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HOW ARE DEEP-SEA ANIMALS GETTING INTO SEDIMENT TRAPS IN ANTARCTICA?

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JULIA
AGE: 11

MUHAMMAD
AGE: 13

THEO
AGE: 12

A sediment trap is a tool to collect small, sinking particles in the sea. Unexpectedly, we found deep-sea animals inside four traps placed in the Amundsen Sea, Antarctica. The animals were long, slim worms, sea urchins, and baby scallops. These animals do not swim, so how did they enter the traps? As this surprising finding happened mostly during winter, we think that ice may have helped them get into the traps. If enough of a certain kind of ice, called anchor ice, forms on an animal's body, it can make the animal float. If the animal floats up to the sea ice on the ocean's surface, it can attach and be transported as the ice moves around. When the anchor ice melts the animals are released, and they enter our traps as they sink to the ocean bottom. Future research is needed to know for sure if this is how the animals entered our traps!

WHAT ARE SEDIMENT TRAPS?

The Amundsen Sea, one of the major seas surrounding Antarctica, is experiencing serious melting of glaciers and **sea ice** due to global warming. As the sea ice melts, small ponds open in the Amundsen Sea for 2–3 months during the summer. This area of open water is called a **polynya** (Figure 1a). When the polynya opens in summer, the region becomes like a green soup, crowded with many organisms that make a lot of carbon-containing particles that sink to the seafloor (Figure 1b). This process by which organisms, especially phytoplankton make carbon-containing particles by using the oxygen and sunlight is called, "primary production". These particles are the main sources of sinking particles. In addition to that, sinking particles are usually combinations of dead organisms, feces (poop), resuspended sediment, dust, and other similar substances. Most particles are very small (smaller than 1 mm). Together, these tiny particles are called **particulate organic carbon** (POC). Particulate organic carbon sinks into the deep ocean and finally ends up in the **sediments**, which are deposits on the floor of the ocean **sediment traps** are widely used to collect sinking particles in the oceans (Figures 2a, b). We attached sediment traps to a line and threw the line into the Amundsen Sea—the traps float underwater, but the weighted lines anchor them in place. Slowly sinking particles are captured inside the sediment traps. After 1–2 years, we revisited the sites and recovered the sediment traps in summer, when the sea ice is melted and it is easier to visit the Antarctic. In this study, our traps were positioned at four locations with different sea-surface conditions: a sea ice-covered area (Station K1), the central Amundsen Sea Polynya (Station K2), near the Dotson Ice Shelf (Station K3), and near the East Getz Ice Shelf (Station K4) (Figure 1a).

SEA ICE

Frozen seawater that floats on the ocean, especially in the Arctic and Antarctic. Sea ice can move by the winds and currents.

POLYNYA

Polynya is an area of water surrounded by sea ice or land. Polynyas can be sustained by winds or ocean heat.

PARTICULATE ORGANIC CARBON

Tiny particles made by marine organisms in the ocean's surface water, such as feces (poop) or dead organisms. These particles slowly sink down into the deep ocean.

SEDIMENTS

All kinds of particles sink and settle on the seafloor. This includes sinking particles made by marine organisms in the ocean's surface water and small parts of rock or sand.

SEDIMENT TRAP

An ice cream cone-shaped device to collect particles sinking to the bottom of the deep ocean.

A COLLECTION OF MYSTERIOUS WORMS

Unexpectedly, at three locations (K1, K3, and K4), deep-sea animals were found in the sediment traps, including long, slender worms, sea urchins, and baby scallops of varying sizes (Figures 2c–e). This was the first reported collection of these deep-sea animals in sediment traps. In the laboratory, we counted the number of animals, including entire bodies and body parts. The lengths and thicknesses of the worms were measured using a ruler and Vernier calipers. The worms were similar in appearance (Figure 2e) and had a rubbery texture. The bodies were round, slender, and <5 mm thick. Five worms were dried, weighed, and finely ground to analyze the carbon content in their bodies.

At Station K3, a total of 33 worms were collected from April–August and in December 2012, and 24 worms were collected in July 2013 alone. Two worms were collected at station K1 in June 2012 and early March 2013. The worms collected at stations K1 and K3 varied in length from 2 to 69 cm (Figure 2e). At Station K4, we found 11 baby scallops,

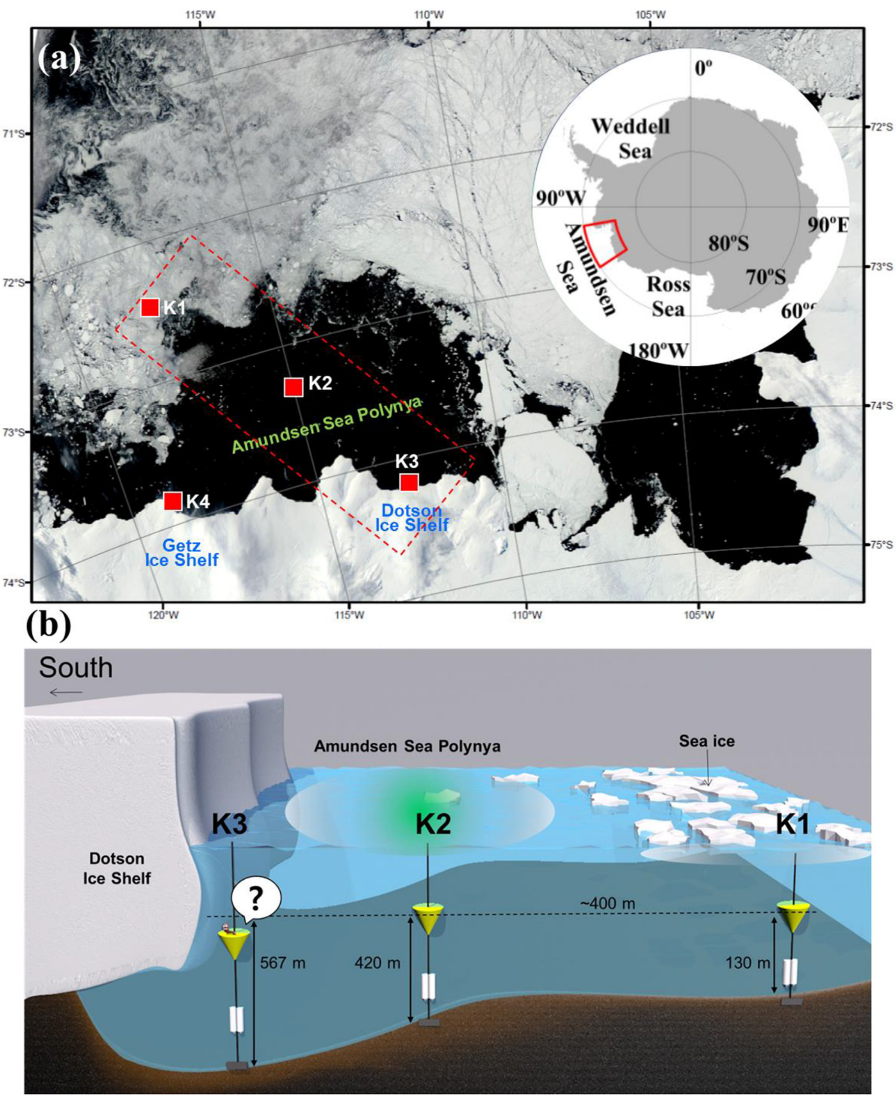

Figure 1

Figure 1

(a) Locations of sediment traps (red squares) in the Amundsen Sea. The satellite image shows the sea ice on February 15, 2012. The black areas in the image are open water (Amundsen Sea polynya) and the white regions are covered by sea ice. **(b)** Showing the locations and depths of the sediment traps in the Amundsen Sea (figure modified from [1]).

1 baby sea urchin, and 12 worms (including seven incomplete bodies). Worms were found between March and September 2016 and from June to July 2017. One scallop was collected from August–September 2017, and 10 from October–November 2017. The scallops were babies and varied in size from 1.2 to 2.8 cm. One baby sea urchin was collected between October and November 2017. No specimens were collected when there was not any sea ice present.

HOW DID THESE ANIMALS GET INTO THE SEDIMENT TRAPS?

The lid of the sediment trap, consisting of mesh with holes about 2.5 cm in diameter would have prevented any larger creatures larger than that diameter from falling into the trap. So, it is puzzling that deep-sea animals that cannot swim were collected in sediment traps

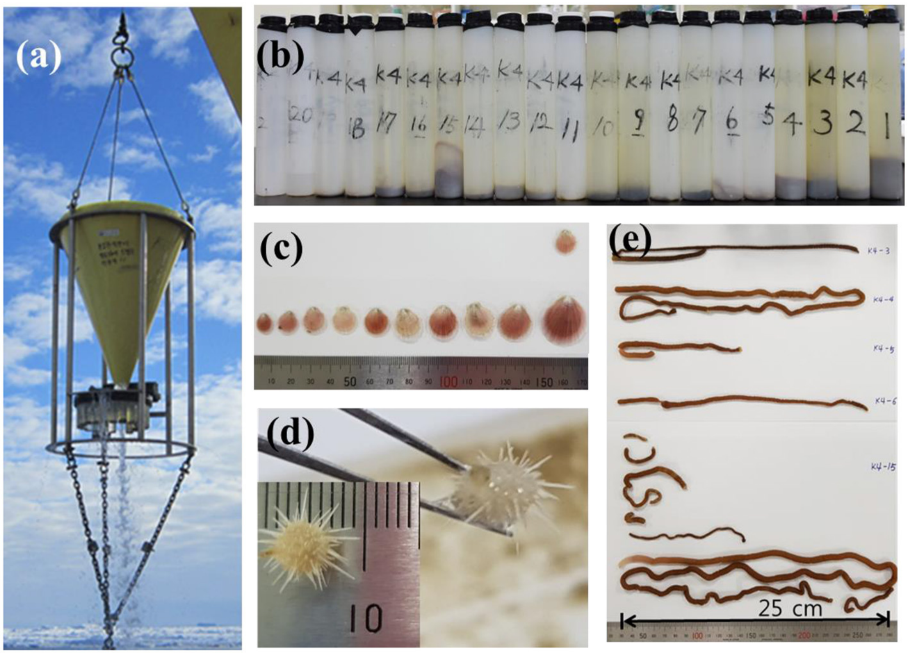

Figure 2

Figure 2

(a) One of the sediment traps we used in the Amundsen Sea. **(b)** Bottles containing the worms found in trap K4. **(c)** Baby scallops, **(d)** a sea urchin, and **(e)** worms collected at Station K4.

ANCHOR ICE

A type of ice that forms usually when the water is supercooled. The ice crystals in the water attach to marine organisms or sediments, like the anchor.

SUPERCOOLED

In cold polar waters, sometimes the water is not frozen even though temperatures drop below the freezing point. This process is called supercooling.

130–567 m above the seafloor. It is unlikely that these animals crawled up the mooring lines and jumped into the traps! Strong ocean currents may have carried these animals to trap sites. Small, light, baby scallops might be particularly affected by strong currents. However, the current was not particularly strong at the time the animals were collected. We think it is possible that the animals were transported in, and released from, sea ice. **Anchor ice**, which forms in **supercooled** water [2], may have gently trapped these animals. Like the "anchor", anchor ice is the attached ice to the bottom. Ocean animals living in the seafloor can be captured by the anchor ice when it forms. Any anchor ice formed on deep-sea animals' bodies would cause them to float, lifting them to the sea ice floating on the ocean surface. The animals could then stick to the sea ice via the anchor ice on their bodies [2]. The sea ice with attached animals moves around following the surface water current. When the attached anchor ice melts, the animals are released from the sea ice and drift back down toward the bottom. In the process, some of them may have been caught in our sediment traps.

ANCHOR ICE IN THE AMUNDSEN SEA?

Studies on anchor ice formation have focused mainly on the Arctic, where anchor ice is the main way that sediment ends up in sea ice and is transported to new areas [3]. In the Antarctic, anchor ice has been reported at several locations, such as the McMurdo Sound in the Ross Sea [2]. Although supercooling may happen in the Amundsen Sea, it has not been reported because no data from this area are available except from the summer, when anchor ice would not form anyway.

However, strong winds, freezing temperatures, and strong turbulence in an open, shallow sea all occur in the Amundsen Sea in winter, and those are the necessary conditions for anchor ice formation [4]. Future research is needed to verify that anchor ice forms in the Amundsen Sea, as such data would support our hypothesis.

WHAT DID WE LEARN AND WHY IS IT IMPORTANT?

The lifting of deep-sea animals to the sea surface by ice is thought to be important for the ocean food web. The role of anchor ice in carrying deep-sea animals far away from the coast has not yet been investigated in Antarctica. The amount of carbon contained within these organisms is about five times larger than the amount of carbon found in the average concentration of particulate organic carbon in ocean water, so these lifted animals may provide energy for other ocean animals during the winter, particularly when there is not enough food. If deep-sea animals can survive being trapped in anchor ice that is attached to the sea ice, this process may serve as a way for animals to spread to distant areas. We have no evidence of whether the animals entered our sediment traps alive or dead, so more research is needed in this area. Overall, this article taught us the impact of anchor ice on Antarctic biology. This information is important for understanding not only the existence and formation of anchor ice in the Amundsen Sea, Antarctica but its role to supply the energy and food to the deep-sea.

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YOUNG REVIEWERS

JULIA, AGE: 11

Julia is a 6th grader student. She is passionate about music and science. Julia plays the drums, the piano, and the bass. She plays in the orchestra and in the jazz band and recently she and her band wrote a song. Julia loves science class and would like to become an F1 engineer.

MUHAMMAD, AGE: 13

The turning point in my curiosity came when I secured first place in my grade 3 Science project. It was about photosynthesis, which I chose after knowing the fact that plants are universal food makers. The Science textbook of every grade always familiarized me about the magical wonders behind my daily life's surroundings.

THEO, AGE: 12

Theo is a 6th grader. His favorite class is science and he would like to be a photographer for National Geographic. Theo plays in a band with his friends and they recently wrote a song. Theo has played a variety of sports and basketball is his favorite.

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I am Minkyoung Kim, assistant professor at Kyungpook National University. As an early career scientist, I am exploring all around the world including the Antarctic and Arctic! My research interest is oceanic carbon cycling. You can find more information about me from my homepage (https://mini3248.wixsite.com/minkyoungkim). *minkyoung@knu.ac.kr

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As a principal research scientist at the Korea Polar Research Institute, I am primarily focused on investigating the circulation patterns of seawater in the Southern Ocean. Specifically, I am dedicated to studying the movement of warm seawater and its influence on melting ice shelves.

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I am a principal research scientist at the Korea Polar Research Institute and an associate professor at University of Science and Technology. My research focuses on the ecology of polar marine life such as zooplankton, fish, and marine mammals, addressing how environmental changes affect their behavior and distribution in polar marine ecosystem.

SANGHOON LEE

I was a chief scientist during the Amundsen Cruise. During the cruise, we investigated the animals in sediment traps. As a principal research scientist at the Korea Polar Research Institute, my research interest is microbial ecology.

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