The seasonal photophysiological responses of Atlantic Southern Ocean phytoplankton to iron addition

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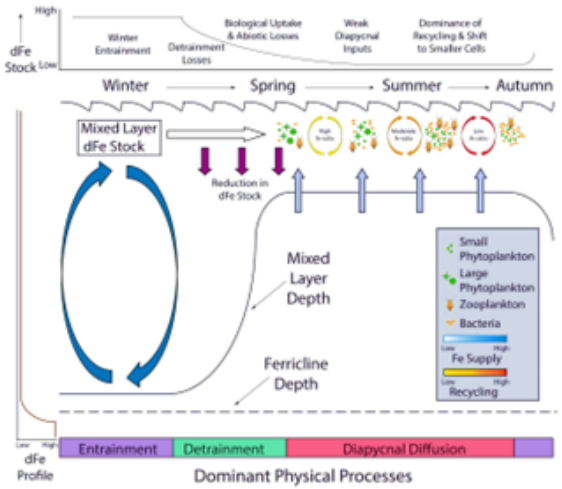
Introduction

- The **Southern Ocean** is **seasonally** limited by **light and iron**
- **Winter:** Low light and low chlorophyll; Entrainment results in a seasonal resupply of nutrients
- **Spring/summer:** Iron is depleted following the spring/summer bloom due to biological uptake; Shoaling of the mixed layer depth takes place due to light availability
- **Autumn:** Bloom declines; Nutrients are depleted
- **Sub-seasonal resupply mechanisms** exist, such as storm-driven entrainment and remineralization
- **Iron also varies regionally** as it is dependent on sources and supply mechanisms



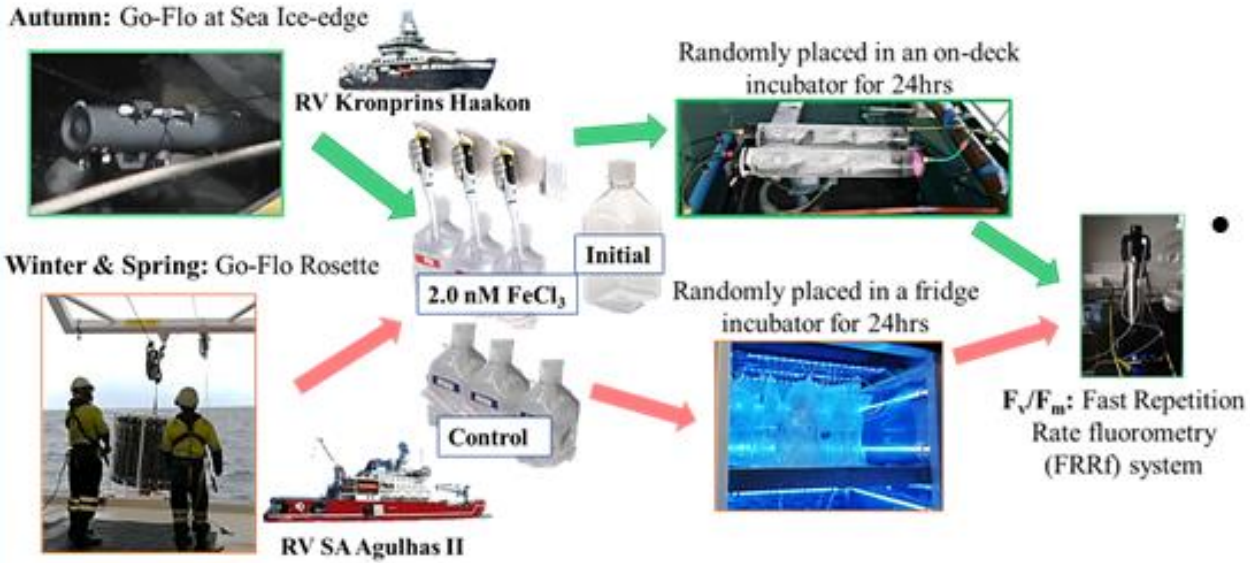
Tagliabue et al., (2014)

Active chlorophyll-a fluorescence:

- provides a rapid assessment of phytoplankton physiology in response to variable environmental conditions
- Measures the response in physiology to manipulated drivers through incubations experiments
- F_v/F_m = Photosynthetic Efficiency

Methods

Short-term (24hr) Trace Metal Clean Incubations



- **Long-term (>24hr) incubations:** Difficult to disentangle between the physiological response of phytoplankton to a driver and the community-driven change as different communities having different baseline F_v/F_m (Suggett et al. 2009)
- **Short-term (24hr) incubations:** rule out community-driven changes
  - Incubations were conducted using surface (~25-30 m depth) Trace Metal clean seawater
  - Triplicate Fe-spiked and Control samples were incubated and assessed for changes in F_v/F_m

Results

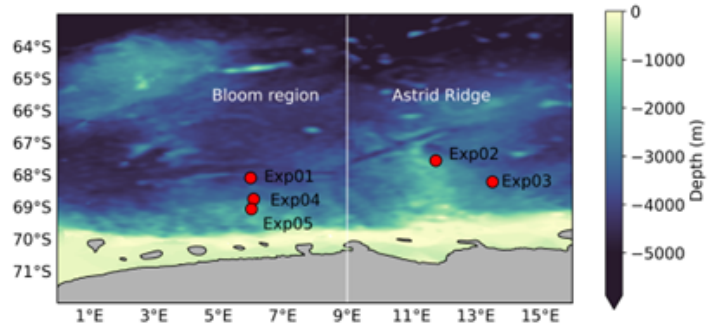


Figure 1. Autumn stations in Kong Håkon VII Hav (Sea)

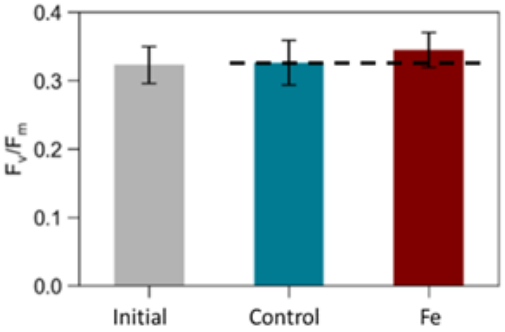


Figure 2. Significant differences in F_v/F_m

Incubations conducted in the Dronning Maud Land sea-ice edge:

- Declining autumn bloom region (Kauko et al., 2021)
- Astrid Ridge region which has shallow topography
- No significant differences ($p>0.05$) between Fe and Control for all stations

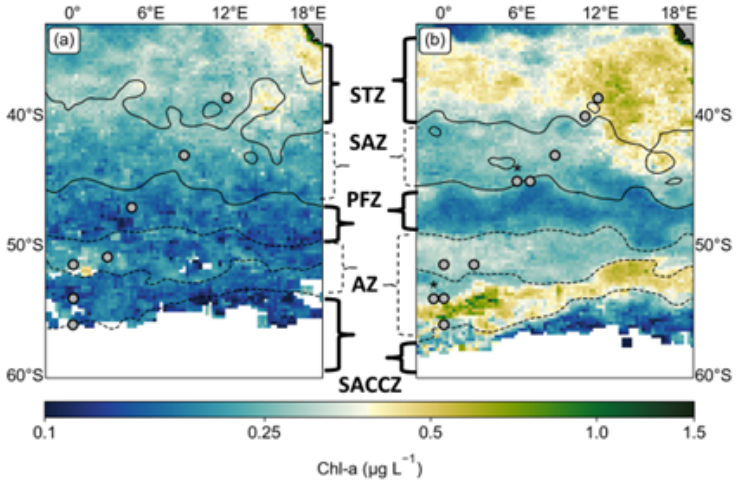


Figure 3. (a) Winter and **(b) Spring** stations in the Atlantic Southern Ocean

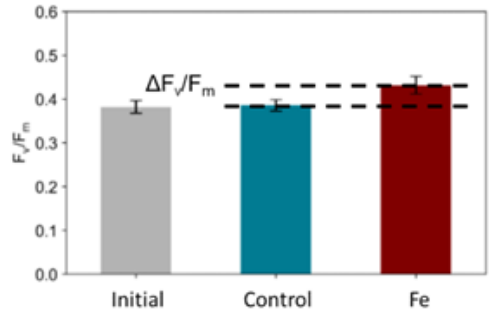


Figure 4. Significant differences in F_v/F_m

STZ = Sub-Tropical Zone; **SAZ** = Sub-Antarctic Zone; **PFZ** = Polar Frontal Zone; **AZ** = Antarctic Zone and **SACCZ** = Sub-Antarctic Circumpolar Current Zone

Incubations conducted across the different zones in the Atlantic Southern Ocean over winter and spring:

- Spring reoccupation resulted in intra-seasonal differences (~1 month apart)
- $\Delta F_v/F_m$ was significant ($p<0.05$) between Fe and Control for some stations in accordance with changes seen in the mixed layer depth

Conclusions

- **Lack of significant differences** between F_v/F_m for Fe and Control suggest that phytoplankton are **not iron-limited in autumn** in the **Antarctic Sea-Ice Zone**
  - This is because there is likely **sufficient iron** to meet the cellular iron requirements
- **Significant differences** seen between F_v/F_m for Fe and Control **in winter and spring** suggests
  - **Variable seasonal responses of iron limitation**
  - Linked to the **seasonal cycle of the mixed layer depth**
  - Plays a role in **driving winter and spring iron stress** in the **Atlantic Southern Ocean**

References

[1] Tagliabue et al., *Nature Geoscience*, 7(4): 314-320 (2014).
[2] Suggett et al., *Marine Ecology Prog. Ser.* 376:1-19, 2009.
[3] Kauko et al., *Frontiers in Mar. Sci.*, 8:623856 (2021).

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