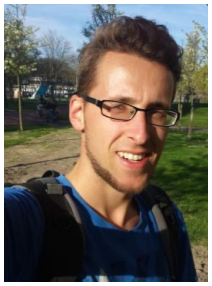
Port sediments as carbon sink and source

SedNet Lisbon 2023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Mud is not just mud...

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Oxidized **Suspended particulate matter SPM**

Fluid mud FM

Oxidized or reduced

Pre-consolidated sediment PS

Reduced

Consolidated sediment CS

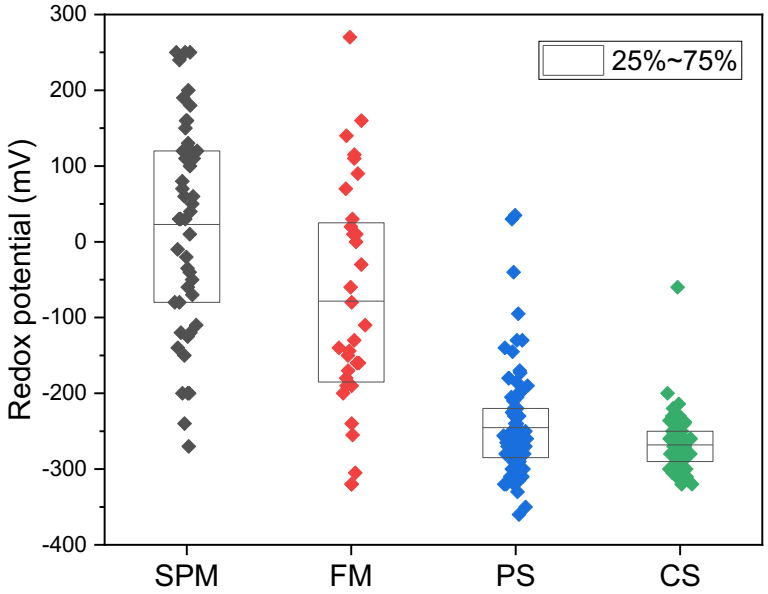
Reduced

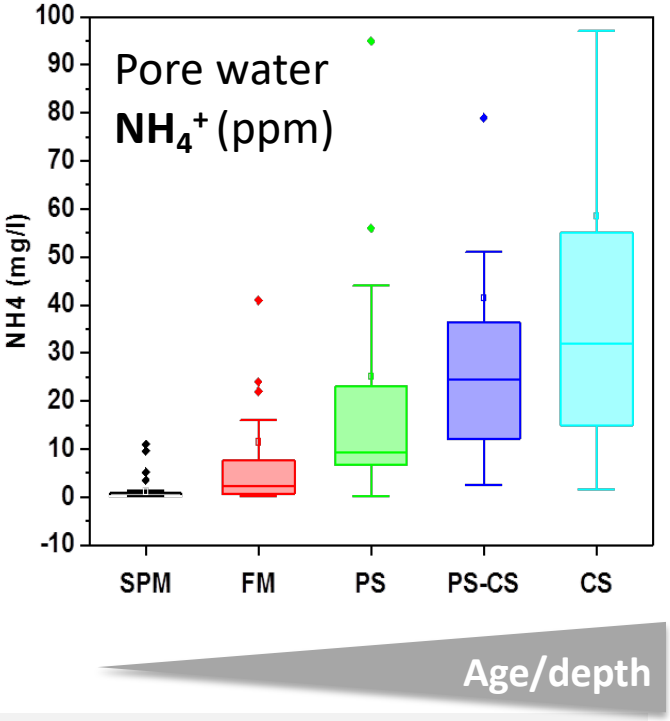
BIO MUD

A detailed look reveals...

- A multi-layered system
- Chrono-sequence of consolidation level, redox potential, pore water composition…
- > 80% fines (< 63 µm)
- **~ 10% organic matter**

State of sediment in the water



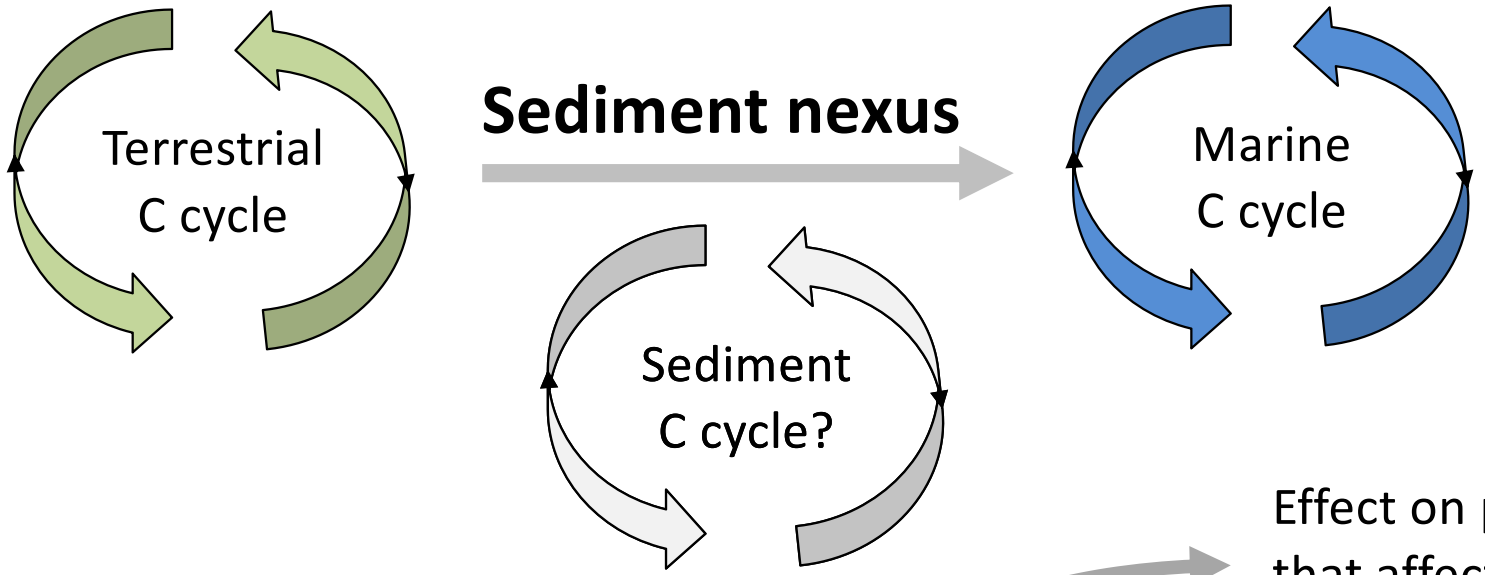


- Mostly, sediments are under anoxic conditions (negative redox potential)
- Upper few mm may be oxidized
- RP gets more negative and NH_4^+ increases with depth/age

Gas in the Port of Hamburg

Intense microbial activity degrading sediment organic matter under anaerobic conditions

Sediment continuum… organic matter continuum



Effect on properties that affect navigability (yield stress)?

- How much OM degrades?
- How much OM is stable and stored in the sediment?
- How do dredging interventions affect C release?

Where carbon goes when water flows…

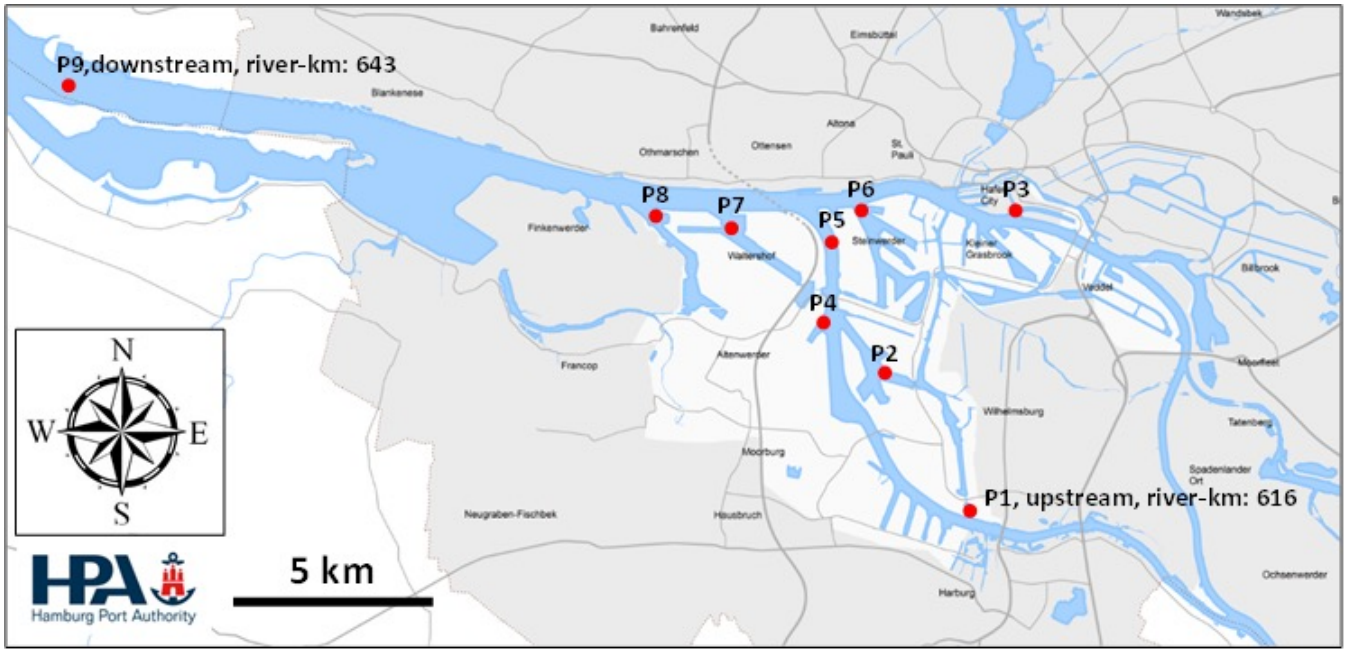
Ward et al. (2017):

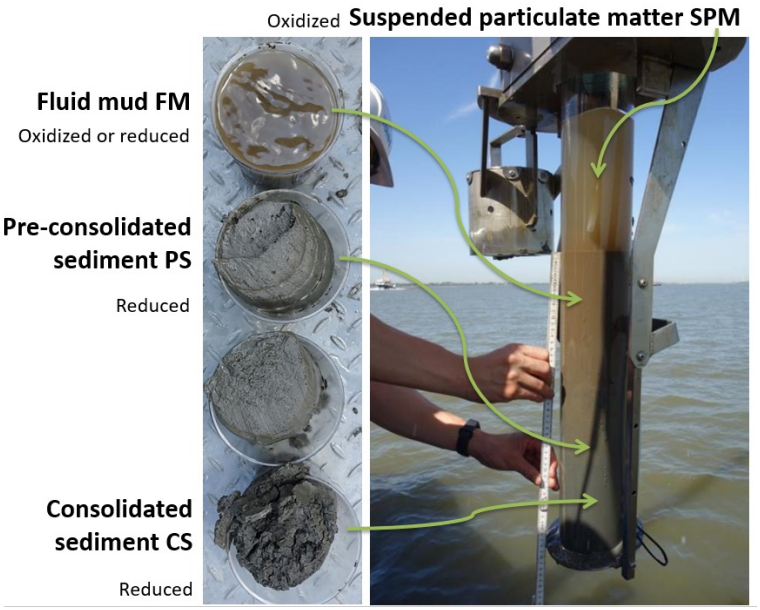
"There are large gaps in current coverage of environmental observations along the aquatic continuum. For example, tidally-influenced reaches of major rivers and near-shore coastal regions around river plumes are often left out of carbon budgets due to a combination of methodological constraints and poor data coverage."

https://doi.org/10.3389/fmars.2017.00007

Investigation area

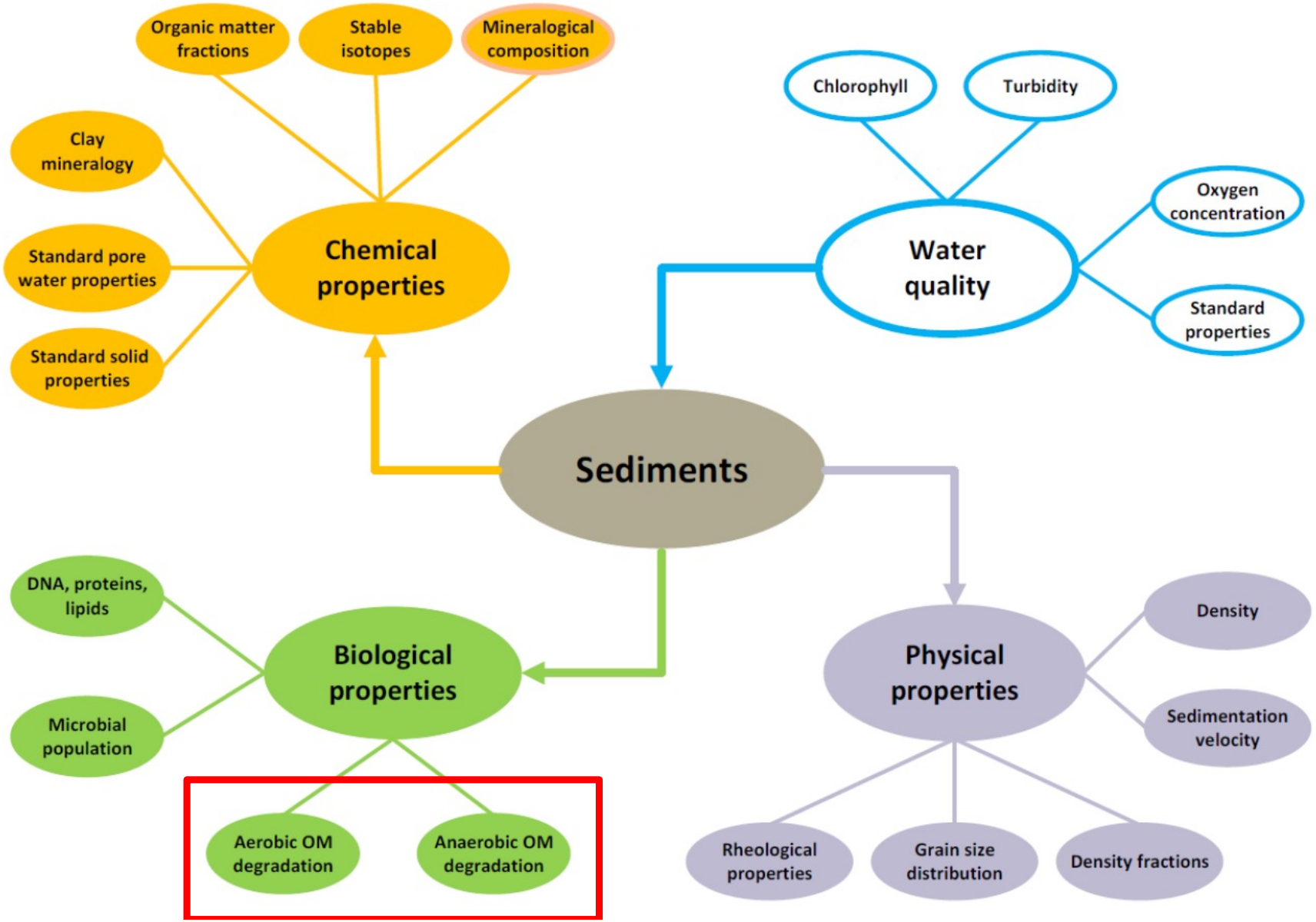
Approach





2018-2020 Stratified sampling of sediment cores every 4-6 weeks at fixed locations along the transect

Analyses



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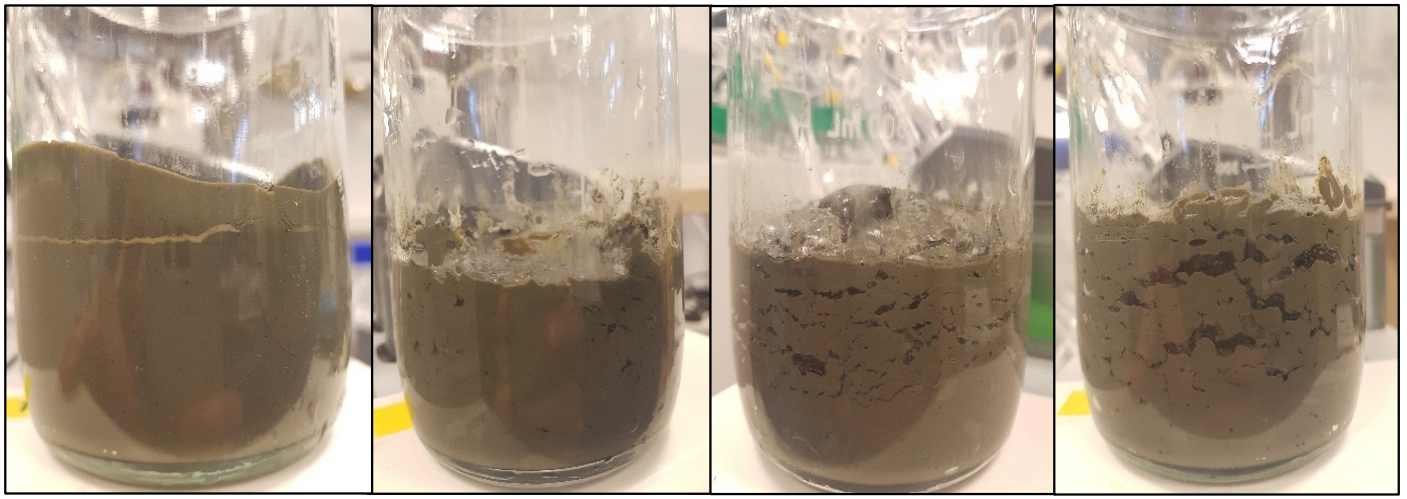
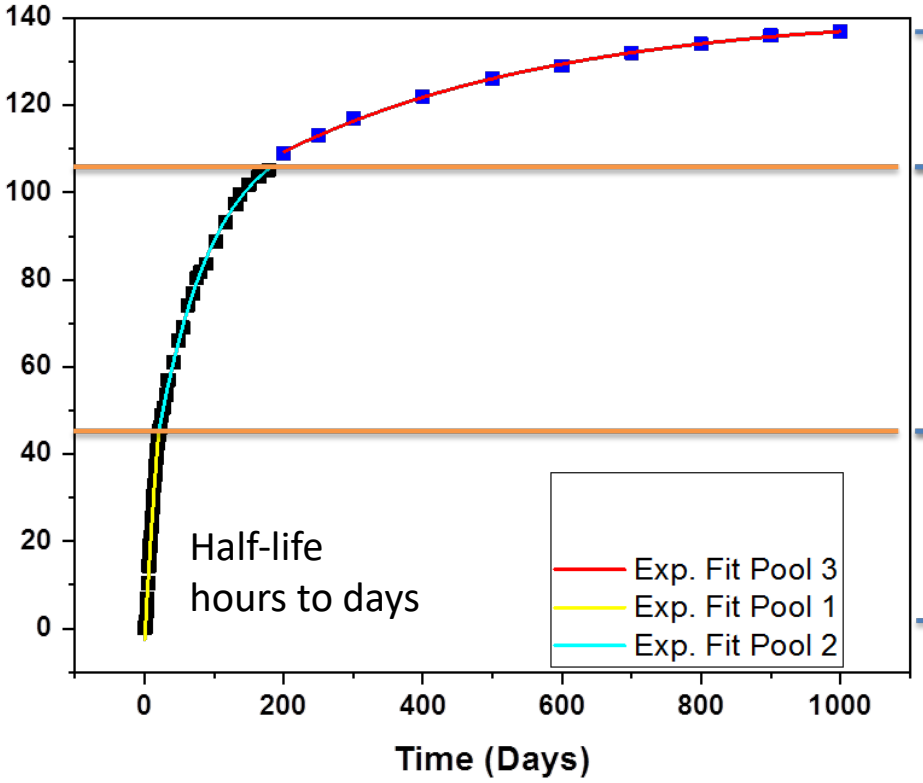
Experimental approach



- Oxic and anoxic incubation of sediment
- Measurement of carbon release (CO_2 and CH_4)
- Relate C release to TOC indicates degradability

Kinetics of OM degradation

C release (mg C/g TOC)



SLOW

Pool 3: 3.5 % TOC

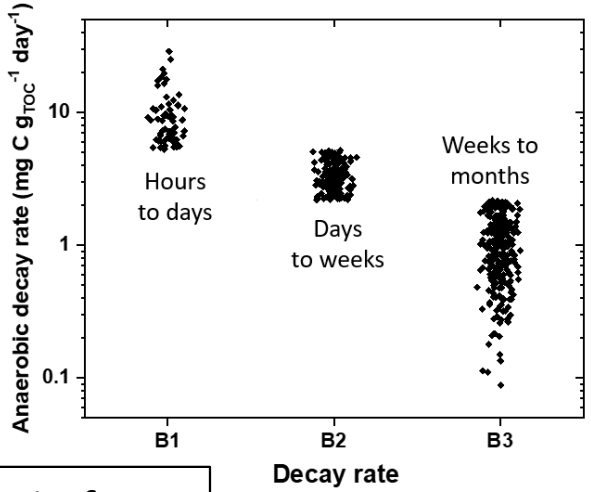
MED

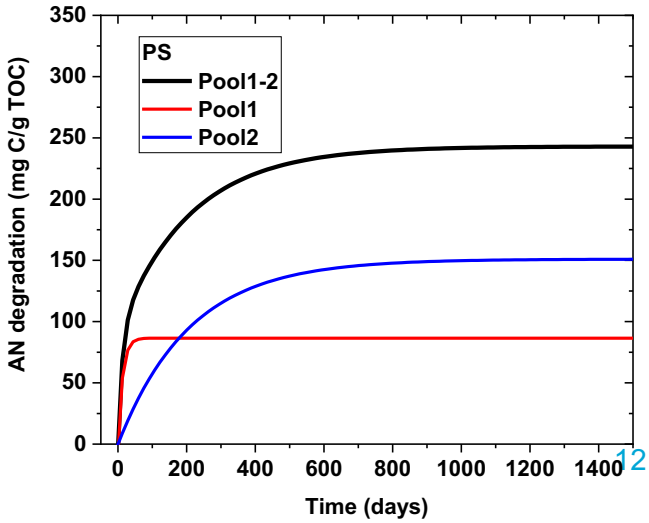
Pool 2: 6 % TOC

FAST

Pool 1: 4.5 % TOC

Only 14% of TOC is degradable



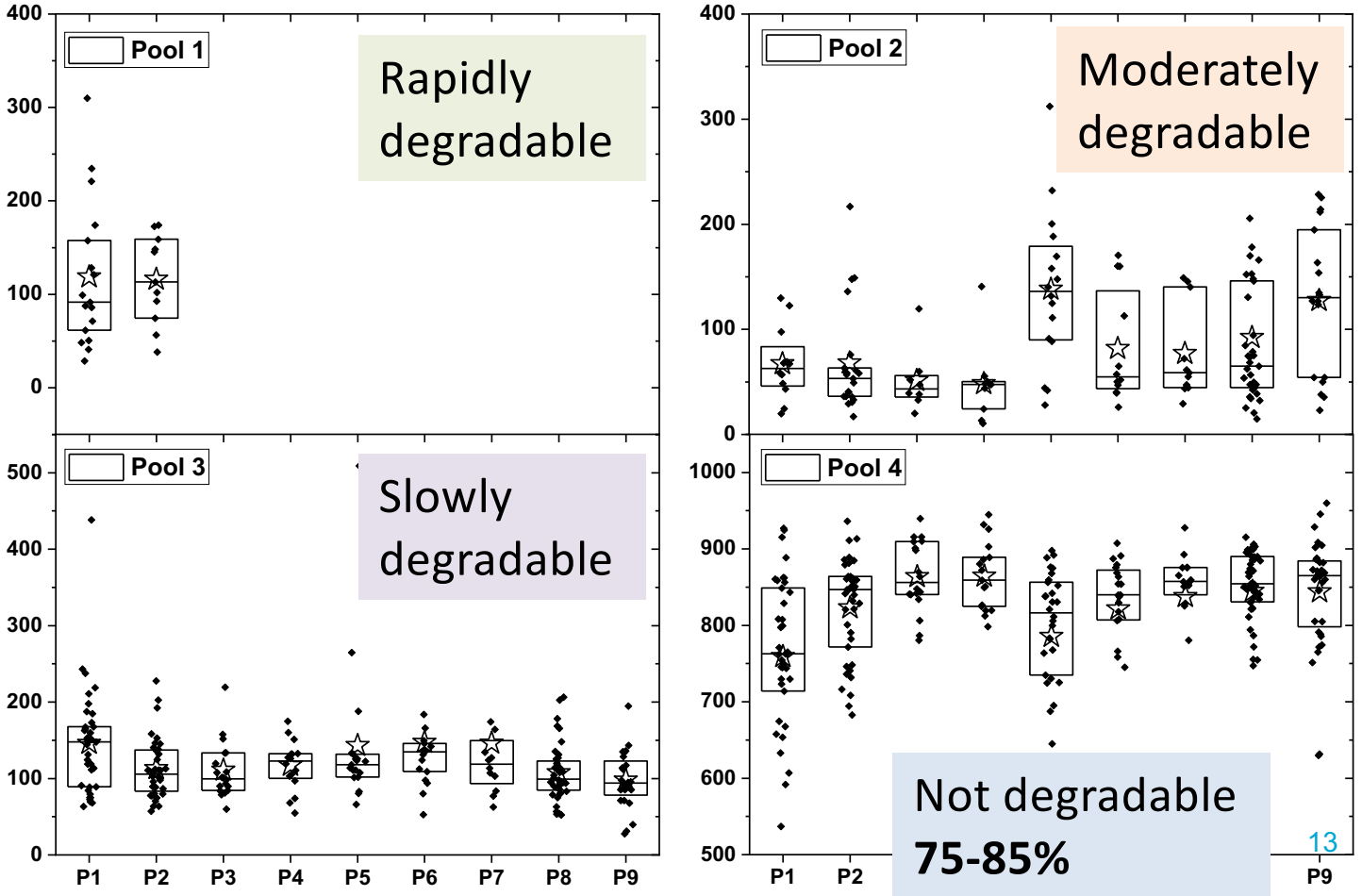


- OM decay can be described by exponential fits with 1 to 3 phases (pools). Pool 4 is the non-degradable SOM fraction.

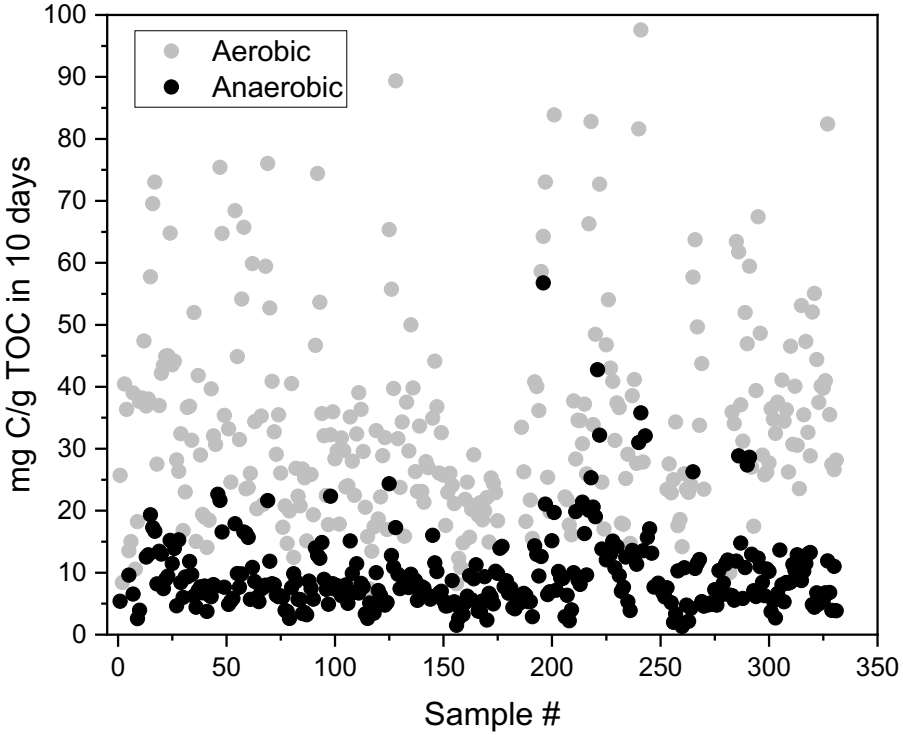
Stability of organic carbon along the transect

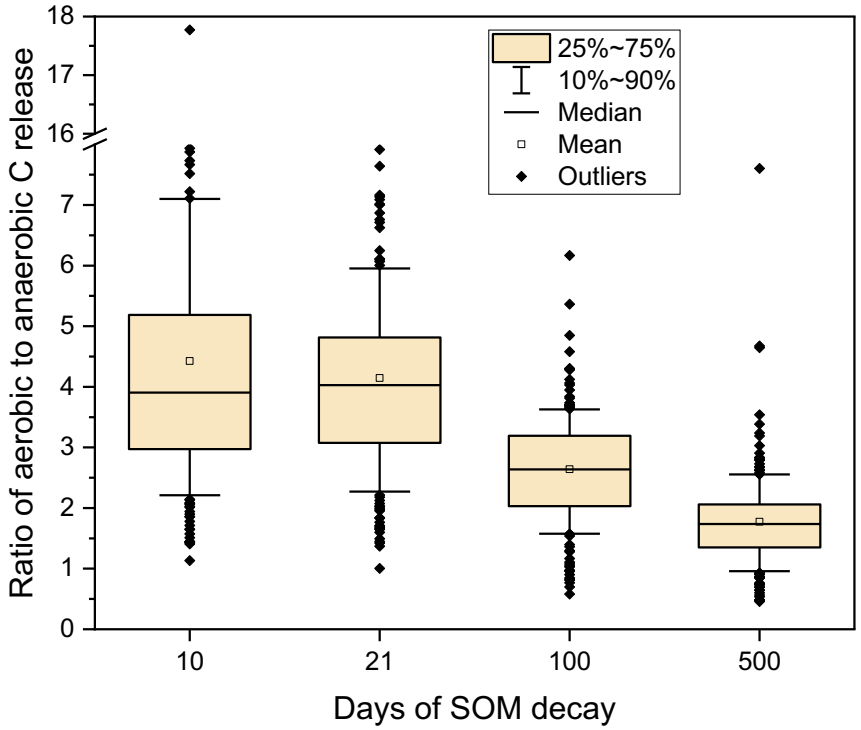
- Labile OM only upstream (input from NPP)
- Only 15-25% degradable
- **75-85% of carbon stored in the sediment → a huge mass of C!**

Zander et al. (2022). https://doi.org/10.1016/j.limno.2022.125997.



Ratio between aerobic and anaerobic decay

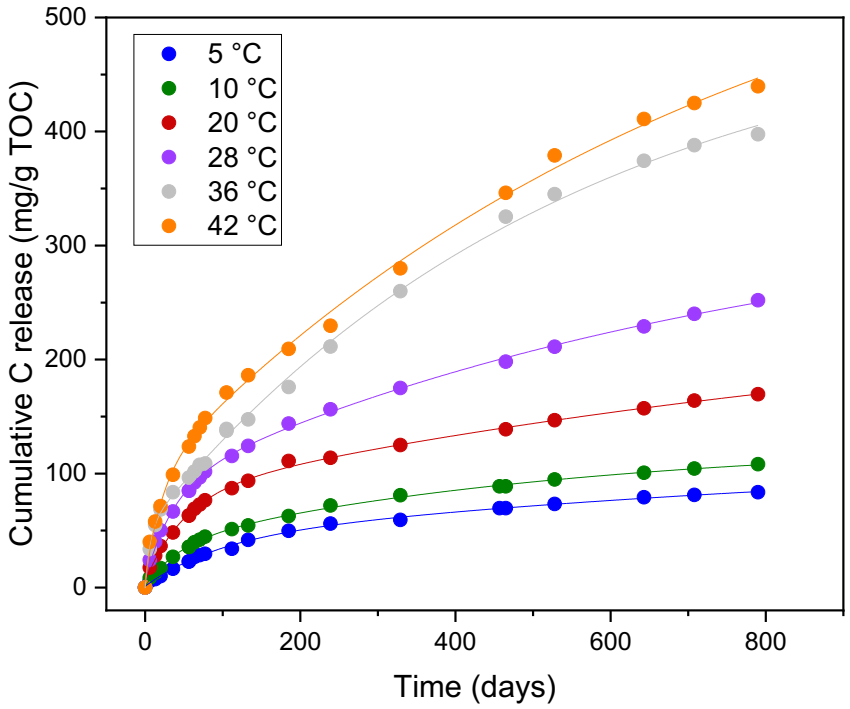




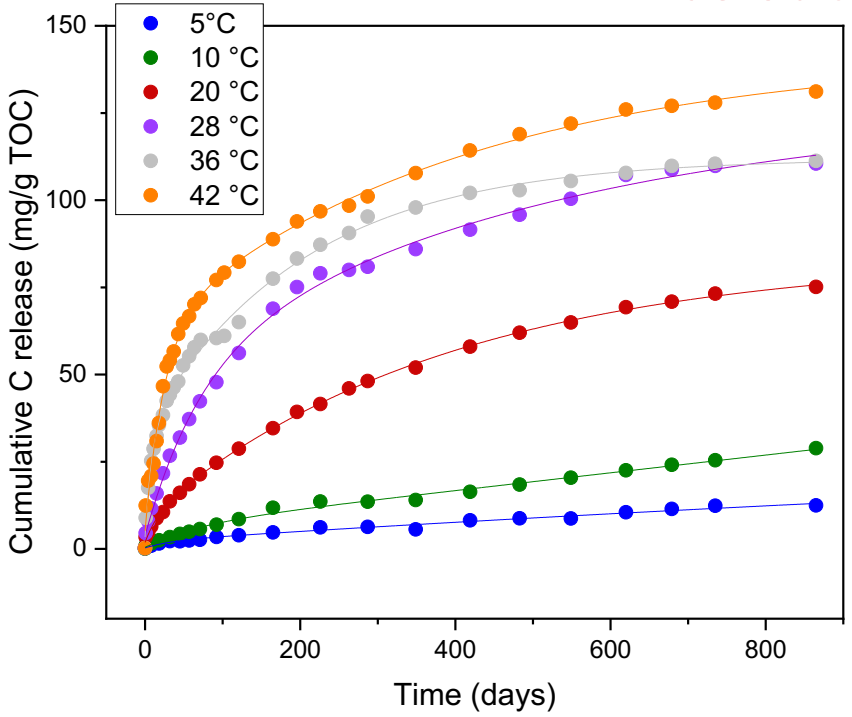
- Aerobic C release >> anaerobic C release
- Differences largest in the short-term (time-scale of interventions)

Temperature response

Aerobic

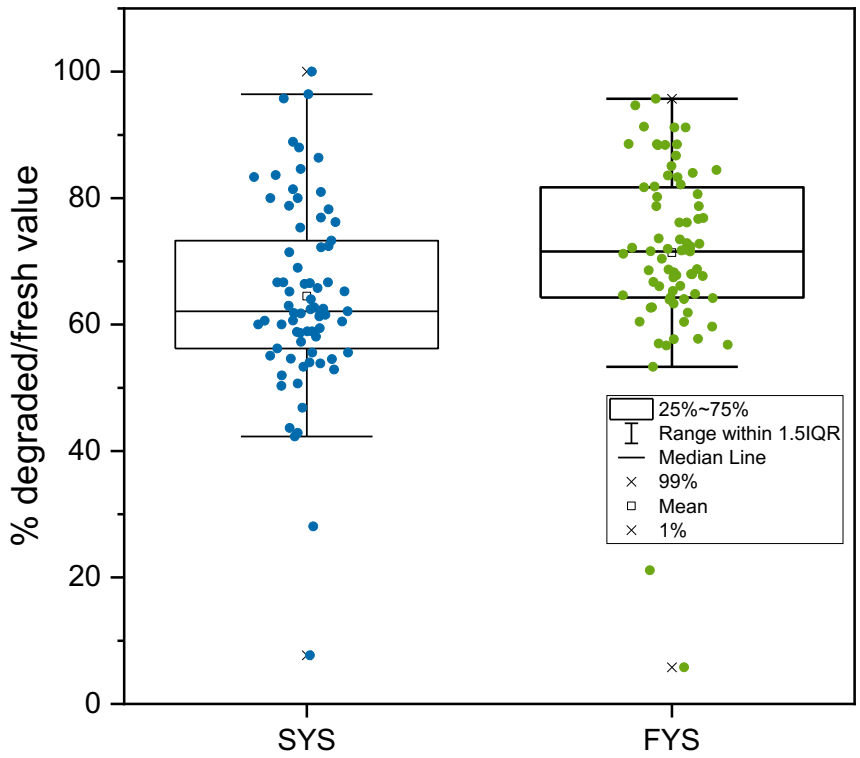


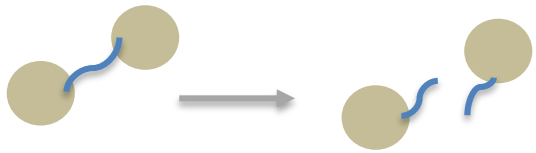
Anaerobic



- Temperature effects of climate change on SOM mineralization can be quantified

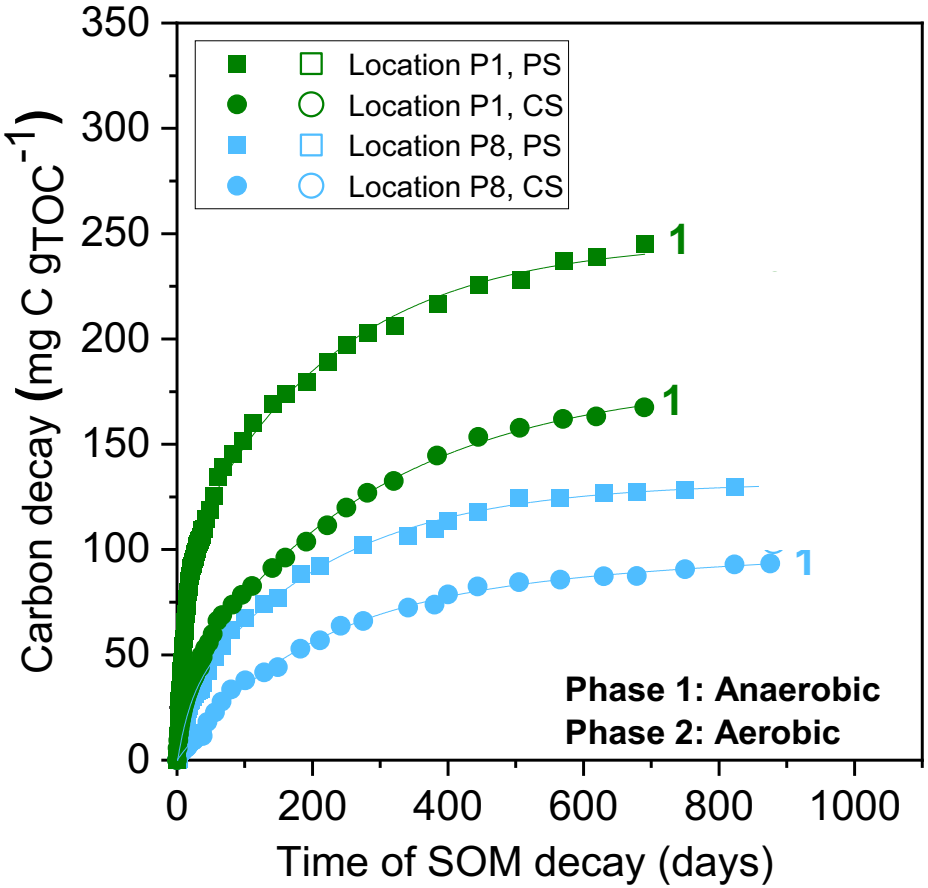
Effect of OM degradation on yield stress





- Decay of organic bridges fluidizes the sediment!

What happens if anaerobically stabilized sediment comes in contact with O_2?



- 30-50% of the C released by previous anaerobic decay is released after re-exposure to O_2

Main take-aways

- Fine-grained sediments represent an enormous C sink in the aquatic continuum
- The degradable share may be small but greatly affects properties such as yield stress
- Significant shares of C can be re-activated when 'exhausted' anaerobic sediment is exposed to oxygenated water
  → need for 'C-sensitive' dredging
- No interventions enhance C burial

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Thanks to all Nautical Depth and MUDNET colleagues!

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