LENFEST OCEAN PROGRAM

RESEARCH SERIES

APRIL 2011

Krill availability explains shifts in penguin abundance.

PENGUIN AND KRILL DECLINES

A SUMMARY OF NEW SCIENTIFIC ANALYSIS:

Trivelpiece, W.Z., Hinke, J.T., Miller, A.K., Reiss, C.S., Trivelpiece, S.G. and G.M. Watters. 2010. Penguins in peril: variability in krill biomass links harvesting and climate warming to penguin population changes in Antarctica. *Proceedings of the National Academy of Sciences (PNAS)*.

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ANTARCTIC ECOSYSTEMS FACE profound changes due to rapid climatic warming and expanding fishing efforts. Previous studies have implicated changes in sea-ice cover due to climate change as a major driver of population shifts in predators, such as penguins, because some species prefer extensive ice cover while others do not. Yet, penguin populations are also likely to be influenced by the availability of their primary prey, krill, whose abundance has been altered by climatic warming. Fishing for krill and increased competition among other krill predators may also have made krill less available to penguins.

With support from the Lenfest Ocean Program, Dr. Wayne Trivelpiece, with the National Oceanic and Atmospheric Administration (NOAA), and his colleagues used more than 30 years of field studies and recent surveys to show that populations of both Adélie ("ice-loving") and chinstrap ("ice-avoiding") penguin species have declined by more than 50 percent in the South Shetland Islands region of the Antarctic since the 1970s. The scientists propose that these trends refute a direct connection between sea-ice cover and penguin populations. Instead, they suggest that penguin populations more closely track patterns in krill abundance over time. If warming trends and decreases in krill continue, these penguin populations are likely to continue to decline. Indeed, the ice-avoiding chinstrap penguins may be among the hardest hit because they reside only in this area. *This Lenfest Ocean Program Research Series* report is a summary of the scientists' findings.

SEA-ICE, PENGUINS AND KRILL IN THE ANTARCTIC

STUDY AREA

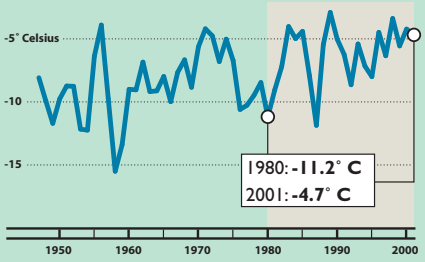
The Antarctic is among the fastest warming ecosystems on the planet, with 5–6 °C increases in mean winter air temperatures in the last few decades. Some have predicted that climate change will influence predators in this region, such as penguins, primarily through the availability of winter sea-ice cover. In particular, Adélie penguins favor sea-ice habitat in the winter, while chinstrap penguins forage in ice-free water during that time. The "sea-ice hypothesis" proposed by some scientists predicts that as winter sea-ice declines in the Antarctic due to a warming climate, the "ice-loving" Adélie penguin populations will decline, while the "ice-avoiding" chinstrap populations will increase.

However, the abundance of the primary prey of these penguins, a tiny crustacean called krill, also plays a crucial role in penguin population dynamics. Although krill populations exhibit a great deal of variability over time and in different regions, krill reproductive success depends in large part on sufficient sea-ice extent and duration, which is contingent on climatic warming trends. Thus, availability of prey could influence penguin populations more directly than access to sea-ice. However, teasing apart the relative impacts of possible influences on predator populations has proven difficult due to a lack of long-term monitoring data.

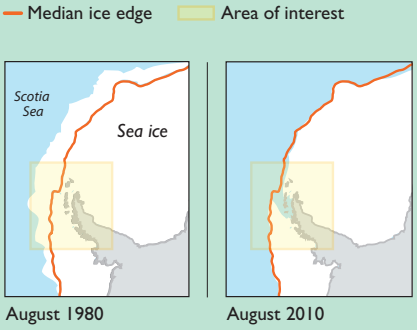
KRILL SHORTAGE A TOP REASON FOR PENGUIN LOSSES

WARMING AIR TEMPERATURES AND ...

Mean winter temperature (May-September), in degrees Celsius, at Faraday station, British Antarctic Survey



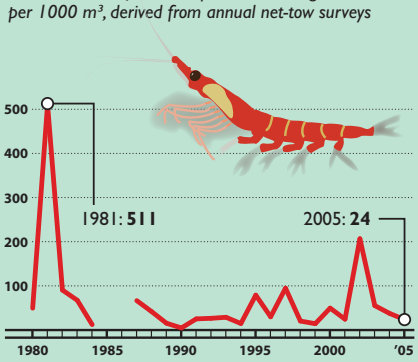
... SHRINKING WINTER SEA ICE EXTENT...



Credit: National Snow and Ice Data Center, University of Colorado, Boulder

... LEAD TO KRILL DECLINES ...

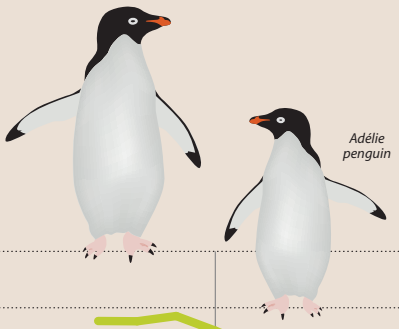
Krill abundance for the Elephant Island region, per 1000 m³, derived from annual net-tow surveys

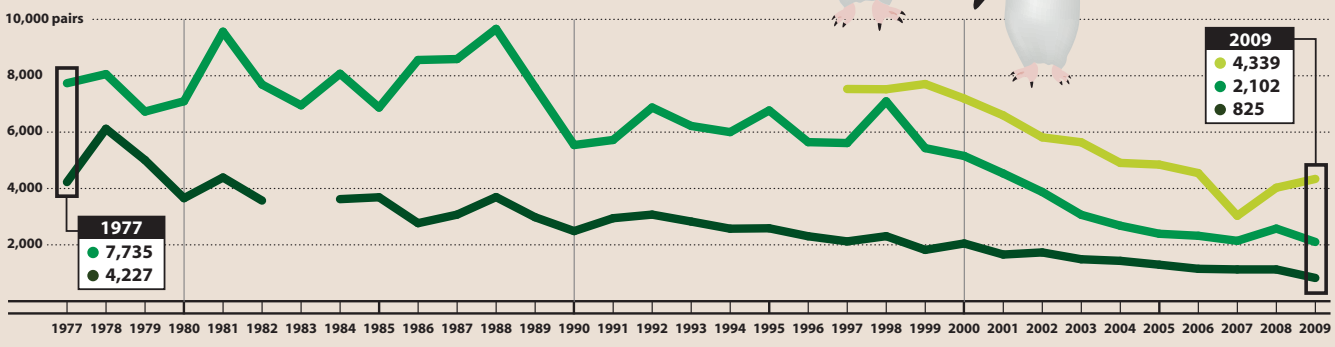


Note: Data for 1985-86 not available.

...AND, THEREFORE, SHRINKING POPULATIONS OF ADÉLIE AND CHINSTRAP PENGUINS

Number of breeding pairs at study sites





Note: Data for 1983 not available.

STUDY DESIGN

In order to address the impacts of sea-ice and krill on penguin populations, Dr. Trivelpiece and his colleagues analyzed an extensive data set consisting of 30 years of field work on population size and breeding success of Adélie and chinstrap penguins in the South Shetland Islands in Antarctica. The scientists also assessed krill abundance, air temperature changes and sea-ice levels in the region during the same time period to explore the relationship between these factors and penguin abundance.

KRILL

Antarctic krill, *Euphausia superba*, are tiny, shrimp-like crustaceans that serve as the key prey for many predators like penguins, seals, whales and seabirds, as well as the target of an expanding commercial fishery aimed in part at obtaining ingredients for aquaculture feeds. In many areas, the commercial fishery operates in the feeding grounds of breeding, krill-dependent predators, such as penguins.

KRILL AVAILABILITY EXPLAINS SHIFTS IN PENGUIN ABUNDANCE

Instead of finding sustained increases in some penguin populations, Dr. Trivelpiece and his colleagues showed that both Adélie ("ice-loving") and chinstrap ("ice-avoiding") penguins and krill abundance have generally decreased over the last 30 years, even as sea-ice cover has started to diminish. Their results suggest that trends in krill biomass explain fluctuating penguin populations more effectively than sea-ice cover alone.

The scientists used previous studies of penguin and krill abundance to support their hypothesis that penguin populations are tracking krill abundance. For example, others have estimated that 150 million extra tons of krill might have been available to other krill predators, such as penguins, following intensive whaling in the 19th and early 20th century. Indeed, some studies show that Adélie and chinstrap penguin populations followed this change and increased between the 1930s and 1970s. Since then, however, climatic warming, a targeted krill fishery and recovering whale and fur seal populations have depressed krill abundance by almost 80 percent in the Southern Ocean. Accordingly, Dr. Trivelpiece's study estimates that populations of both Adélie and chinstrap penguins have declined in the South Shetland Islands by more than 50 percent, and other studies have shown declines of up to 75 percent in nearby regions during this time. If warming continues, winter sea-ice may disappear from much of this region and exacerbate krill and penguin declines.

These findings are particularly critical for chinstrap penguins because they breed almost exclusively in the Scotia Sea region, unlike Adélie penguins, which have southern breeding refuges in the Indian Ocean and Ross Sea. Once thought to benefit from diminished sea-ice, chinstrap penguins may instead be among the most vulnerable to climatic warming. Given their limited range, the authors suggest that chinstrap penguins be evaluated by the International Union for the Conservation of Nature for a higher status within their Red List, which describes the vulnerability of a species or population to extinction.

Once thought to benefit from diminished sea-ice, chinstrap penguins may instead be among the most vulnerable to climatic warming.

About the Authors

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LENFEST OCEAN PROGRAM

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