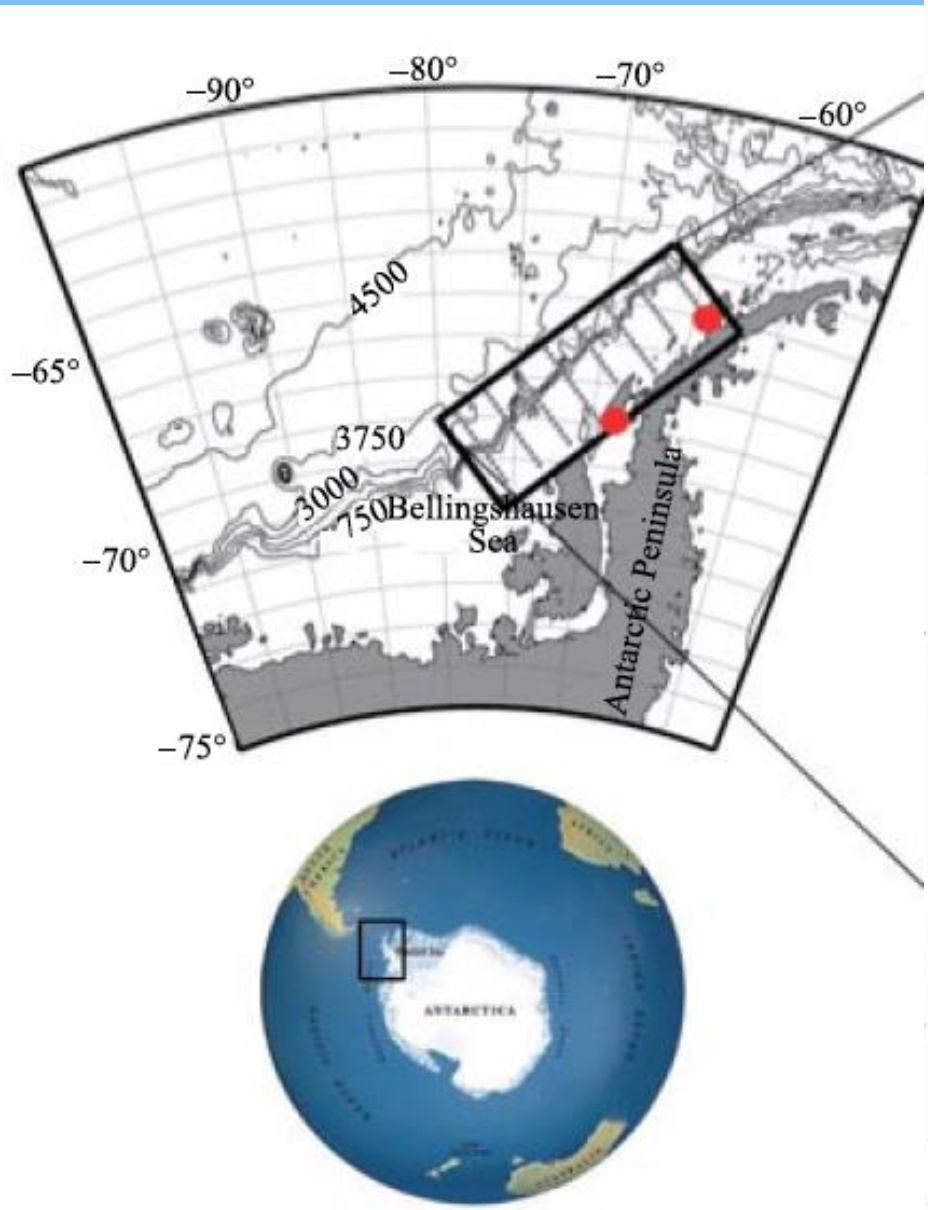
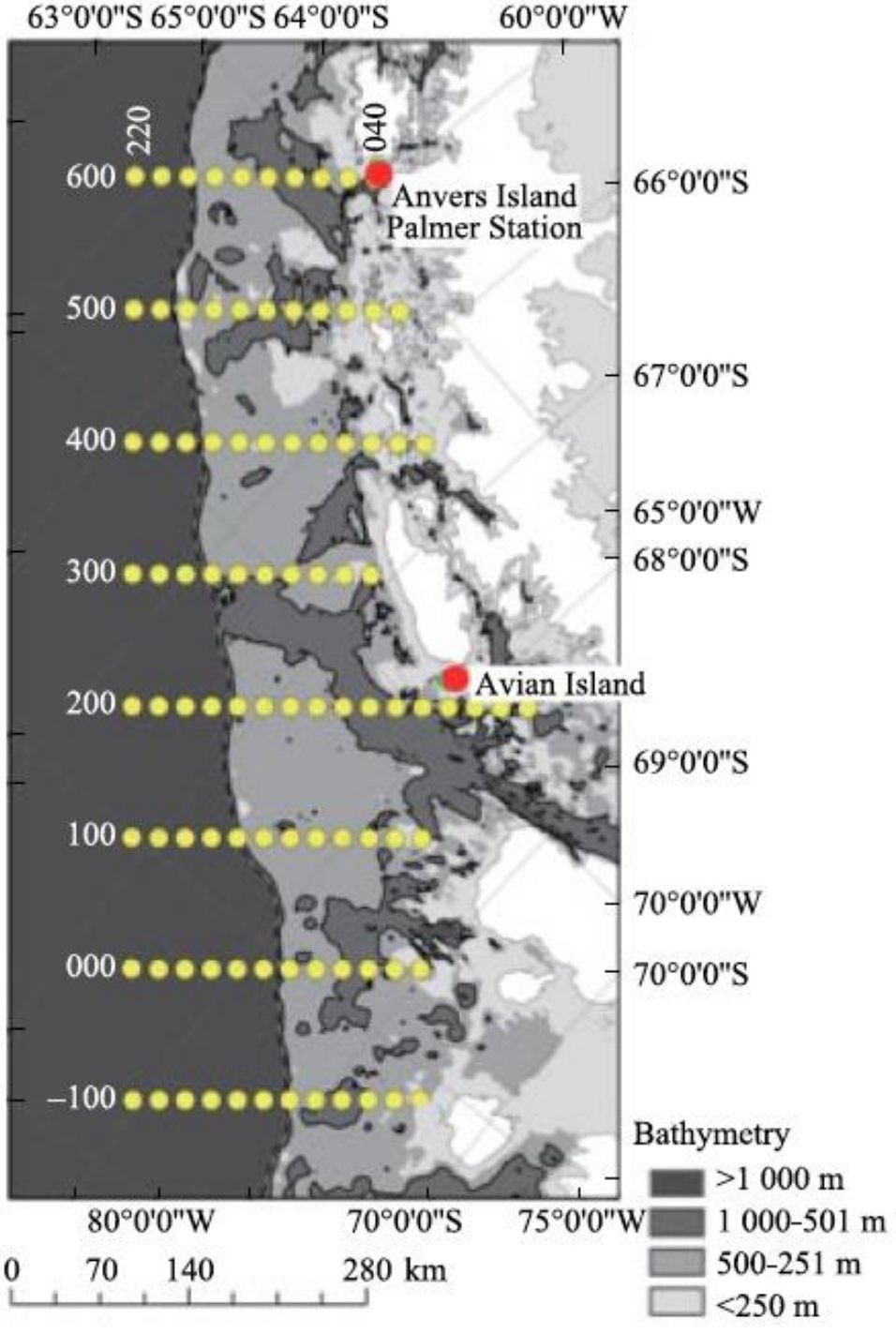
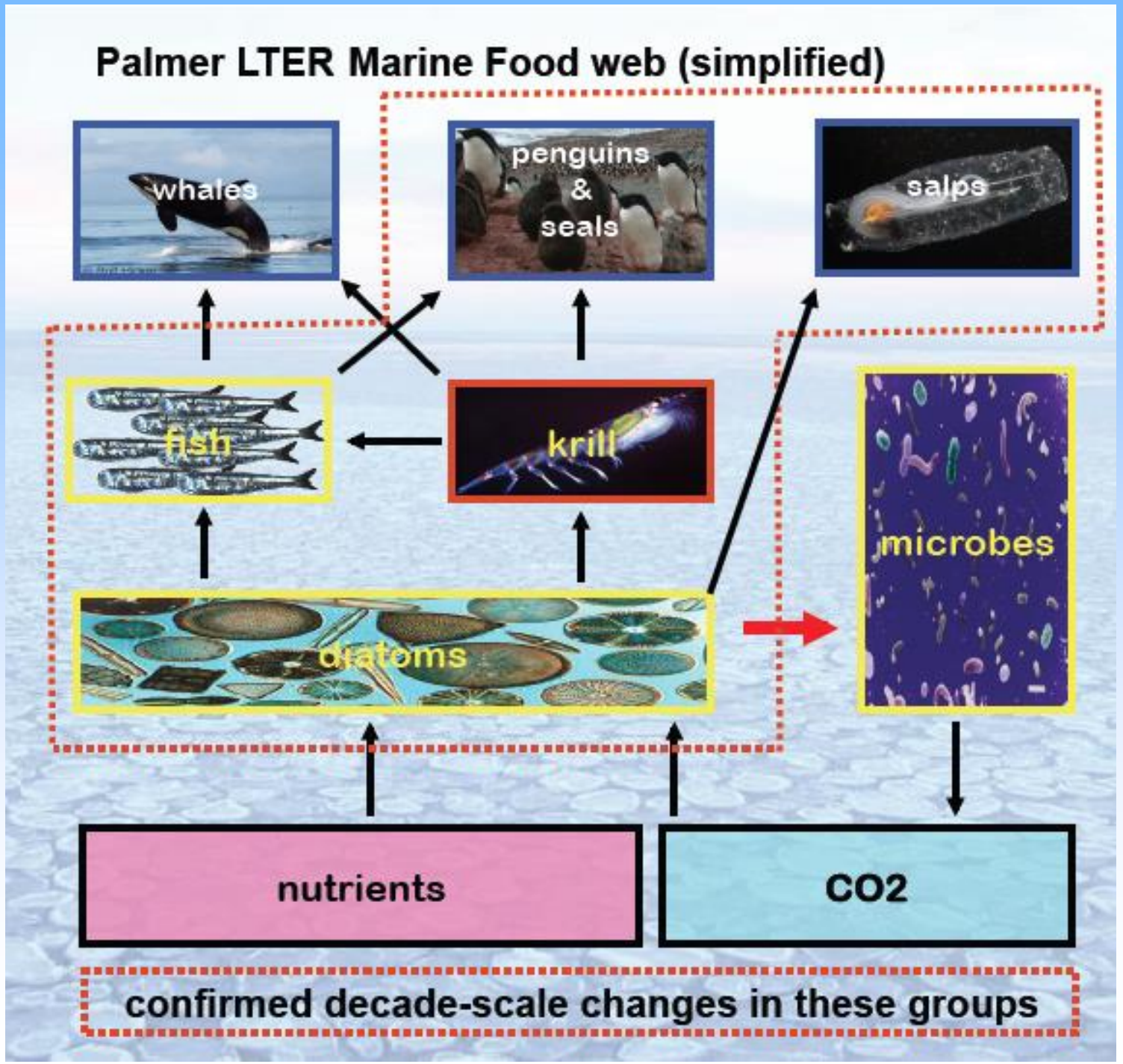
Changing Coastal-Ocean Biogeochemistry Along The Western Antarctic Peninsula

Scott Doney Woods Hole Oceanographic Institution &
Palmer Station Antarctica LTER Team (http://pal.lter.edu)

Palmer LTER Region





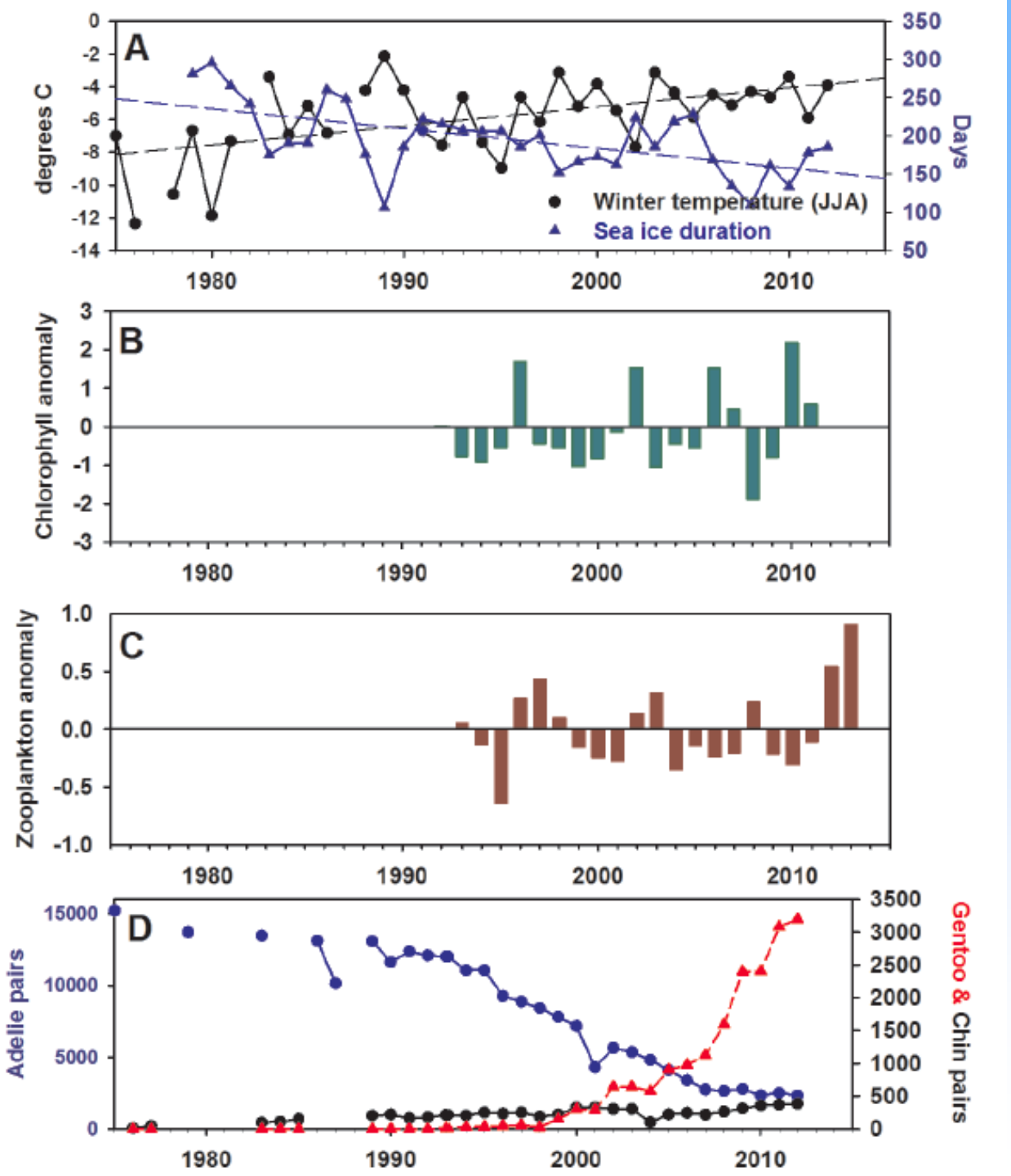

Palmer LTER Marine Food web (simplified)
whales
penguins & seals
salps
fish
krill
microbes
diatoms
nutrients
CO2
confirmed decade-scale changes in these groups

-Surface warming
-Shorter sea-ice duration

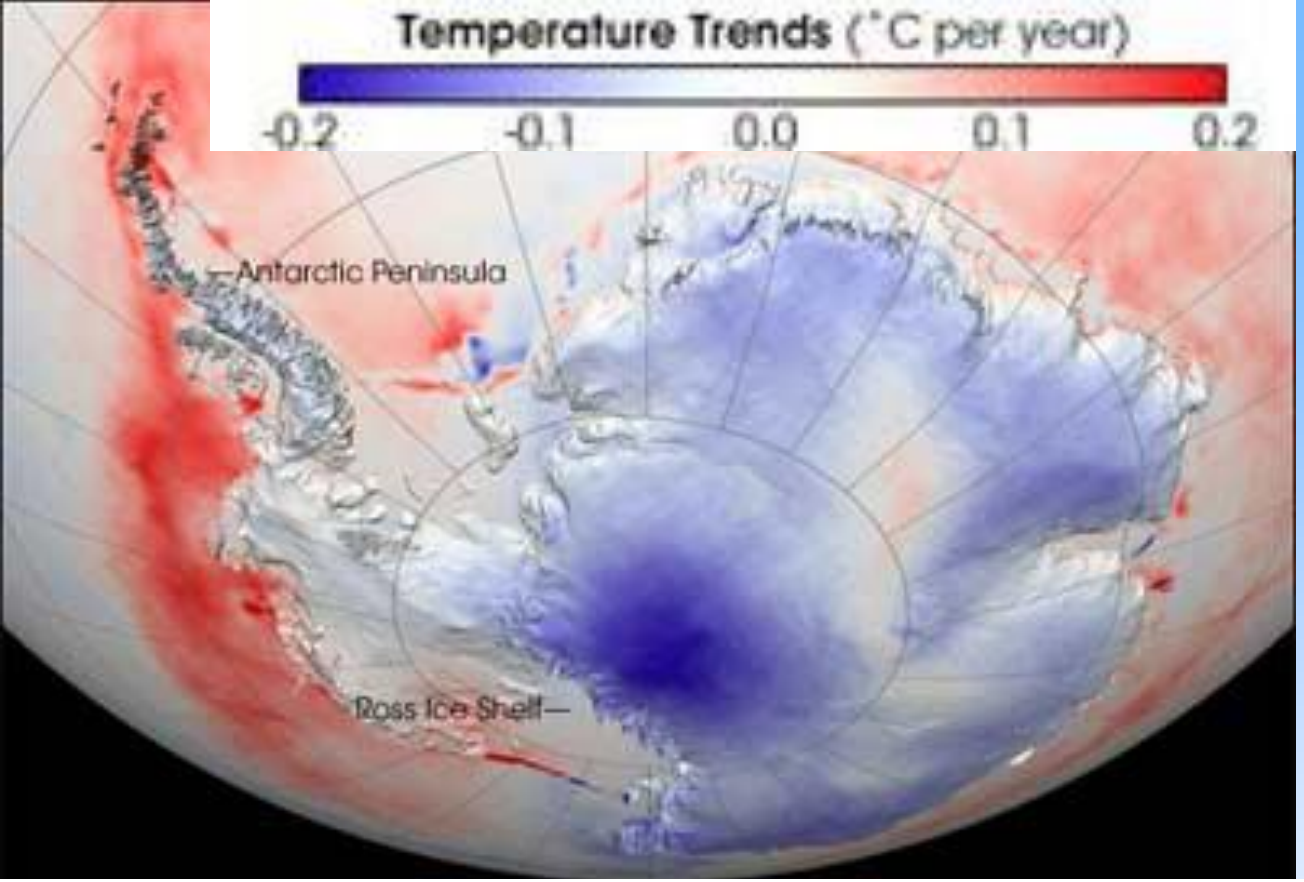
-Phytoplankton blooms every 3-5 years

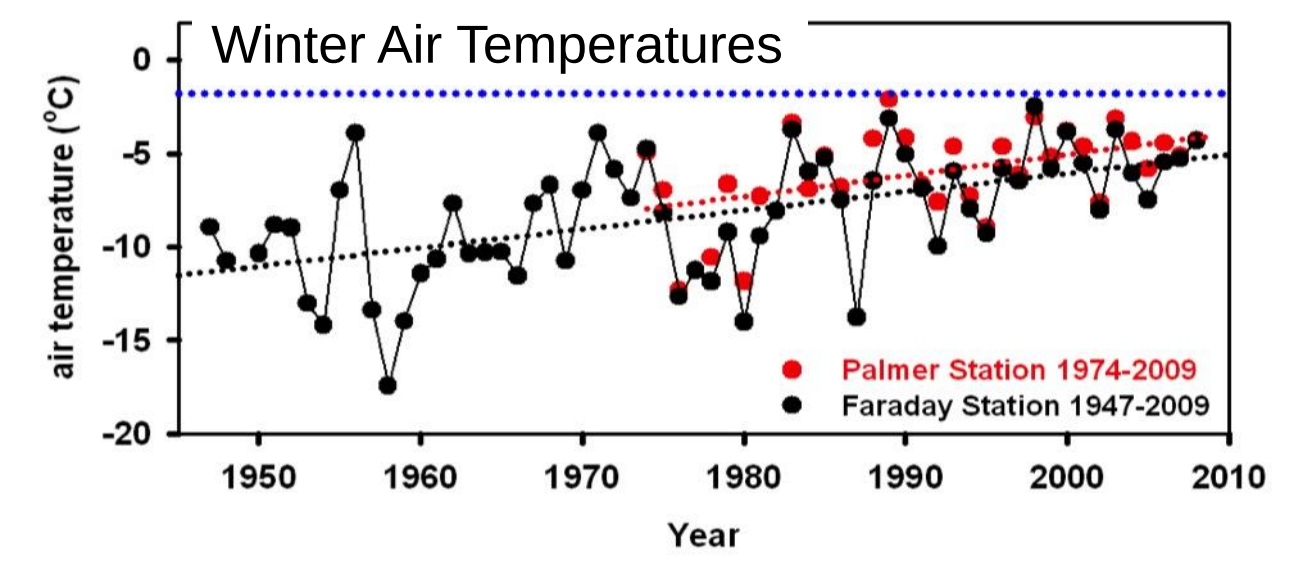
-Zooplankton lag phytoplankton blooms

-Reduced penguin abundance & shift in species



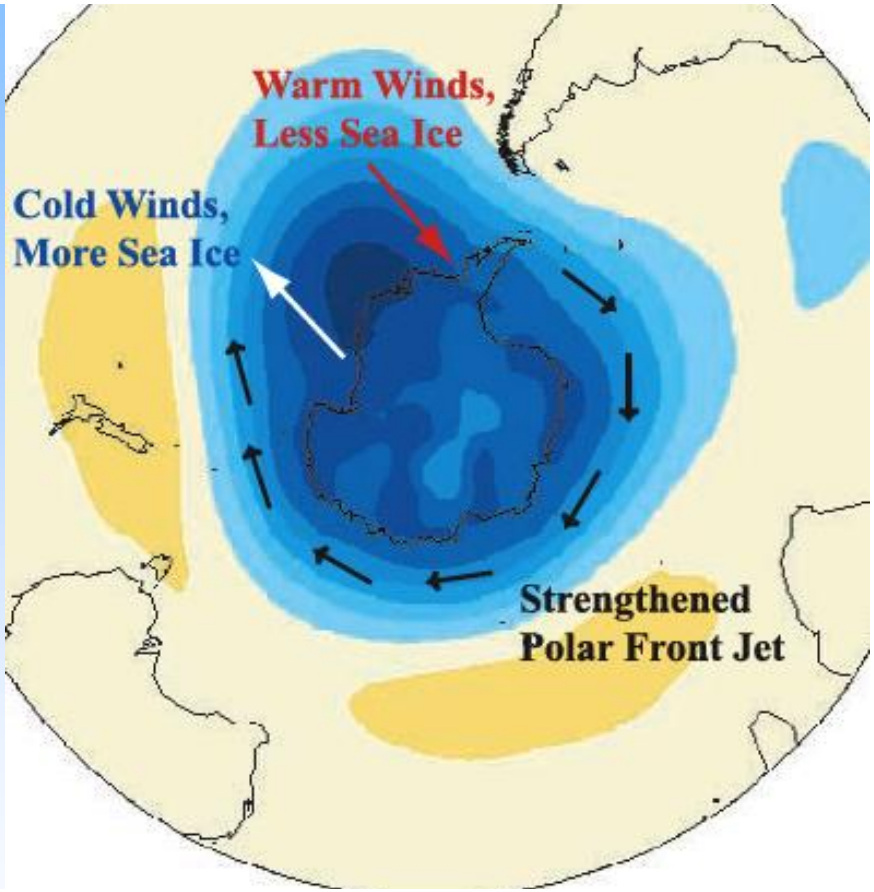
Rapid Warming along Western Antarctic Peninsula





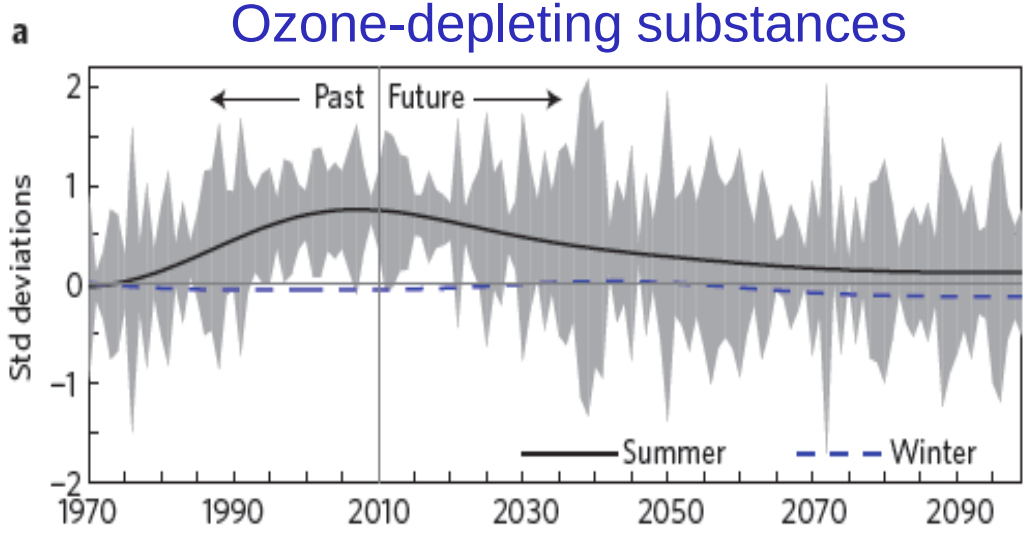
Southern Annular Mode, Winds & Sea-ice

Surface Pressure Anomalies for + Southern Annual Mode

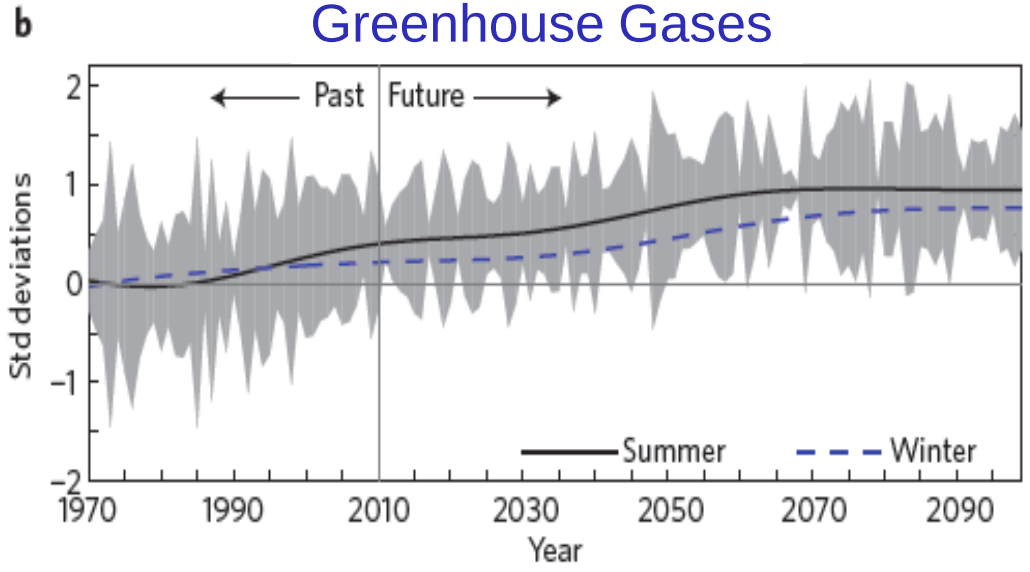


Stammerjohn et al.
J. Geophys. Res. 2008
Meredith et al.
Progress Oceanogr. 2010

Ozone-depleting substances

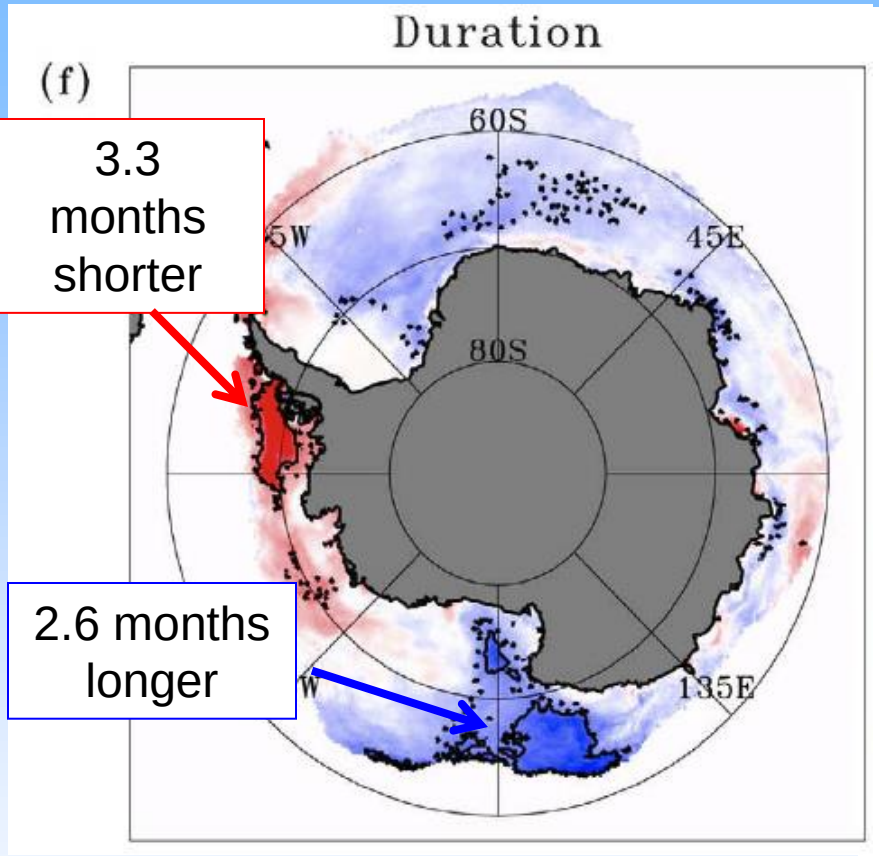


Greenhouse Gases



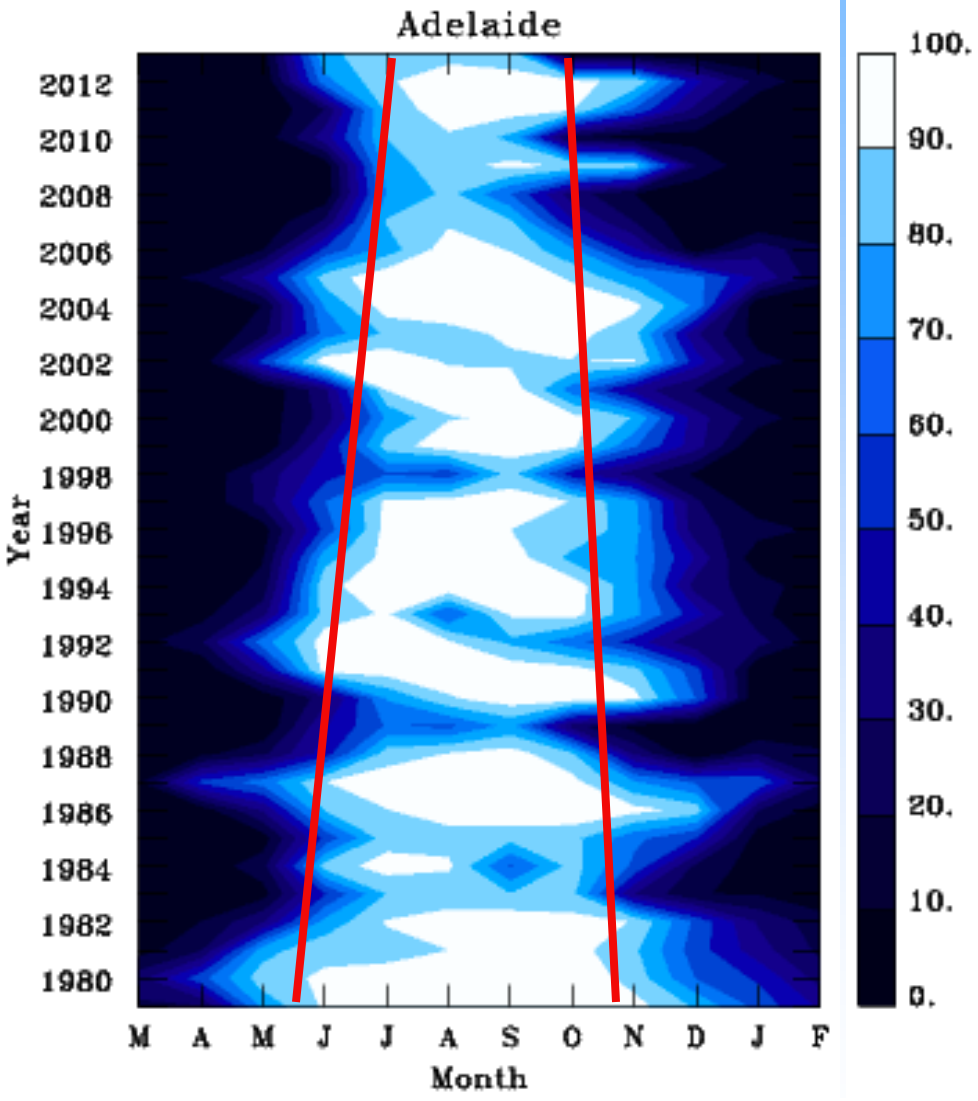
Thompson et al.
Nature Geoscience

Declining Seasonal Sea-ice along Peninsula



(1979/80 – 2010/11)

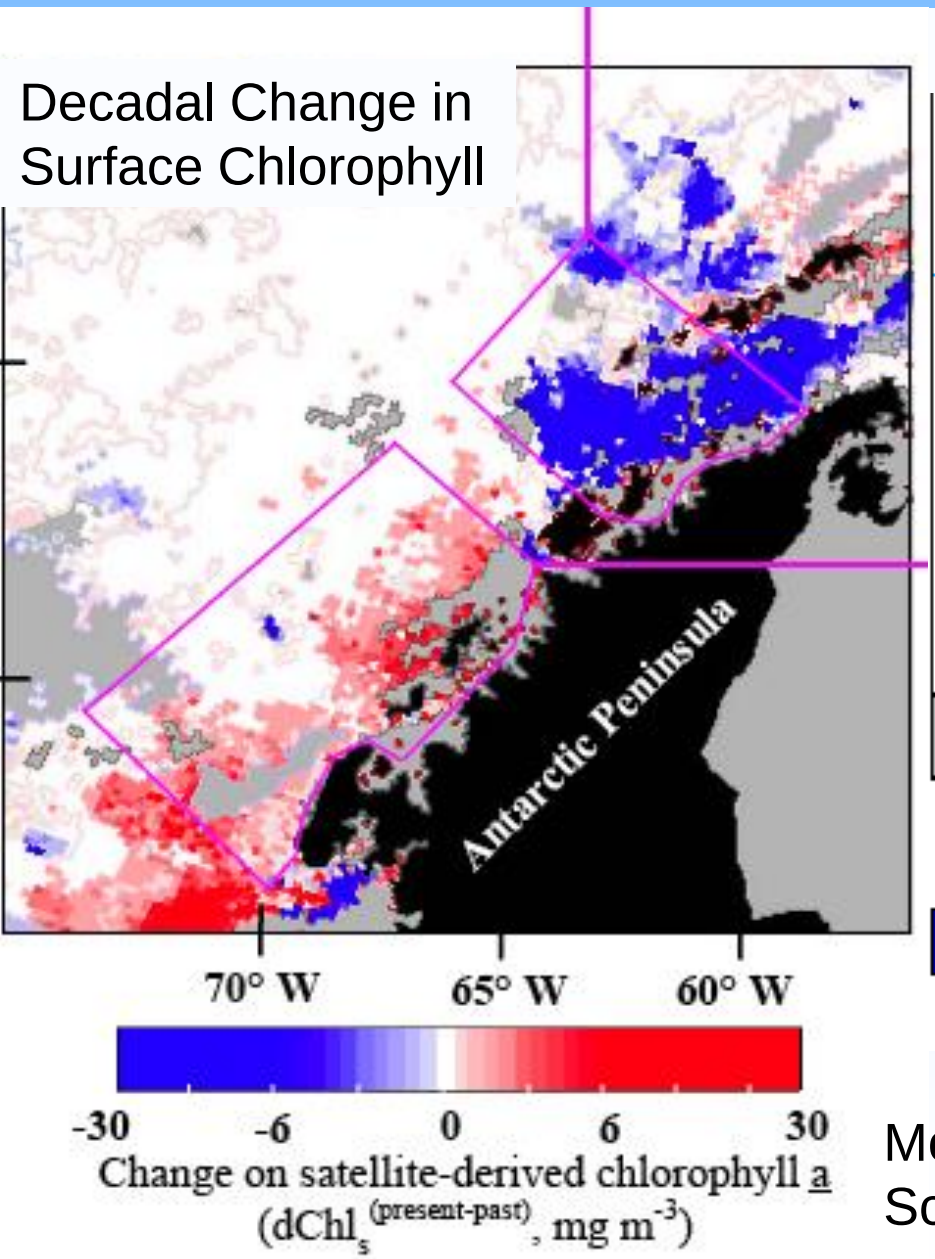
Stammerjohn et al.
Geophysical Research Letters
2012



Sharon Stammerjohn U Colorado Boulder

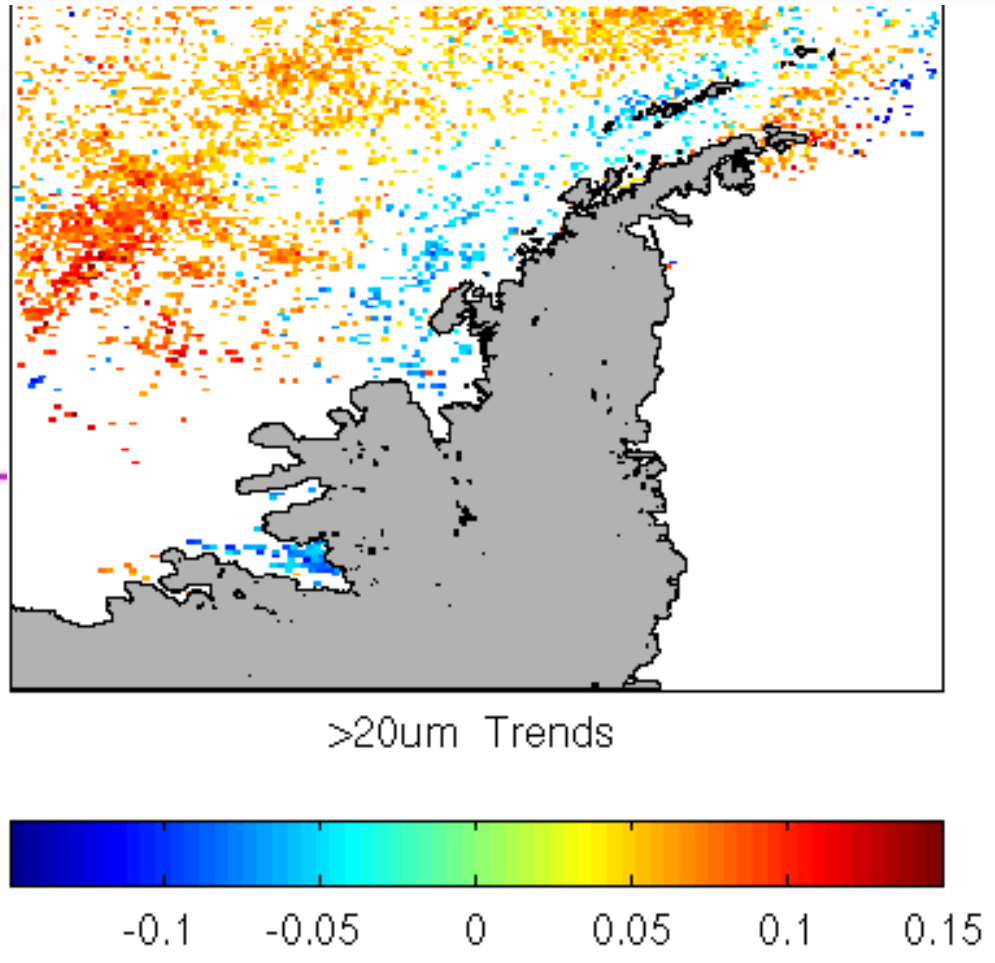
Ecological Changes to Retreating Sea-Ice

Decadal Change in Surface Chlorophyll

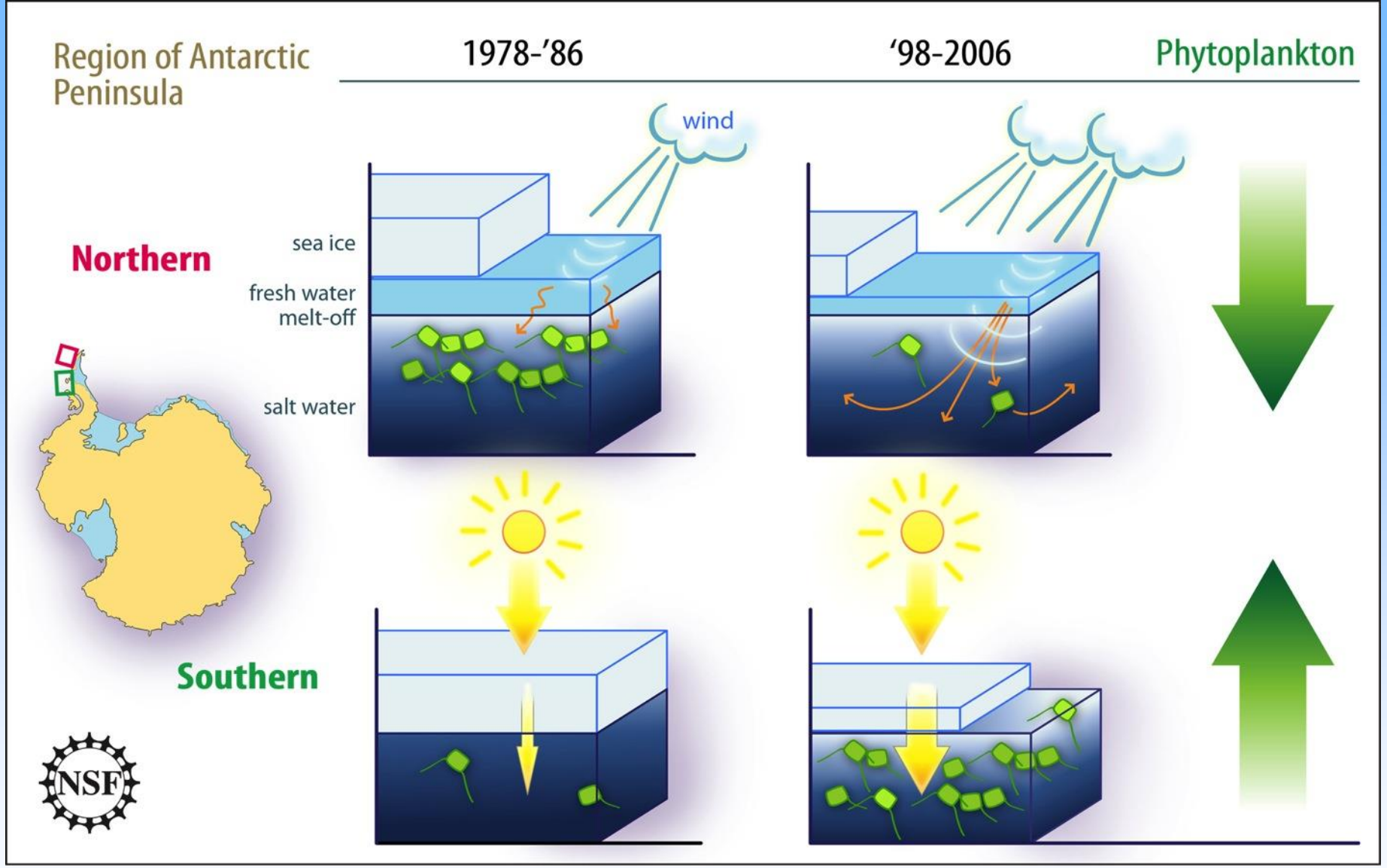


Montes et al. Science (2009)

Trend in Large Phytoplankton Fraction



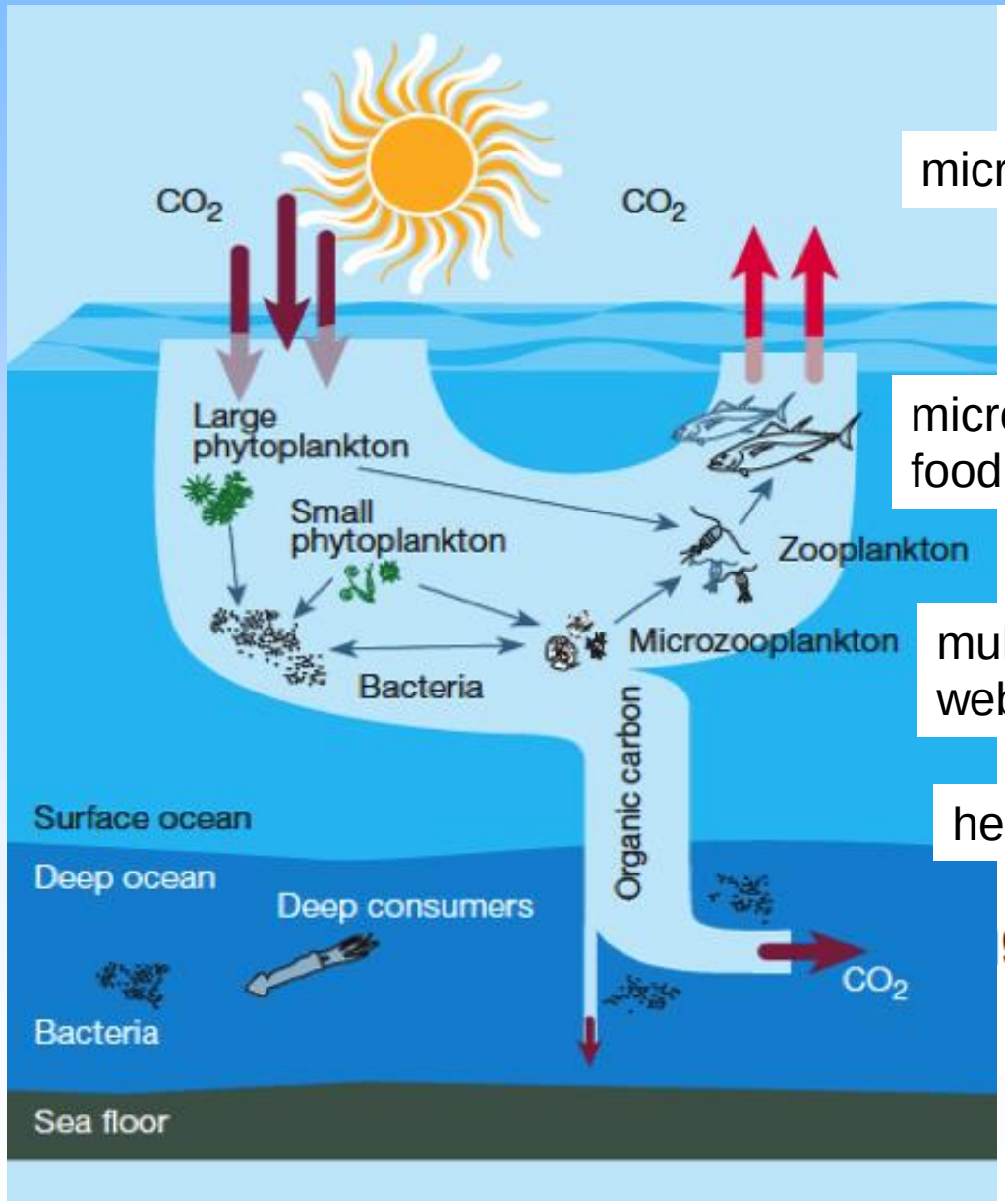
M. Kavanaugh et al. in preperation



-Sea ice melt stabilizes upper ocean and fosters phytoplankton growth
-Long sea ice duration acts as a barrier to light penetration and prevents growth

Courtesy Zina Deretsky, NSF

Ecosystem & Biogeochemical Trends

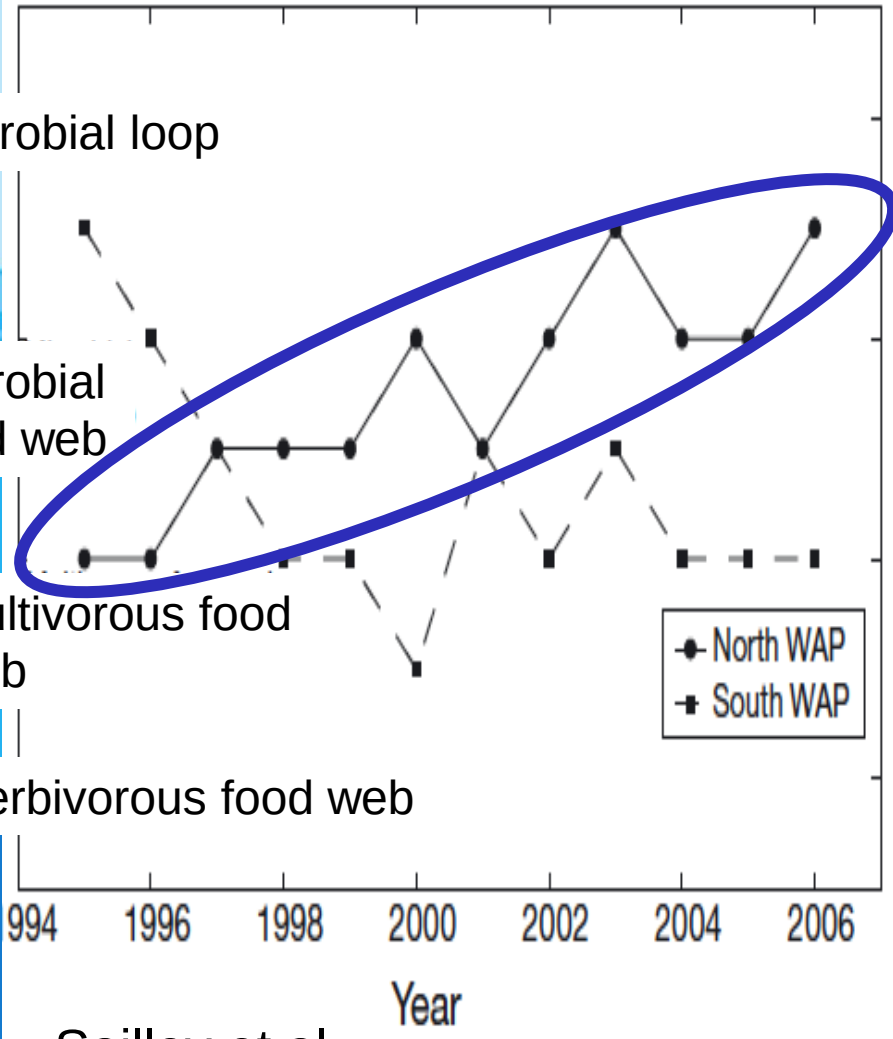


microbial loop

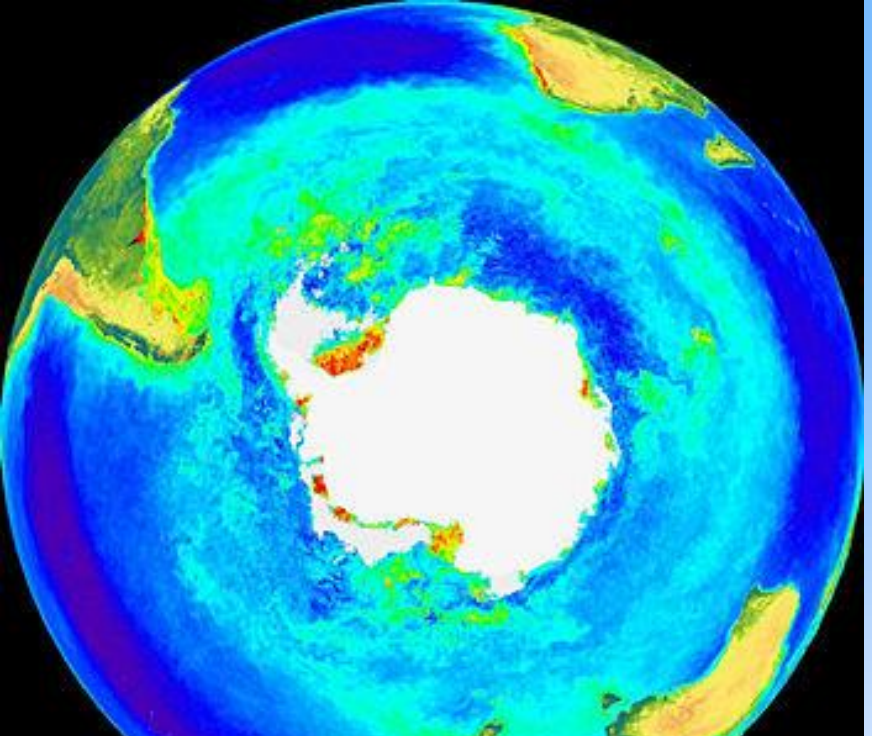
microbial food web

multivorous food web

herbivorous food web

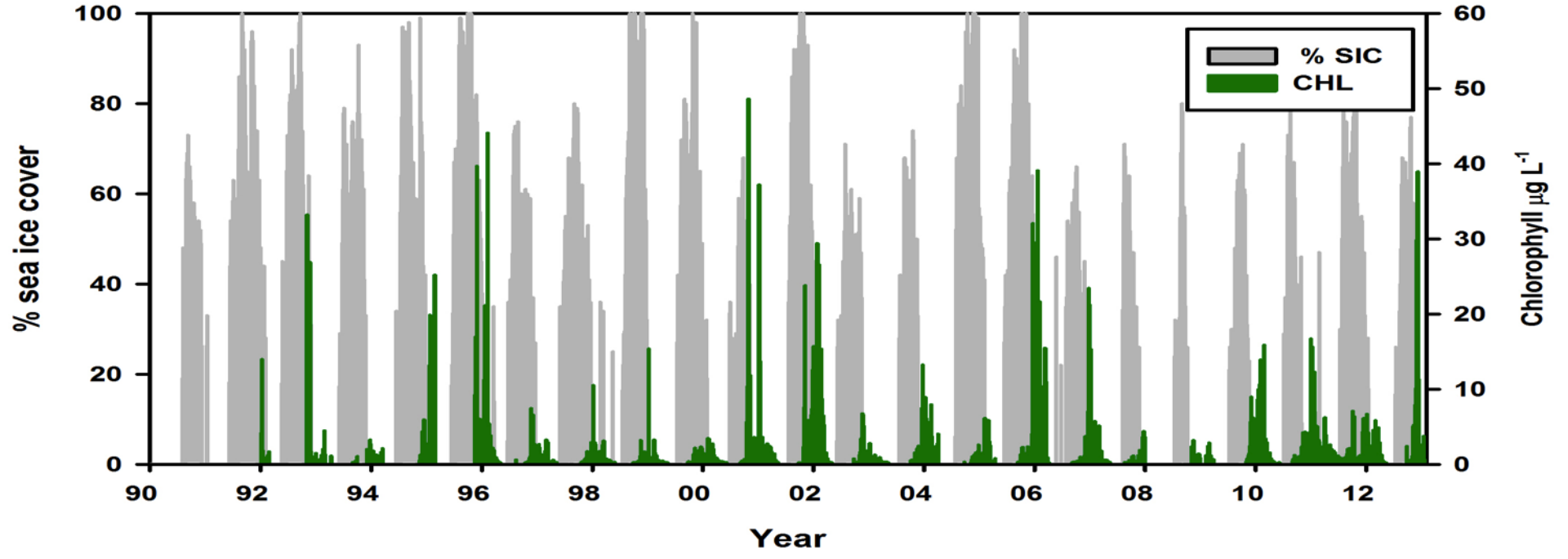


Sailley et al.
Marine Ecological
Progress Series 2013

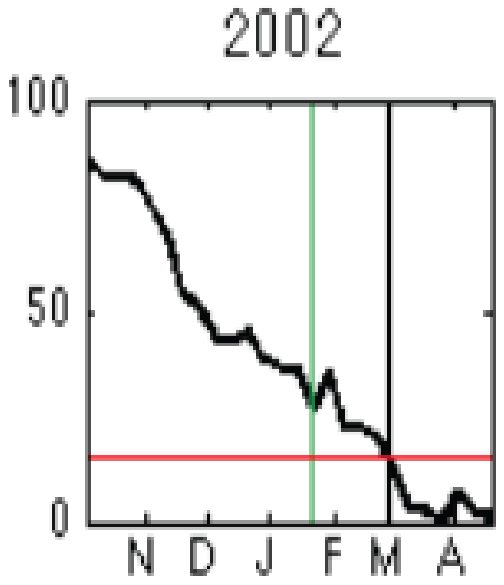


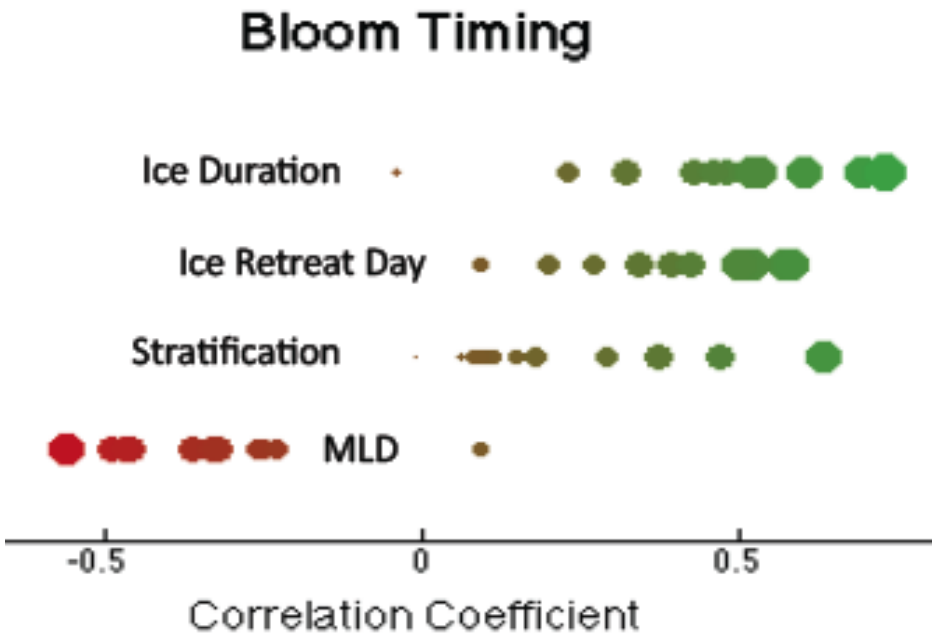
Phytoplankton Blooms, Iron Limitation & Seasonal Sea-Ice Dynamics

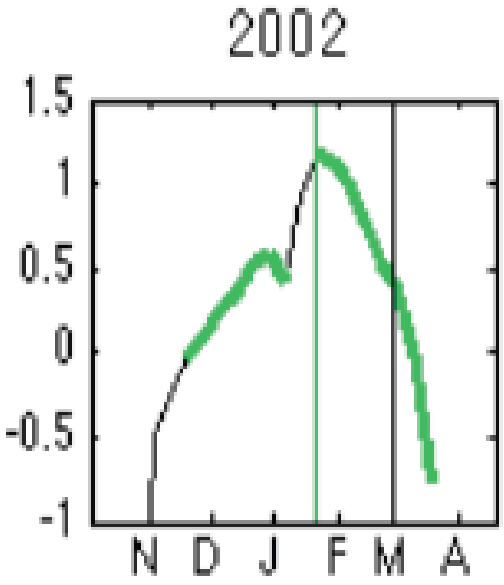
Ducklow et al.
Oceanography 2013

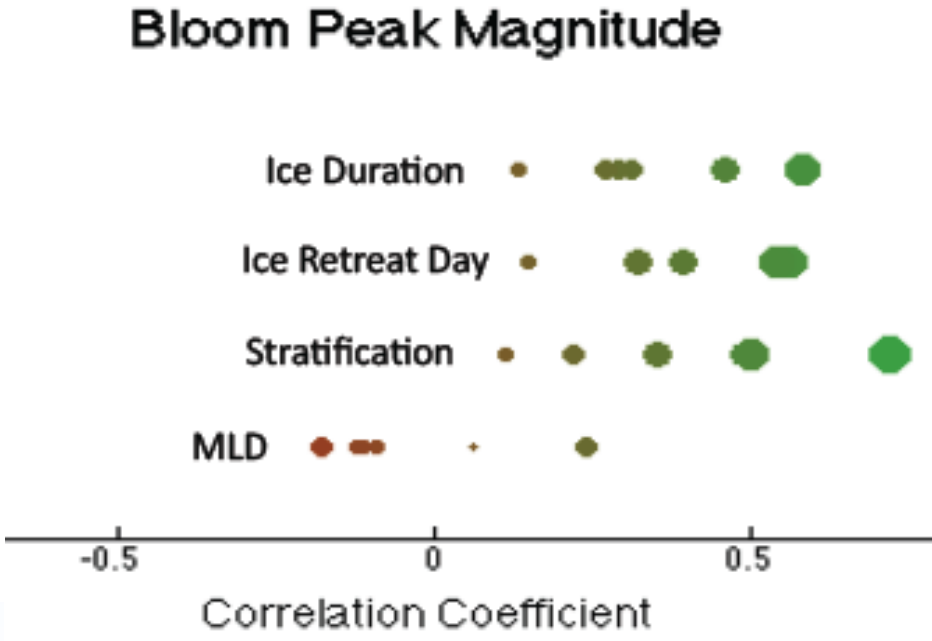


Bloom Phenology



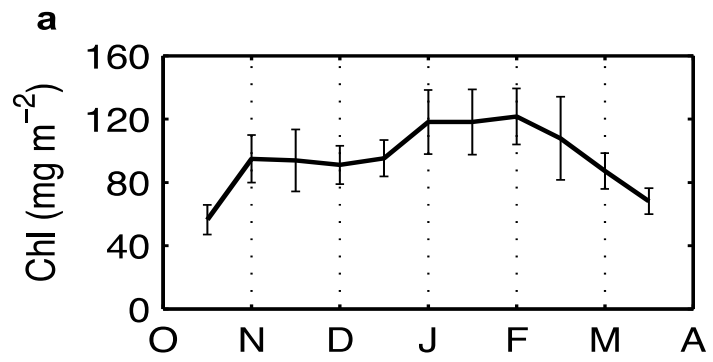


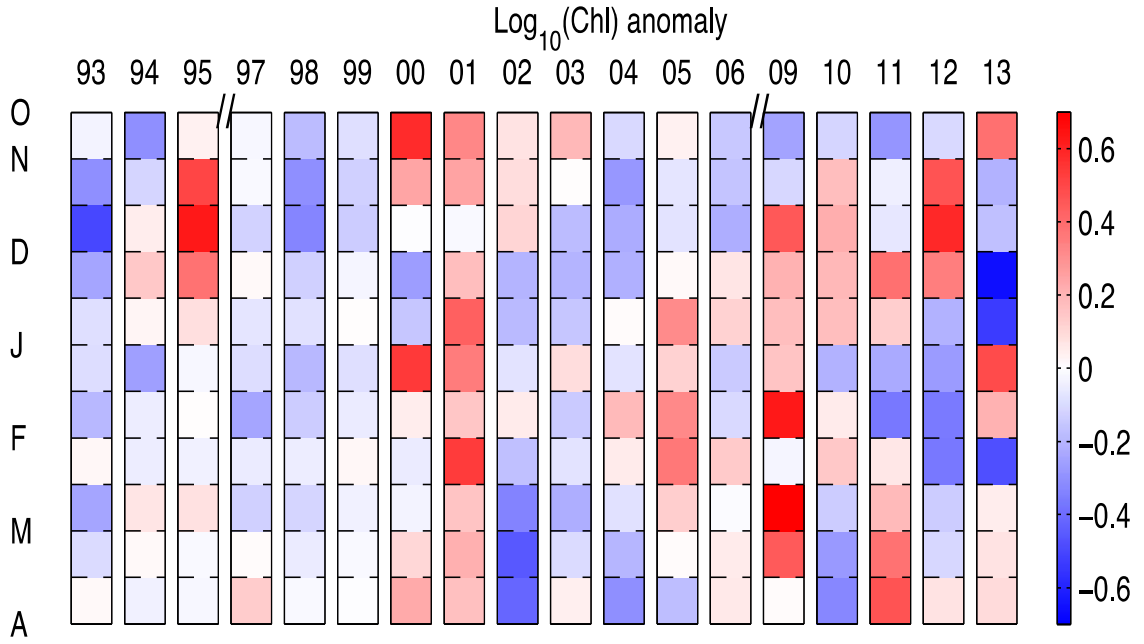




Crews et al. AGU poster 2015

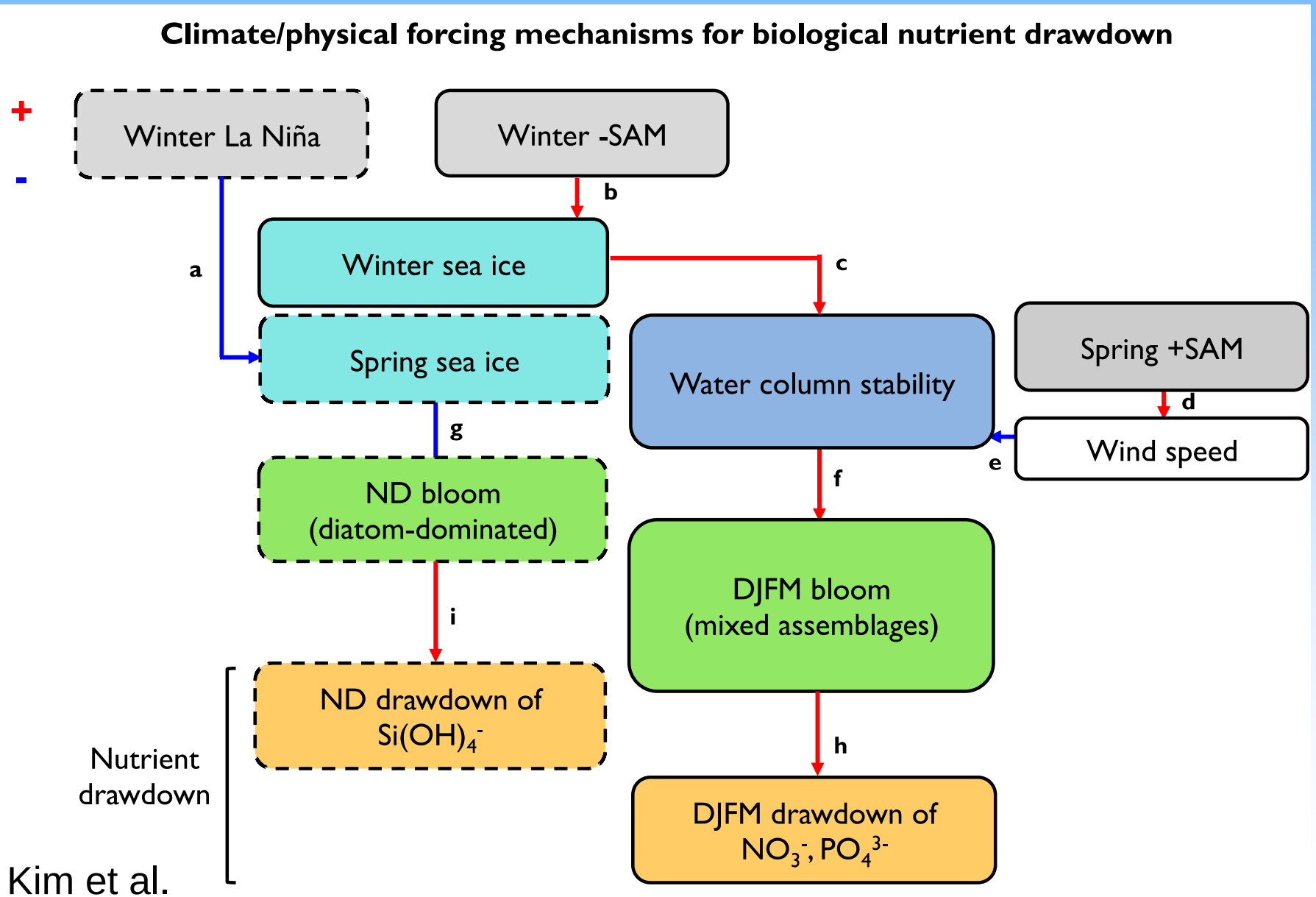
Seasonal Cycle & Interannual Variability at Palmer Station





Kim et al.
J. Geophysical Res. Biogeosciences
submitted

Climate Dynamics & Bloom Variability

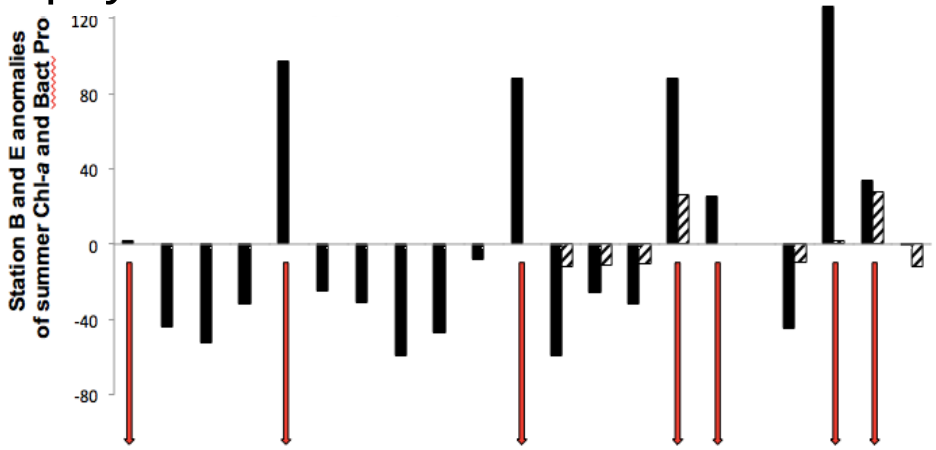


Kim et al.

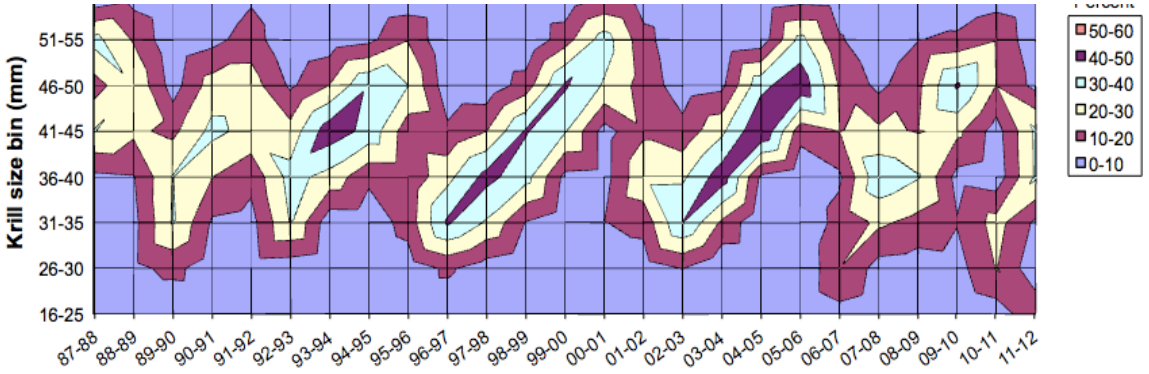
J. Geophysical Res. Biogeosciences submitted

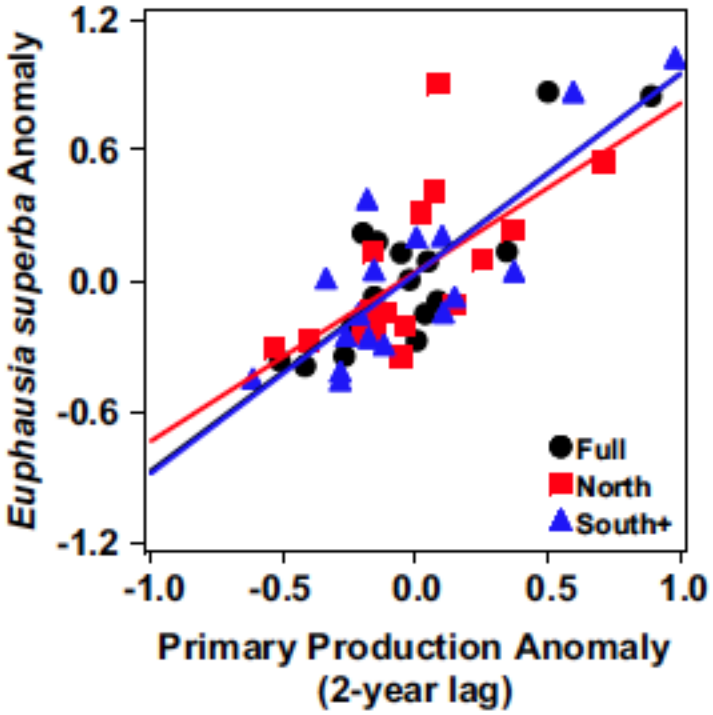
Krill Recruitment & Primary Productivity

Chlorophyll anomalies



Krill size class anomalies (penguin diet)

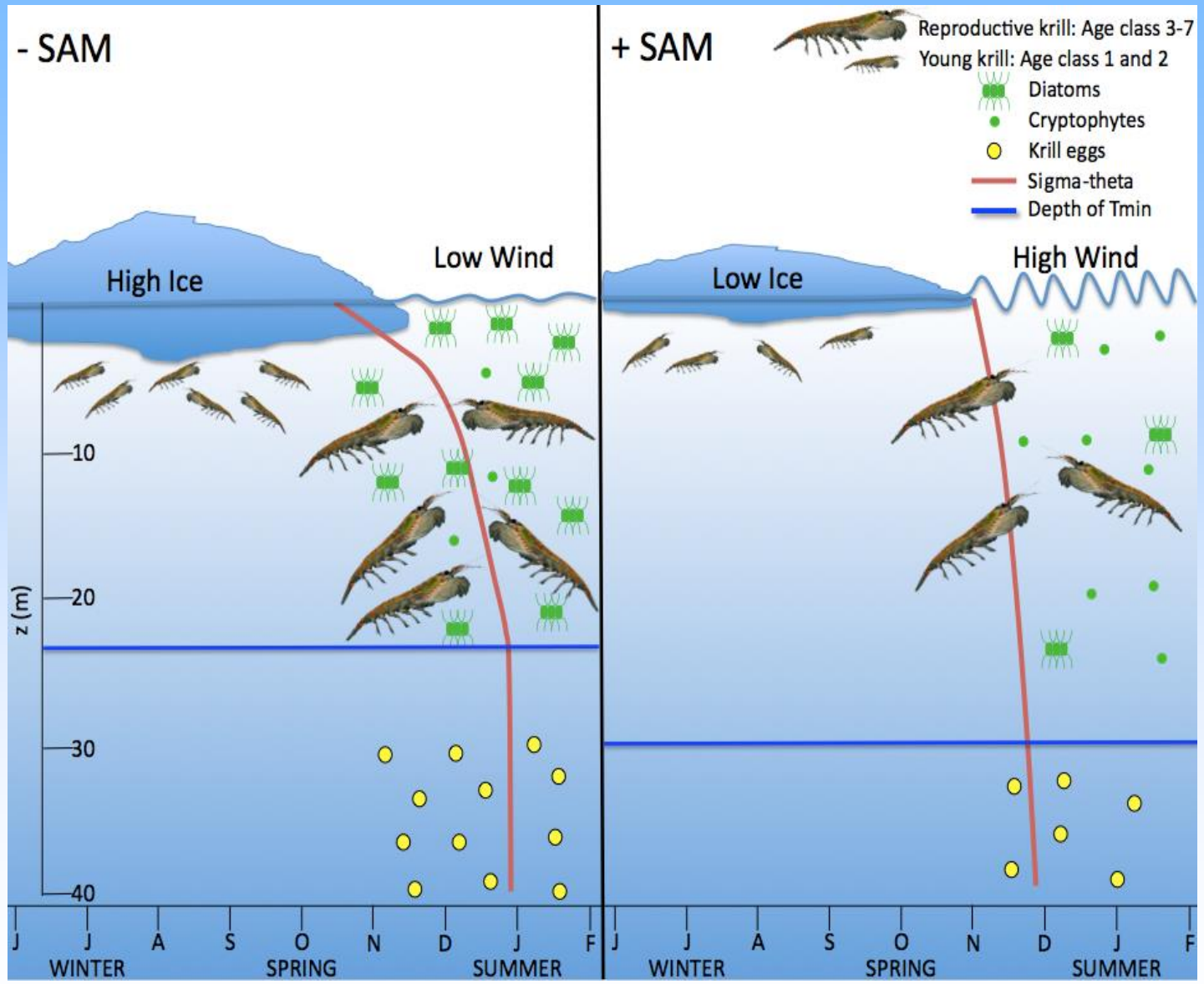




Steinberg et al.
Deep-Sea Res. I
2015

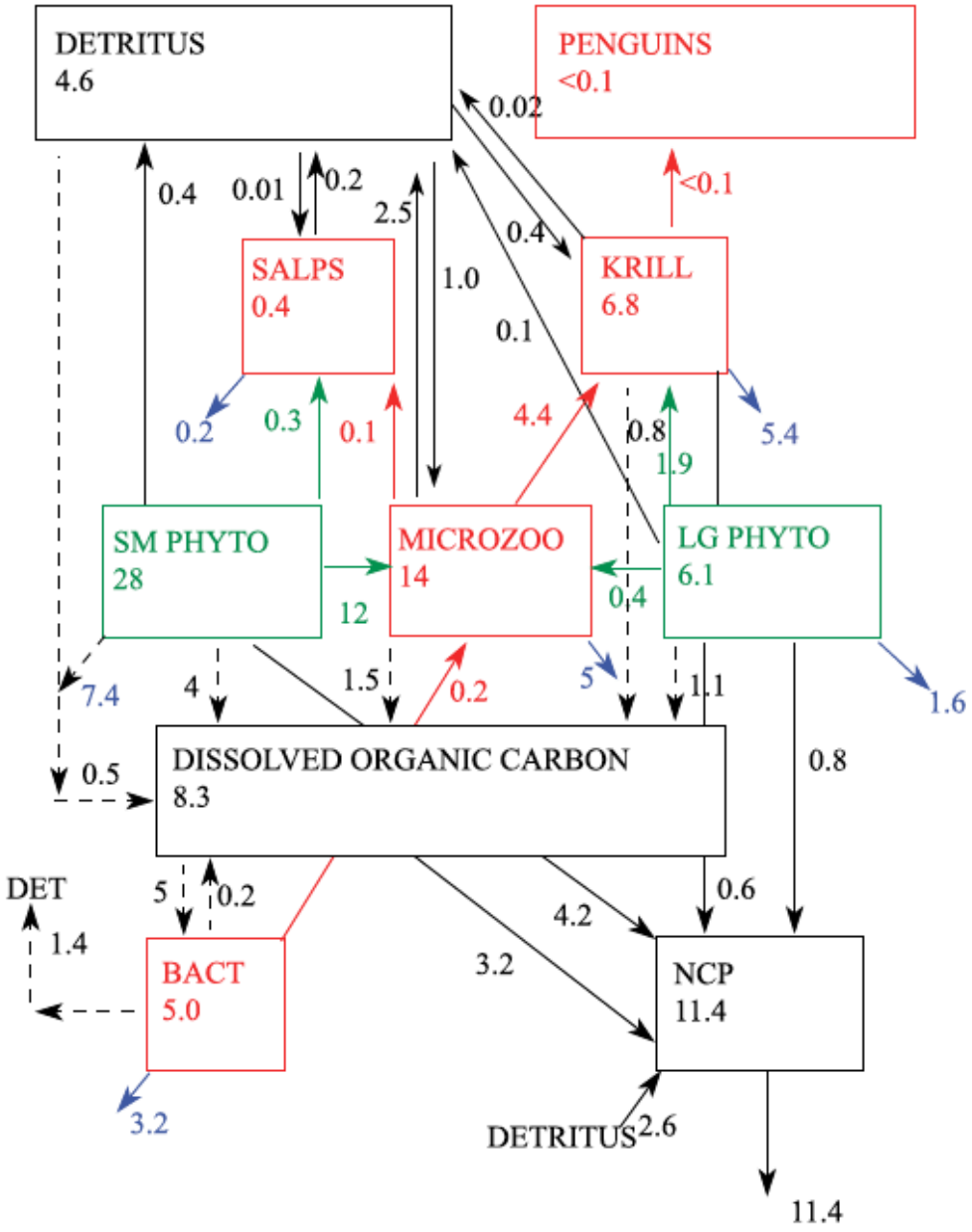
Saba et al. Nat. Comm. 2014

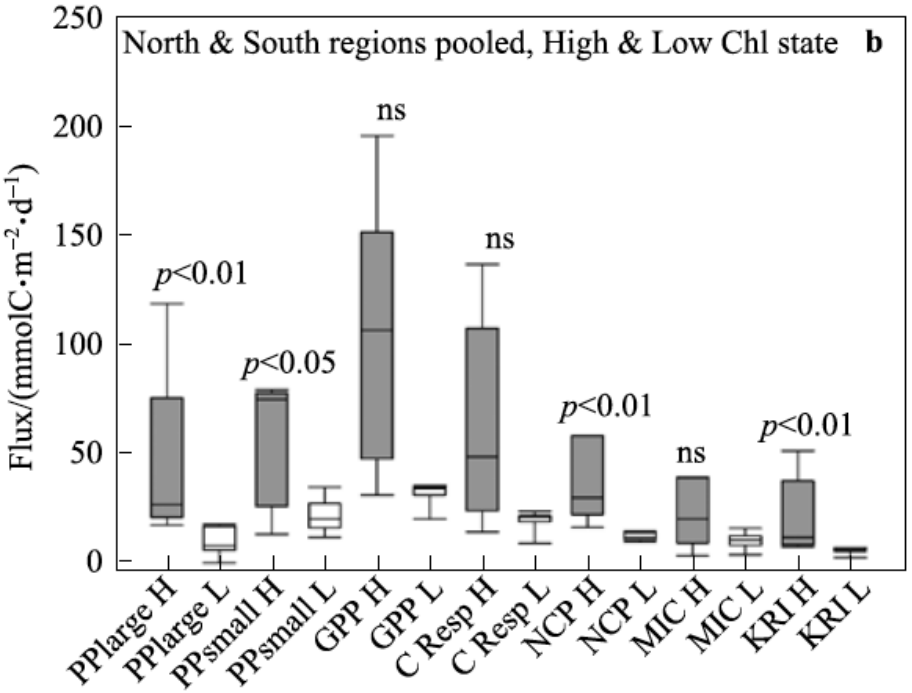
Ecosystem Response to Sea-ice Variability



Saba et al. Nature Communications 2014

Inverse Food-Web Model

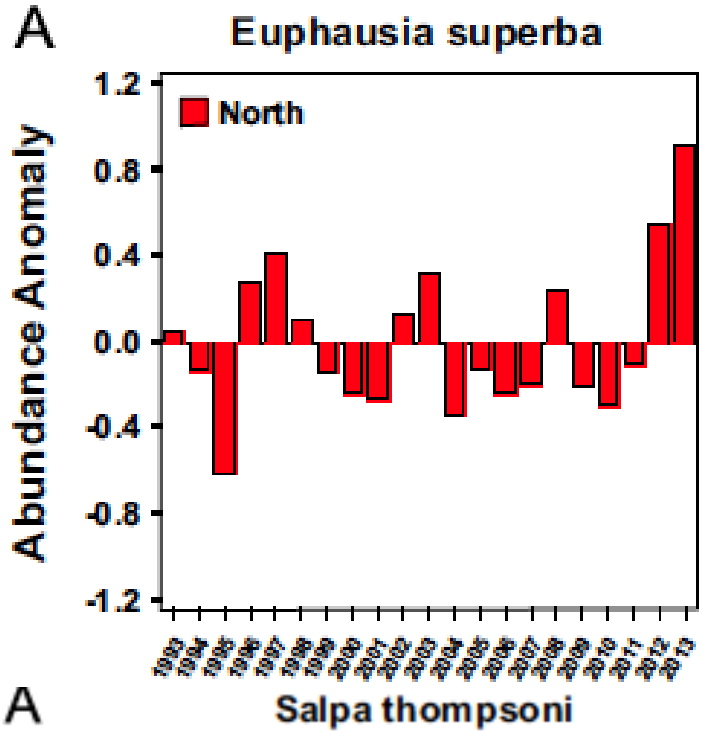


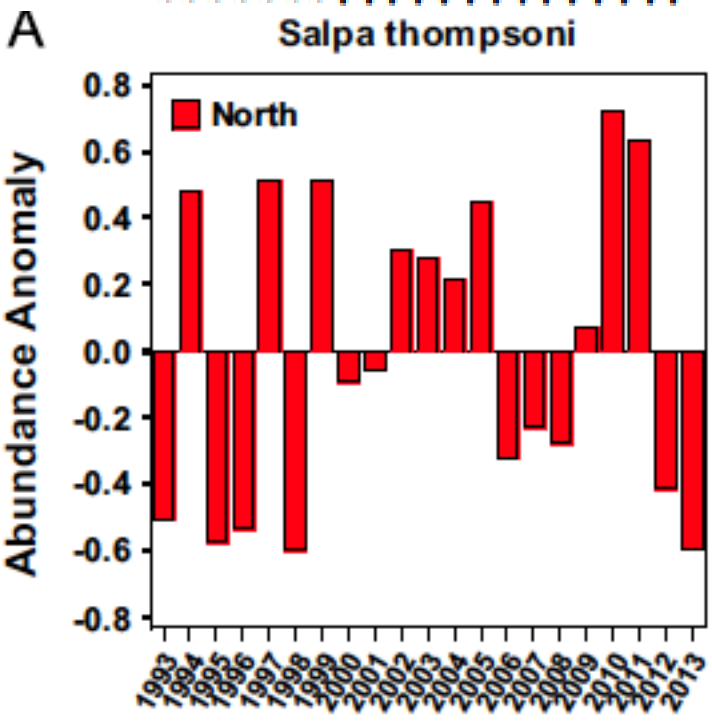


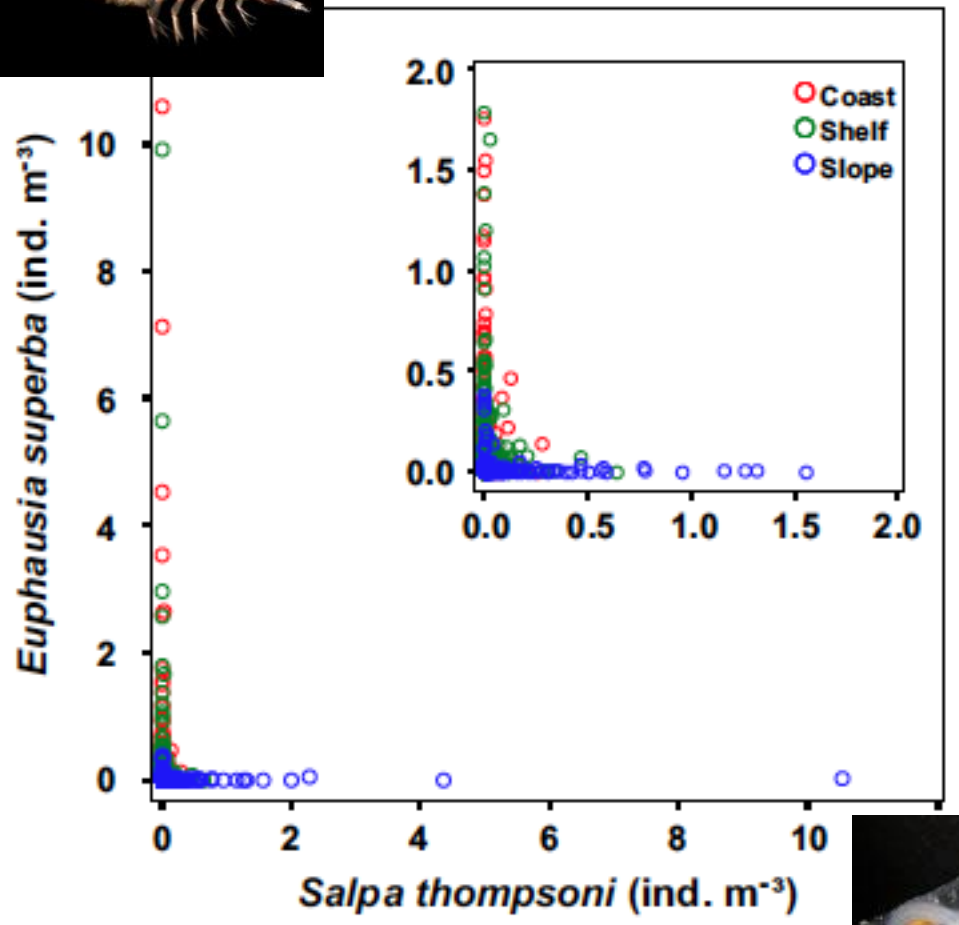
Ducklow et al.
Advances in Polar Science
2015

Sailley et al.
Marine Ecological Progress
Series 2013

Krill & Salps





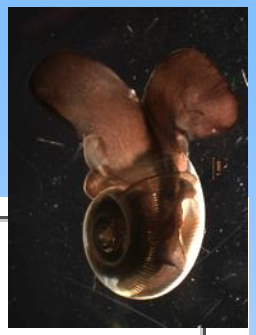


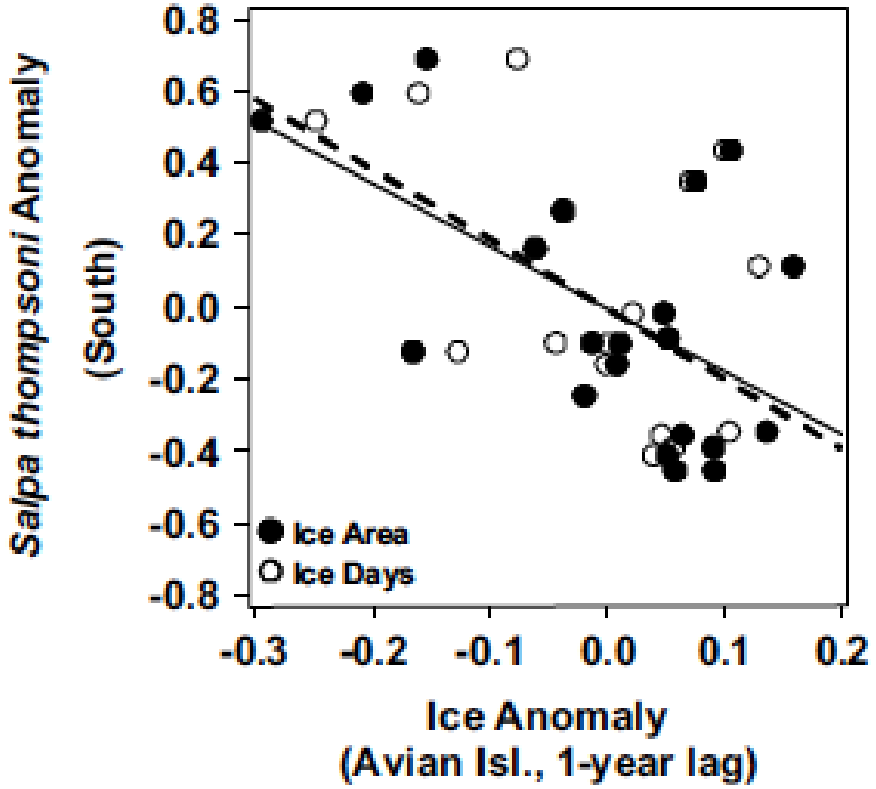
D. Steinberg Deep-Sea Res. I 2015

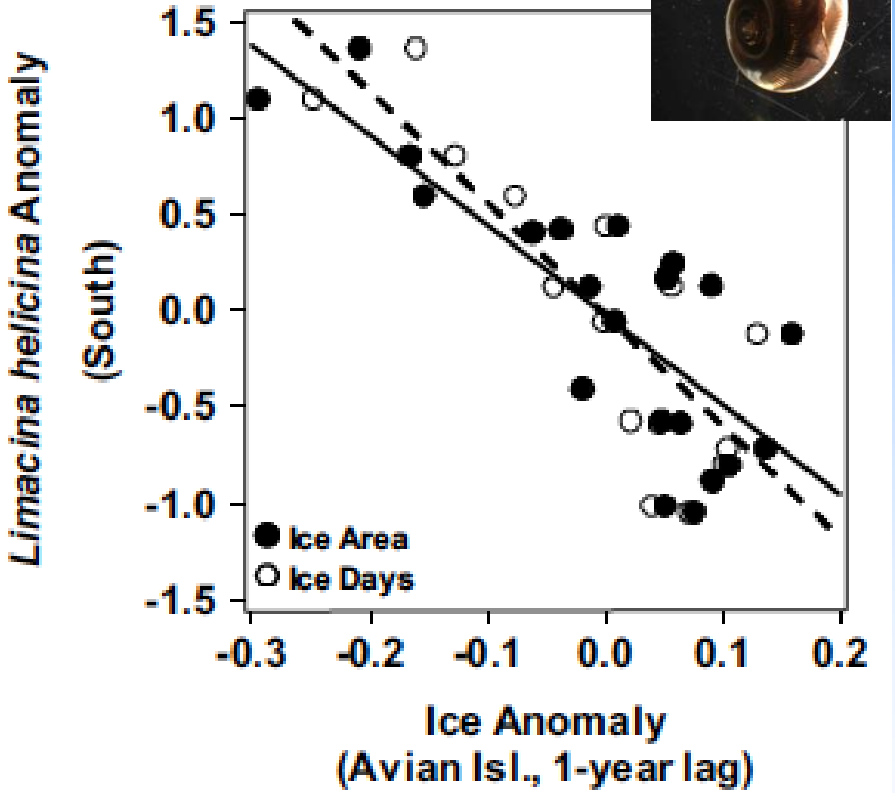
Ice Avoiding Species

Salps
Salpa thompsoni

Pteropods
Limacina helicina

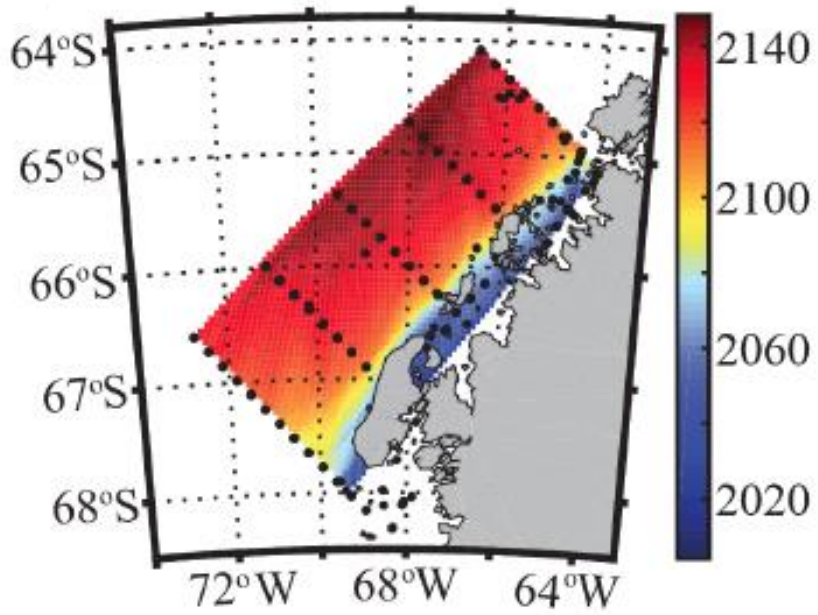




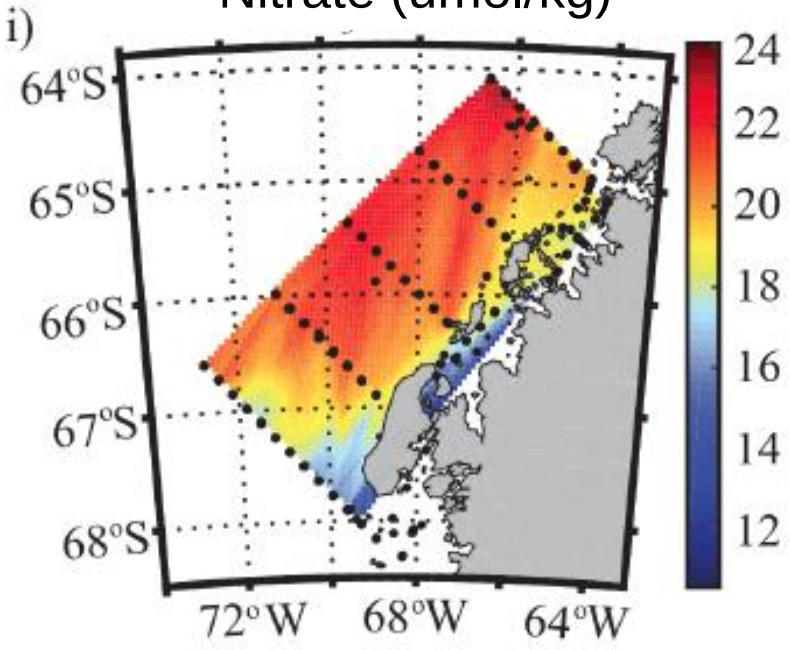


Climatological Surface Means

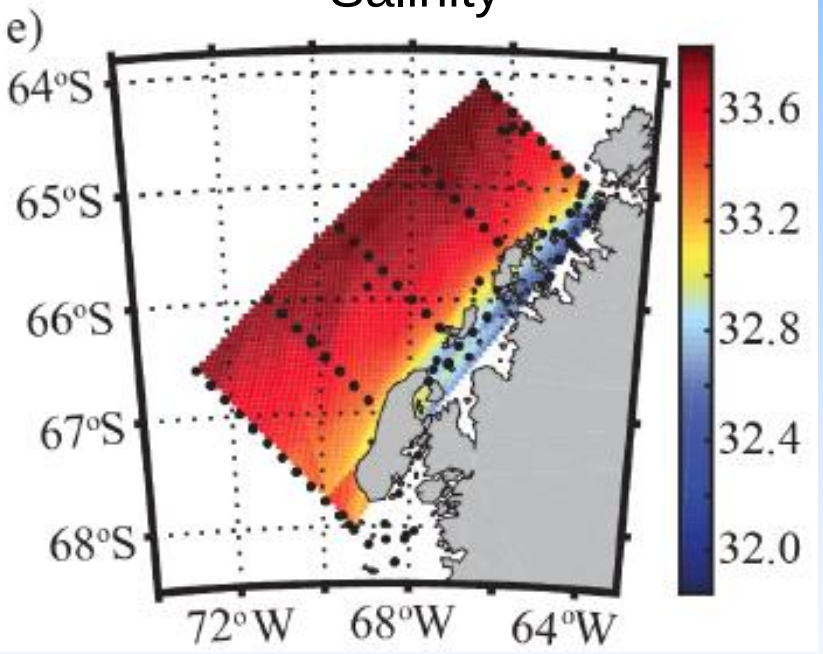
Dissolved Inorganic Carbon (umol/kg)



Nitrate (umol/kg)

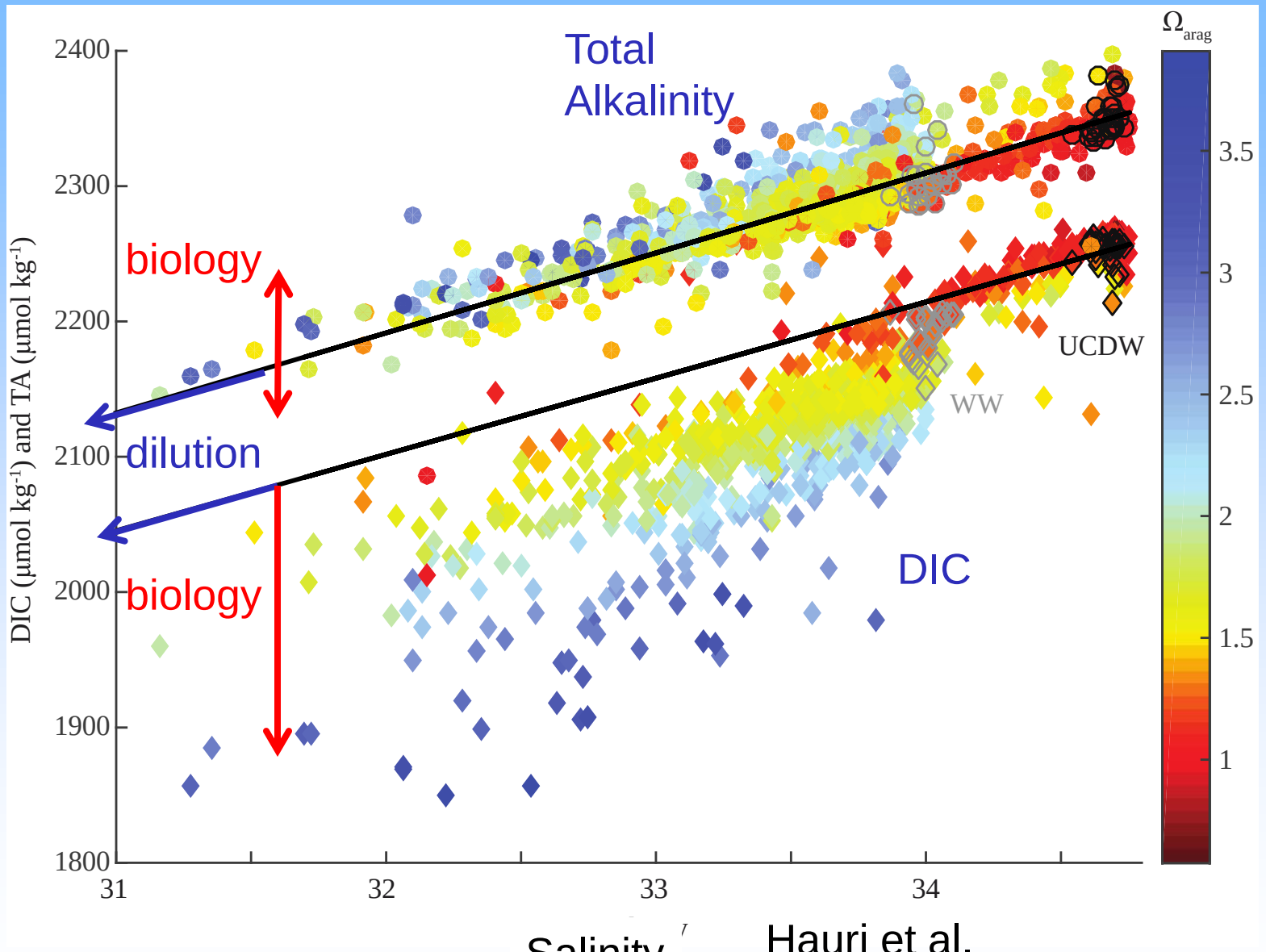


Salinity



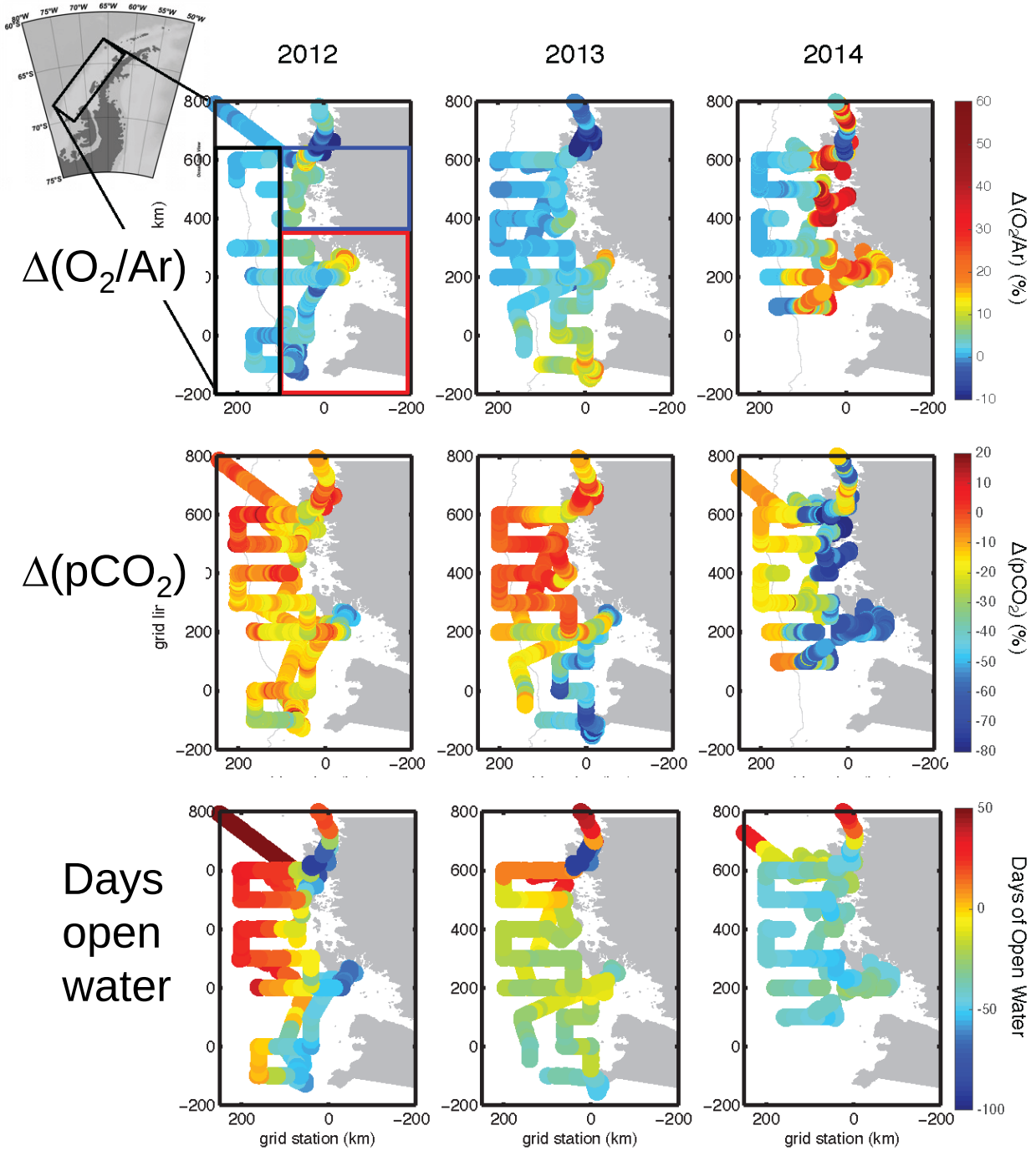
Hauri et al.
Biogeosciences 2015

Mixing versus Biological Drawdown



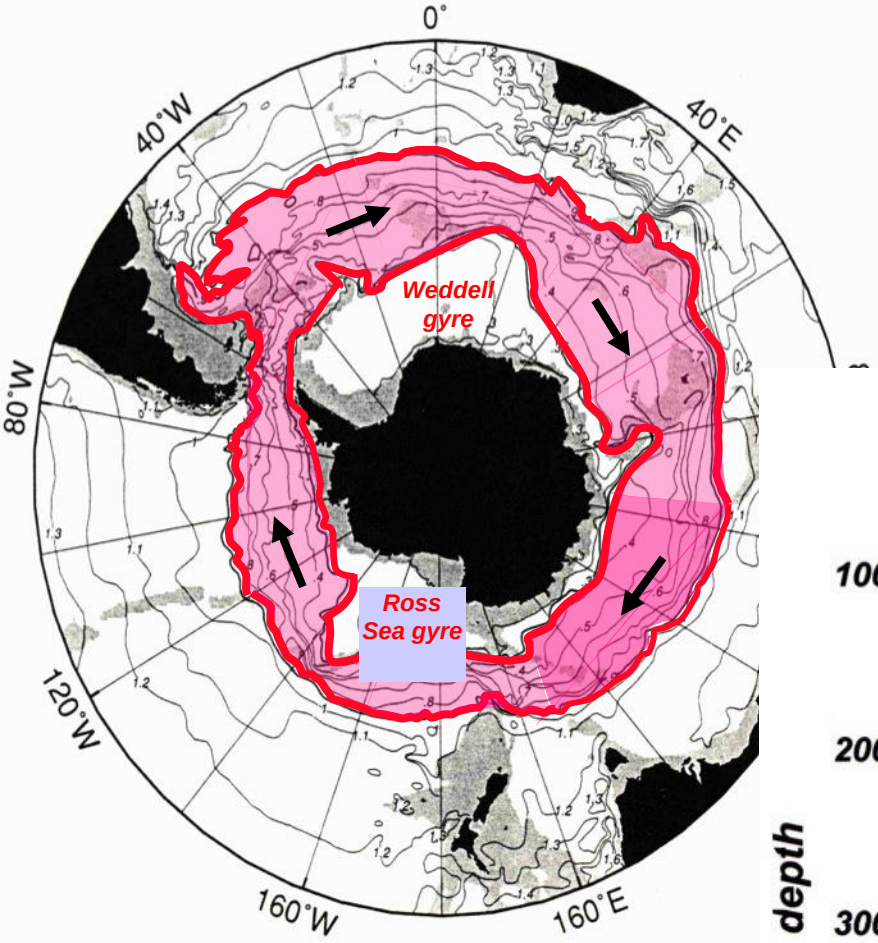
Hauri et al.
Biogeosciences 2015

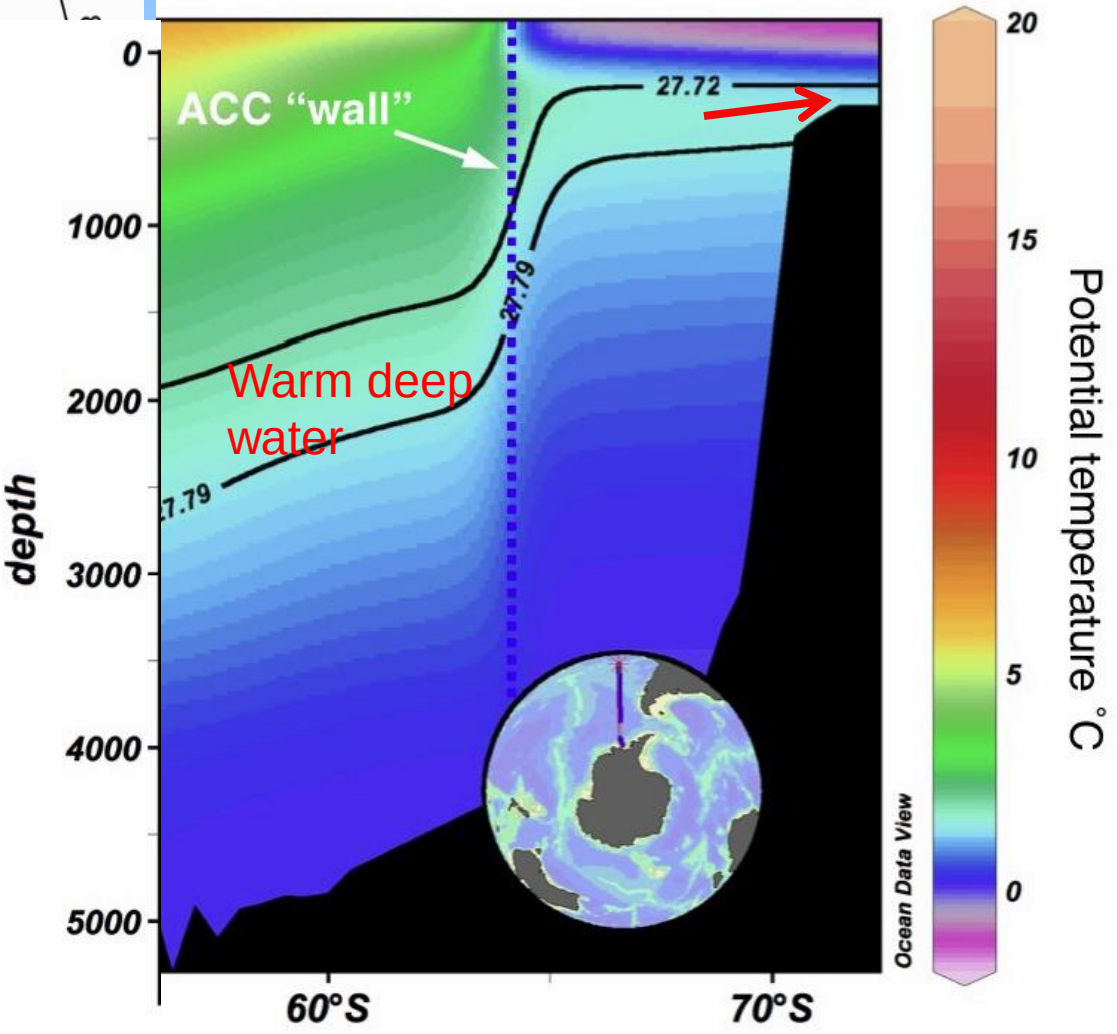
Biogeochemical Imprint of Seasonal Productivity



R. Eveleth, N. Cassar et al.
Deep-Sea Res. II submitted

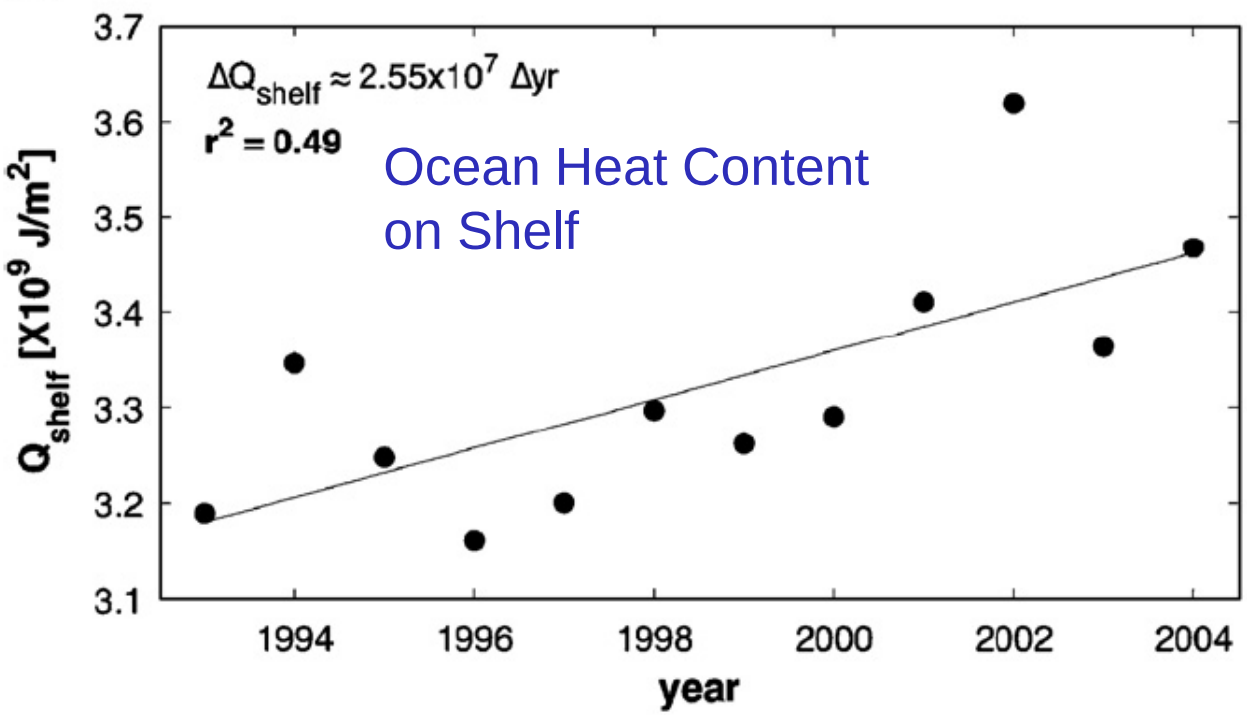
Intrusion of "Warm" Antarctic Circumpolar Current onto Shelf



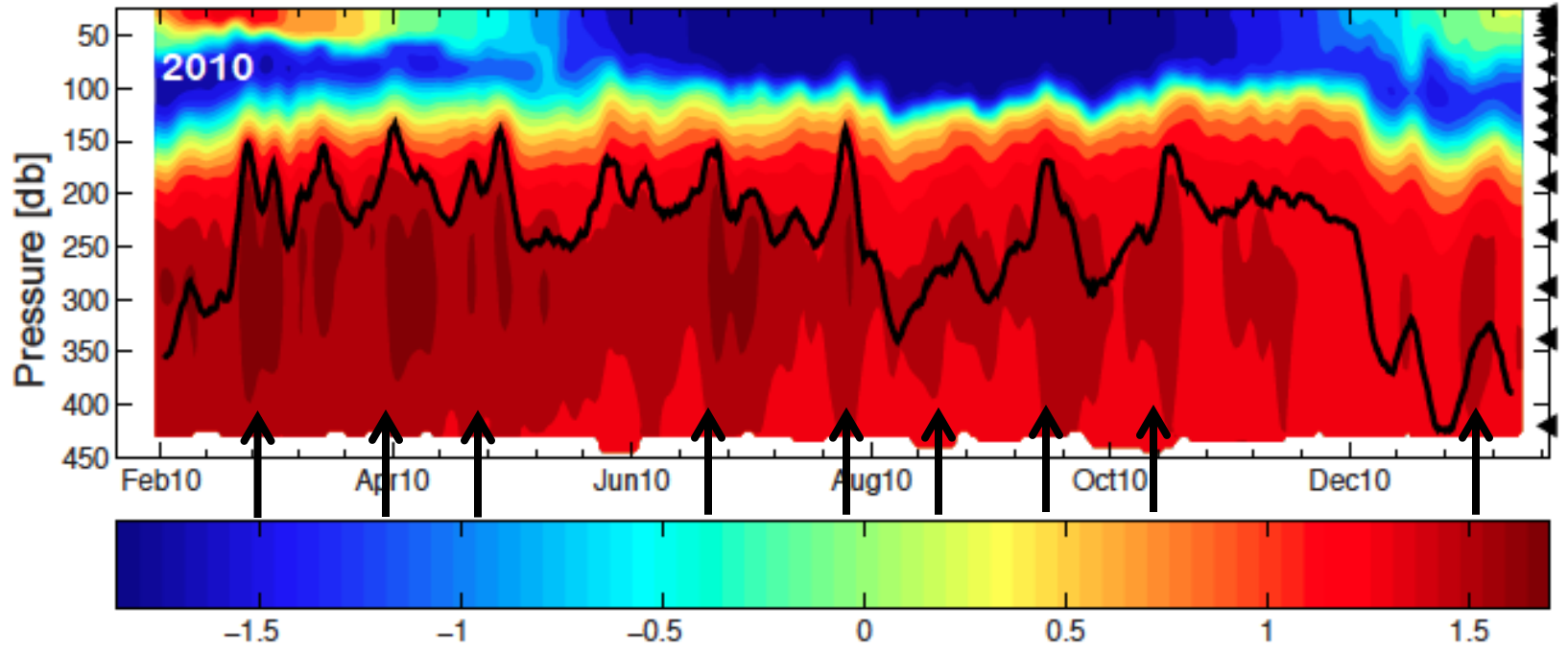


Martinson et al. Deep Sea Res. II 2008
Martinson & McKee Ocean Science 2012

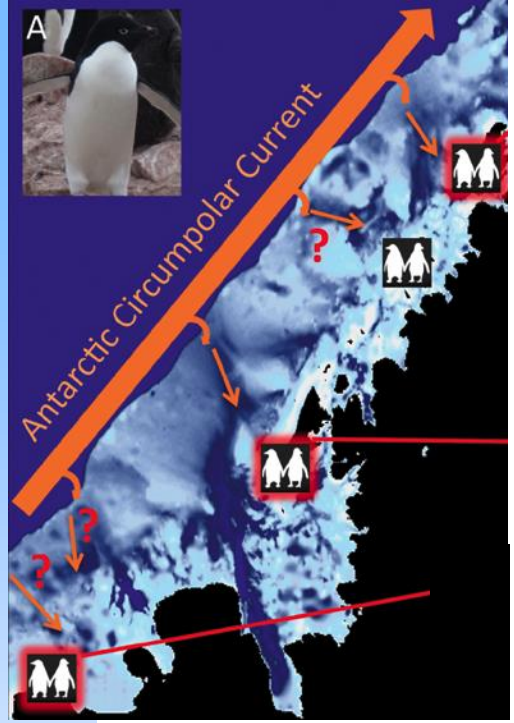
Rising Ocean Heat Content

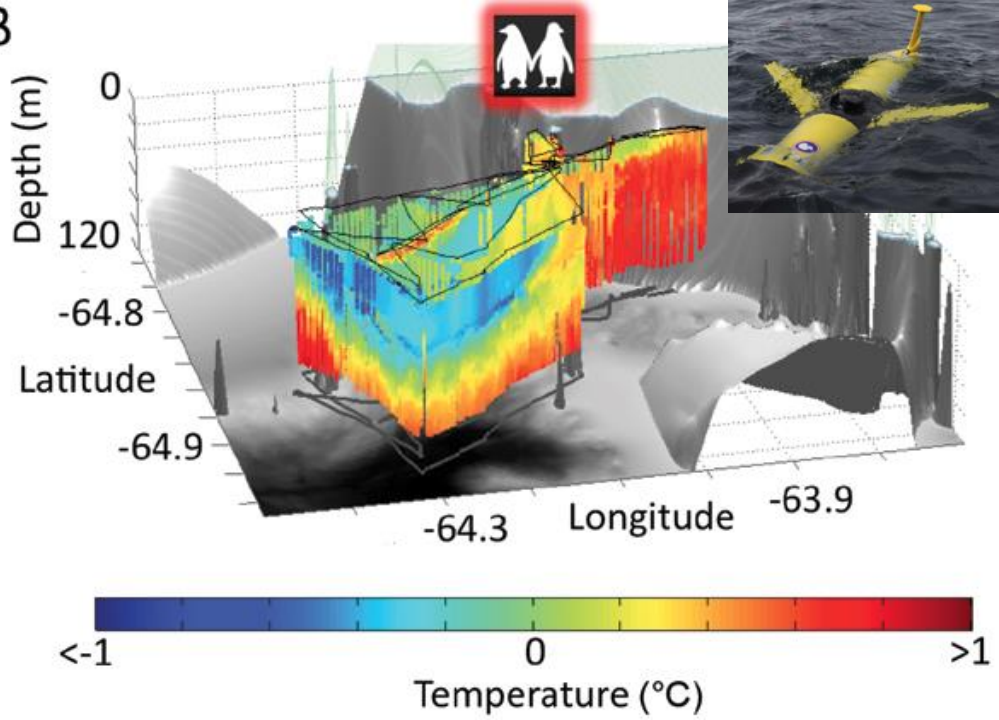


Martinson et al. Deep Sea Res. II 2008
Martinson & McKee Ocean Science 2012



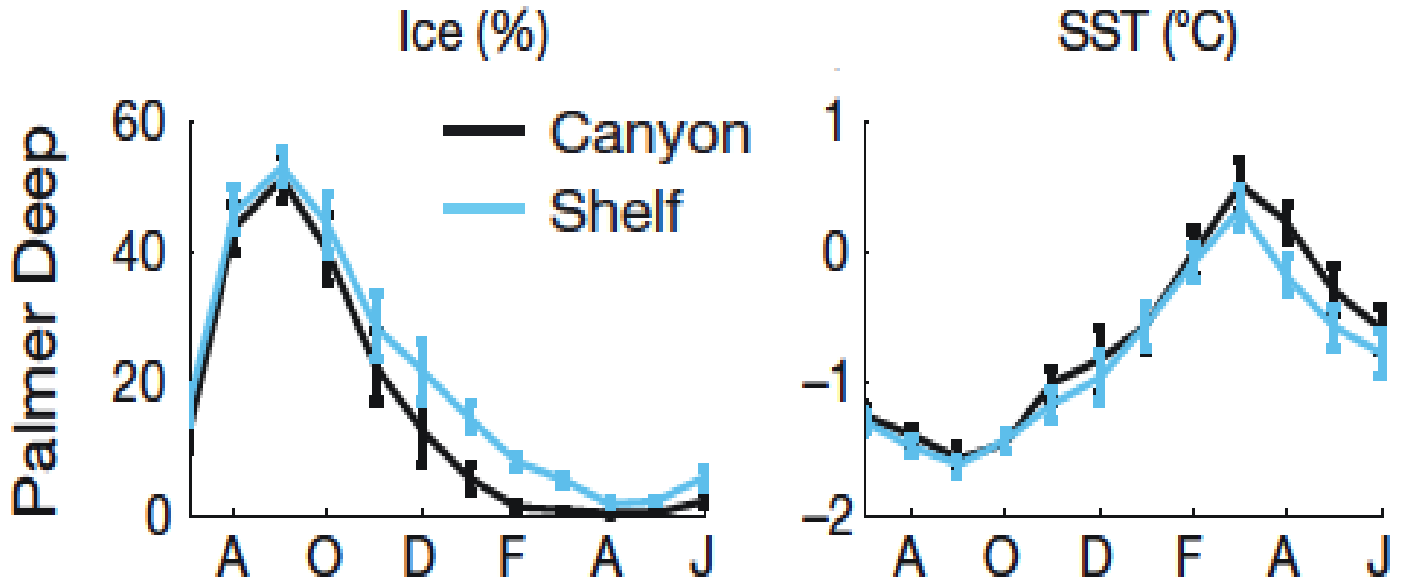
Localized Canyon Effects



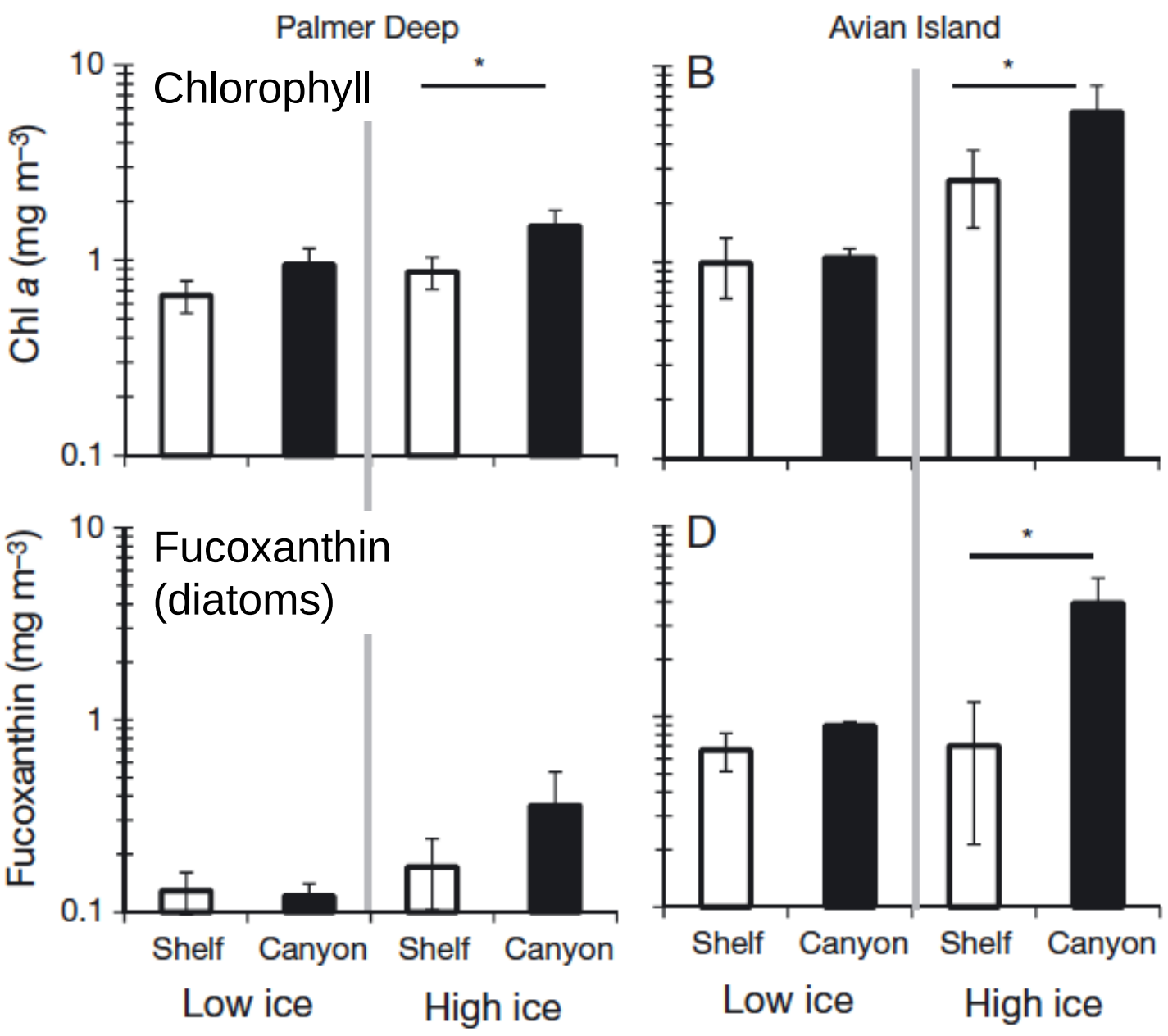


Schofield et al. Oceanography 2013

Kavanaugh et al. MEPS 2015

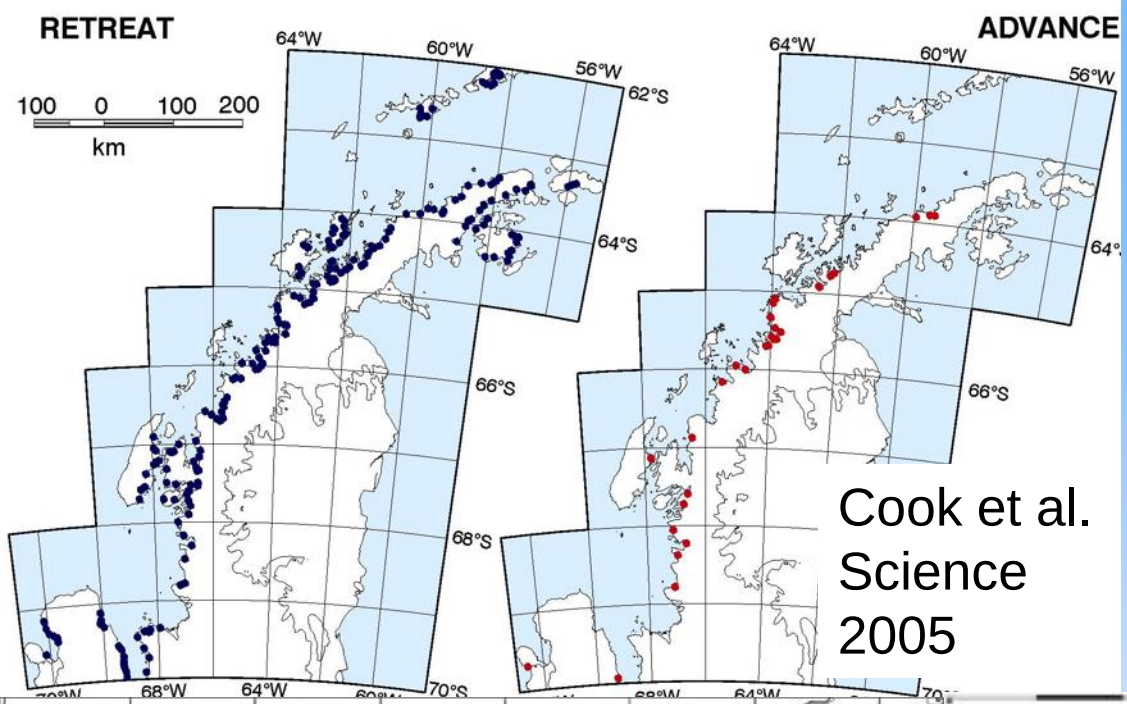


Biological Effects of Canyons in High Ice Years



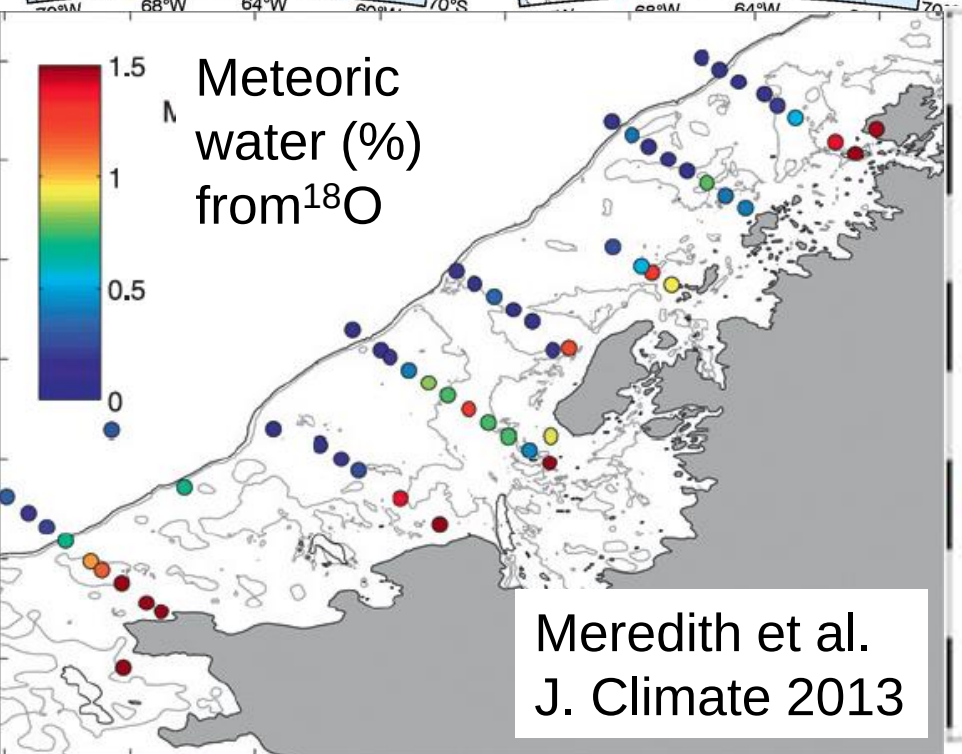
Kavanaugh et al.
MEPS 2015

Retreating Glaciers, Melt Water & Trace Metals



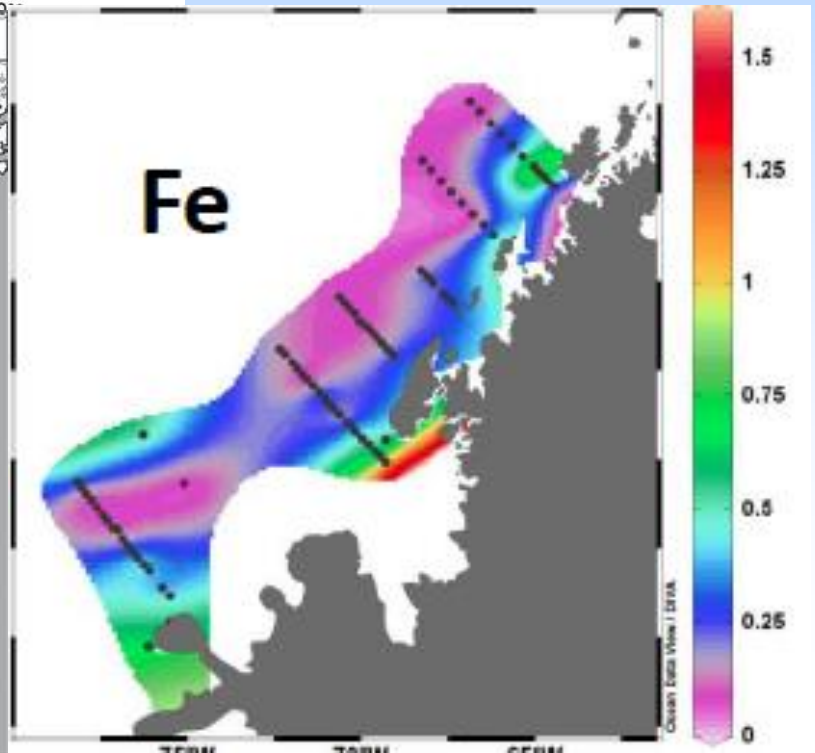
Cook et al.
Science
2005

R. Sherrell & J. Fitzsimmons
Rutgers



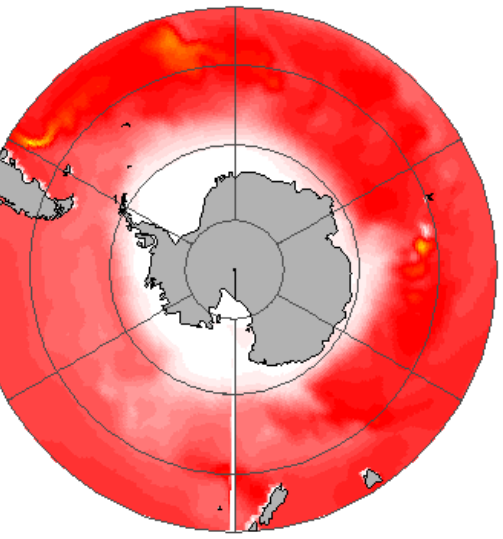
Meteoric water (%) from ^{18}O

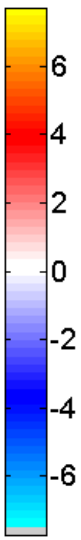
Meredith et al.
J. Climate 2013



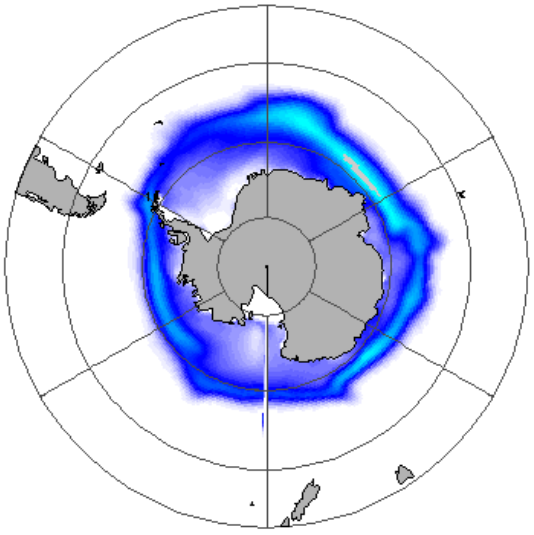
Earth System Model Projections of the Future

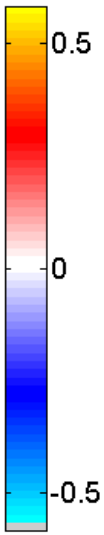
Temperature



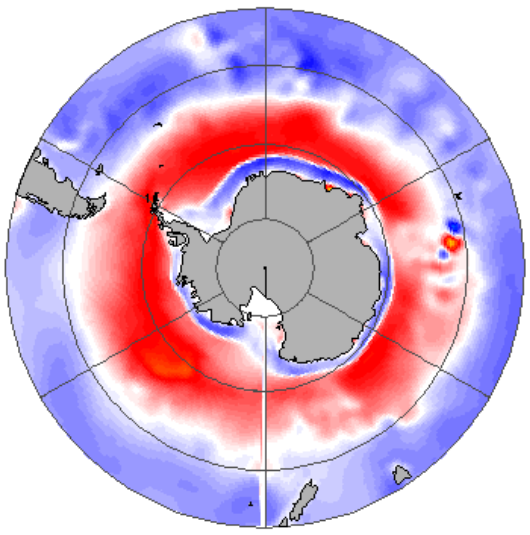


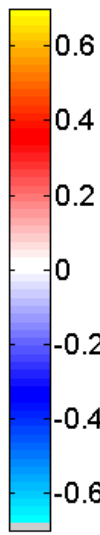
Ice Fraction



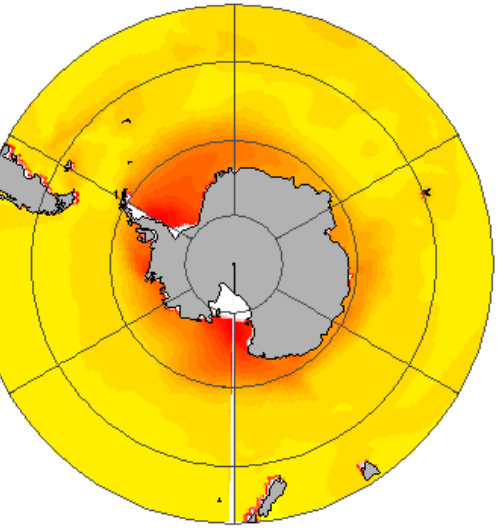


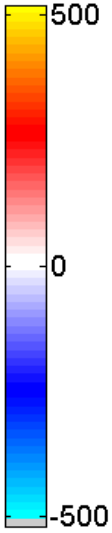
Wind Stress



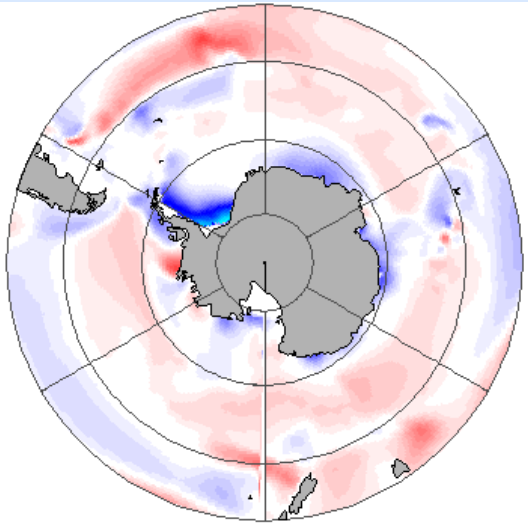


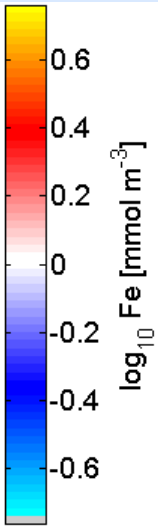
CO_2 Partial Pressure





Dissolved Iron

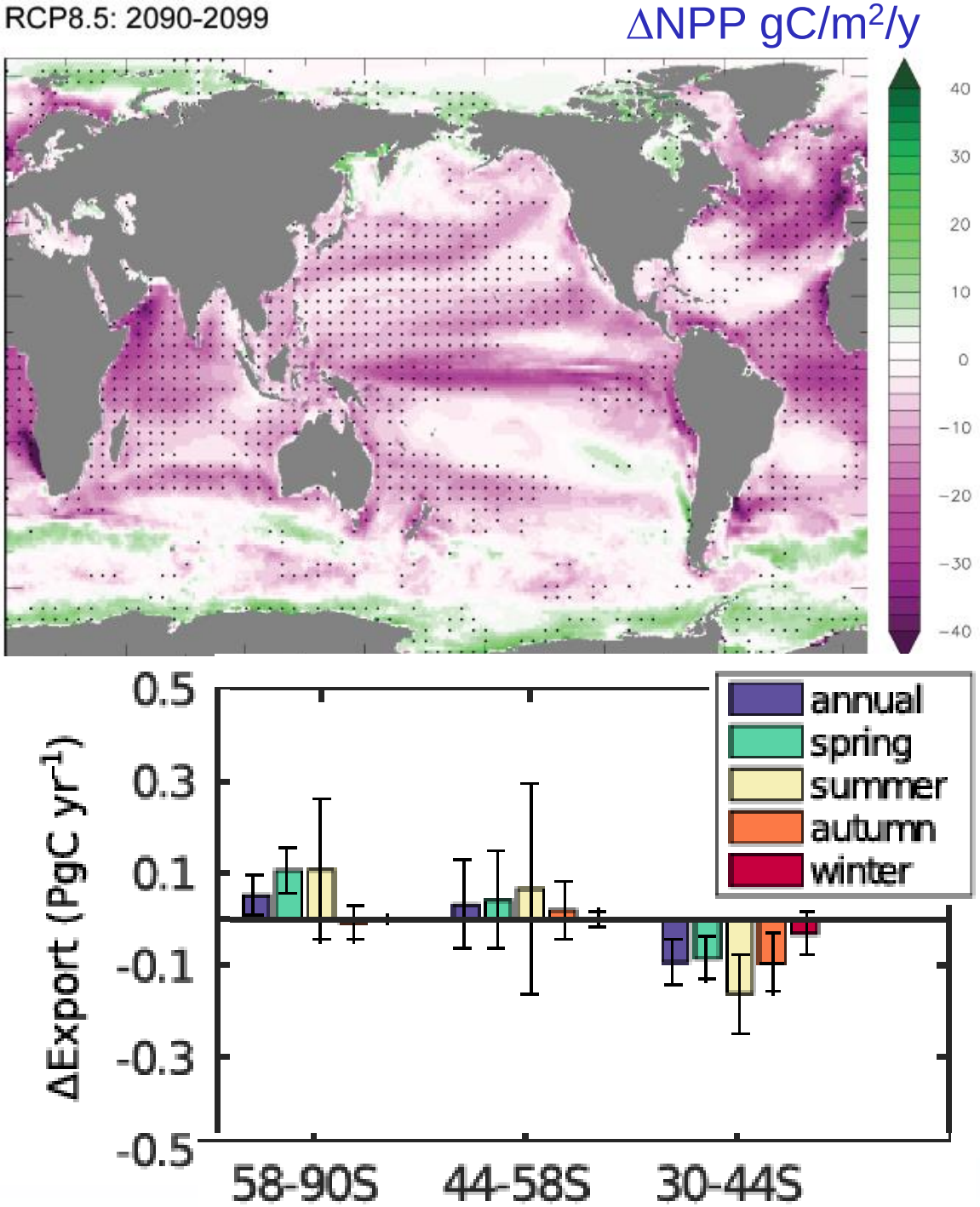




Δ 2100 – 2000
RCP8.5
CESM1(BGC)
Moore et al. J. Climate 2013

Boyd et al. Nature Climate Change 2015

Climate Change & Productivity



Bopp et al.
Biogeosciences 2013

Hauck et al.
Global Biogeochemical Cycles 2015

Summary

-Palmer LTER dataset (1992-2016):

- ocean-ice physical dynamics
- carbon cycle & nutrients
- productivity, phyto- & zooplankton

-Patterns & trends

- seasonal phenology
- spatial gradients (on-/off-shore, north-south)
- localized canyons
- temporal variability & trends

Substantial climate change already impacting physics, chemistry & biology in some regions

PALMER STATION ANTARCTICA LTER

NSF

NASA

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930