Ecosystem Response to Antarctic Climate Variability and Change

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Antarctic Sea Ice Variability


https://svs.gsfc.nasa.gov
Tight coupling between physics and biology

% Diatoms: 65%
% Prasinophytes: 16%
% Haptophytes: 5%
% Flagellates: 52%
% Cryptophytes: 5%

Tight trophic coupling

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

Sea Ice Extent Anomaly (x 1 million km²)

Joshua Stevens/NASA Earth Observatory
Long-term Trend in Total Antarctic Sea Ice Extent

Sea Ice Extent Anomaly (x 1 million km$^2$)
Long-term Sea Ice Trend Driven by Ross Sea

Yuan et al. 2017, Sci. Reports

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

Sea Ice Extent Anomaly (x 1 million km²)

Friday, December 2016

SIC Anomaly

1979-2013

Sea Ice Extent Anomaly

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

Steinberg et al. 2015, Deep Sea Res. I
Recent changes in Krill

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Palmer LTER

- Omnivorous
- Not ice-dependent
Human impact on Antarctic Krill

Precautionary catch limited on the krill fishery in the CCAMLR Area

Note: Precautionary catch limit = 8.6 million tonnes

Nicol et al. 2012, Fish & Fisheries
Human impact on Antarctic Krill

Precautionary catch limited on the krill fishery in the CCAMLR Area

Overlap of krill fishery with krill-dependent predators

Note: Precautionary catch limit = 8.6 million tonnes

Nicol et al. 2012, Fish & Fisheries

Hinke et al. 2017, PLoS ONE
Recent and Projected Changes in Penguins

- WAP: Recent decrease in Adélie penguins; increase in subpolar Gentoo and Chinstrap penguins.

Schofield et al. 2010, Science
Recent and Projected Changes in Penguins

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

Schofield et al. 2010, Science

Courtesy of Bill Fraser
Recent and Projected Changes in Penguins

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

Recent changes in Whales
Recent changes in Whales

Pallin et al. 2018, R. Soc. open sci.
Recent changes in Seals

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

- Ice covered
- Light limitation
- Low productivity

- More open water
- Freshening
- Shallow MLD
- High productivity

- All open water
- Deep MLD
- Low productivity

Sea Ice Extent

Prim. Prod

- RECENT
- YEAR 2100
- YEAR ???

Leung et al. 2015, Biogeosci.
Evolution of Antarctic Climate Change

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Sea Ice Extent

Recent

Year 2100

Year ???

Prim. Prod

Leung et al. 2015, Biogeosci.
Acidification: The “Other” CO₂ 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: Sven Thatje

Photo: Steve Clabuesch, NSF
Research Priorities


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?
Thank you!

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