Effect of Fe-Mn co-limitation on phytoplankton communities composition of natural assemblages across the Drake Passage.

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Context of study

- The Southern Ocean is a High Nutrient Low Chlorophyll (HNLC) region
  → Trace metals and especially **Iron (Fe)** availability are the key control for community composition and biomass (Martin *et al.,* 1990 ; Boyd *et al.,* 2007 ; Sunda, 2012)
- Co-limitation of **Fe** with **manganese (Mn)** in the Drake Passage was suggested early in1990 (Martin *et al.,* 1990)
- Indirect observations on the **species composition** observed in low-Mn environment :
  - Subartic Pacific (Coale, 1991)
  - Southern Ocean : Drake Passage, Scotia and Weddell Sea (Martin *et al.,* 1990 ; Buma *et al.,* 1991 ; Middag *et al.,* 2011; Middag *et al.,* 2013 ; Browning *et al.,* 2014)
- Only supply of Fe and Mn together led to optimal growth, photochemical efficiency and carbon production of the Antarctic diatom *Chaetoceros debilis* (Pausch *et al.,* 2019)

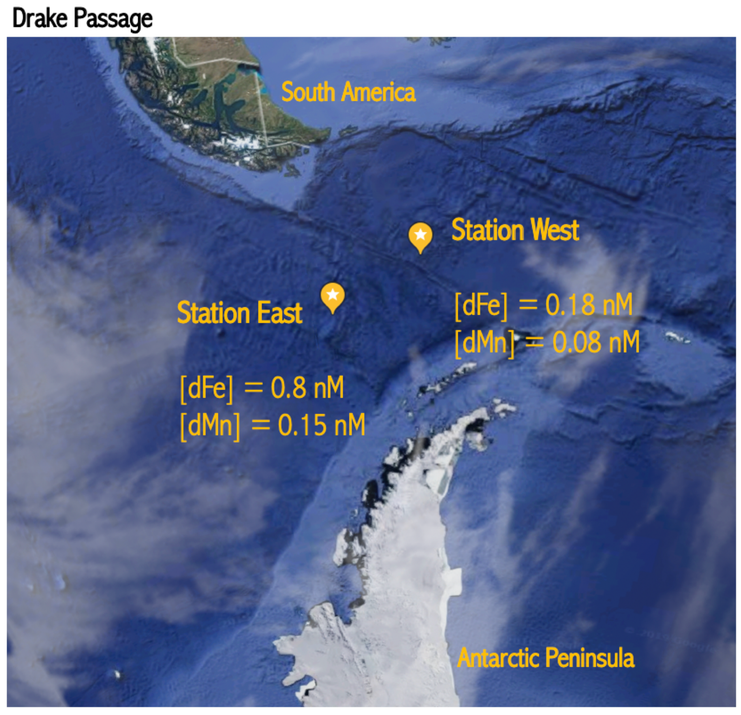
Can Mn act as a limiting factor with Fe ?

Experiment design

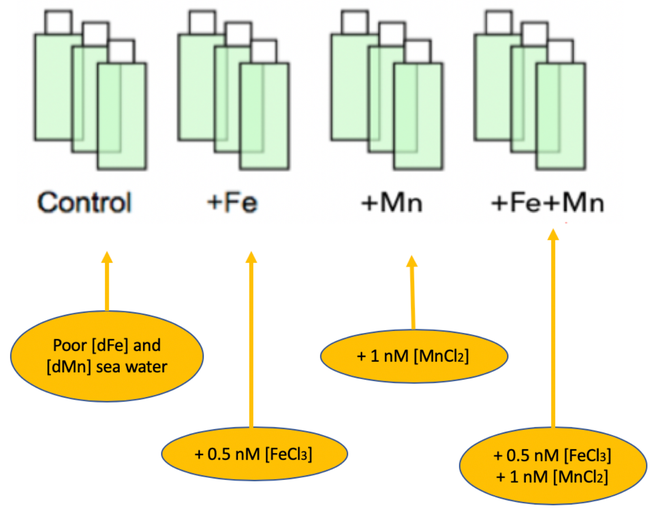
2 indoor trace metals addition experiments conducted for 14 days during Polarstern 97 Expedition in 2016

Goal - Identify Fe-Mn co-limitation and assess phytoplankton sensitivity towards altered trace metal concentrations

Drake Passage



Light = 100 µmol photons m^{-2} s^{-1}
Light:dark cycle of 16:8 h
Temperature = 2 °C



As expected for HNLC region -> High macronutrients concentration
[N] > 23 µmol.L^{-1} // [P] > 1,5 µmol.L^{-1} // [Si] > 16 µmol.L^{-1}

Results

The dark-adapted maximum PSII quantum yield Fv/Fm

Chlorophyll *a* (Chl*a*)

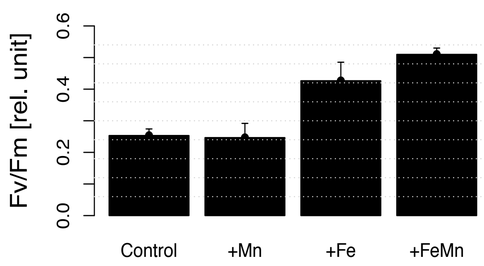
Size fraction response

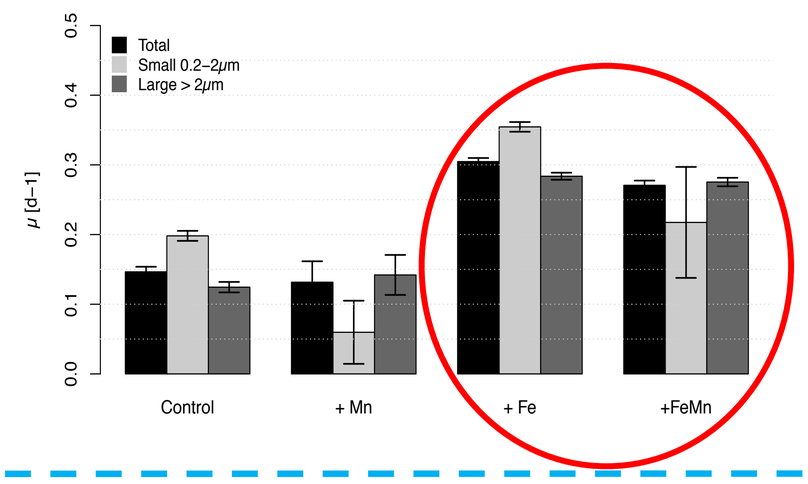
Flow cytometry determination

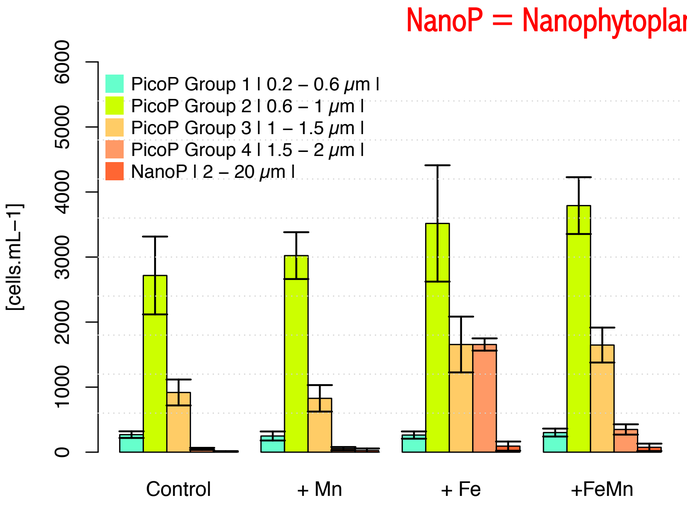
* PicoP = Picophytoplankton
NanoP = Nanophytoplankton

Station East

Day 1 of the experiment
Fv/Fm = 0.26 [rel.unit]
Chl*a* = 0.04 [ug.L^{-1}]

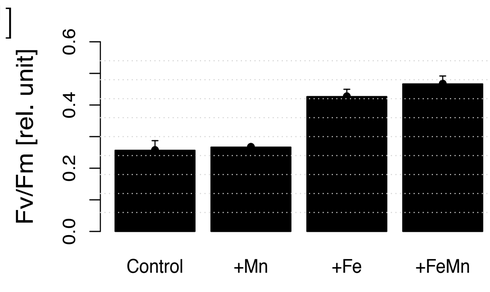


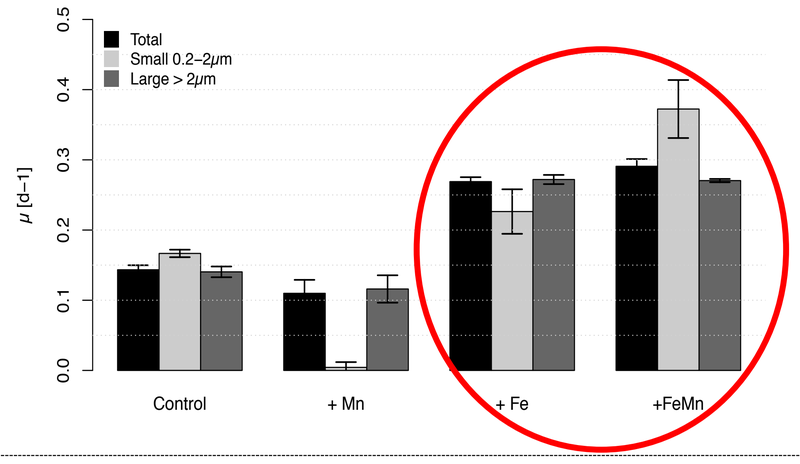


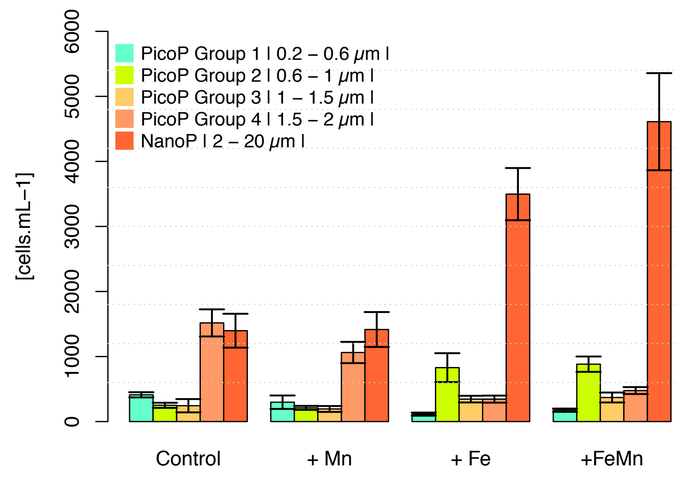


Station West

Day 1 of the experiment
Fv/Fm = 0.18 [rel.unit]
Chl*a* = 0.09 [ug.L^{-1}]







Ecological implications

- **Initial concentrations** of the trace elements Fe and Mn shape the response of the community
- **Observe changes are not only explained by Fe** → Addition of both trace elements together promotes a shift in the species composition and biomass build up
- **Maximum photosynthetic efficiency** reached only when Fe and Mn were added together
- **To go further** → Species identified in field aims to do more experiments under altered trace metal concentrations for a better understanding of the requirements and adaptations of the cells

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