Physical and biogeochemical conditions during a summer bloom in the Ross Sea

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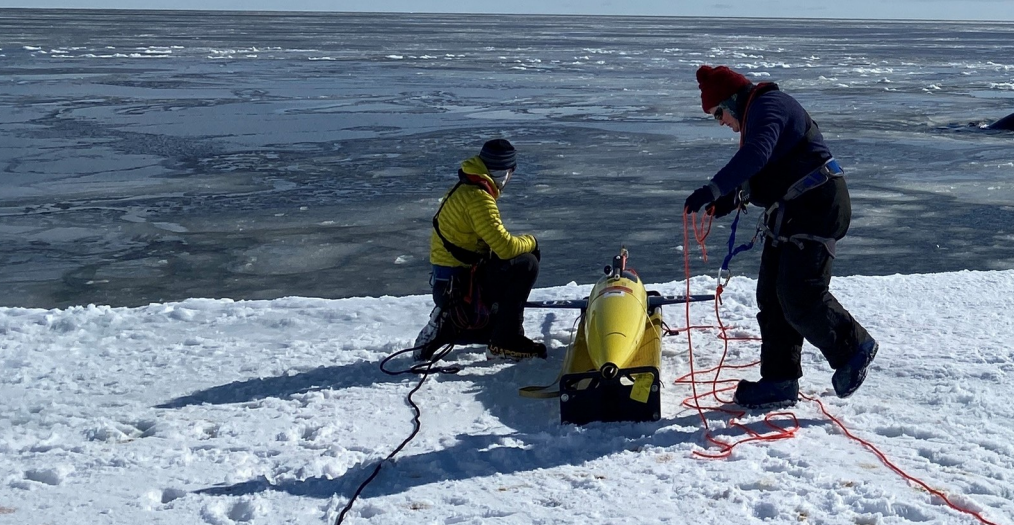

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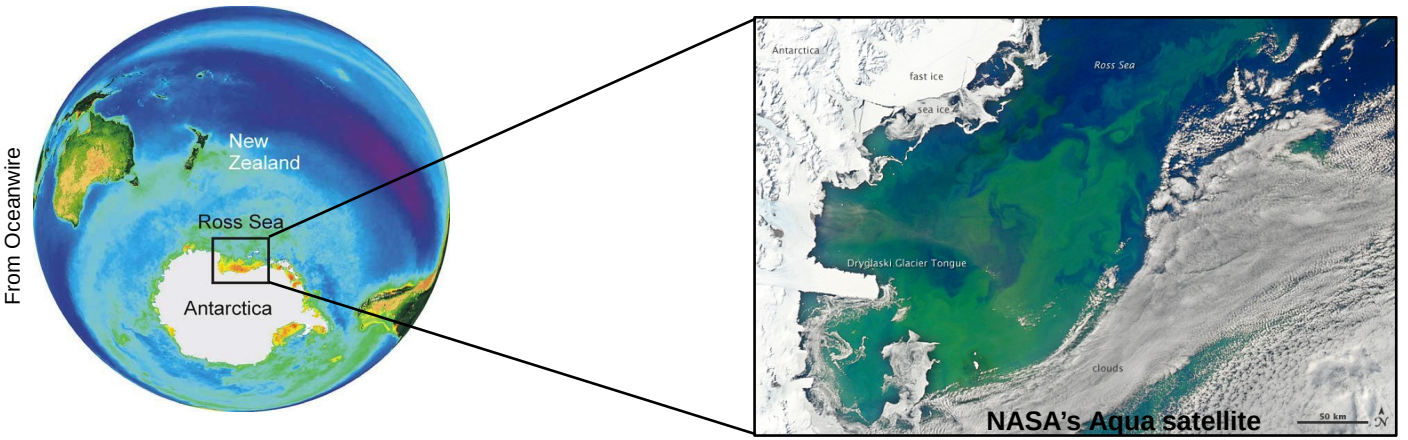
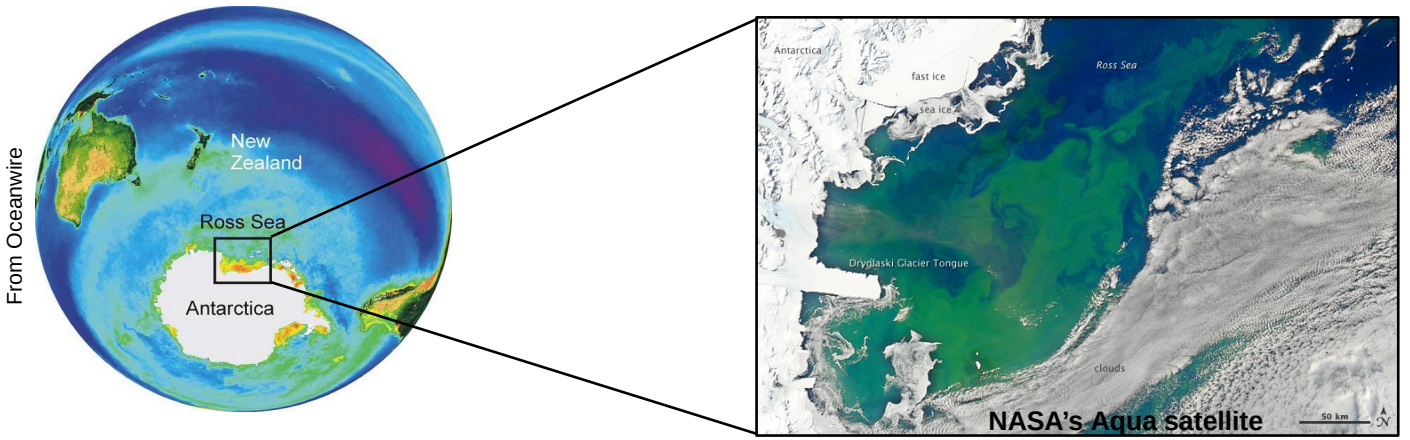
Introduction:



- The Ross Sea is the most productive region in the Southern Ocean, leading to large phytoplankton blooms.
- It supports substantial stocks of higher trophic levels.
- It accounts for up to 27% of the Southern Ocean biological CO_2 uptake.

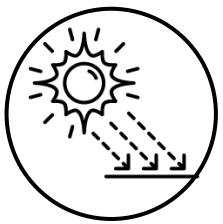
Introduction:



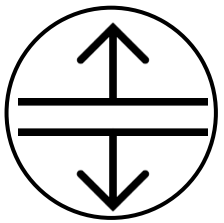
- Phytoplankton growth varies spatially and temporally in the Ross Sea as a function of:

Sea-ice concentration

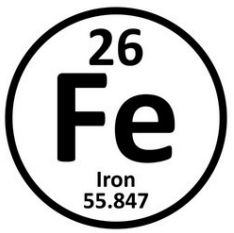
Solar irradiance



Vertical mixing depths

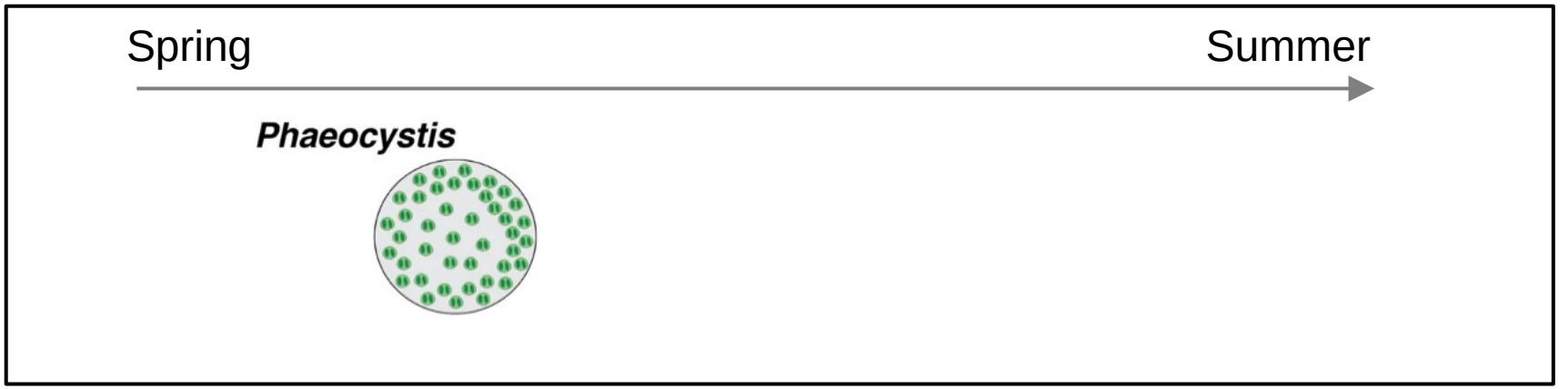


Iron concentrations



Introduction:

- As the sea ice retreats, solar irradiance increases, and phytoplankton growth accelerates



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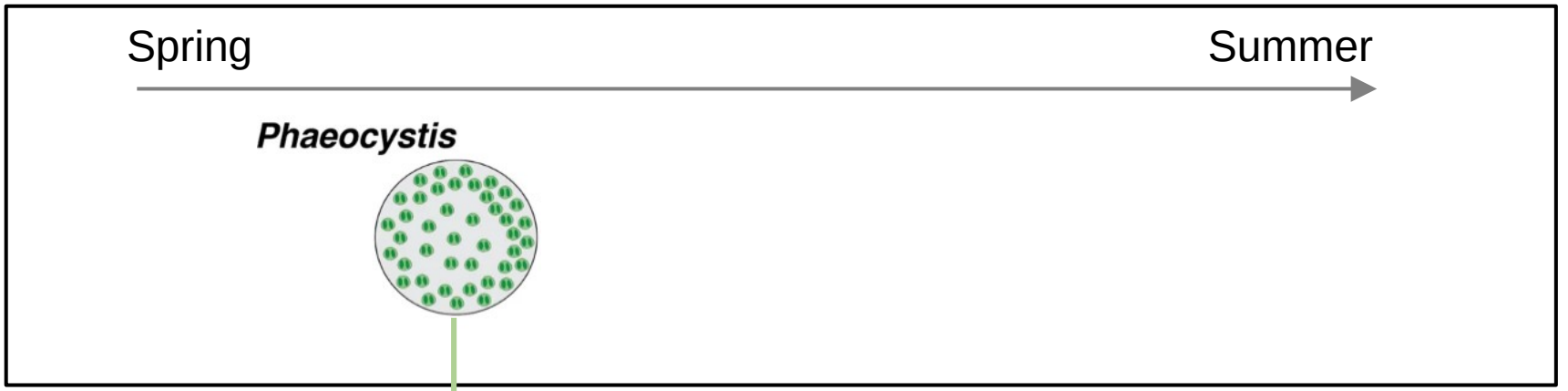


- Deep mixed layers
- High iron requirement
- Grow in low light environments

Introduction:

- As the sea ice retreats, solar irradiance increases, and phytoplankton growth accelerates

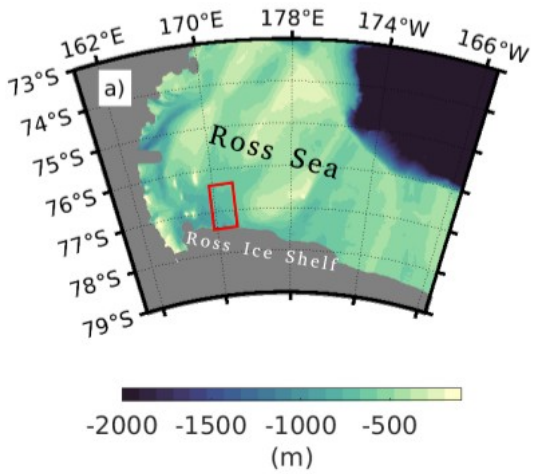
- Deep mixed layers
- High iron requirement
- Grow in low light environments

- Stratified waters
- Low iron requirement

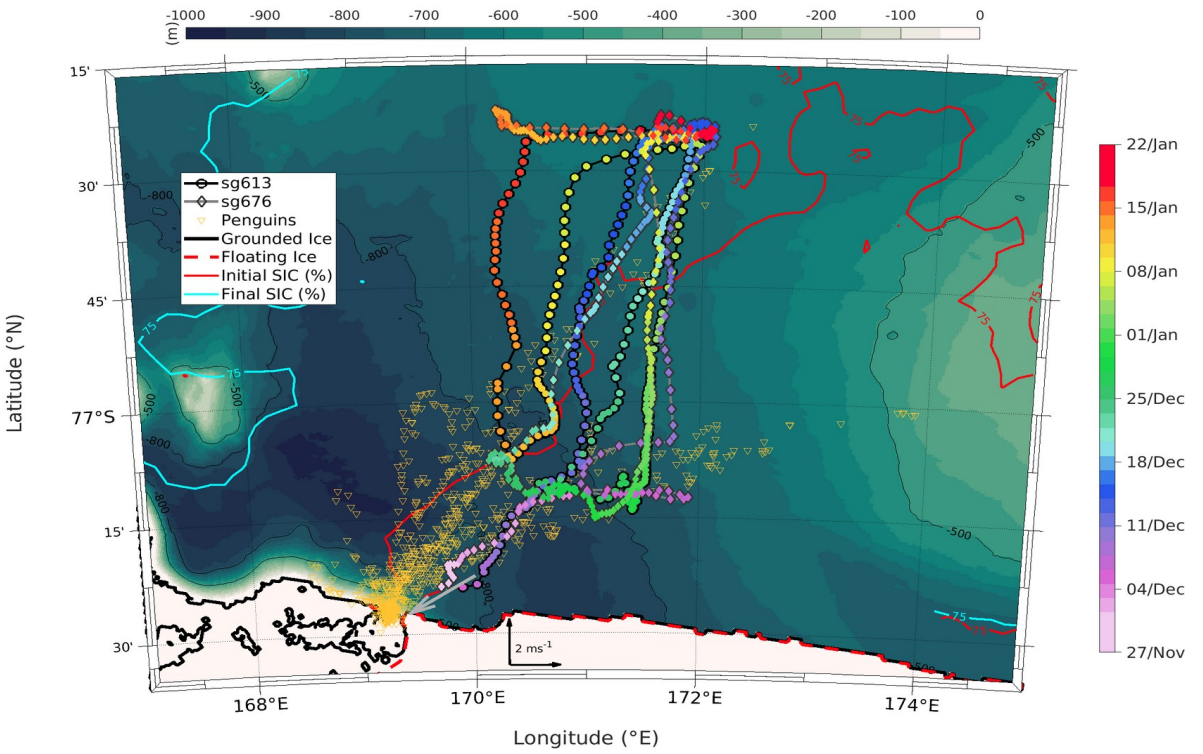
The combined effect of the controls on phytoplankton growth and composition is still unclear.

Plankton to predators (P2P) project:

"Assessing the food web structure in the southwestern Ross Sea"



27th November 2022 – 18th January 2023



<u>Two multi-sensor Seagliders</u>

- CTD
- Fluorescence
- Backscatter
- Oxygen
- PAR
- Active and passive acoustics

<u>Tagged Adélie penguins</u>
(Cape Crozier colony)

Spatial patterns

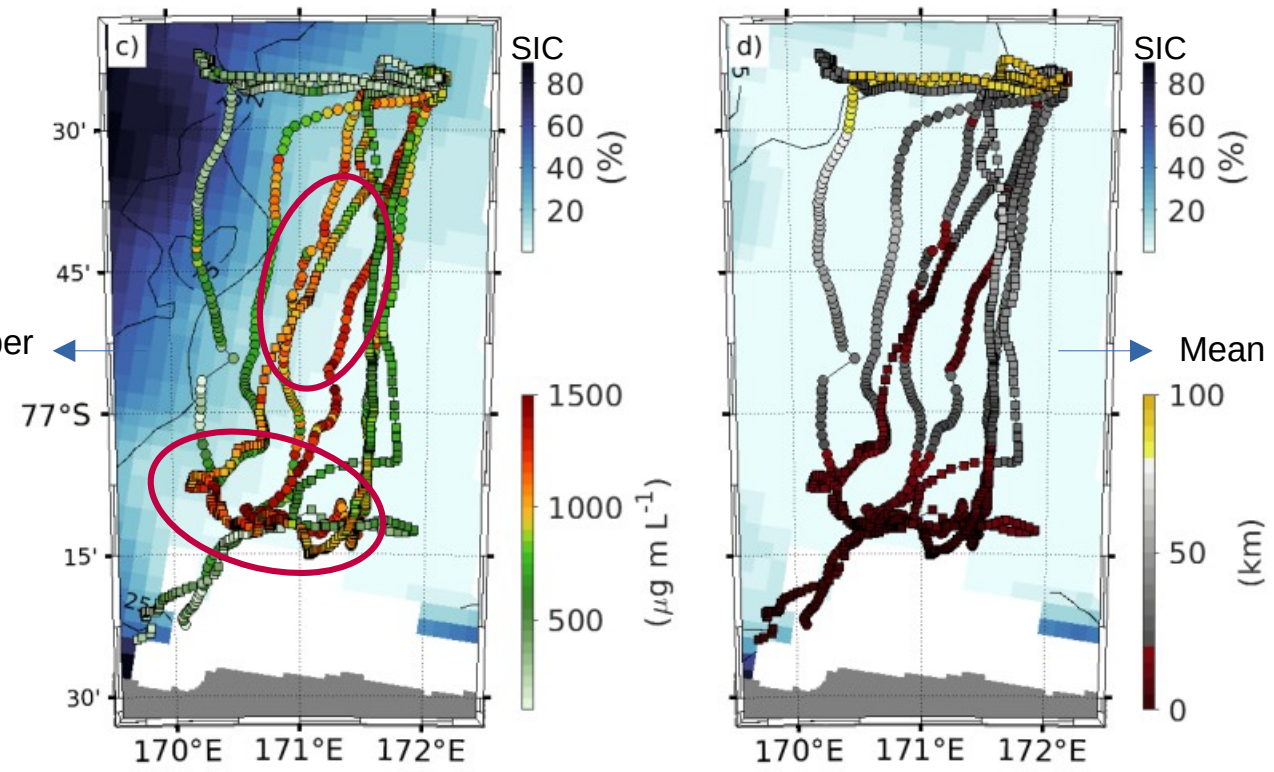
- Significant ice cover during our observations, gliders transited near sea-ice patches
- Both gliders measured similar fluorescence.
- The integrated Chl-a does not follow a spatial pattern

Integrated 50m-depth Chl-a

Distance to the 25% SIC contour

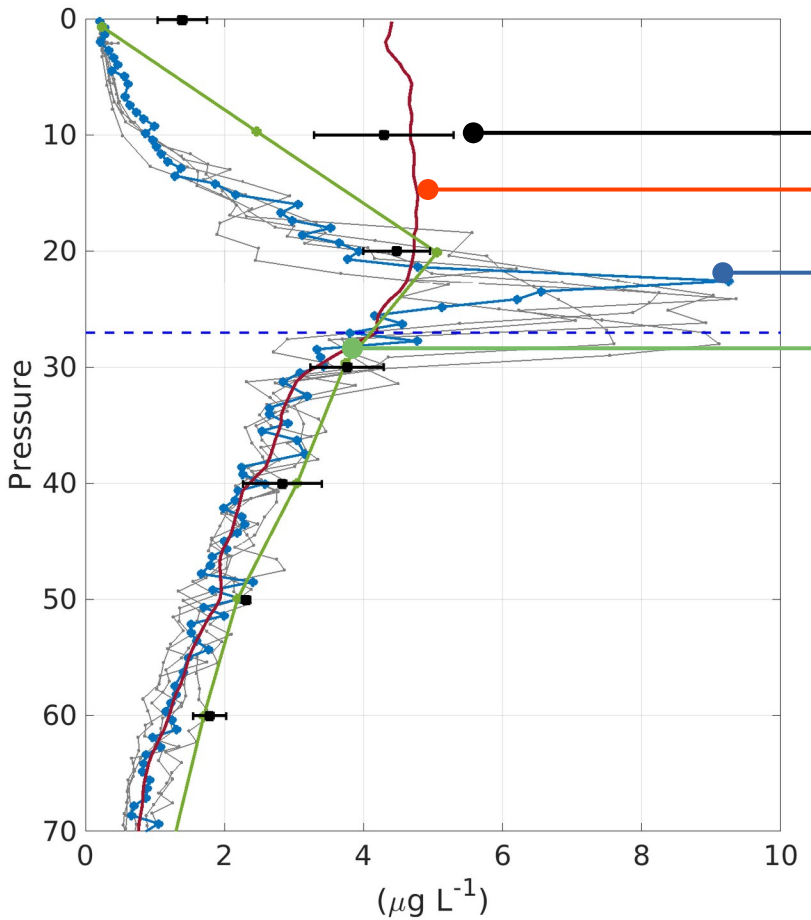
Mean SIC in December

Mean SIC in January



Methods: Calibration, validation and correction

- Calibration cast with CTD and bottle samples upon glider recovery
- Correction for Non-Photochemical Quenching (NPQ)



Extracted Chl-a

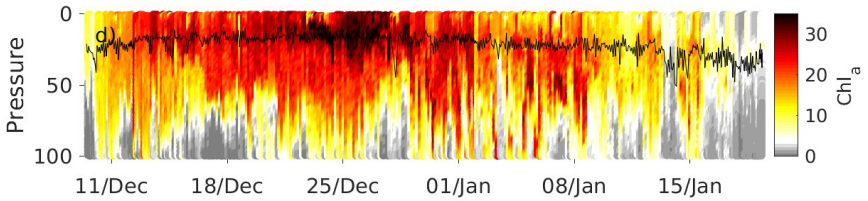
NPQ-corrected and smoothed fluorescence

Uncorrected glider fluorescence

Ship-measured fluorescence

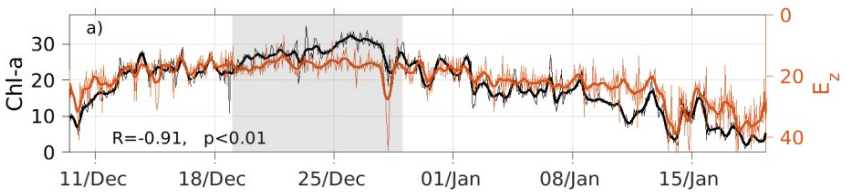
Fluorescence:Chl-a ~1:1

Physical and biogeochemical conditions



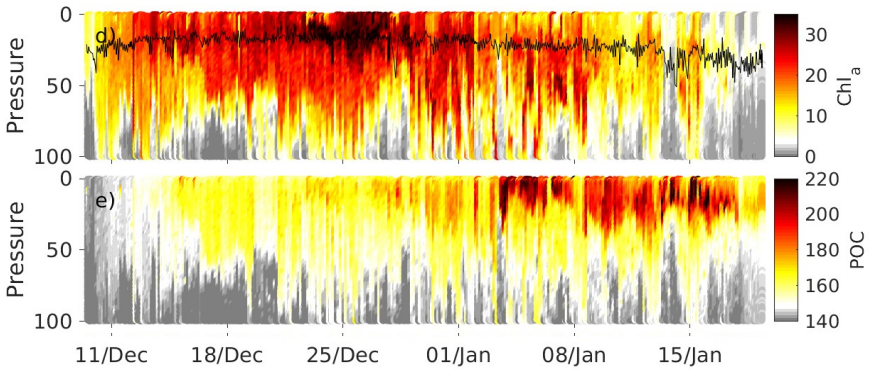
- Intense and sustained phytoplankton bloom over more than one month.

Mean euphotic-depth Chl-a and Euphotic depth



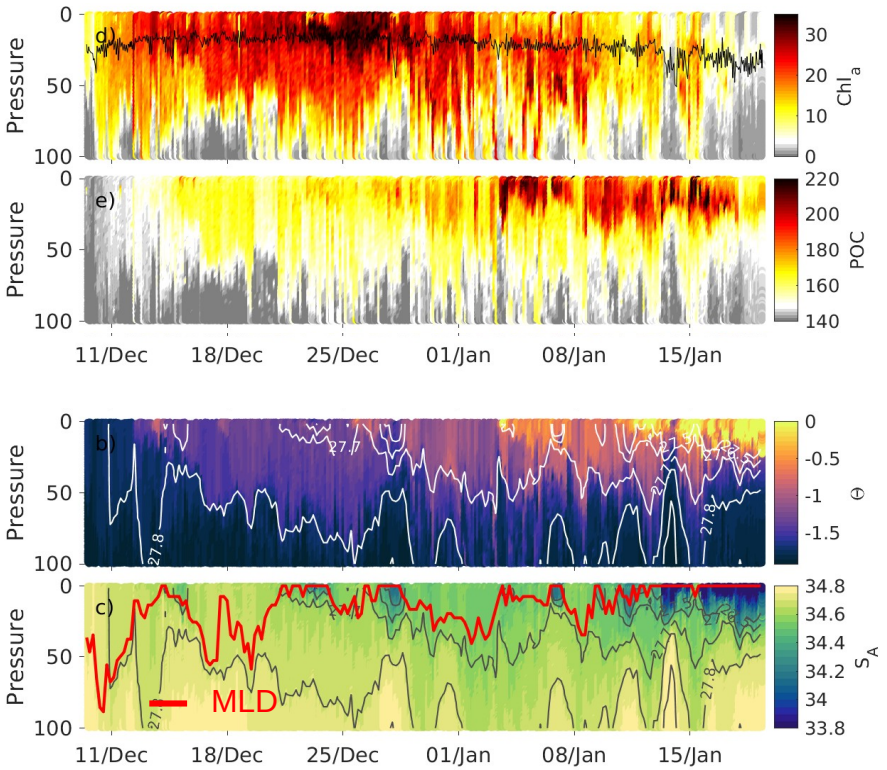
- Mean Chl_a within the euphotic zone = 20.3±8.5 µg L^{-1}
  - Historical regional mean ~ 1-6 µg L^{-1}
  - Historical regional maxima ~ 15 µg L^{-1}

Physical and biogeochemical conditions



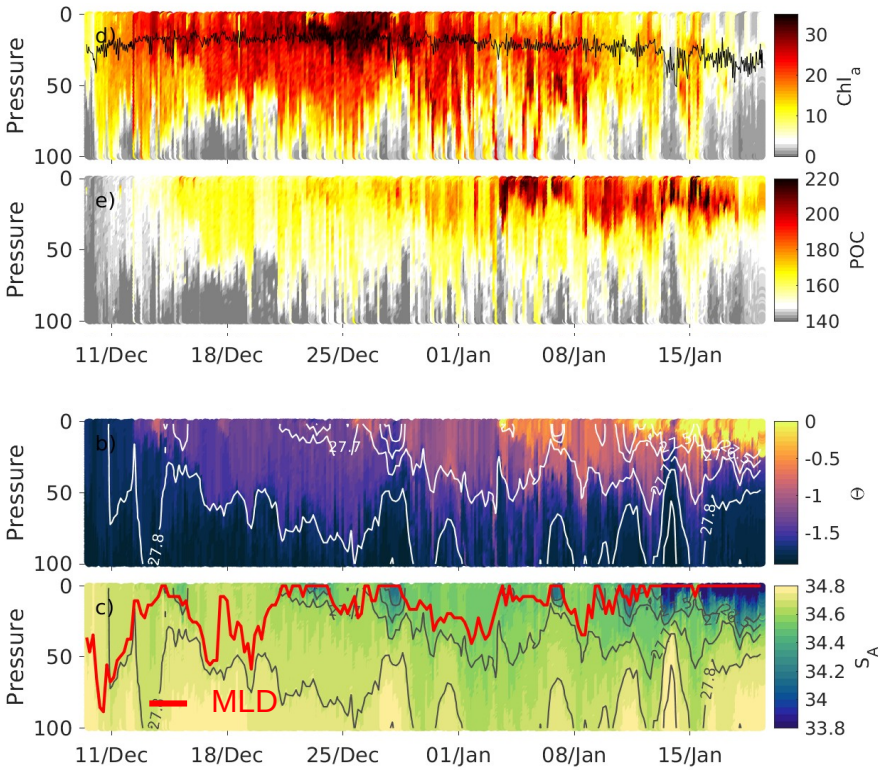
- Intense and sustained phytoplankton bloom over more than one month.
- Relatively low POC

Physical and biogeochemical conditions



- Intense and sustained phytoplankton bloom over more than one month.
- Relatively low POC
- Progressive seasonal warming and freshening due to solar warming and sea-ice melt.
- Presence of mesoscale features that alter the vertical structure of the water column.

Physical and biogeochemical conditions



- Intense and sustained phytoplankton bloom over more than one month.
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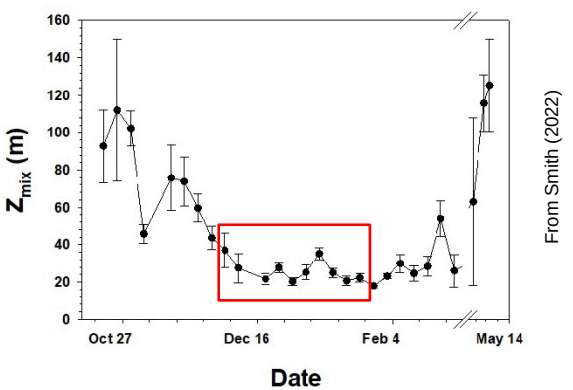
- Progressive seasonal warming and freshening due to solar warming and sea-ice melt.
- Presence of mesoscale features that alter the vertical structure of the water column.

- Mixed layer mostly oscillated between 10 and 50 m depth (typical regional depth)
- But mean MLD in 2022-2023 is 15 m



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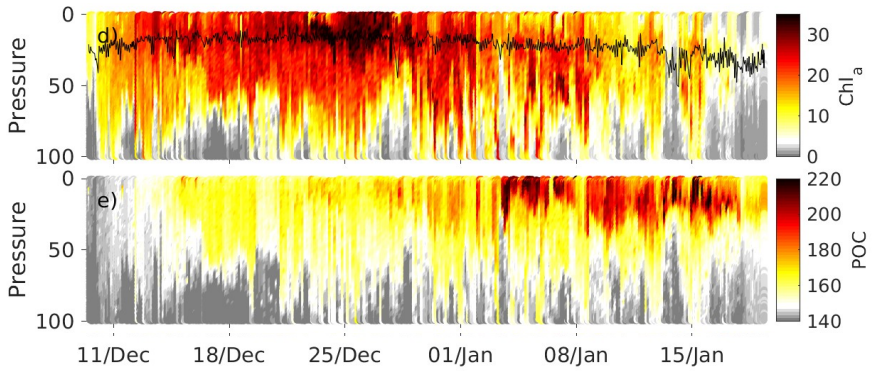

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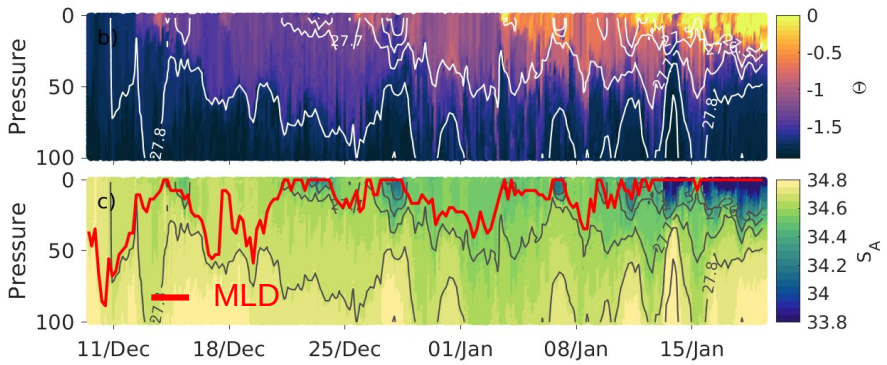

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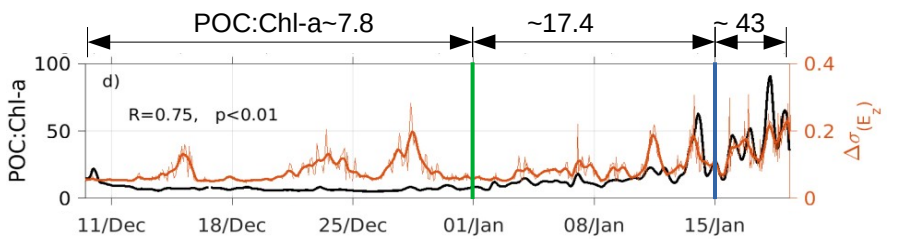


POC:Chl-a ratio and stratification through E_z

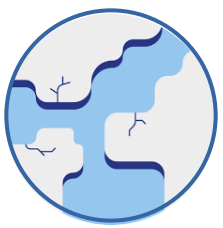
- Exceptionally low POC:Chl-a ratios (Phaeocystis dominance)
  - Mean POC:Chl-a =15
  - Regional mean POC:Chl-a ~ 50-150
- Increased stratification by the end of the time series induces a change in phytoplankton composition

Looking for suspects...

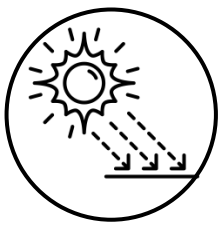
- Photoacclimation?
- Iron fertilization?
- Mixing/stratification?

- Reminder: Factors controlling phytoplankton growth in the Ross Sea

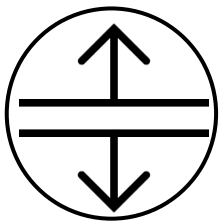
Sea-ice concentration



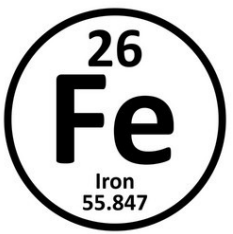
Solar irradiance



Vertical mixing depths



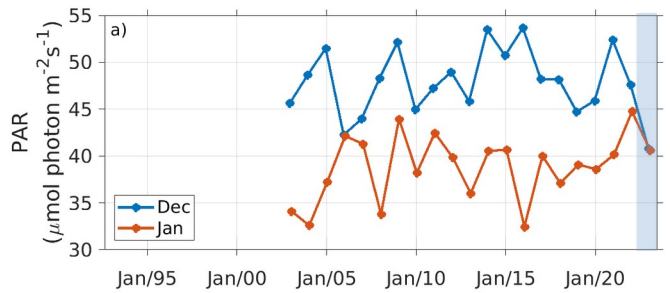
Iron concentrations



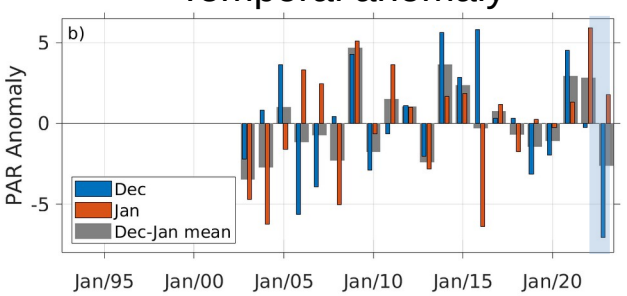
Our data in the long-term context

- **Photoacclimation? → Very low surface PAR in December 2022**

Time series



Temporal anomaly



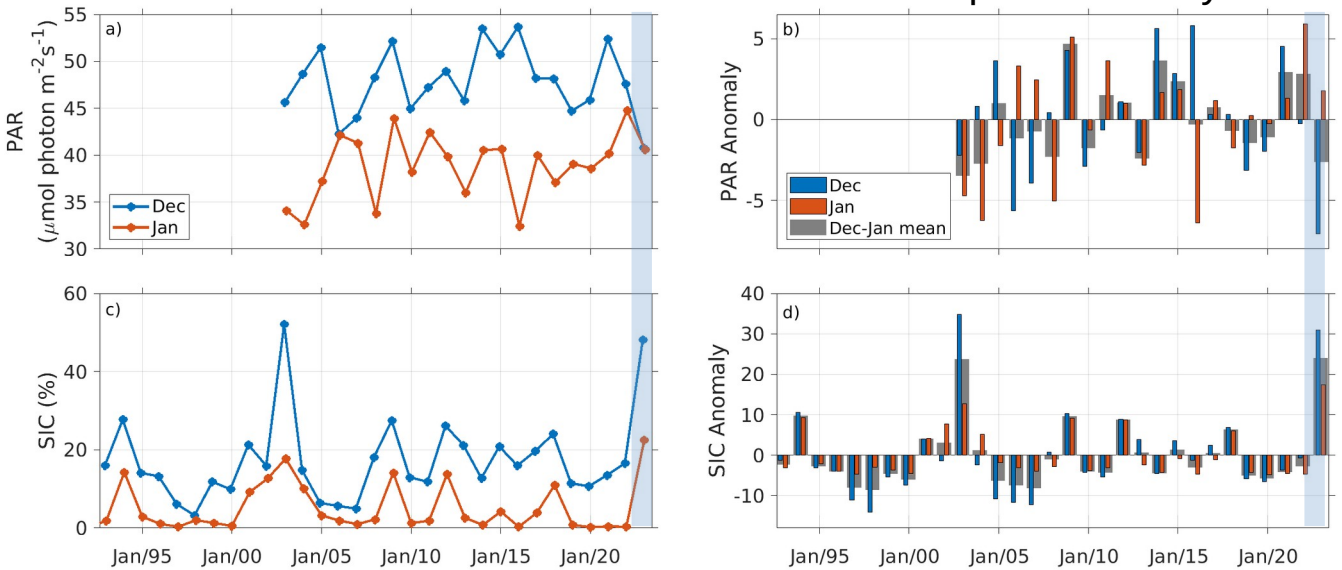
- Photoacclimation to low irradiance can result in an observed increase in Chl-a that not necessarily translates into large phytoplankton biomass.

Our data in the long-term context

- Photoacclimation? → Very low surface PAR in December 2022
- **Iron fertilization? → Maybe, the polynya was quite closed in December**

Time series

Temporal anomaly

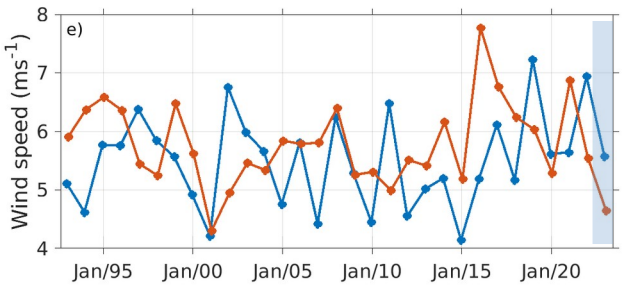


- Ice-edge regions are known to support large phytoplankton blooms :
  - Meltwater increases water-column stratification which favors primary production
  - Iron release from sea-ice melt is the main driver of the ice-edge blooms

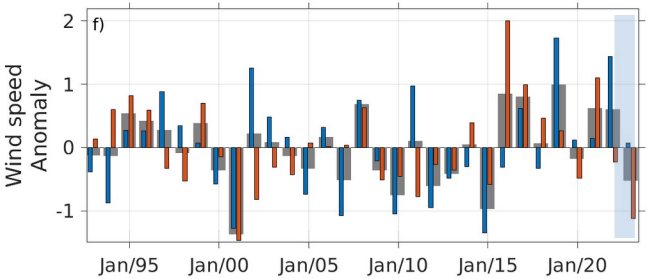
Our data in the long-term context

- Photoacclimation? → Very low surface PAR in December 2022
- Iron fertilization? → Maybe, the polynya was quite closed in December ice melt is observed
- Mixing/stratification? → **Slightly low wind**

Time series



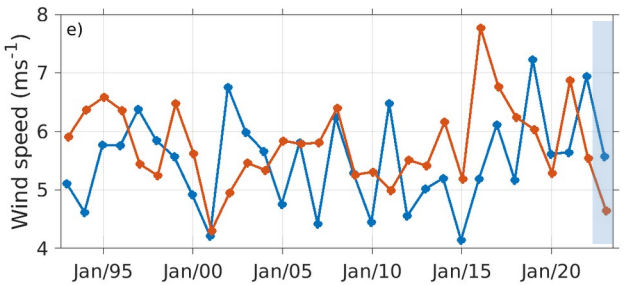
Temporal anomaly



Our data in the long-term context

- Photoacclimation? → Very low surface PAR in December 2022
- Iron fertilization? → Maybe, the polynya was quite closed in December ice melt is observed
- Mixing/stratification? → **Slightly low wind, but no impact on mixing/stratification**

Time series



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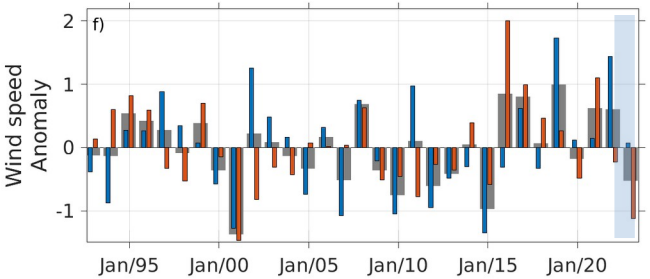
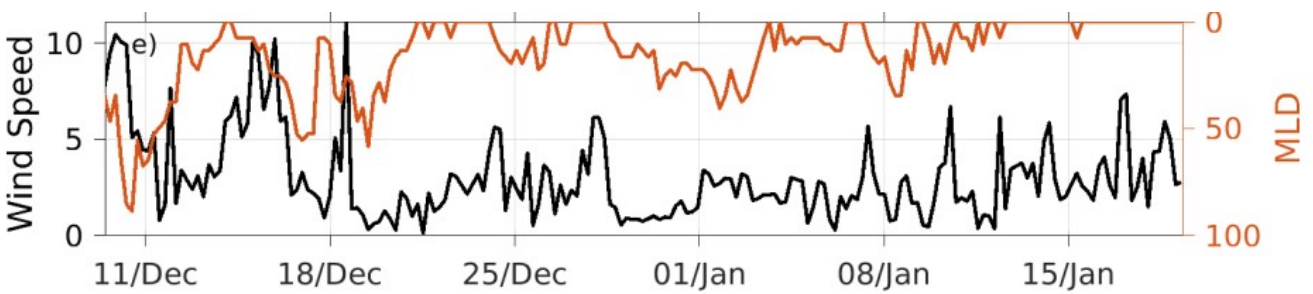


Wind and MLD during the glider's sampling



Summary and conclusions

- High resolution observations with two Seagliders in the Ross Sea revealed an extreme phytoplankton bloom that persisted for over a month during austral summer 2022-2023.
- We hypothesize that our observations correspond with an ice-edge bloom:
  - Fueled by iron release and high stratification during an anomalously ice-covered summer.
  - Strongly dominated by Phaeocystis (favored over diatoms due to low light and high iron availability)
  - Maybe boosted by increased Chl-a concentration due to photoacclimation to low PAR but is unlikely to explain the observed, large, and sustained bloom.
- Recent work supports the idea that this was indeed a very productive year….to know why, go to Meredith Meyer's talk!

- Acknowledgements -

- Gillian Damerrel, Gareth Lee and other UEA fellow pilots
- Funders of the P2P project
- Voice of the Ocean for the Making Waves grant

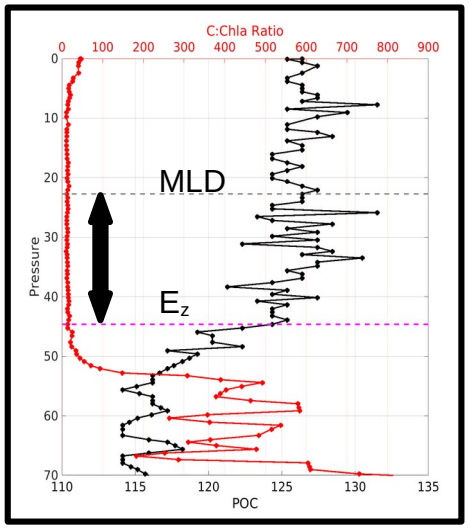
UKRI Natural Environment Research Council

NSF

VOTO Voice of the Ocean

Methods: Calibration, validation and correction

- Fluorescence:Chl-a ratio, the big question -



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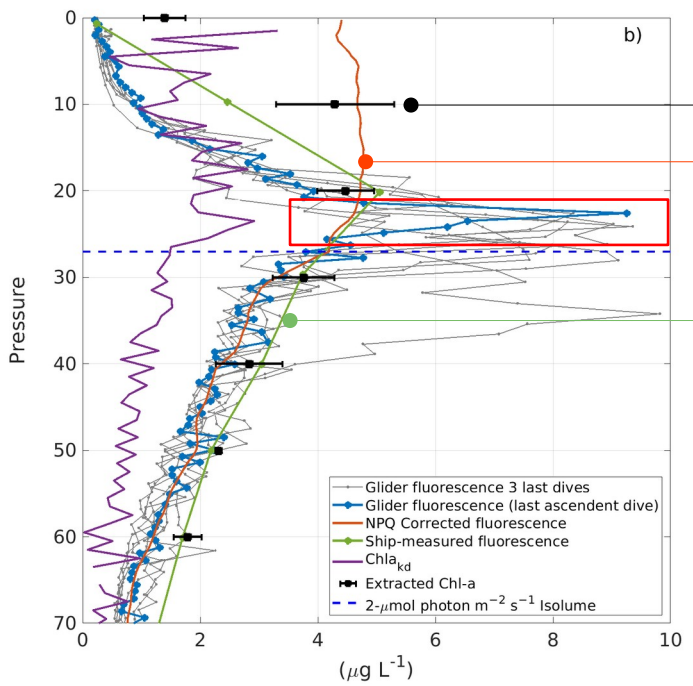


Extracted Chl-a

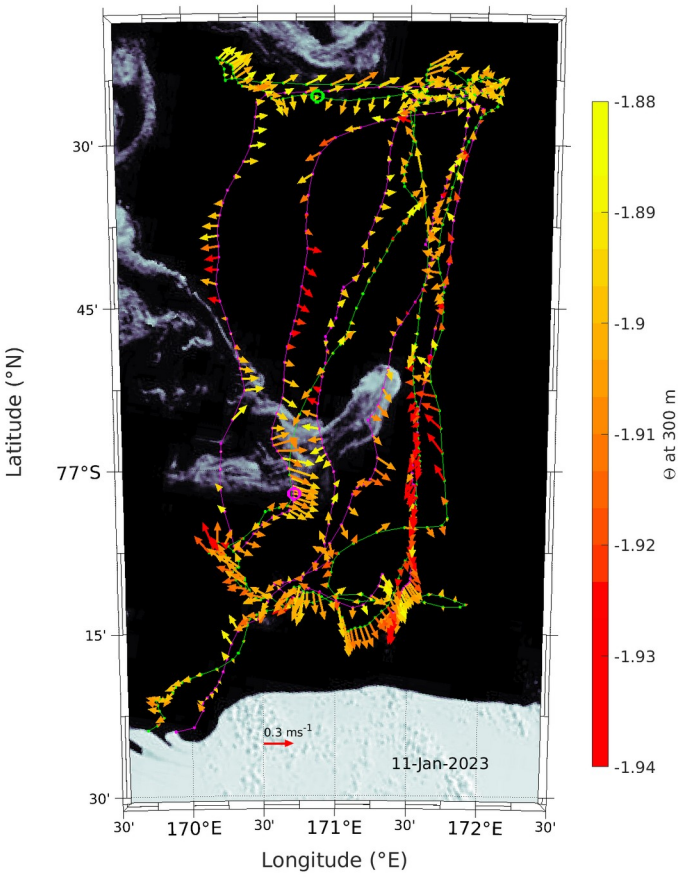
NPQ-corrected and smoothed fluorescence

Ship-measured fluorescence

Variability linked to mesoscale eddies

Properties and Dive Averaged Currents (DAC) at 300 m depth

Temperature



Salinity