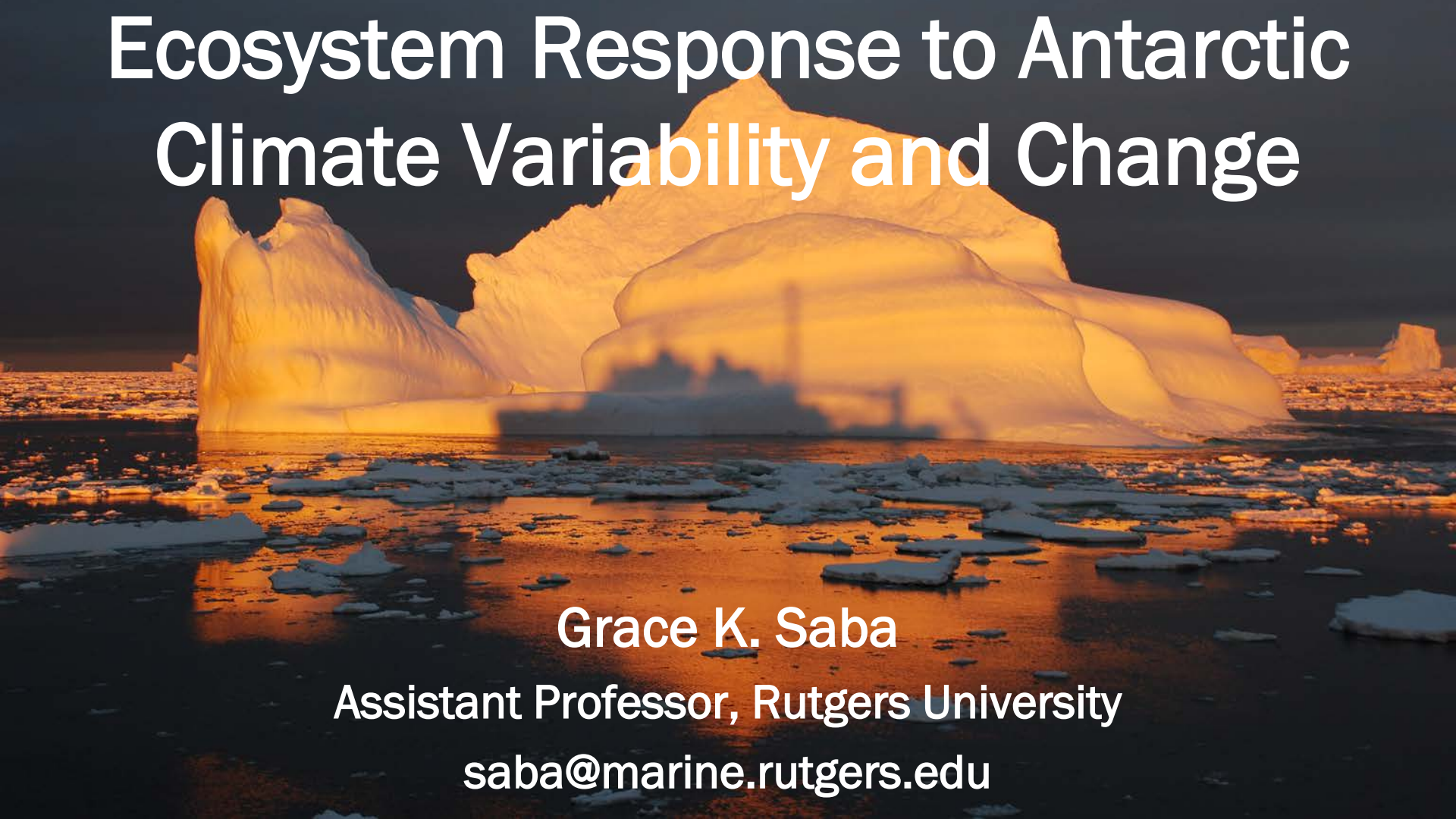
Ecosystem Response to Antarctic Climate Variability and Change



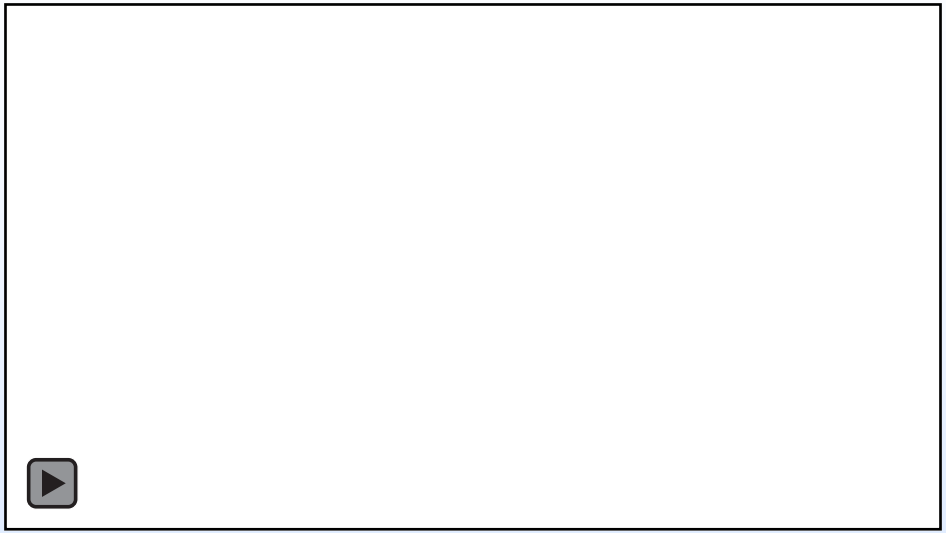
Grace K. Saba

Assistant Professor, Rutgers University

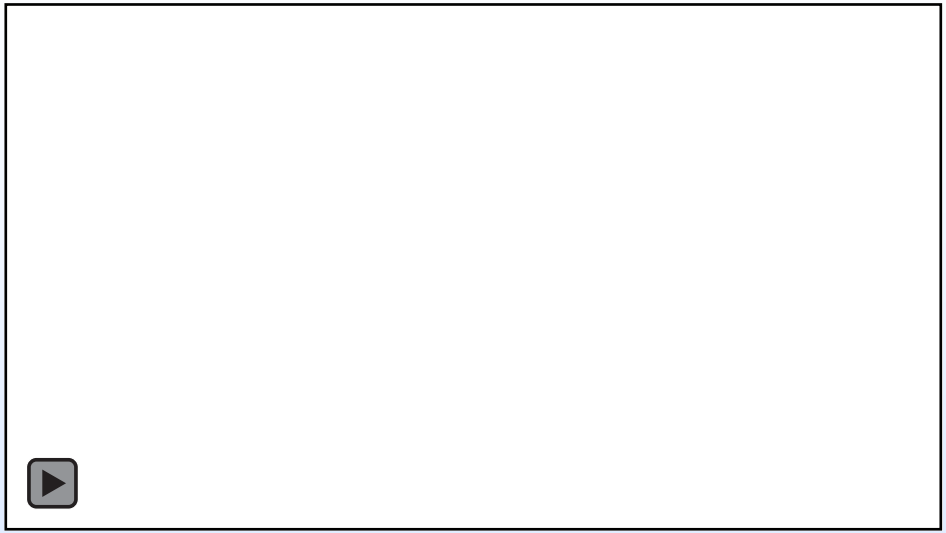
saba@marine.rutgers.edu

Antarctic Sea Ice Variability

Seasonal: May 2009 – July 2010

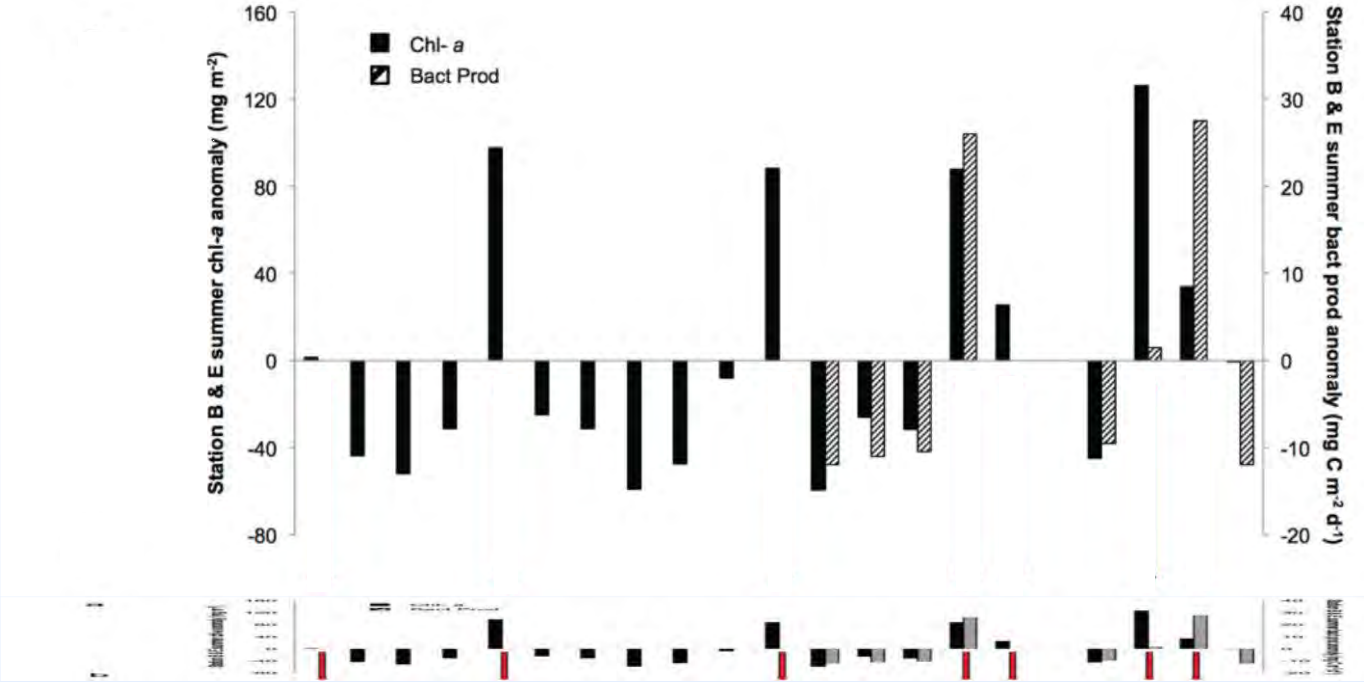


Annual: 1979 – 2008

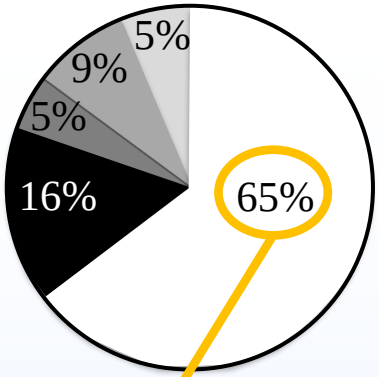


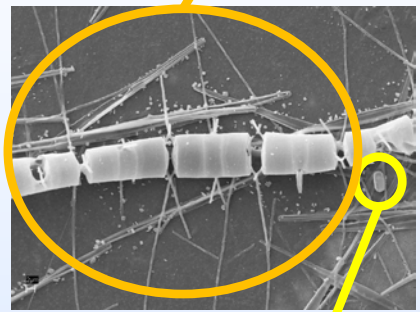
https://svs.gsfc.nasa.gov

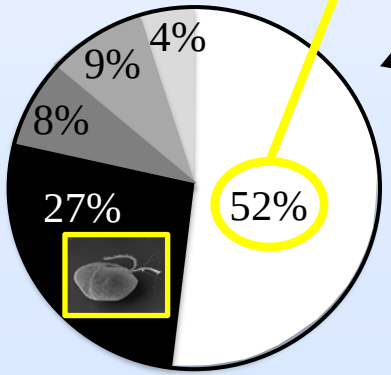
Tight coupling between physics and biology

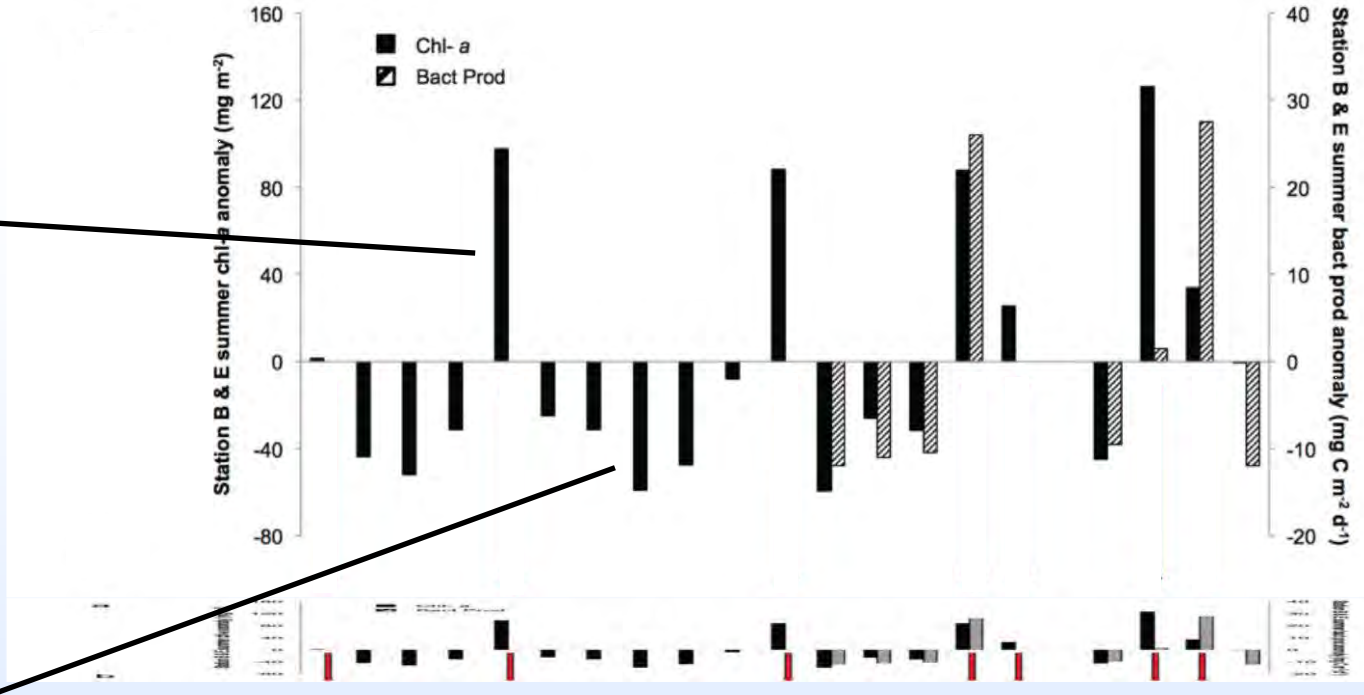


Saba et al. 2014, Nat. Commun.









% Diatoms

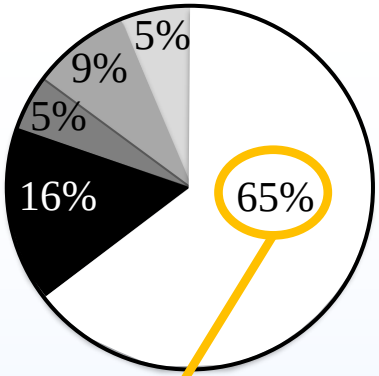
% Prasinophytes

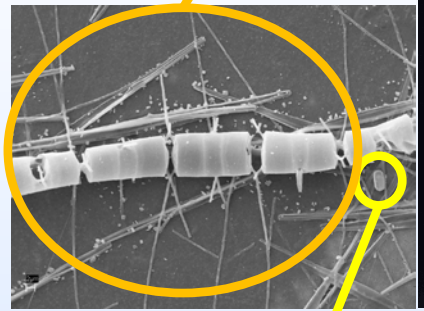
% Haptophytes

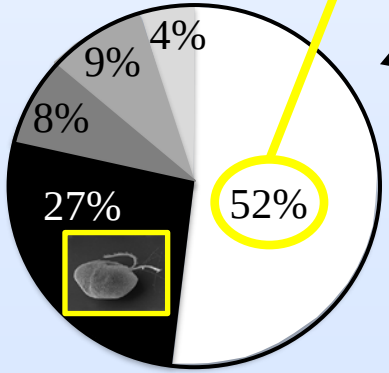
% Flagellates

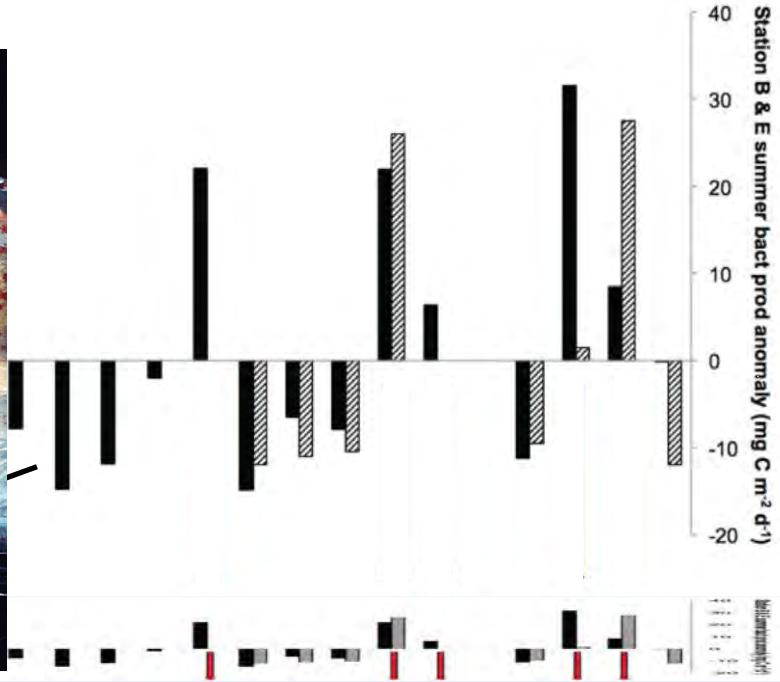
% Cryptophytes

Saba et al. 2014, Nat. Commun.
Schofield et al. 2017, Deep Sea Res. II









% Diatoms

% Prasinophytes

% Haptophytes

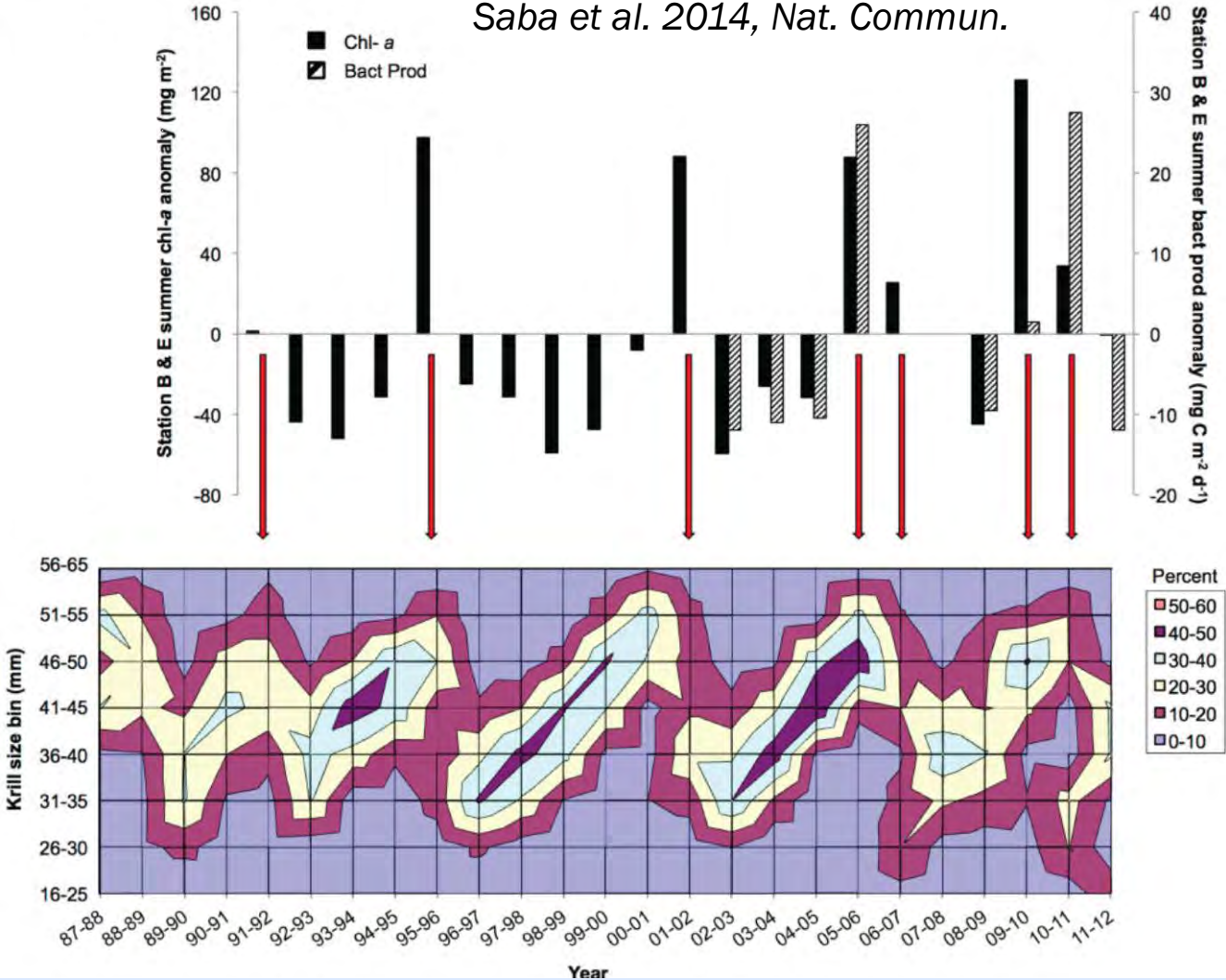
% Flagellates

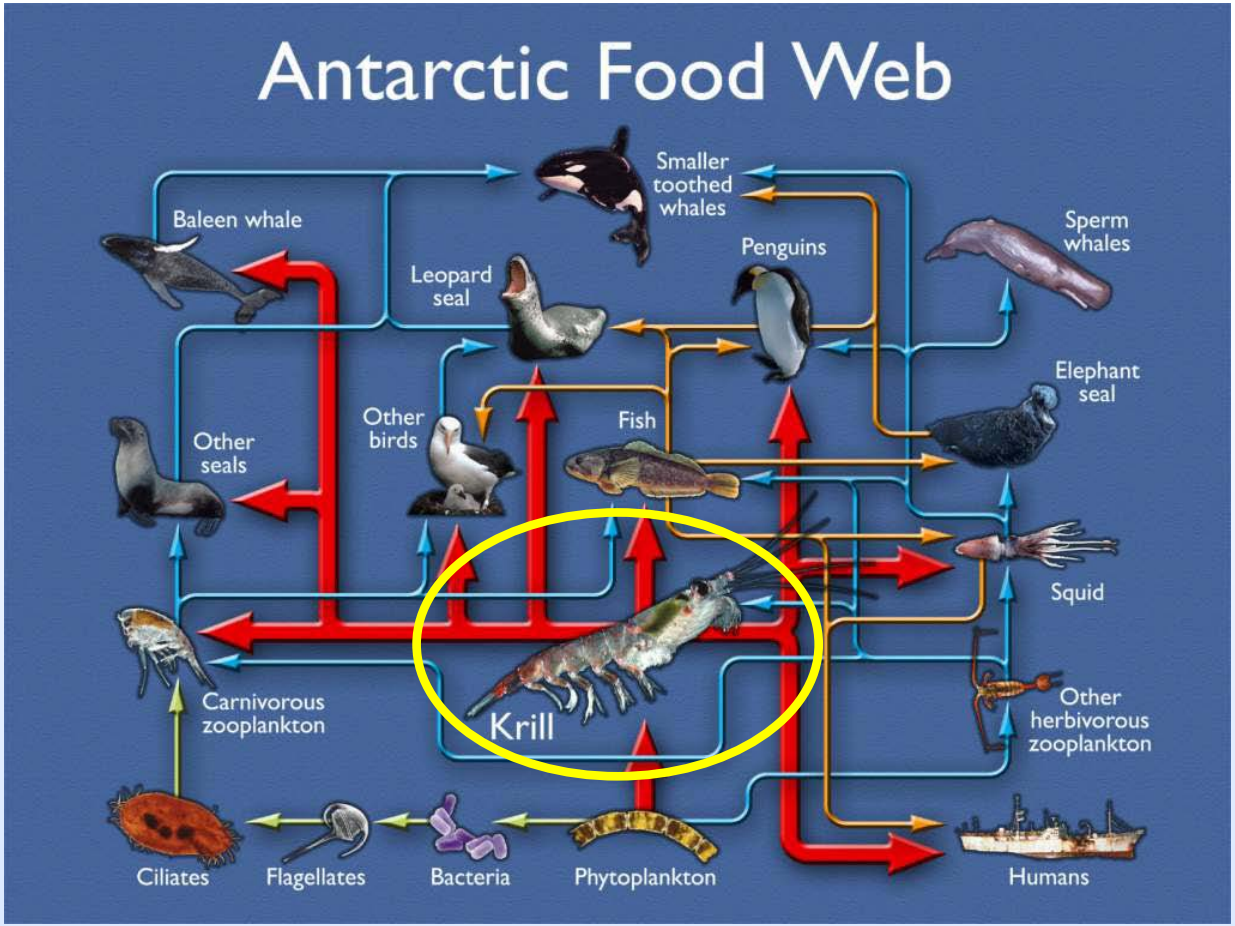
% Cryptophytes

Saba et al. 2014, Nat. Commun.
Schofield et al. 2017, Deep Sea Res. II

Tight trophic coupling

Saba et al. 2014, Nat. Commun.

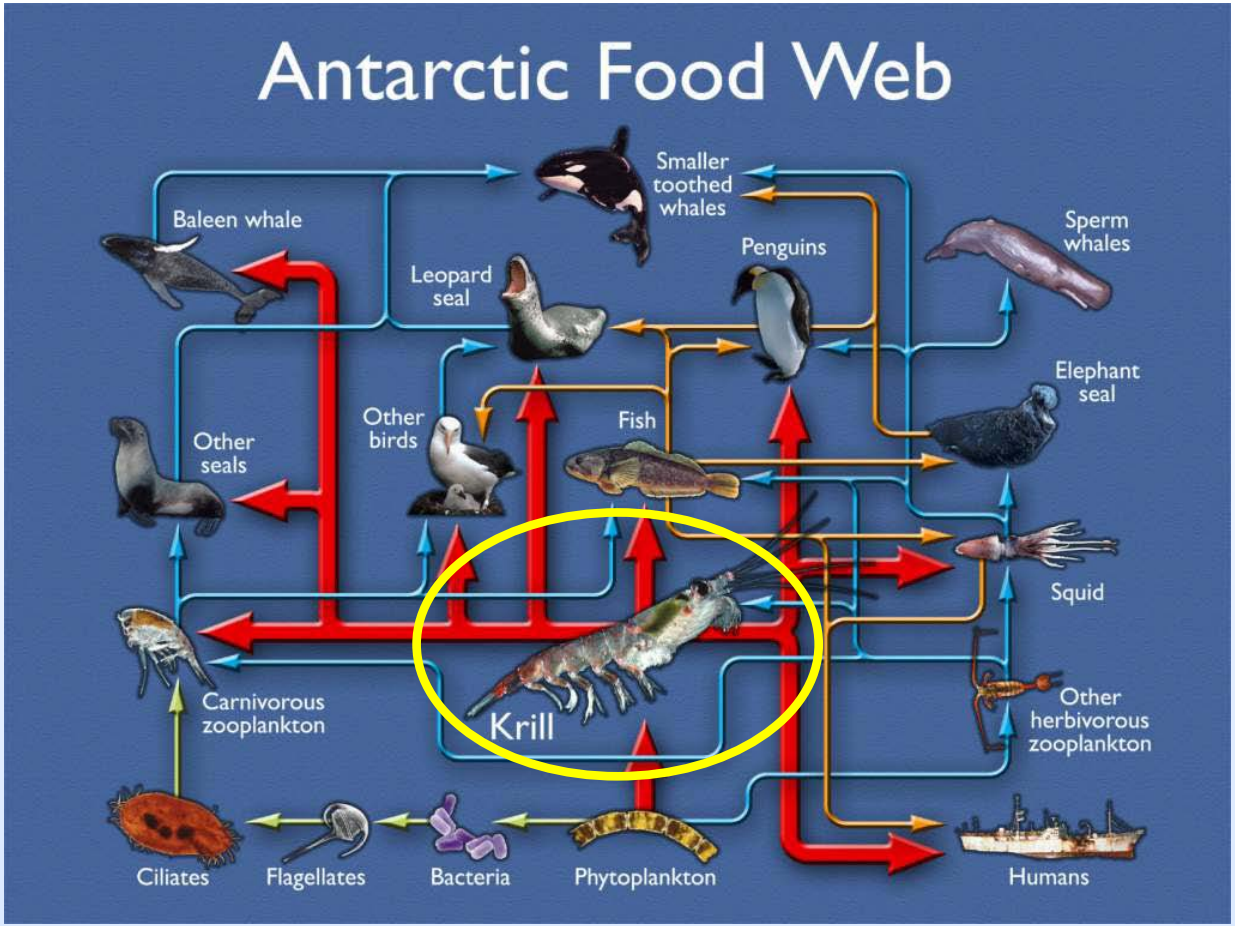



Antarctic Food Web
Smaller toothed whales
Baleen whale
Penguins
Sperm whales
Leopard seal
Elephant seal
Other seals
Other birds
Fish
Squid
Krill
Carnivorous zooplankton
Other herbivorous zooplankton
Ciliates
Flagellates
Bacteria
Phytoplankton
Humans

WAP:

Diatoms, Cryptophytes

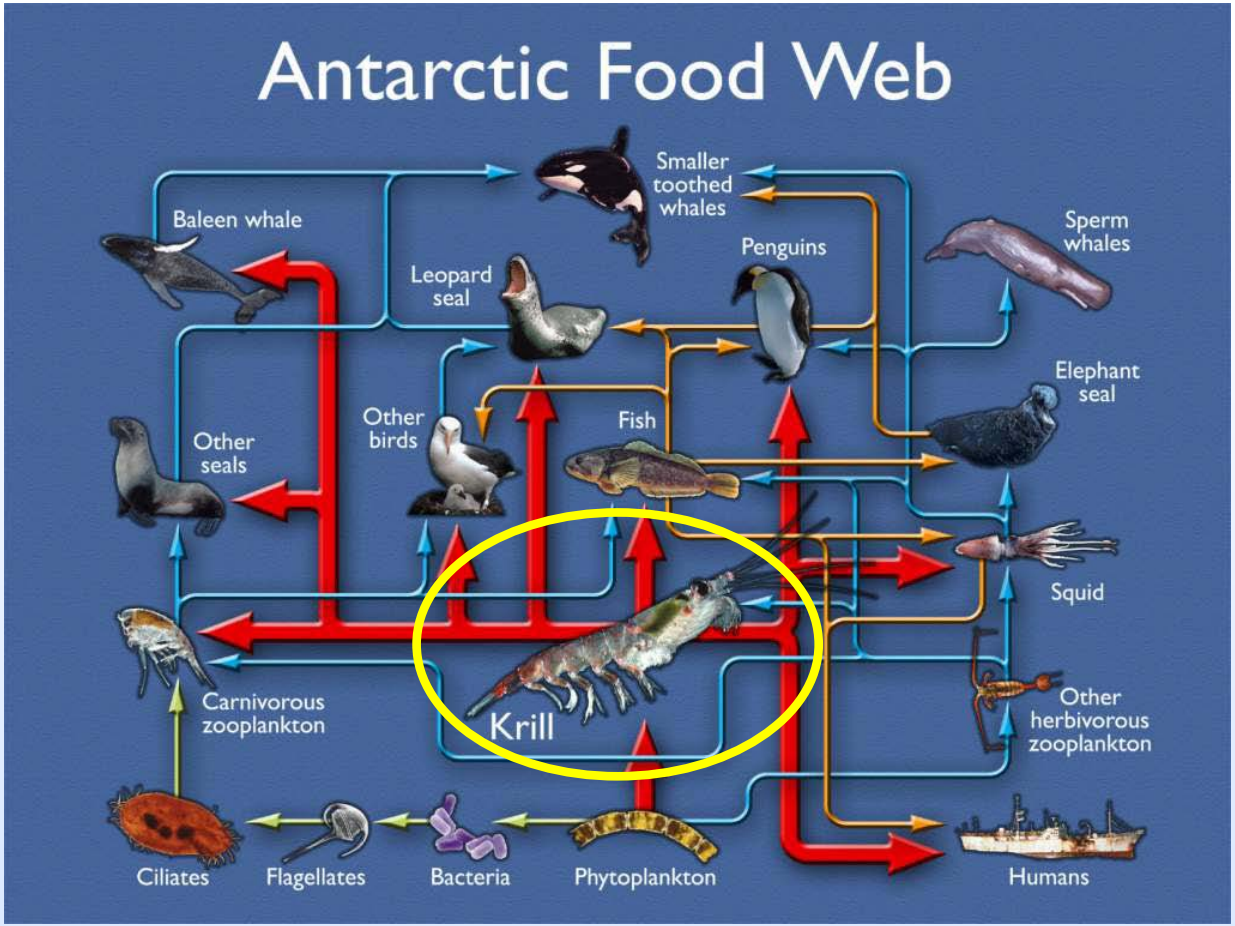
Antarctic krill *Euphausia superba*



WAP:

Diatoms,
Cryptophytes

Antarctic krill
Euphausia superba

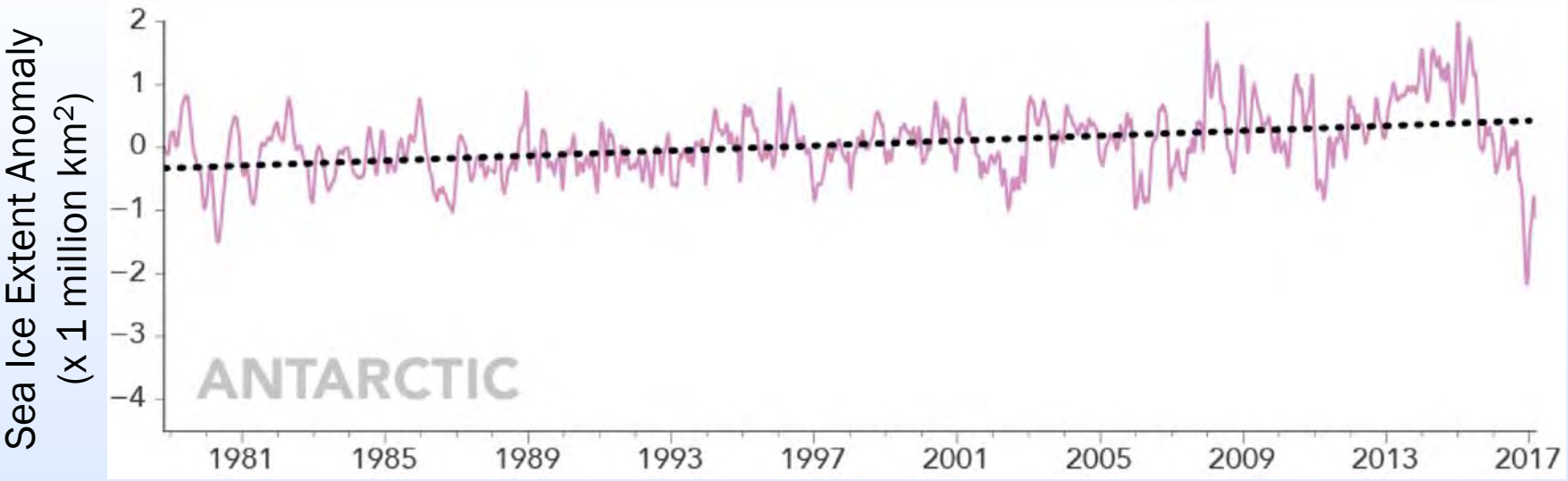


Ross Sea:

Phaeocystis,
Diatoms

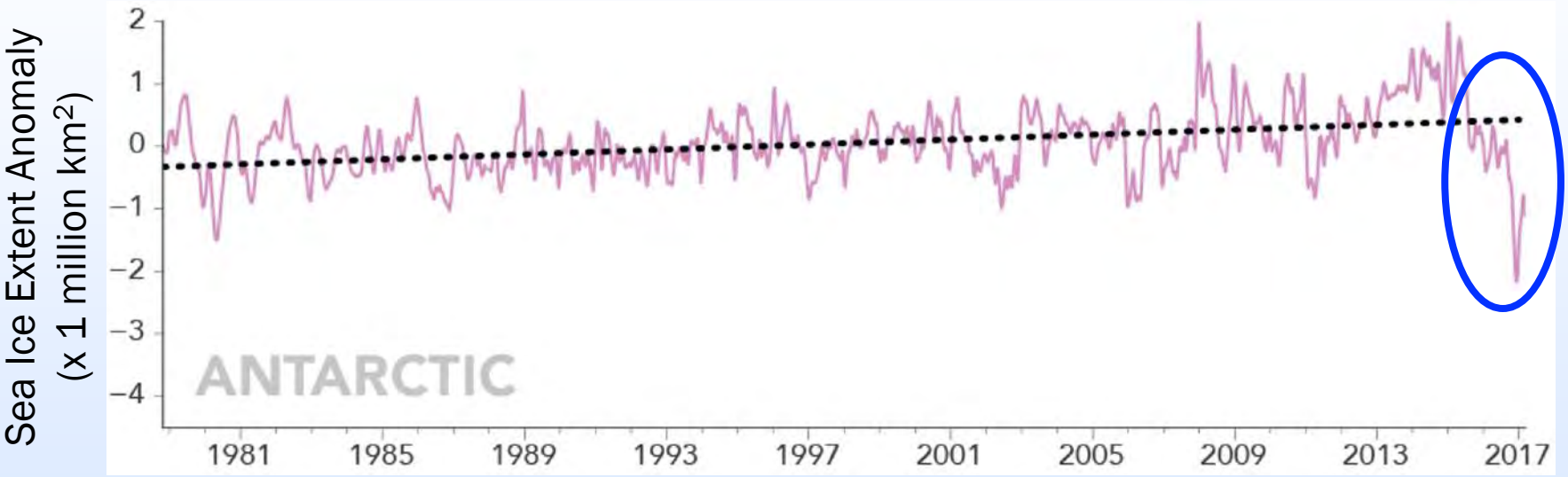
Crystal krill
Euphausia crystallorophias

Long-term Trend in Total Antarctic Sea Ice Extent



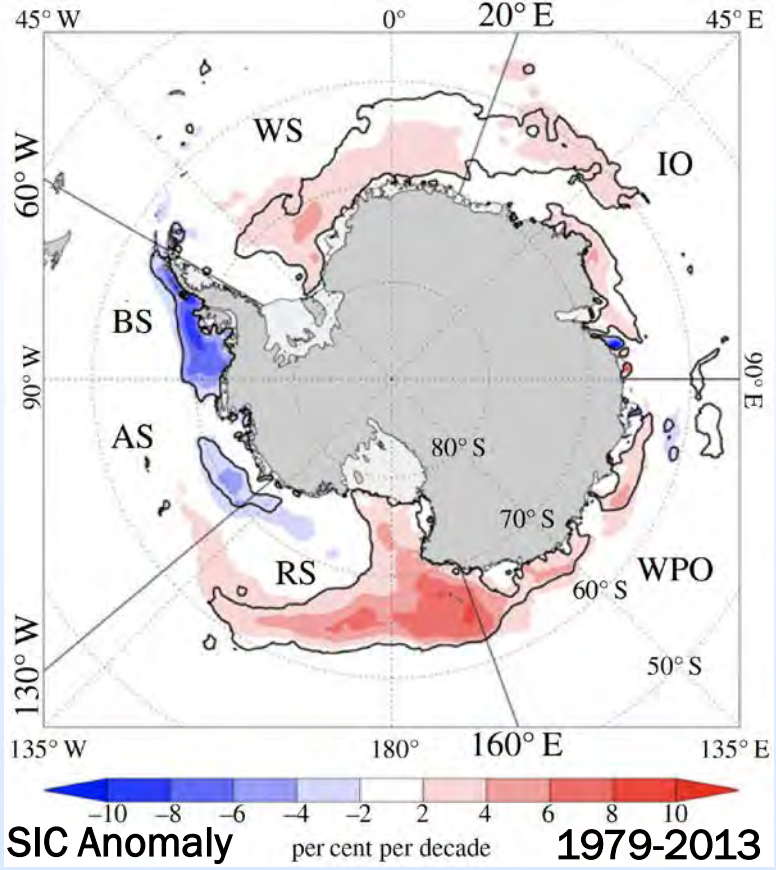
Joshua Stevens/NASA Earth Observatory

Long-term Trend in Total Antarctic Sea Ice Extent

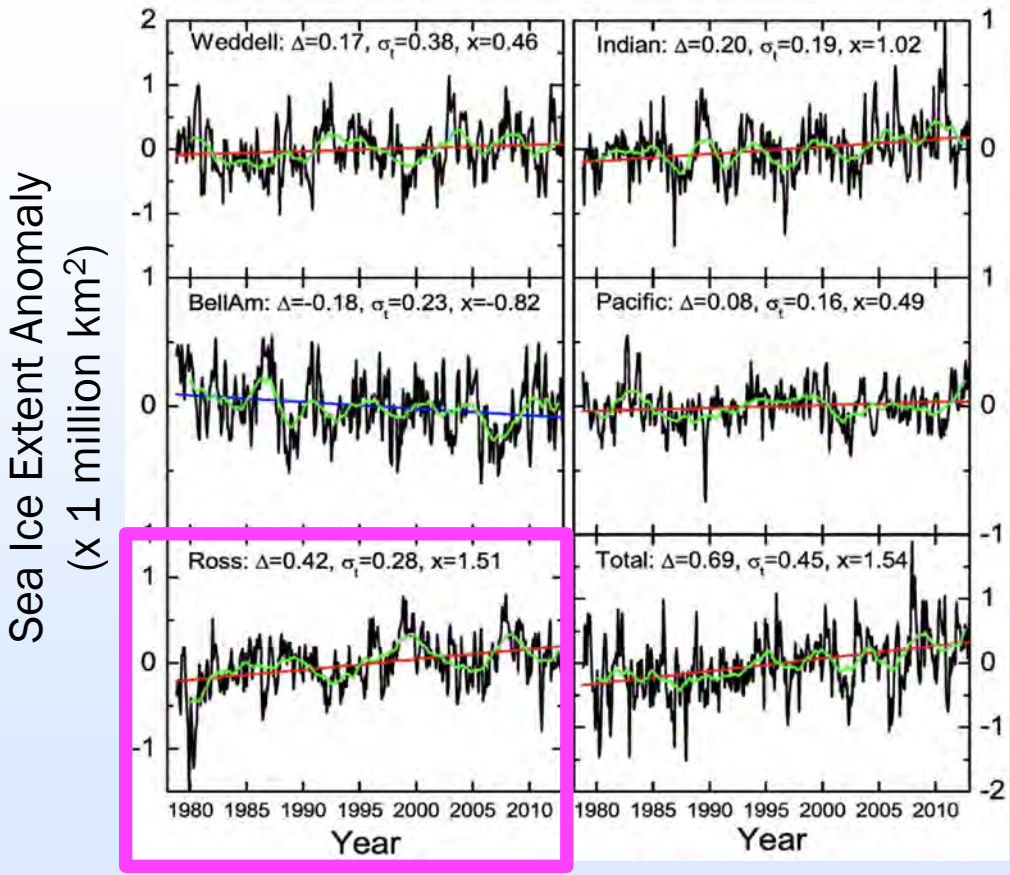


Joshua Stevens/NASA Earth Observatory

Long-term Sea Ice Trend Driven by Ross Sea



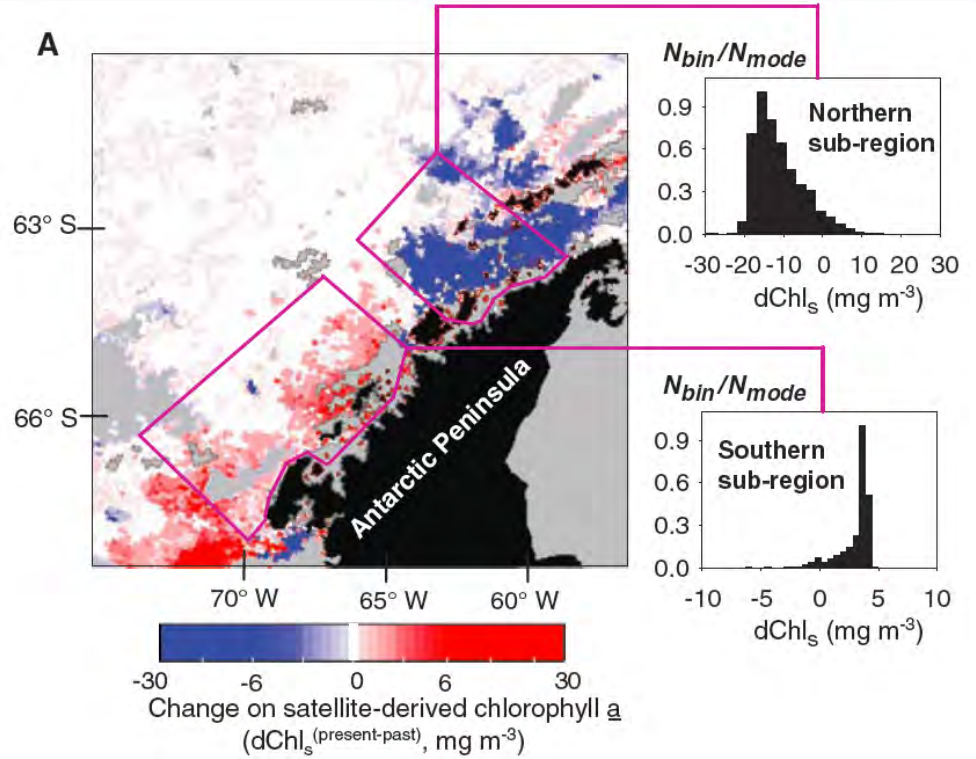
Turner et al. 2015, Phil. Trans. R. Soc. A

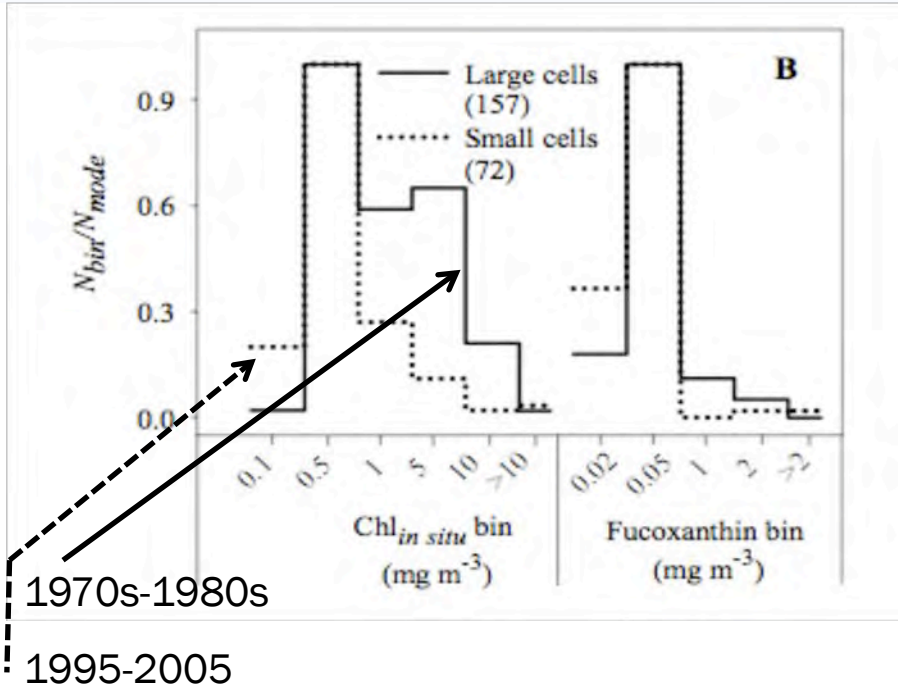


Yuan et al. 2017, Sci. Reports

Recent changes in WAP phytoplankton

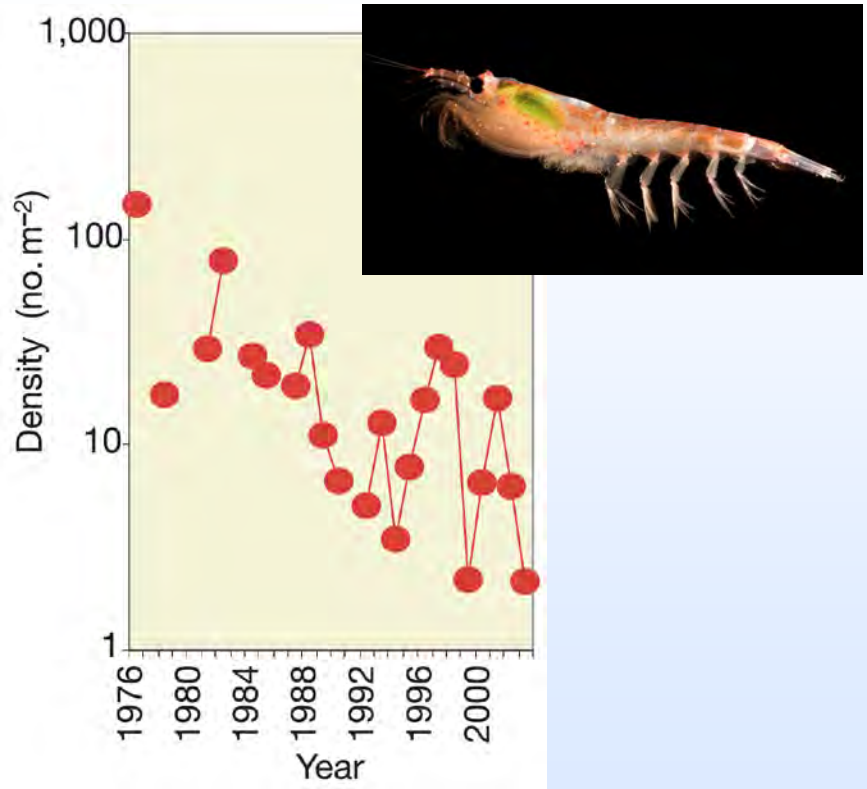
- 12% overall decrease in chl-*a* over past 30 years, particularly northern WAP
- Shift from large to small phytoplankton





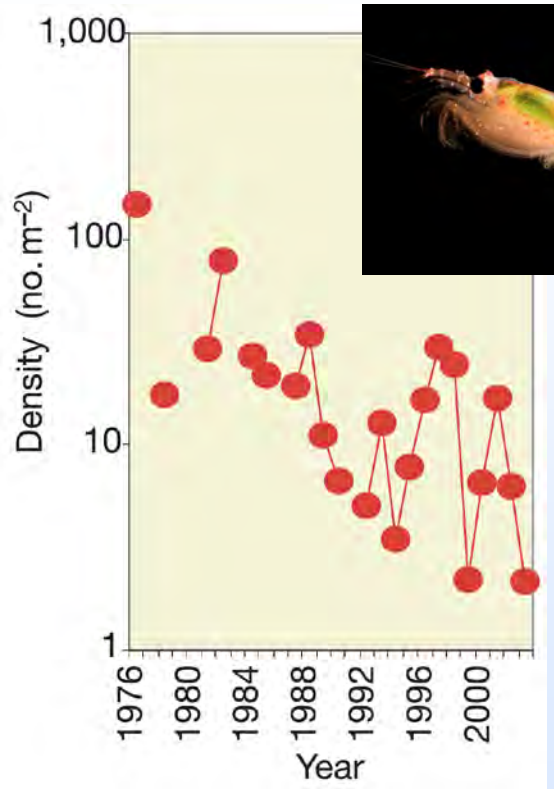
Montes-Hugo et al. 2009, Science

Recent changes in Krill



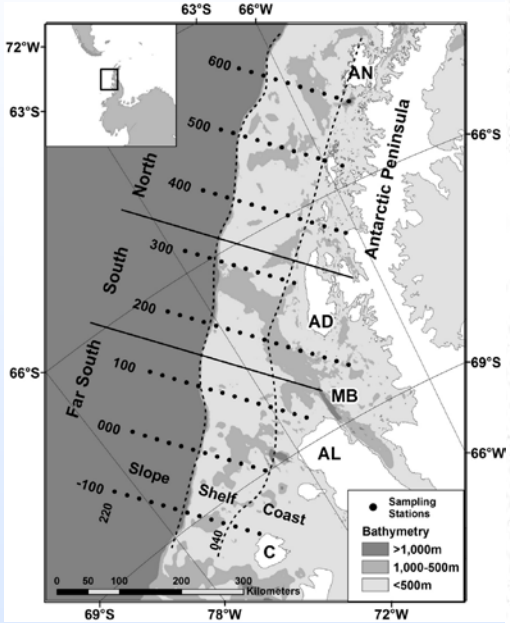
Atkinson et al. 2004, Nature

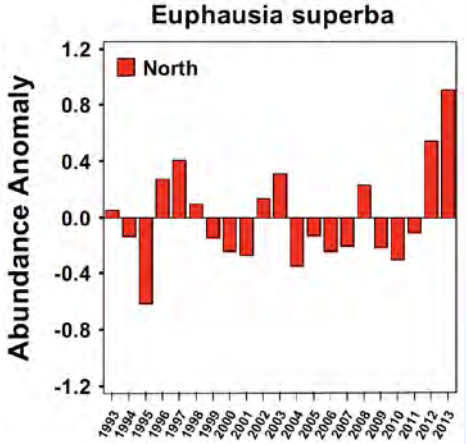
Recent changes in Krill

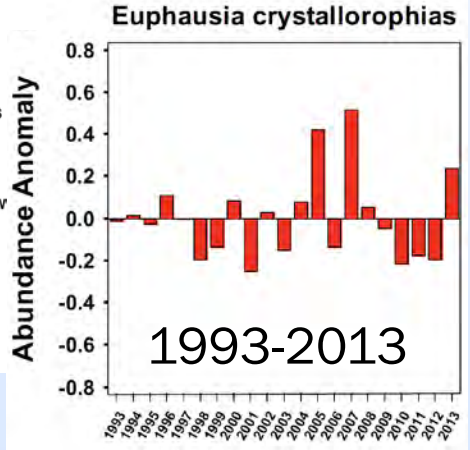


Atkinson et al. 2004, Nature

Palmer LTER

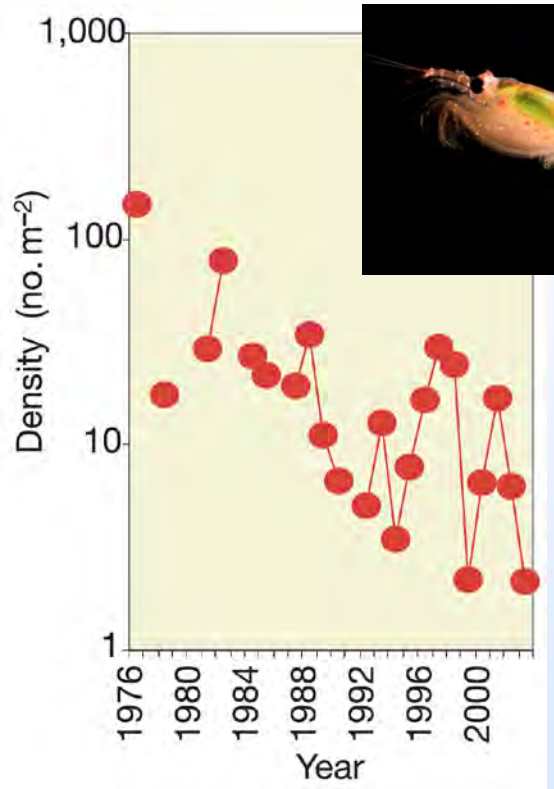






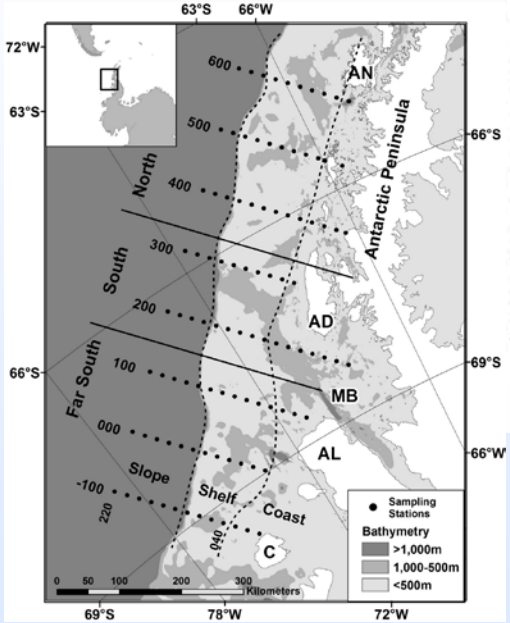
Steinberg et al. 2015, Deep Sea Res. I

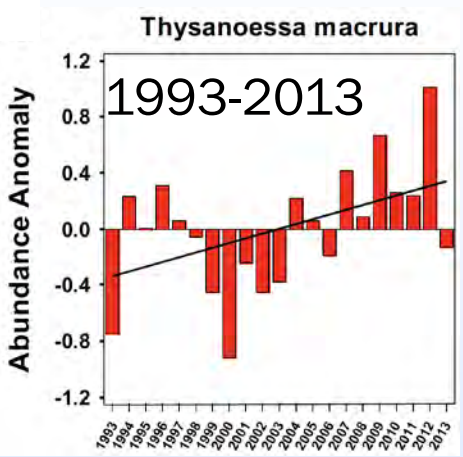
Recent changes in Krill



Atkinson et al. 2004, Nature

Palmer LTER



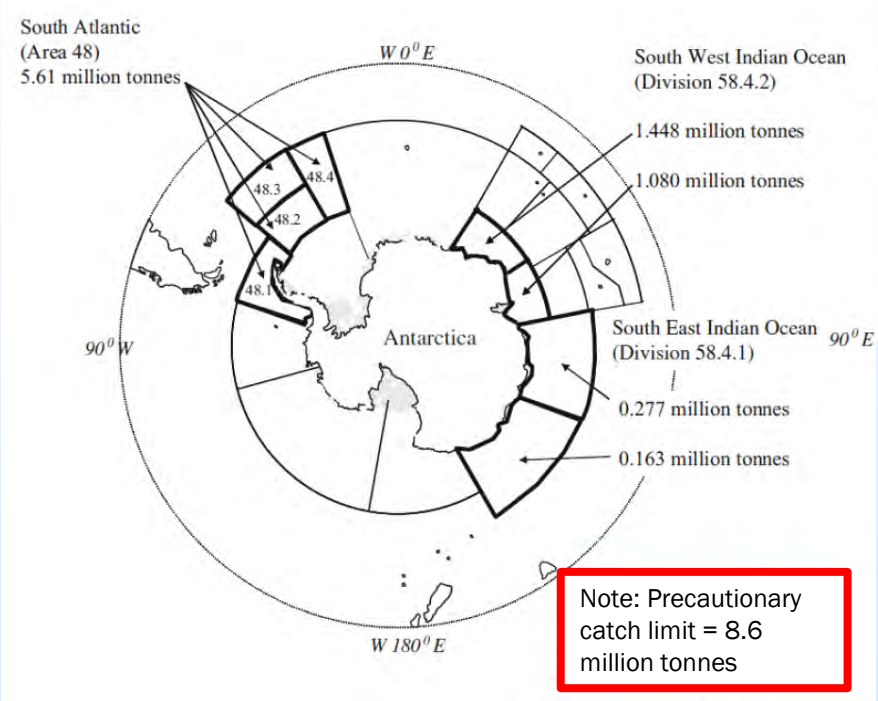


- Omnivorous
- Not ice-dependent

Steinberg et al. 2015, Deep Sea Res. I

Human impact on Antarctic Krill

Precautionary catch limited on the krill fishery in the CCAMLR Area



Nicol et al. 2012, Fish & Fisheries

Human impact on Antarctic Krill

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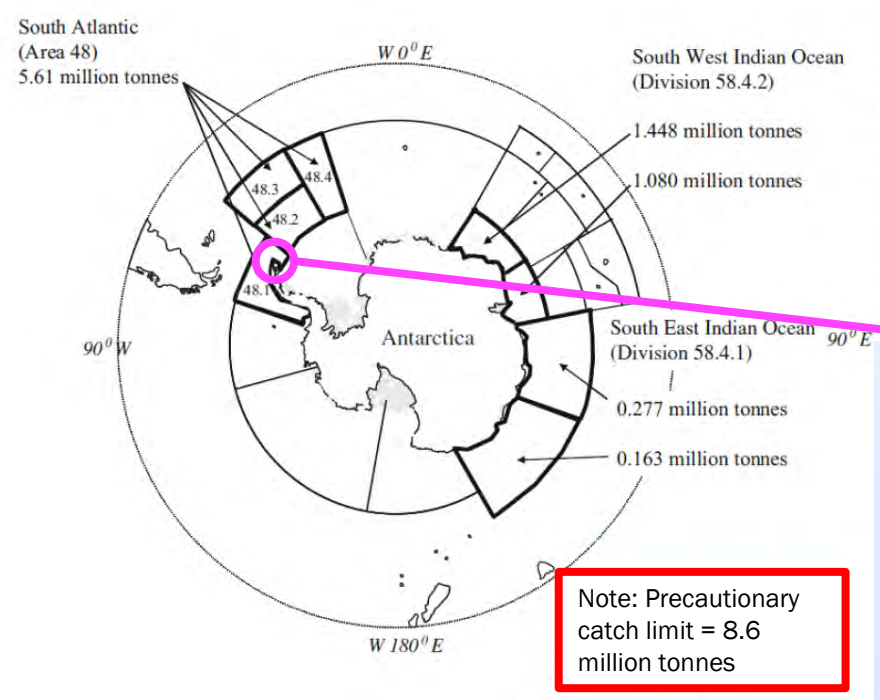
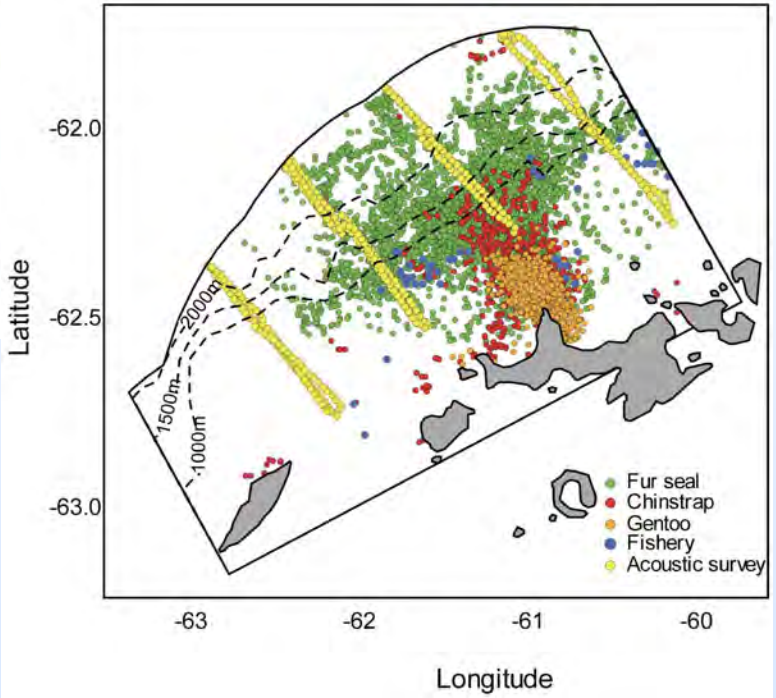


Overlap of krill fishery with krill-dependent predators



Nicol et al. 2012, Fish & Fisheries

Hinke et al. 2017, PLoS ONE

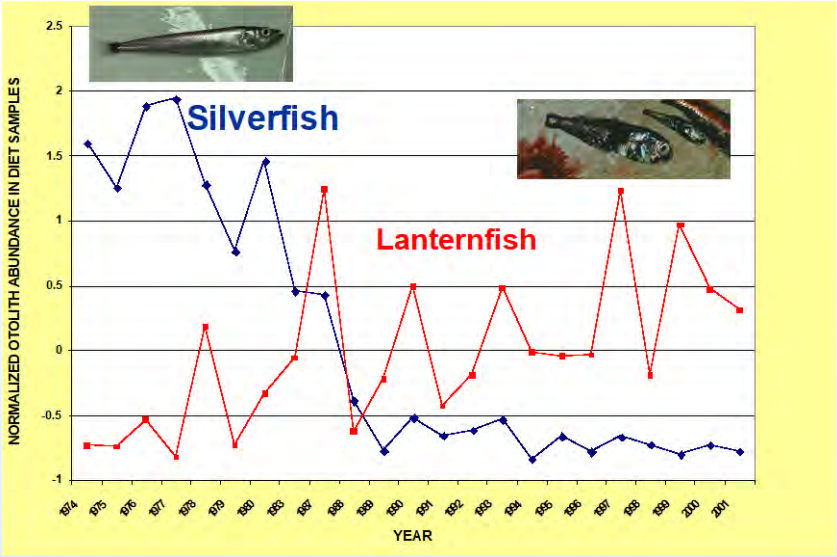
Recent and Projected Changes in Penguins

Schofield et al. 2010, Science

- WAP: Recent decrease in Adélie penguins; increase in subpolar Gentoos & Chinstraps

Recent and Projected Changes in Penguins

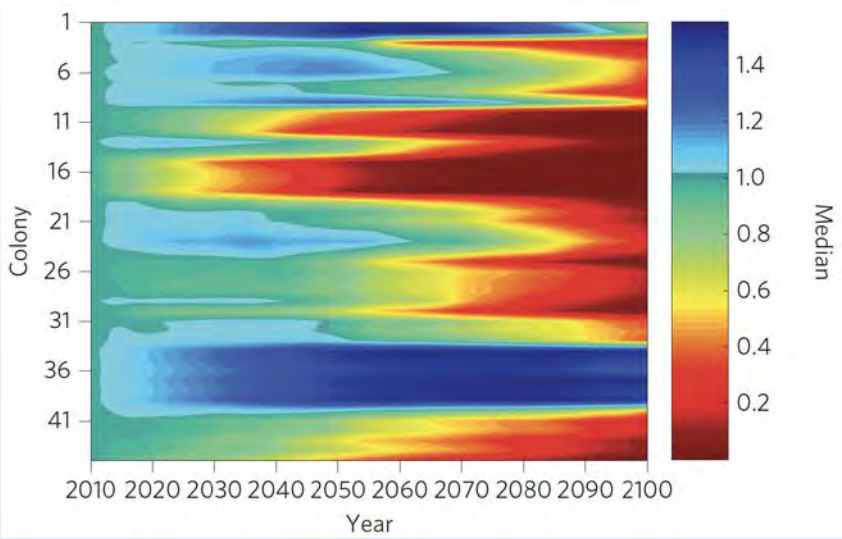
Schofield et al. 2010, Science

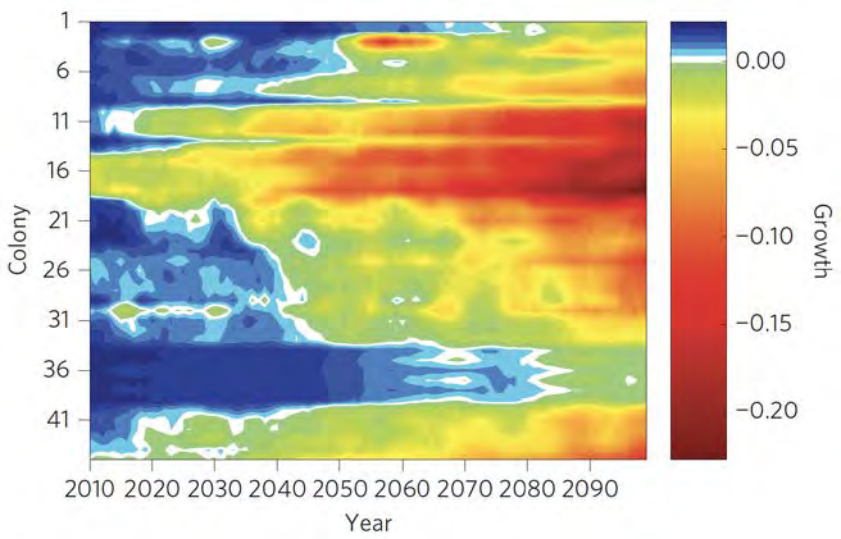


Courtesy of Bill Fraser

- WAP: Recent decrease in Adélie penguins; increase in subpolar Gentoos & Chinstraps

Recent and Projected Changes in Penguins





Jenouvrier et al. 2014, Nat. Clim. Change

- Continent-wide: Projected decreases in Emperor penguin growth and breeding pairs

Recent changes in Whales

MEPS 575:195-206 (2017) - DOI: https://doi.org/10.3354/meps12211

Running fast in the slow lane: rapid population growth of humpback whales after exploitation

L. L. Wedekin[1,2,*], M. H. Engel[1], A. Andriolo[3], P. I. Prado[2], A. N. Zerbini[4,5,6], M. M. C. Marcondes[1], P. G. Kinas[7], P. C. Simões-Lopes[8]

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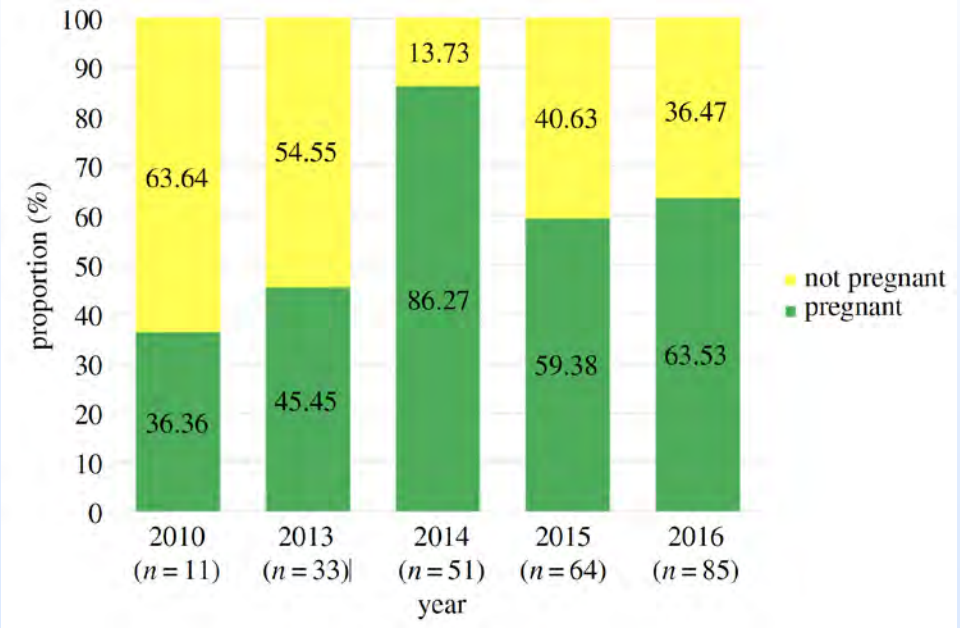


Pallin et al. 2018, R. Soc. open sci.

Recent changes in Seals

Photo credit: Glenn Browning

Photo credit: Paul Ward

Marine Mammal Science

Article

An apparent population decrease, or change in distribution, of Weddell seals along the Victoria Land coast

David G. Ainley, Michelle A. Larue, Ian Stirling, Sharon Stammerjohn, Donald B. Siniff

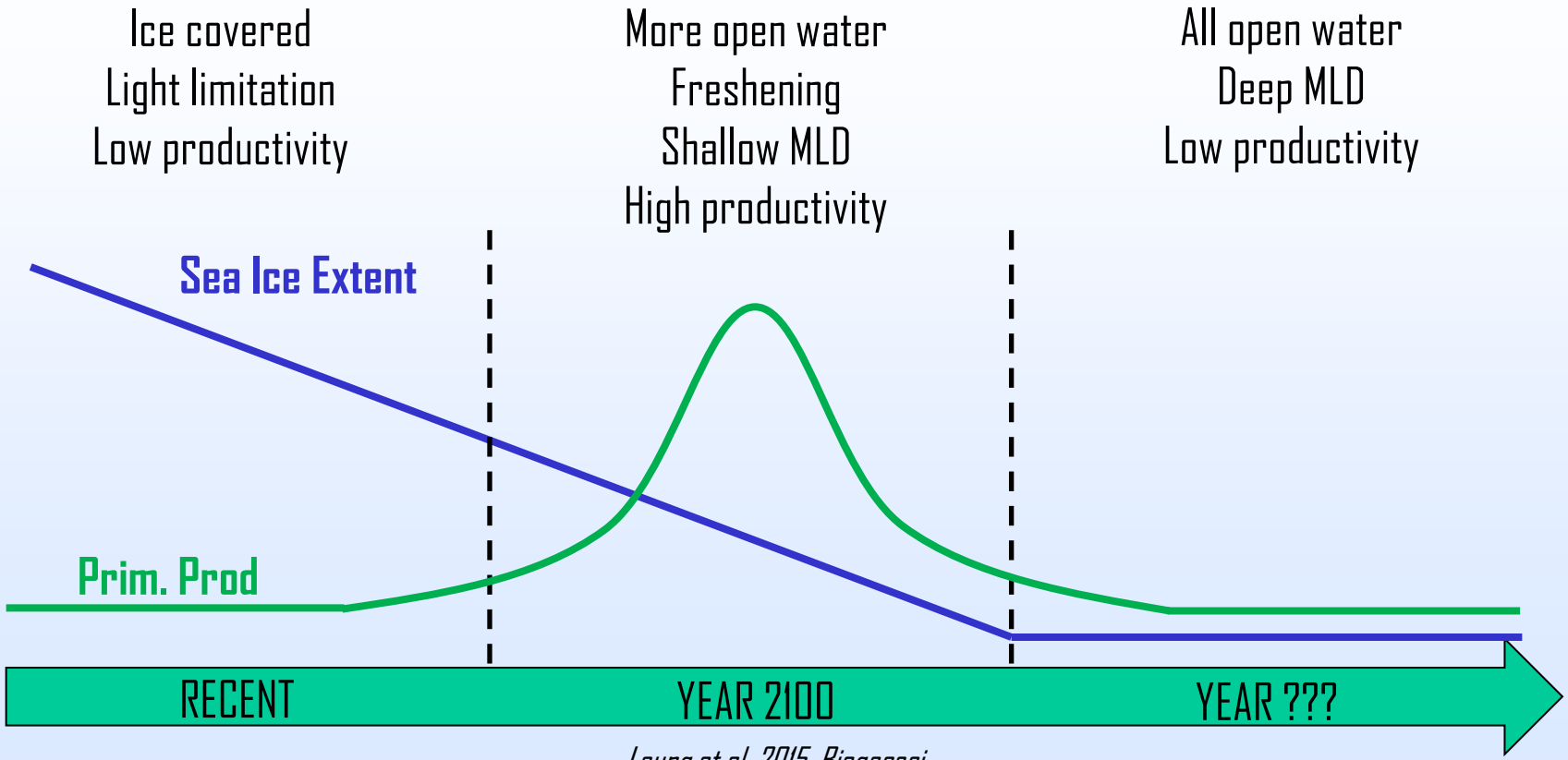
First published: 02 April 2015 | https://doi.org/10.1111/mms.12220 | Cited by: 11

Population biology: Fur seals signal their own decline

Tim Coulson & Sonya Clegg

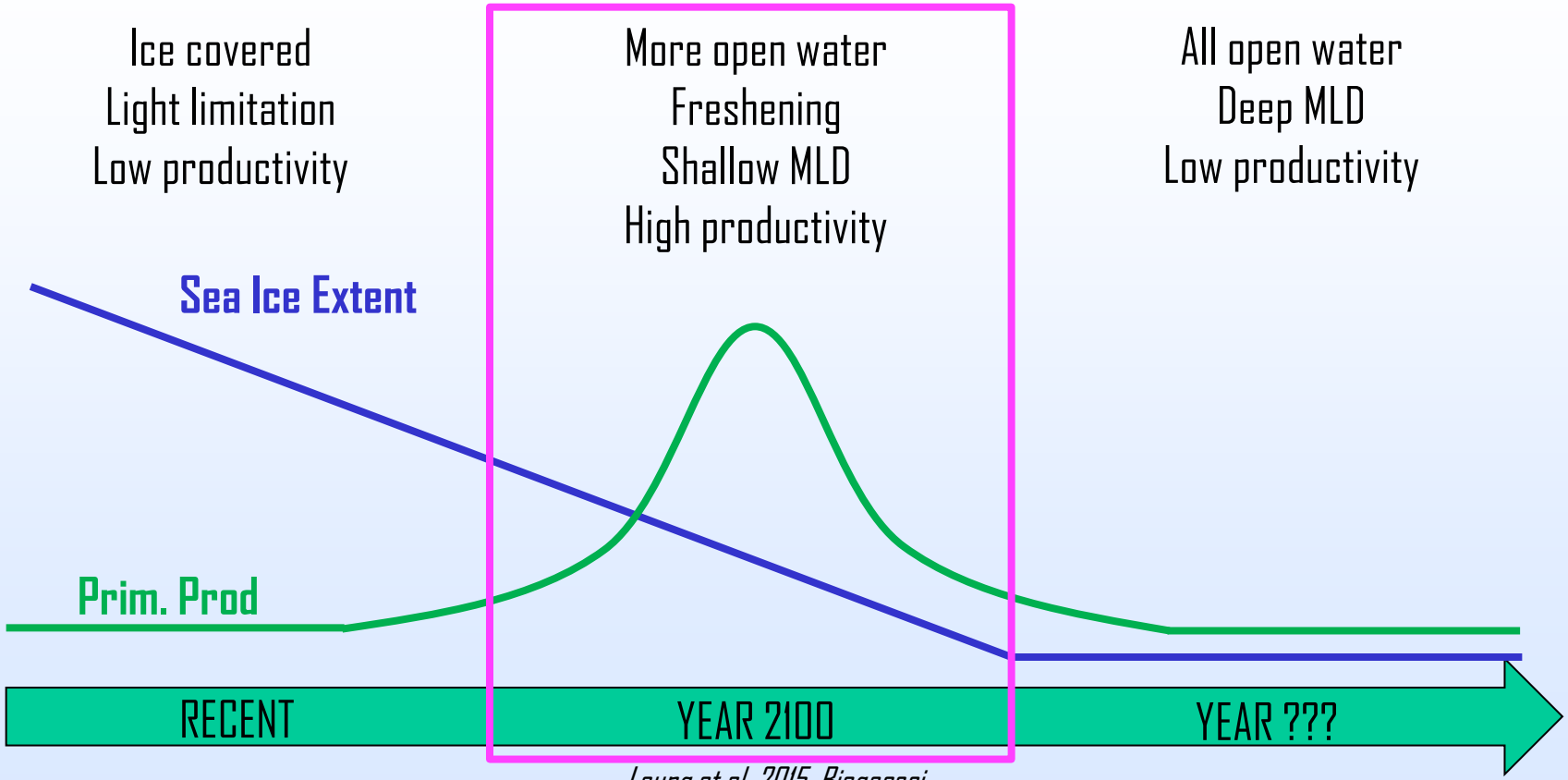
Data on three generations of Antarctic fur seals suggest that climate change is reducing the survival of less-fit individuals with low genetic variation, but that overall seal numbers are falling. **See Letter p.462**

Evolution of Antarctic Climate Change



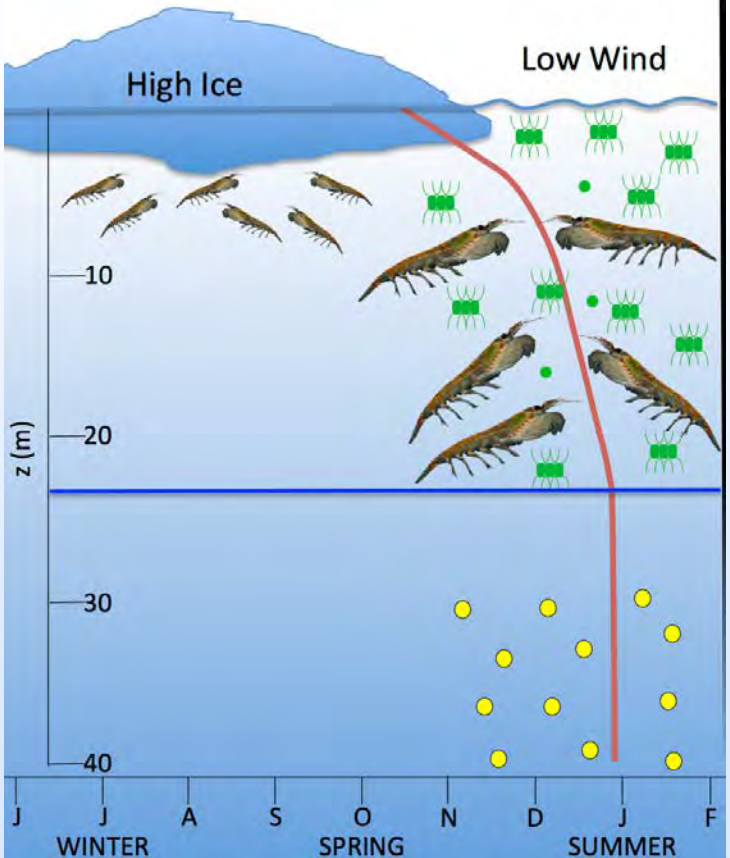
Leung et al. 2015, Biogeosci.
Rickard & Behrens 2016, Antarct. Sci.

Evolution of Antarctic Climate Change



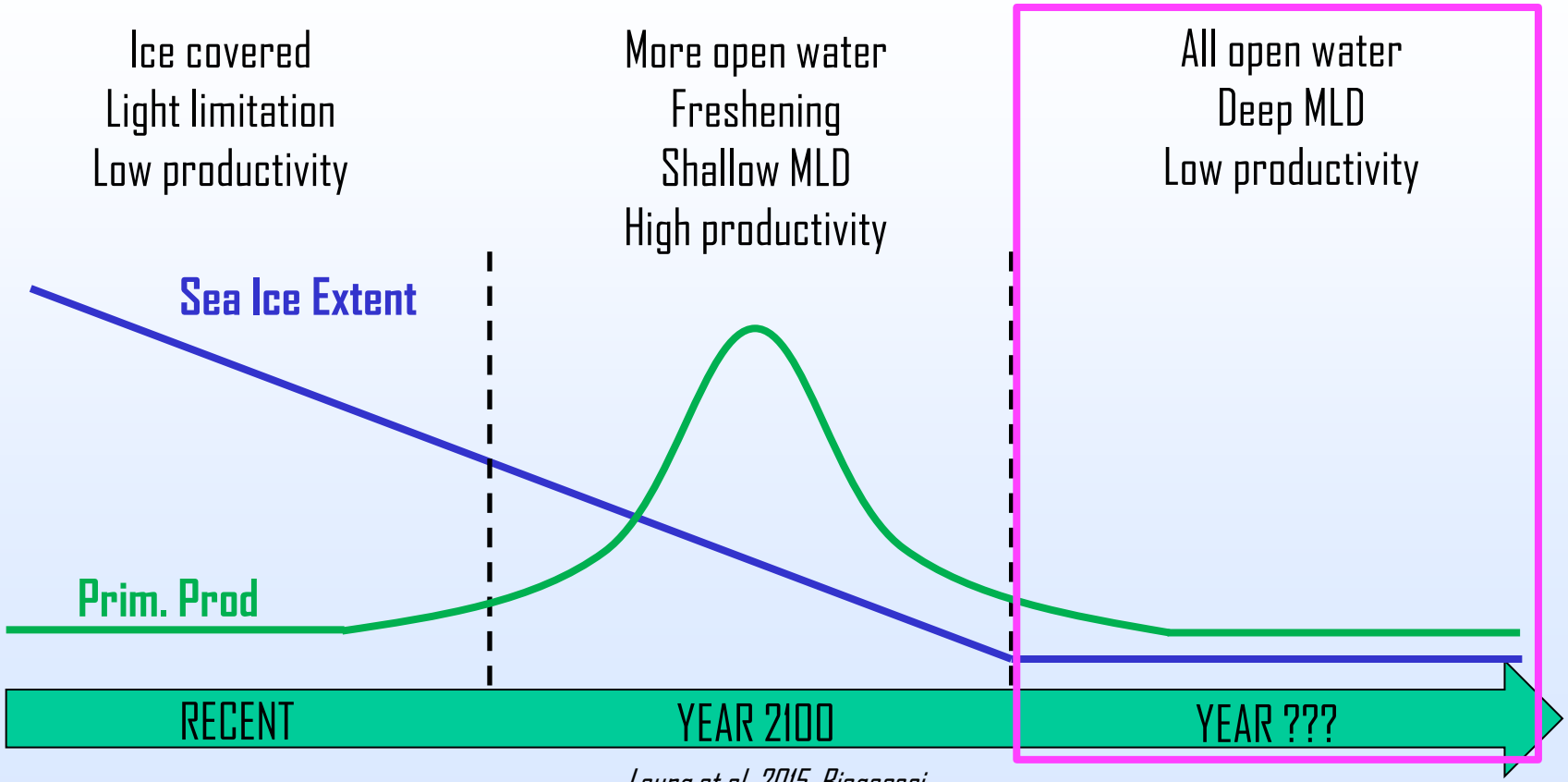
Leung et al. 2015, Biogeosci.
Rickard & Behrens 2016, Antarct. Sci.

- SAM

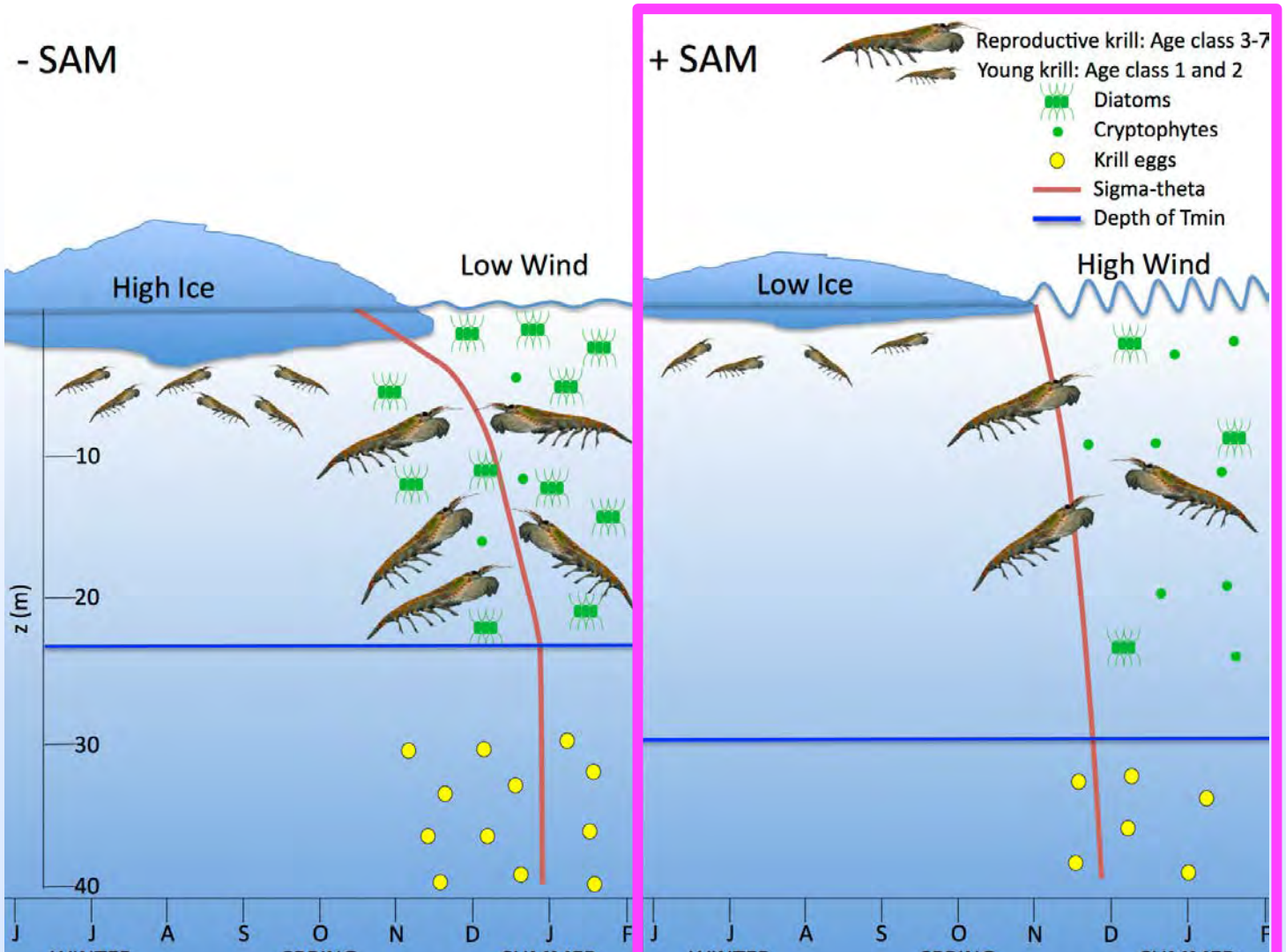


Reproductive krill: Age class 3-7
Young krill: Age class 1 and 2
Diatoms
Cryptophytes
Krill eggs
Sigma-theta
Depth of Tmin

Evolution of Antarctic Climate Change



Leung et al. 2015, Biogeosci.
Rickard & Behrens 2016, Antarct. Sci.


- SAM
+ SAM
Reproductive krill: Age class 3-7
Young krill: Age class 1 and 2
Diatoms
Cryptophytes
Krill eggs
Sigma-theta
Depth of Tmin
High Ice
Low Wind
Low Ice
High Wind
z (m)
10
20
30
40
J
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A
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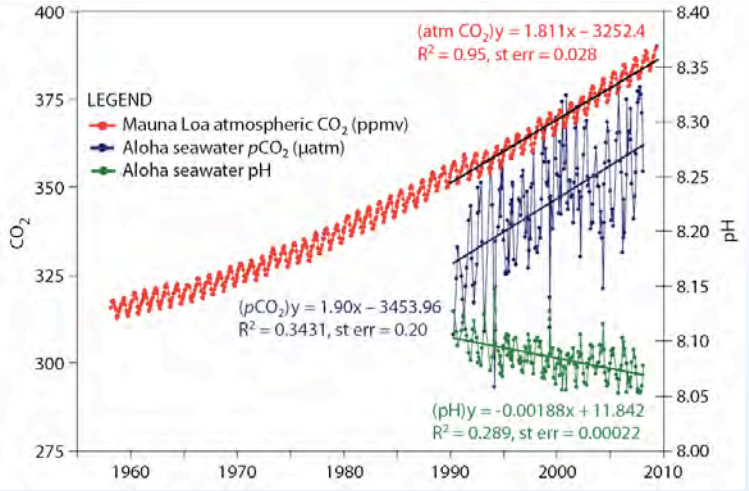
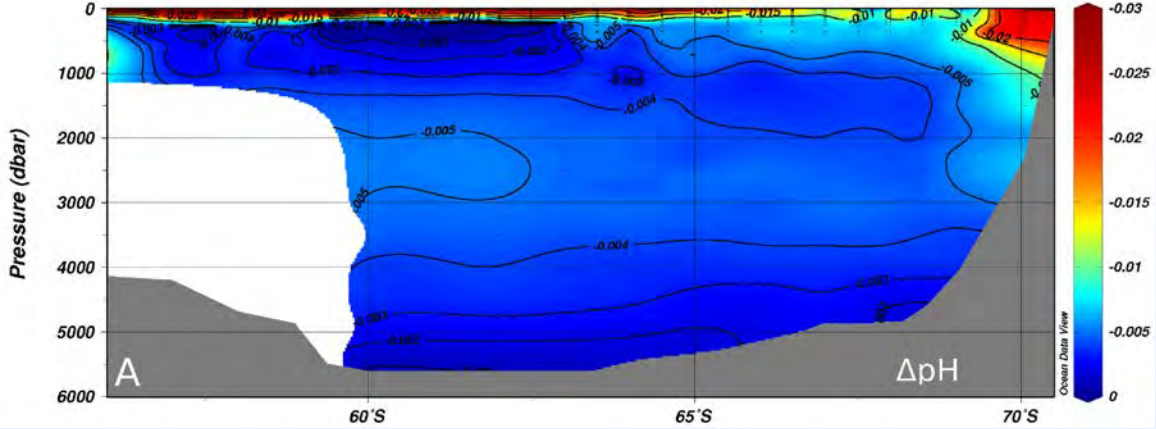
O
N
D
J
F

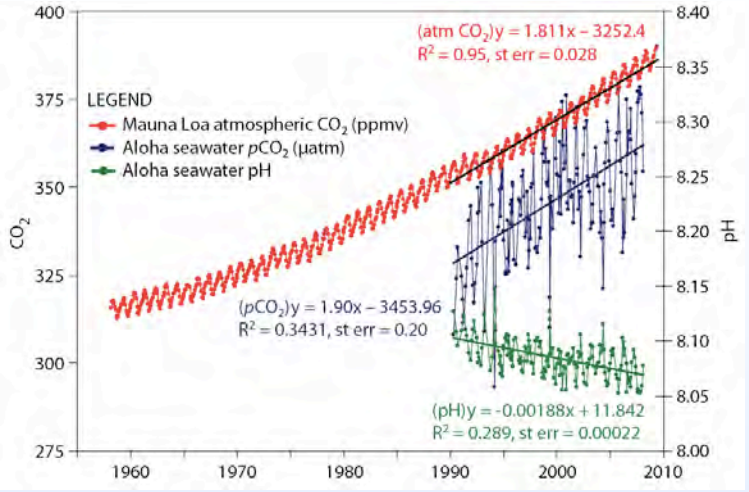
Acidification: The "Other" CO_2 Problem



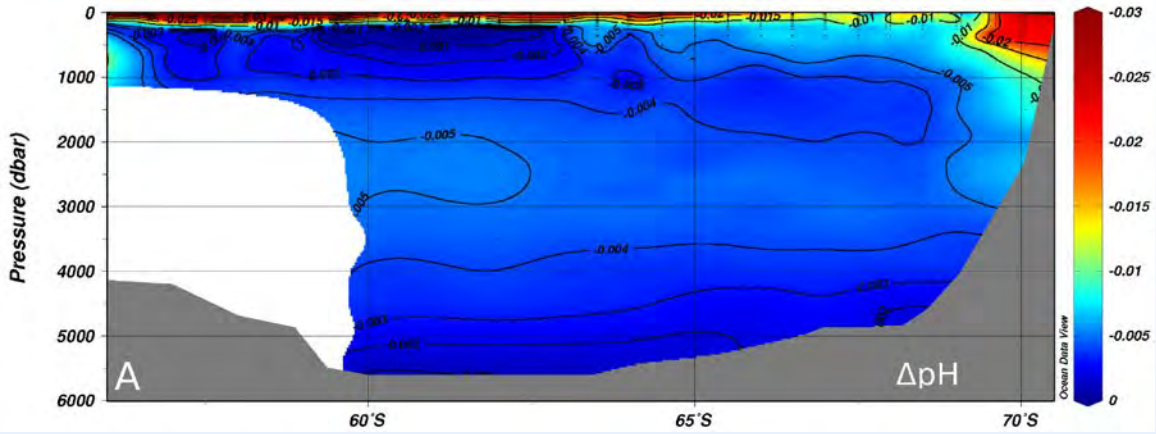
Weddell Sea, 1992-2008 (*Hauck et al. 2010*)

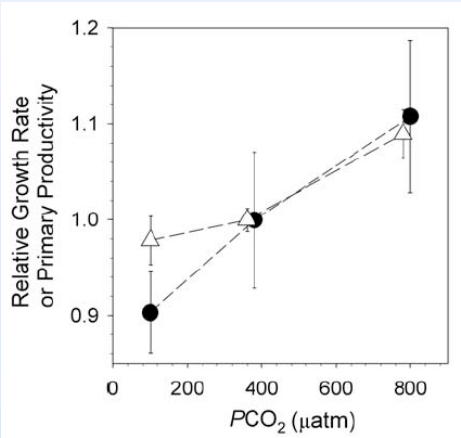


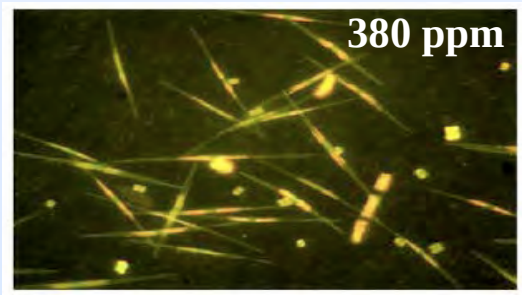
Acidification: The "Other" CO_2 Problem

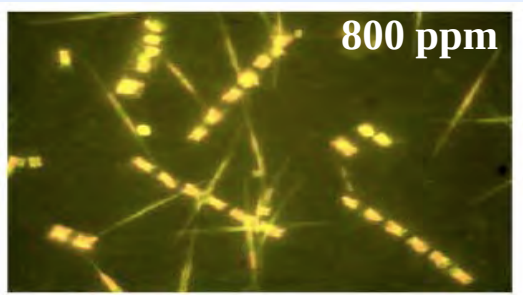


Weddell Sea, 1992-2008 (*Hauck et al. 2010*)

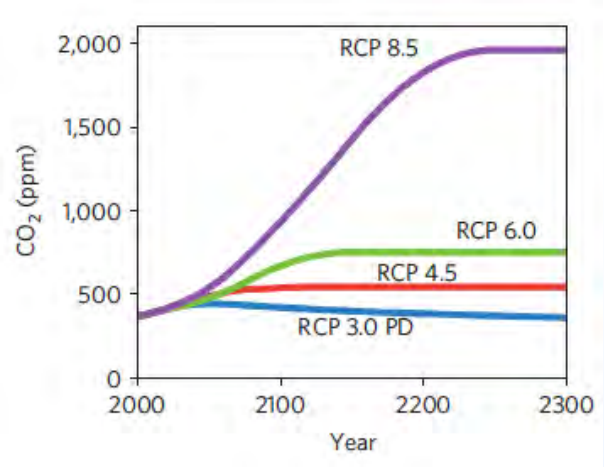








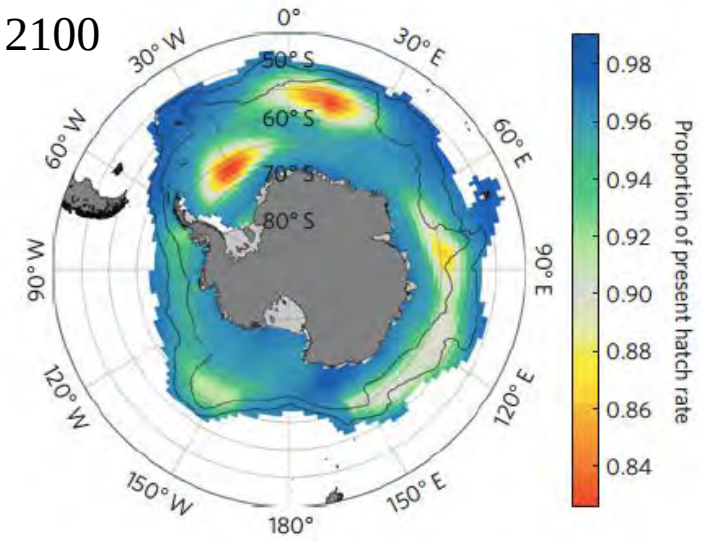
Tortell et al. 2008

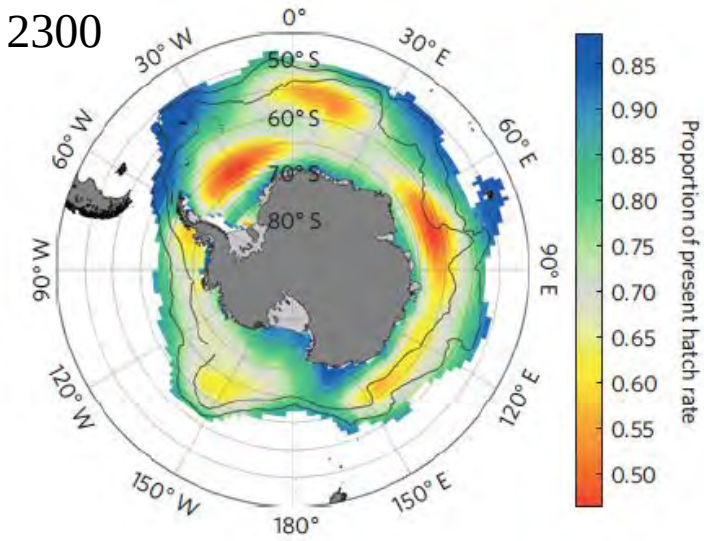


Krill at High Risk under Acidification

(Kawaguchi et al. 2013)

RCP 6.0 scenario

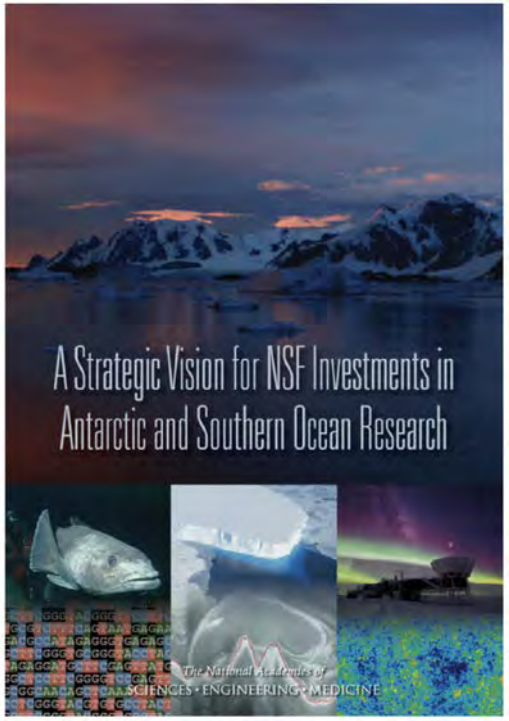




Invasive species

Photo: Steve Clabuesch, NSF

Photo: Sven Thatje



Research Priorities

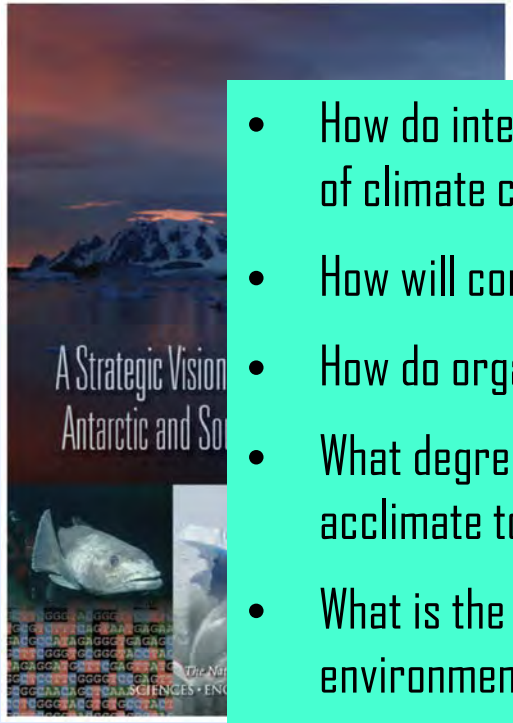
National Academies of Sciences, Engineering, and Medicine. 2015. A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research. Washington, DC: National Academies Press.

Results of the SCAR Horizon Scan. 2014. Nature 512: 23-25.

Six priorities for Antarctic science

Mahlon C. Kennicutt II, **Steven L. Chown** and colleagues outline the most pressing questions in southern polar research, and call for greater collaboration and environmental protection in the region.

Research Priorities



- How do interactions between the atmosphere, ocean and ice control the rate of climate change?
- How will continued change affect biodiversity?
- How do organisms respond to multiple stressors?
- What degree of phenotypic plasticity exists in organisms and is it enough to acclimate to rapid change?
- What is the potential for Antarctic biota to evolve and adapt to the changing environment?
- How are humans impacting Antarctica?
- What are potential mitigation strategies?