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Response of the coastal filter to multiple drivers in the Baltic Sea region

Jacob Carstensen, Aarhus University

Coastal ecosystem = complex ecosystem

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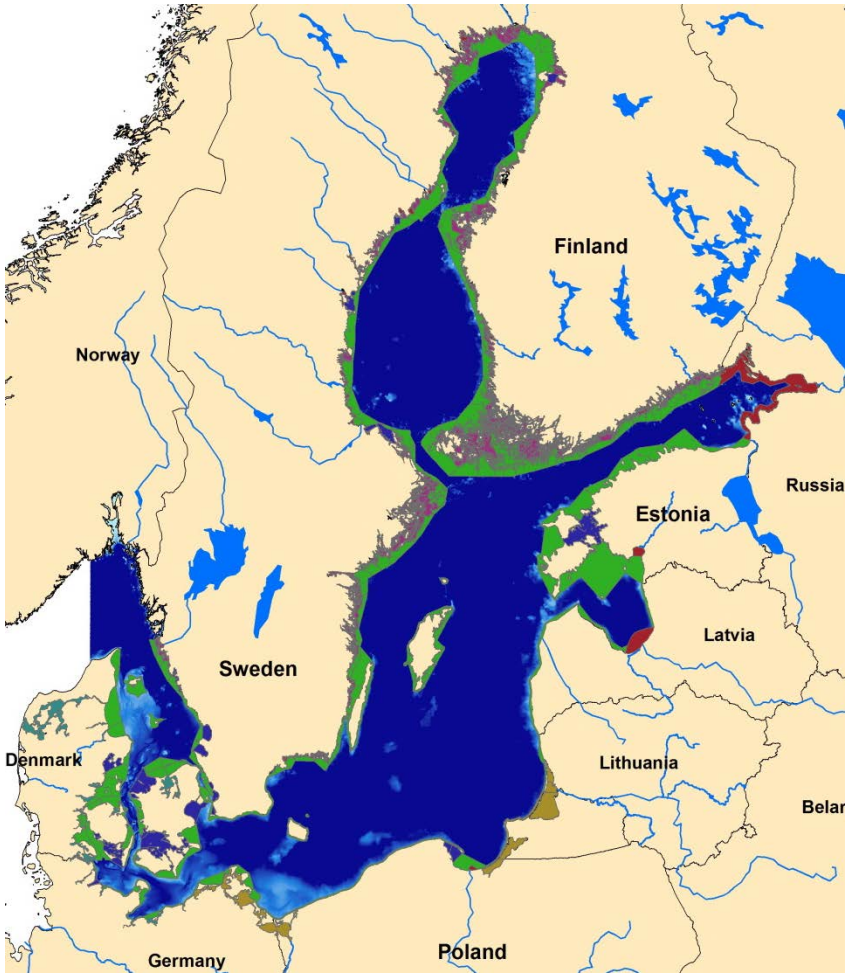
How effective is the coastal zone for removing nutrients?

C N P Si

C N P Si



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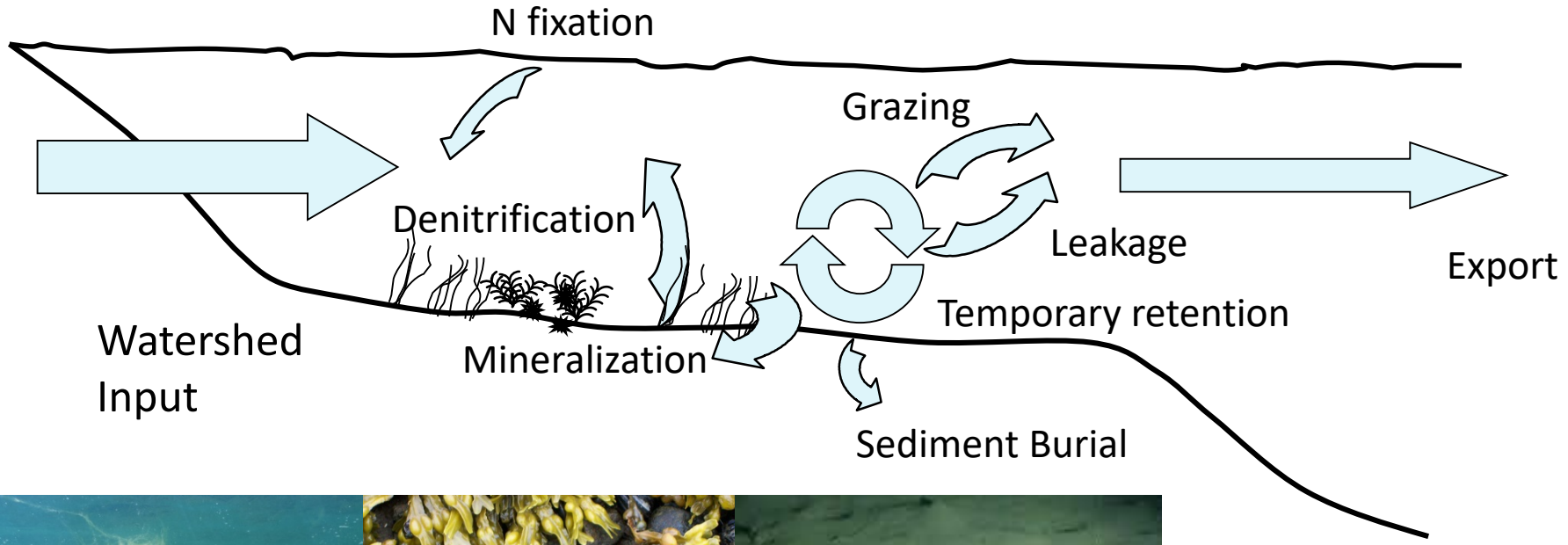
Nitrogen cycling in coastal environments





McGlathery et al. 2004

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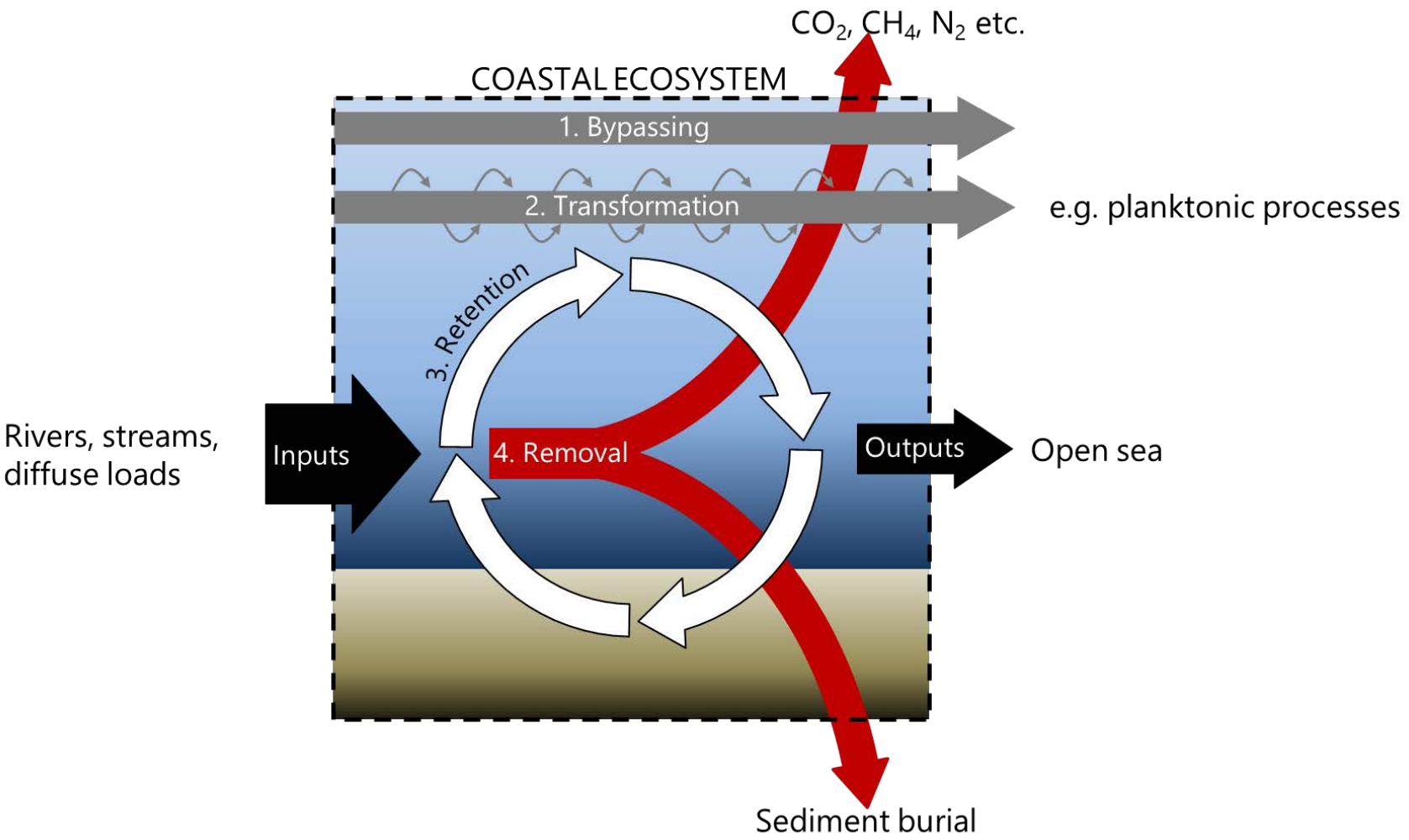
Concept of the coastal filter



Asmala et al. 2017

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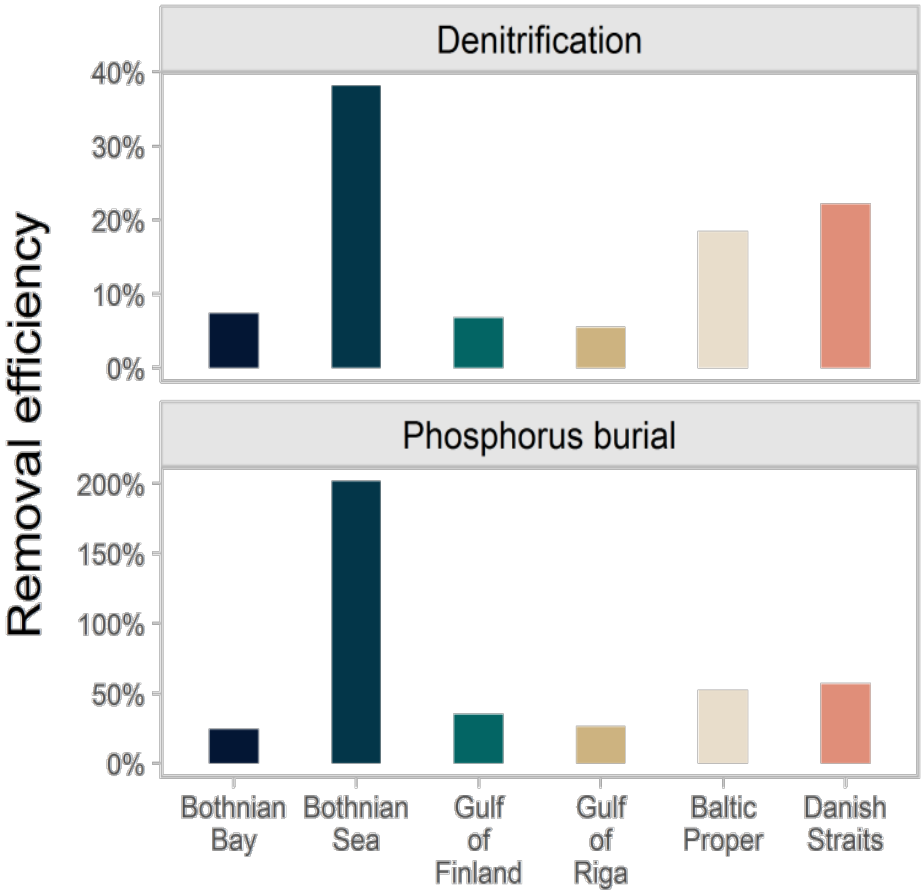
Effectiveness of the coastal filter



- coastal zone removes 16% of N and 53% of P inputs from land by DN and P burial
  - coastal zone is 27% of total area of the Baltic Sea

  → DN is <u>less</u> efficient, P burial is <u>more</u> efficient in the coastal zone compared to open Baltic Sea

c.f. Gustafsson et al. (2012): whole Baltic Sea removes 87% of N and 78% of P

Asmala et al. 2017

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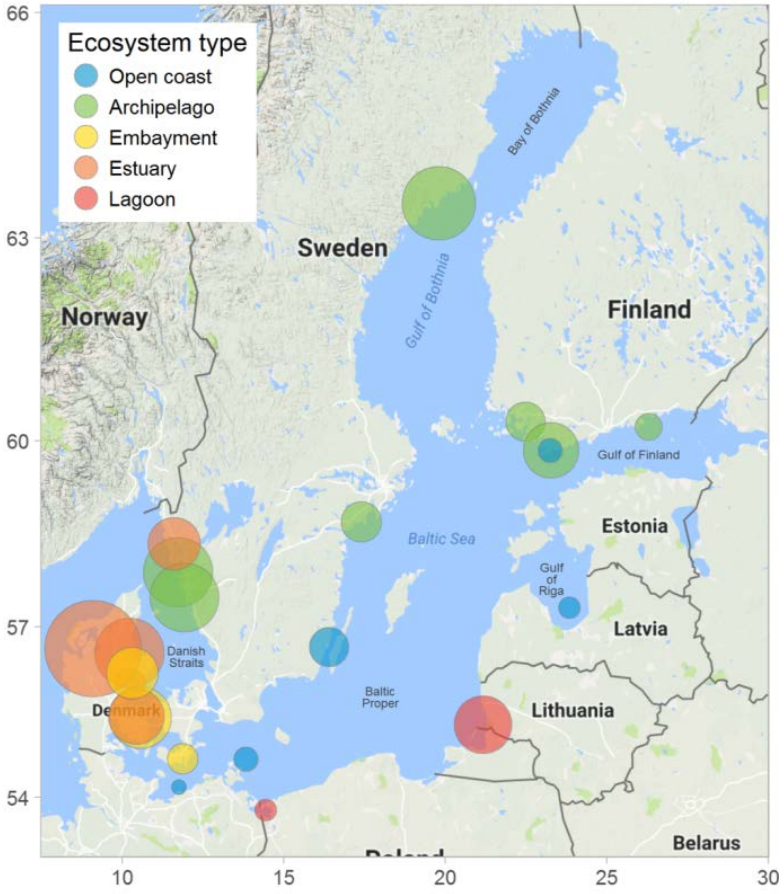
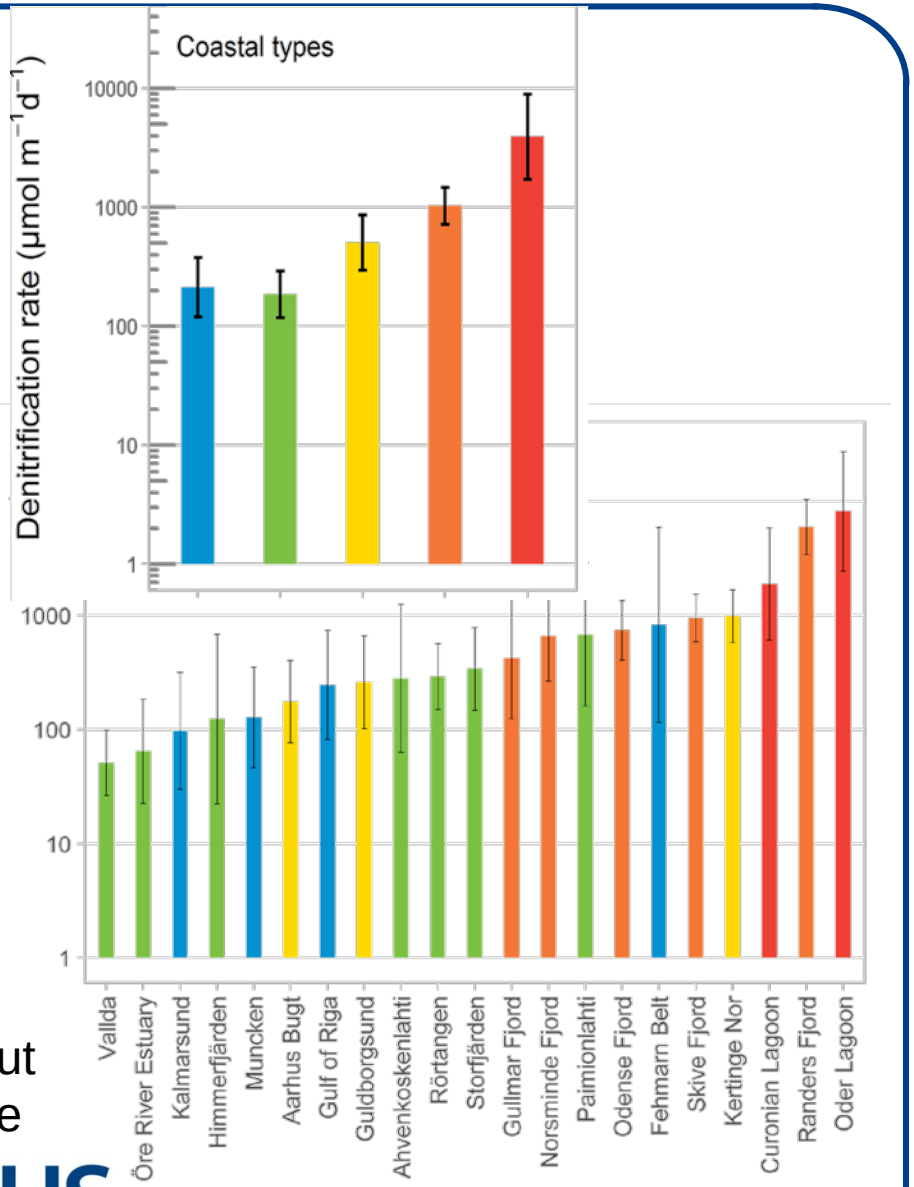
Denitrification rates variability





Rates increase with promiximity to land, but vary by more than two orders of magnitude

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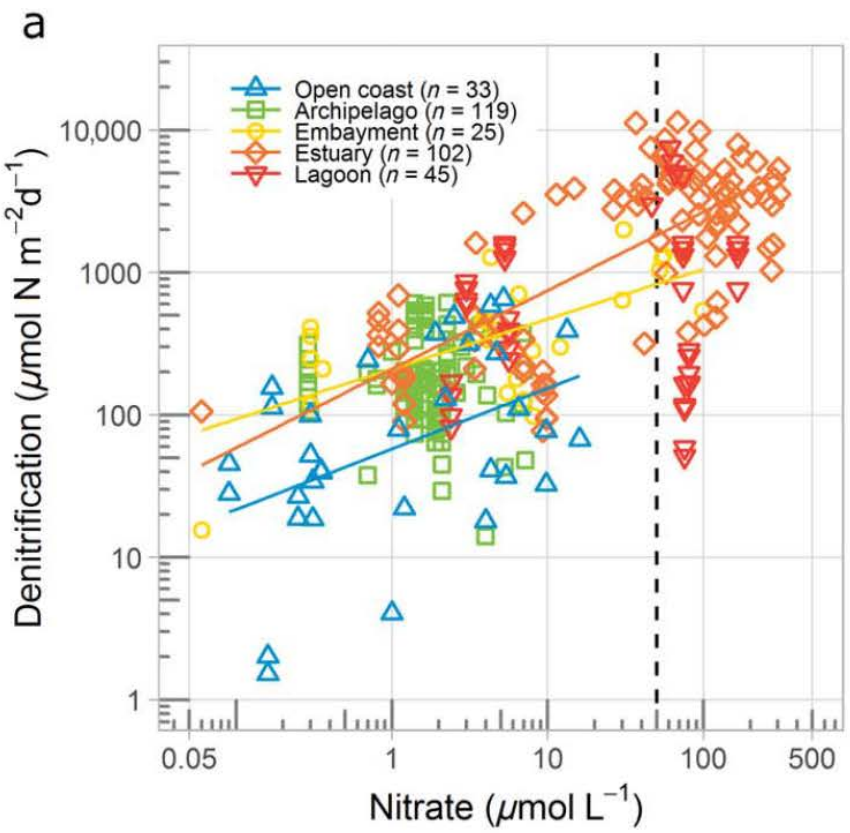
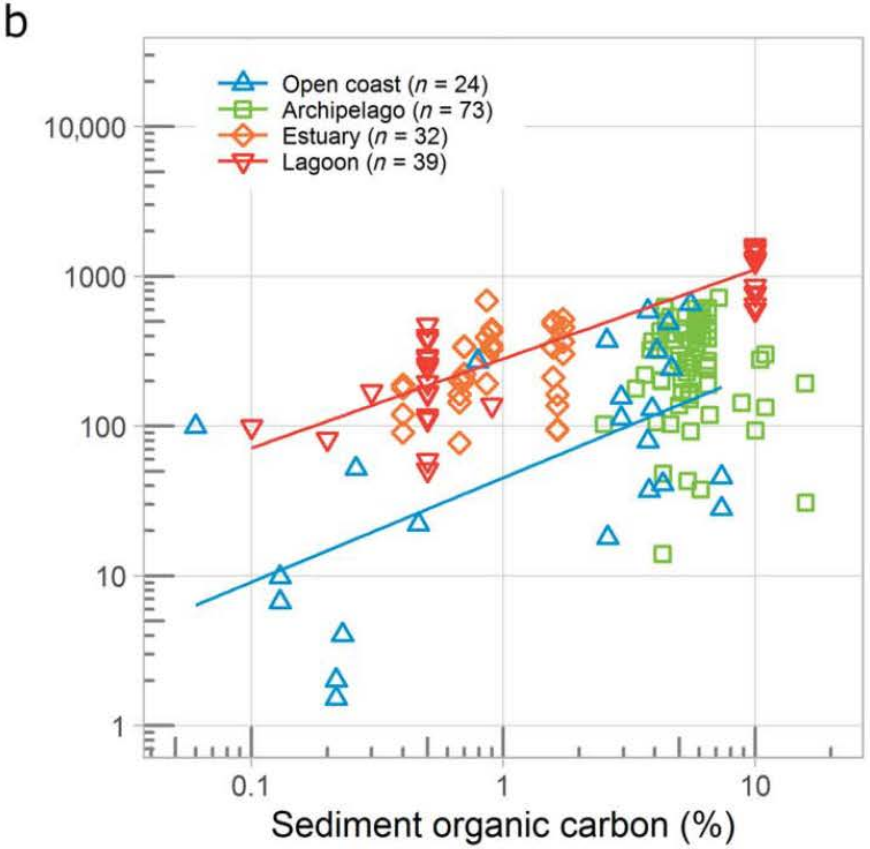
Factors controlling denitrification





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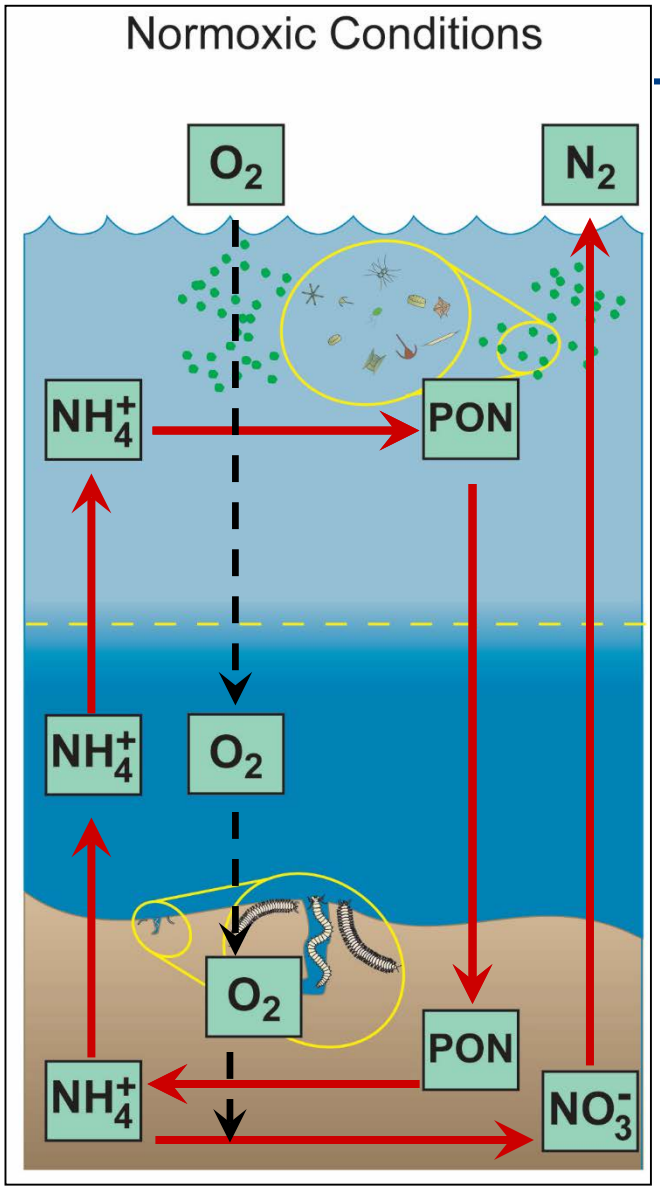
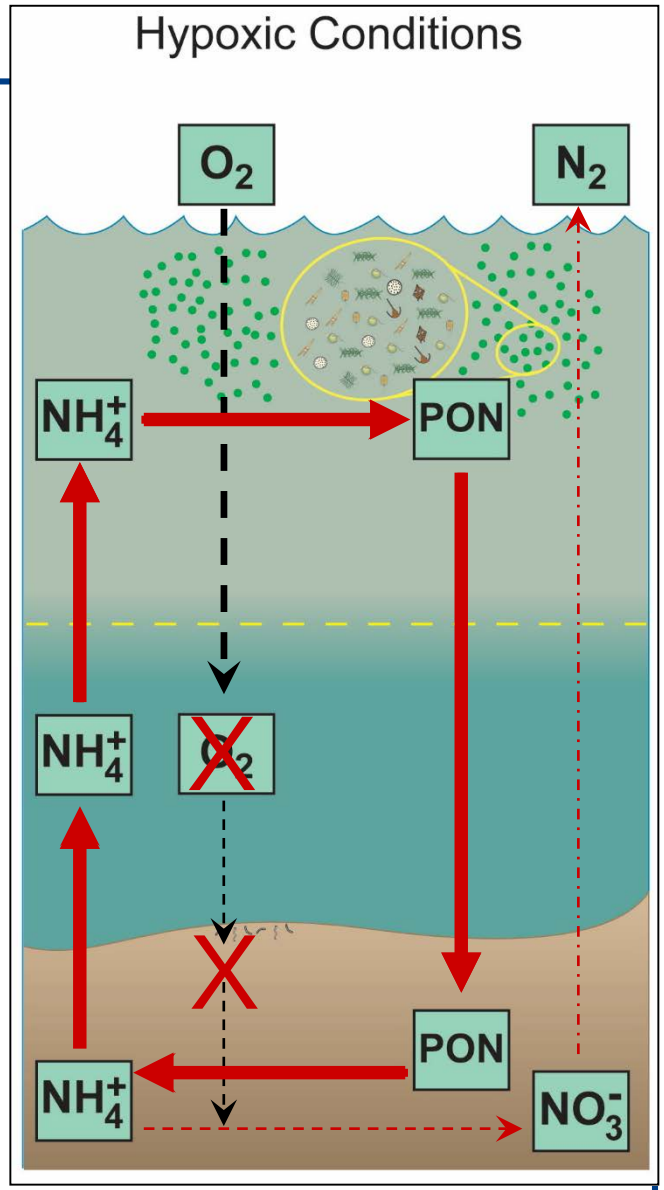
Hypoxia reduces DN and can lead to alternative stable states





Source: Jeremy Testa

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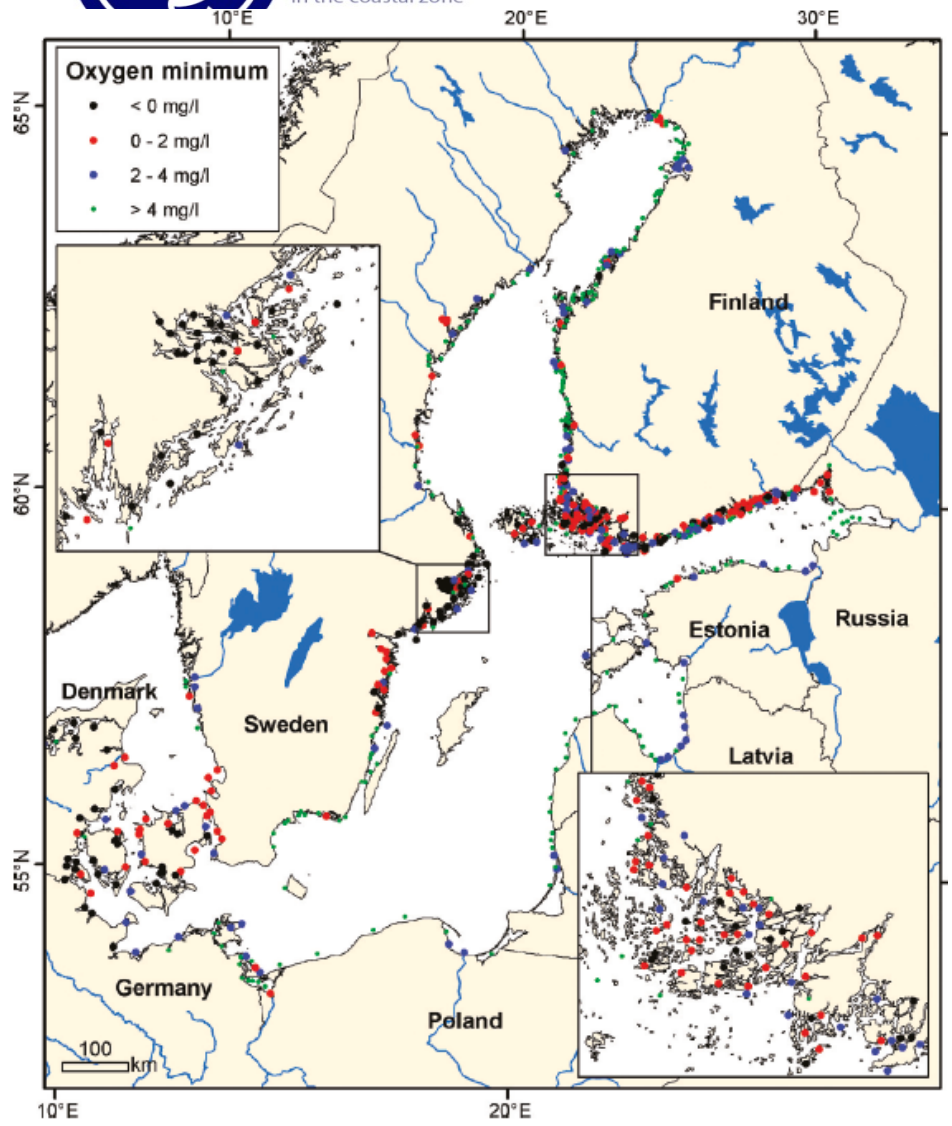
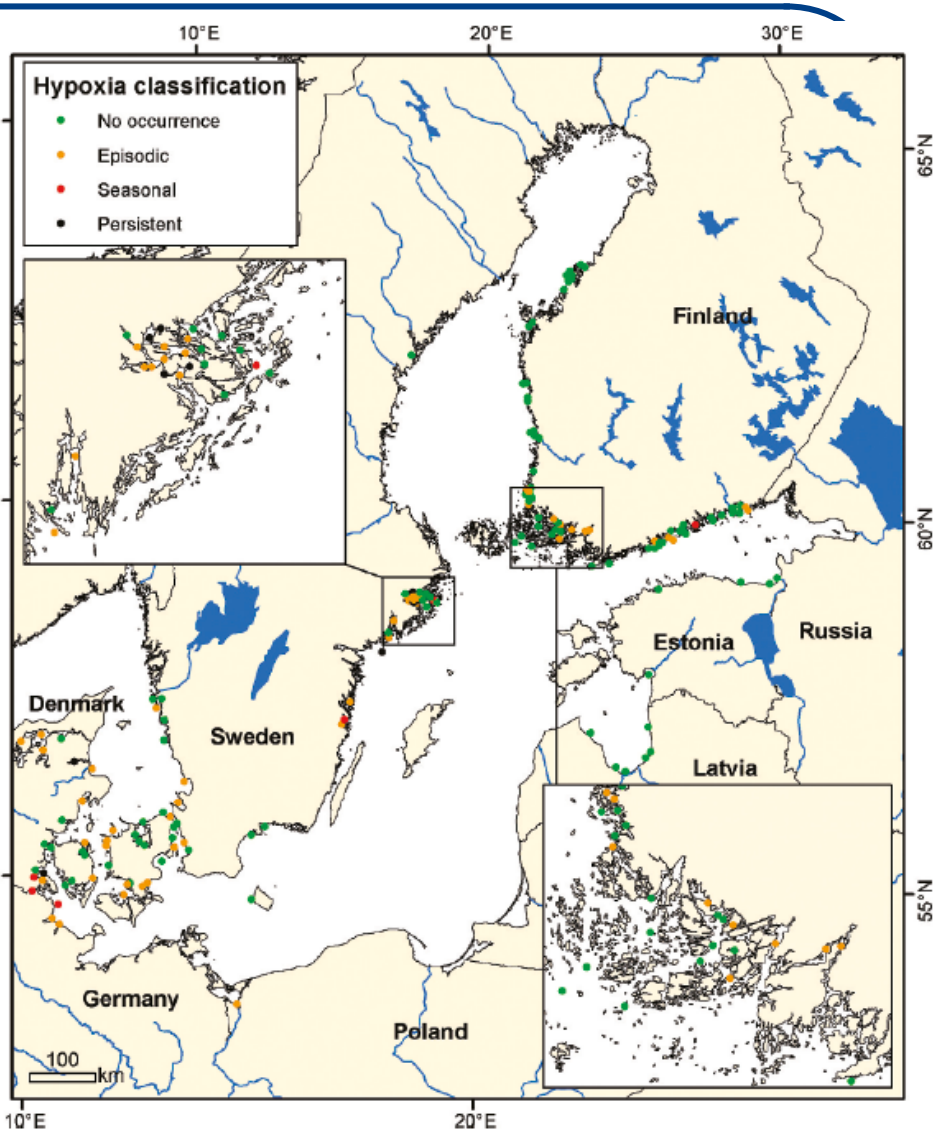
Coastal hypoxia is spreading





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Conley et al. 2011

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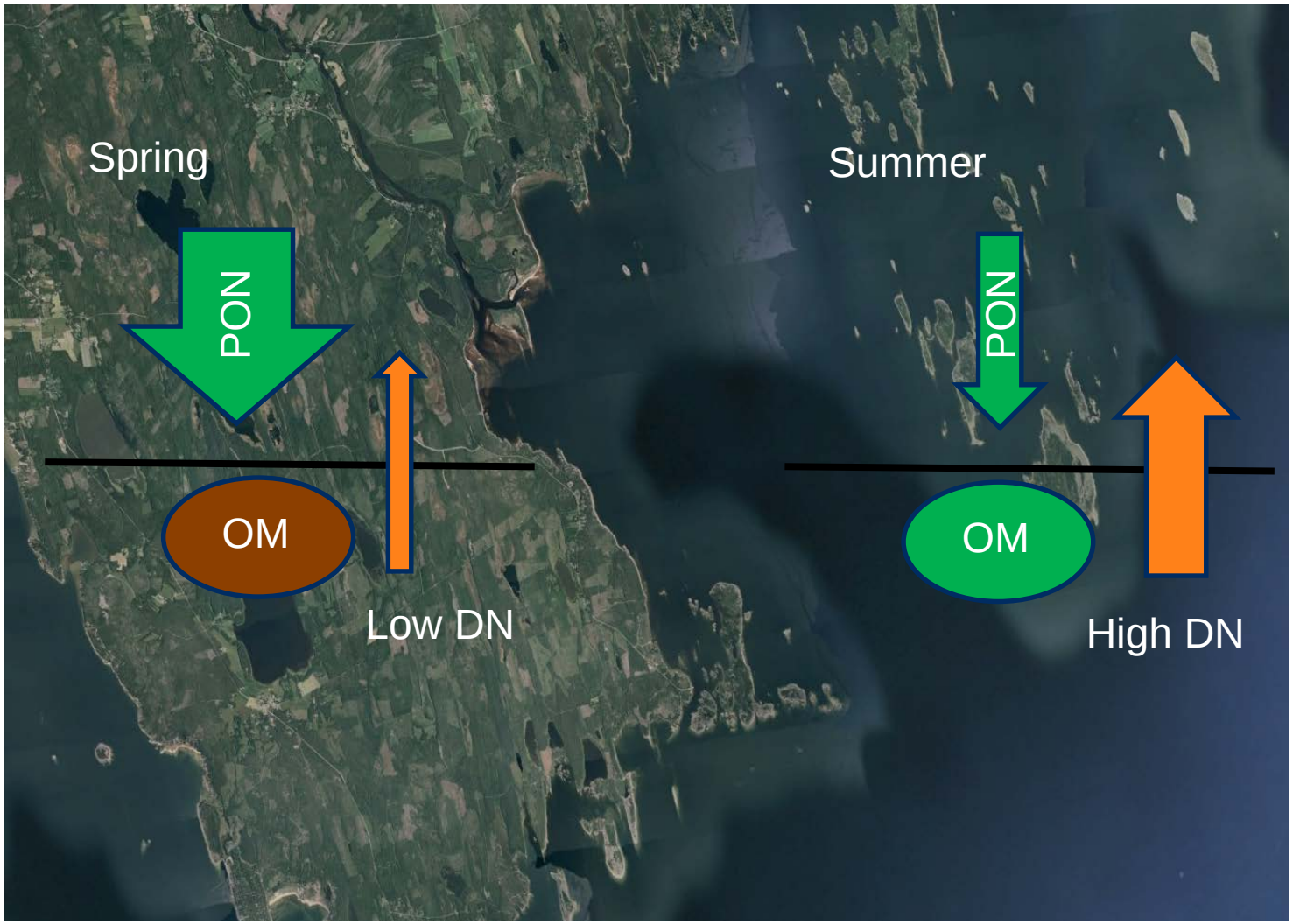
DN and labile organic carbon



Hellemann et al. 2017

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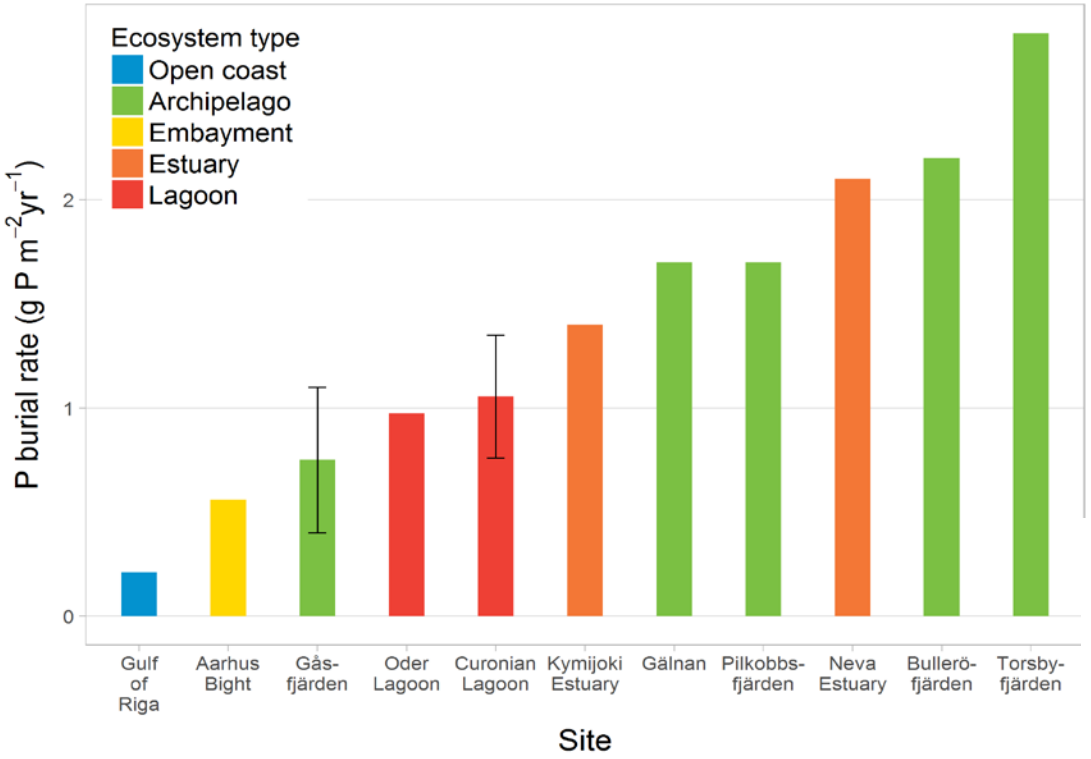
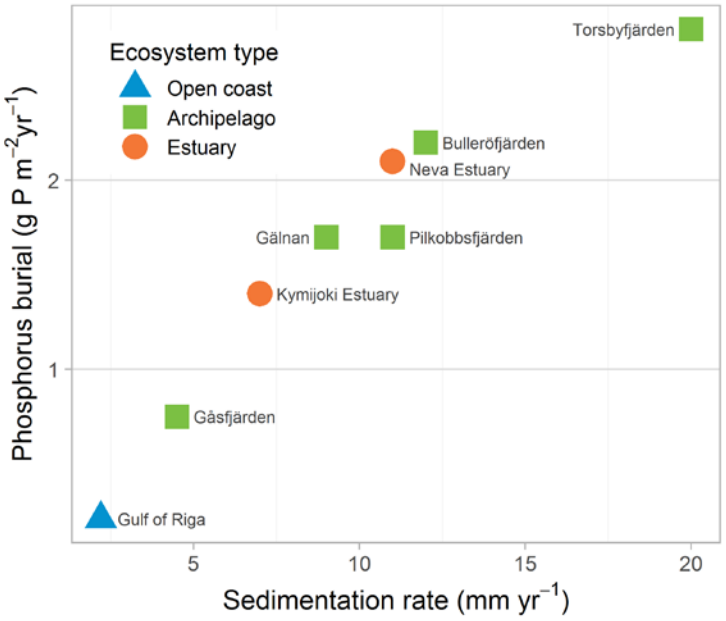
Phosphorus burial in sediments





Asmala et al. 2017

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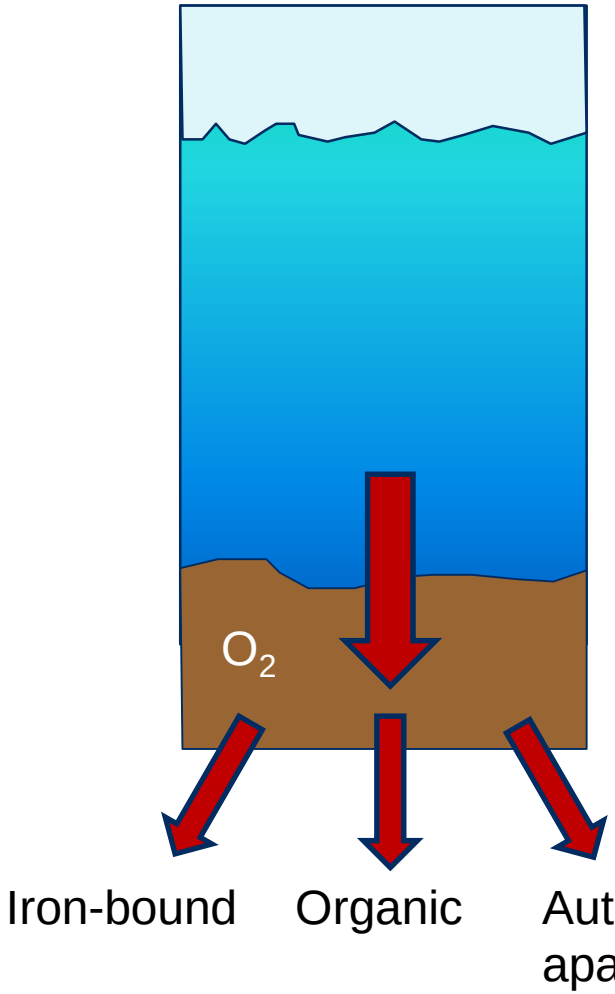
Forms of phosphorus burial



- Liberated P from the deeper sediments binds to Fe-oxides or escapes to the water column
- Fe-bound P retention decreases with salinity, because Fe-oxides are sequestered into Fe-sulfides
- Currents limit the organic P burial and the formation of P minerals

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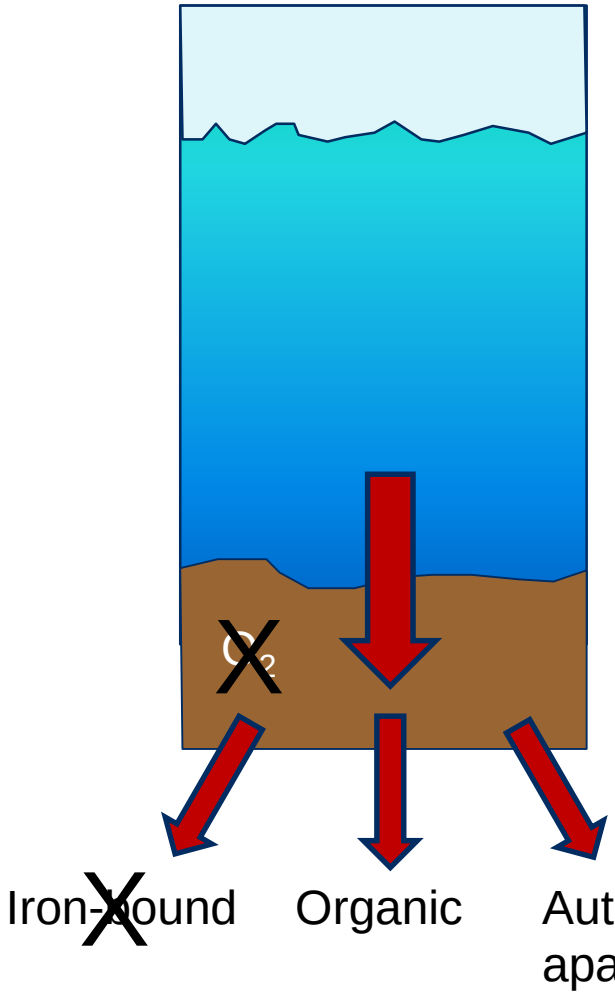

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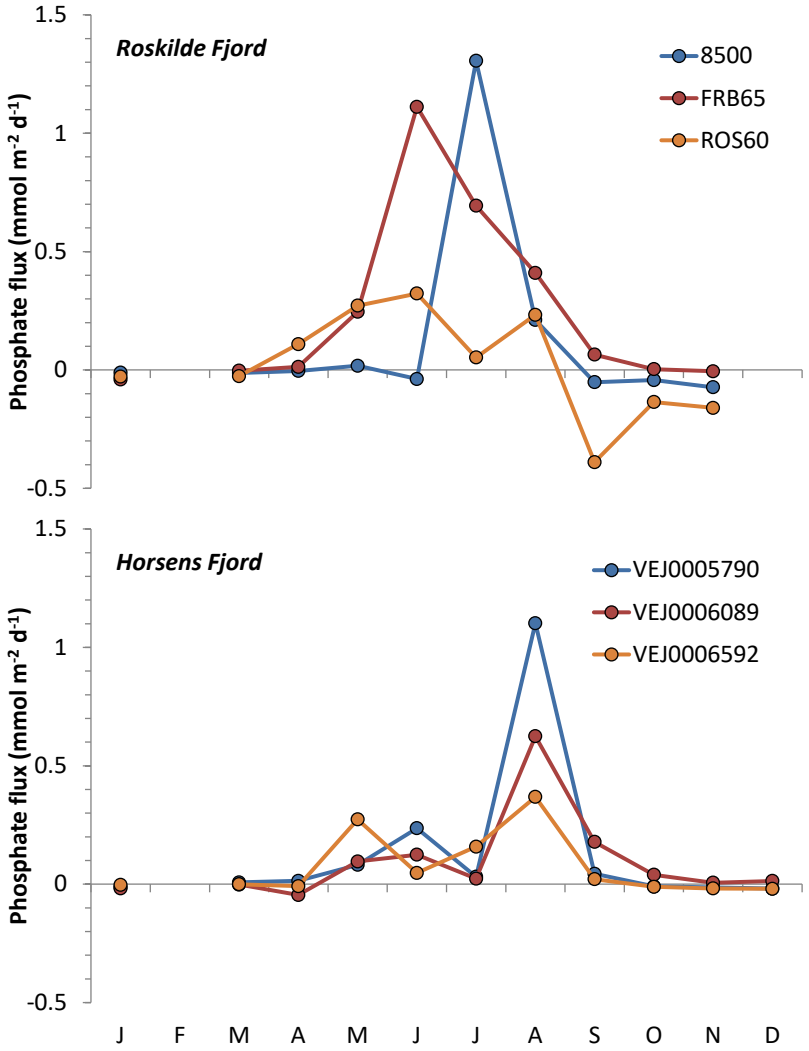
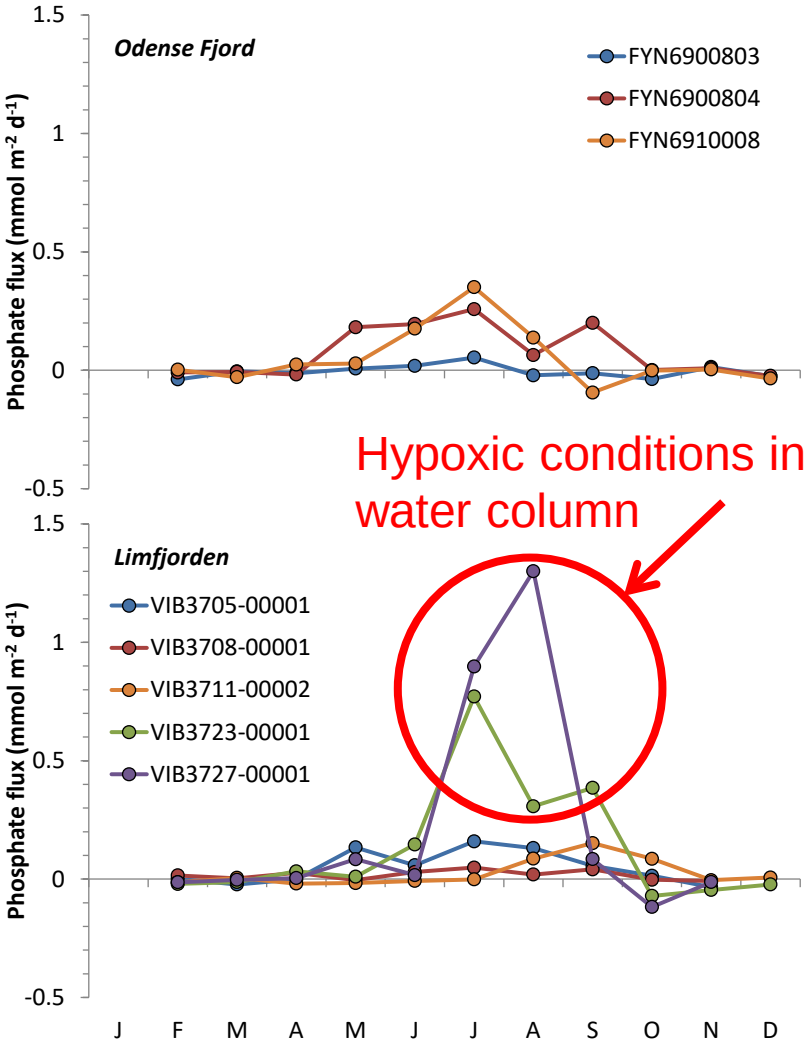
Phosphorus release from sediments





Hypoxic conditions in water column

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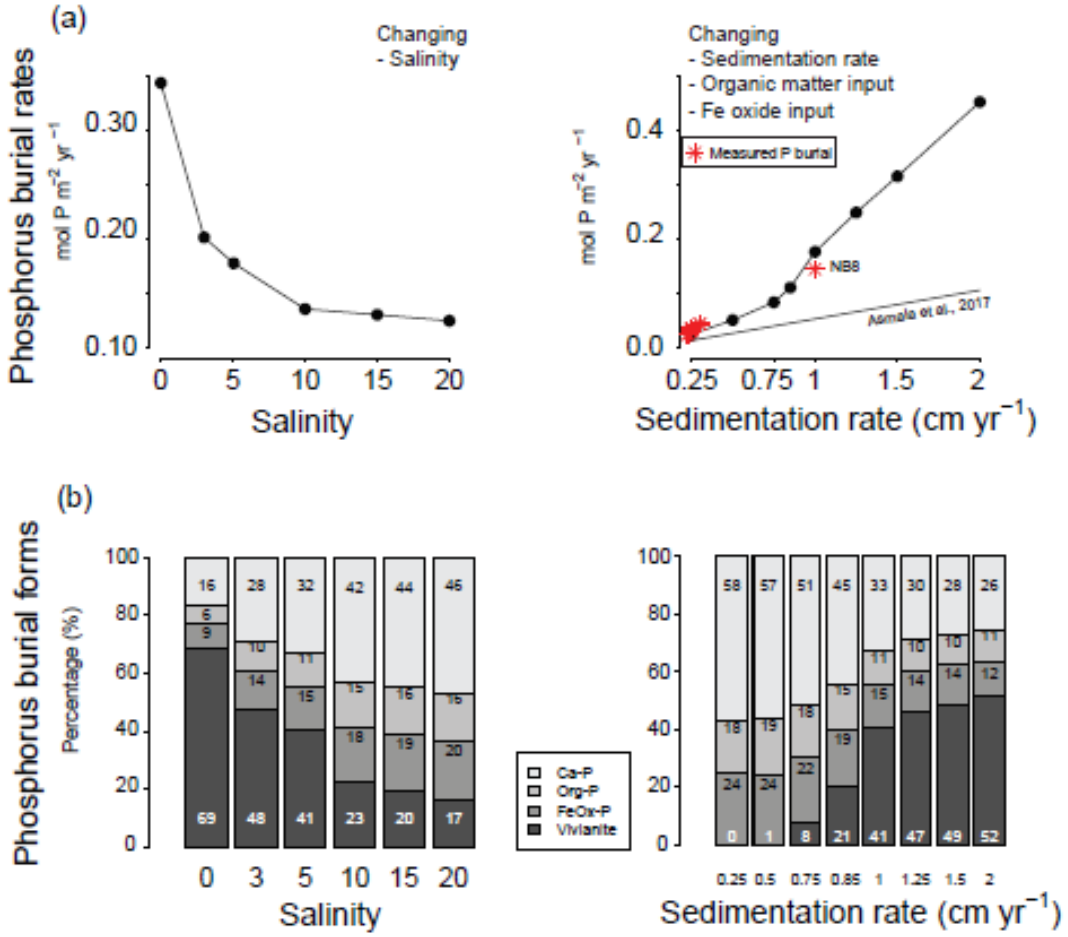
Factors controlling P burial forms

Simulations from Öre River estuary



- Burial forms of P change with
  - Salinity
  - Sedimentation rate
  - Fe inputs from land
  - OM inputs from land
- Burial forms of P have different stability
- Increasing Fe inputs and decreasing salinity will enhance vivianite formation

Lenstra et al. 2018

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Conclusions

- The Baltic Sea coastal zone is very heterogeneous in hydromorphology and nutrient retention
- Estuaries and lagoons are efficient N filters
- Coastal denitrification accounts for ~16% N retention of inputs from land
- P burial occurs as Fe-bound P, apatite and organic P
- The long-term stability of these burial forms is unknown
- Coastal P burial account for ~53% of inputs from land, but this is highly variable among systems depending on sedimentation rates

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Outlook for the future coastal filter

- Increasing hypoxia with warming will reduce denitrification and enhance Fe-bound P release
- Temperature increase may enhance coupled nitrification-denitrification but also promote OM limitation of DN
- Increasing inputs of organic carbon from boreal watersheds are unlikely to enhance denitrification because of low lability
- Increasing freshwater input will enhance P burial in more stable forms such as vivianite in the Gulf of Bothnia

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