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EMPEROR PENGUINS ON THIN SEA ICE

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YOUNG REVIEWERS:

JOSEPHINE
AGE: 11

TANISHKA
AGE: 14

Emperor penguins are tough birds that breed on sea ice, which is the frozen surface of the ocean. They are famous for walking across the sea ice, to and from the open ocean, to get food for their chicks. Their bodies and behaviors help them live in the cold, dark winters of Antarctica. However, though they live far away from people, human actions are not always good for emperor penguins. Humans are causing the world to warm. With warmer temperatures, sea ice around Antarctica will melt. For emperor penguins, this means their homes might disappear. We know so much about emperor penguins because scientists and explorers have been studying them for over 70 years. In this article, we will tell you about what is likely to happen to emperor penguins—and what their future can tell us about our own future.

SEA ICE

Sea ice is frozen water that forms on the surface of the ocean. It is like a big icy blanket that covers parts of the sea when the weather gets really cold. Sea ice is important because it gives some animals a place to rest and hunt, and it also affects the weather and the whole Earth's environment.

Figure 1

The life cycle of emperor penguins is tied to sea ice (Image credit: Zina Deretsky, National Science Foundation: https://photolibrary.usap.gov/PhotoDetails.aspx?filename=PENGUIN_LIFECYCLE_H.JPG). Emperor penguins come to their rookery on a stable sea ice platform in April. In May and June, the mom penguins lay one egg. The dads take care of the egg, keeping it warm, and both moms and dads give food to the baby penguins from August when they are born to November when they are left alone at the colony. The arrows on the map show the path they travel from their home on the ice to the water where they find food. By December, everyone has left the colony.

VIDEO 1

The life cycle of emperor penguins is tied to sea ice (https://youtu.be/--JabgZFEjg).

GREENHOUSE GASSES

Gasses like carbon dioxide that trap the sun's heat in Earth's atmosphere, like a blanket of gasses that surrounds our planet and heats it up.

LIVING ON SEA ICE: A VITAL HABITAT UNDER THREAT

Emperor penguins breed on **sea ice**, which is the frozen surface of the ocean. These birds are specialized to survive in cold conditions that would be too harsh for humans. Emperor penguins have some specific requirements. If there is *not enough* sea ice, they do not have a place to live. If there is *too much* sea ice, they have a long walk to get to the open ocean, where they hunt for food for themselves and their chicks. So, the sea ice must be just right for emperor penguins to live, get food, and raise their chicks (Figure 1 and **Video 1**).

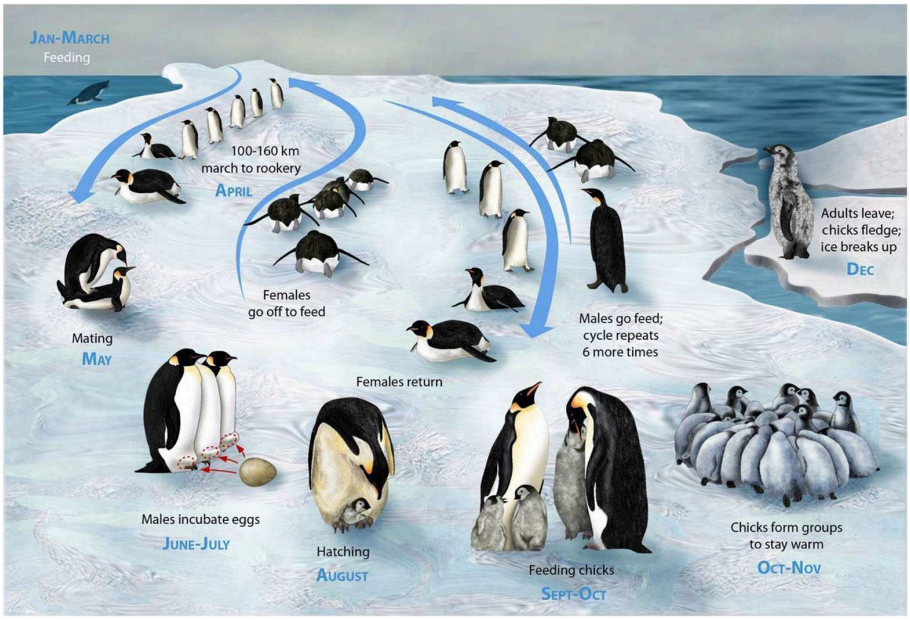

Figure 1

We know the world is getting warmer and that there might be less sea ice for emperor penguins in the future. The world is warming because humans are producing **greenhouse gasses** (such as carbon dioxide) that trap the sun's heat near the Earth. Greenhouse gasses come from human activities such as burning oil, gas, and coal. The faster the world warms, the less likely emperor penguins are to have sea ice. Will Emperor penguins march to **extinction**?

SURVIVING THE UNIMAGINABLE

About 250 years ago James Cook, a captain in the British Navy, was sailing around the world. He and his crew may have been the first people to see emperor penguins. What we know for sure is that later, someone noticed that emperor penguins were a different species than king penguins [1]. In the early part of the 1900s, Robert Falcon Scott, another captain in the British Navy, sailed to Antarctica. He found the first **rookery** of emperor penguins. Now, using pictures of the world

taken from satellites in space, we know that there are 61 **colonies** of emperor penguins in Antarctica [2].

Even though we have been studying emperor penguins for about 100 years, we still have a lot to learn. These penguins live in dangerous places, and that makes them hard to study. But that has not stopped people from trying. Around 70 years ago, two famous scientists, Bernard Stonehouse and Jean Prévost, visited Antarctica to study emperor penguins. These scientists learned how important sea ice is to these penguins [3]. In the winter when it gets cold, the surface of the ocean freezes. These icy spots on the sea are where emperor penguins gather in special groups to take care of their baby chicks. Those areas are called rookeries or colonies. After forming colonies, the emperor penguins choose their mates in March/ April. The females lay one egg each in May or early June, and the males keep the eggs warm by holding them on the tops of their feet. Males do this for nearly 3 months—and it is not easy! Wintertime in Antarctica is dangerously cold and stormy—temperatures can get down to −50°C, and winds can blow at over 150 km per hour. The males must huddle together to keep warm and to survive. The penguins take turns being in the middle of the huddle, where temperatures can reach 37°C. The penguin dads keep the eggs warm and cozy while the mommies search for food (Figure 1).

When the females have eaten enough squid, fish, and krill (shrimp-like creatures), they come back to feed the newborn chicks. The males, which have not eaten in 4 months, are starving by this time. The females take over keeping the chicks warm, while the males search for their own food. Then, mommy and daddy penguins take turns feeding their chick, so the chicks grow up fast and strong. In early spring, the chicks are twice as big as when they hatched, and they can be left on their own. Chicks huddle together to keep warm and to defend each other against other birds species that might attack them, while the parents search for food for a few days at a time. It is hard work raising an emperor penguin chick! Chicks must grow enough to get their waterproof adult feathers before the sea ice melts away for the year. The soft, fluffy feathers the chicks have when they are born are not waterproof, so if chicks get wet, they can freeze. From early November, chicks begin to get their adult feathers, and they leave the colony in early summer, from December to January. Without their parents, the chicks hang out together on the ice.

TROUBLING TRENDS

Even though emperor penguins are difficult to study, we have a few clues from a colony found at Pointe Géologie, where they have been studied for a long time. This is where the movie *March of the Penguins* was filmed! There is a mystery at Pointe Géologie. In the 1970s, the number of emperor penguins decreased from about 12,000 birds to

EXTINCTION

The end of a species' existence on Earth. Once a species becomes extinct, no more individuals exist and it is gone forever.

ROOKERY

A breeding colony or nesting area of birds, particularly seabirds. It is a location where birds gather in significant numbers to build nests, lay eggs, raise their young (chicks), and engage in various reproductive activities. The term is commonly used in the context of penguins, seals, and other marine birds and mammals.

COLONY

Animals living together for mutual benefit, such as stronger defense against predators. For emperor penguins, living in colonies is a great defense against the cold and wind.

about 6,000 birds [4]. Scientists think that many of the adults were dying, and the sea ice was a clue to this mystery. More males died when there was not enough sea ice. Emperor penguins eat animals that live under the sea ice (fish, squid, and krill), and less sea ice probably meant less food. Males need more food than females because they go without eating for 4 months during winter.

Another mystery is that the population of emperor penguins at Pointe Géologie has not yet returned to 12,000 birds. Scientists observed that, in years with *too much* sea ice, fewer chicks survived. Too much sea ice means penguins must travel longer distances to reach open water, where they can find food. So, there is a sea-ice "Goldilocks zone." *Too much* sea ice means adults take too long to get food, so both adults and chicks may starve. *Not enough* sea ice means less food for penguins, and chicks may not grow their waterproof feathers before the sea ice melts away.

Today, Antarctica is changing because of greenhouse gasses. Warmer temperatures around the world will cause the sea ice to melt and break up earlier in the spring. Scientists have created **computer models** to see what would happen to emperor penguin populations if these penguins have less ice to live on. If we do not change the way we make and use energy, penguins at Pointe Géologie will be at risk of extinction by 2100 [5].

Scientists want to see what will happen to all other emperor penguin colonies, too. Some colonies, such as those in the Ross Sea, might be OK in the future because sea ice declines are less severe at those locations. Sadly, if we continue to put greenhouse gases into the air, all emperor penguin colonies will probably decrease by the year 2100 (Figure 2). If we keep warming the air, the temperatures around the world will be much higher than we want them to be (increase of 4.3°C above the temperature in 1850), and most emperor penguin colonies

COMPUTER MODELS

Computer-based versions of a natural system, which scientists can use to understand the system and the way that various factors might change the system in the future.

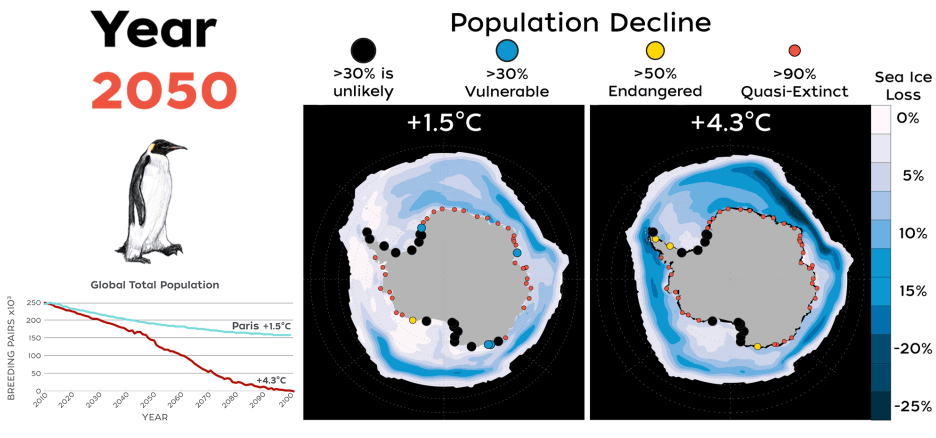

Figure 2

Figure 2

(A) The curves in the graph show the total number of breeding pairs of emperor penguins from 2009 to 2100, for two possible futures: one in which we do nothing to reduce greenhouse gas emissions and the temperature rises by 4.3°C (red line); and one in which we are able to reduce greenhouse gas emissions and the temperature rises by 1.5°C (blue line). **(B)** Dots show emperor penguin colonies. The colors and sizes of dots show population decline by 2050, 2080, and 2100 under the two temperature scenarios. The percentage of sea-ice loss (see color scale) is also shown for the same years. The warmer Antarctica will become, the less colonies of emperor penguins will exist.

will disappear. If we can limit global warming to only 1.5°C, emperor penguins will still exist in Antarctica by 2100.

Recently, scientists wondered what would happen to emperor penguin colonies if **extreme weather events** happened. For example, at Halley Bay (Figure 3a), an estimated 10,000 chicks or more died in one year because of very low sea ice. Halley Bay was the world's second- largest emperor penguin colony before this extreme event. Scientists can observe these rare extreme weather events using satellites. At Halley Bay, such satellite images showed that, in 2016, the sea ice broke up early, before the chicks could swim (Figures 3b–d). By better understanding how extreme weather events affect penguins, scientists now think that 98% of colonies will be disappear by 2100 if we do not control greenhouse gas emissions—this means that almost all the emperor penguins in the world will be gone. Emperor penguins will only stand a chance if greenhouse gas emissions are slowed from their current course.

EXTREME WEATHER EVENT

Any occurrence of rare, severe weather that is outside of normal weather patterns. Extreme events can cause devastating impacts on communities and ecosystems.

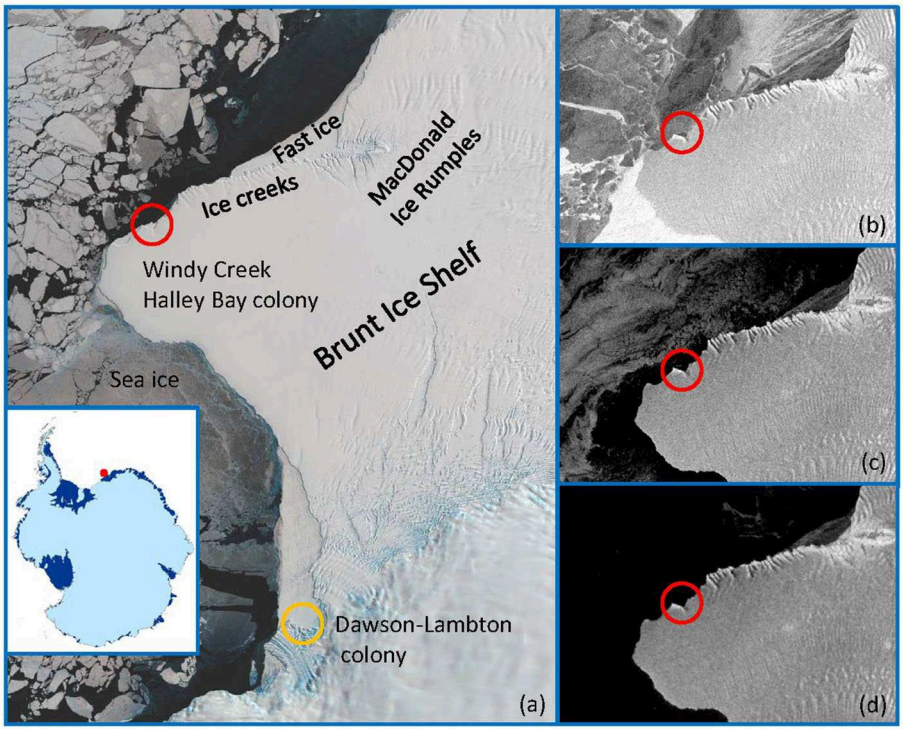

Figure 3

Satellite images from October 2016. **(a)** The Halley Bay colony is at Windy Creek, and the Dawson-Lambton colony is on the Dawson-Lambton Glacier. In 2016, breeding failed at Halley Bay; many adult birds are thought to have moved to Dawson-Lambton in later years. Inset shows the location of Halley Bay. **(b)** Sea ice around Windy Creek is decreasing. The red circled areas show the location of the Halley Bay colony on 3 November 2016; **(c)** 17 November 2016; and **(d)** 1 December 2016 (Image credit European Union Copernicus Sentinel 1 satellite, using the EO Browser).

Satellite images have also helped us understand how colonies might change as penguins move from one spot to another. Does moving between homes mean penguins could find new places to live as the sea ice melts? Scientists initially thought that penguins might leave places that were not good homes and would search for better locations so they could survive. But sadly, it seems that moving between homes does not help, and emperor penguins will still

face a risk of extinction if we do not stop releasing greenhouse gasses [5].

LIVING ON THIN ICE

Emperor penguins cannot change the way they live fast enough to deal with climate change. So, to save them, humans should reduce greenhouse gas emissions. If we can keep the increase in air temperature around the world to <1.5°C, emperor penguins will have a better chance of surviving. In 2015, people from 195 countries met in Paris, France and agreed to limit global warming to well below 2°C. This meeting led to a legal document known as the **Paris Agreement**. This agreement represents the first time that all nations have joined the common cause to fight climate change. Governments must take actions *now* to reduce greenhouse gas emissions, to protect the Earth and its species for today's and future generations [6]. You can find out more about whether governments are meeting the 1.5°C Paris Agreement by looking at the Climate Action Tracker.

PARIS AGREEMENT

A plan to reduce greenhouse gas emissions to limit the average global temperature increase. It was signed by 195 nations that agreed to the importance of fighting climate change.

Climate change affects everyone. Today, emperor penguins serve as a signal to show us whether we are effectively controlling greenhouse gas emissions. They can tell us if we are in danger. We are *all* on thin ice. The future of emperor penguins, humans, and all other life on Earth as we know it depends upon the decisions we make *today*.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

JOSEPHINE, AGE: 11
My name is Josephine, I am 11 years old and I am in 6th grade. I live with my mom and dad, my four parakeets and a husky. My favorite color is neon-orange, I figure skate, swim and play golf. I like to read and watch shows about animals, dragons and mythology. I love animals, but I do not have a favorite since all have different skills and features. I enjoyed working on the article and I hope to do another one.

TANISHKA, AGE: 14
Possessing a strong affinity for science/health, Tanishka enjoys participating in numerous science competitions. She persistently receives 1st fair in STEM Fair and has gotten the Best of Fair award. She has also published two scientific articles in high-impact-factor journals. She is a part of numerous health-science-related clubs such as hosa and has gotten 1st place at the international level in the hosa international conference. Tanishka can be found playing her violin or reading whenever not studying or part-taking in competitions.

AUTHORS

STEPHANIE JENOUVRIER
Dr. Stephanie Jenouvrier is a seabird biologist at Woods Hole Oceanographic Institution (MA, USA). She is the founder of the FLEDGE lab. That is short for Forecasting the Long-Term Ecological and Demographic Impacts of Global Environmental Changes. Big words, right? But it means Stephanie is like a detective

trying to understand how climate change and people's actions affect birds. Dr. Stephanie uses special computer codes to help her figure out what might happen to seabirds as the Earth gets warmer. Stephanie is like a bird fortune-teller! She is even been part of important work to make sure the emperor penguin is kept safe. Thanks to her work, these penguins are now protected under a law called the US Endangered Species Act. She worked closely with talented artists to craft captivating illustrations that bring the Emperor Penguin's story to life, and you can access and enjoy these vibrant visuals for free right here: https://www2.whoi.edu/site/jenouvrier/outreach/exhibits-cartoons/. *sjenouvrier@whoi.edu

MICHELLE LA RUE

Dr. Michelle LaRue is an Antarctic marine ecologist at the University of Canterbury (New Zealand) and a research associate at the University of Minnesota (USA). Dr. Michelle has super cool tools in her science kit, like satellite images and photos. With these tools, she learns all about animals in Antarctica. Can you believe she is been to Antarctica eight times? Dr. Michelle is not only a scientist but also a storyteller! She wrote a special book just for kids called "Young Zoologist: Emperor Penguin."

PHILIP TRATHAN

Dr. Philip Trathan is a marine ecologist. Before he retired, Phil was head of Conservation Biology at the British Antarctic Survey (UK). He is now a visiting professor at the University of Southampton. Dr. Philip is like an explorer—he is been to the Antarctic a whopping 20 times! He is not looking for treasure though; he is trying to understand what happens to animals like birds and sea mammals when the climate gets warmer and when people go fishing. His discoveries have been so important that they helped create safe zones, called marine protected areas in the Antarctic and sub-Antarctic. Dr. Philip is like a guardian of the Antarctic ocean!

CHRISTOPHE BARBRAUD

Dr. Christophe Barbraud is a seabird ecologist at Centre d'Etudes Biologiques de Chizé (France). Dr. Christophe does not just stay in his lab; he is like an adventurer! Every year, he sets off on exciting journeys to gather information about birds and marine mammals. He and his team have been collecting data for several decades! They want to know how things like climate change, fishing, and pollution affect seabirds and marine mammals. With their smart minds and field trips, they have learned so much! They have even told everyone how climate change can affect emperor penguins and albatrosses. And guess what? They have helped make sure that fishing does not hurt the seabirds too much. Dr. Christophe and his team are true heroes of the ocean!