

# Is Antarctica losing its penguins?



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## Abstract

Why is Antarctica called “the frozen continent”? Because it is ICY! The majority of the land, including the South Pole is covered with ice. There are even sheets of ice on the ocean -*sea ice*. Antarctic animals rely on sea ice as *habitat* for finding food. But Antarctica is warming up lately, sea ice is melting, and the ecosystem is changing. As a result, many animals are suffering and their populations are declining rapidly. Here, we studied effects of changing climate conditions on Adelie penguin (*Pygoscelis adeliae*)

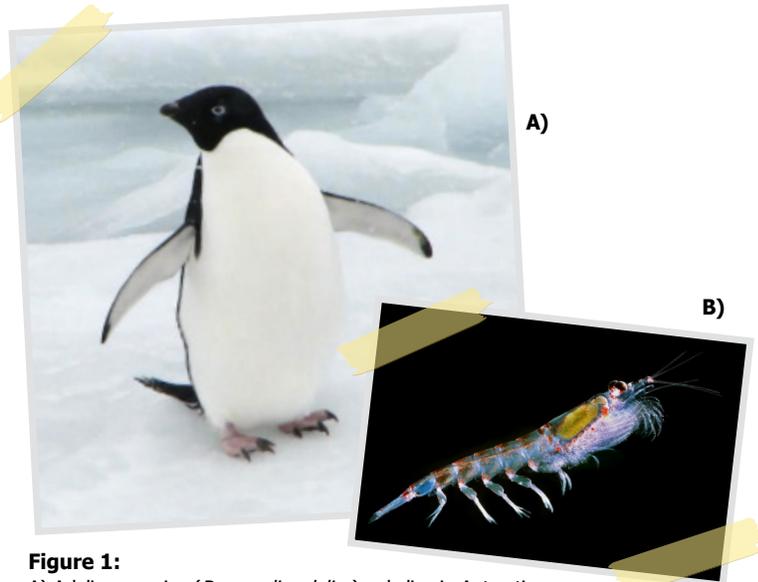
populations. We monitored a *colony* (large group) in the northernmost region of the continent. For 30 years, we kept track of adults and juveniles (young penguins). We recorded how successful they were at surviving and reproducing each year. Then, we created a mathematical model that could help us predict the size of a colony in the future. We found out that, as climate conditions worsen, this colony and many other colonies of penguins in the northern region may disappear within the next 30 years.

## Introduction

Antarctica, the southernmost continent, is the coldest, driest, and windiest place on Earth. This frozen continent is too harsh for humans but it is home to penguins, seals, whales and other hardy creatures. These animals rely on sea ice to survive. Sea ice is simply frozen sheets of ocean water.

Unfortunately, *climate change* affects Antarctica more than most other places. As air and water surface temperatures increase, sea ice melts. This causes many marine mammals and seabirds to lose their habitat and food source, among them Adelie penguins (Fig. 1a).

Adelie penguins live on the Antarctic continent and the surrounding coastal islands (Fig. 2). They gather on rocky shores where they build nests and lay eggs. The main food source of Adelie penguins is Antarctic krill (*Euphasia superba*) (Fig. 1b). Krill are small shrimp-like *crustaceans* that form the base of Antarctic *food web*. Krill also rely on sea ice to survive. They feed on *phytoplankton* that grow underneath the sea ice and use the crevices as shelter.



**Figure 1:**  
A) Adelie penguins (*Pygoscelis adeliae*) only live in Antarctica. The mainly feed on krill B) (small shrimp-like marine creatures). Krill image by Uwe Kils.

**Please see  
Figure 2 on Page 2**

However, climate change and increasing temperatures make the sea ice formation very unreliable in the Southern Ocean. As a result, krill populations as well as krill-dependent Adelie penguin populations decrease rapidly. In fact, the number of Adelie penguins in the Antarctic Peninsula (northern parts of the continent) is less than half of what it was in 1970s.

If climate change continues at its current rate, scientists predict even warmer temperatures and less sea ice in Antarctica's future. How will this affect Adelie penguins in the region? Will they disappear?

## Methods

To find out, we needed to know how penguin populations responded to their changing environment (declining sea ice levels, warming temperatures) in the past. So, we examined the Copacabana colony on King George island, on the Antarctic Peninsula (Fig. 3). For 30 years (1982-2011), we collected *data* during the penguins' breeding season. We monitored adult and juvenile penguins, keeping track of all factors that might influence the population size of the colony - number of breeding pairs, adult and juvenile survival rates, and reproductive success (number of chicks per breeding age penguin) of the colony.

During this time period, the number of breeding pairs reached a high of 9600 (in 1989) and dropped to a low of 2038 pairs (in 2013). This is a nearly 79% decline. The same trend has occurred in other colonies in the Antarctic Peninsula region.

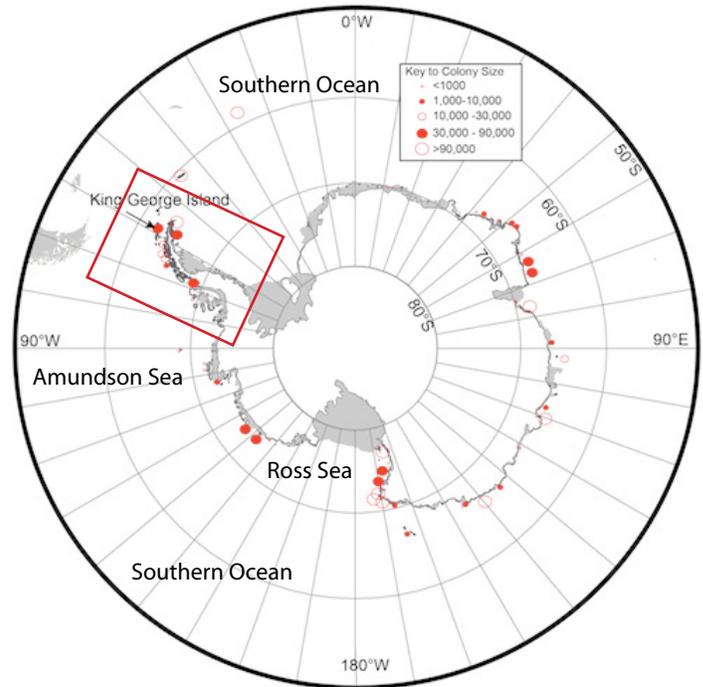
Next, we built a mathematical model to predict the future size of the penguin population based on survival rates of adults and juveniles, and the production of new chicks each year. Then, we examined the effect of having "good" survival conditions and "poor" survival conditions for 30 years into the future. Finally, we predicted the change in population size over the next 30 years depending on how often "poor" conditions occurred.

## Results

Our results created a picture of the Copacabana colony 30 years forward. There are three possible scenarios: pessimistic/ no change/optimistic (Fig. 4).

**1 Pessimistic scenario:** If conditions for survival worsen (less sea ice, less krill) and the likelihood of "poor" years increases, then the chance that the colony will disappear greatly increases.

**2 No change scenario:** If conditions don't change, and



**Figure 2:**  
A view of Antarctica with nesting sites of Adelie penguins highlighted in red. About 29% of all Adelie population live around the Antarctic Peninsula (land area within red box).



**Figure 3:**  
We studied this "Copacabana" colony of Adelie penguins on King George Island continuously for more than 30 years. Photographed by Wayne Trivelpiece.

the probability of "poor" years stays similar to historical data:

**a)** The colony will certainly decline by 50% over the next 30 years. This is the endangered species threshold determined by International Union of Conservation of Nature (IUCN).

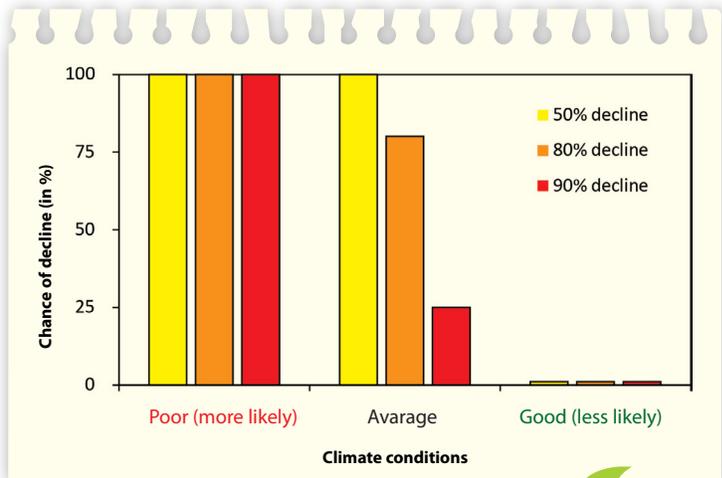
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Figure 4 on Page 3*

**b)** There is a high (80%) risk that the colony will decline by 80% and reach critically endangered species threshold.

**c)** There is a lesser but significant risk that the colony will decline more than 90% and reach *quasi-extinction* threshold.

**3 Optimistic scenario:** If conditions improve (reliable sea ice, more krill) and the probability of “poor” years decreases, the penguin population will recover.

**Figure 4:** shows the chance of a certain percentage decline of the penguin populations under various climate scenarios. If climate conditions are bad, the chance of decline is high for all levels. If conditions are average, 50% declines (yellow bars) are more likely than 90% declines (red bars). If conditions are all good, the chance of large declines is very small. You can see that poor climate conditions are more likely to happen than good ones.



What is the trend as climate conditions move from good to poor? What is the most likely outcome for the penguins in the next 30 years?

## Discussion

Climate change is faster and more severe in Antarctica than most other places in the world. As a result, sea ice - a critical component of *marine ecosystems* in Antarctica, is becoming unreliable. Analyzing the dynamics of an ecosystem, and predicting how it would respond to such a significant change require long term data. Here, **our data on survival and reproduction show how warming temperatures and loss of sea ice impact the Antarctic food chain (phytoplankton, krill, Adelie penguins) and can cause major decline in penguin populations.**

How will the loss of Adelie penguins affect the ecosystems in the region? If our model applies to all the other Adelie penguin colonies in the Antarctic Peninsula, then we might lose most

Adelie penguins in the very near future.

**Adelie penguins are a key component of the Antarctic ecosystem. They keep krill and fish population under control, exchange marine and terrestrial nutrients, also are an important food source for many marine mammals.**

Losing Adelie penguins would weaken the ecosystem and make it less *resilient* to further disturbances such as warmer temperatures. Given the high risk of this happening, **we urgently need to increase our conservation efforts to save this important species.**

## Conclusion

Adelie penguins need our help. Besides doing your part to reduce the impact of climate change (i.e. reducing our carbon footprints, see our paper on **More Stuff = more climate change?**), you can find out more by checking out organizations that help protect wildlife in Antarctica, like

the World Wildlife Fund (**WWF**), or the International Union for Conservation of Nature (**IUCN**) among others. They influence decisions that governments make about what to do about climate change, marine protection, and managing krill fishers to prevent over-catching for human use.

## REFERENCES

Hinke, J. T., S. G. Trivelpiece, and W. Z. Trivelpiece (2017) *Variable vital rates and the risk of population declines in Adelie penguins from the Antarctic Peninsula region*. *Ecosphere* 8(1)  
<http://onlinelibrary.wiley.com/doi/10.1002/ecs2.1666/full>

A cool map that lets you map penguin populations:  
<http://www.penguinmap.com>

Info on Antarctica  
<https://www.coolantarctica.com/>

## Glossary of Key Terms

**Data** – information/facts that scientists collect to test their research question (hypothesis).

**Carbon footprint** – amount of greenhouse gases that are emitted to produce the things we buy and to support our lifestyles. Can be expressed per person, family, city etc.

**Climate change** – a change in climate patterns apparent since the mid 20th century and attributed largely to the increased levels of atmospheric carbon dioxide and “greenhouse gases” produced when we burn fossil fuels.

**Colony** – a group of animals (in our case penguins on land).

**Critically endangered** – this is the highest category of risk on the “IUCN Red List of Threatened Species”, just before extinction.

**Crustacean** – a type of arthropod, meaning it is an animal that has an external skeletal support system (“exoskeleton”) with jointed legs and other appendages. Crabs, shrimps, and lobsters are well-known crustaceans. However, the group also includes barnacles, pill bugs, amphipods, copepods, krill, crayfishes, sea fleas, clam shrimps, fairy shrimps, and many others.

**Ecosystem** – a biological community of interacting organisms and their physical environment.

**Ecosystem resilience** – the capacity of an ecosystem to recover from disturbance or withstand ongoing pressures.

**Endangered** – a term given to a species, or subspecies that is at risk of extinction.

**Fishery** – the people, equipment, and organizations involved in catching fish for food, fun, or profit.

**Food chain** – a hierarchical series of organisms each dependent on the next as a source of food.

**Food web** – an interlocking set of species that eat and are eaten by each other in an ecosystem.

**Habitat** – a natural environment of an animal or plant (or other living organism). It provides food and shelter.

**IUCN** – the International Union for the Conservation of Nature. This is the organization that manages the “Red List of Threatened Species”.

**Krill** – small (5-6 cm) shrimp-like crustaceans (invertebrate animal with an exoskeleton) that are found throughout the world’s oceans. Antarctic krill (*Euphausia superba*) are found in the Southern Oceans surrounding Antarctica.

**Marine ecosystem** – an ecosystem that occurs in or near salt water, which means that marine ecosystems can be found from a sandy beach to the deepest parts of the ocean.

**Phytoplankton** – tiny types of algae (a type of plant) in the ocean. Most phytoplankton are near the surface of the water, because like plants on land, they need light to grow. Plankton move around with waves and water currents or sink.

**Quasi-extinction** – a level at which the number of adults may be insufficient to assure persistence of the species.

**Sea ice** – frozen seawater.

**Terrestrial** – living or growing on land.

## Check your understanding



**1** How does the loss of sea ice affect Adelie penguin populations in Antarctica?

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**2** What important ecological role do Adelie penguins play in the Antarctic ecosystem?

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**3** Why is Antarctic krill so important for Adelie penguins and the Antarctic marine ecosystem?

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**4** Antarctic krill is used as natural supplements (krill oil) and feed for farmed fish. As krill populations decline, krill fisheries become a problem for Adelie penguins. How can we manage fisheries to prevent the competition with penguins ?

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**5** How did our mathematical model help us predict Adelie penguin population responses to climate change?

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