The Scientist Who Stays Out in the Cold

by Lonny Lippsett

Sarah Das, WHOI

Alison Criscitiello

Spending a month working in subzero conditions in Antarctica might not sound like fun to most people, but to Alison Criscitiello, it's heaven.

"I definitely have a thing for cold places," said Criscitiello, a graduate student in the MIT/WHOI Joint Program. "I love being cold. I *love* it."

Her love of cold places has led her to the summits of many high, ice-covered mountains. An accomplished climber, she has worked as a National Park Service climbing ranger and a mountain guide for a private company. In 2010 she led two friends on the first all-women climb of Pinnacle Peak, a 6,930-meter (22,736-foot) mountain in the Himalayas. So it was only natural that the focus of her research would be someplace cold: the massive West Antarctic Ice Sheet.

Scientists have concerns that warming ocean temperatures are accelerating the flow of ice from the continental ice sheet into the ocean, which could raise global sea levels. In the Amundsen Sea coastal region where Criscitiello works, winds are driving warming deep-ocean waters onto the continental shelf and beneath the ice shelves extending from glaciers into the ocean. Melting from below, the glacial fronts are breaking up more easily, draining more ice into the Amundsen Sea.

In Criscitiello's study area, two large outlet glaciers emptying into Pine Island Bay—the Pine Island and Thwaites Glaciers—have been accelerating and losing mass over the past 25 years. During the same time, sea ice that forms in the Amundsen Sea has declined significantly. Criscitiello is exploring the relationship between the two phenomena, as well as another factor that may be playing an important role: polynyas.

Polynyas, a Russian word meaning "natural ice holes," are patches of open ocean surrounded by sea ice. They form

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when warmer waters upwell to the surface, or when ocean currents or winds traveling offshore push sea ice away from the coast, leaving ice-free areas.

Polynyas can have big impacts on local climate and on the generation of sea ice in winter. The areas of open water allow heat exchange between the ocean and atmosphere. They also affect ocean circulation.

Frozen clues

How do polynyas, sea ice, and ice sheets weave together? And can we find new ways of extending records of their behavior in the past so that we can understand their interplay on longer time scales? To answer those questions, scientists need to see the full tapestry, and therein lies the problem.

"Satellite images have captured sea-ice behavior around Antarctica over the past 20 years, but before that, we really have very little idea what sea ice looked like," Criscitiello said.

To put sea-ice changes into context, Criscitiello is trying to reconstruct the history of sea ice off West Antarctica—a history that may be recorded within layers of the ice sheet itself.

"In the austral spring and summer when sea ice breaks up, it is the first time that year that the upper part of the ocean sees sunlight," she explained. "All the little plants of the sea—the phytoplankton—bloom, and they release a chemical that eventually becomes methanesulfonic acid, or MSA, into the atmosphere. This MSA is carried by the wind over the ice sheet and precipitated as snow. So year after year, bloom after bloom, and snowfall after snowfall, the MSA gets laid down in layers on the ice sheet."

The less sea ice, the more open water there is, the bigger the phytoplankton bloom, and the more MSA produced. Even with limited sunlight in wintertime, phytoplankton can still bloom in polynyas and release the chemical that becomes MSA and ends up in the ice-sheet layers, Criscitiello said. "So MSA may be an indirect recorder of sea-ice and polynya variability off the coast."

"The way to extract this record from the ice sheet is to drill or dig," she said. "We hand-dig snow pits about 10 feet deep. To get samples from further back in time, we use a mechanized ice-core drill."

The ice cores, up to 377 feet deep, represent about 200 years of ice accumulation. Criscitiello cuts the cores into narrow slices corresponding to specific periods of time and measures the concentrations of MSA in each slice.

Uncertain terrains

When she started her research, Criscitiello did not know whether all her hard work would lead to a dead end. Scientists trying the MSA method elsewhere have had mixed results; MSA preserves a reliable record of sea-ice behavior in some places, but not in others, probably because of differences in local wind and precipitation patterns throughout the year, among other factors. Thus, scientists must validate MSA ice-core records from any new site to ensure that they tell a reliable story about sea ice in a particular location.

"It was possible that this method was not going to work here," she said. But she went after it—just as she and her friends had in 2010 when they reached their final ascent of Pinnacle Peak at 18,000 feet. They faced a choice between a nearly vertical ice wall and a route where an avalanche appeared likely.

"The three of us sat there beneath this nearly vertical ice face knowing it was the only way we could go up," she said. "It was the first time I ever had the thought: 'Oh no, maybe I'm in over my head.' " It took two difficult days but they made it to the summit, high above a sea of clouds.

Back in Antarctica, the story told by the MSA concentrations in Criscitiello's ice-sheet records has bolstered her confidence that ice-core records from this dynamic region may provide a reliable proxy for reconstructing how sea ice and polynyas in the Amundsen Sea and Pine Island Bay have varied in the era before satellites.

"Sometimes you have to just try things," she said, "even though you have no idea what the outcome is going to be."

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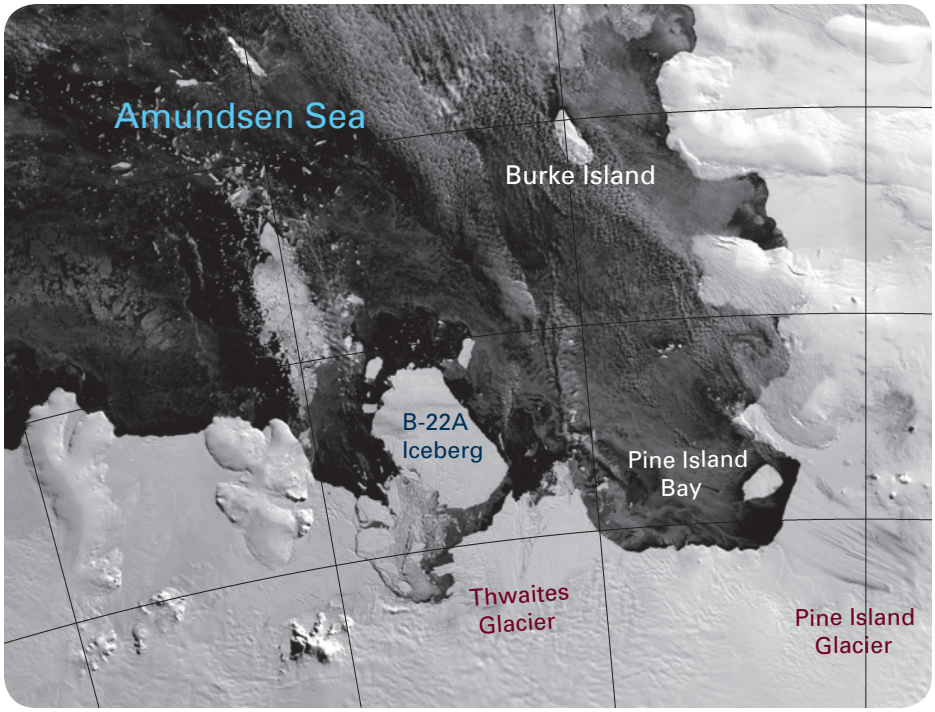

Image/photo courtesy of the National Snow and Ice Data Center, University of Colorado, Boulder

In the Amundsen Sea coastal region, warming seawater is being driven beneath ice shelves extending from glaciers into the bay. Melting from below, the fronts of glaciers are weakening. In the past 25 years, two large outlet glaciers emptying into Pine Island Bay—the Pine Island and Thwaites Glaciers—have been flowing faster and losing more ice to the ocean.

Alison Criscitiello removes the inner barrel of a drill containing an ice core from the West Antarctic Ice Sheet. Snow falls atop the ice sheet in annual layers, so the deeper you drill, the further back in time you go. The graduate student is analyzing a chemical compound in the ice to reconstruct how sea ice has changed over hundreds of years in the Pine Island Bay region.