



Global Climate Change, Antarctica, and Krill

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The Earth's climate is gradually warming, and a number of changes are already being observed, among them a rise in global temperatures of almost 2.0° F since 1900, earlier onset of spring thaw, more intense summer heat waves, a longer growing season in some regions, and

increased coastal flooding from rising sea levels.¹

The consequences of climate change are especially profound for Antarctica. Temperatures for the Antarctic Peninsula have risen two to three times faster than elsewhere on Earth.²

Of the 244 marine glacier fronts on the Antarctic Peninsula, 87% have retreated, and the boundary between advance and retreat has shifted progressively southward. Sea ice around the Antarctic Peninsula and in the southern Bellingshausen Sea to the west has also decreased in duration and thickness.³

Global warming is also changing the chemistry of the Southern

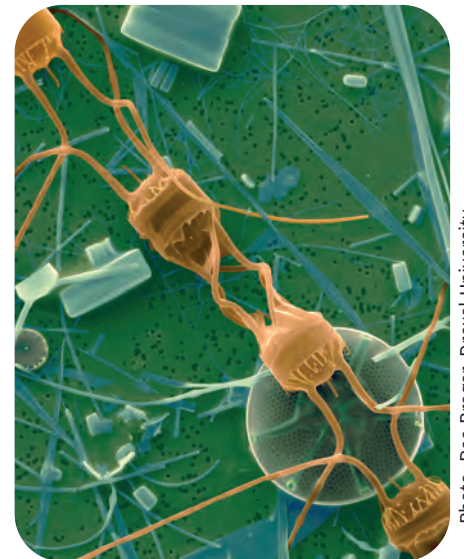


Photo: Dee Breger, Drexel University

A string of diatoms (1200x magnification), large phytoplankton that are the preferred food of krill. Low ocean salinity, caused by ice melt, discourages the proliferation of these larger phytoplankton and stimulates production of smaller plankton, poorly grazed by krill.

Ocean around Antarctica. Acidification from global air pollution, together with warmer temperatures and lower salinity due to ice melt, has been linked to a major shift in Antarctica's phytoplankton. When pH, water temperature, and salinity are normal, diatoms—single-celled algae and a primary food source for Antarctic krill—are a predominant species. When sea water is more dilute, acidic, and warmer, cryptophytes—much smaller single-celled organisms



Photo: Flip Nicklin, Minden Pictures

Krill are dependent on algal blooms under sea ice which occur during the austral winter (May to October).

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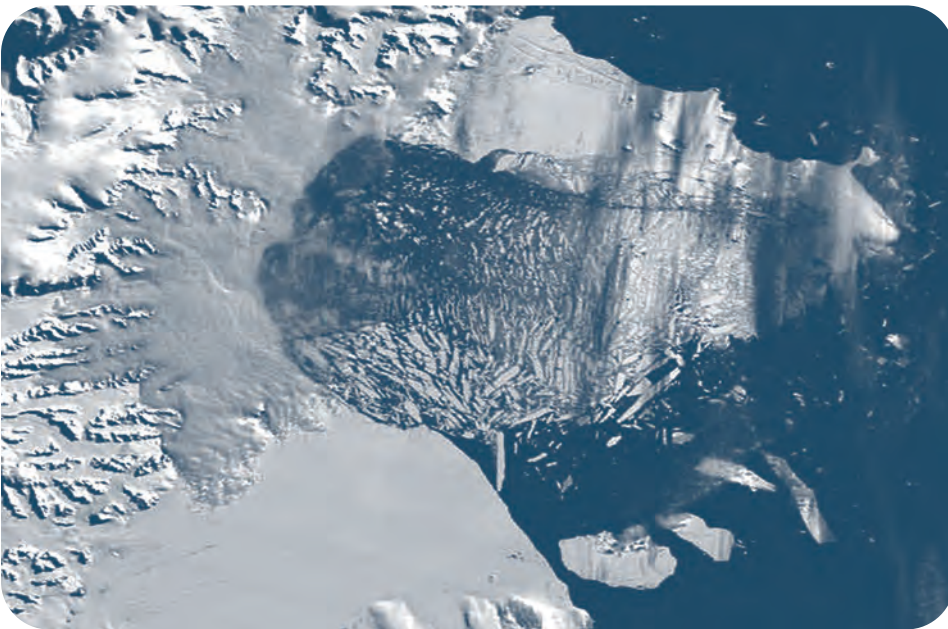
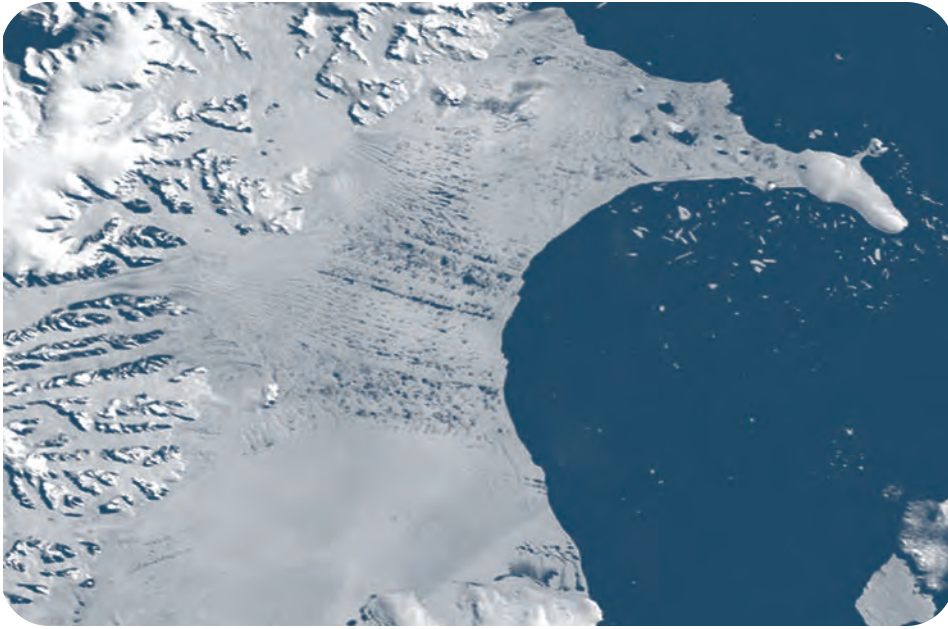


Photo: British Antarctic Survey

Two satellite photographs of the Larsen B ice shelf at the tip of the Antarctic Peninsula show the effects of global warming. The image at top, taken in January 2002, shows the ice shelf still intact although thinning. By March (bottom), it had disintegrated.

—dominate the phytoplankton community.

Because of their small size, Cryptophytes are poorly grazed by Antarctic krill, a keystone species in the Antarctic ecosystem.⁴ Less abundant primary food

will have an impact on krill populations and give an advantage to salps, a type of gelatinous plankton that is generally avoided as food by major krill predators such as penguins and seals.⁵

The extent and duration of sea ice also

affects krill populations. Long periods of sea ice extending over a large area offer two advantages to krill, first by providing cover under the ice from predators, and secondly by giving rise to algal blooms beneath ice shelves where krill feed during the winter and early spring (May through October).⁶ Coincident with a decline in sea ice, krill populations around the Antarctic Peninsula have declined significantly since the 1970s (down 80% in one region).⁷ The retreat of sea ice in the Antarctic Peninsula and Southern Scotia Arc, major krill spawning and nursery habitats, affect krill density across the whole ocean basin, including areas north of the Seasonal Ice Zone.

The disappearance of sea ice, especially around the tip of the Antarctic Peninsula, also affects many other species. Several studies have shown a relationship between sea ice cover, duration, krill recruitment, availability of prey, and the foraging ecology of krill predators.⁸ For example, reduced krill populations have been shown to cause extreme variation in reproductive output of fur seals, Macaroni and Gentoo penguins, and Black-browed albatross



Photo: Aker BioMarine

The *Atlantic Navigator*, one of several specially equipped vessels, can take up to 120,000 tonnes of krill in a single season.

breeding at South Georgia Island. The amount of krill in the diets of some of these predators declined by 90%, although the exact cause—krill fishing or population declines from warming—remains unclear.⁹ Evidence also suggests that the populations of some whale species fluctuate in direct proportion to relative krill abundance.¹⁰

Sea ice coverage also affects Antarctic wildlife in a more direct way. Researchers estimate, for example, that 56,000 Adelie penguins perished in a 50-square-mile area over recent decades because the ice no longer extends far enough into the sea for the birds to reach their winter feeding grounds. An entire colony that numbered 1,000 breeding pairs 30 years ago disappeared in 2006.¹¹

While more information is needed to understand how long-term changes in the physical environment will affect krill population dynamics, it is already clear that the breeding performance and success of krill-dependent predators fluctuates with the frequency and magnitude of these changes. Therefore, current scientific information should to be used to forecast possible changes in krill availability to predators when setting krill catch limits in areas where predators and krill fishing overlap.

Because information is deficient on the potential cumulative impacts of climate change and fishing on krill and their predators, precaution must be exercised. Monitoring programs are a key tool for detecting local or regional harm to krill or krill predators due to a long-term decline of this crucial species—a decline that may be hastened by the krill fishery. ■



Photo: Emily Stone, National Science Foundation

Adelie penguins depend heavily on krill for food. The decline in krill abundance has led to the disappearance of thousands of Adelies on Anvers Island off the southwestern coast of the Antarctic Peninsula.



Photo: Ingrid Visser, SeaPics.com

Fur seals are heavily dependent on krill, but their foraging areas are also intensively fished by commercial krill vessels.

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FOOTNOTES

- ¹ Intergovernmental Panel on Climate Change, Working Group II, Fourth Assessment Report, *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability*, <www.ipcc.ch/SPM6avr07.pdf>.
- ² Jonathan Amos, "Antarctic glaciers show retreat," BBC News, April 21, 2005, <<http://news.bbc.co.uk/2/hi/science/nature/4471135.stm>>.
- ³ British Antarctic Survey, "Hundreds of Antarctic Peninsula Glaciers Accelerating as Climate Warms," press release, June, 6, 2007, <www.sciencedaily.com/releases/2007/06/070605121037.htm>.
- ⁴ M.A. Moline *et al.*, "Alteration of the food web along the Antarctic Peninsula in response to a regional warming trend," *Global Change Biology*, 10:12 (December 2004), pp. 1973-1980.
- ⁵ Ibid.
- ⁶ Stephen Nicol and Maria Clippingdale, "Krill," entry under "Invertebrates" on Australian Government Antarctic Division Website, <www.aad.gov.au/default.asp?casid=1540>.
- ⁷ A. Atkinson *et al.*, "Long term decline in krill stock and increase in salps within the Southern Ocean," *Nature*, 432 (2004), pp. 100-103.
- ⁸ W. R. Fraser and E. Hofmann, "A Predator's Perspective on Causal Links between Climate Change, Physical Forcing, and Ecosystem Response," *Marine Ecology Progress Series*, 265, pp. 1-15.
- ⁹ K. Reid and J.P. Croxall, "Environmental response of upper trophic-level predators reveals a system change in an Antarctic marine ecosystem," *Proceedings of the Royal Society of London, Series B*, 268 (2001), pp. 377-84.
- ¹⁰ D. Thiele *et al.*, "Seasonal variability in whale encounters in the Western Antarctic Peninsula," *Deep-Sea Research*, 11:51 (2004), p. 2312, <<http://cet.uscd.edu/projects/pubs/Thieleetal.pdf>>.
- ¹¹ William Mullen, "Penguins' struggle is a warning to world," *Chicago Tribune*, July 11, 2007, p. 2, <www.popmatters.com/pm/news/article/43748/penguins-struggle-is-a-warning-to-world/>.