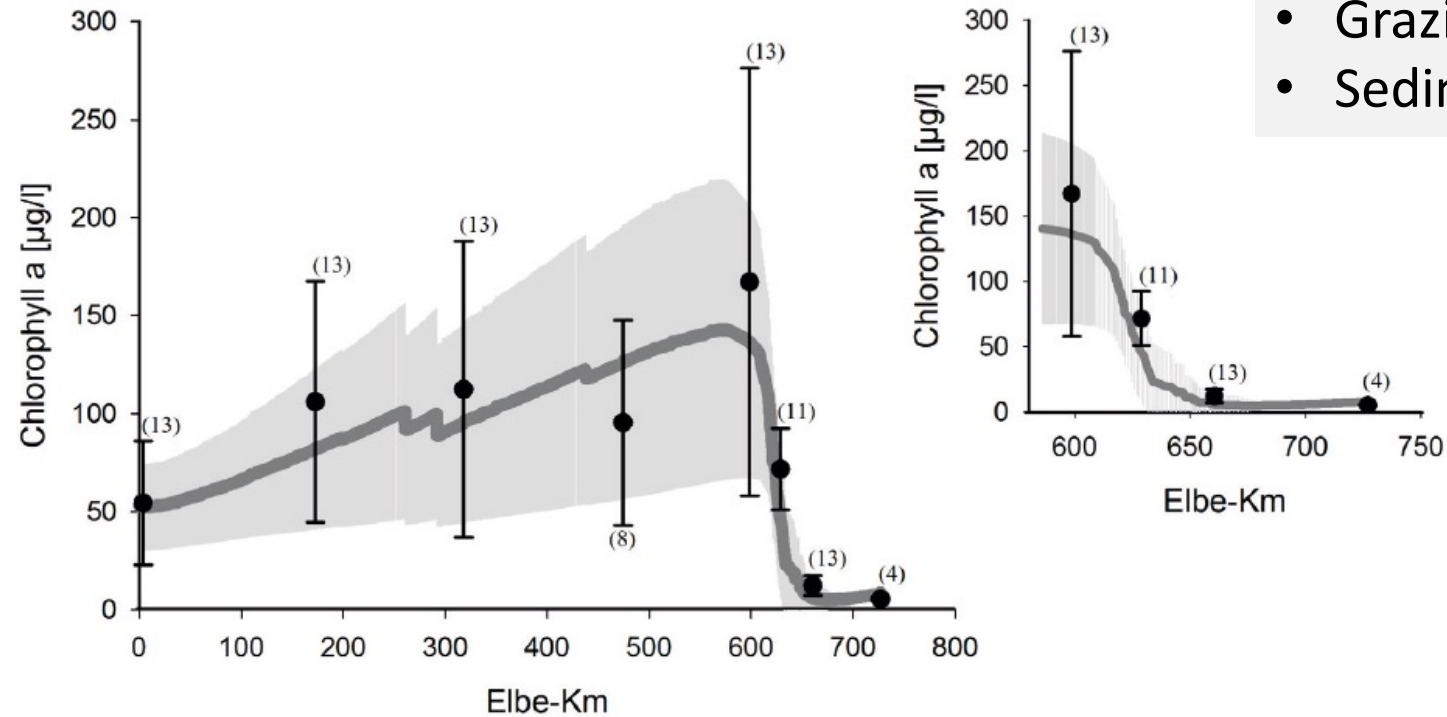


Figure 5: Longitudinal profile of measured (black dots) and modelled (dark grey line) seasonal means of chlorophyll a [$\mu\text{g}\cdot\text{l}^{-1}$] from Schmilka (km 0) to Cuxhaven (km 727) for May to October 2006. Number of measurements is given in brackets. Standard deviations of measurements reflected by bars and of modelled data ($n = 184$) by the light grey area.

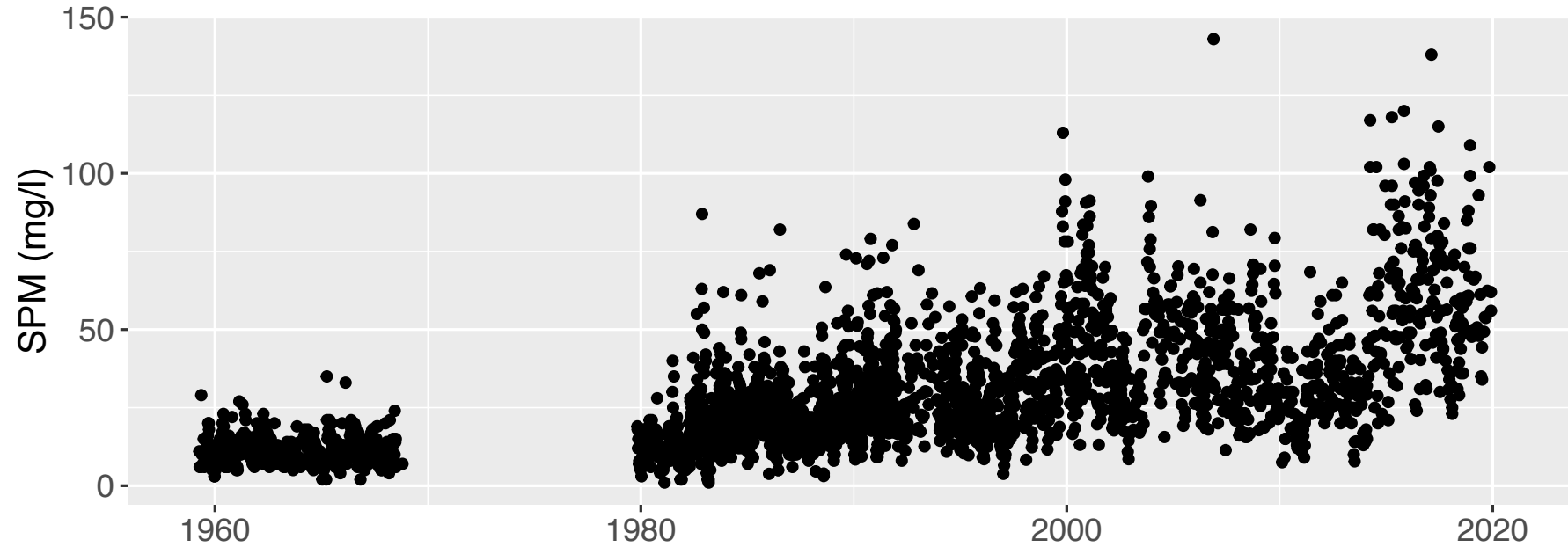
Hamburg Harbor area

long-term station: SPM @ Seemannshöft/Teufelsbrück

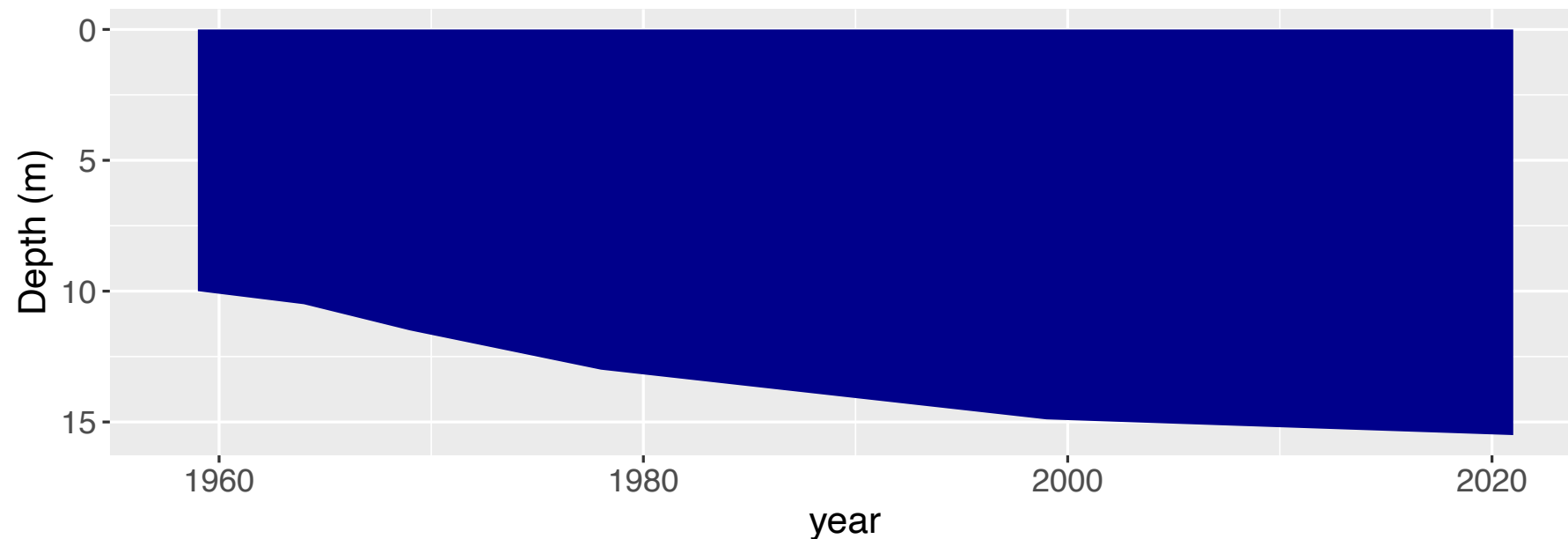


SPM Time Series Seemannshoft/Teufelsbrück

SPM increases:
Marine SPM
dominates

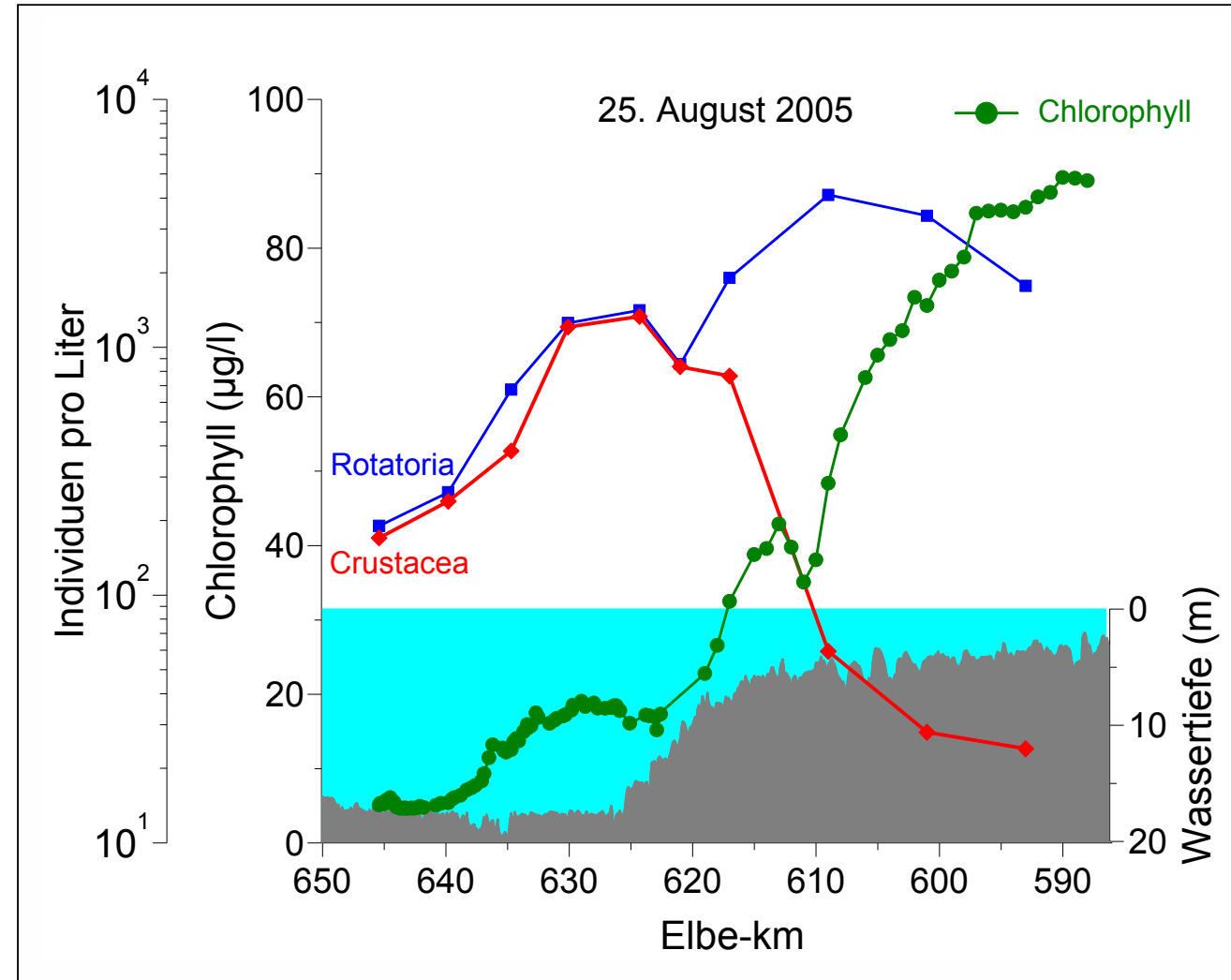


Depth increases:
Dredging



Hamburg Harbor area: rapid decrease of phytoplankton biomass

- River:
shallow (~5m) -> vigorous growth
- Harbor:
deep (~18m) -> reduced growth
turbid -> reduced growth
- Loss factors
Grazing of Phytoplankton (?)
- Virusses(?)
- Sedimentation



Schöl et al, 2008

Challenge:

Can we distinguish between the fresh organic matter component from the river and the more recalcitrant organic matter associated with the marine SPM in the estuary?

Assumption:

Phytoplankton has a much higher C content per unit weight than SPM dominated by sediment particles

Equations for C in SPM

- $M_{\text{tot}} = M_{\text{org}} + M_{\text{anorg}}$ (Mass of OM associated with primary production and with clay/silt)
- $C_{\text{tot}} = C_{\text{org}} + C_{\text{anorg}}$ (Carbon associated with primary production and with clay/silt)
- $C_{\text{org}} = K_{\text{org}} * M_{\text{org}}$ (relation between Mass and C content of OM from primary Production)
- $C_{\text{anorg}} = K_{\text{anorg}} * M_{\text{anorg}}$ (relation between Mass and C content of OM associated with clay/silt)

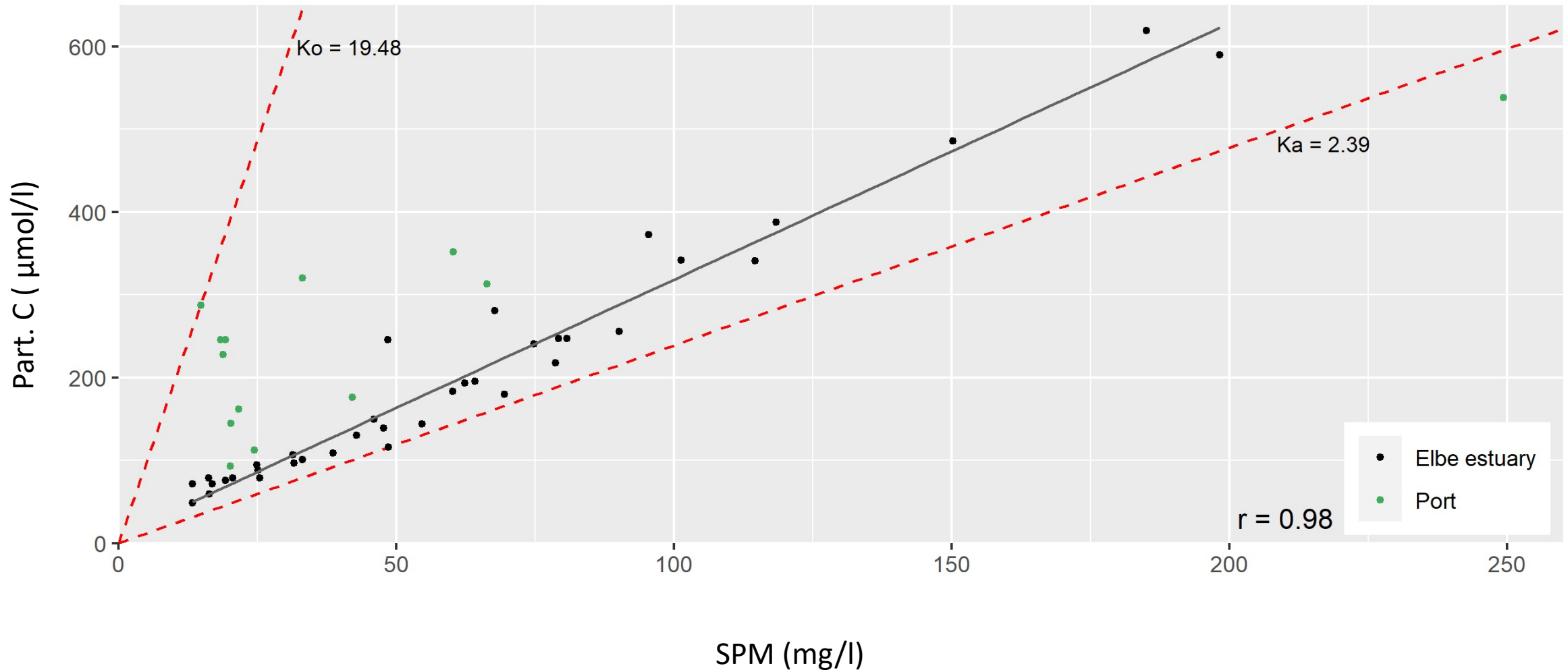
- $K_{\text{org}} = \sim 20 \text{ mM/g}$
- $K_{\text{anorg}} = \sim 3 \text{ mM/g}$

4 equations with 4 unknowns can be solved

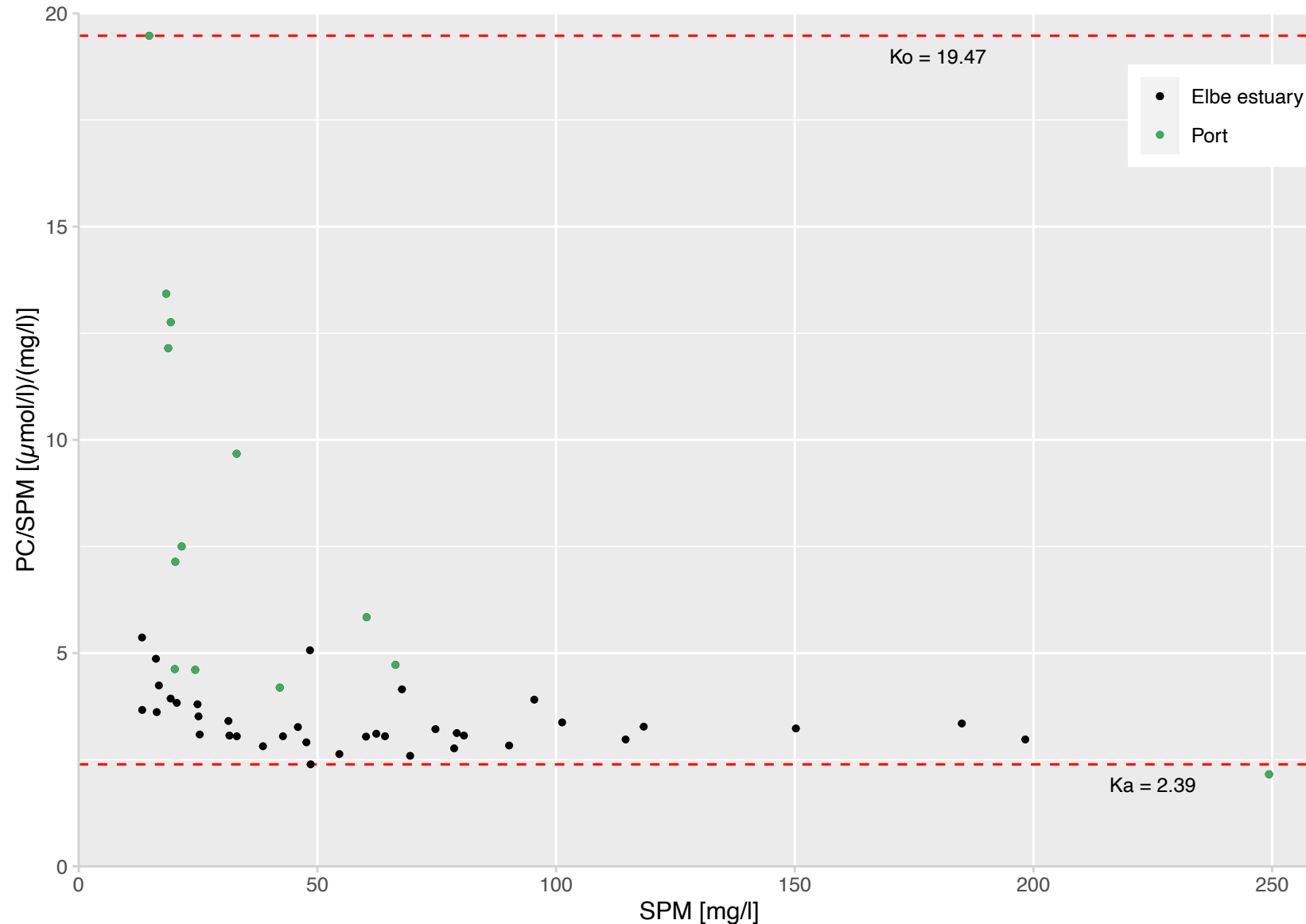
(M = mass; C = Carbon content)

Relation between part.C and SPM

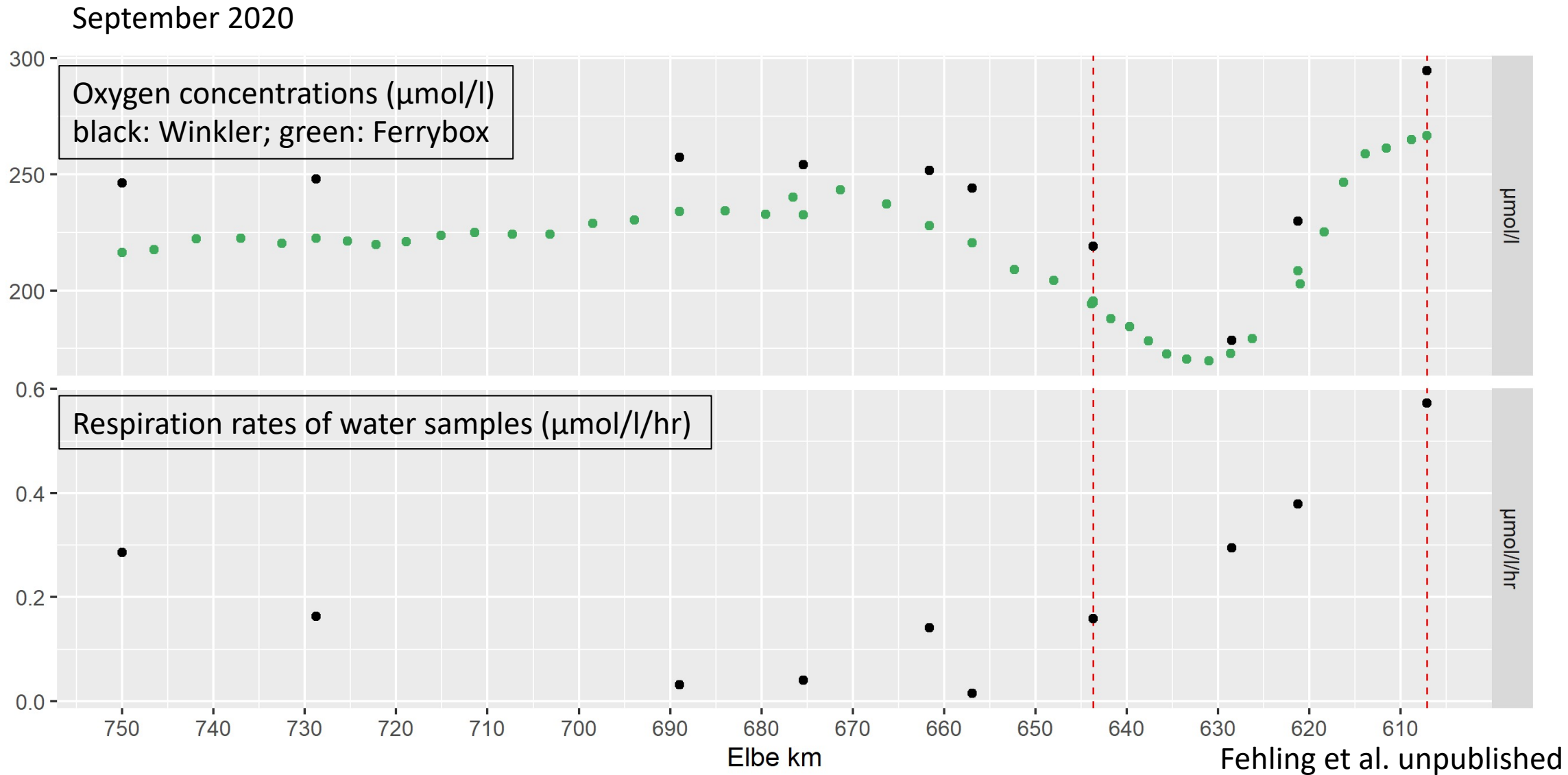
The red lines envelop the max. and min.



High PC/SPM ratios in the harbor reaching up to $\sim 20 \mu\text{mol}/\text{mg}$
Low PC/SPM ratios in the rest of the estuary reaching an asymptotic value of about $2.4 \mu\text{mol}/\text{mg}$

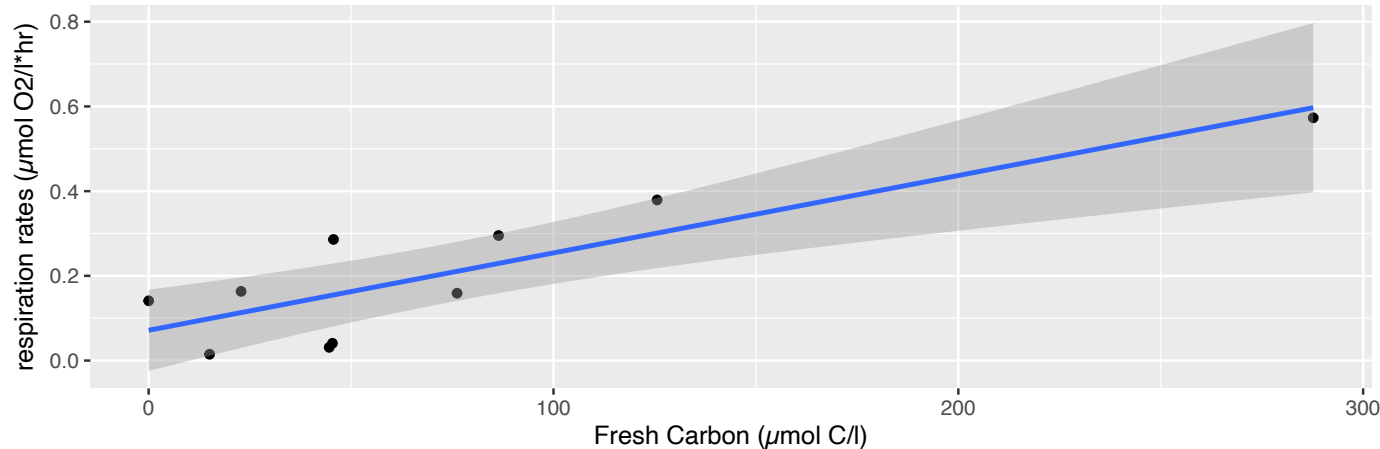
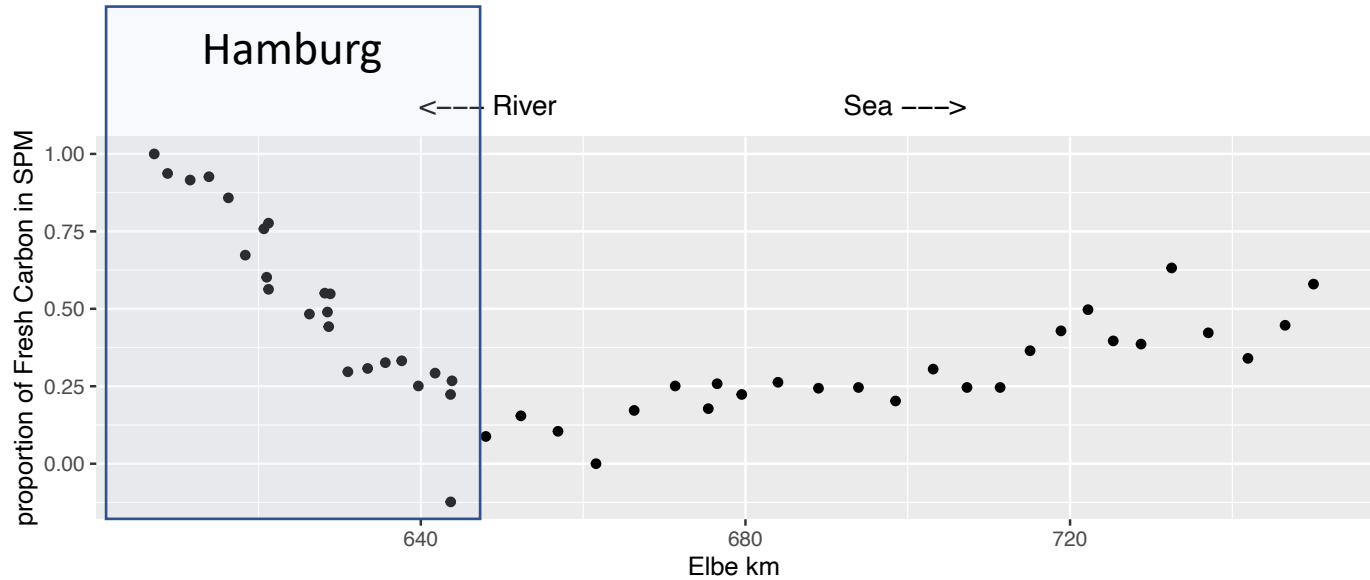


Oxygen distribution and Respiration rates in the Elbe Estuary, September 2020



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Thank you
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