

# Ecosystem Response to Antarctic Climate Variability and Change

A photograph of several large icebergs floating in the ocean under a dark sky. The icebergs are illuminated from below by a warm, golden light, likely from a low sun, creating a strong contrast and highlighting the textures of the ice. The water is dark, and the foreground is filled with smaller ice floes.

Grace K. Saba

Assistant Professor, Rutgers University

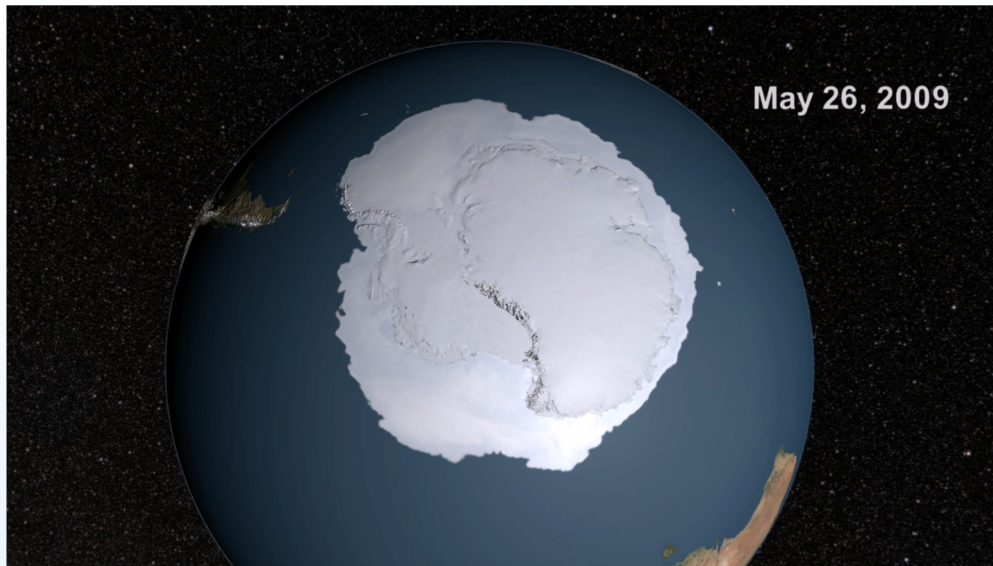
[saba@marine.rutgers.edu](mailto:saba@marine.rutgers.edu)



# Antarctic Sea Ice Variability

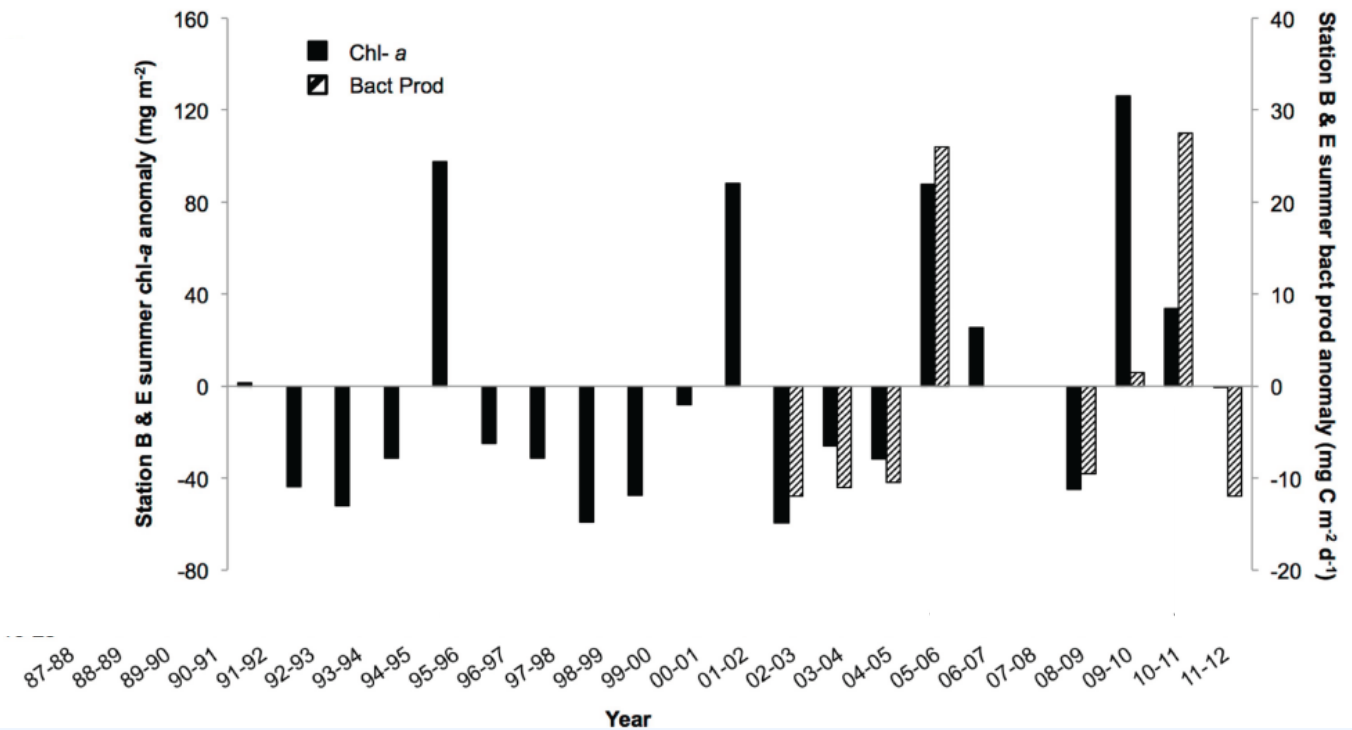
Seasonal: May 2009 – July 2010

Annual: 1979 – 2008



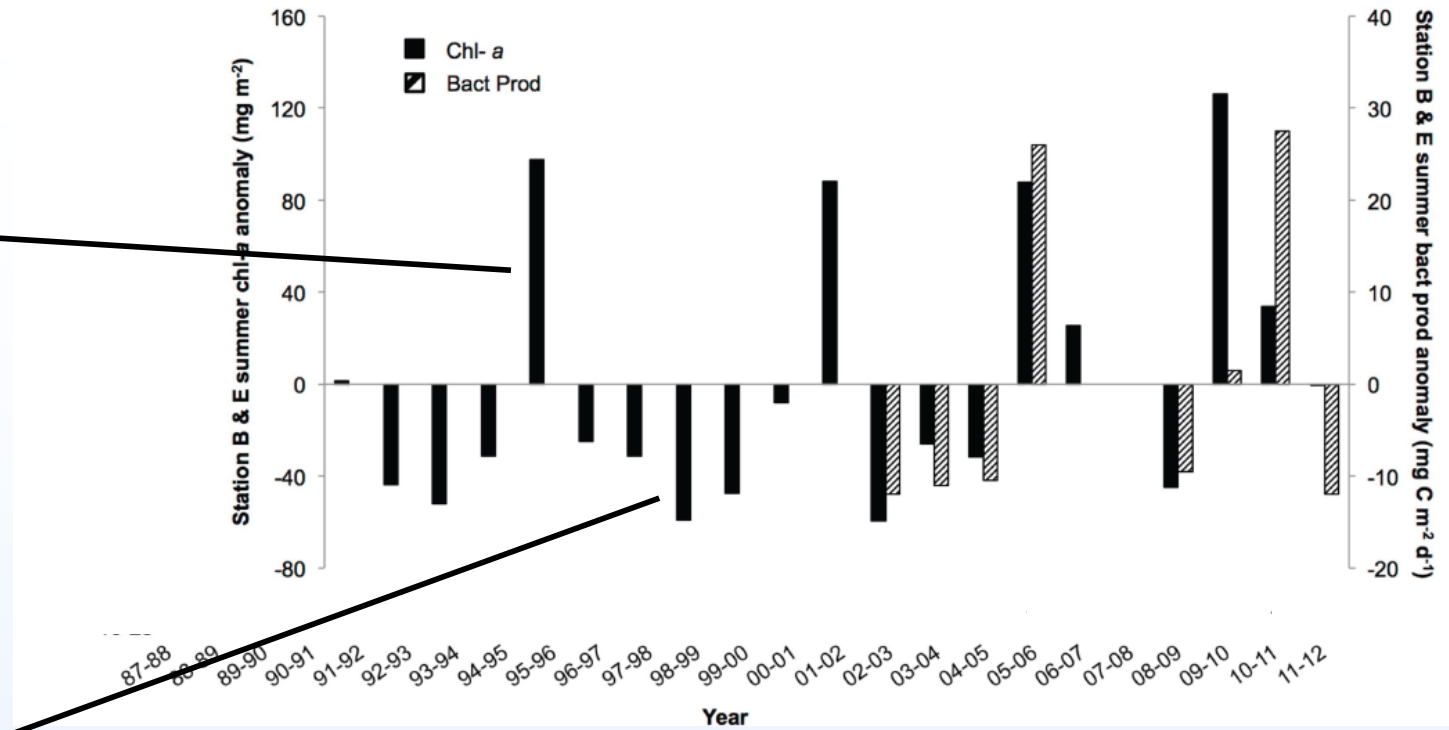
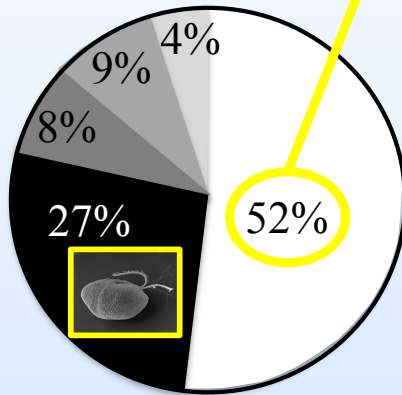
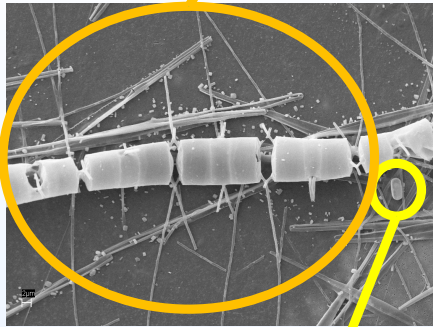
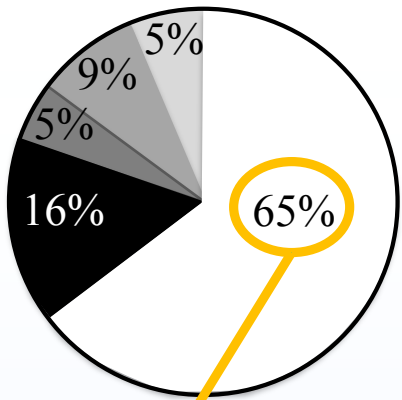


# Tight coupling between physics and biology



*Saba et al. 2014, Nat. Commun.*

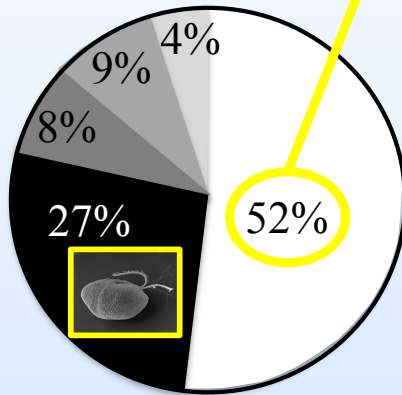
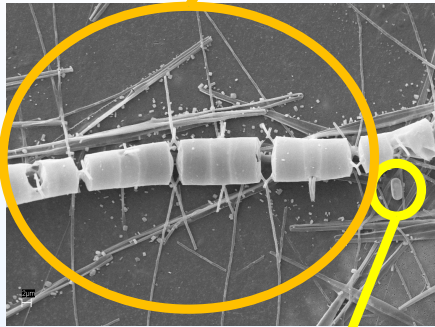
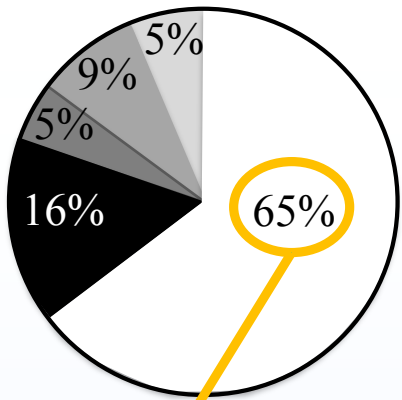




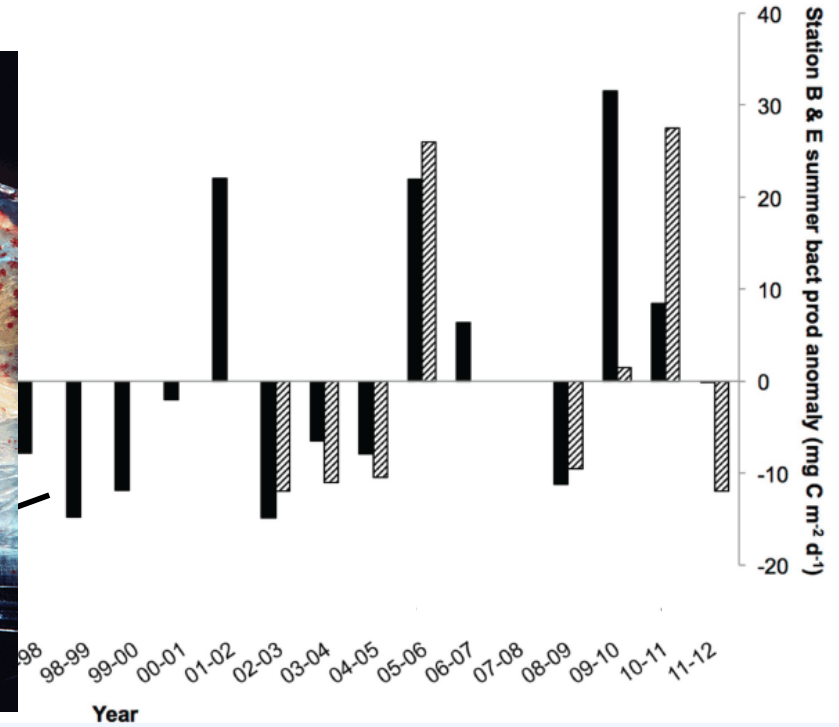
- % Diatoms
- % Prasinophytes
- % Haptophytes
- % Flagellates
- % Cryptophytes

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





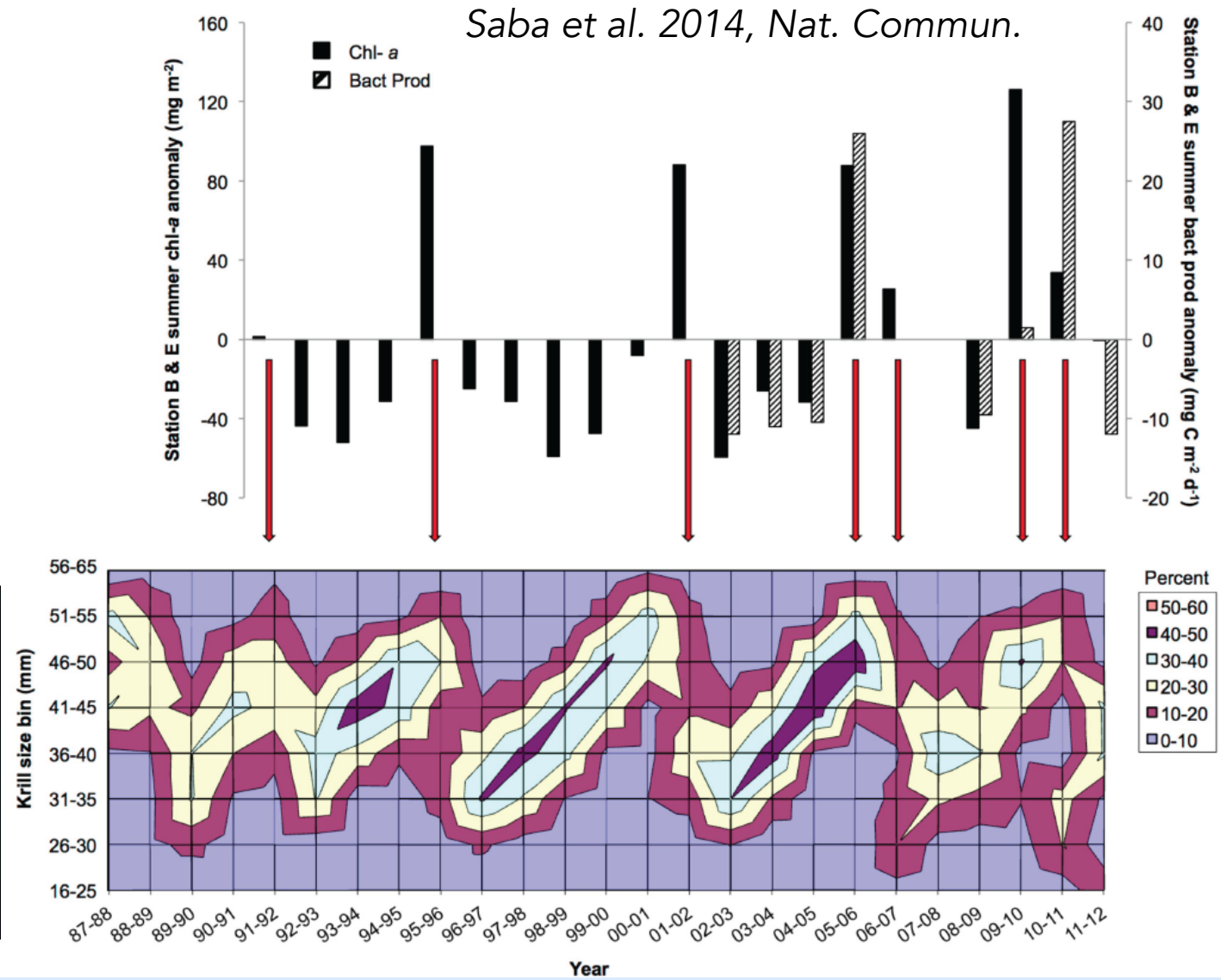
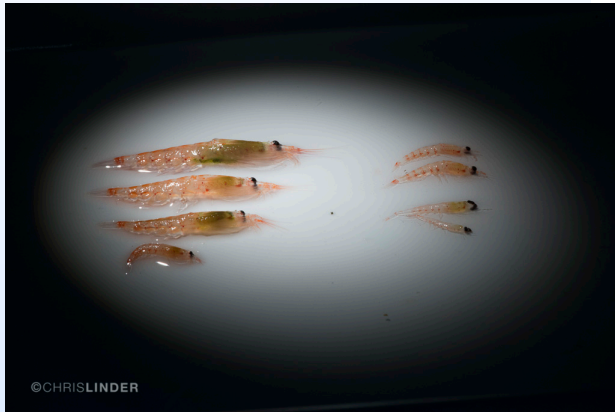
- % Diatoms
- % Prasinophytes
- % Haptophytes
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Saba et al. 2014, Nat. Commun.  
 Schofield et al. 2017, Deep Sea Res. II

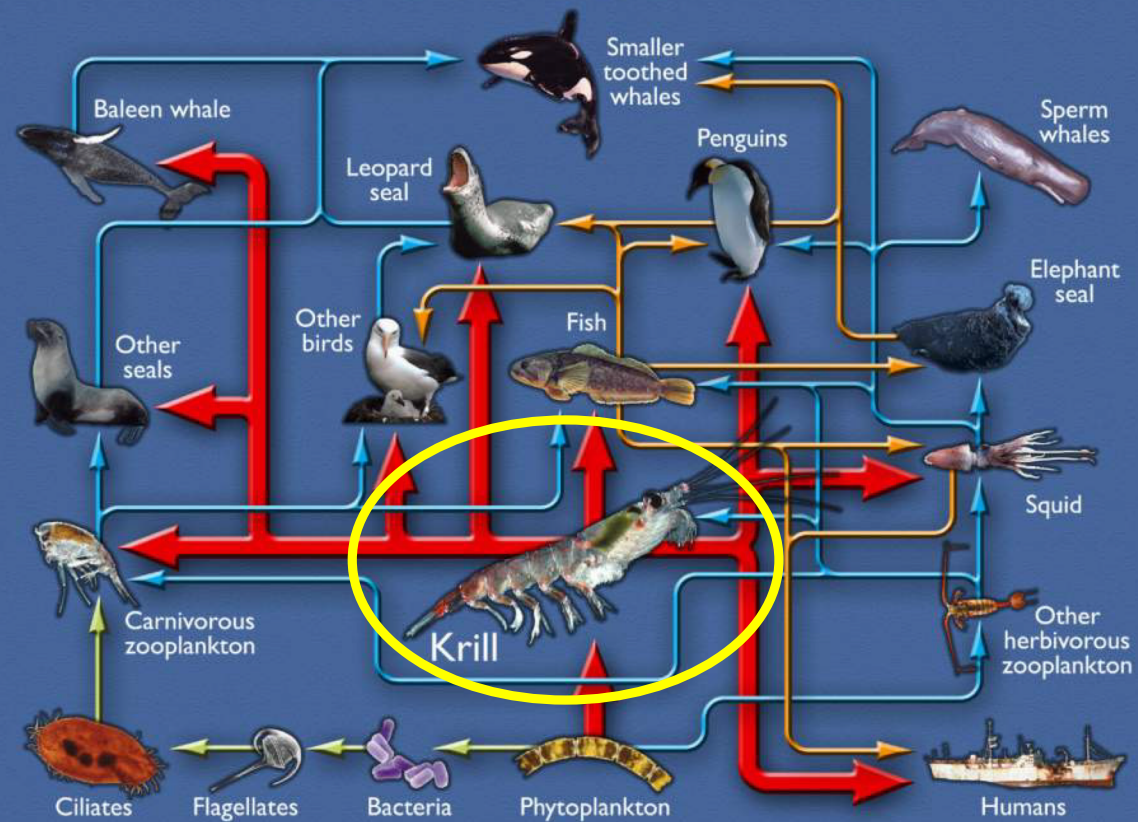


# Tight trophic coupling





# Antarctic Food Web

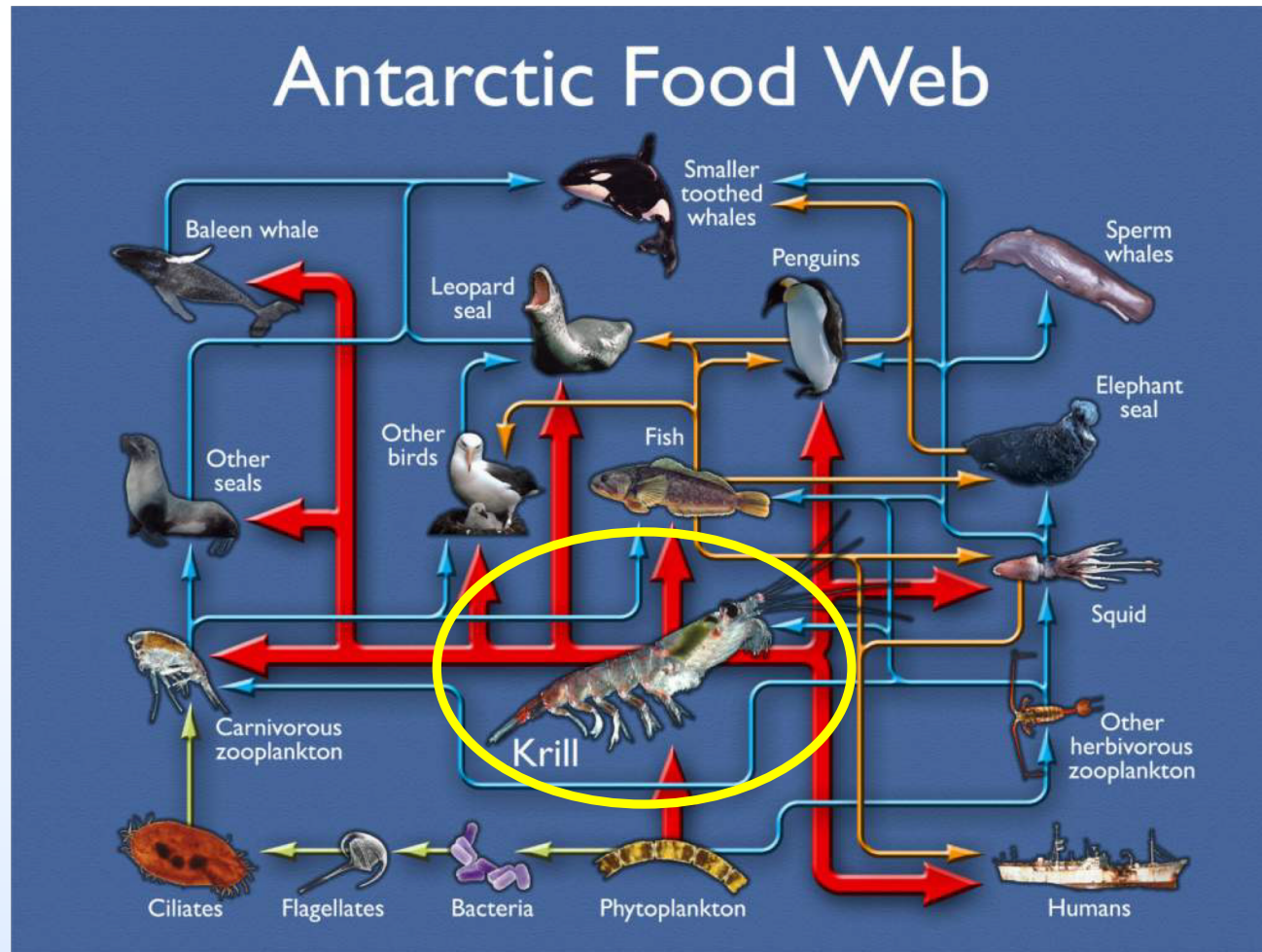


# Antarctic Food Web

WAP:

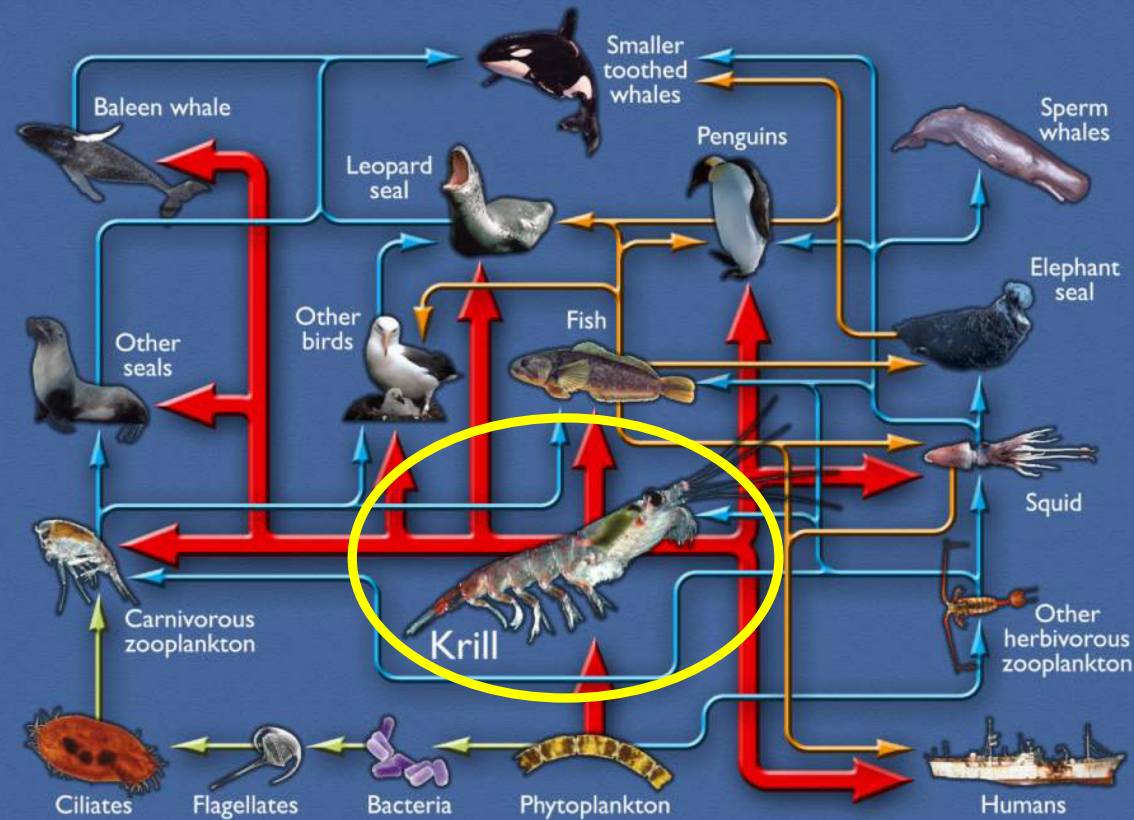
Diatoms,  
Cryptophytes

Antarctic krill  
*Euphausia  
superba*





# Antarctic Food Web



WAP:

Diatoms,  
Cryptophytes

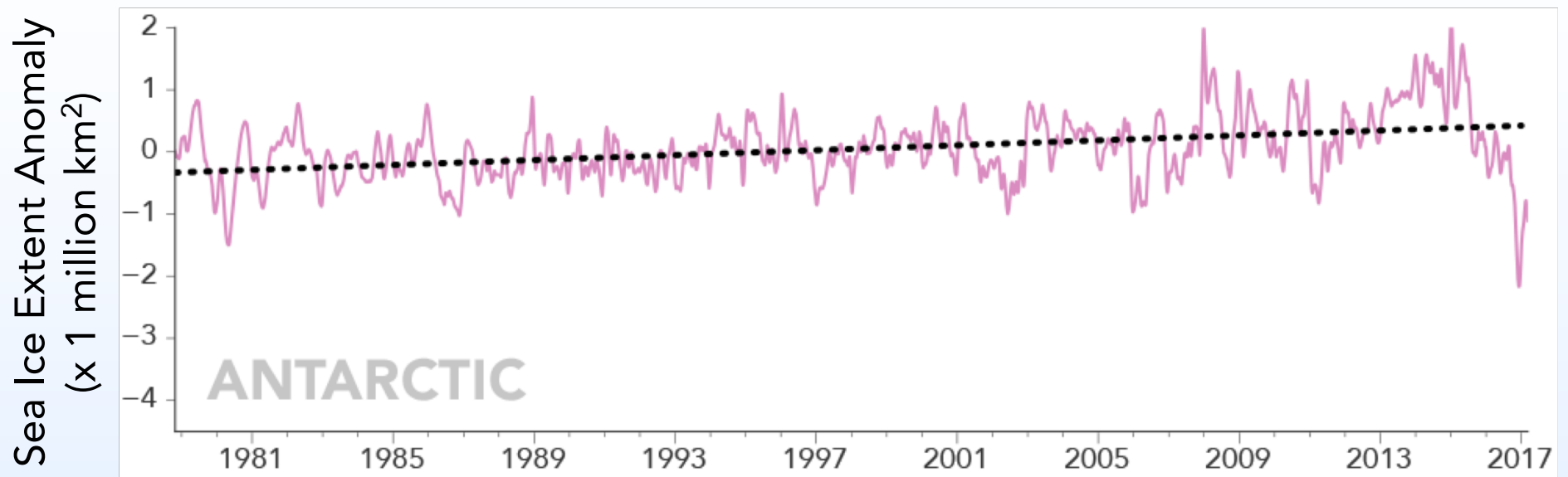
Antarctic krill  
*Euphausia  
superba*

Ross Sea:

*Phaeocystis*,  
Diatoms

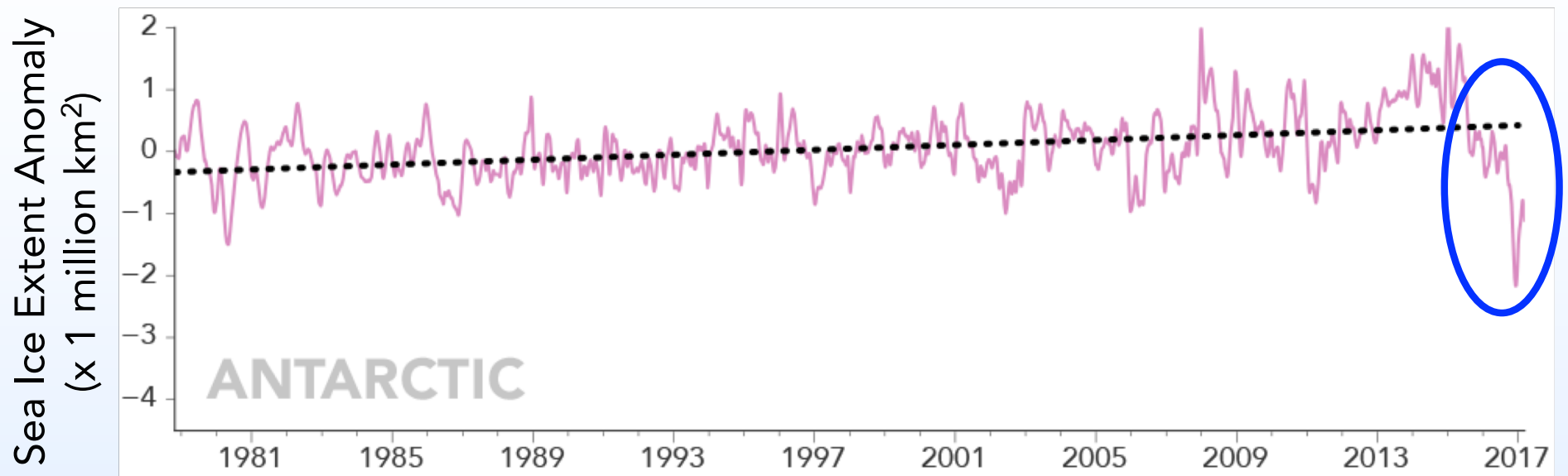
Crystal krill  
*Euphausia  
crystallorophias*

# Long-term Trend in Total Antarctic Sea Ice Extent



*Joshua Stevens/NASA Earth Observatory*

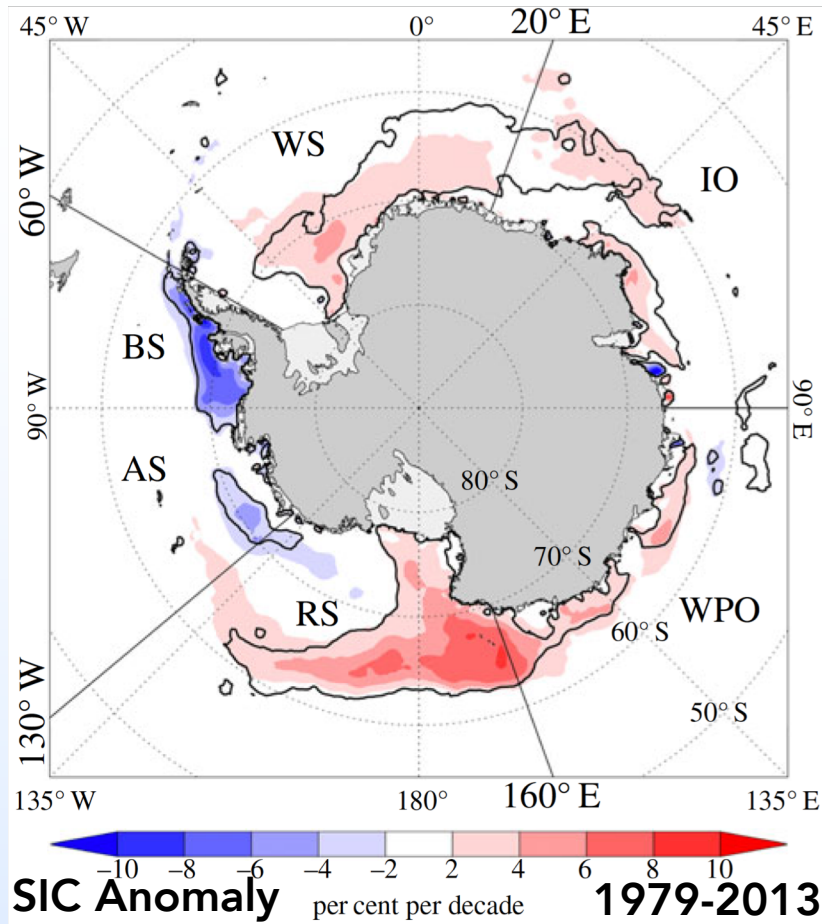
# Long-term Trend in Total Antarctic Sea Ice Extent



*Joshua Stevens/NASA Earth Observatory*

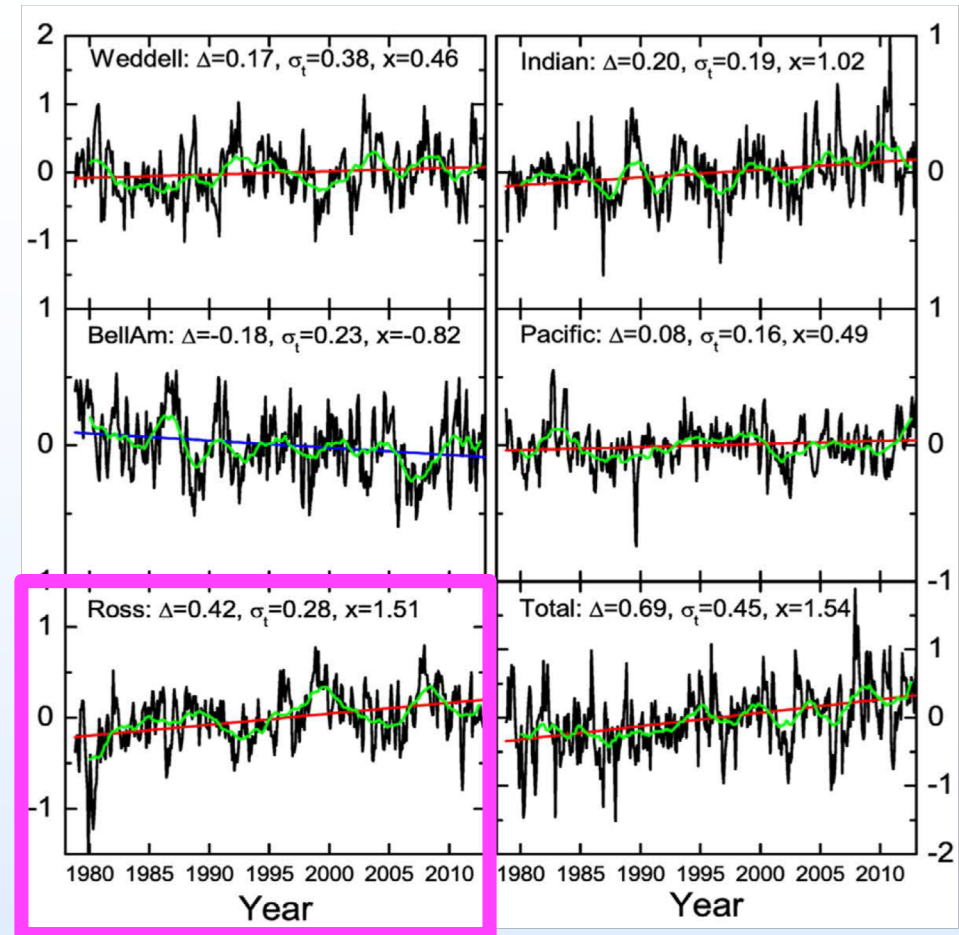


# Long-term Sea Ice Trend Driven by Ross Sea



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

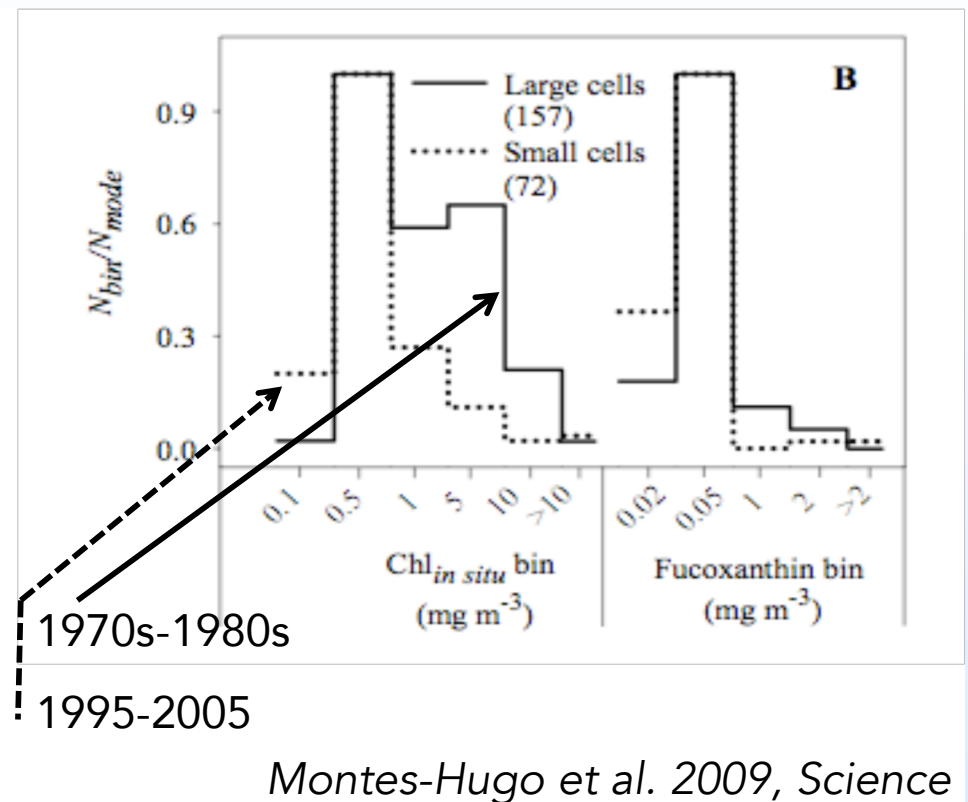
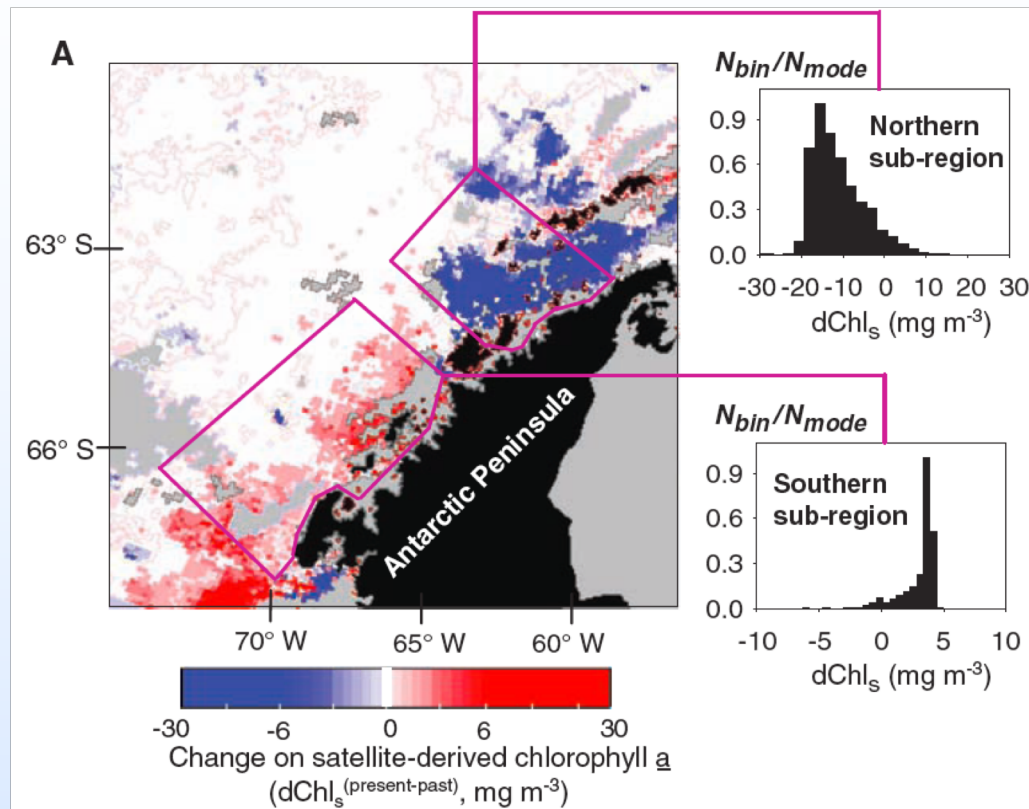
Sea Ice Extent Anomaly  
(x 1 million km<sup>2</sup>)



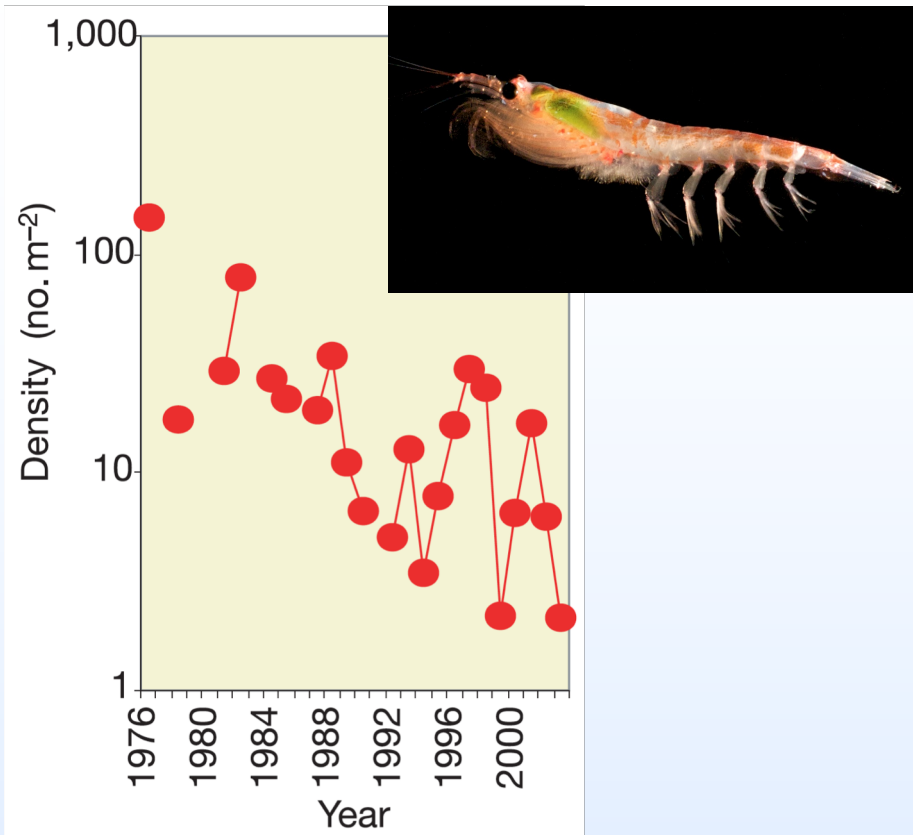
Yuan et al. 2017, *Sci. Reports*

# Recent changes in WAP phytoplankton

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



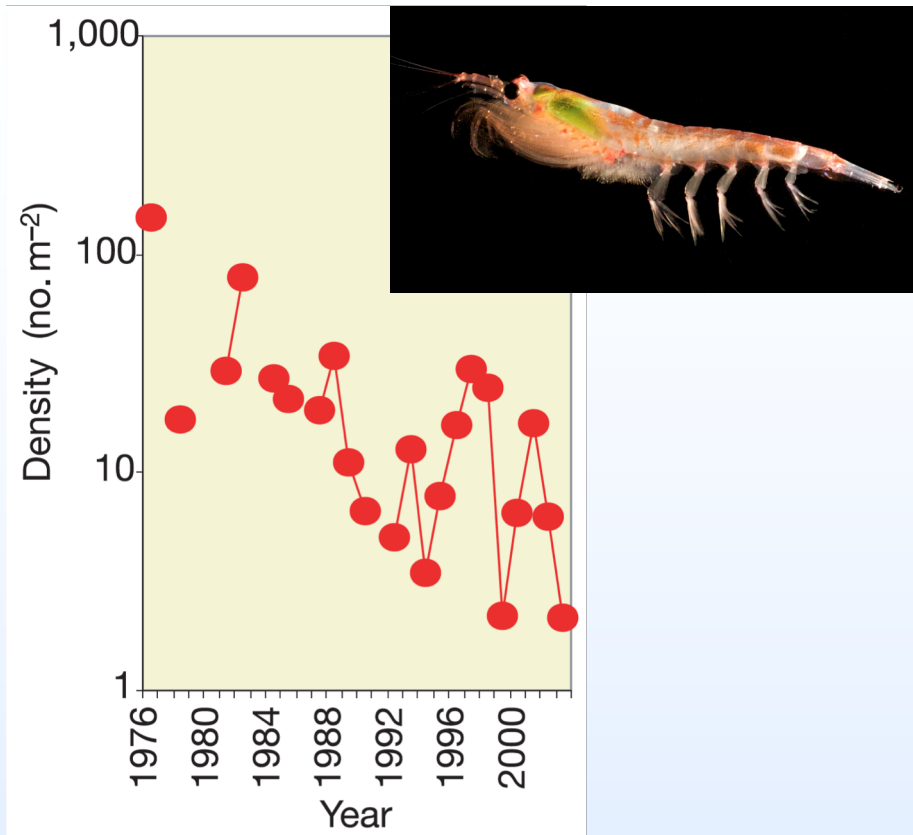
# Recent changes in Krill



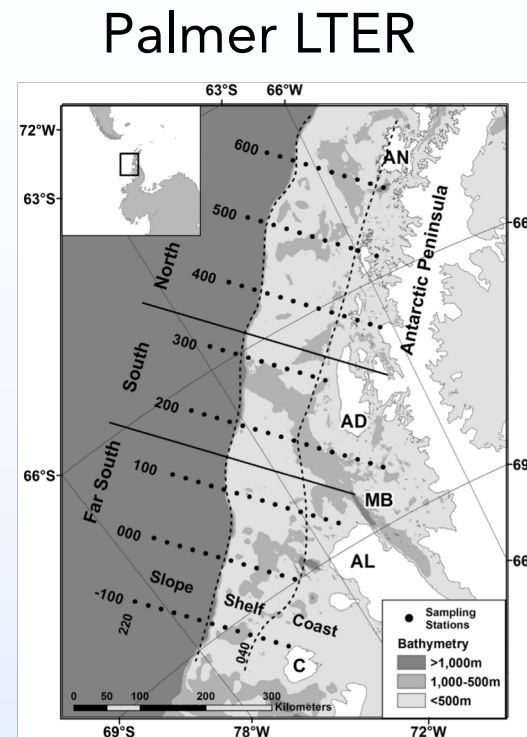
*Atkinson et al. 2004, Nature*



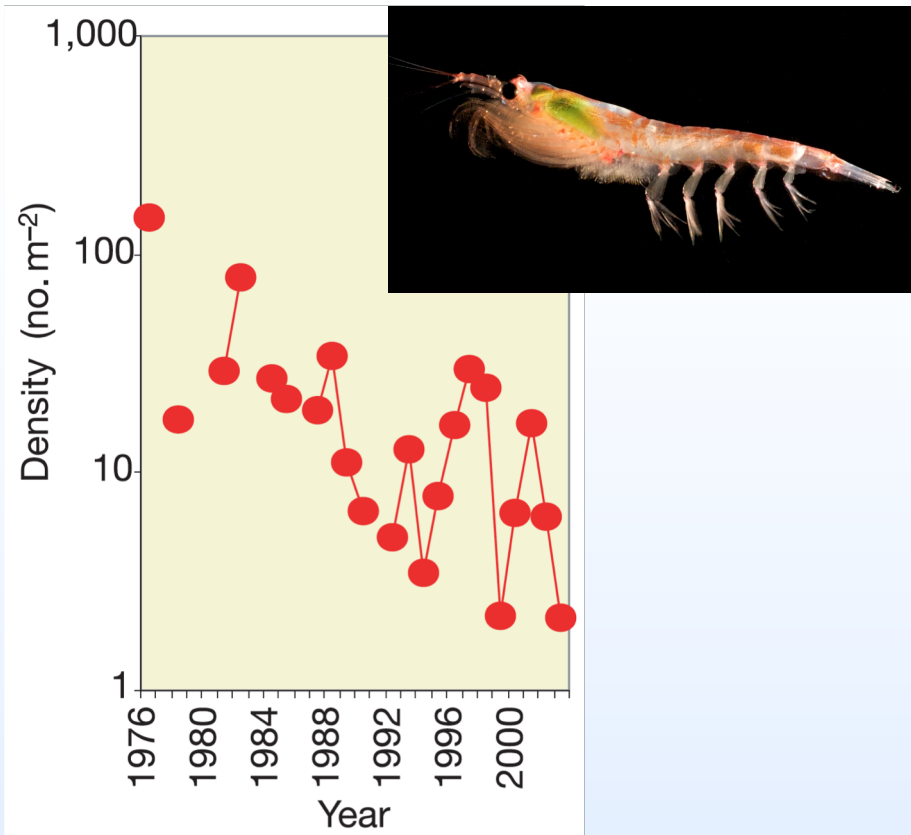
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Atkinson et al. 2004, Nature

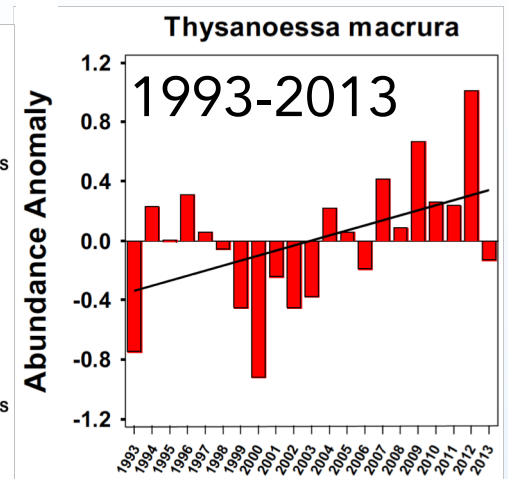
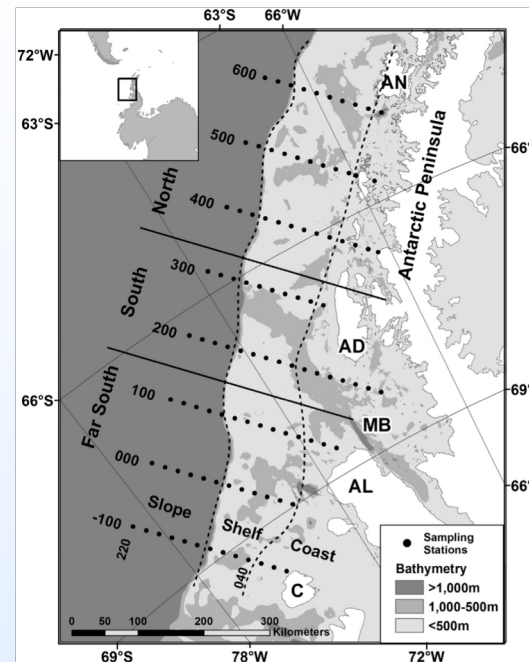


# Recent changes in Krill



Atkinson et al. 2004, Nature

## Palmer LTER

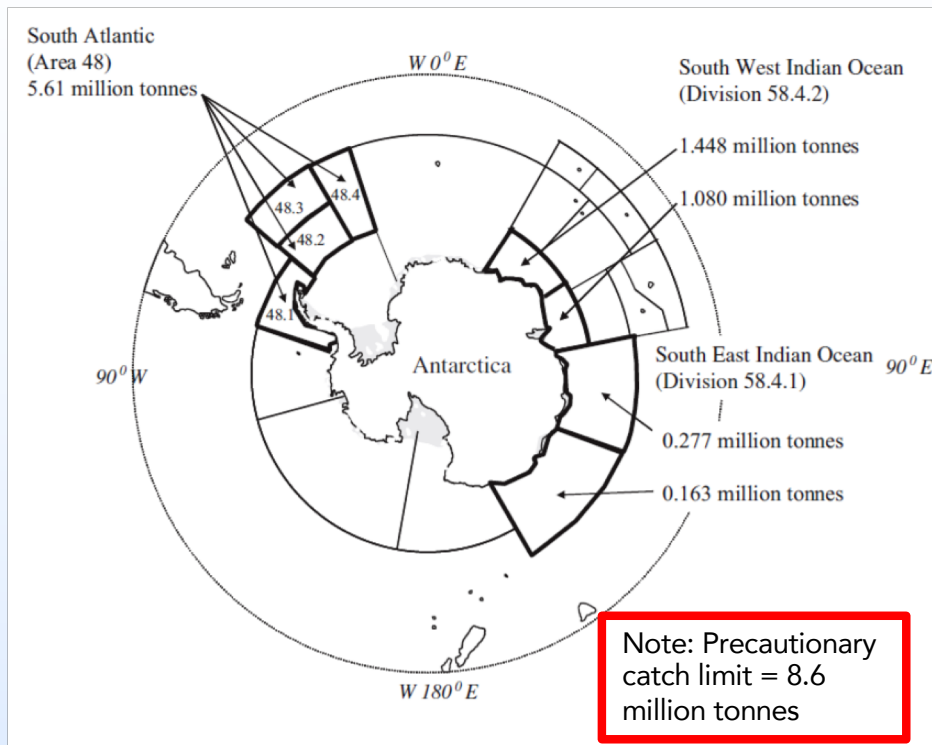


- Omnivorous
- Not ice-dependent

Steinberg et al. 2015, Deep Sea Res. I

# Human impact on Antarctic Krill

Precautionary catch limited on the krill fishery in the CCAMLR Area

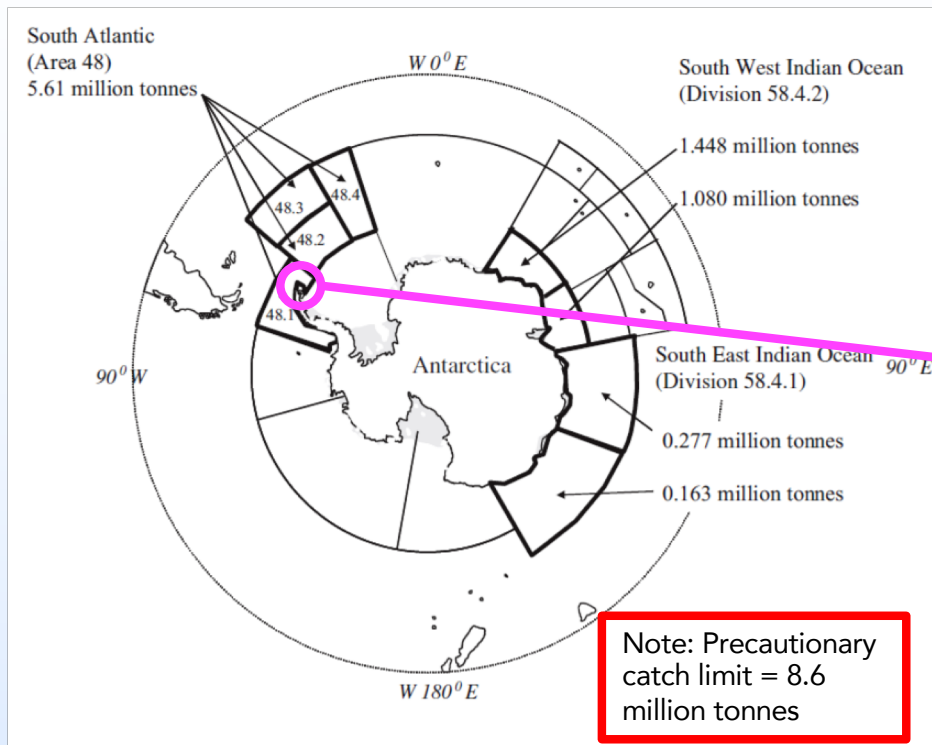


Nicol et al. 2012, Fish & Fisheries



# Human impact on Antarctic Krill

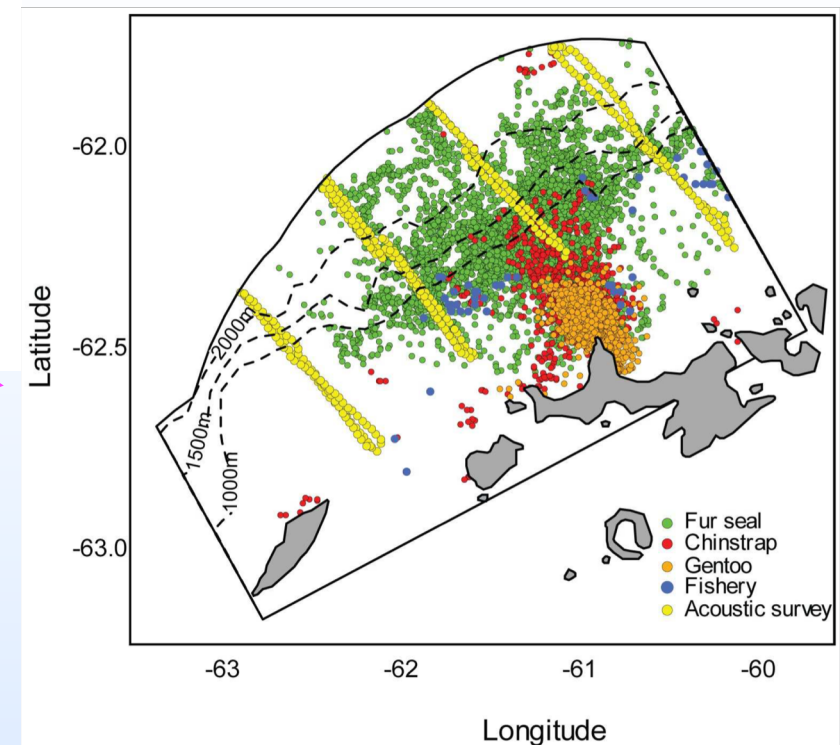
Precautionary catch limited on the krill fishery in the CCAMLR Area



Nicol et al. 2012, Fish & Fisheries

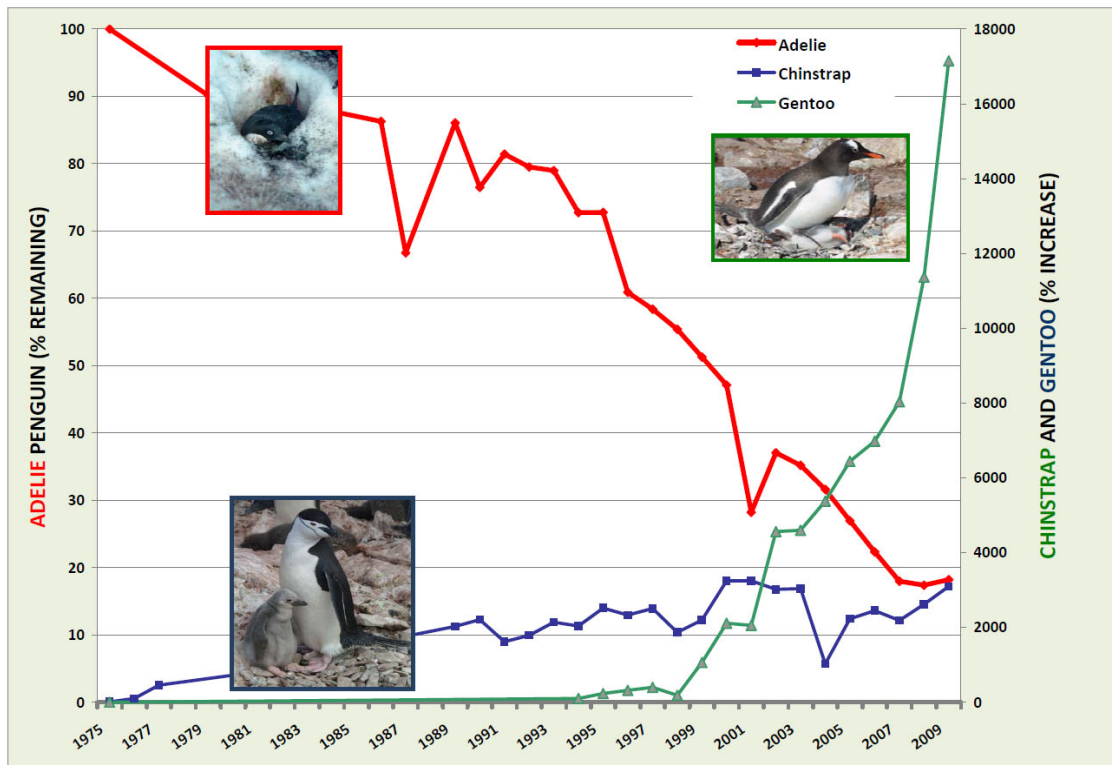


Overlap of krill fishery with krill-dependent predators



Hinke et al. 2017, PLoS ONE

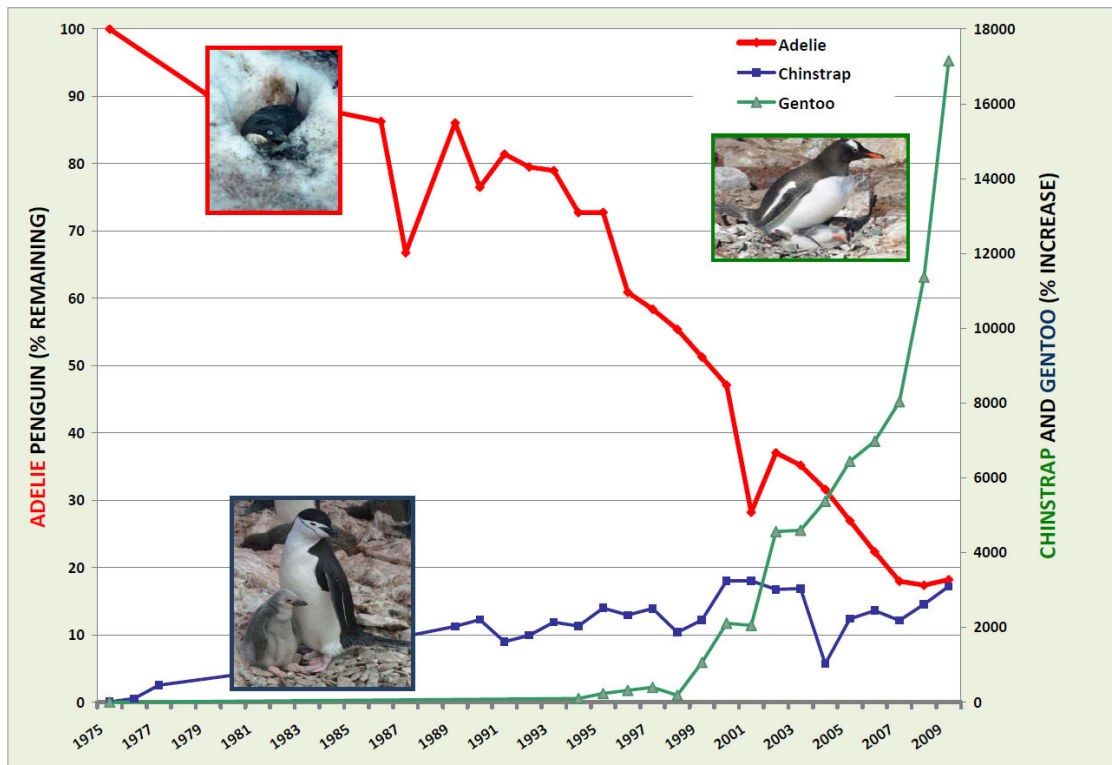
# Recent and Projected Changes in Penguins



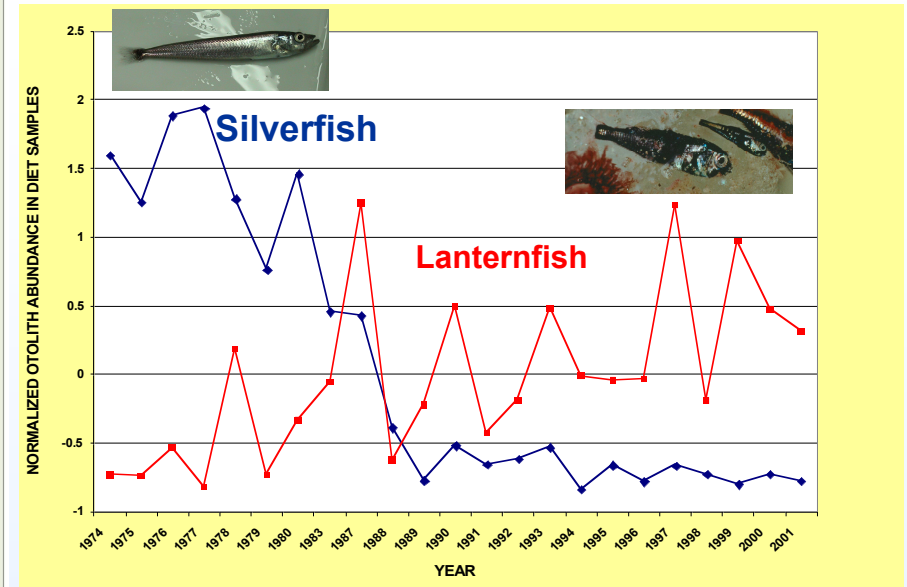
*Schofield et al. 2010, Science*

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

# Recent and Projected Changes in Penguins



*Schofield et al. 2010, Science*

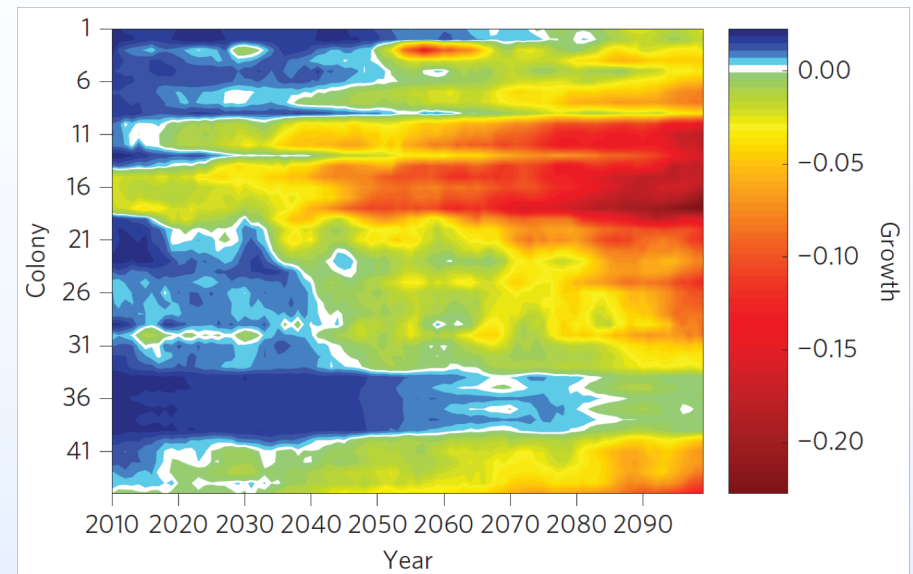
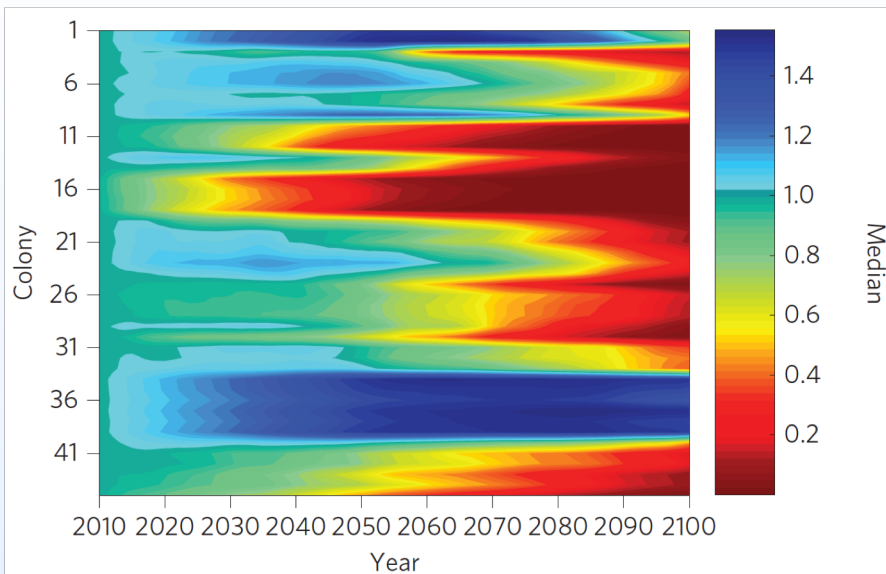


*Courtesy of Bill Fraser*

- 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<sup>1,2,\*</sup>, M. H. Engel<sup>1</sup>, A. Andriolo<sup>3</sup>, P. I. Prado<sup>2</sup>, A. N. Zerbini<sup>4,5,6</sup>, M. M. C. Marcondes<sup>1</sup>, P. G. Kinas<sup>7</sup>, P. C. Simões-Lopes<sup>8</sup>

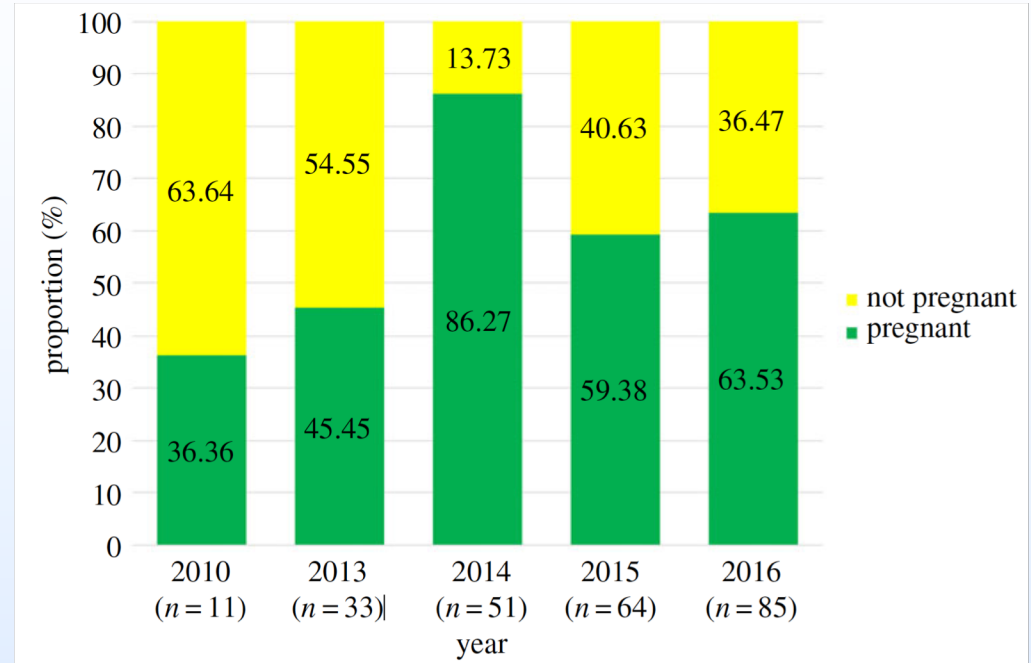


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*Pallin et al. 2018, R. Soc. open sci.*

# 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

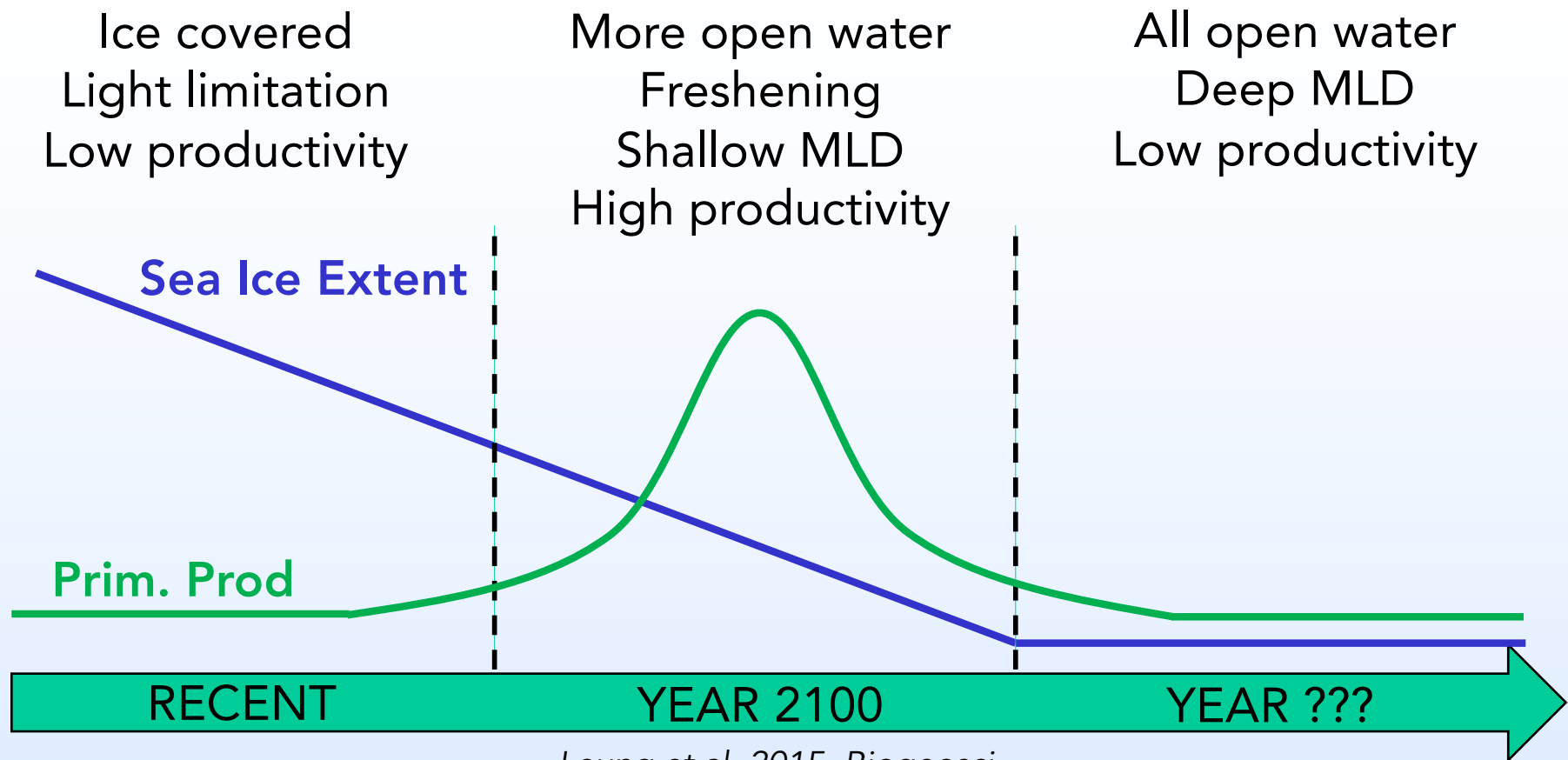
### Population biology: Fur seals signal their own decline

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](#)

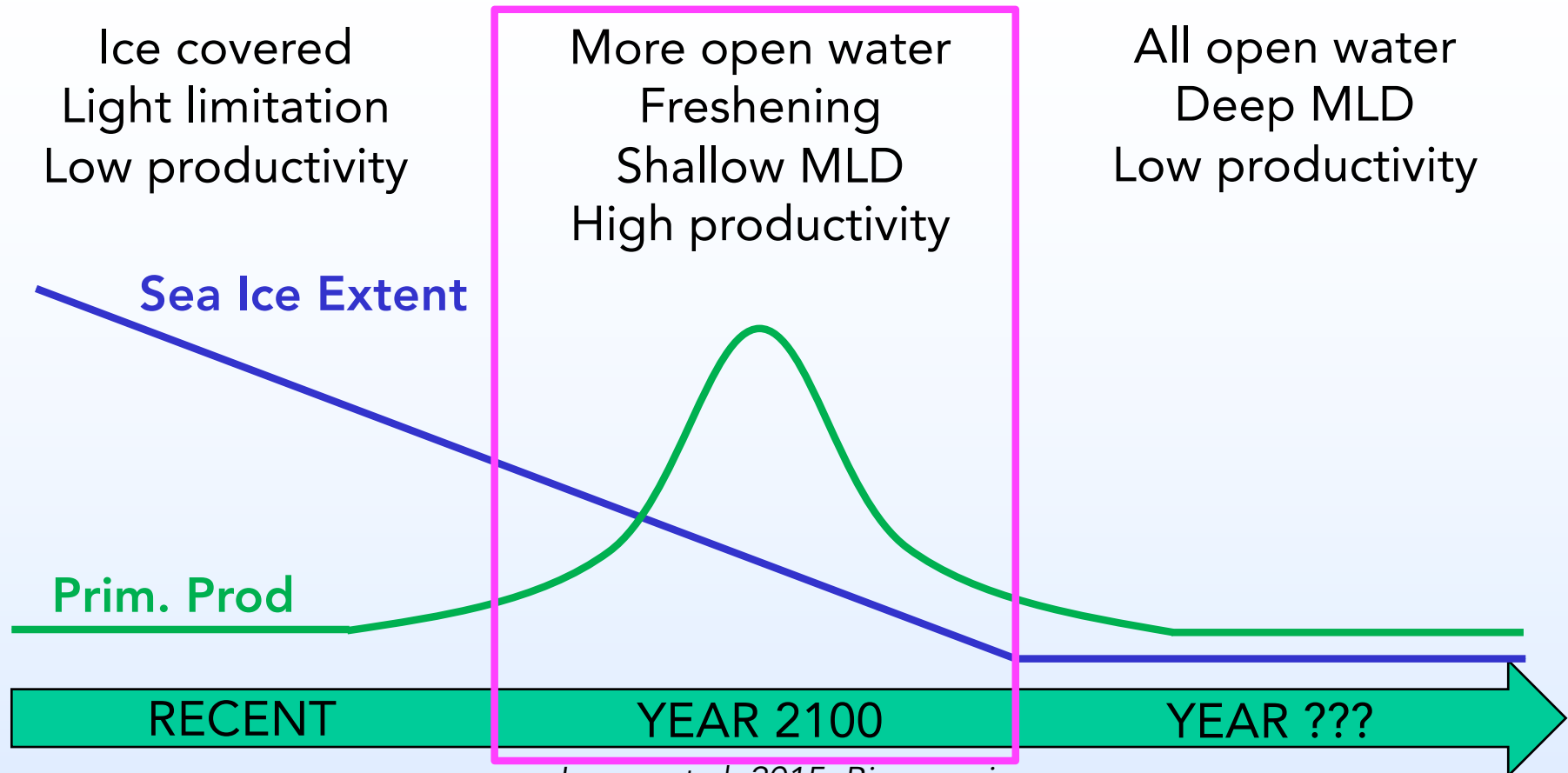


# Evolution of Antarctic Climate Change



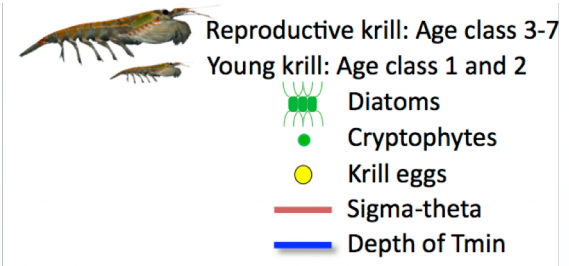
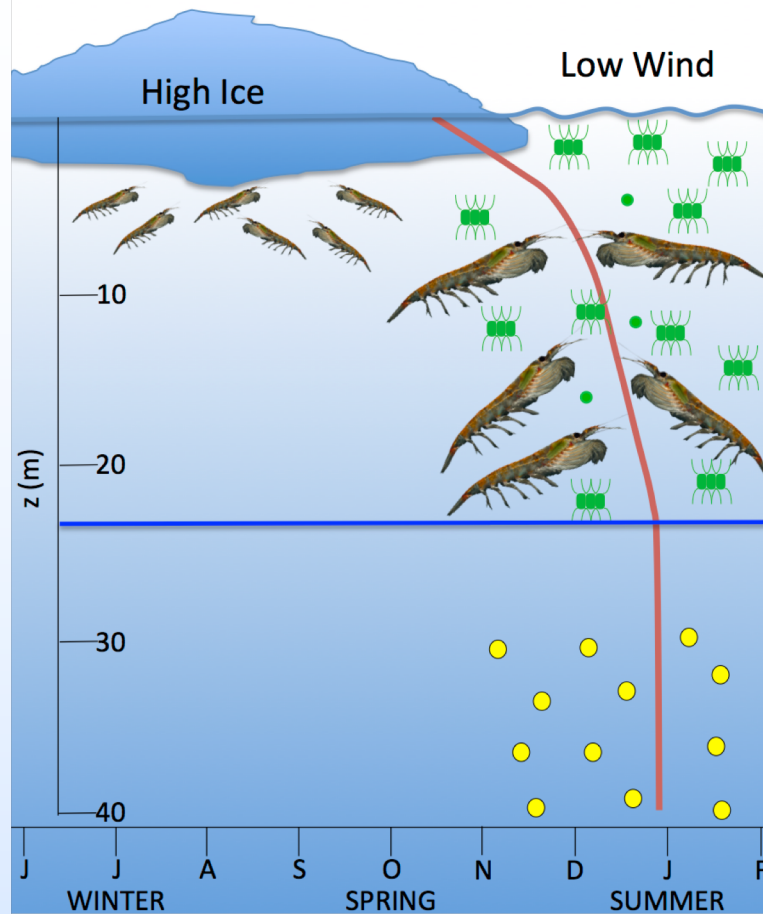
*Leung et al. 2015, Biogeosci.*  
*Rickard & Behrens 2016, Antarct. Sci.*

# Evolution of Antarctic Climate Change

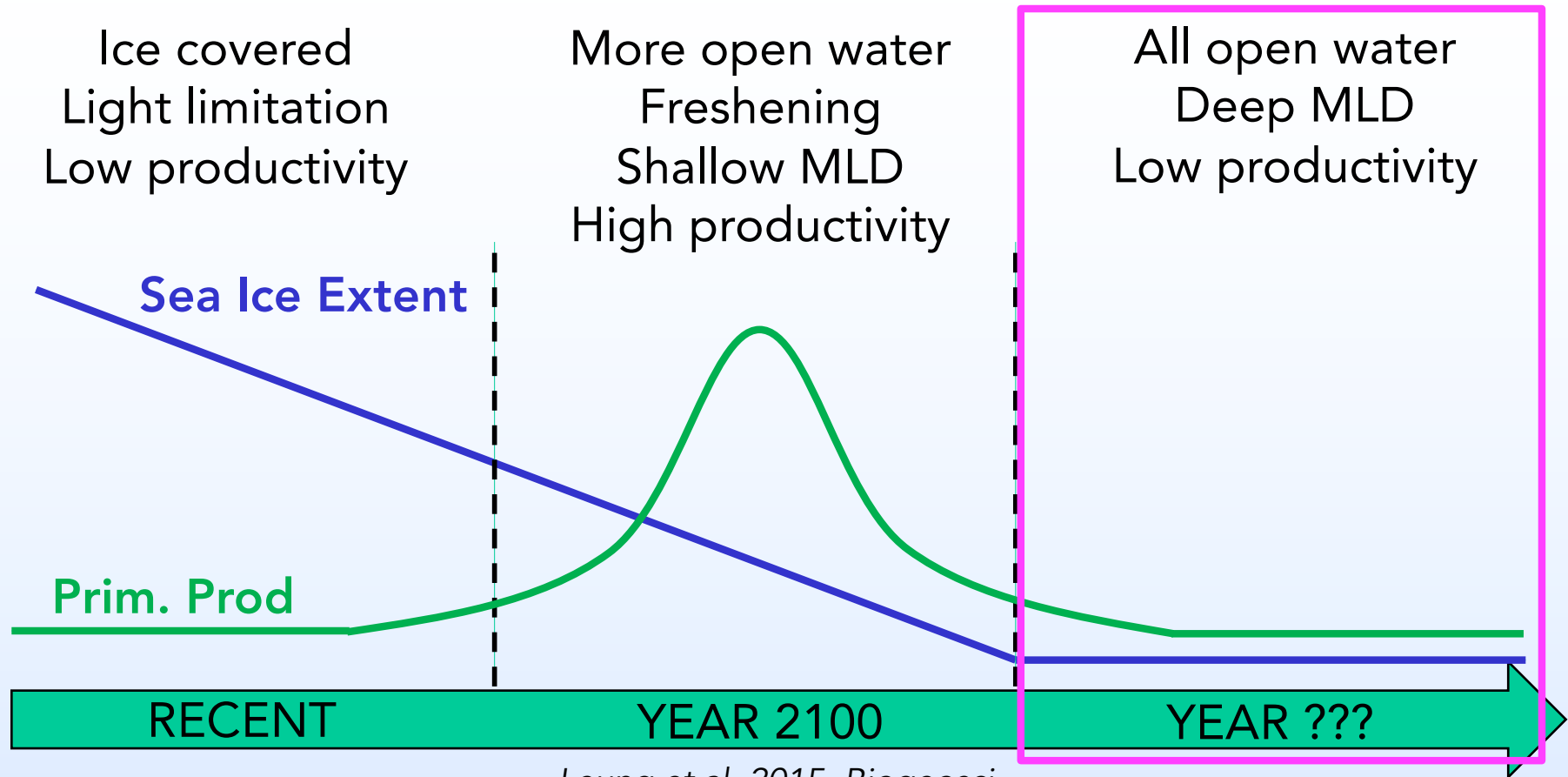


Leung et al. 2015, Biogeosci.  
Rickard & Behrens 2016, Antarct. Sci.

- SAM



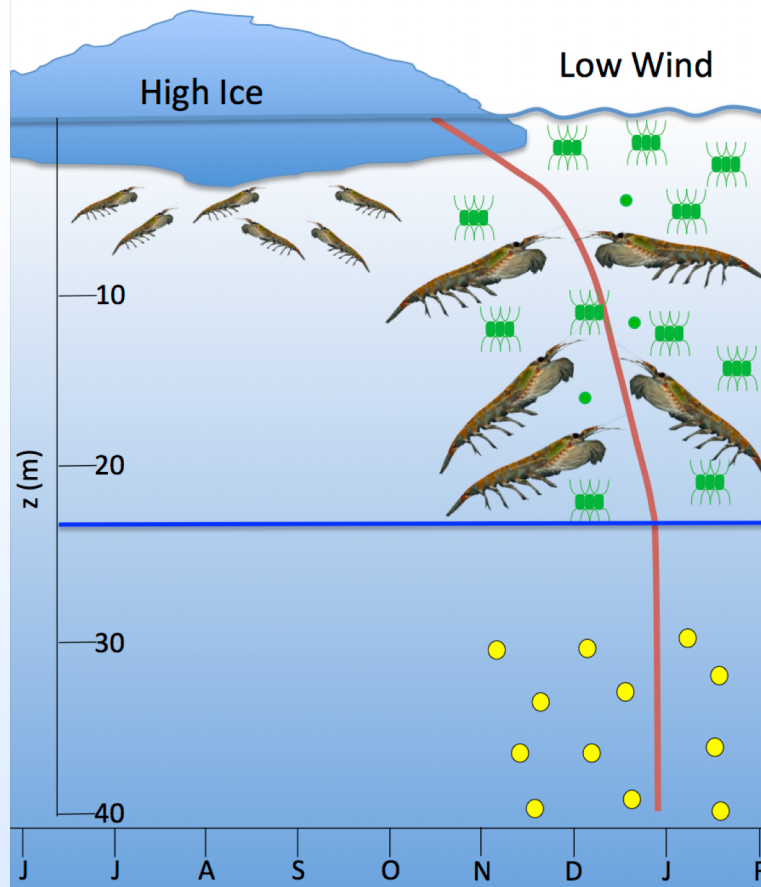
# Evolution of Antarctic Climate Change



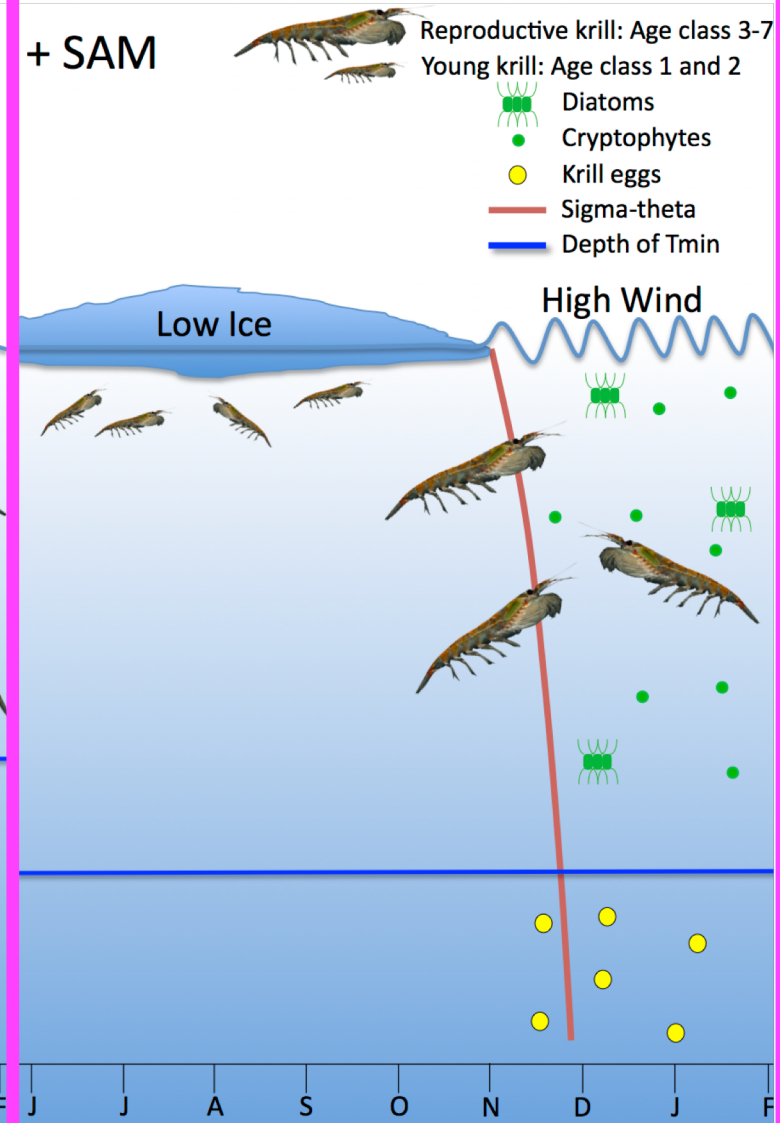
Leung et al. 2015, Biogeosci.  
Rickard & Behrens 2016, Antarct. Sci.



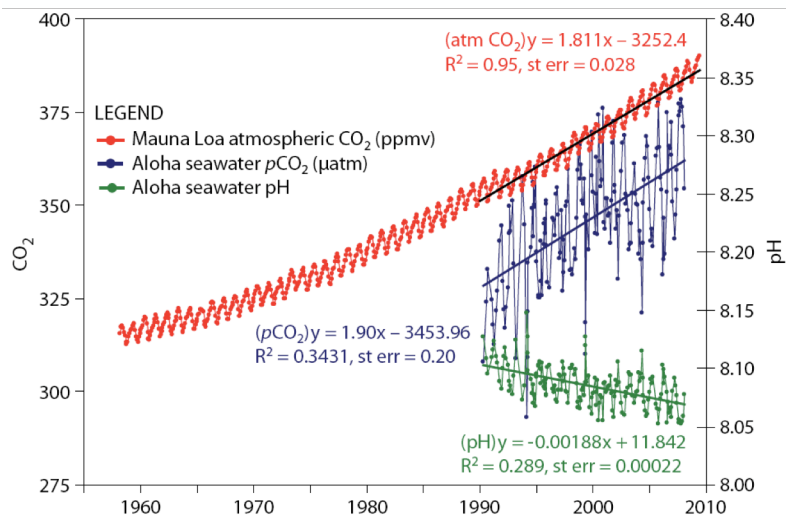
- SAM



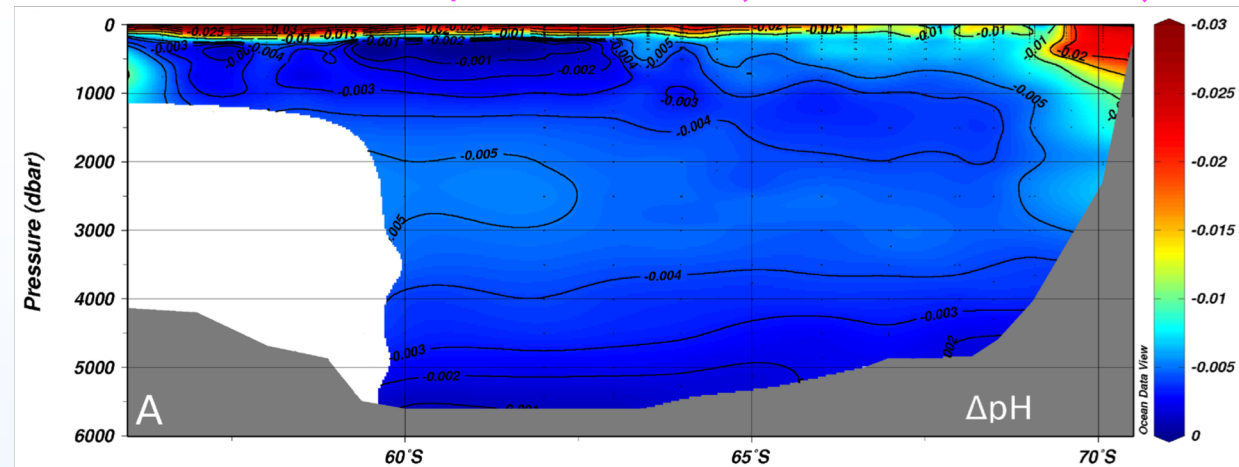
+ SAM



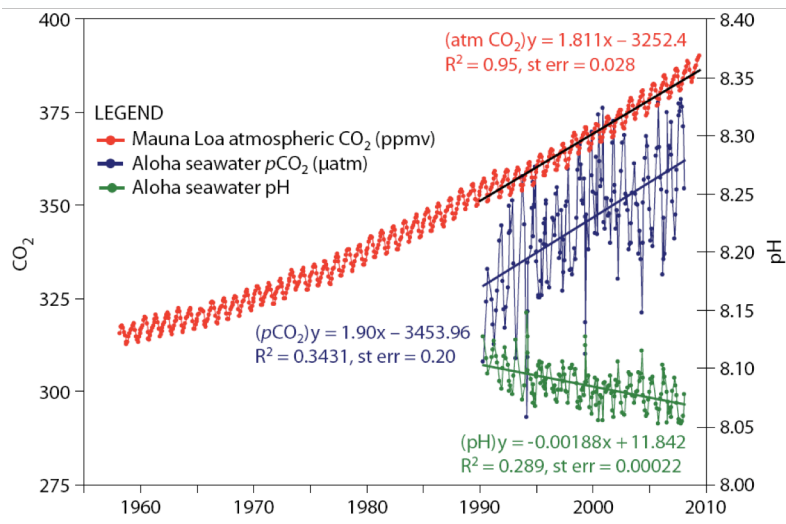
# Acidification: The “Other” CO<sub>2</sub> Problem



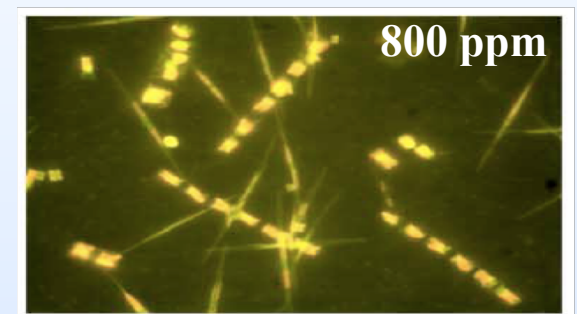
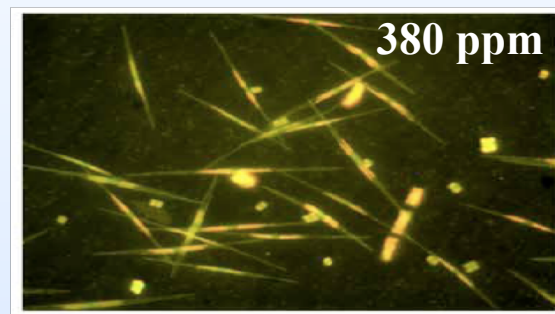
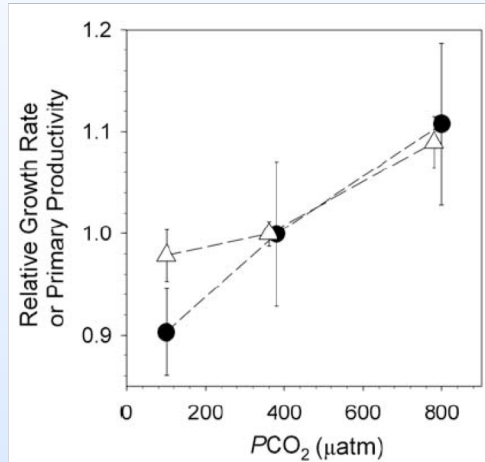
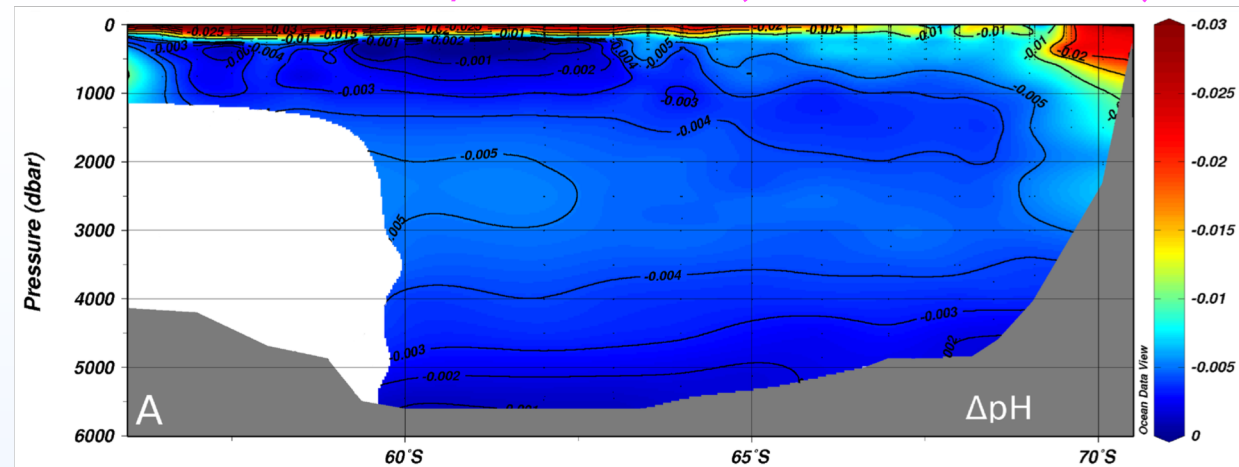
Weddell Sea, 1992-2008 (*Hauck et al. 2010*)



# Acidification: The "Other" CO<sub>2</sub> Problem



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

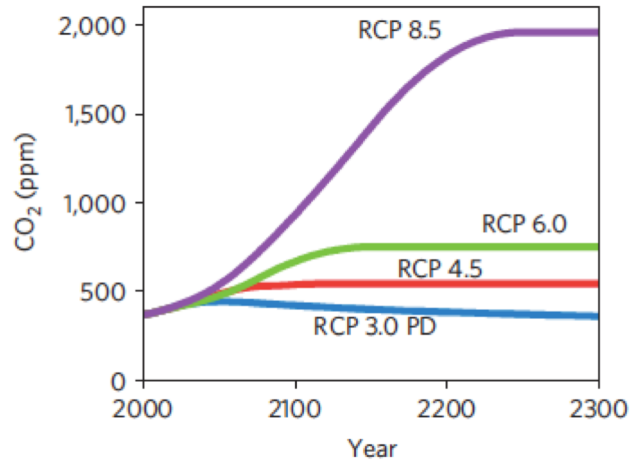


Tortell et al. 2008

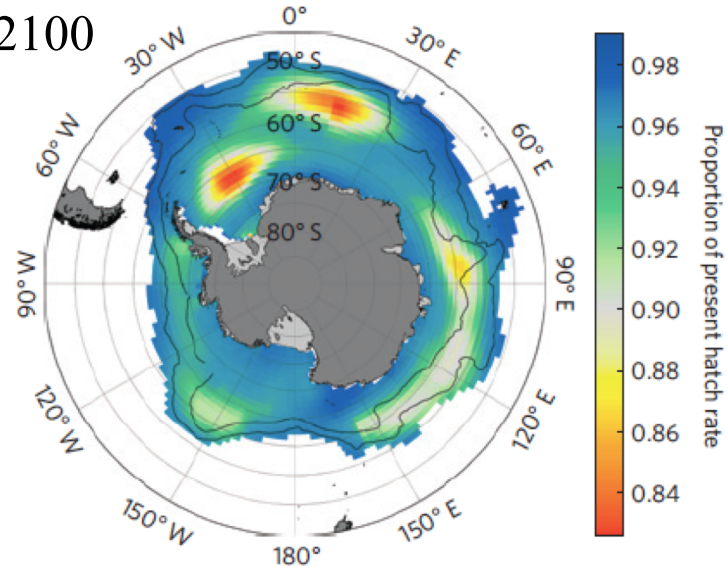
# Krill at High Risk under Acidification

(Kawaguchi et al. 2013)

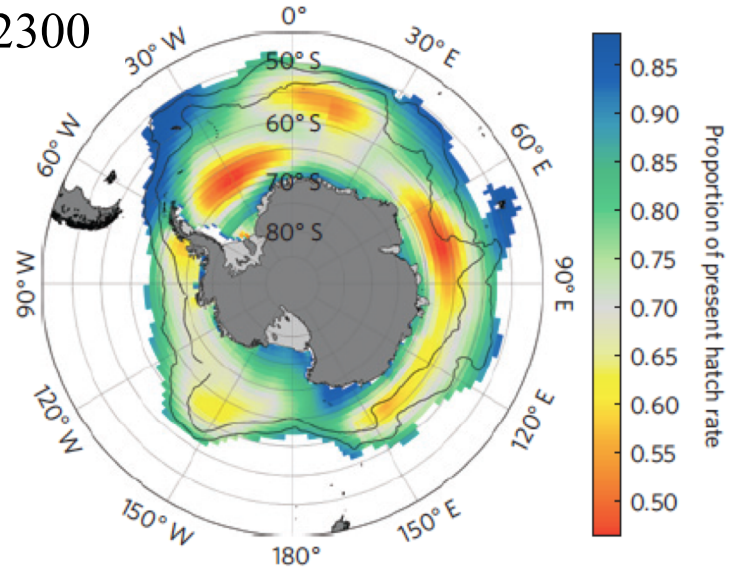
RCP 6.0 scenario



2100



2300

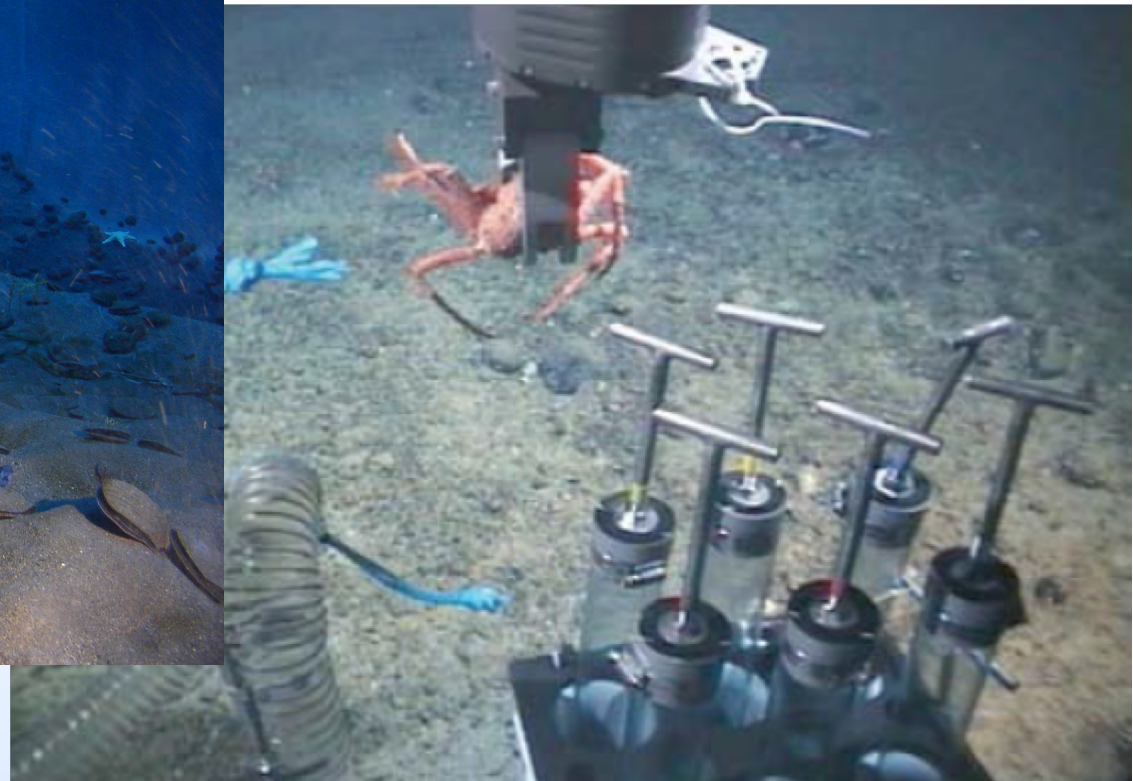




# Invasive species



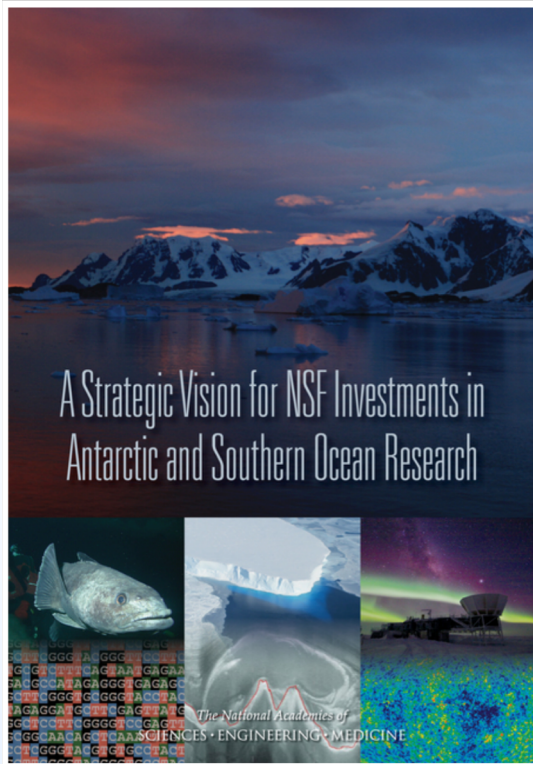
*Photo: Steve Clabuesch, NSF*



*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.*



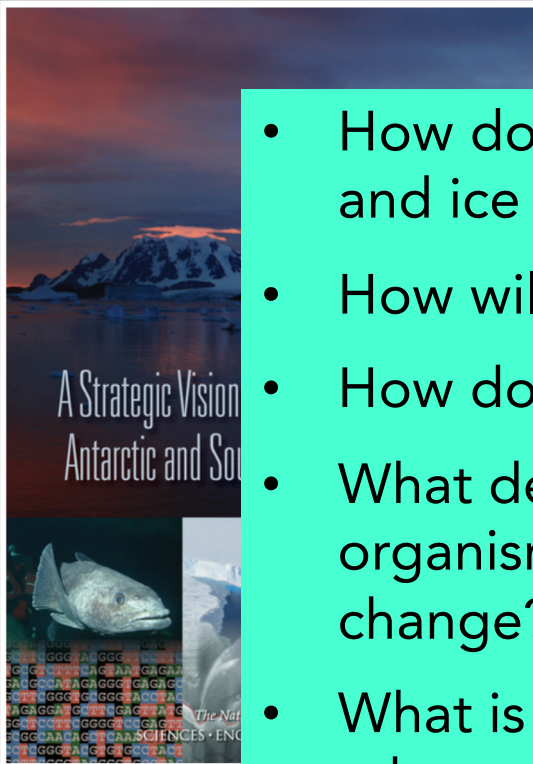
*Results of the SCAR Horizon Scan. 2014. Nature 512: 23-25.*

## 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?



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: 23-25.

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gion.



# Thank you!

Contact: [saba@marine.rutgers.edu](mailto:saba@marine.rutgers.edu)

