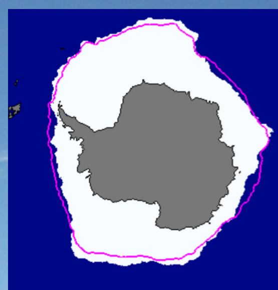
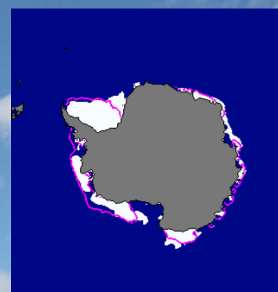
PALMER STATION ANTARCTICA
LTER
Palmer Antarctica Long Term Ecological Research
Land-Shelf-Ocean Connectivity, Ecosystem Resilience and
Transformation in a Sea-Ice Influenced Pelagic Ecosystem
The Team
Hugh Ducklow PI (Bacteria, Biogeochem)
Scott Doney
(Models, Biogeochem)
Janice McDonnell
(Outreach)
Doug Martinson
(Physical Ocean, Ice)
Debbie Steinberg
(Zooplankton)
Ari Friedlaender
(Whales, Seals)
Dave Johnston
(Whales, Seals)
Sharon Stammerjohn
(Climate, Ice)
Oscar Schofield
(Phytoplankton)
Bill Fraser
(Birds)
Doug Nowacek
(Whales, Seals)
James Connor
(Data)

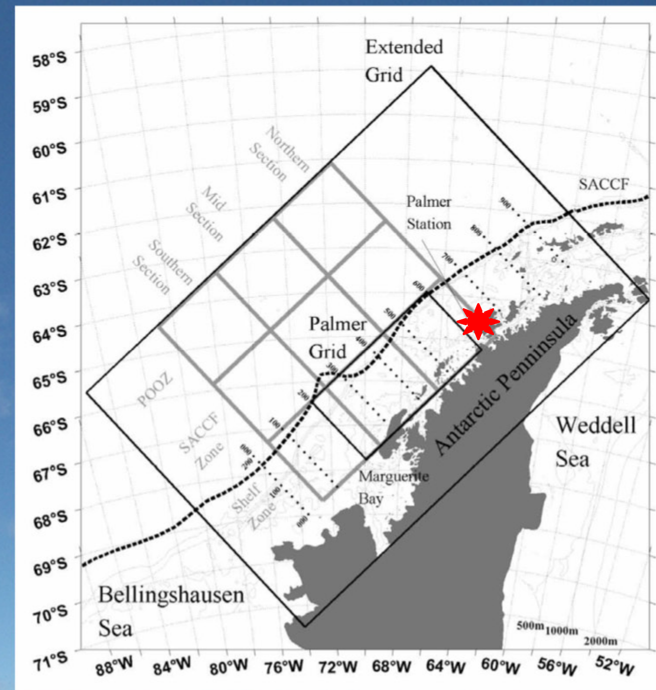
The central hypothesis when the LTER began was that sea ice timing and magnitude structure the productivity and composition of the Antarctic ecosystem. The ice dynamics are driven by large-scale interactions of the atmosphere and ocean.

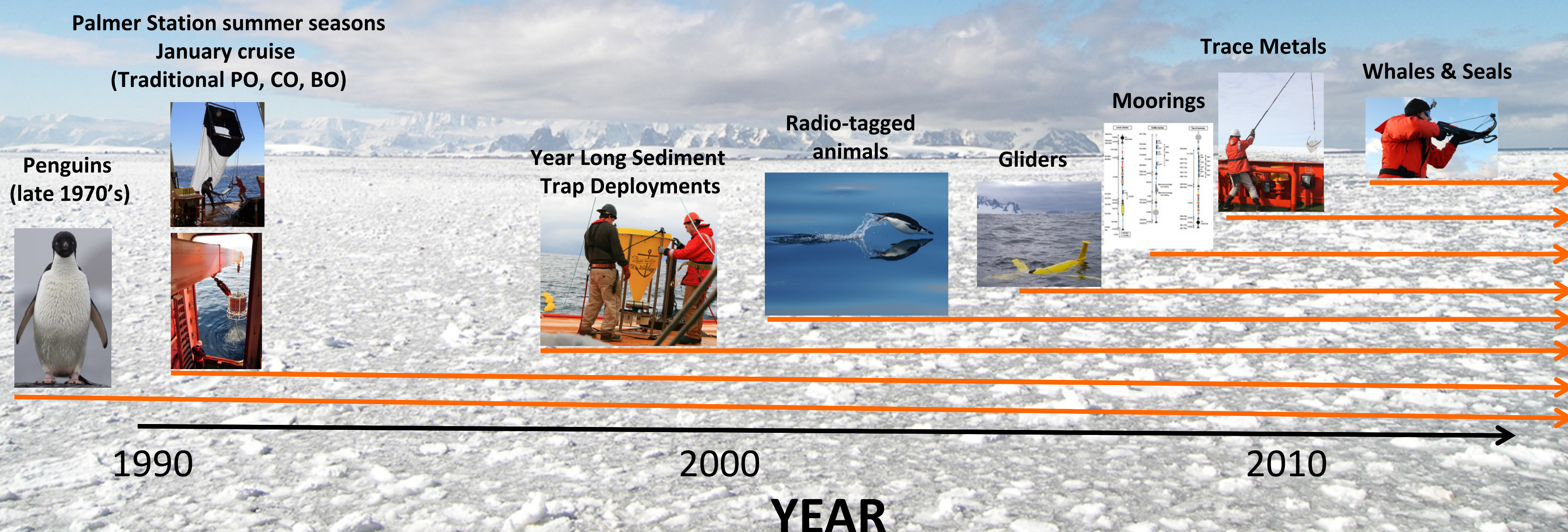


Winter 2007

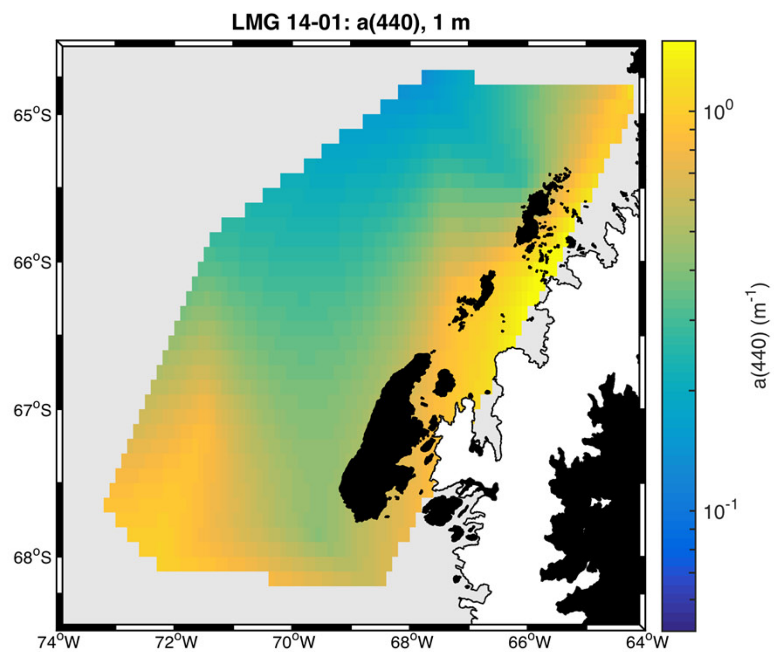


Summer 2007



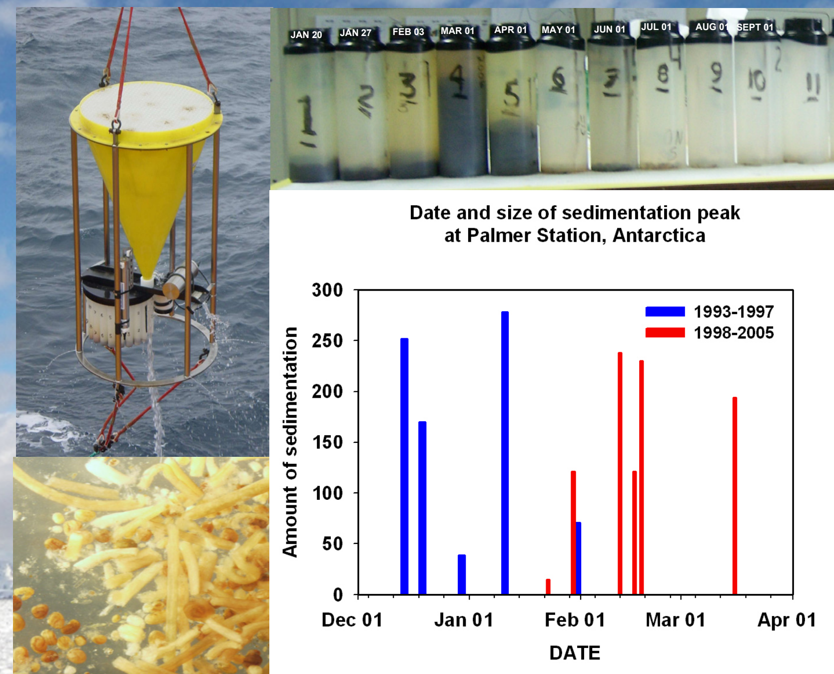


Phytoplankton biomass highest near the coast and near the sea ice edge

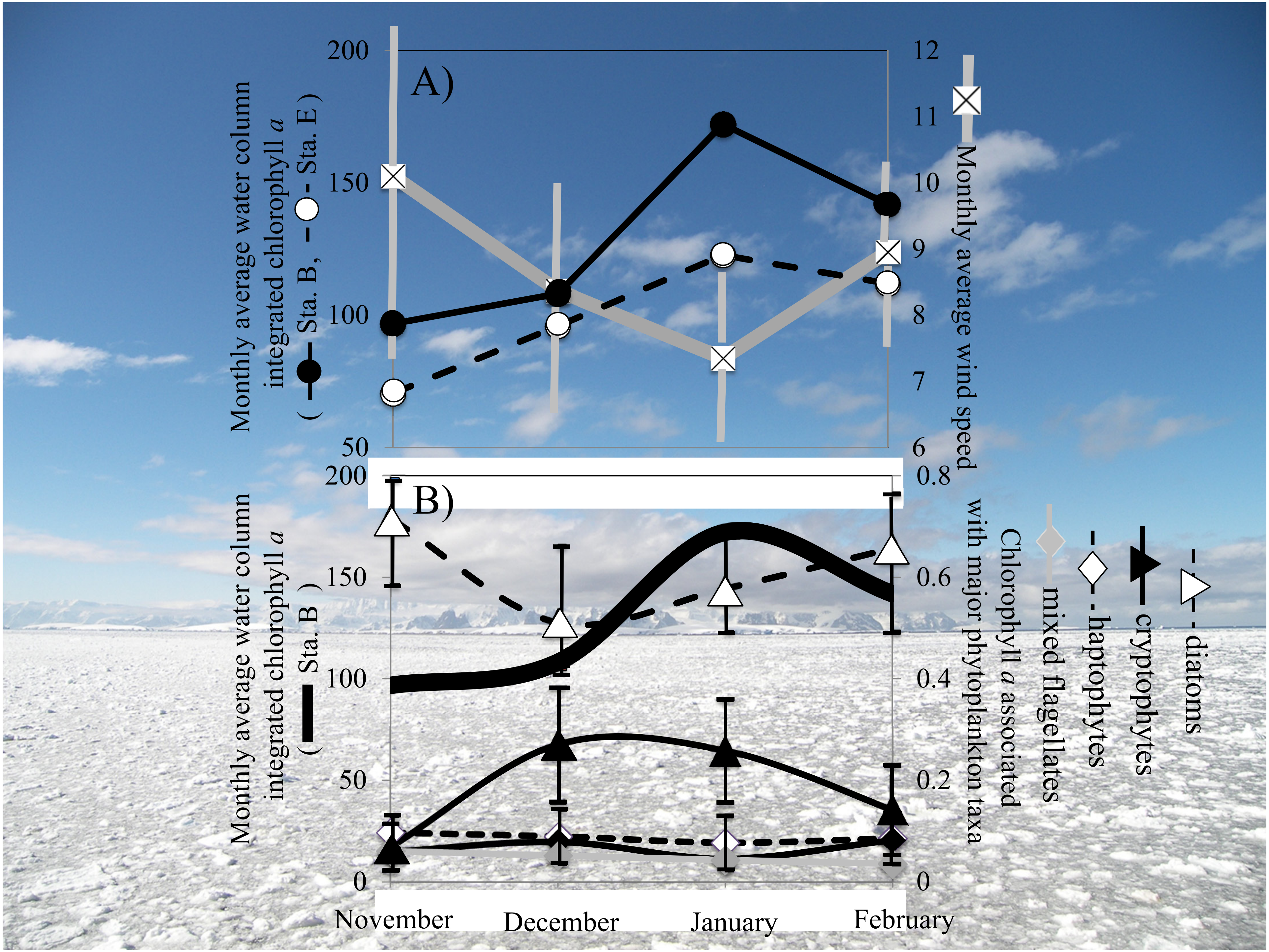


Thanks Michael Brown

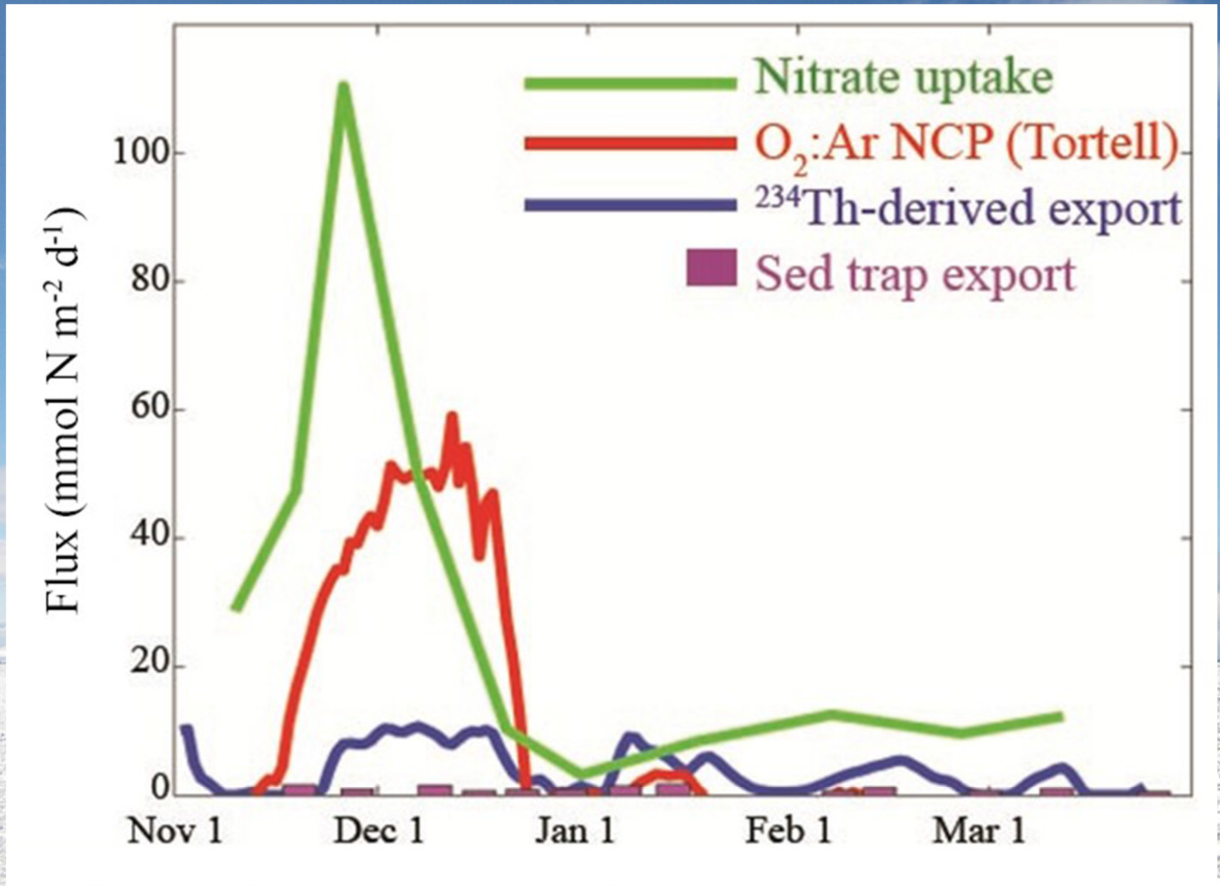
Export fluxes are episodic



Ducklow et al. 2008


A)
B)
Monthly average water column integrated chlorophyll a (Sta. B, Sta. E)
Monthly average wind speed
Monthly average water column integrated chlorophyll a (Sta. B)
Chlorophyll a associated with major phytoplankton taxa
diatoms
cryptophytes
haptophytes
mixed flagellates
200
150
100
50
0
12
11
10
9
8
7
6
0.8
0.6
0.4
0.2
November
December
January
February

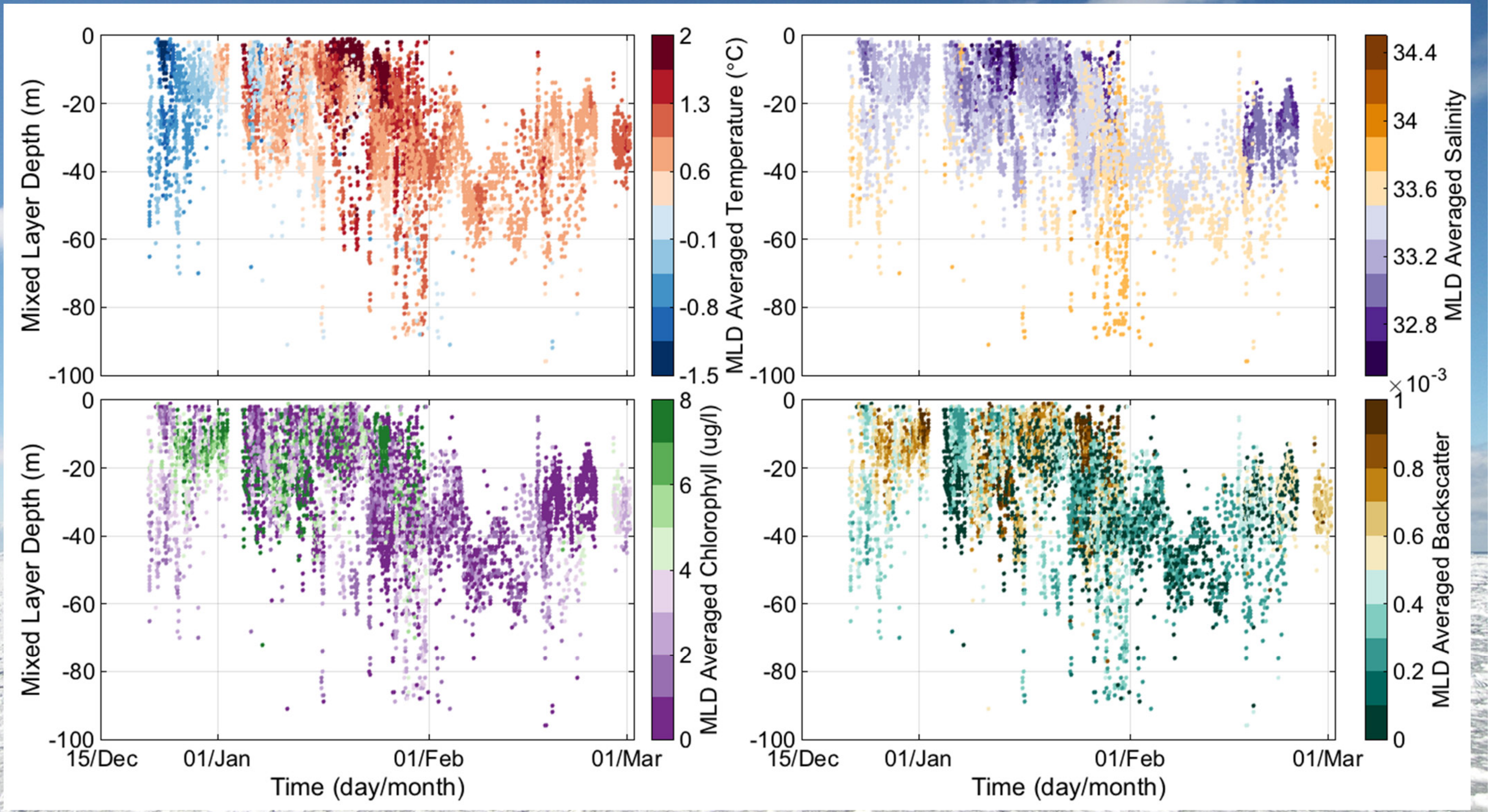
Cumulative seasonal NCP exceeds the export by a factor of 2-3. After an episode of very high NCP during the diatom bloom, the system was poised near zero NCP (production = respiration) for the remainder of the season (3 months) export continued at a low level.



O_2:Ar – surface via 10-m seawater intake (MIMS)
^{15}N, ^{234}Th, traps – upper 50 meters

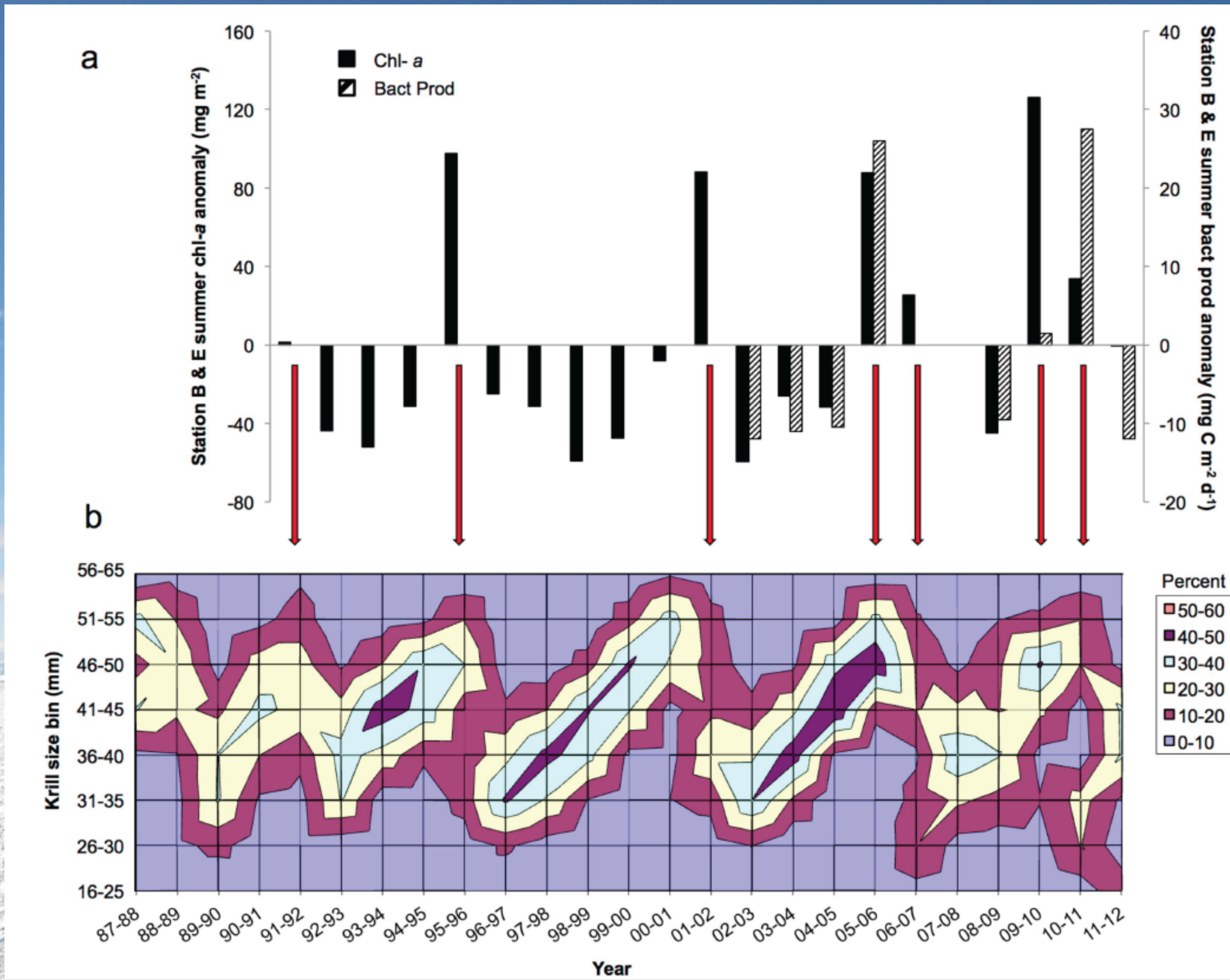
Stukel et al (Revision under review)

Phytoplankton blooms associated with shallower MLD. Shallower MLD consistently associated with lower salinity water (glacial and sea ice melt)



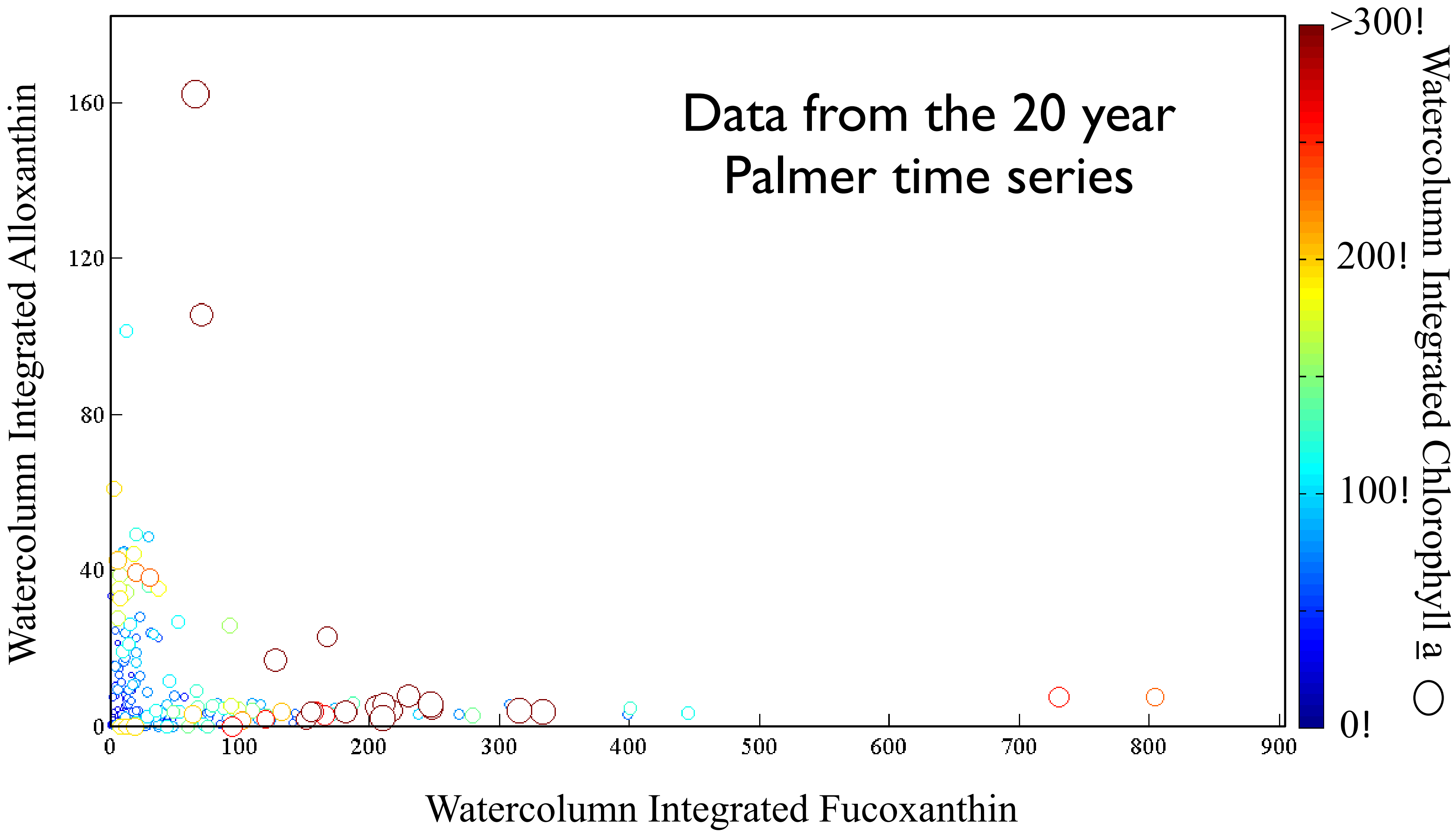
Carvalho et al. In prep.

Big Ice Winters Drive the Larger Phytoplankton Spring Blooms Which Primes the Food Web as a Whole

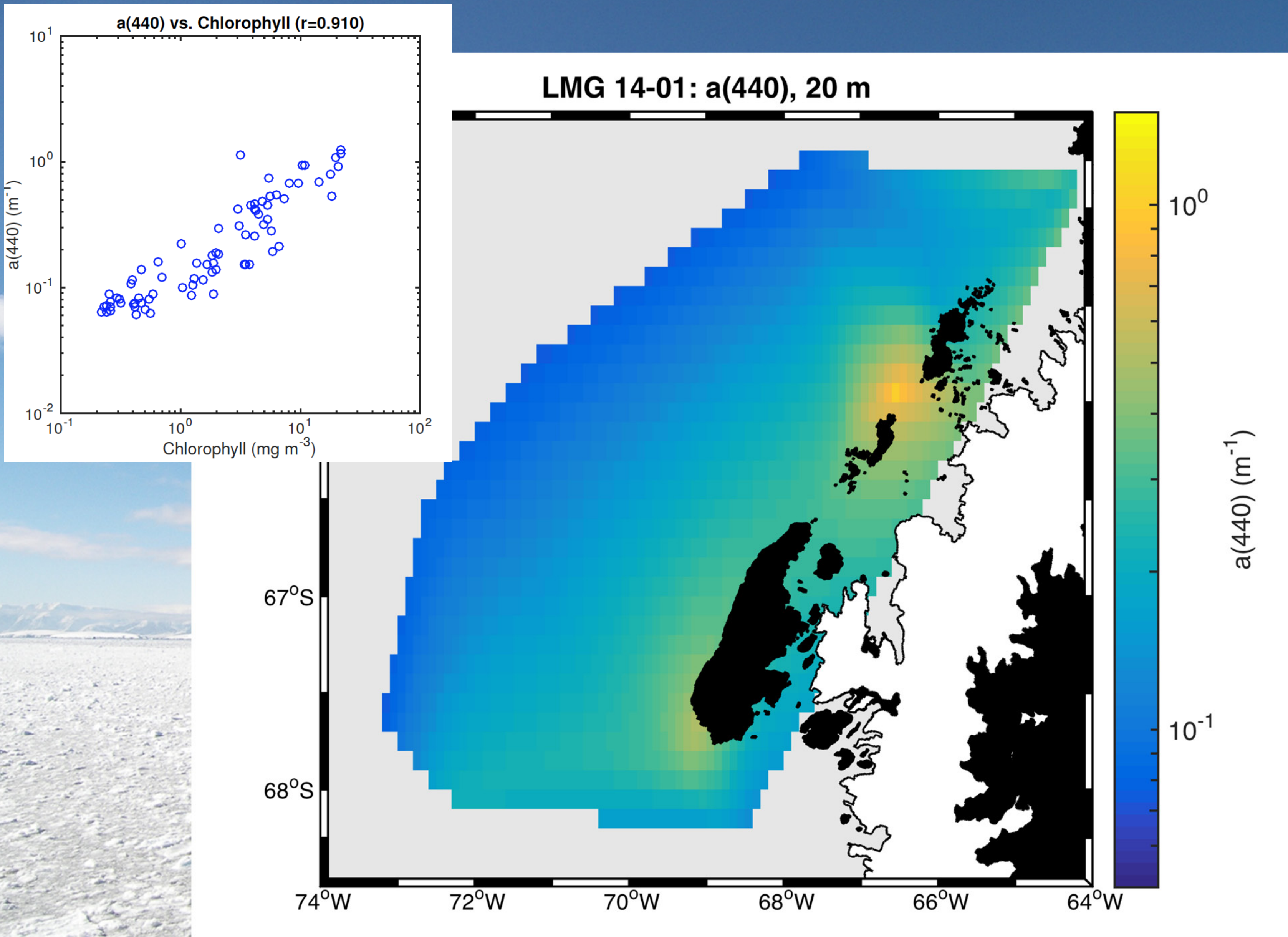


Saba et al. 2014

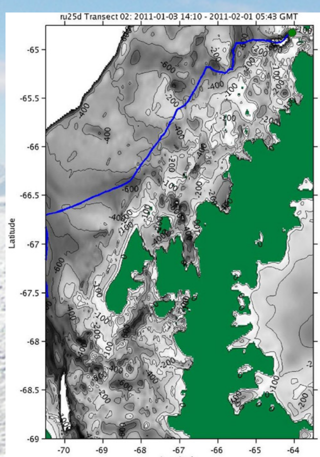
Generally you find phytoplankton populations dominated by either large diatoms or small cryptophytes, these two phytoplankton taxa explain ~80% of the variability in the chlorophyll

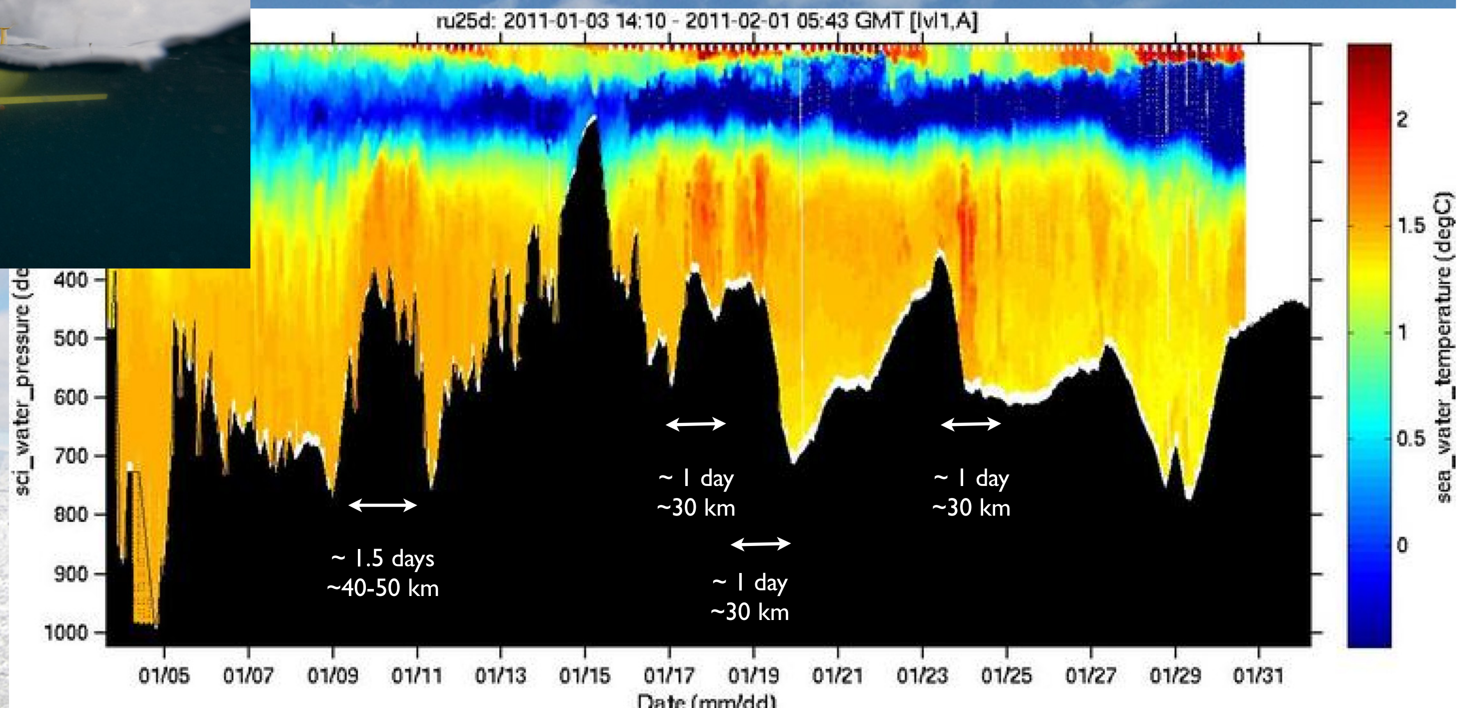


Bio-optical hotspots seen at depth

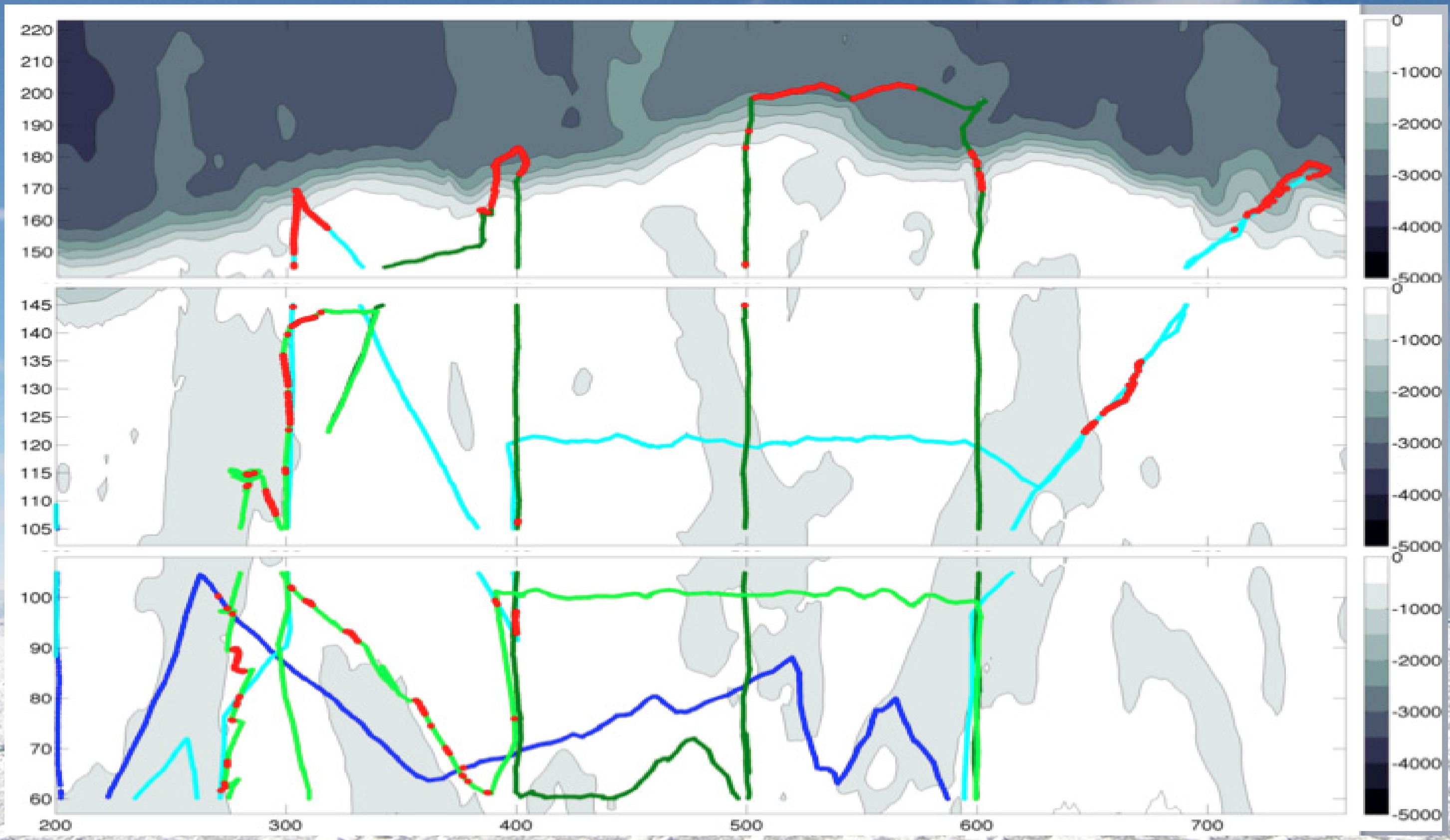


Heat is delivered via eddies (small) formed at the shelf-slope

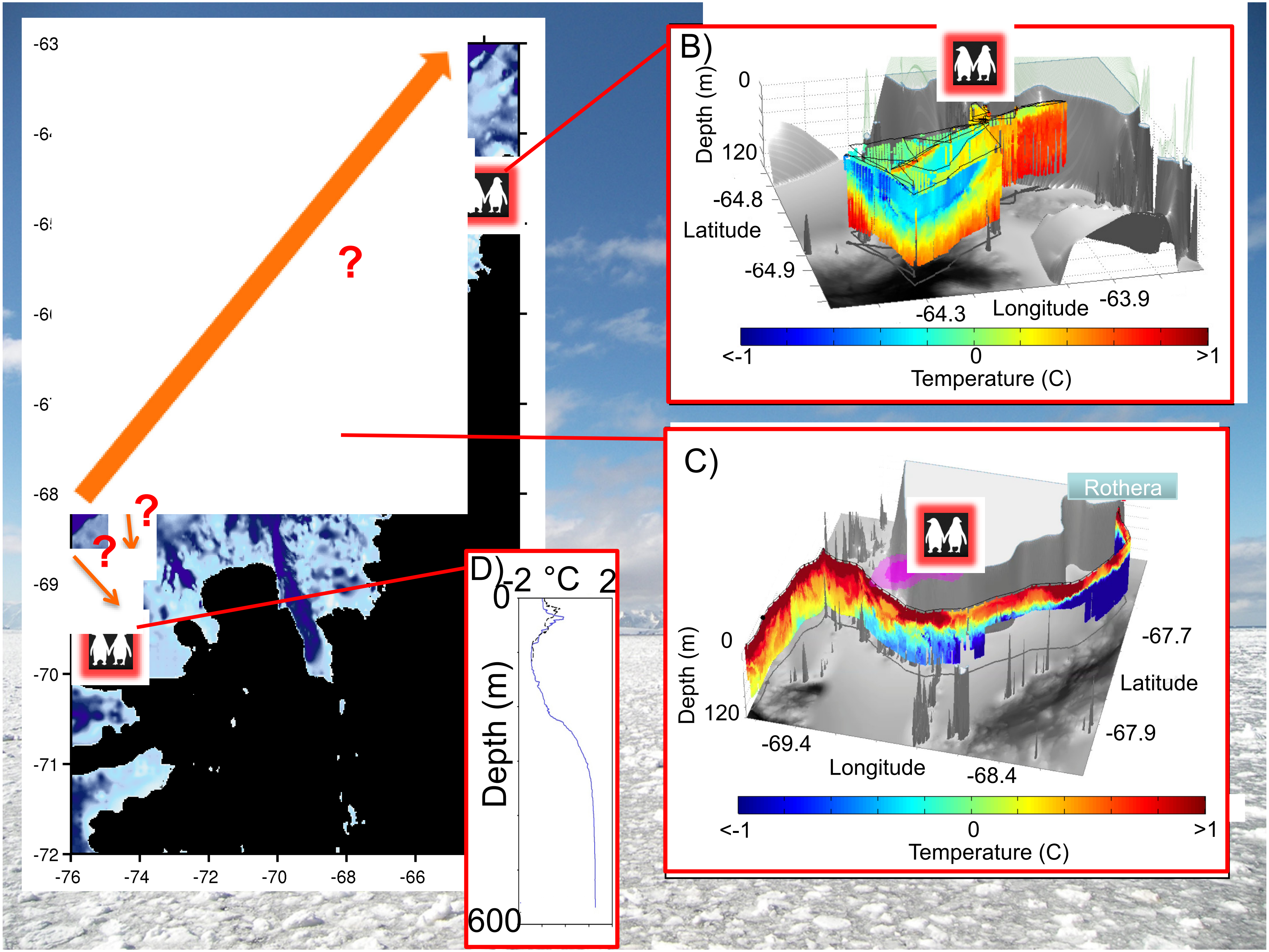




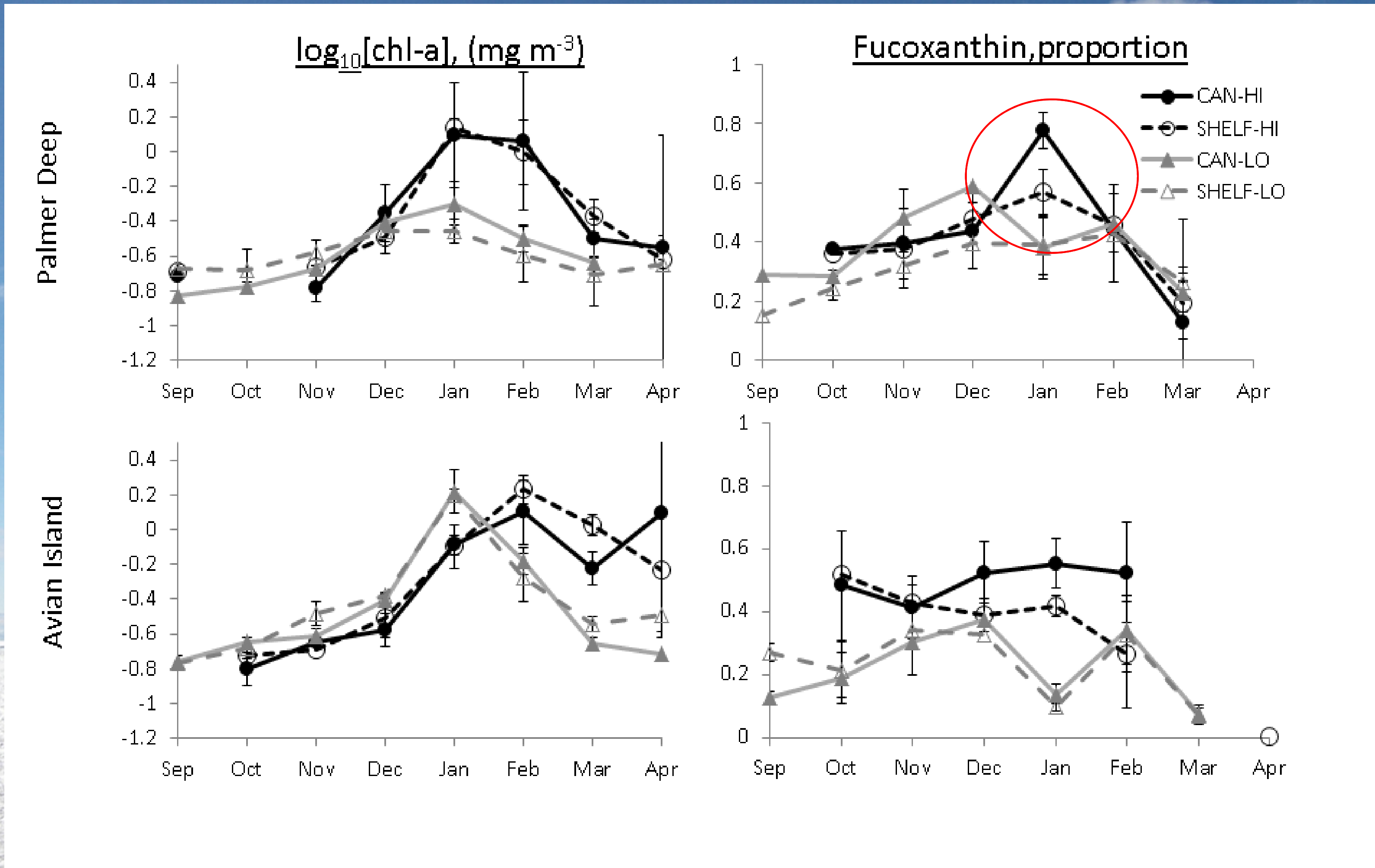
Subsurface eddies spatially associated with northern side of the sea floor canyons across the Peninsula



thanks to Nicole Cuorto

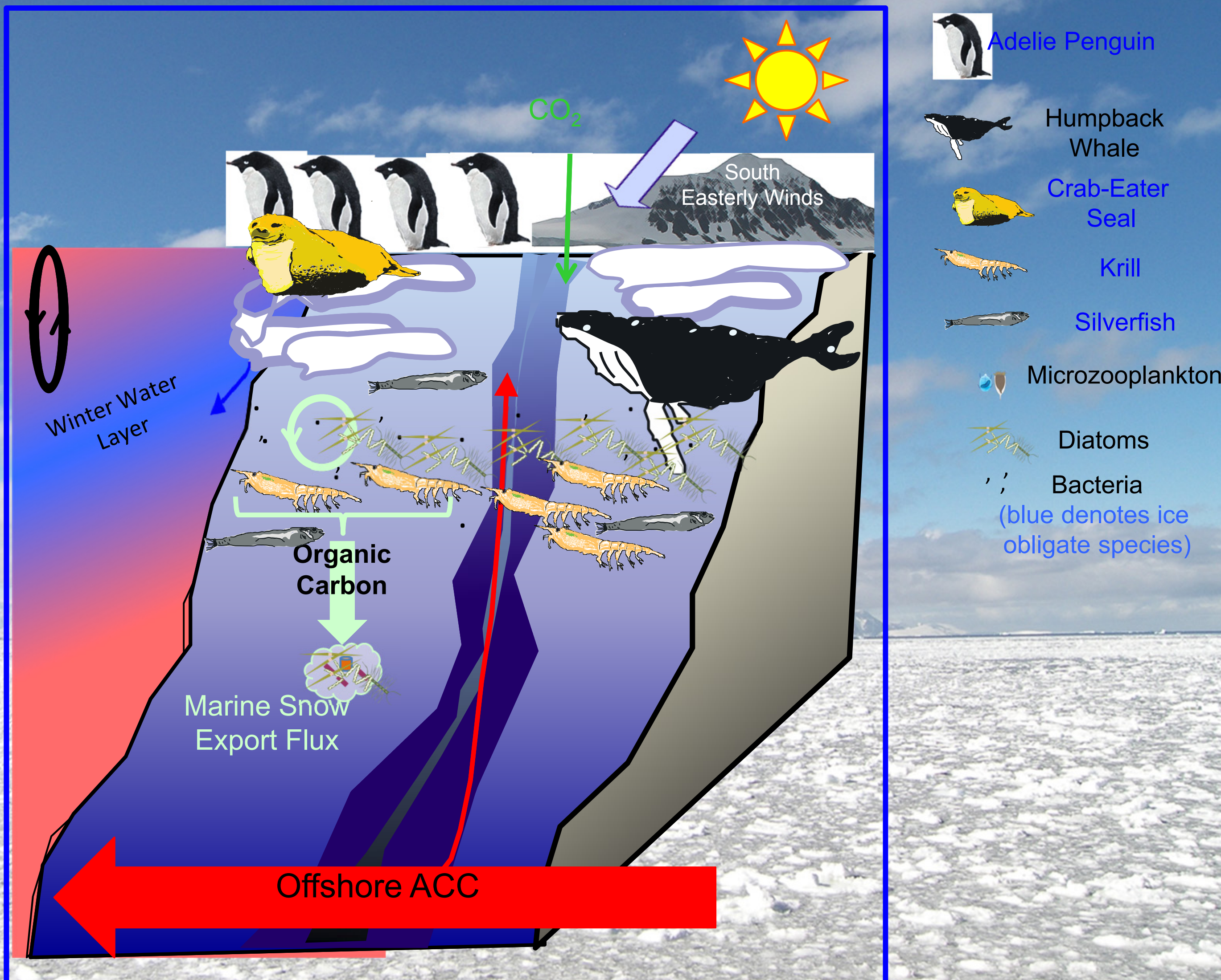

-63
-68
-69
-70
-71
-72
-76
-74
-72
-70
-68
-66
?
B)
Depth (m)
0
120
-64.8
Latitude
-64.9
-64.3
Longitude
-63.9
<-1
0
>1
Temperature (C)
C)
Rothera
0
Depth (m)
120
-67.7
Latitude
-67.9
-69.4
Longitude
-68.4
<-1
0
>1
Temperature (C)
D)
-2 °C 2
0
Depth (m)
600

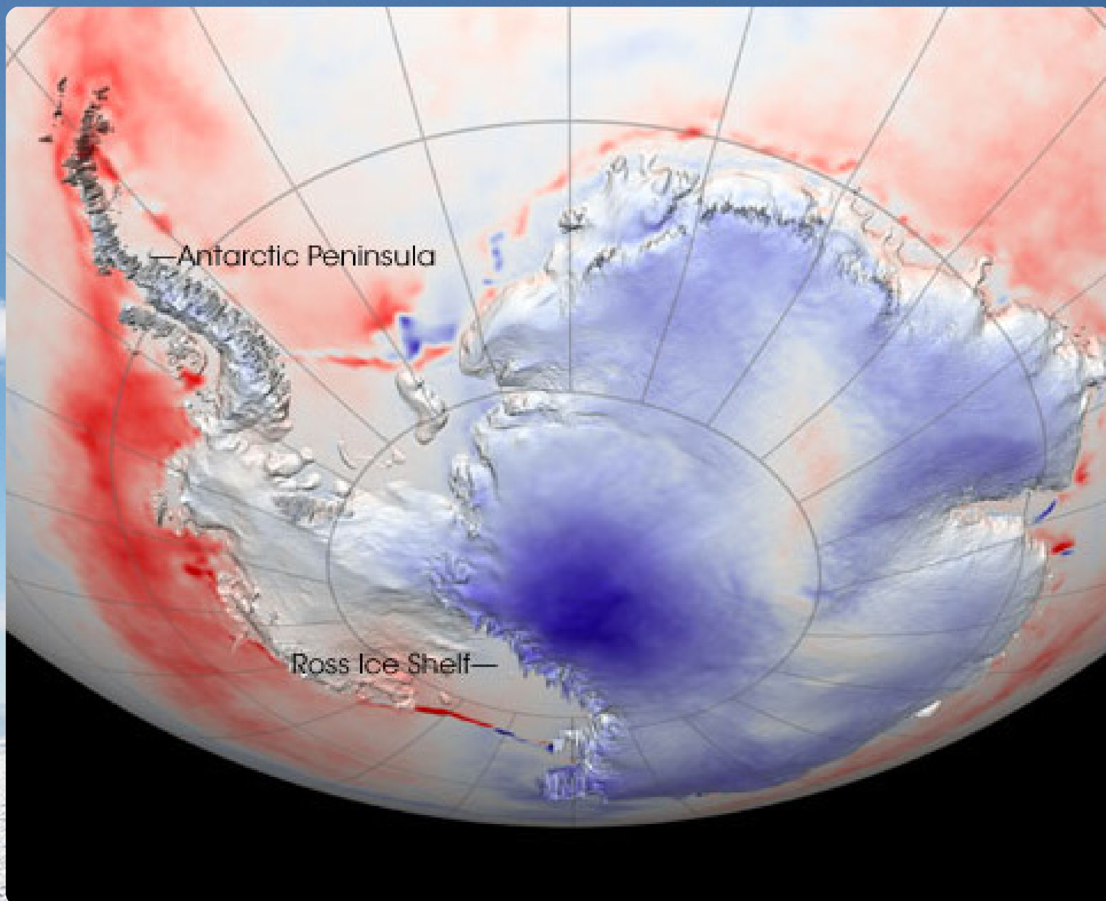
Lots of chlorophyll (no evidence of enhanced biomass) but evidence of enhanced diatom presence



Kavanaugh et al. 2015

Historical paradigm for WAP is short food-web fueled by large blooms of "large" diatom blooms

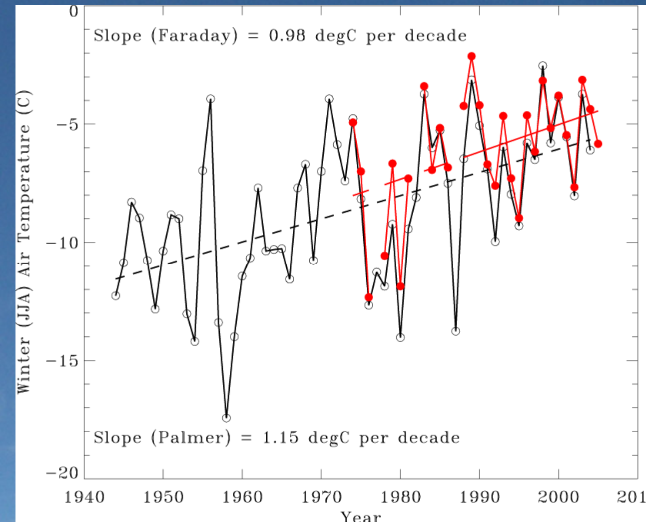




Temperature Trends (degrees C per year)

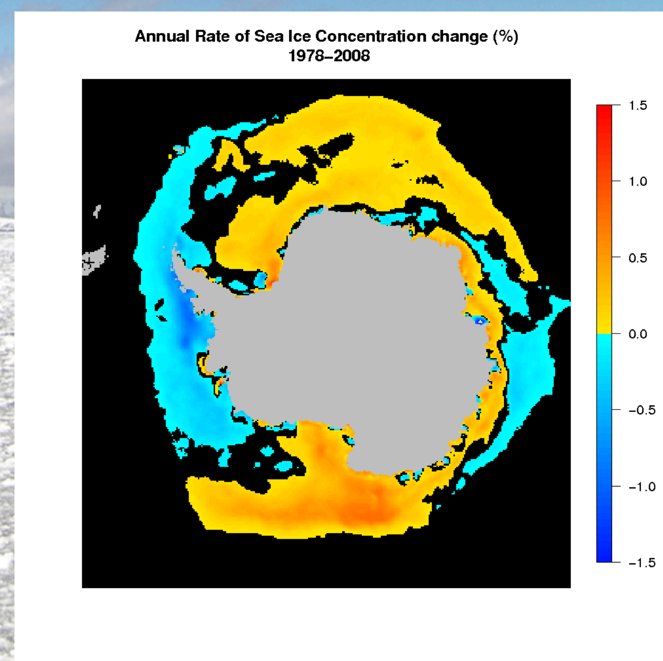
-0.2 0.2

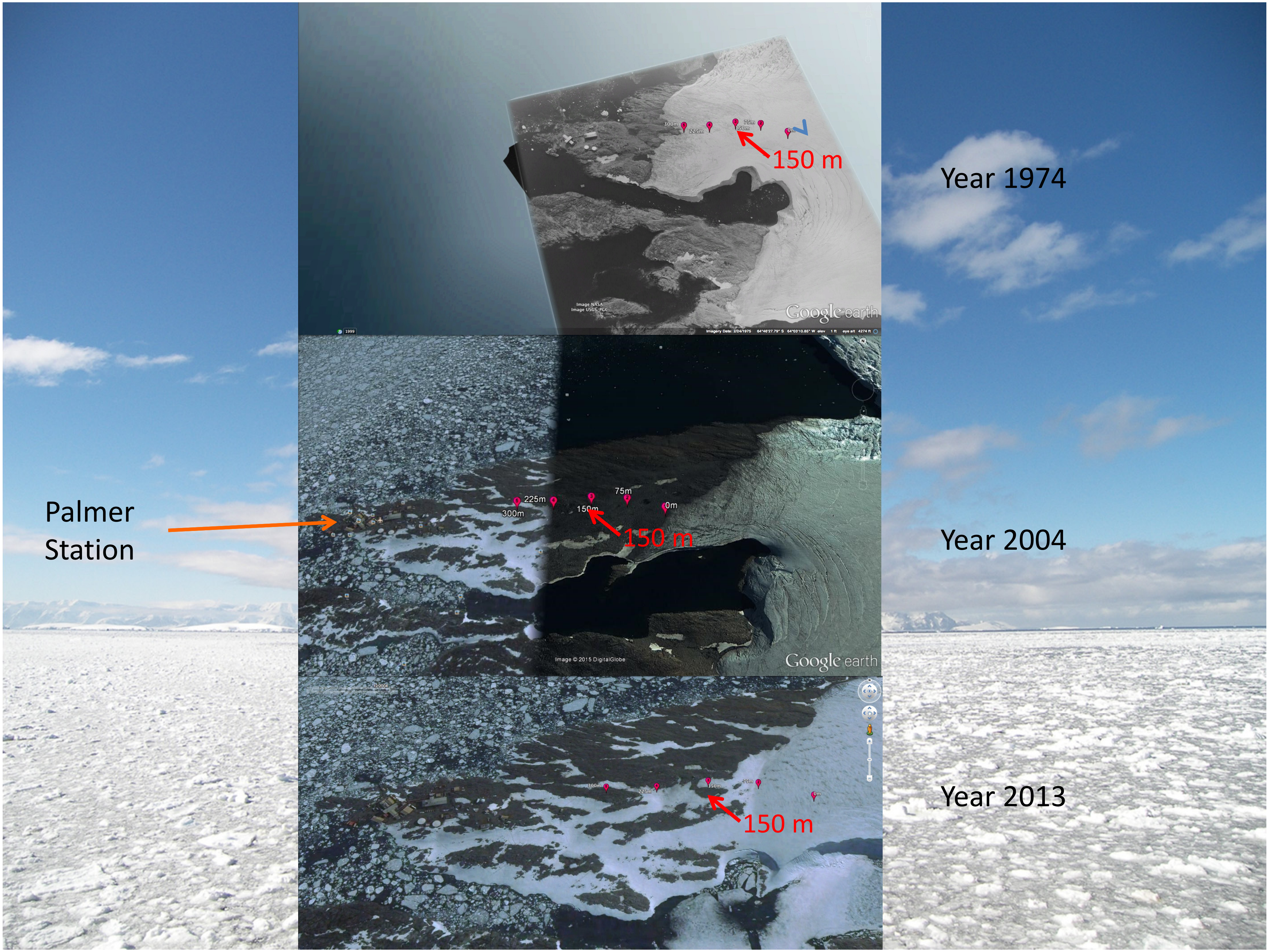
Mean Winter Temperatures



Black is British Faraday & Ukraine Vernadsky Station
Red is US Palmer Station

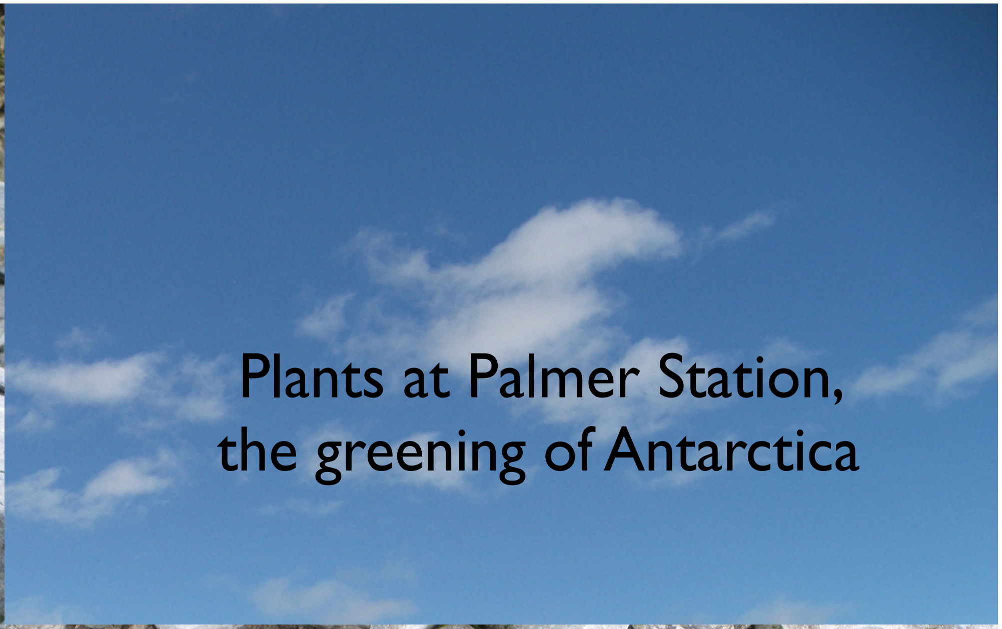
10 year analysis annual trends



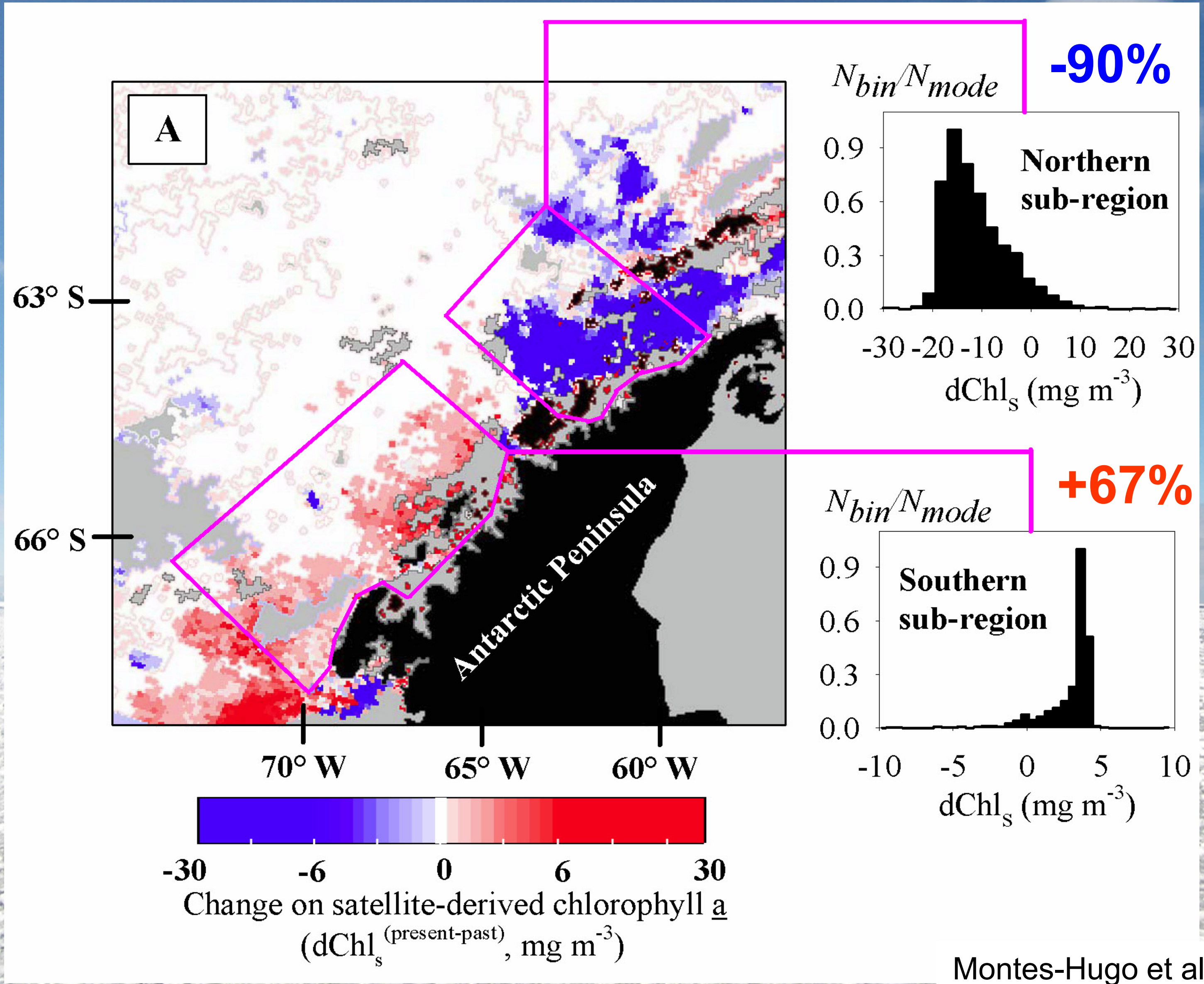


Year 1974
150 m
Google earth
Palmer
Station
225m
300m
150m
75m
0m
150 m
Image © 2015 DigitalGlobe
Google earth
Year 2004
150 m
Year 2013

Plants at Palmer Station, the greening of Antarctica



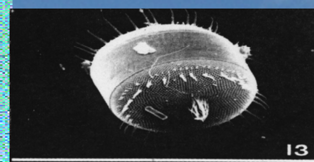
Changes in phytoplankton (1978-86 to 1998-2006) in response to sea ice loss: decreasing in North dominated by small cells, increasing in South, dominated by large diatoms: Two regimes: High Chl/Large cells – Low Chl/small cells



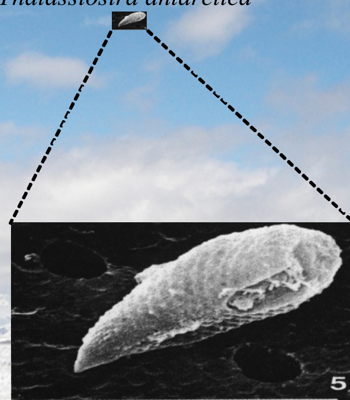
Montes-Hugo et al Science 2009

Picture of some the players

Corethron criophilum



100µm
Thalassiosira antarctica

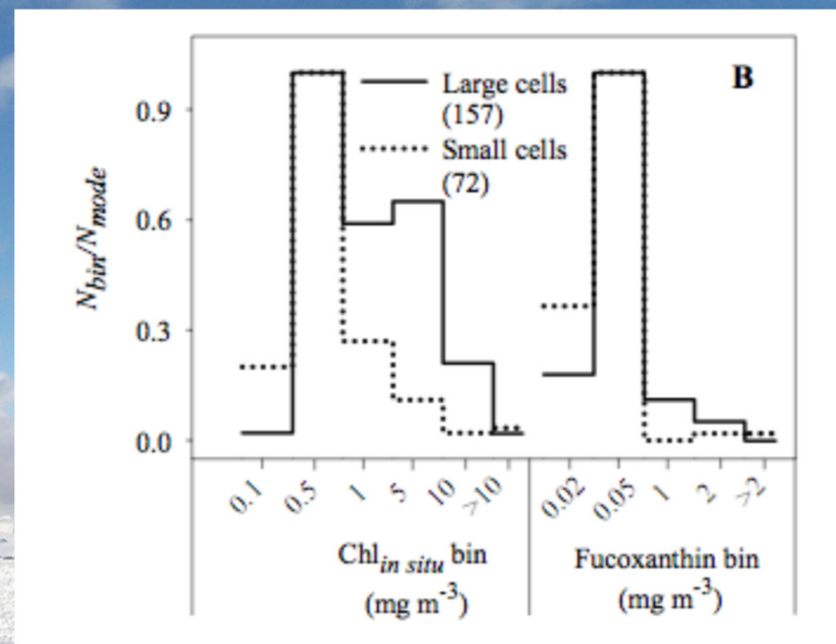


10µm
Cryptomonas cryophila

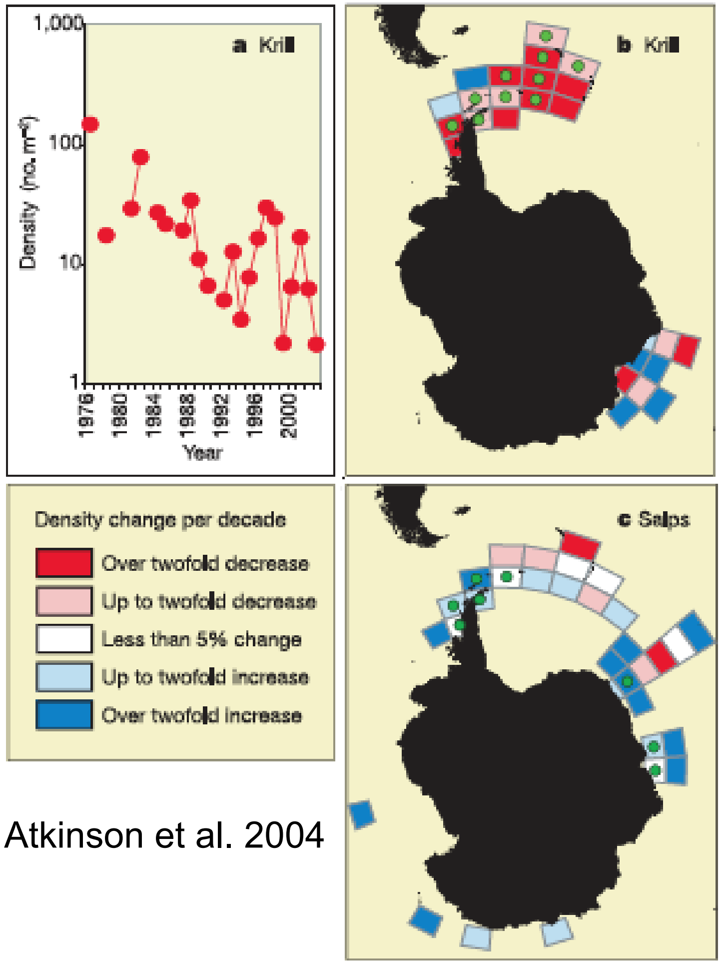
Palmer Cryptophytes --> 8 ± 2µm

SEM Micrographs from *McMinn and Hodgson* 1993

From satellite

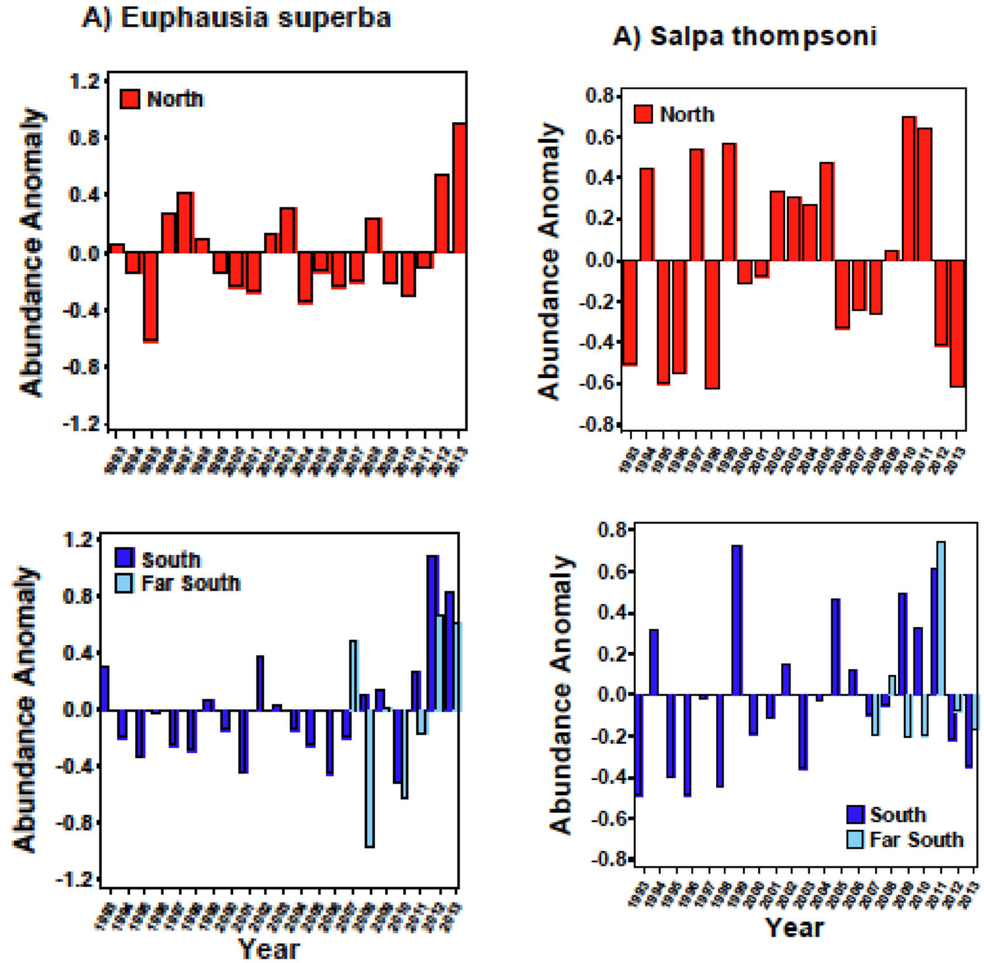


Decadal patterns suggest a shift

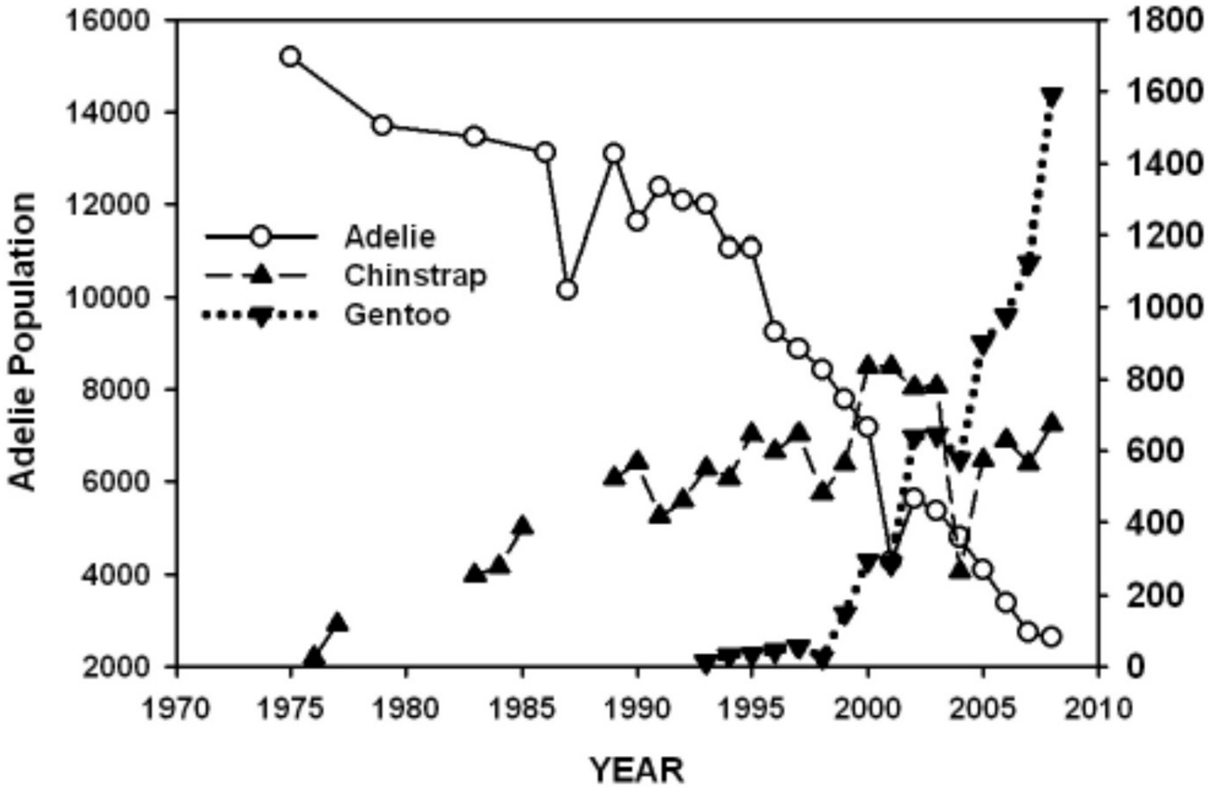


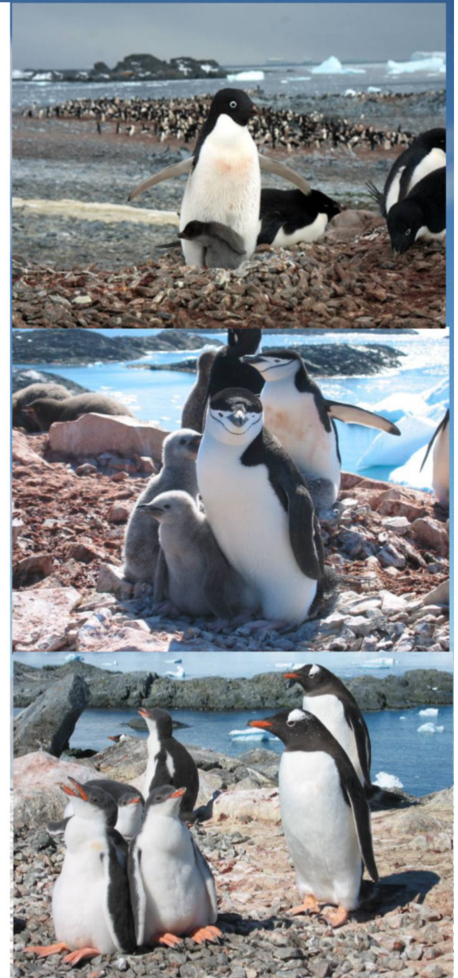
Atkinson et al. 2004

Not as clear in LTER



Decadal shifts in highest trophic levels

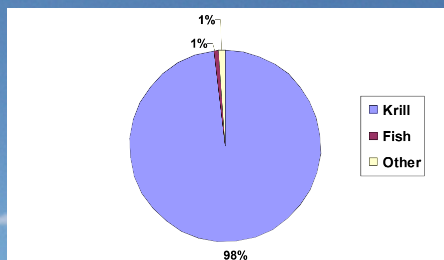


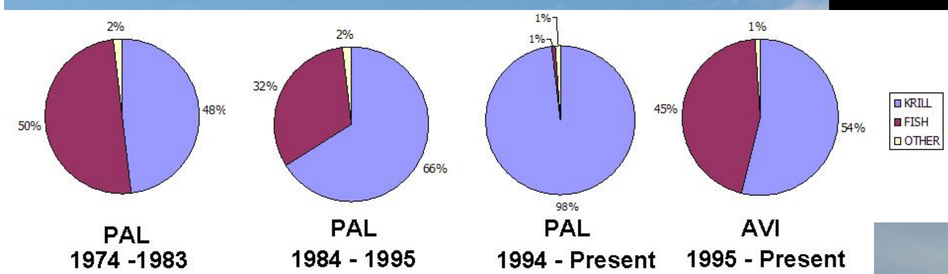


Changes reflect decrease in food resource, changes in the type of food (Antarctic silverfish gone), and increase in atmospheric deposition

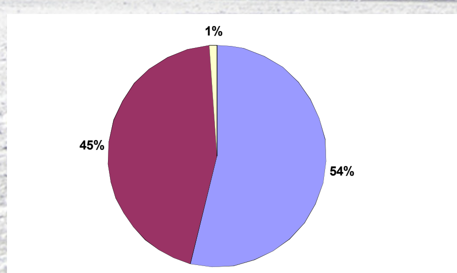
Changing diets for the Adelie penguins

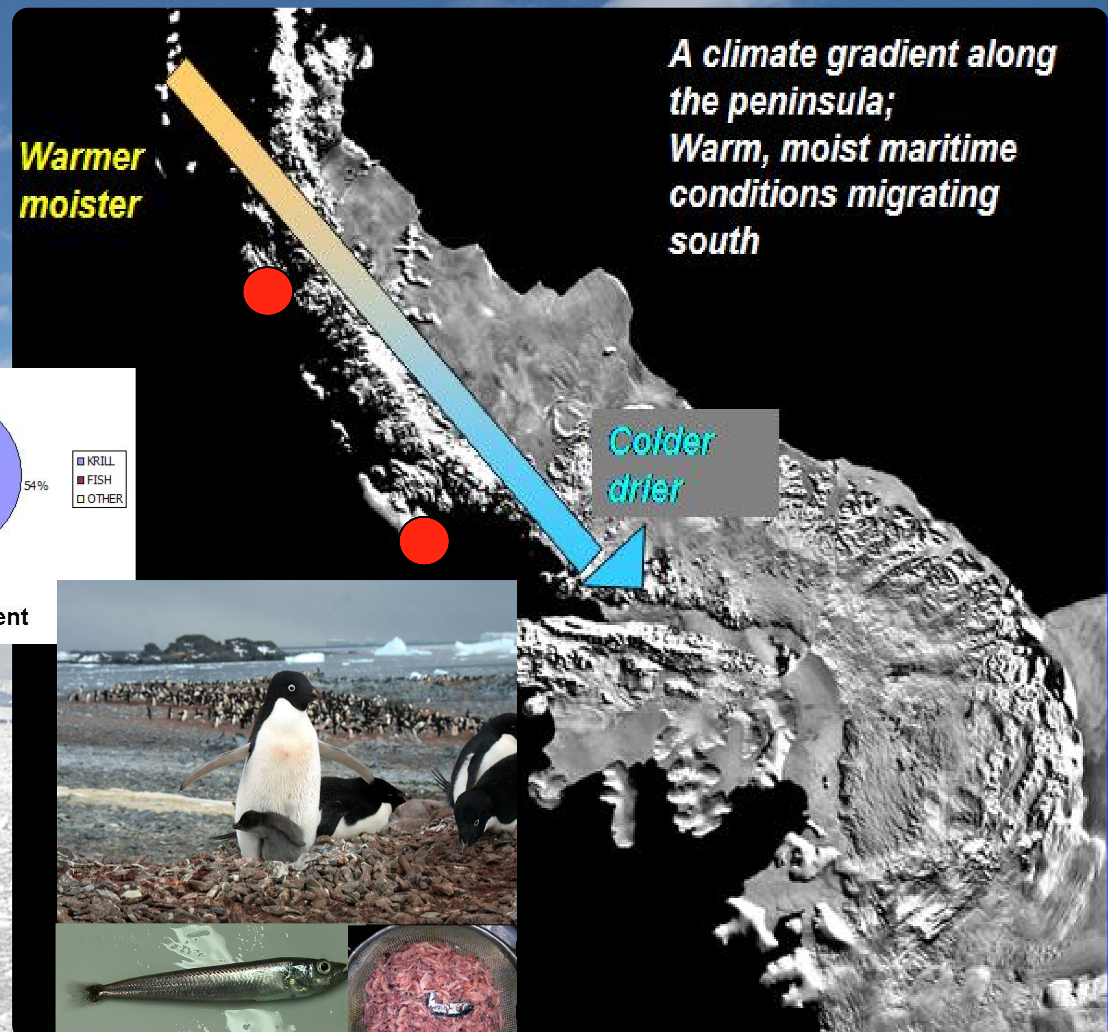
1994-
present





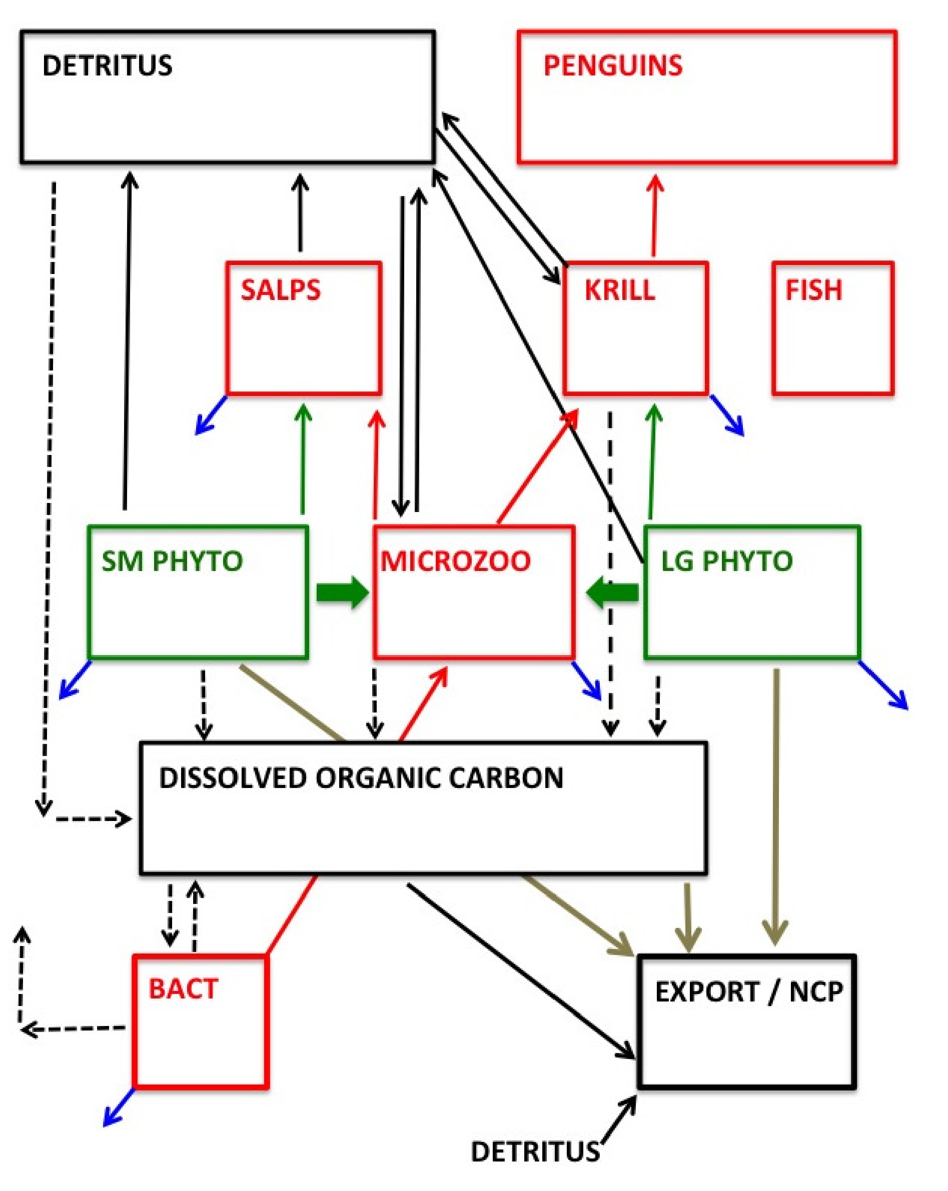
1995-
present





Thanks Bill Fraser

Inverse foodweb model-based estimates of NCP:



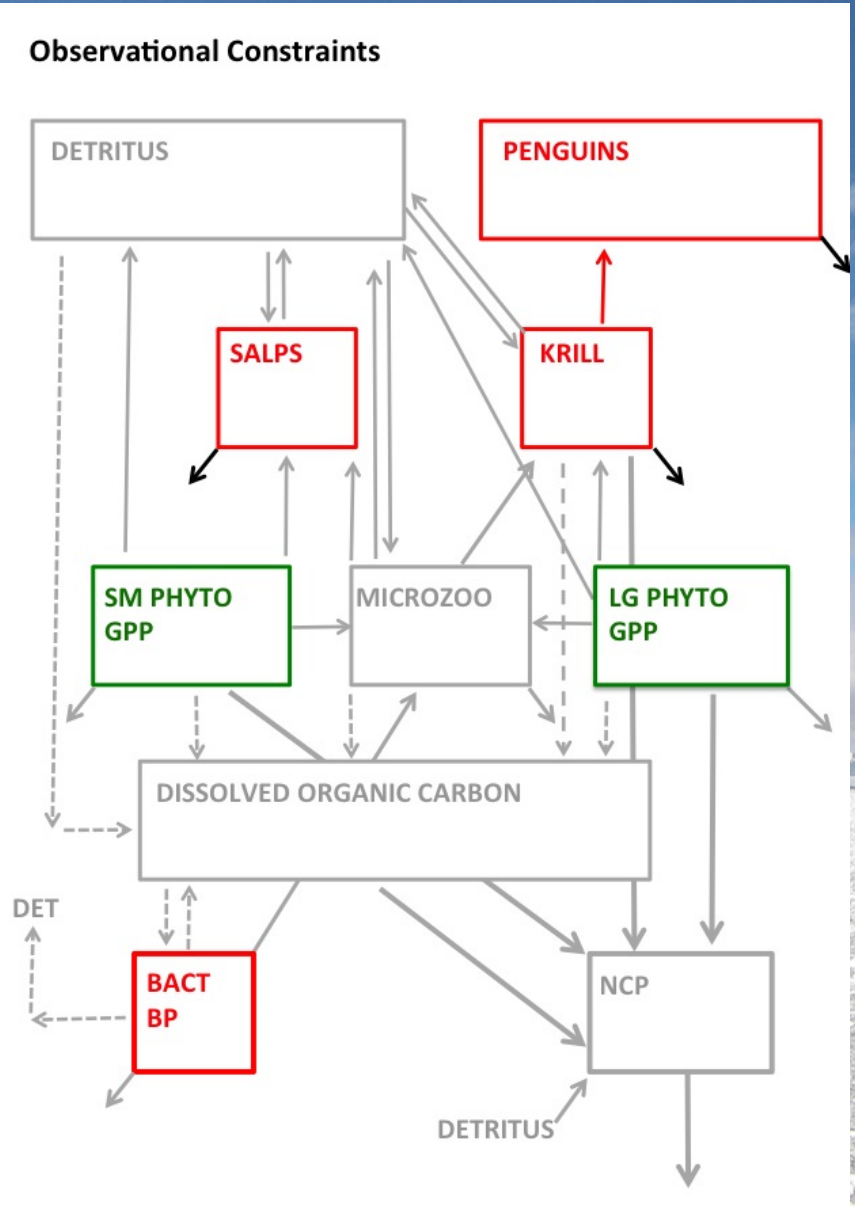
Yields estimates of trophic exchange rates for a specific foodweb structure, consistent with observations, constraints and other assumptions.

Complete solutions for North & South regions, 1995-2006.

NCP = GPP- CR =
Sum of unconsumed production = “Export”

Sevrine et al 2013

Inverse foodweb model-based estimates of NCP:



Observational constraints:

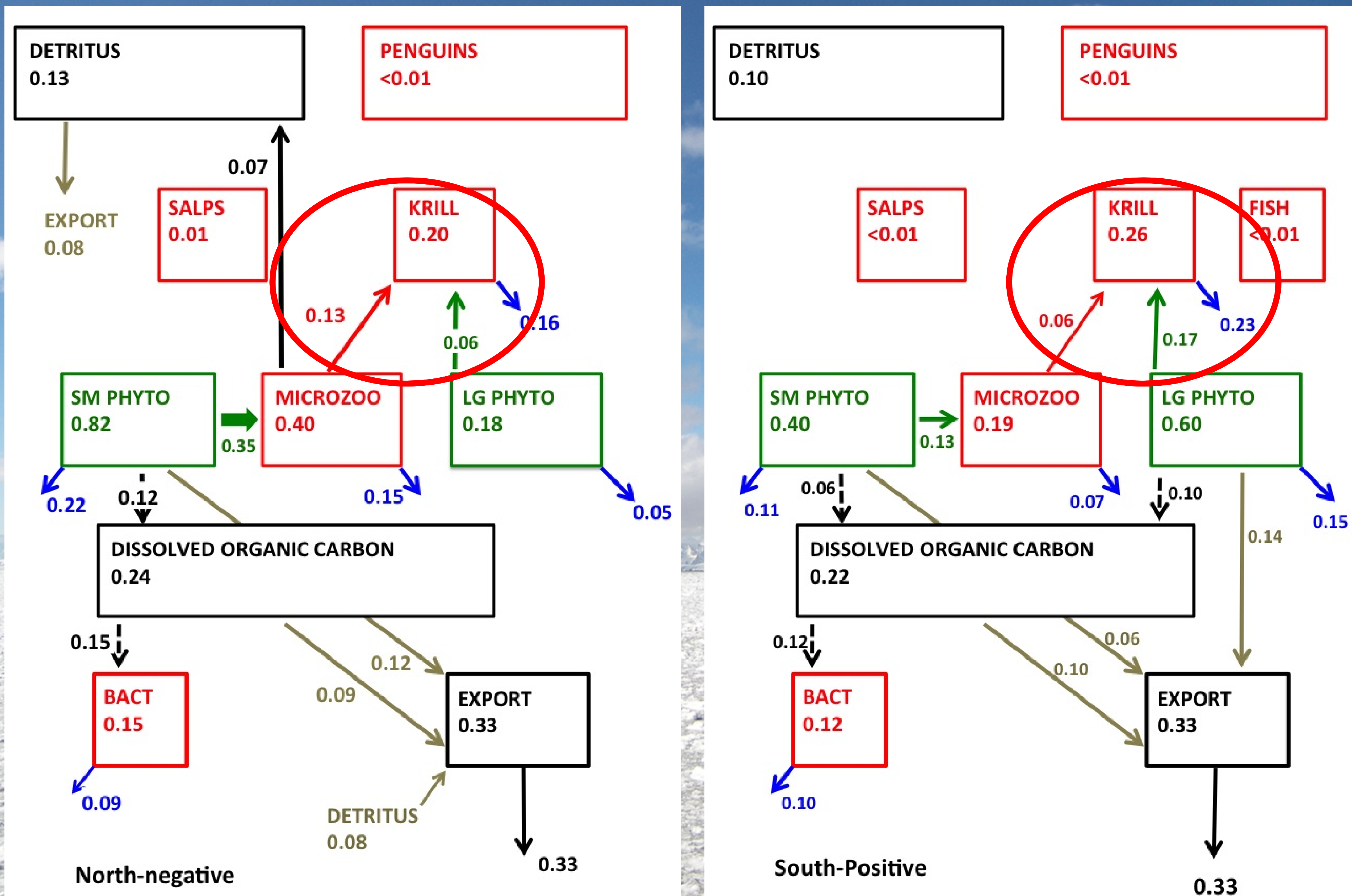
Stocks: Chl, krill, salps, penguins, bacteria

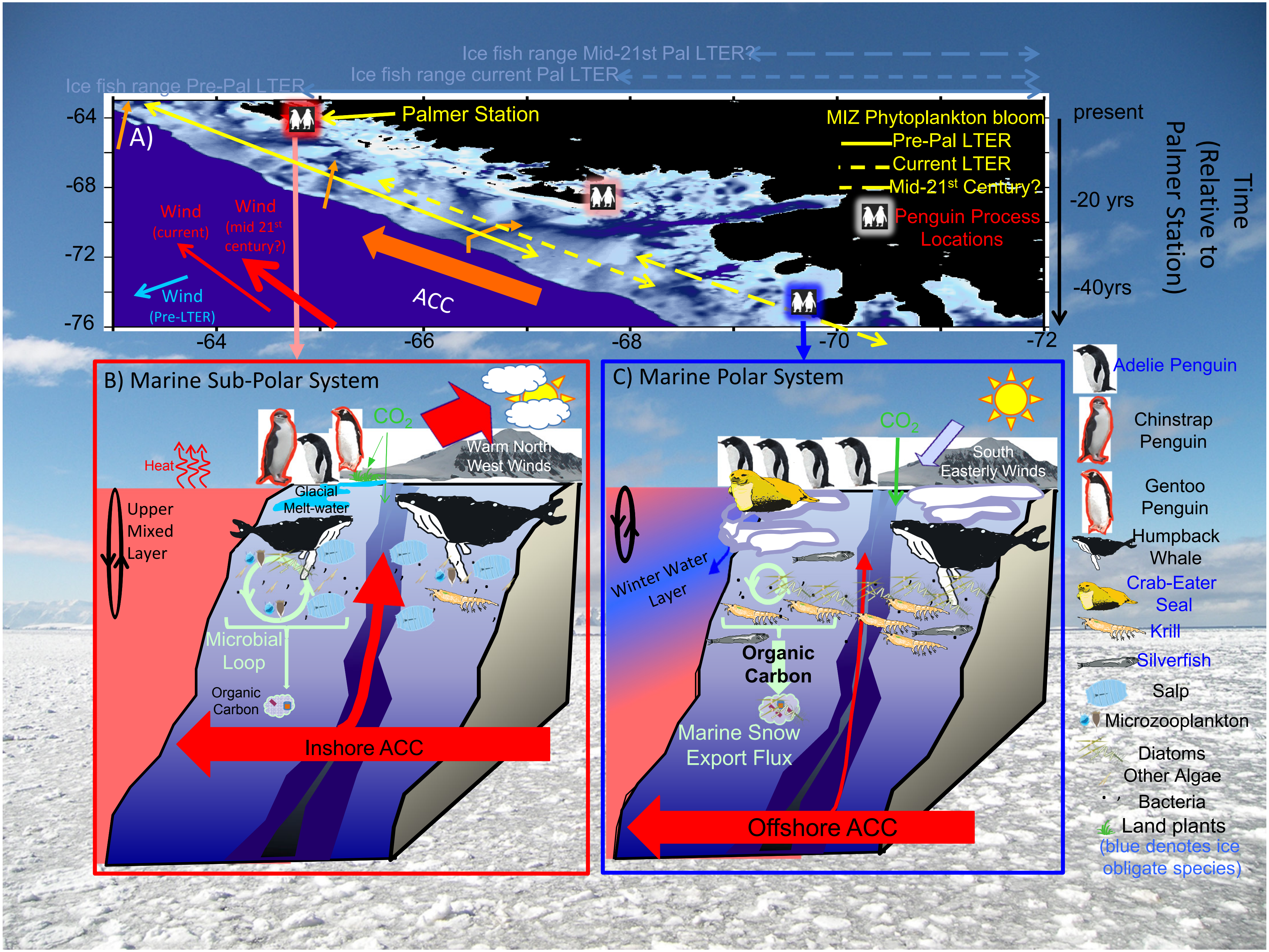
Rates: primary, bacterial production

Size structure: Chl & PP allocated between Large and Small fractions based on size-frac Chl and/or HPLC

See Tables for other constraints

North-Low Chl vs South High Chl: Polar Opposite Regimes
Flows normalized to GPP; only flows < 5% GPP shown





Ice fish range Mid-21st Pal LTER?
Ice fish range current Pal LTER
Ice fish range Pre-Pal LTER
-64
-68
-72
-76
-64
-66
-68
-70
-72
A)
Palmer Station
MIZ Phytoplankton bloom
Pre-Pal LTER
Current LTER
Mid-21st Century?
Penguin Process Locations
Wind (current)
Wind (mid 21st century?)
Wind (Pre-LTER)
ACC
present
-20 yrs
-40yrs
Time (Relative to Palmer Station)
B) Marine Sub-Polar System
CO2
Heat
Warm North West Winds
Glacial Melt-water
Upper Mixed Layer
Microbial Loop
Organic Carbon
Inshore ACC
C) Marine Polar System
CO2
South Easterly Winds
Winter Water Layer
Organic Carbon
Marine Snow Export Flux
Offshore ACC
Adelie Penguin
Chinstrap Penguin
Gentoo Penguin
Humpback Whale
Crab-Eater Seal
Krill
Silverfish
Salp
Microzooplankton
Diatoms
Other Algae
Bacteria
Land plants
(blue denotes ice obligate species)

CONCLUSIONS

WAP is undergoing changes driven by the circumpolar current communication to the continental shelf.

The north is transitioning to a sub-polar marine system with an increased importance of the microbial loop.

The changes in the northern system are reflected in higher trophic levels

LTERS are long term investments for many scientists, thanks to past Pis
Barbara Prezelin, John Klinck, Maria Vernet, Robin Ross, Langdon Quetin, Eileen Hoffman, Dave Karl, Ray Smith and MANY MANY others