Elephant seals help uncover slower-than-expected Antarctic melting

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Don't let the hobbling, wobbling, and blubber fool you into thinking elephant seals are merely sluggish sun bathers. In fact, scientists are benefiting from these seals' surprisingly lengthy migrations to determine critical information about Antarctic melting and future sea level rise.

A team of scientists have drilled holes through an Antarctic ice shelf, the Fimbul Ice Shelf, to gather the first direct measurements regarding melting of the shelf's underside. A group of elephant seals, outfitted with sensors that measure salinity, temperature, and depth sensors added fundamental information to the scientists' data set, which led the researchers to conclude that parts of eastern Antarctica are melting at significantly lower rates than current models predict.

"It has been unclear, until now, how much warm deep water rises below the Fimbul Ice shelf, and previous ocean models, focusing on the circulation below the Fimbul Ice Shelf, have predicted temperatures and melt rates that are too high, suggesting a significant mass loss in this region that is actually not taking place as fast as previously thought," said lead author of the study and PhD student at the Norwegian Polar Institute (NPI), Tore Hattermann.

The Fimbul Ice Shelf - located along eastern Antarctica in the Weddell Sea - is the sixth largest of the forty-three ice shelves that dapple Antarctica's perimeter. Both its size and proximity to the Eastern Antarctic Ice Sheet - the largest ice sheet on Earth, which if it melted, could lead to extreme changes in sea level - have made the Fimbul Ice

Shelf an attractive object of study.

The team is the first to provide direct, observational evidence that the Fimbul Ice Shelf is melting from underneath by three, equally important processes. Their results confirm a 20-year-old theory about how ice shelves melt that, until now, was too complex to be further investigated with models that had no direct observations for comparison. These processes likely apply to other areas of Antarctica, primarily the eastern half because of its similar water and wind circulation patterns, Hattermann said.

The scientists report their findings on June 22 in the journal *Geophysical Research Letters*, a publication of the American Geophysical Union.

Using nearly 12 tons of equipment, the scientists drilled three holes of an average depth of 230 meters (820 feet) that were dispersed approximately 50-100 kilometers (31-62 miles) apart along the shelf, which spans an area roughly twice the size of New Jersey. The location of each hole was strategically chosen so that the various pathways by which water moves beneath the ice shelf could be observed.

What the team observed was that during the summer, relatively warm surface waters are pushed beneath the ice shelves by strong wind-driven currents. While this happens, another process transports warm water deeper in the ocean towards the coast and below the ice.

Combining with those effects is a process inherent to the cold ocean waters: The freezing point of water depends on its depth. The deeper the water, the lower its freezing point. Water of a constant temperature will freeze on the surface but remain liquid (or melt, if it was already frozen) at a given depth, like at the bottom of an ice shelf. Therefore, there is a slight but continuous melting of the Fimbul Ice Shelf's undersides due to this physical phenomenon.

To understand the extent to which these three processes interact and melt the ice shelf, scientists needed a detailed record of annual water cycles and circulation around eastern Antarctica. Enter nine male elephant seals that swam 1,600 kilometers (about 1,000 miles) from Bouvet Island (written as Bouvetoya in Norwegian), in the middle of the Southern Ocean, to the outskirts of the Fimbul Ice Shelf.

Hattermann and his team borrowed the "seal data" from biologists of the Norwegian Polar Institute, who originally gathered the data during their Marine Mammal Exploration of the Oceans Pole to Pole (MEOP) research project, part of the International Polar Year program.

"Nobody was expecting that the MEOP seals from Bouvetoya would swim straight to the Antarctic and stay along the Fimbul Ice Shelf for the entire winter," Hattermann said. "But, this behavior certainly provided an impressive and unique data set."

For nine consecutive months, the sensors atop the seals' heads read the temperature and salinity of the waters along the outskirts of the Fimbul Ice Shelf and recorded their changes over time. To collect the same amount of continuous data from a ship would not only incur far greater cost but would be almost impossible during the winter months due to dangerous ice buildup.

From the "seal data", the scientists accumulated enough knowledge concerning the area's water circulation and how it changes over the seasons to construct the most complete picture of what and how the Fimbul Ice Shelf is melting from the bottom up.

It turns out that past studies, which were based on computer models without any direct data for comparison or guidance, overestimate the water temperatures and extent of melting beneath the Fimbul Ice Shelf. This has led to the misconception, Hattermann said, that the ice shelf is losing mass at a faster rate than it is gaining mass, leading to an overall loss of mass. The model results were in contrast to the available data from satellite observations, which are supported by the new measurements.

The team's results show that water temperatures are far lower than computer models predicted, which means that the Fimbul Ice Shelf is melting at a slower rate. Perhaps indicating that the shelf is neither losing nor gaining mass at the moment because ice buildup from snowfall has kept up with the rate of mass loss, Hattermann said.

"Our data shows what needs to be included in the next generation models, in order to be able to do a good job in predicting future melt rates," Hattermann said.

Because wind patterns and water cycles are similar for large parts of eastern Antarctica, Hattermann said, his team's results could help predict the next time when a section of the Fimbul Ice Shelf, or other ice shelves along the eastern coast of Antarctica, may break off. Because ice shelves are already submerged, their melting does not directly influence sea level rise. However, the rate that ice shelves are melting is still crucial to this issue, he said.

"Ice shelves act as a mechanical barrier for the grounded inland ice that continuously moves from higher elevation towards the coast," Hattermann said. "Once an ice shelf is removed, this ice flow may speed up, which then increases the loss of grounded ice, causing the sea level rise."

More information: "Elephant seals help uncover slower-than-expected Antarctic melting" *Geophysical Research Letters*.

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