Under Polar Sea Ice, A Spectacular Bloom

Melting sea ice forms pools of water that act like skylights, allowing algae to bloom beneath the ice.

Scientists have discovered a massive bloom of phytoplankton beneath ice-covered Arctic waters. Until now, sea ice was thought to block sunlight and limit the growth of microscopic marine plants living under the ice.

The abundance of phytoplankton growing in this under-ice bloom was four times greater than in neighboring ice-free waters. The bloom extended laterally more than 100 kilometers (62 miles) underneath the ice pack, where ocean and ice physics combined to create a phenomenon that scientists had never seen before.

Reporting in the June 8, 2012, edition of the journal *Science*, a multi-institutional team of scientists concluded that ice melting in summer forms pools of water atop the ice that act like skylights and magnifying lenses. These pools focused sunlight through the ice and into the waters below.

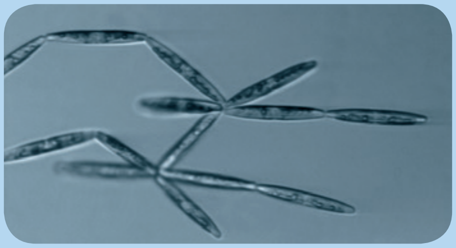
The largest part of the bloom occurred far away from the ice-free open ocean. It happened under thick ice north of Alaska and close to the continental shelf break, where the shallow seafloor plunges steeply into deeper water. There, currents steer nutrient-rich waters from the depths up toward the surface. This convergence of light and nutrients provided all the ingredients for phytoplankton under the ice to thrive.

"Way more production is happening under the ice than we previously thought, in a manner that's very different than we expected," said Sam Laney, a biologist from Woods Hole Oceanographic Institution (WHOI). Just as a rainstorm in the desert can cause the landscape to explode with wildflowers, events that happen on very short timescales, like the pooling of meltwater atop sea ice, can have major effects on the Arctic ecosystem. "If you don't catch these ephemeral events, you're missing a big part of the picture," he said.

Laney was part of the team that made the unexpected discovery on a 2011 expedition led by chief scientist Kevin Arrigo of Stanford University aboard the U.S. Coast Guard icebreaker *Healy*. It was part of the NASA-funded ICESCAPE program to investigate the impact of climate change in the polar Chukchi and Beaufort Seas.

"If someone had asked me before the expedition whether we would see under-ice blooms, I would have told them it was impossible," Arrigo said. "This discovery was a complete surprise."

The scientists found themselves in the right place at the right time in early July of 2011, as the *Healy* made its way above the



Images courtesy of Sam Laney

Arctic Circle and into year-old ice. Atop the meter-thick ice, pools of sky-blue meltwater were accumulating as the Arctic summer progressed.

The scientific party expected that, as in years past, the waters beneath the ice would have minimal amounts of chlorophyll, the fluorescent compound found in photosynthetic marine plants. Instead, they observed the opposite: As the ship broke further into the ice, chlorophyll in the dark waters below shot up to levels rarely seen even in the most productive ocean regions. It became evident that there was a phytoplankton bloom of astonishing magnitude happening under the ice.

Measurements of the light field under the ice showed that four times as much light penetrated ice covered with meltwater ponds than ice covered with snow. "Although the under-ice light field was less intense than in ice-free waters, it was sufficient to support the blooms of under-ice phytoplankton, which grew twice as fast at low light as their open-ocean counterparts," the scientists wrote in *Science*.

Another member of the ICESCAPE team, WHOI physical oceanographer Bob Pickart, showed that easterly winds churned out by monster storm systems along the Aleutian Islands can reverse the current along the shelf break. The change in circulation drives cold, nutrient-rich water up from the abyss and refreshes the supply of nutrients available to phytoplankton growing near the surface.

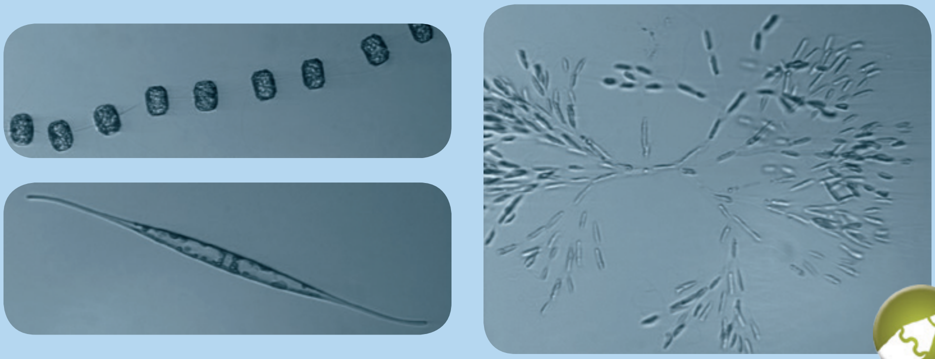
"Without a doubt, the bloom was enhanced at the shelf break," Pickart said. As the meltwater pools introduced light through the ice, phytoplankton in shelfbreak waters likely experienced ideal growing conditions.

What types of organisms participated in the bloom? Laney caught them on camera with the Imaging FlowCytobot, an automated microscope imaging system that was specially adapted by Laney and WHOI biologist Rob Olson for use on the *Healy*.

Since their return, Laney and MIT/WHOI Joint Program graduate student Emily Brownlee have been working with WHOI biologist Heidi Sosik, who developed the original Imaging FlowCytobot system with Olson. They are sorting through and classifying organisms in the millions of images collected by the instrument in an effort to unravel intricacies of the under-ice ecosystem.

Finding the bloom "was very serendipitous," Pickart said. But the region is so harsh and remote that it remains largely unexplored and wide-open for surprising discoveries.

—*Elizabeth Halliday*



WHOI biologist Sam Laney used an automated underwater microscope imaging system to collect images of a wide variety of phytoplankton growing beneath the ice.

Watch the Slideshow:
www.whoi.edu/oceanus/feature/arctic-bloom

Photo by Chris Linder, WHOI