NITRIFICATION AND NITRATE REDUCTION IN THE GULF OF FINLAND SEDIMENTS

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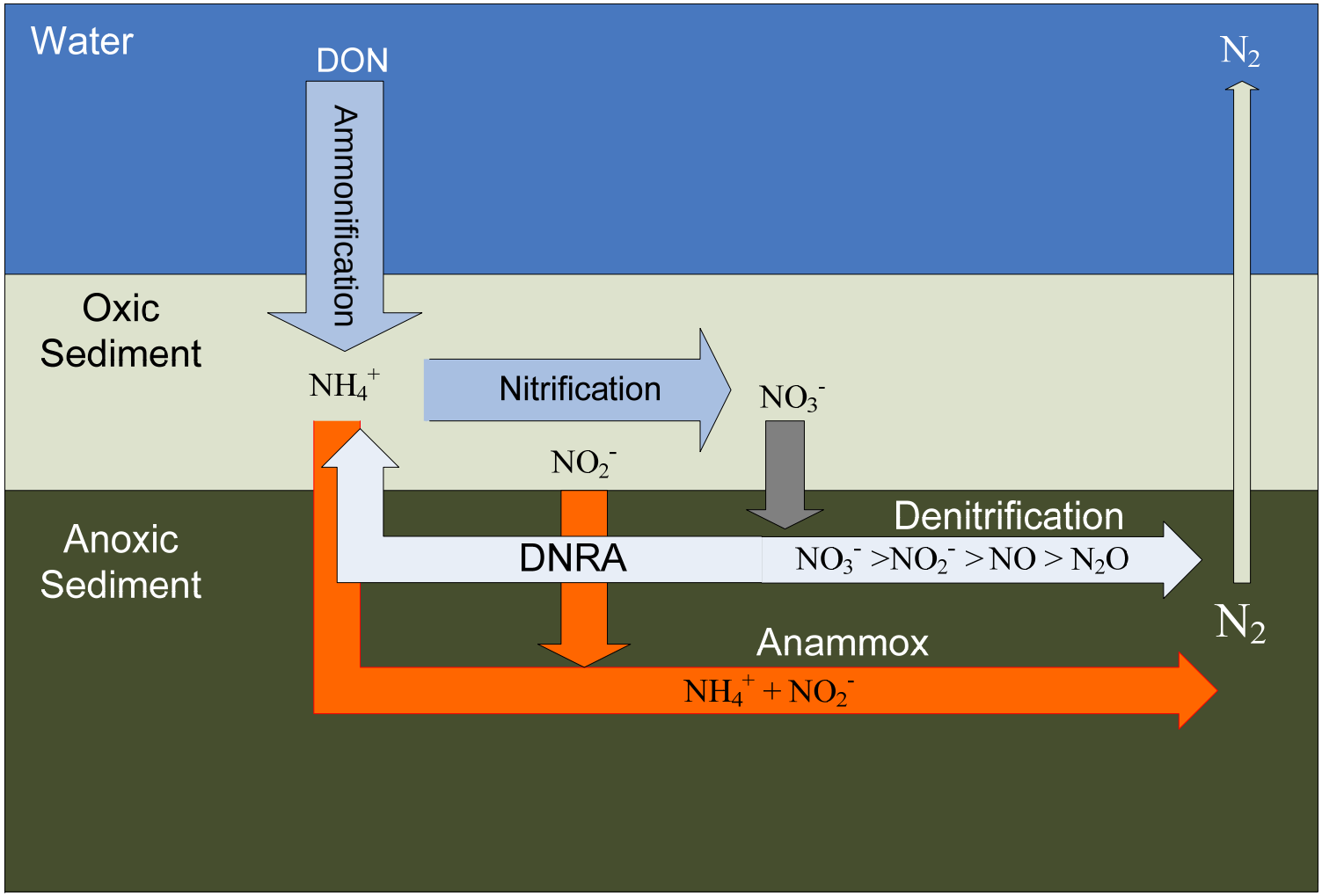
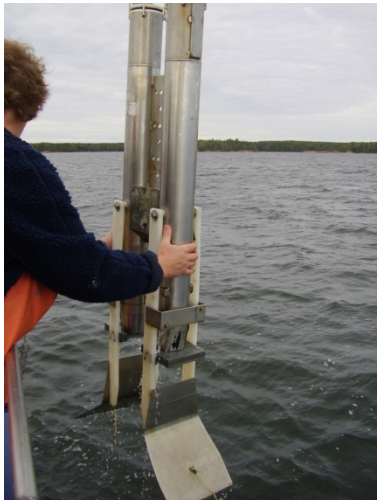
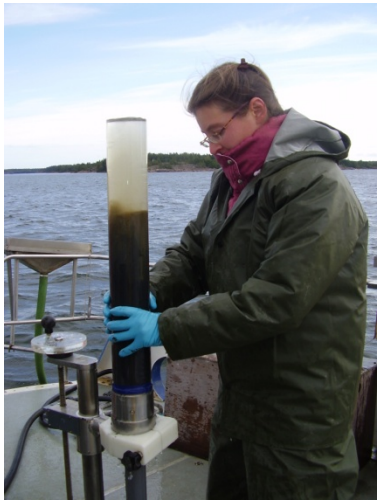
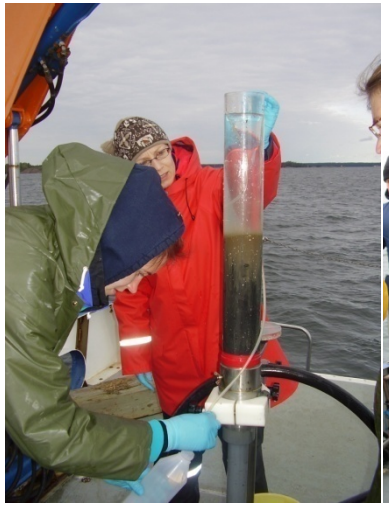
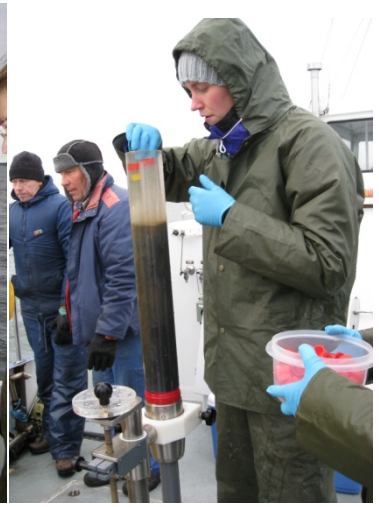
NITROGEN CYCLE IN THE SEDIMENT



MEASUREMENTS

COASTAL GULF OF FINLAND

NITRIFICATION

$NH_4^+ + O_2 \rightarrow NO_2^- + O_2 \rightarrow NO_3^-$

- Highest *in situ* rates occur late summer (up to 700 µmol N m^{-2} d^{-1}) and lowest in early spring (50 µmol N m^{-2} d^{-1})
- Highest potentials were found in early spring
- If NH_4^+ is available in excess, nitrification can produce NO_3^- more than denitrification can take up.

DENITRIFICATION

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$

- Highest rates in late summer (300 µmol N m^{-2} d^{-1})
- Frequently limited by organic carbon
- Can remove only 2-3 % of the N load entering the sampling area
- Denitrification rates measured 2008-2009 were nearly 50 % lower than in 2003-2004
  - Higher abundance of low O_2 tolerant *Marenzelleria* spp. compared to 2003-2004 → more hypoxia?

ANAEROBIC AMMONIUM OXIDATION (ANAMMOX) AND DNRA

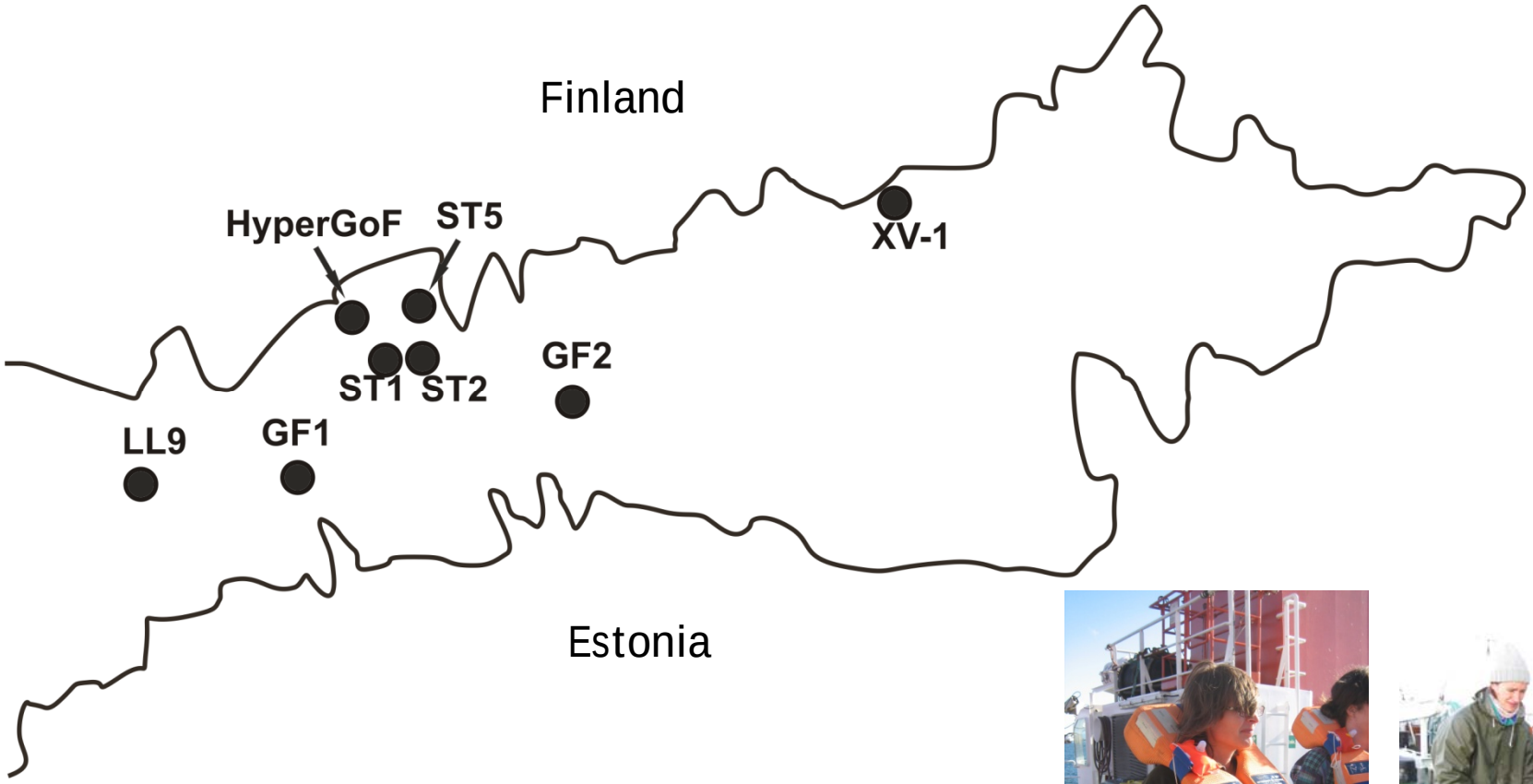
$NH_4^+ + NO_2^- \rightarrow N_2$ (anammox)

$NO_3^- \rightarrow NO_2^- \rightarrow NH_4^+$ (DNRA)

- Low anammox rates were found late fall (November 2008, December 2009)
- Always low DNRA rates

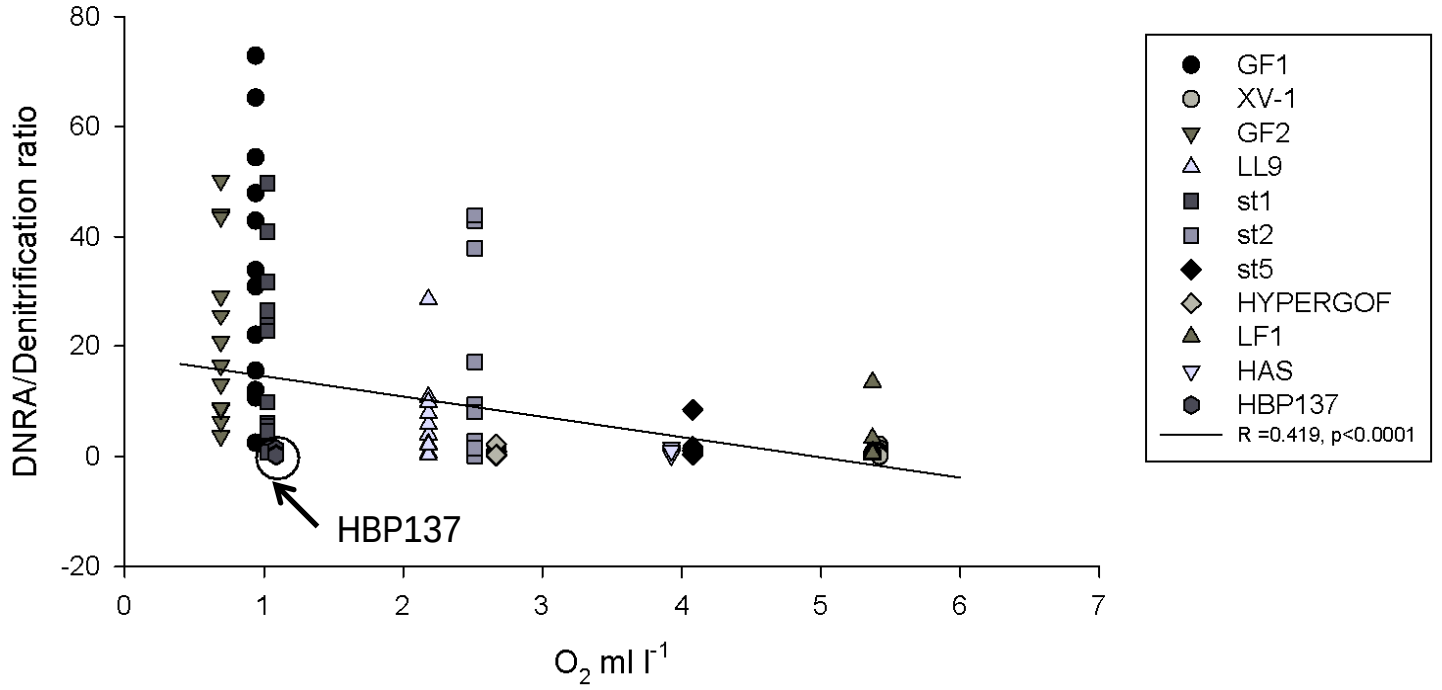
→Not important NO_3^- reduction pathways

OPEN GULF OF FINLAND



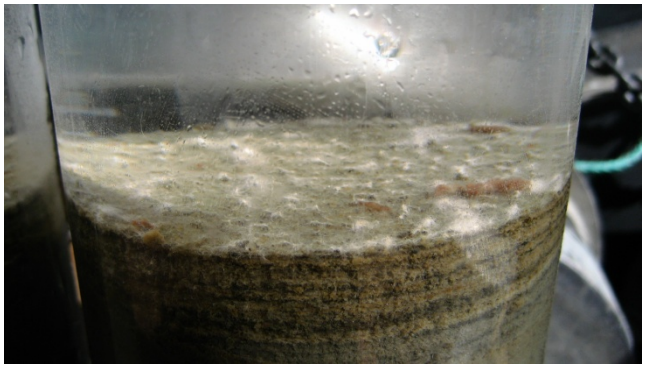
DNRA/DENITRIFICATION

- Importance of DNRA in NO_3^- reduction increased near hypoxia (O_2^-<2.5 ml l^{-1})



DNRA

- High DNRA rates were found in low organic content sediments →driven most likely by sulfur oxidation rather than fermentation



- Might be linked to the *Beggiatoa* spp. found in sites where DNRA rates were extremely high

NITROGEN REMOVAL

- Nitrogen removal estimated in mid-90s and 2003-2004 suggest the denitrification removes approximately 1/3 of the N load…
- Nitrogen removal rates measured 2008-2009 show much lower denitrification →inter-annual fluctuations of the nitrogen removal capacity

WHY?

Stronger halocline 2008-2009 compared to mid 90s

→ no mixing of the bottom water
→ more wide spread hypoxia

WHERE DOES THE NITROGEN IN THE GULF OF FINLAND GO?

- Low coastal denitrification rates
- Low denitrification rates in the open sea
  - Sedimentation?
  - Transported to the Baltic Proper?

CONCLUSIONS

- Coastal nitrogen cycling is controlled by the availability of organic matter
  - NH_4^+ for nitrification
  - Organic carbon for denitrification
- Coastal sediments in the Gulf of Finland remove only small percentage of the nitrogen entering from the drainage basin

- The importance of denitrification in NO_3^- reduction decreases when the O_2 concentration is below 2.5 ml l^{-1}
- The nitrogen removal capacity in the Gulf of Finland was less 2008-2009 than in mid-90s

FORTHCOMING PEER REVIEWED PUBLICATIONS:

- Measuring nitrification in sediments – comparison of two methods and three $^{15}NO_3^-$ measurement techniques (submitted)
- Seasonal variation in nitrification and nitrate reduction pathways in coastal sediments in the Gulf of Finland, Baltic Sea (Accepted to AME)
- The effects of hypoxia on sediment nitrogen cycling in the Baltic Sea (submitted)
- Nitrification and the actively nitrifying microbial community in the Baltic Sea water column (in prep.)
- Oder lagoon nitrogen cycling…

RELEVANCE OF THE RESULTS FOR POLICY AND STAKEHOLDERS

- There are high seasonal and inter-annual fluctuations in the sediment nitrogen removal capacity
- → Unfortunately the highest N-loads arrive in spring when the sediment nitrogen removal capacity is the lowest
- → The amount of nitrogen that sediment can remove is not constant but varies from year to year.

QUESTIONS?

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