Like many other glaciated areas worldwide, the Greenland ice sheet is losing mass, and this loss is contributing to sea-level rise.

Evgeny A. Podolskiy and other scientists have studied Bowdoin Glacier in Greenland to understand changes in its calving behaviour.

Underwater thunder in Greenland

WHAT THE SOUNDS OF ICEBERG CALVING CAN TELL US

Researchers are trying to better understand the impacts of accelerating ice-mass loss on the Arctic and global environment. As **EVGENY A. PODOLSKIY** explains, monitoring iceberg calving is an essential part of this work. Recordings of the sounds of calving are yielding insights into ice dynamics and posing questions about how Arctic wildlife cope with all this sound.

WHEN YOU'RE TRYING to drop an underwater microphone next to the calving front of an ocean-terminating glacier, you have to be ready to move quickly. No one can predict when the calving might occur, but when it does, it can trigger a massive "tsunami" wave. This hazard is common in cold regions, and many explorers have faced it, including Charles Darwin, who almost lost the boat he needed for his return to the *Beagle*.

Like many other glaciated areas worldwide, the Greenland ice sheet is losing mass, and this loss is contributing to sea-level rise. This is happening not only because of intensified melting, but also due to the mechanical loss of ice from more than 200 outlet glaciers—valley glaciers that originate in ice sheets, ice caps and ice fields. Such losses, known as calving, are caused by the formation of crevasses and the collapse of icebergs into the sea.

Even though iceberg calving takes place in remote areas, Inuit are familiar with it and take it seriously. For example, in our research area in northwest Greenland, local Inuit will rush to protect their boats if they hear rumbling from massive glaciers several kilometres away. From experience, they know that destructive ocean waves may arrive minutes later.

Melting and mechanical loss of ice from more than 200 outlet glaciers in Greenland is diminishing the Greenland ice sheet and contributing to sea-level rise.

Photo: Evgeny Podolskiy

LISTENING IN TO THE SOUNDS BELOW

The dramatic calving process, which can involve cubic kilometres of ice, generates sound waves in the air, in solid earth and underwater. This means scientists can use microphones, seismometers and hydrophones to obtain valuable information, including the estimated sizes of calved icebergs. This research is still in its infancy, given that it has been going on for just 15 years. But as a scientist, I find calving sounds to be a fascinating acoustic phenomenon.

Sound waves can propagate for thousands of kilometres underwater. Still, it's important to be as close to the source as possible to record clear sound. Otherwise, the ocean can distort and filter the original sound through reflections, refractions, scattering and absorption.

This means that to record calving sounds effectively, we need to get dangerously close. We drop our instruments to the bottom of a glacier fjord a few hundred metres deep—and flee. Weeks or months later, we summon our instruments to the surface using an acoustic command. Later, on a computer, we can explore an underwater cacophony of sounds composed of characteristic iceberg booms, degassing icebergs, boats and marine mammals.

A MEMORABLE SOUND EXPERIENCE

I was particularly surprised on one occasion by recorded calving sounds that lasted almost half an hour and were so loud that colleagues from neighbouring laboratories and floors thought an earthquake was happening as I replayed it.

There are two main types of calving events: "small" (where the calved ice is less than 100,000 cubic metres in volume) and "large" (where the volume can reach a few cubic kilometres). The former events usually involve ice falling from a high ice cliff into the water. This causes cavitation—the collapse of a large air pocket formed by plunging ice—and generates a particular type of sound. The latter events involve the full-depth calving of gravitationally unstable icebergs that capsize after detachment and smash into the newly formed ice cliff hard enough to generate seismic waves that can be detected thousands of kilometres away. This is happening more frequently now because of climate change.

Our analysis of the sound of a large calving suggested that glaciers can generate the loudest underwater sounds in the entire Arctic Ocean. This volume places calving in Greenland in the same category as the most powerful natural sounds possible in the ocean after undersea volcanic eruptions and earthquakes.

EFFECTS ON WILDLIFE

Earlier studies reported that disintegrating tabular icebergs near Antarctica were also extremely loud and could be "heard" thousands of kilometres away, equivalent to noise from more than 200 supertankers. Yet no one wondered how such a powerful sound might affect animals in the region.

For example, in summer, seals and narwhal may stay close to the calving fronts of Greenlandic glaciers. To estimate the risk of auditory injury to them, we analyzed the sound of calving using recognized technical guidance from the US National Marine Fisheries Service. To our surprise, we found that calving likely does have detrimental effects on the hearing of marine mammals who live close to the calving front.

We still don't know how animals respond to calving sounds. For now, we can only conclude that the risk of hearing loss must be a worthy trade-off for the benefits of remaining in what seem to be some of the noisiest places in the ocean. ●

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