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HOW MIGHT PLASTIC POLLUTION AFFECT ANTARCTIC ANIMALS?

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YOUNG REVIEWERS:

ANVITHA
AGE: 11

RAUL
AGE: 9

SRINIKA
AGE: 11

Antarctica is the least populated place on Earth, but the frozen continent and its surrounding Southern Ocean are still affected by human activities. Scientists have found large pieces of plastic such as fishing nets, and microscopic-sized pieces of plastic, too. Some plastics can be hundreds of times smaller than a grain of sand, and these are called nanoplastics. The Southern Ocean, which surrounds Antarctica, is also warming faster than other oceans and is becoming more acidic. Thus, Antarctic marine animals that have lived in an untouched, stable environment for millions of years are now being exposed to plastic pollution and human-caused climate change. We are studying how Antarctic marine life is coping with plastic pollution in this quickly changing ocean. We focus on Antarctic krill, a small crustacean that supports the Antarctic marine food web. Findings show that krill embryos subjected to ocean acidification and nanoplastics develop less than embryos in ordinary seawater conditions.

HOW DOES PLASTIC GET TO THE END OF THE EARTH?

Antarctica is the most remote place on earth, but it is not protected from plastic pollution which accidently enters the ocean. In the Southern Ocean which surrounds Antarctica, plastic can be very large such as lost fishing nets or very small particles, which are called micro- and nano-plastics.

As polar scientists working on plastic pollution, we are often asked the question: "Nobody lives in Antarctica, so where does all the plastic pollution come from?" This is a very good question. It is true that Antarctica does not have a permanent human population. But more and more people can now reach the South Pole, at the end of the Earth. People might be in Antarctica for science, for industry activities such as fishing, or even for tourism. The more people that visit Antarctica, the more potential there is for plastic to be released into the water by accident. Nobody wants our plastic waste to end up in the ocean, but plastic is in so many products, it is difficult to avoid. For example, plastic fibers can come off our clothes especially when they are being washed and paint chips from ships end up in the water, too.

Not all the plastic pollution in the Southern Ocean (the ocean that surrounds Antarctica) is from people who have traveled to Antarctica. Plastics can travel exceptionally long distances across the ocean. Previously, scientists thought that plastics would not be able to reach the Southern Ocean from other oceans because there is a strong current around Antarctica that acts as a barrier (Figure 1A). But scientists now believe plastics can pass through this strong current. Microscopic plastic particles can be carried by subsurface currents, by sticking to seaweed, or they can be carried within marine animals that have eaten plastic. This means that plastics that accidently end up in the oceans all over the world could eventually end up in Antarctica [1].

MACROPLASTIC

plastic litter larger than ~5 mm (about the size of a grain of rice).

WHAT TYPES OF PLASTICS ARE IN THE SOUTHERN OCEAN?

Plastics of all shapes and sizes are found in the Southern Ocean. Lost fishing nets or plastic bottles are examples of large **macroplastics** that break down in the ocean into smaller pieces. This can happen due to processes such as wind and waves, combined with the ultraviolet (UV) rays from the sun that make the plastics weak. The UV rays are very strong in Antarctica. When plastic pieces are smaller than 5 mm, they are called **microplastics**, and even smaller pieces, called **nanoplastics**, are <0.001 mm in size. That is at least 2,000 times smaller than a grain of sand! Nanoplastics are so tiny they are invisible to the human eye. Microplastics and nanoplastics can result from the breakdown of larger plastics, or they might be manufactured at those small sizes.

MICROPLASTIC

small plastic litter <5 mm, some might not be seen without the help of microscope because they are so small.

NANOPLASTIC

Tiny pieces of plastic even smaller than microplastic, they are below 0.001 mm (hundreds of times smaller than a grain of sand) and cannot be seen by eye.

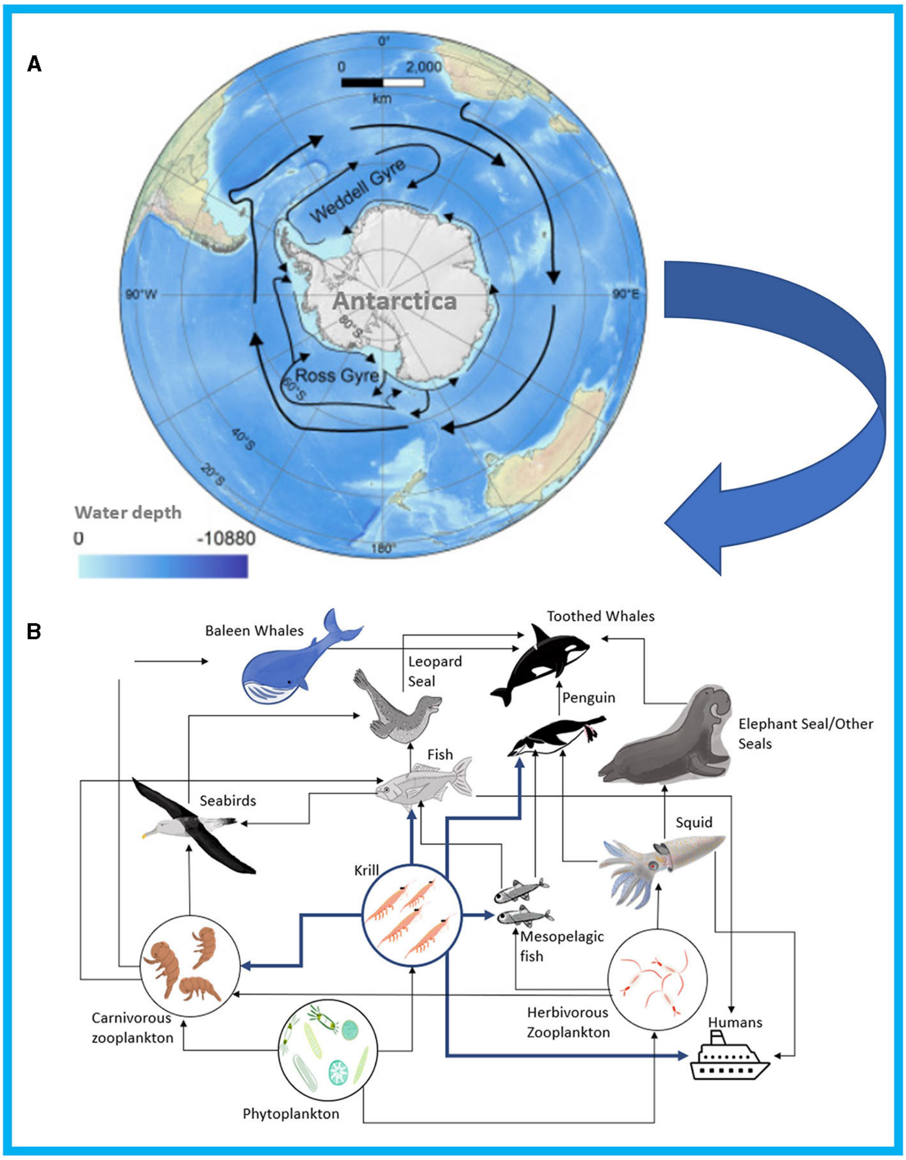

Figure 1

Figure 1

(A) The strong ocean currents that surround Antarctica might impact how plastic pollution reaches the Southern Ocean but does not protect the Polar regions from plastic pollution passing through (Figure adapted from Armitage et al. [2]). **(B)** Antarctic food web showing the importance of Antarctic krill (blue arrows; all arrows indicate who eats whom). Carnivorous zooplankton eat other zooplankton, while herbivorous zooplankton eat algae (phytoplankton). You can see that Antarctic krill are at the base of the entire Antarctic food web, which is why it is important to understand how nanoplastics and other changes affect them.

Small plastic pieces are used in lots of products, such as face washes, cosmetics, and some medical supplies.

Small plastics have been found floating on the sea surface, throughout the **water column**, and on the seabed of the Southern Ocean [3]. These small plastics can also become trapped in sea ice. This means that when the sea ice melts, large amounts of collected plastics are released into the ocean, too [4].

WATER COLUMN

A stretch of water between the surface and the seafloor.

ANTARCTIC ANIMALS ARE IN DANGER

It is easy to see the harm that macroplastics cause to ocean animals. For example, animals at the top of the Antarctic food web, such as seals and penguins, can get caught in lost fishing nets. The harm that microplastics or nanoplastics can cause is not as easy to see. But small animals such as the Antarctic **zooplankton**, which are food for the larger animals in the food web (Figure 1B), may mistake tiny plastic pellets for food [5]. Because sea ice has high concentrations of plastic pollution, melting sea ice can be worrying for zooplankton like Antarctic krill that feed on sea-ice algae.

ZOOPLANKTON

Animals that only have weak swimming movements so drift with the ocean/wind driven currents.

Plastics are just one piece of the puzzle. The ocean is like a giant sponge it absorbs both heat and carbon dioxide from the Earth and the atmosphere. This leads to ocean warming and **ocean acidification** (in which the ocean becomes more acidic), both of which change the marine environment for the animals that live there. We must consider these changes when thinking about how animals will cope with plastics and other new pollutants in the environment (Figure 2). This is particularly important in Antarctica. The Southern Ocean has some of the fastest-warming areas on the whole planet. Ocean acidification is also more of a problem in Antarctica than in other places, partly because cold water absorbs more carbon dioxide than warm water, and the Southern Ocean is very cold compared to other oceans.

OCEAN ACIDIFICATION

As the world's oceans absorb fossil fuel derived CO_2 from the atmosphere the water becomes acidic.

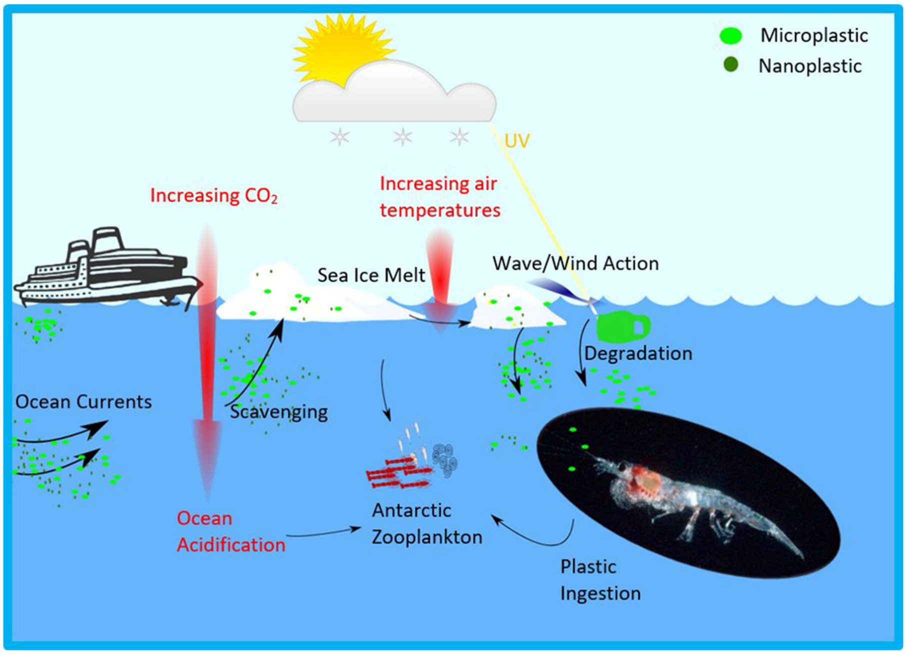

Figure 2

Figure 2

Movement of microplastics and nanoplastics in the Southern Ocean and interaction with zooplankton. Other human influenced stressors to the Southern Ocean are also shown, including ocean acidification and ocean warming.

Antarctic marine animals are incredibly special. They have evolved over millions of years in an isolated environment. If you remember when you were 8, you would have to relive those 8 years *125 thousand times* to reach just 1 million! Ancient Antarctic animals have lived in a stable and remote system for over 40 million years, which impacts their ability to adapt to environmental changes such as those caused by pollution and climate change. This is why it is so important to understand how Antarctic marine animals are coping in a changing ocean.

Antarctic krill are one of the most abundant animals on the planet, with swarms so huge they can be seen from space! They support the large populations of penguins, seals, whales, and other marine life in Antarctica. Plastic pollution, ocean warming, and ocean acidification are already known to impact the development of Antarctic krill, as well as their ability to lay healthy eggs, and their overall behavior [6]. Scientists currently know little about how these important animals will react to the other environmental changes like ocean warming and acidification that are happening at the same time.

NANOPLASTICS AND OCEAN ACIDIFICATION IMPACT ANTARCTIC KRILL

In the laboratory, scientists can mimic the expected water conditions of the Southern Ocean to learn about how marine animals will cope in the conditions of the future. We did experiments like this to understand how Antarctic krill embryos respond to nanoplastics and ocean acidification. To achieve this, we went to the Southern Ocean in search of female krill ready to spawn. Spawning is when aquatic animals release embryos into the water. We took krill embryos and mimicked various seawater conditions. Some embryos were in ordinary seawater, some were in seawater with nanoplastics added, and some were in seawater that we made more acidic. Some embryos were in seawater that was more acidic *and* had nanoplastics added, to see how the combination would affect them (Figure 3A).

Beginning as a single cell, Antarctic krill go through multiple development phases over ~6 days before they hatch (Figure 3B). In the laboratory, we watched embryos develop in the various seawater conditions. Embryo development is important to explore because early life stages can be the most sensitive to environmental changes.

What did we find? The good news is that the embryos with nanoplastics in the water and the embryos in water simulating ocean acidification conditions did not show any differences in development compared to those in ordinary seawater. The bad news is that, when embryos were in seawater that contained both nanoplastics *and* higher acidity, it was harder for them to develop. Fewer embryos developed limbs and hatched [7].

WHAT DOES THIS MEAN FOR THE FUTURE?

In this article, you learned about how plastic pollution can reach the isolated region of Antarctica, and how this pollution might impact the animals which live in the Southern Ocean surrounding the frozen continent. In the real world, many changes are happening to the Southern Ocean at the same time. It is important that we understand

Figure 3

(A) In our experiment, we investigated the impact of nanoplastics and ocean acidification on Antarctic krill embryos by adding embryos to different seawater conditions with and without plastic and in water of different acidity. **(B)** The early life stages of Antarctic krill from a single cell to a newly hatched Krill.

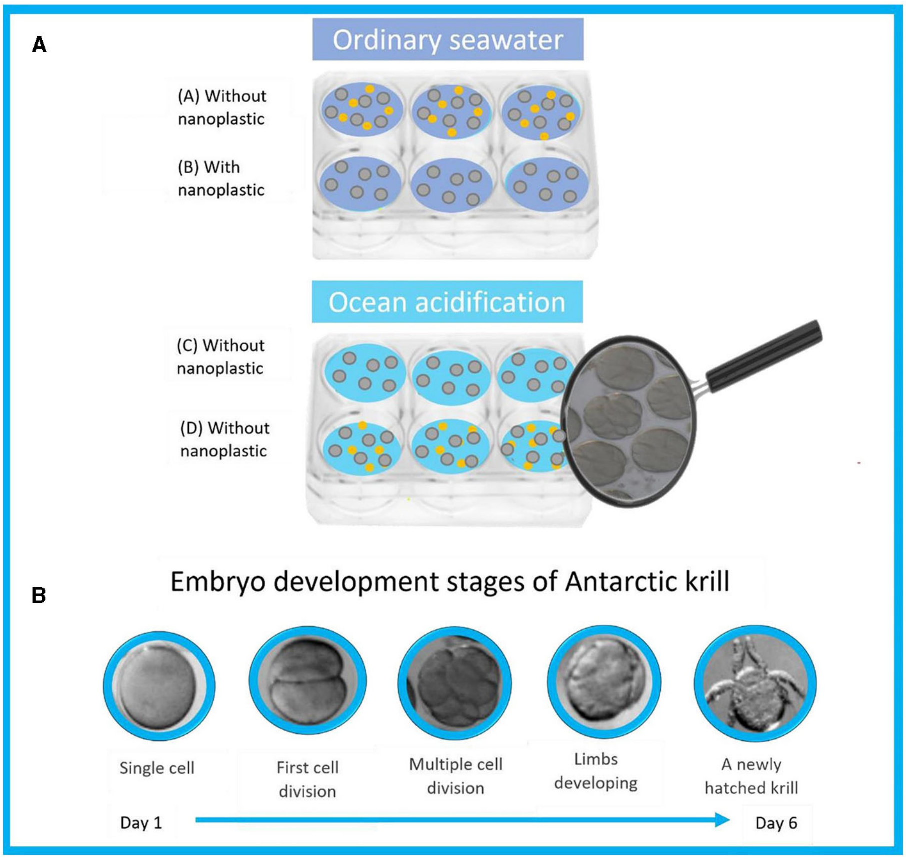

Figure 3

what impacts these combined changes might have on Antarctic animals like krill, so that we can do what we can to protect our oceans for the future.

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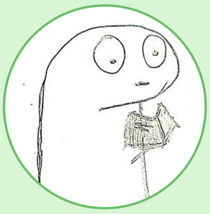
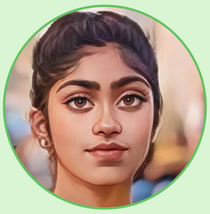
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANVITHA, AGE: 11
My name is Anvitha and I think polar bears are awesome! I also love music; dancing to it, making it or just listening to it. I enjoy learning about what is going on in the world, so I am really happy to be a young reviewer for the journal Frontiers for Young Minds.



RAUL, AGE: 9
I live on the Brazilian coast, I like to draw, play the piano and play tennis. At school I love math classes.



SRINIKA, AGE: 11

My name is Srinika, and I love trying new things. I love playing chess, drawing, and biking. I also love the outdoors. My favorite subjects are math and science. I hope, that someday in the future, I become a doctor.

AUTHORS

EMILY ROWLANDS

Emily Rowlands is a marine biologist at the British Antarctic Survey. Most of Emily's research focuses on plastic pollution, how much pollution is in Antarctica and what impact this has on the animals that live in the ocean surrounding Antarctica. To do this Emily has spent many months on a research ship in Antarctica where she enjoys watching the wildlife, especially the whales, when she is not working. In her spare time at home, Emily enjoys being on the water on her paddleboard with her rescue dog Bruno. *emirow@bas.ac.uk

TAMARA GALLOWAY

Tamara Galloway is Professor of Ecotoxicology (the study of how toxic chemicals affect animals) at the University of Exeter, UK. Tamara explores how animals adapt and survive in polluted environments and she studies the health effects of some of the most urgent global pollutants, including microplastics. Her research has helped to protect the environment by supporting global laws to control microplastics. She has won many awards and her work has been show in the news and on social media, helping millions of people across the world learn about microplastics.

KIRSTIE JONES-WILLIAMS

Kirstie Jones-Williams is a Sustainability Manager at a waste management company but before this, Kirstie completed her doctorate studying the impact of microplastics in the Arctic and Antarctic. From investigating impacts of plastic pollution in remote and fragile parts of the world, Kirstie now uses her skills to advise on how to recycle plastic and prevent pollution in the waste industry.

CLARA MANNO

Clara Manno dreamed of traveling the word and explore the nature since she was a child. She worked in Italy, France, Norway, and UK as Biological Oceanographer. Clara studies how zooplankton, tiny marine organisms, support the health of our planet by transporting part of human-produced atmospheric CO_2 in the deep oceanic sediments. Zooplankton are in danger because of microplastic pollution and Clara's work is to understand how this pollutant could be detrimental to the role of these organisms in fighting climate change. In her free time, Clara enjoys hiking and camping with the two daughters Aurora and Morgana.