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Above, scientist Bruce Elder, of the Cold Regions Research and Engineering Lab, and colleagues measure the thickness of the ice through a newly formed crack.
(Courtesy CRREL)

An Icy Dance

In theArctic

CRREL Team Studies Impact

Of Wind on a Frozen World

By Kristen Fountain

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Out on the ice floes off the northern Alaska coastline, polar bears feed on seals and arctic foxes scavenge in the snow for what they left behind. But for three Upper Valley scientists and a Hartford High School teacher who spent two weeks last month in the Beaufort Sea 200 miles north of Prudhoe Bay, the most active creature they observed was the ice itself.

Minute by minute during their visit, the ice slowly slid and heaved. It changed shape in spurts of inexorable activity while they placed instruments and took measurements, buzzed in and out of camp on snowmobiles, ate meals and slept.

“These ridges would form overnight,” said Cathy Geiger, a polar scientist and engineer who lives in Hartford and studies sea ice at the Army Corps of Engineers Cold Regions Research and Engineering Laboratory in Hanover. It was a new experience for her to see the same ice day after day from ground level, she said. On previous trips to the Arctic, she traveled between floes on icebreaker research ships.

Ridges are jumbled piles of ice blocks and stiff shapeless mounds. They appear where a crack in the ice forms and then widens into a channel of steaming blue water as the plains of ice on either side move apart.

Some breaks remain open. Others widen further into a large expanse. Then, in some cases, the ice reverses direction and within days, even hours, the opening closes again, a powerful collision that occurs at a creep. At the seam, a new ridge forms that can be forced up as high as a hedgerow or fortress wall and down into the water as deep as 50 feet.

All this activity is anything but silent. As it split and compressed all around the scientists, the ice field groaned and squeaked. It clicked and growled and crunched. They were small noises but they demanded attention, like the sound of rummaging elbow-deep through Styrofoam peanuts or “fingernails on a blackboard,” Geiger wrote in her journal on April 11.

By then, midway through their last week, the team, an international group of around 35 scientists, was cheerful. They had several days of great weather -- blue skies and daytime highs of balmy minus-4 degrees. (Temperatures while they were there dropped as low as minus-30 or more.) There was no question that they would get the data they set out to record.

Geiger was joined in camp by two ice camp veterans from CRREL, Jackie Richter-Menge and Bruce Elder, as well as by Richard Harris, who teaches sophomore biology at Hartford High School. Harris was there as part of the PolarTREC program, funded by the National Science Foundation, which supports high school teachers taking part in polar research to increase interest in the work among students. The rest of the group included researchers and graduate students from Alaska, Germany, England and Iceland.

That information they were all after would show how winds and ocean currents affect the movement and shape of the ice, which will eventually help other scientists track the impact of anticipated global warming on the Arctic, a region seen by many as a bellwether for the rest of the world.

The push and pull of winds above the ice and currents below is only partly responsible for the polar landscape's changing topography. As the air and ocean warm, the ice floes thin and shrink. In the cold, they thicken and expand.

Thick ice is white and reflects the sun's rays, while thinner ice and the dark ocean absorb them as heat. Called the “albedo effect,” this phenomenon makes the Arctic and Antarctic especially vulnerable to climate change. It also means that what happens in the polar regions has an oversized impact on what occurs elsewhere, according to computer models designed to predict the future climate.

Getting a better handle on how winds and currents lead to changes in ice thickness “takes care of a part of the puzzle,” said Richter-Menge of Hanover, a scientist at CRREL for over 25 years and veteran of almost a dozen ice camps. “Then you can concentrate more on the temperature effect and see it better.”

Climate Change

Improving climate prediction is much of what motivated the National Science Foundation to pay the approximately $1 million it takes to shelter and feed 35 people for two weeks on Arctic ice. But the intricacies of computer models are a world away from drilling holes and dragging heavy machinery across the snow, let alone the day-to-day running of the ice camp.

Richter-Menge and Geiger, along with Jenny Hutchings, a professor at the University of Alaska-Fairbanks and chief scientist on the trip, planned and coordinated the research activity. The foundation awarded them an additional $1.5 million to pay for the entire three-year project -- from planning the field season to writing research papers based on the information they collect. The three women celebrated the all-female leadership, unusual in their field, by calling their project the Sea-Ice Experiment: Dynamic Nature of the Arctic, or SEDNA, an acronym that is also the name of an Inuit sea goddess.

The most complex logistics surrounded laying out and following a plan to measure the same region of ice over and over again with a half dozen different pieces of equipment that operate at very different scales. The team used every technology available for measuring ice thickness -- from sonar, radar and satellite images to the old-fashioned ice auger and tape measure.

“It was an incredibly focused effort to coordinate all these different types of instruments,” said Richter-Menge. The measurements had to overlap so the group could compare the results and test the accuracy and efficiency of each technique. “The helicopters (carrying one instrument) flew the exact lines that we had walked (using hand-held devices),” she said.

In measuring ice thickness, there is a trade-off between getting exact results and results that can help answer the broader climate questions, scientists said.

No automatic measuring device will likely ever improve on simply drilling a hole and sending the tape down, said Elder, who lives in Plainfield. (Scientists at CRREL perfected the tape measure technique more than 30 years ago by fitting the tape with a metal spring that latches onto the bottom edge of the ice.) But it would take far too much time to study the entire Arctic ice sheet that way.

On the other end of the scale are satellite images, which clearly illustrate how much of the Arctic Ocean the ice covers and how that changes over time. But they are likely a decade away from being able show ice thickness well, Richter-Menge said. Sonar mounted on submarines also can cover a large region. But sonar waves cannot penetrate the ice, which means all the submarine can see is what is underwater.

The experiment planned by Richter-Menge, Hutchings and Geiger, who has a joint appointment at CRREL and at the University of Delaware, allows scientists to link data gathered by the different instruments and better interpret the results from each. But it hasn't been done for a decade in the Arctic because of the expense.

During that time, new kinds of measuring devices have been developed, some of them by engineers in the Upper Valley at CRREL and the Lebanon-based engineering firm Geokon Inc. Two types of machines are now strapped to long tubular structures planted in the ice at regular distances around the ice camp. One measures the stress that the ice is undergoing, while the other uses a novel method to measure ice depth. Scientists hope the machines will continue to collect information and send it data back to them for several months to come.

However, at the center of the high-tech equipment is the most basic measurement, which ties all the other results to reality on the ice. “We were the only group that measured the ice with a tape measure,” said Elder, who has participated in four previous ice camps, about the CRREL scientists. “We are the baseline.”

It is the by-hand work that Robert Harris, a sophomore biology teacher at Hartford High, remembers best. In cold 20-mile-per-hour winds, he and Geiger paced out several of the six .6 mile (1 km) lines that all the instruments would follow. They struggled to place the colored flags that would mark 25-meter increments along the line. With every gust, a flag would spin from their hands and send them crawling after it.

Helping out in the field was important to him, said Harris. His primary role was educational outreach to students from Hartford and across the country who followed the team's research via the Internet on the Web site, www.polartrec.com, that he connected to in camp by satellite link-up, and Web-phone conference calls. But he had traveled the Beaufort Sea by icebreaker as a graduate student in the late 1970s, and did not want to be just an extra body in camp.

“This was an opportunity to go back and do field science,” said Harris. “To be out on the ice one last time."

The shapes and forms of the ice, its designs and patterns were as weird and wonderful as he remembered, he said. If you stop and look closely, said Harris, you see things you never noticed before.

The team was able to do just that during the last days as work was wrapping up, touring ridges and cracks they had named and gotten to know like enthusiastic tourists taking a last look at their favorite sites. It wasn't hard to understand why polar scientists who do field work call themselves cryonauts.

"It's as close as you are going to get to outer space on Earth," Geiger said.

Wind, Sea and Ice

The Beaufort Sea ice camp is already gone, taken down soon after the scientists left in mid-April, before the ice became too unstable. By the time they flew out on April 14 and 15, a large crack had already shortened the runway by 200 feet.

The camp, and the research, would not have occurred if not for the U.S. Navy, which had built the village of insulated plywood living spaces in early March for its own use. After staff involved in classified submarine navigational exercises had departed, the service decommissioned the site so that civilian scientists could use it.

Even though it was not built for them, the timing of the camp was perfect for the research that Richter-Menge, Geiger and Elder hoped to do. In spring, the ice has thickened and grown as much as it is going to from cold and has not yet begun melting. "If (the ice thickness) changes, it's going to change because of wind force," Richter-Menge said.

Built at the boundary of new ice just formed over the winter, and older ice that had survived the previous summer and thickened even further over the past year, its location also worked well. It gave them the chance to study the effect of wind on older ice and ice that is thinner and more elastic.

Over the past two decades, that boundary moved farther toward the pole as more of the older ice melted off during the summer. A recent scientific update on from the International Panel on Climate Change stated that between the summer of 1979 and 2005, the Arctic lost almost 20 percent of its perennial ice area, an area almost equal to the United States east of the Mississippi River. Although accurate, long-term thickness measurements are harder to come by, scientists estimate that in the Beaufort Sea the ice was on average around 6 feet thick in the summertime and now is closer to 3 feet.

"We have this information because we've been able to track ice motion with a network of buoys," said John Walsh, of the International Arctic Research Center at the University of Alaska-Fairbanks at a meeting at Dartmouth College in March that marked the beginning of the International Polar Year. But much more is needed, he said.

Arctic ice is currently disappearing faster than the best computer models predict that it should. The models seem to be missing important factors, said James White, of the Institute for Alpine and Arctic research at the University of Colorado, another scientists who lectured at the conference. “Ice is a very non-linear creature, particularly as it melts,” White said.

Part of the goal of the SEDNA project is to improve those measurements so scientists can keep close watch on the ice in the coming decades. They envision an Arctic Observing Network, an array of so-called “buoys,” measuring devices fixed in the ice linked with satellites that send them the data they need.

More information about the role of winds and ocean currents in the behavior of ice will help make computer models that project future ice conditions in the Arctic more realistic, Richter-Menge said. And knowing the capabilities of various instruments will inform scientists' recommendations for what is needed in the observing network, said Geiger. “You need know the range of cost versus return,” she said.

Getting the network up and running is essential for advancing climate science, said Walsh. “The monitoring network is going to be a key part of getting an explanation of what is going on.”

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