Variability in Phytoplankton Size-structure between the Antarctic Polar Front and the Pal-LTER Region: Is there a Connection?

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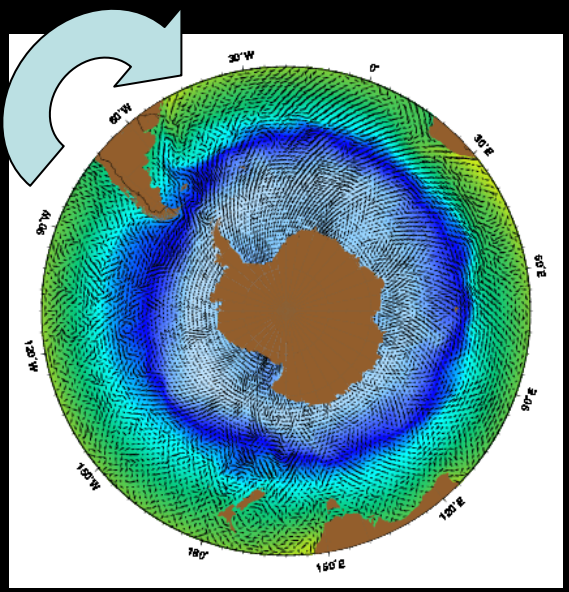
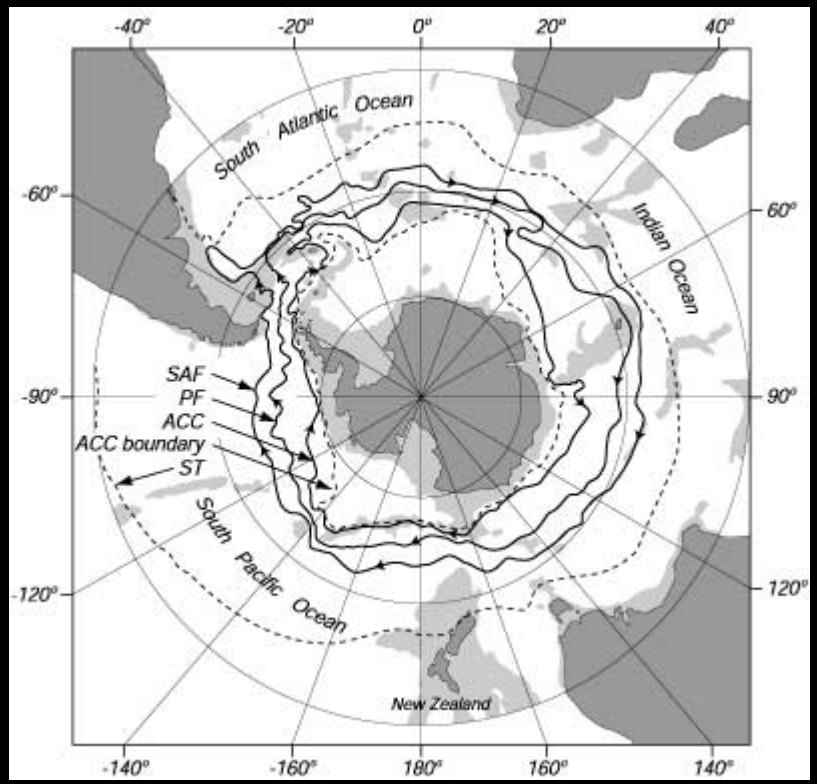
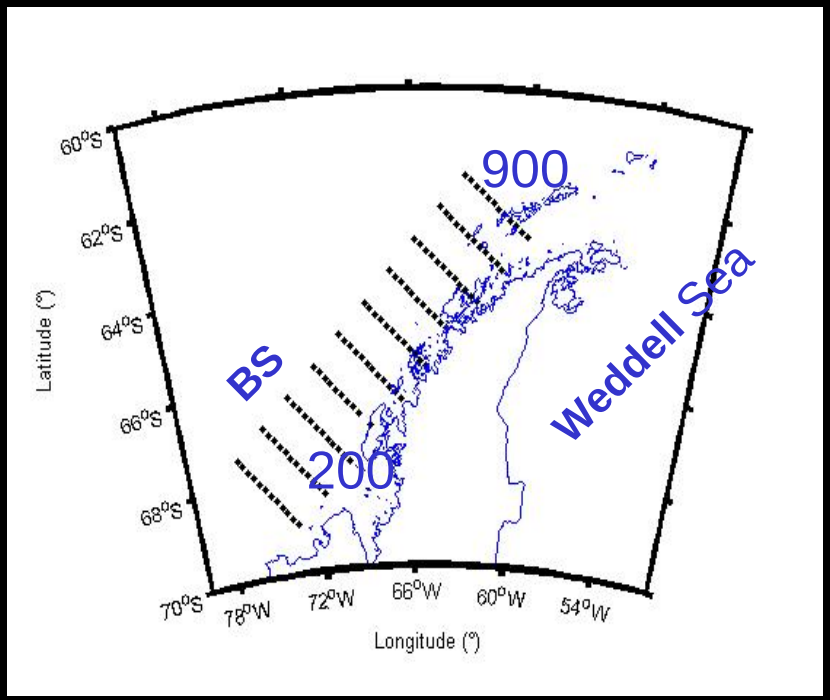
Southern Ocean-ACC

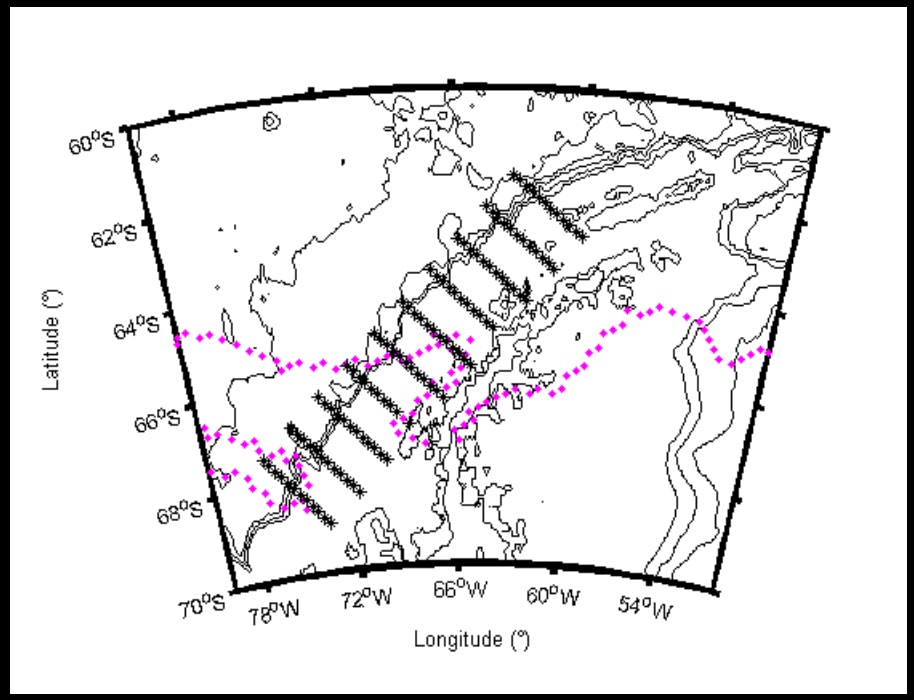




Orsi et al. (2000)

Western Antarctic Peninsula

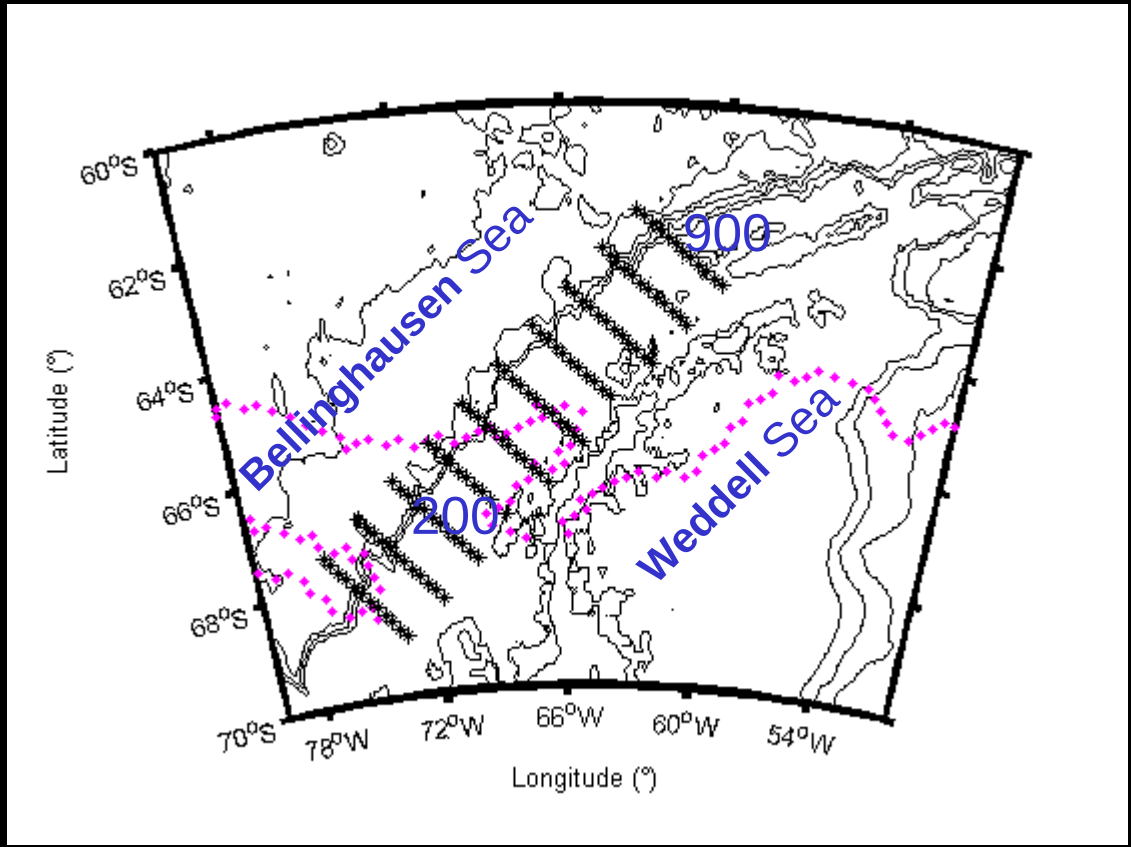




Climate change in Antarctic waters!!

- APF (inside ACC)
- Higher frequencies of positive SAM/AO
- Stronger westerly winds south of APF
- More intense divergence/upwelling
- Higher chl values south
- *Lack of biological observations*!!

Topographic map



Climate change in Antarctic waters!!

- WAP region
- Atmospheric and hydrological long-term warming in the last decades especially since 2002 due to a regime shift
- Lower frequency of ‘cold’ years and shorter ‘winters’ (sea-ice extent)
- Climate migration with concomitant changes on krill, silver fish, and penguin populations

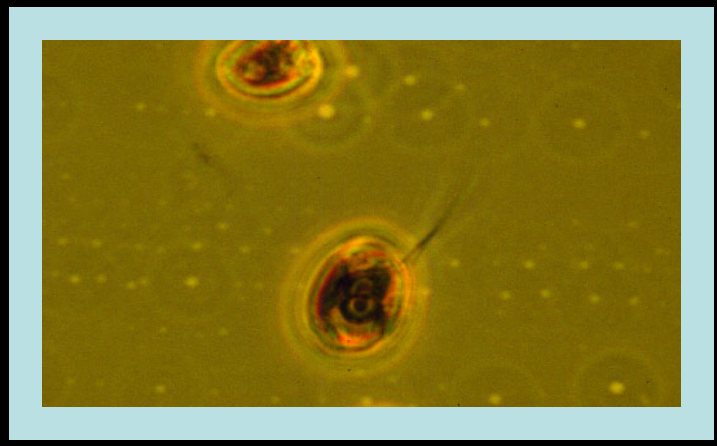
APF-WAP link:
SAM tele-connections

- SAM: southern annular mode or Antarctic Oscillation

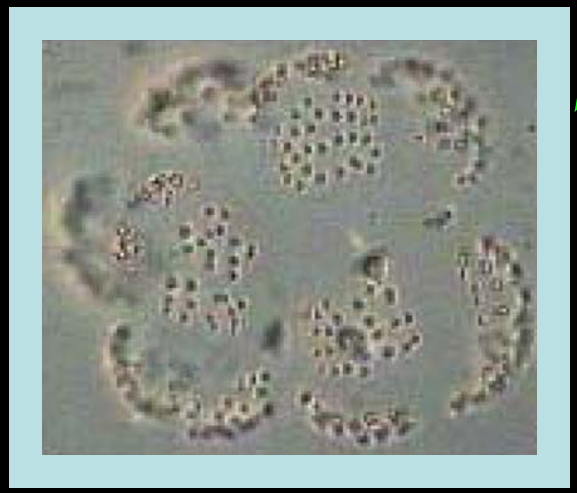
- Definition: Large-scale alternation of atmospheric mass between the mid and high latitudes of the Southern hemisphere (from EOF)

Long-term modifications of phytoplankton assemblages?

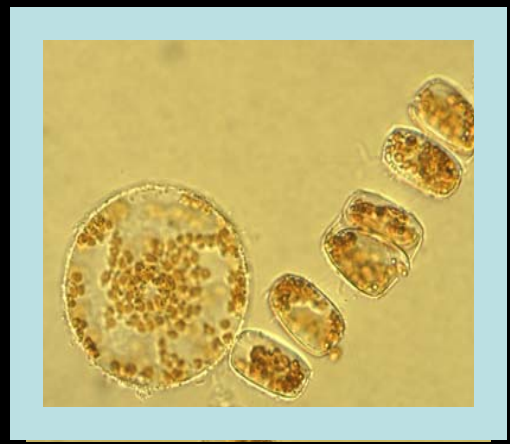
- Nutrient cycling
- Food web pathways
- Taxonomic size changes



Cryptophytes



Prymnesiophytes



Bacillariophytes

Hypotheses

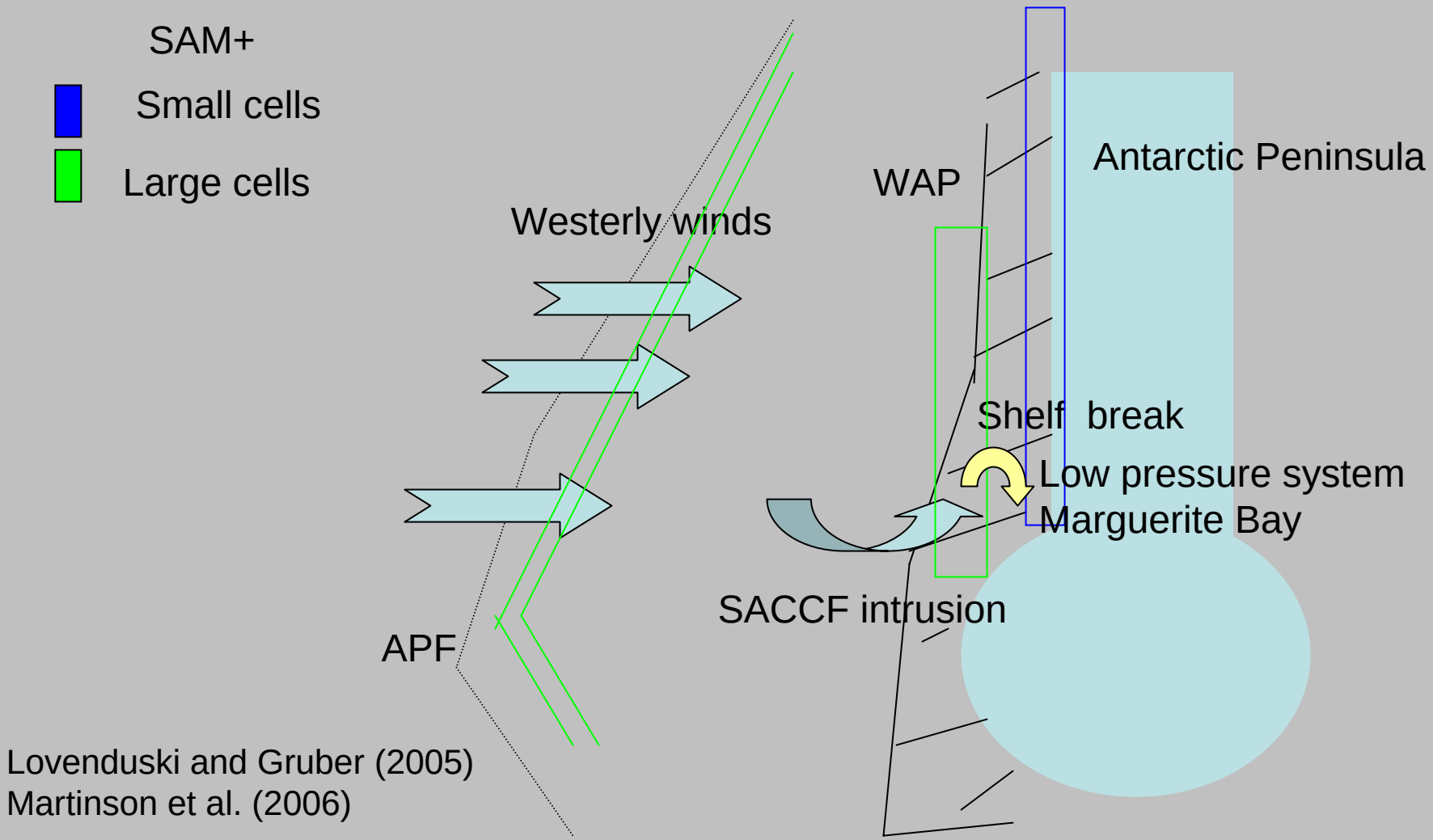
- Phytoplankton size-structure changes might be expected in Antarctic waters:

- phytoplankton communities with **larger** cells (diatoms) will tend to increase in APF and shelf-break waters of WAP during +SAM due to stronger divergence and shelf-break upwelling (ACC intensification)

- Conversely, phytoplankton assemblages with **smaller** cells will tend to be more frequent over the middle shelf and toward the coast during +SAM

NOTE: chl *a* can be high in ‘large’ and ‘small’ phytoplankton communities

Simplified model



Lovenduski and Gruber (2005)
Martinson et al. (2006)

Data & Methods

SAM monthly index from CPC (first EOF component) 1997-present,
Note: SAM has largest variability during winter

Sea-ice extent and concentration (%) 1978-present
US National and Snow and Ice Data Center, SMMR-SSMI

SeaWiFS imagery (MLAC-GAC):

- Total Chlorophyll *a* (Dierssen and Smith, 2000) and particle backscattering slope (Carder et al. 2004)
- Only January scenes for APF

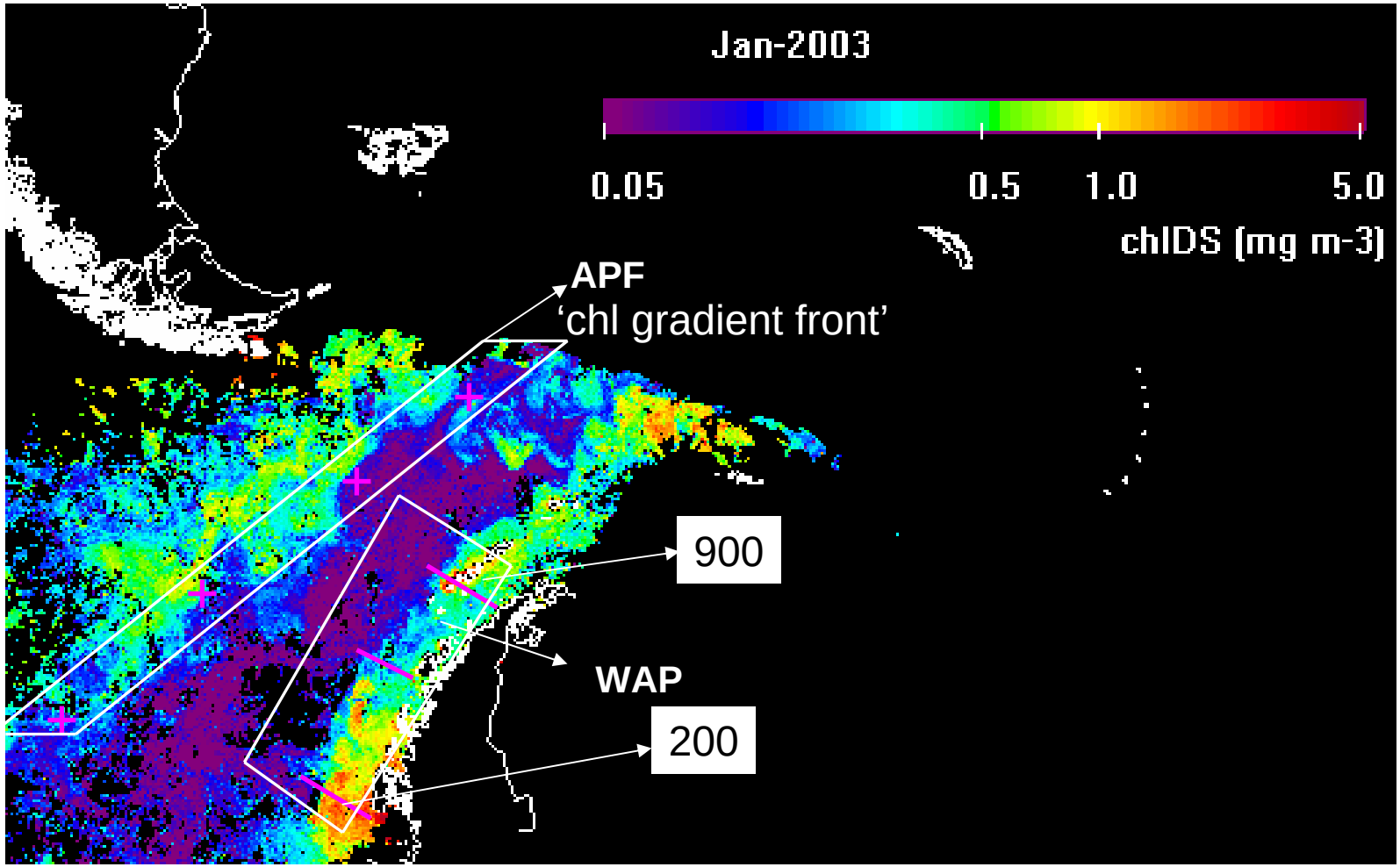
Analysis

- Mann-Kendall time-series trends (sum and seasonal) and Spearman correlation analysis: APF transects *vs* WAP regions

Phytoplankton size-structure index: a remote-sensing approach

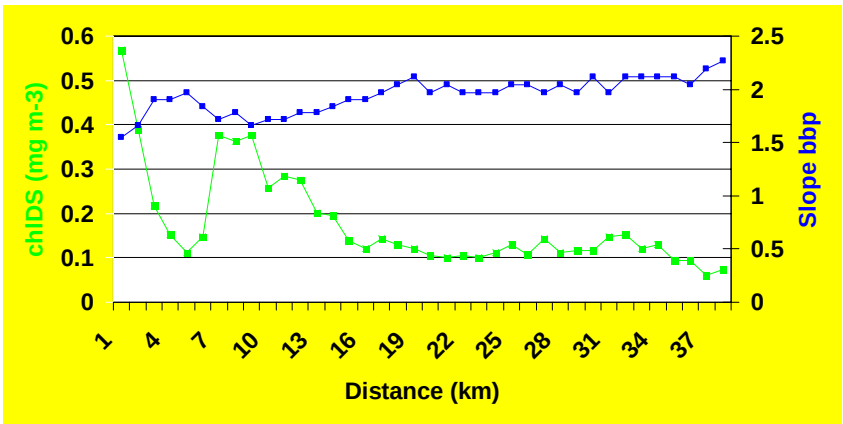
- Functionality: Chl>20µm/chlT-γb_{bp}
- Validation: monthly γb_{bp} SeaWiFS composites and histograms of *in situ* data
- HPLC pigment signatures

Sampling points

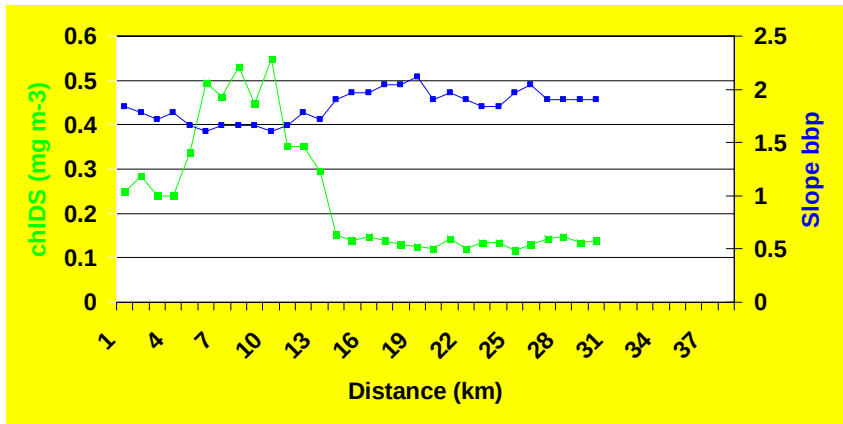


Horizontal *vs* vertical transects across APF

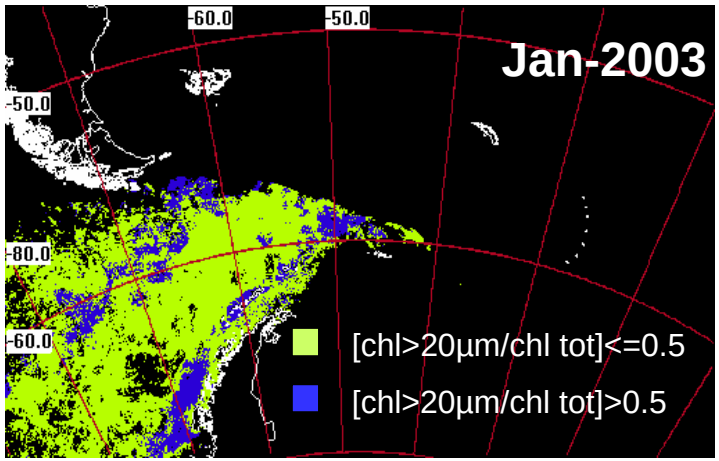
H

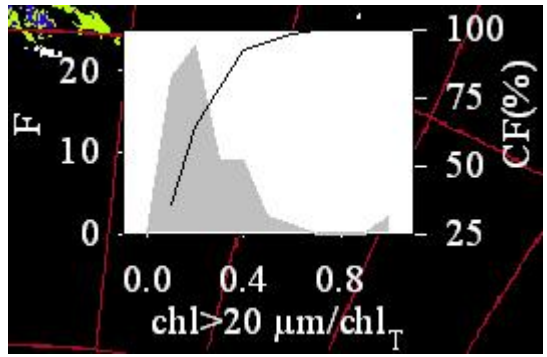


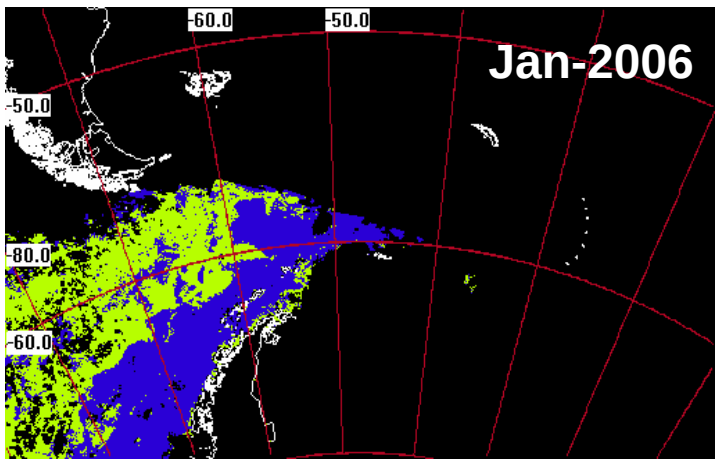
V

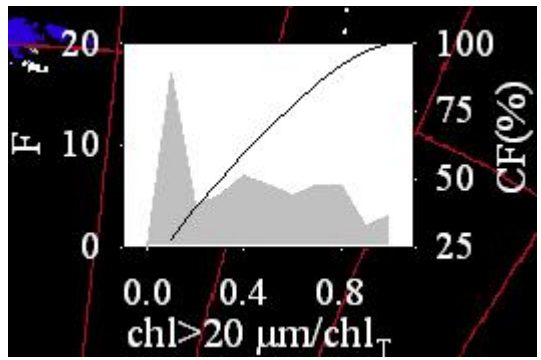


Results: Validation of phytoplankton size-structure index









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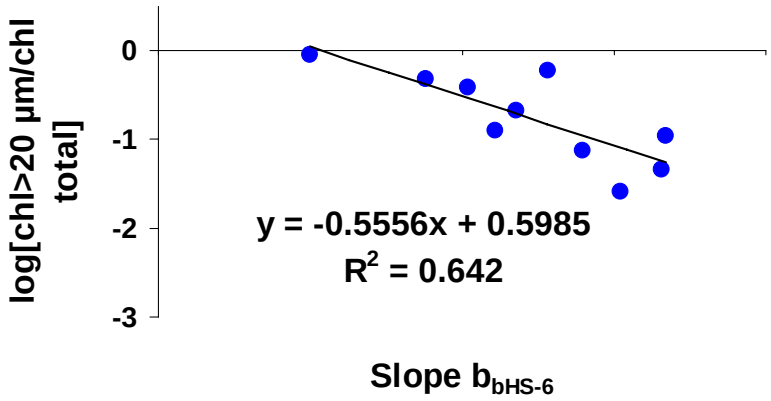
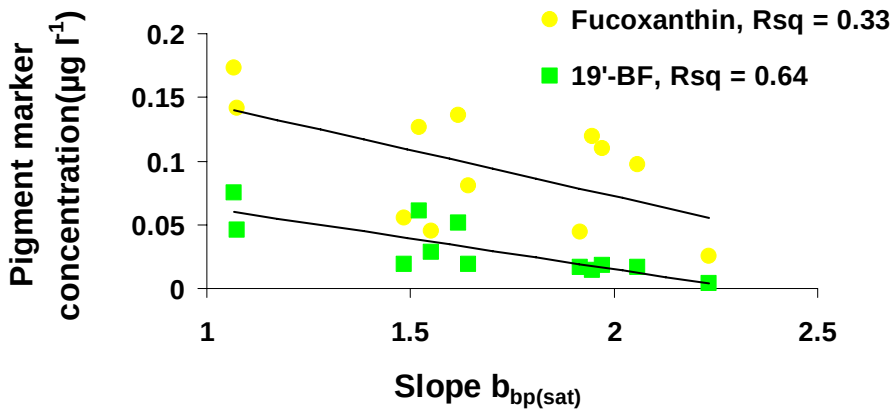




Results: correlations

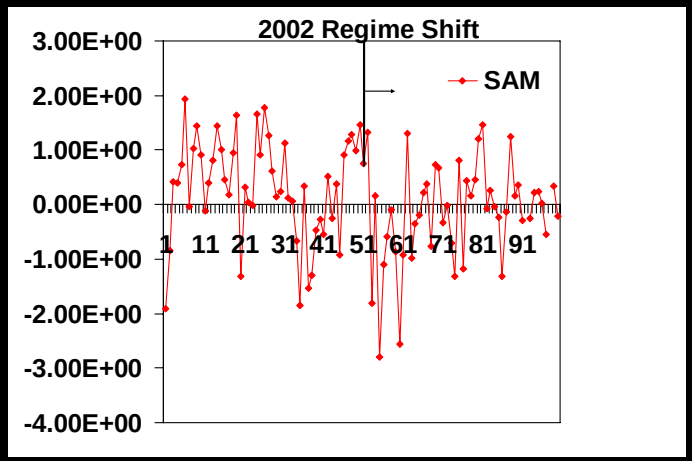
- At the 95% confidence level there were significant non-parametric correlations of γb_{bp} values (negative) between APF-Drake and WAP 'shelf' waters of line 600 (Anvers Island)

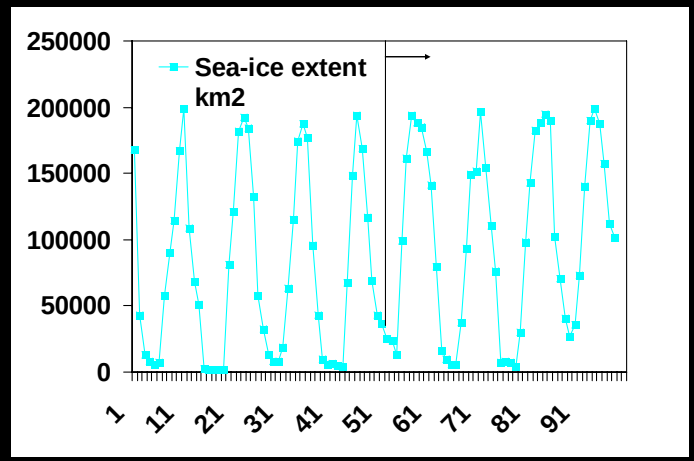
- Also between APF-Anvers and WAP inshore waters (negative) of line 900 for Chl_{DS}

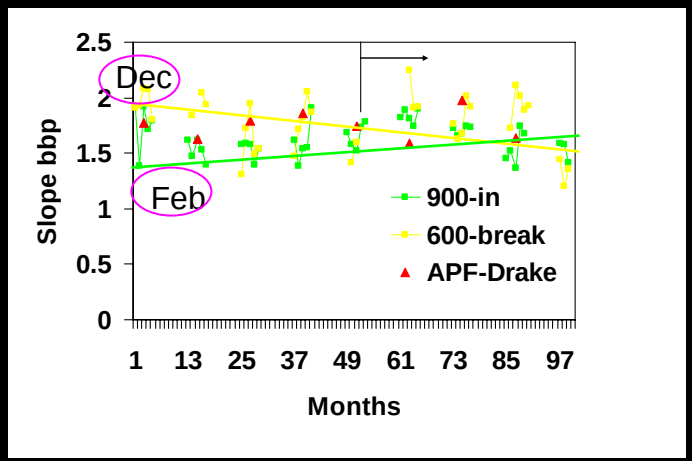
- In terms of phytoplankton size-structure, dynamics of Drake and Anvers APF fronts covaried in a direct way

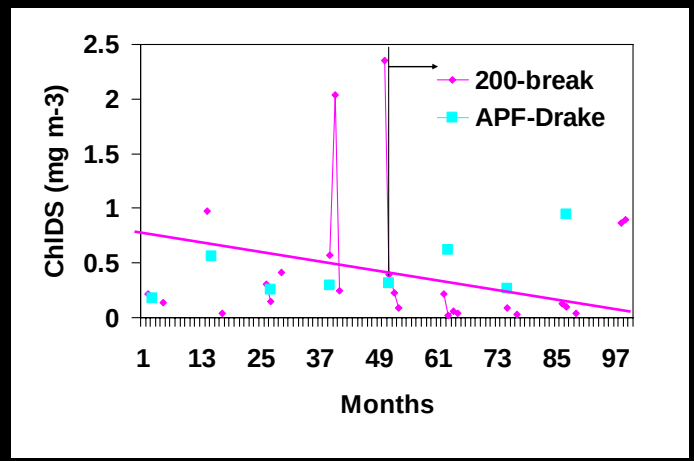
- Chl_{DS} values variability of Drake, King George and Anvers APF's were positively related. Marguerite Bay has a different behavior.

Results: Time-series trends









APF:mean H-V

Results: temporal trends

- As reported by Thompson et al. (2000) and Stammerjohn et al. (2003), positive trend for SAM, negative trend for sea-ice extent over WAP

- Higher γb_{bp} (smaller cells) values King George transect (inshore) between 1997-2006

- Lower γb_{bp} (larger cells) values Anvers transect (shelf-break)

Conclusions

Correlations:

- APF-WAP negative correlation of γb_{bp} values and +SAM due to less sea-ice extent (northern Pal-LTER grid). Thus, 'big' cells would increase along APF and 'small' cells toward the coast of WAP

- Based on January APF data, ACC shelf-break upwelling had a secondary role on phytoplankton size-structure variability of WAP. Heat transfer onto the shelf seems to be the driven forcing

Long-term temporal trends 1997-2006:

- 'smaller' phytoplankton in the northern inshore region of Pal-LTER (line 900)
- 'bigger' phytoplankton in the southern shelf-break region of Pal-LTER (line 600). *Note*: Near-shore field data showed the opposite

Future work

- Longer time-series- CZCS
- APF data for other months
- Lags? auto and cross-correlation
- Eddy activity?


Thank you