10th International Estuarine Biogeochemistry Symposium
18. – 22. May 2008, Xiamen, China

Iron in the Baltic Sea

A possible key parameter for cyanobacteria blooms?

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2. Iron in the Baltic Sea
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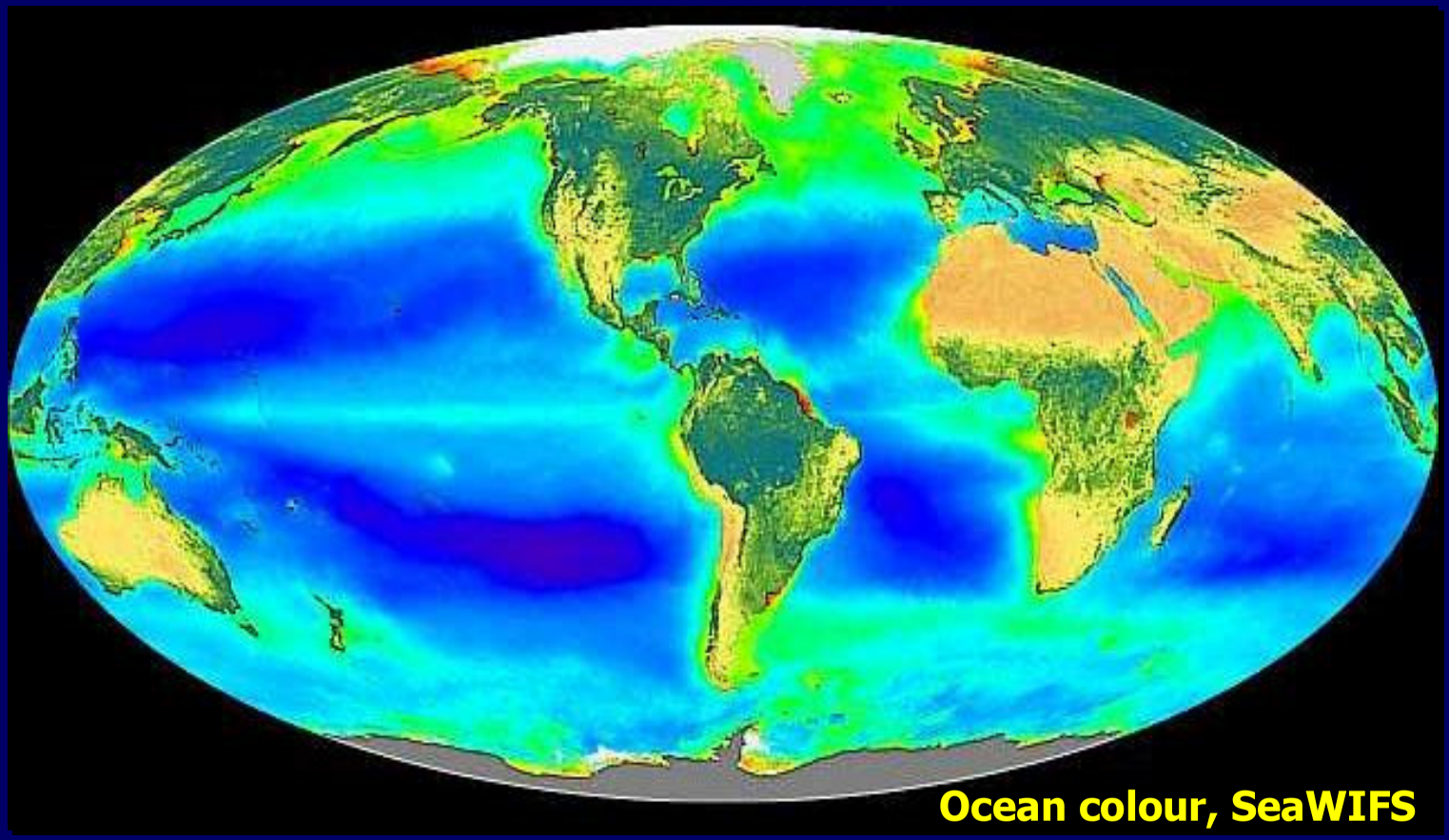
What controls ocean fertility?



Ocean colour, SeaWIFS

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3. Iron in the Baltic Sea
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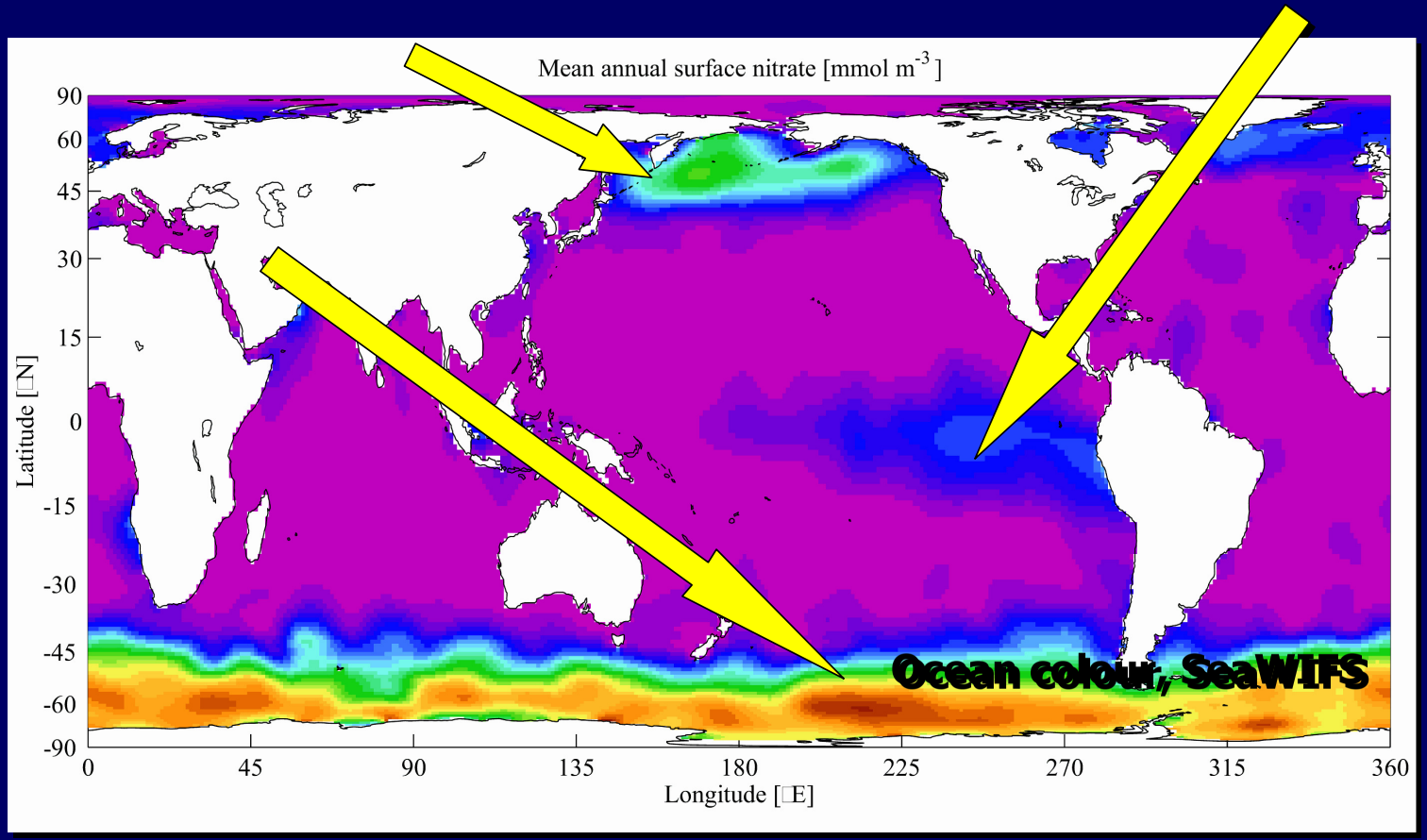
High-Nitrate, Low-Chlorophyll Regions



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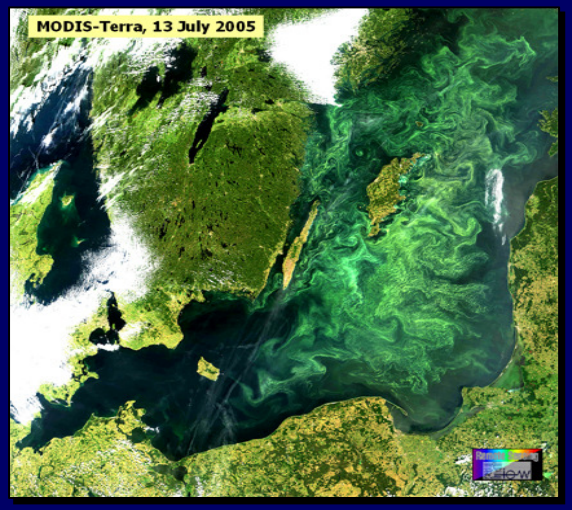
Is Fe a limiting or a promoting factor of cyanobacteria blooms in the Baltic ?

Diazotrophic nitrogen uptake: 200 – 1000 kt / year

Rolff et al. 2007; Schneider et al. 2003



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5. Iron in the Baltic Sea
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Annual distribution of cyanobacterial accumulations

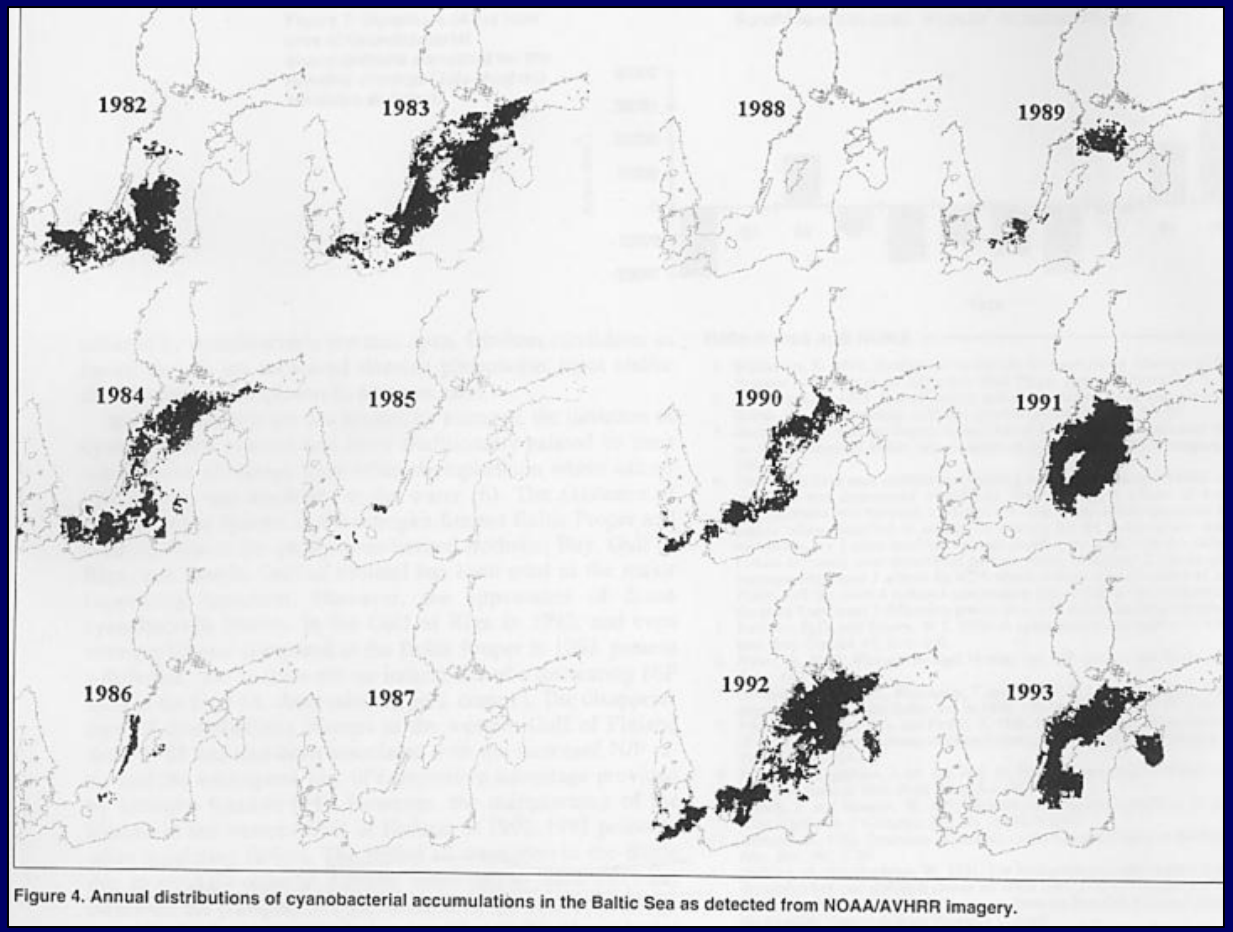


Figure 4. Annual distributions of cyanobacterial accumulations in the Baltic Sea as detected from NOAA/AVHRR imagery.

Kahru et al. (1994): Ambio, 23 / 8, 469-472

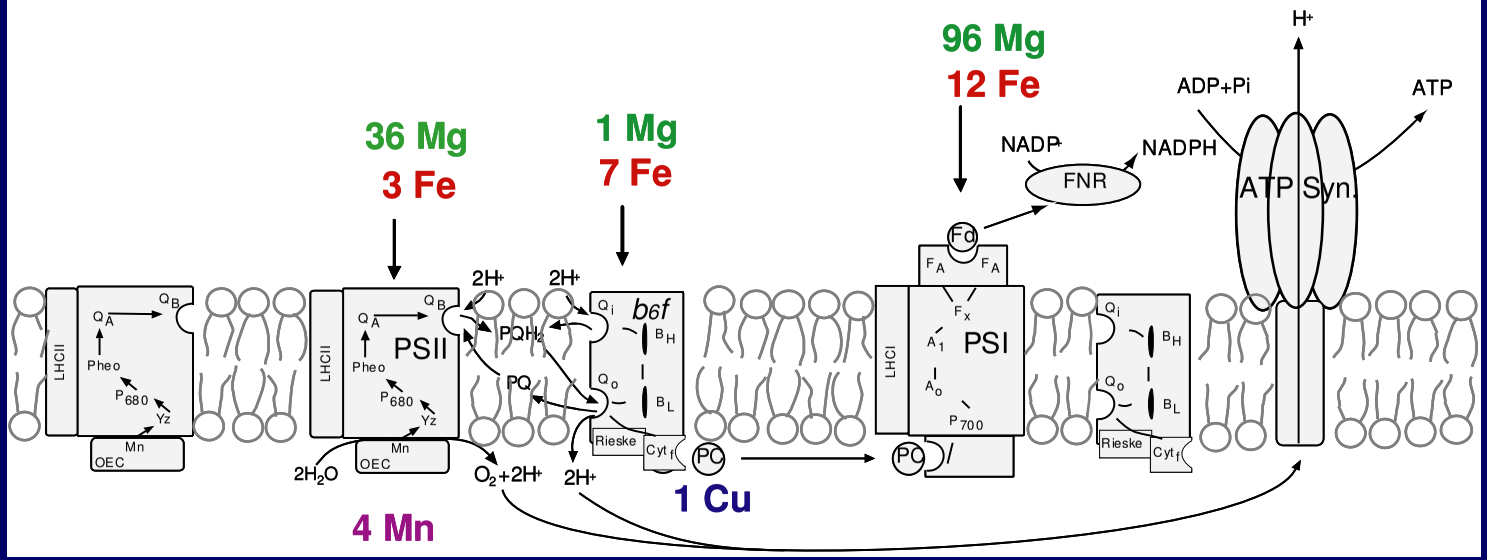
Metal requirements of the photosynthetic apparatus

Mn: *Synechocystis* 6803 1x10^6, *Rhodobacter capsulatus* 1x10^4 , E. coli 1x10^4 atoms/cell

(Keren et al. 2002, Finney and O'Halloran 2003, Shcolnick et al. 2007)

Fe: *Synechocystis* 6803 5x10^6, E. coli 1x10^5 atoms/cell

(Keren et al. 2004, Finney and O'Halloran 2003)



Background: Cyanobacteria and Fe

- Fe-containing enzyme (nitrogenase) of cyanobacteria is required for atmospheric nitrogen fixation
- The Fe requirement for diazotrophic growth is ~10-fold higher than that with fixed nitrogen (Kustka et al. J. Phycol., 39, 12-25, 2003)
- >99% of the dissolved Fe in surface water is possibly organically complexed
- Dissolved Fe ≠ Bioavailable Fe!
- In biological systems only Fe(II) is of importance
- Soluble Fe (II) species from anoxic Baltic deepwater may contribute to the pool of bioavailable Fe from which nitrogen fixing cyanobacteria can fulfill their Fe demands

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Harmful algal blooms – a consequence of eutrophication?

Main factors for cyanobacteria growth:

- Availability of phosphate
- High water temperatures
- Stable surface - water masses
- Speciation and bioavailability of Fe

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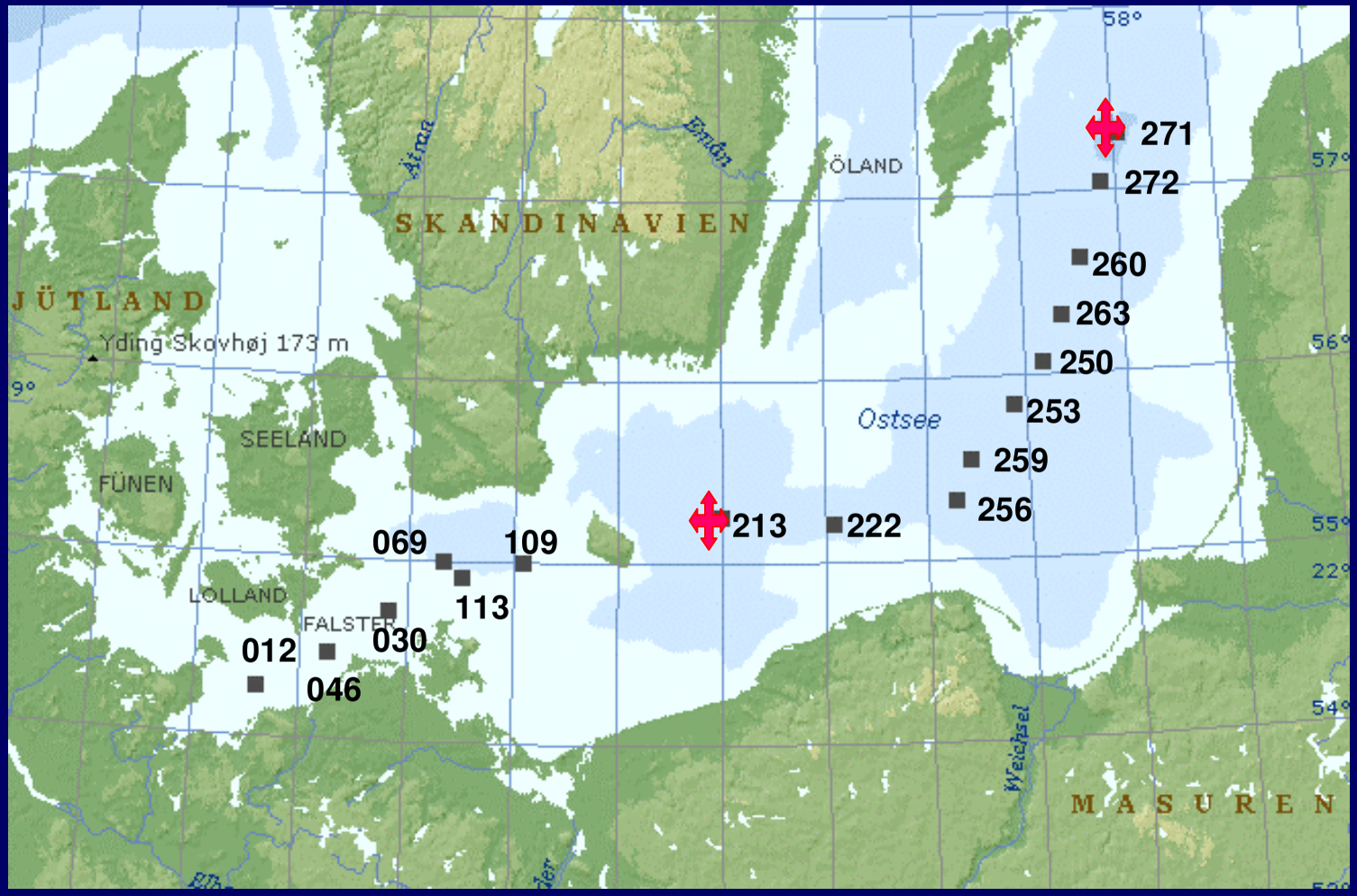
A possible key parameter for cyanobacteria blooms?



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10. Iron in the Baltic Sea
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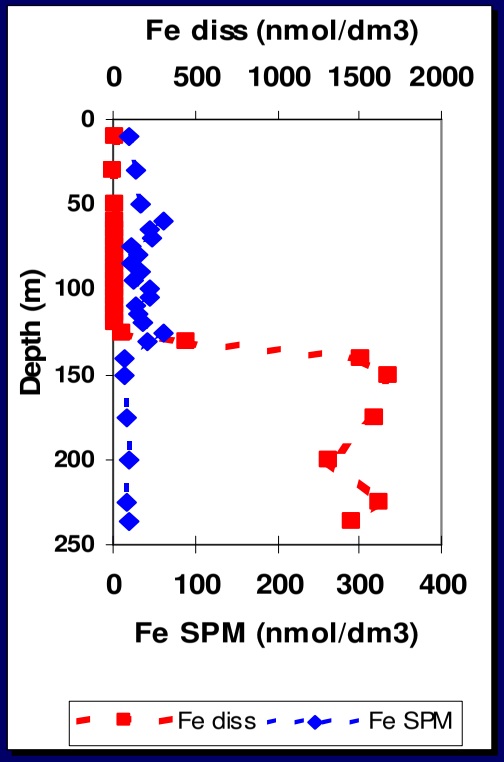
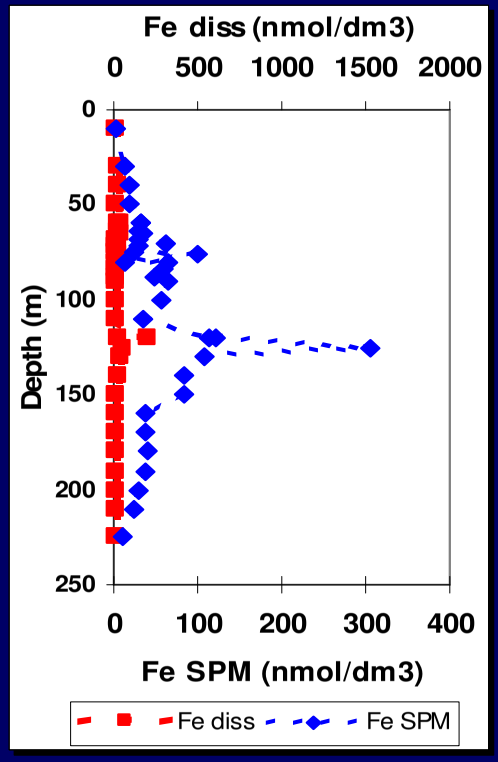
Geochemical characteristics of Fe in the Baltic:
Redoxsenitive : Reduction of Fe (III) to Fe (II) under anoxic conditions



Saltwater inflow event



Feb.2003 **Aug.2003**

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11. Iron in the Baltic Sea
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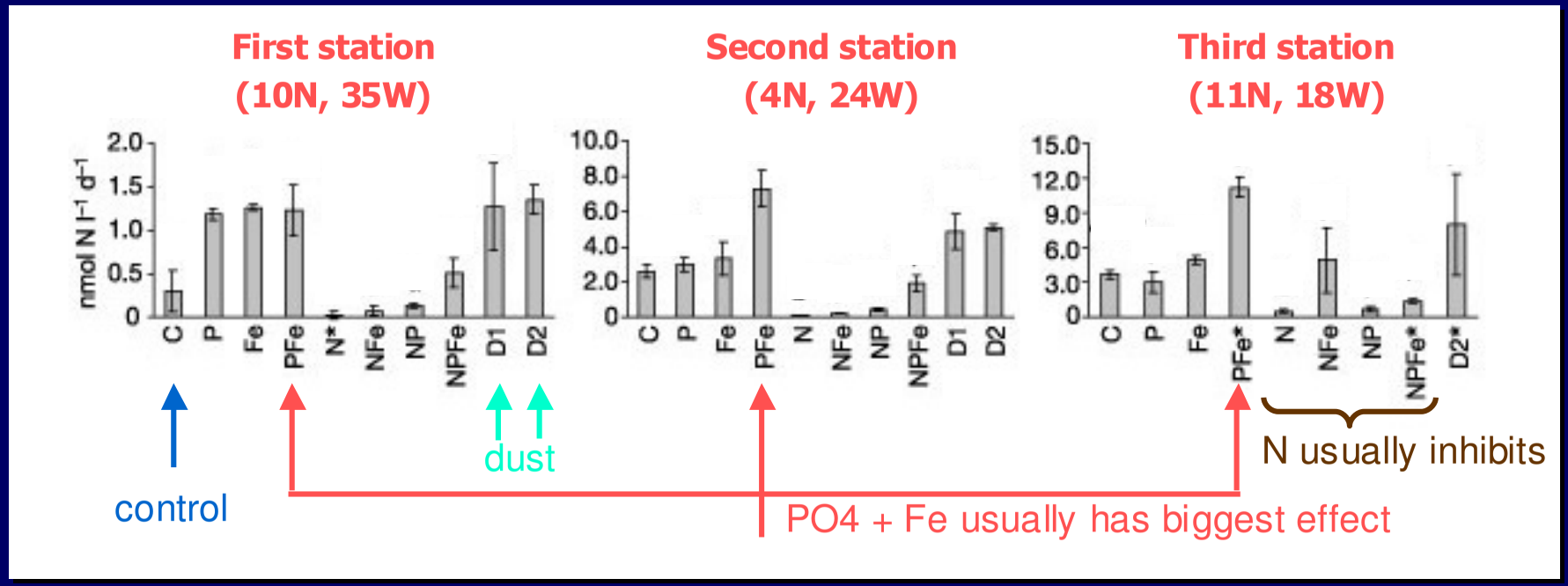
Addition of Fe / PO4 has the biggest effect on the nitrogen fixation rate



Effect of nutrient additions on N2-fixation rate during bioassay experiments. Measurements were taken at three sites in the tropical Atlantic during October–November 2002.

[Mills *et al* (2004) Iron and phosphorus co-limit nitrogen fixation in the eastern tropical North Atlantic *Nature*, 429:292-294]

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12. Iron in the Baltic Sea
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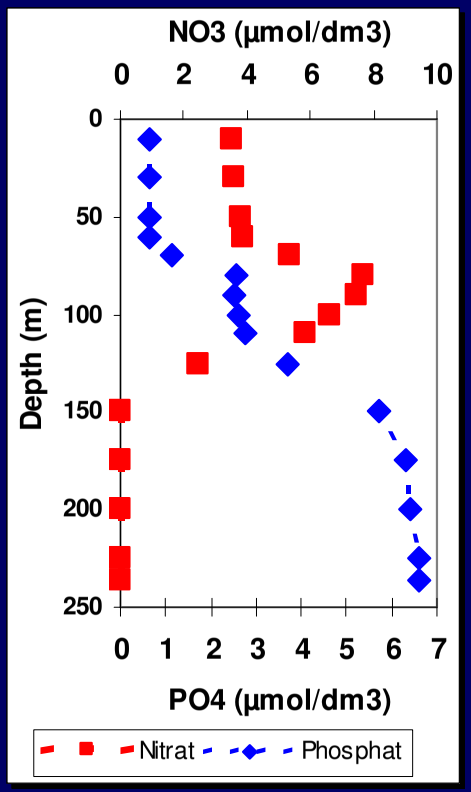
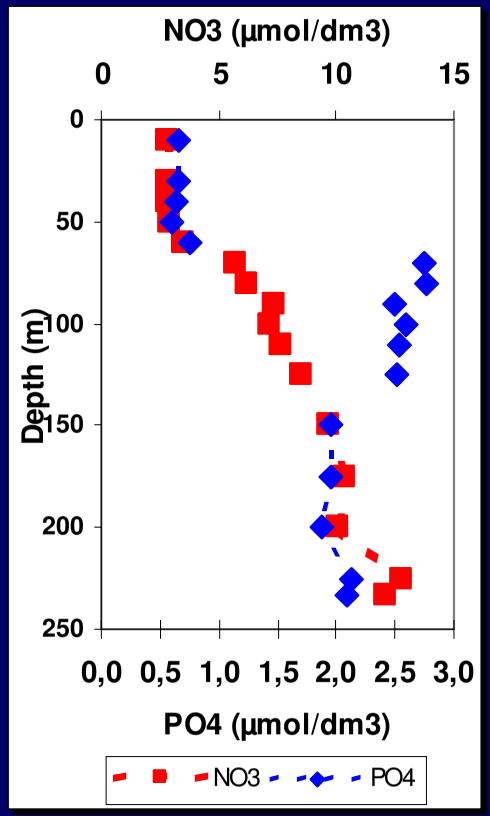
Vertical Phosphate and Nitrat distribution in the Gotland Deep



Feb.2003

Saltwater inflow event



Feb.2004

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13. Iron in the Baltic Sea
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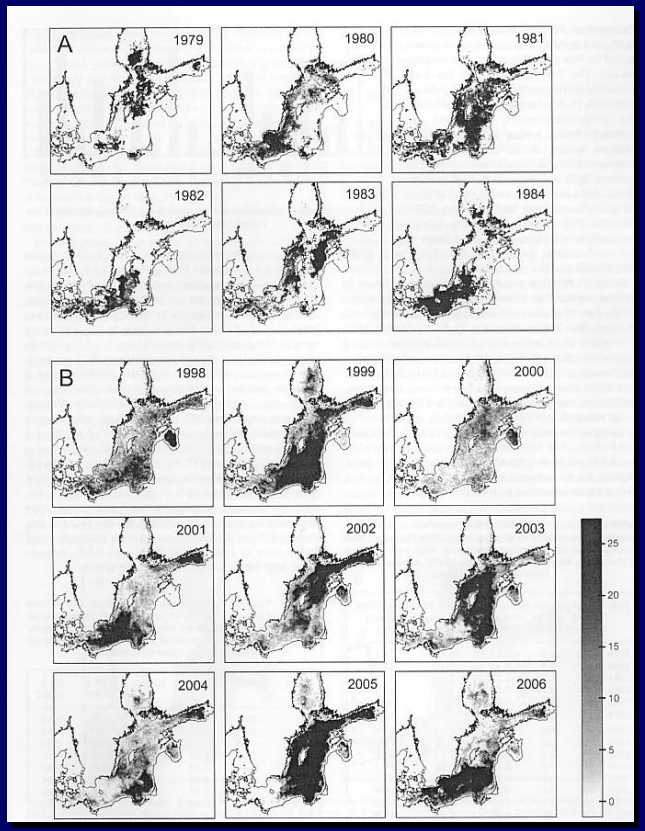
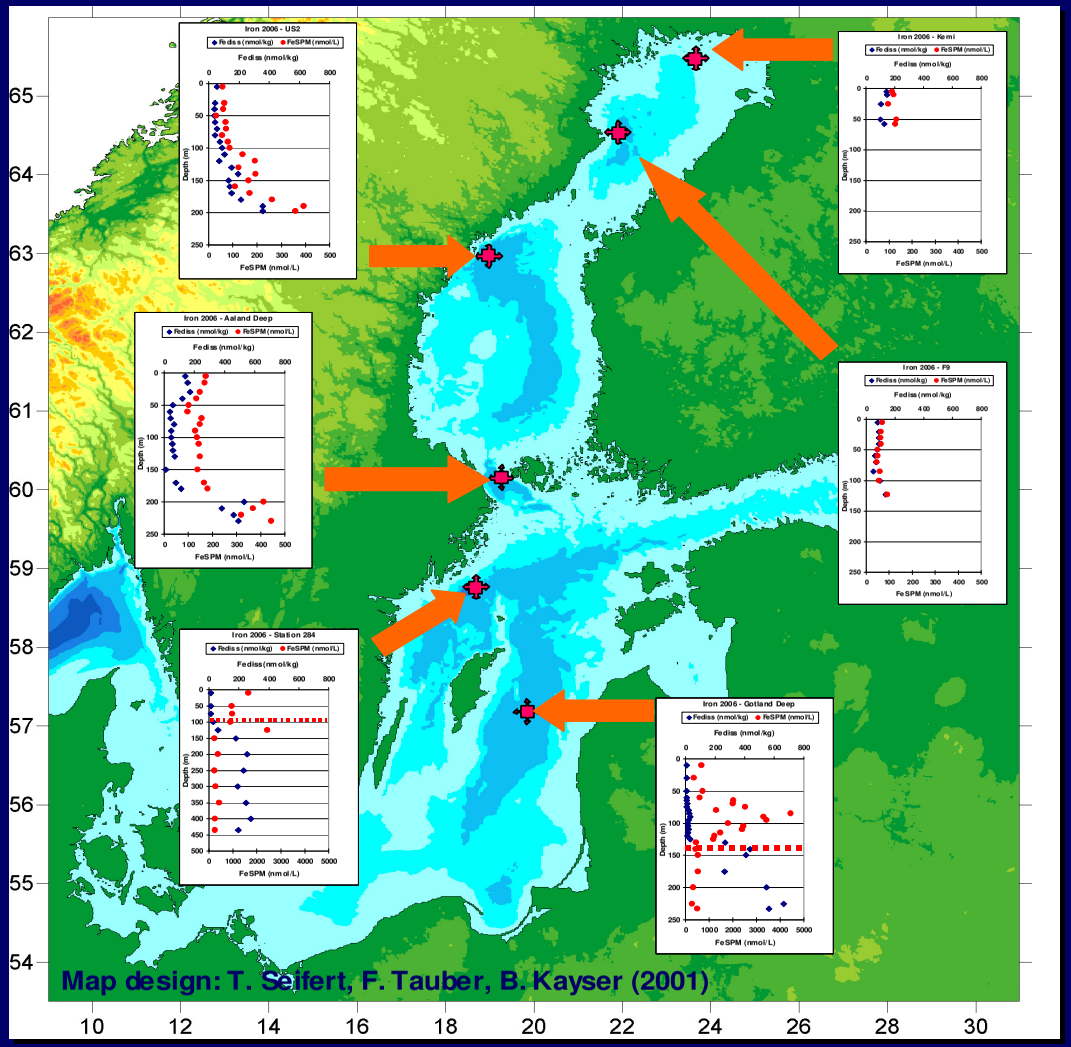
Vertical Fe-distribution in the Baltic Sea in 3/2006



Kahru et al. MEPS, 2007



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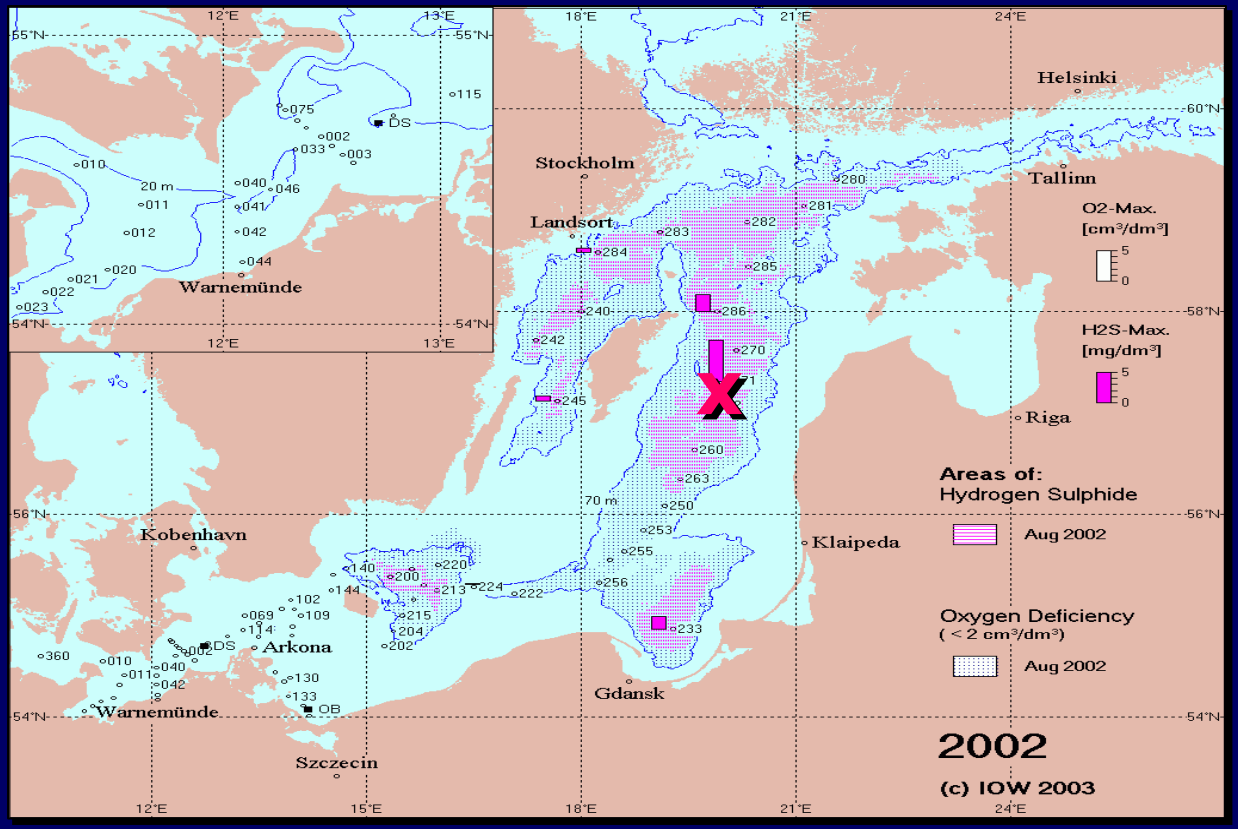
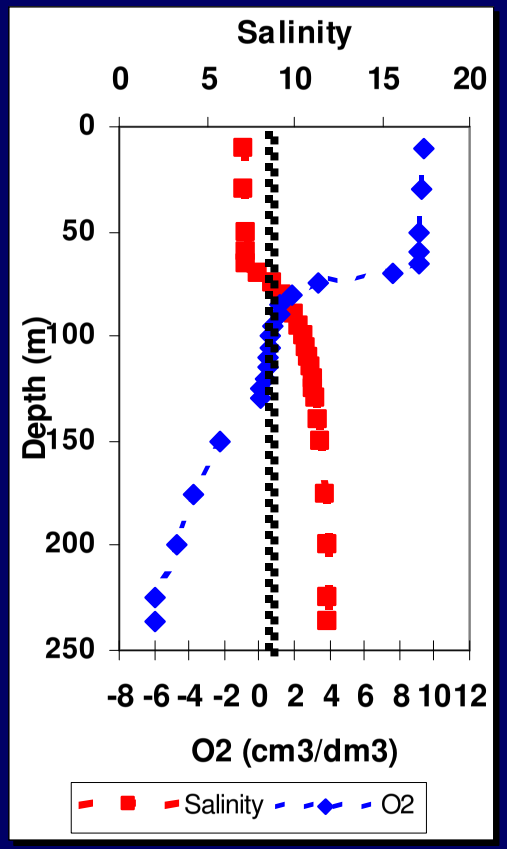
14. Iron in the Baltic Sea
A possible key parameter for cyanobacteria blooms?

Areas of Hydrogen Sulphide & Oxygen Deficiency; August 2002





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15. Iron in the Baltic Sea
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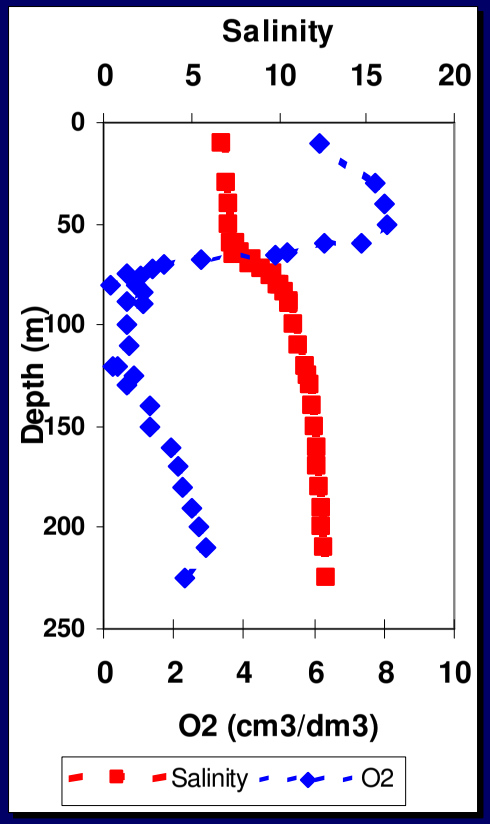
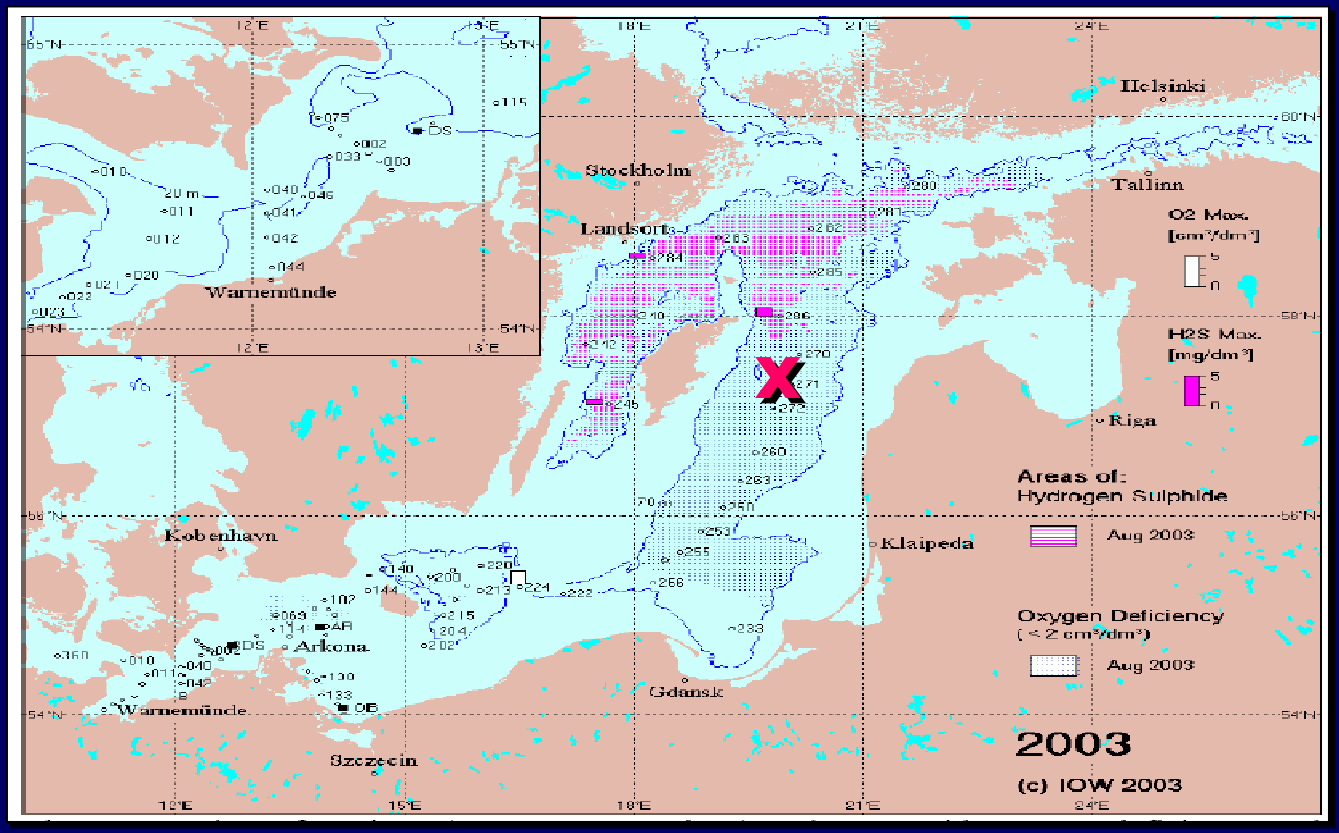
End of Stagnation Period which continued since 1995; August 2003





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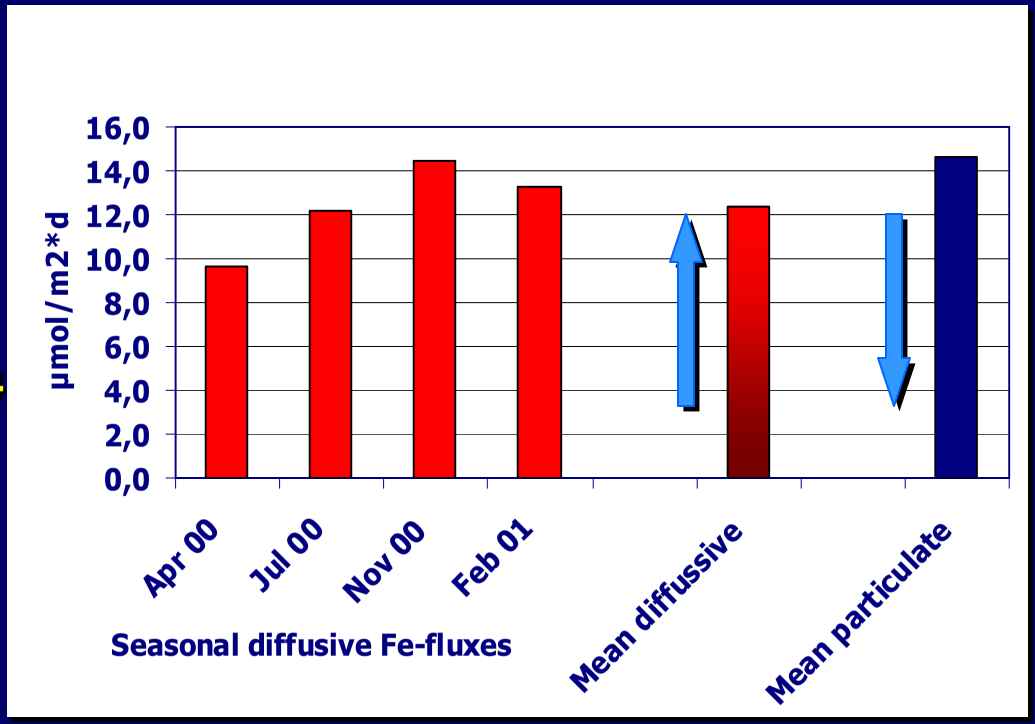
Quantification of mean vertical Fe fluxes across the redox-interface (Pohl & Hennings 2005)

Diffusive Fe (II) flux: F=Kz* (δc/δz)

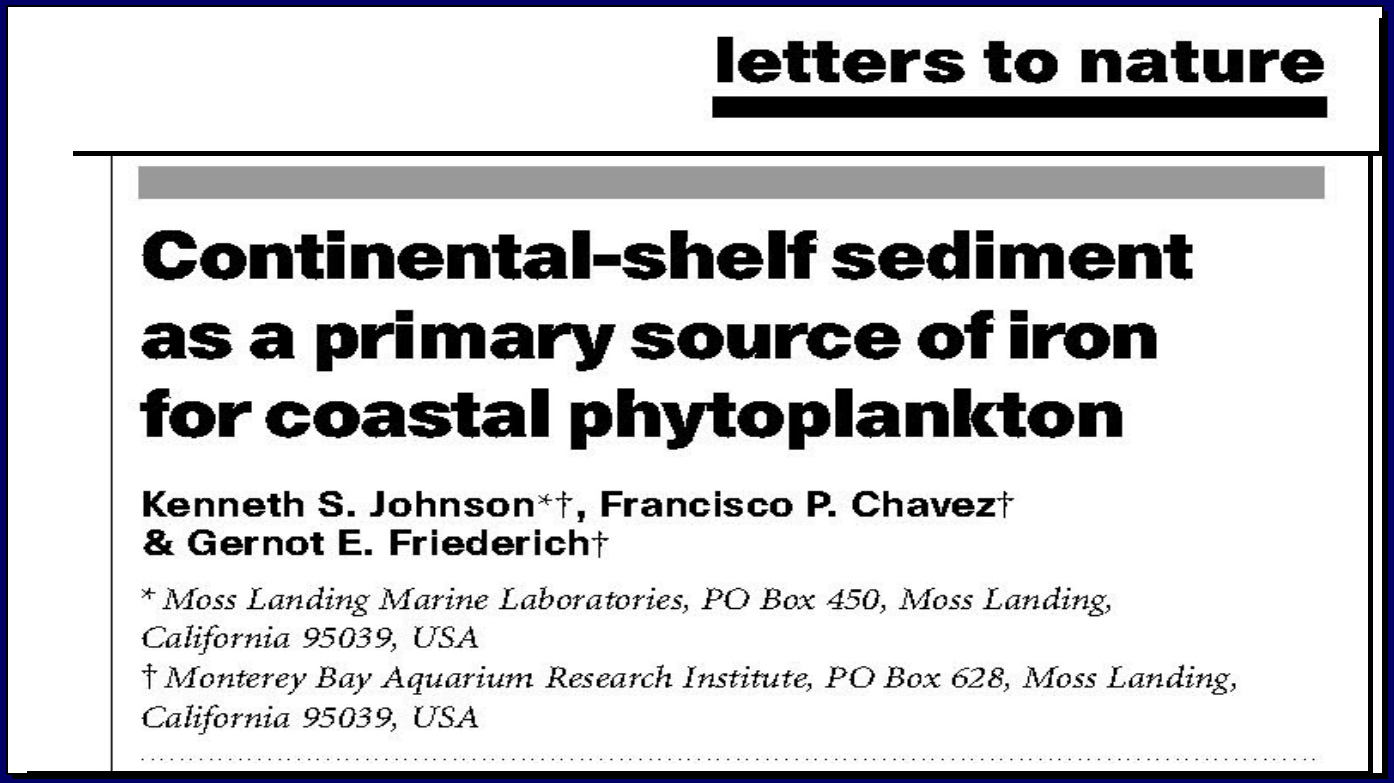
12.4 µmol/m2*d

Particulate Fe (III) flux: Pohl et al. 2004

14.6 µmol/m2*d



The Seafloor is a Source for Iron



letters to nature

Continental-shelf sediment as a primary source of iron for coastal phytoplankton

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18. Iron in the Baltic Sea
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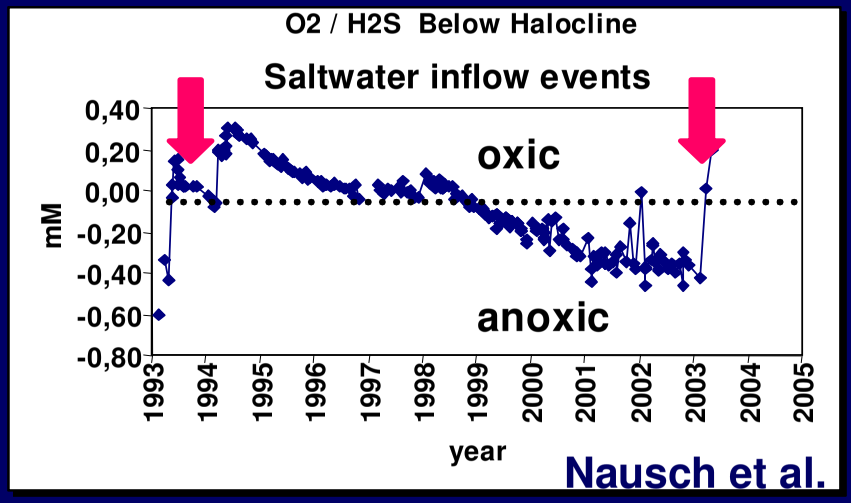
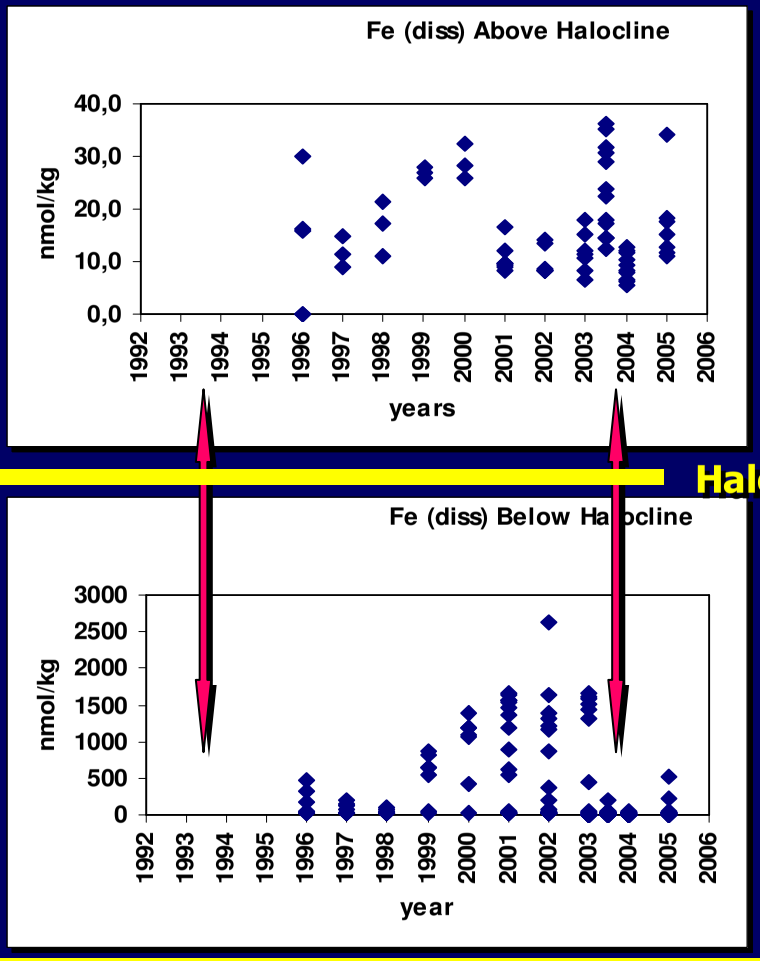
Dissolved Fe trends in surface and deep waters of the Gotland Deep





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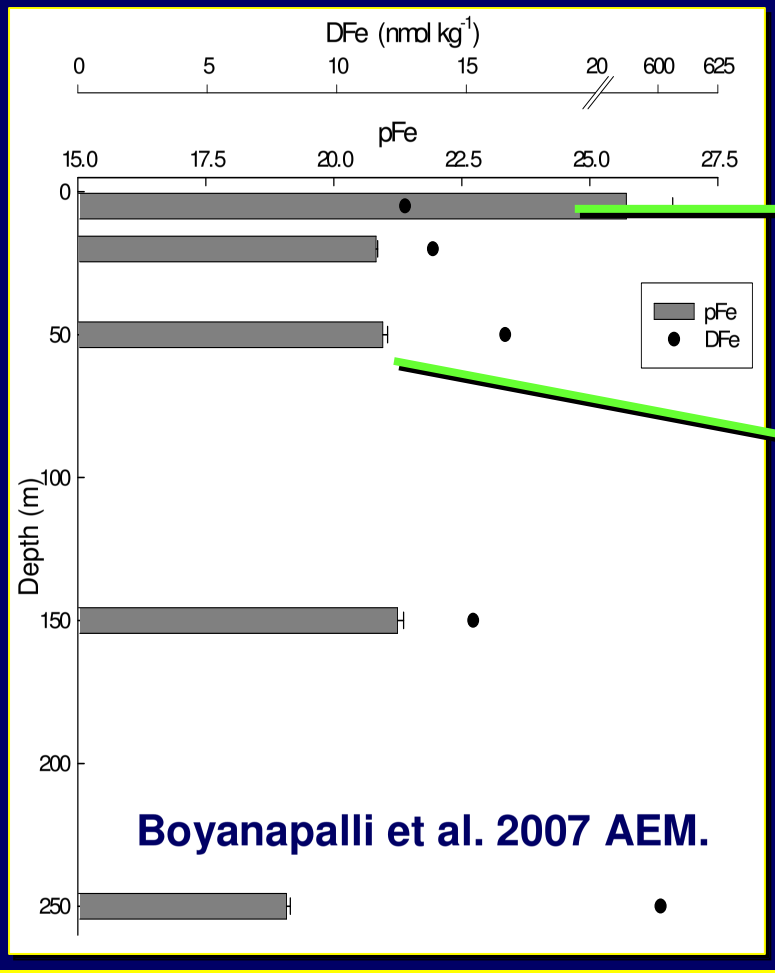
20. Iron in the Baltic Sea
A possible key parameter for cyanobacteria blooms?

Preliminary investigations of a bioreporter to assess bioavailable Fe in the Gotland Basin



July 2005

Lower Fe bioavailability

Higher Fe bioavailability relative to surface

DFe - Dissolved Fe

PFe – Bioluminescent response from Fe- bioreporter strain

Outlook:

What is the role of Fe in regulating cyanobacterial blooms in the Baltic?

What is the magnitude of the pool of bioavailable Fe at the surface?

How are cyanobacteria blooms influenced by Fe-speciation during stagnant anoxic conditions?

Does the transport of Fe(II) from anoxic waters contribute to the pool of bioavailable Fe at the surface?

Do cyanobacteria engage in a strategy of vertical migration to Access deep water pools of soluble Fe (Villareal & Carpenter, 2003)?

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Greetings from Warnemünde

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