Breakup of the Ward Hunt Ice Shelf

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Title graphic image credits: Warwick Vincent, Université Laval (left) Vicki Sahanatien, Parks Canada (center) Mueller et al. 2003 (right)

In the summer of 2002, graduate student Derek Mueller made an unwelcome discovery: the biggest ice shelf in the Arctic was breaking apart. The bad news didn't stop there. Lying along the northern coast of Ellesmere Island in northern Canada, the Ward Hunt Ice Shelf had dammed an epishelf lake, a body of freshwater that floats on denser ocean water. This epishelf lake, located in Disraeli Fiord, was host to a rare ecosystem, and it was the largest and best-understood epishelf lake in the Northern Hemisphere. When the Ward Hunt Ice Shelf fractured, the epishelf lake suddenly drained out of Disraeli Fiord, spilling more than 3 billion cubic meters of fresh water into the Arctic Ocean.

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Mueller and his graduate advisor Warwick Vincent, both of Laval University in Quebec City, realized something unusual was happening to the ice shelf when they found unexpected fractures while doing fieldwork on the ice and during helicopter overflights. They contacted geophysics professor Martin Jeffries at the University of Alaska Fairbanks. Fortunately, Jeffries had planned ahead.

"Knowing that Derek and Warwick would be doing fieldwork, I'd already placed data acquisition requests with the Canadian Space Agency through the Alaska Satellite Facility DAAC," Jeffries said. Jeffries requested data from the agency's RADARSAT-1 satellite. Equipped with a Synthetic Aperture Radar (SAR) sensor, RADARSAT-1 can acquire imagery in almost any kind of weather, with or without sunlight. "I had almost real-time RADARSAT data on my computer in a very short time, and I could confirm Derek's observation."

In their final flight over the Ward Hunt Ice Shelf on August 11, 2002, Mueller and his party learned something else: new icebergs had just calved from the front of the ice shelf. Using the RADARSAT data again, Jeffries confirmed that the icebergs had calved sometime between August 6 and August 11, 2002. "We made an almost real-time detection through a combination of field observations and RADARSAT data," he explained.

This Canadian RADARSAT image, acquired in August 2002, shows the central crack in the Ward Hunt Ice Shelf running down the center of the image. (Image courtesy of the Alaska Satellite Facility, Geophysical Institute, University of Alaska Fairbanks)

Additional images of the Ward Hunt Ice Shelf are available in News and Natural Hazards.

By September 2002, the Ward Hunt Ice Shelf had split several times. By looking at historical RADARSAT data, Mueller, Vincent, and Jeffries determined that the ice shelf actually began to crack as early as April 2000, culminating a century-long decline in the shelf's extent. Though the Ward Hunt is very small compared to Antarctic ice shelves, its breakup and the resulting drainage from Disraeli Fiord concerned the researchers for several reasons.

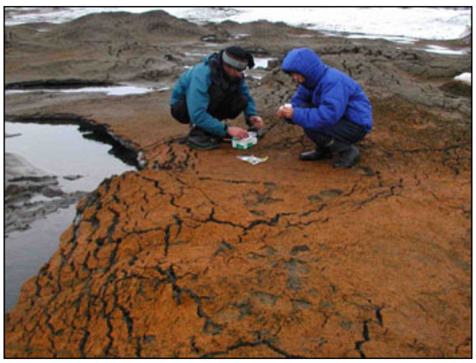
When the Ward Hunt Ice Shelf originally formed, it blocked the mouth of Disraeli Fiord, cutting it off from the Arctic Ocean. In the process, the ice shelf trapped driftwood inside the epishelf lake and kept other pieces of driftwood from entering. Pieces of driftwood found along the shores of Disraeli Fiord have been there since the ice shelf formed, and by radiocarbon dating the wood, researchers have been able to estimate the minimum age of the ice shelf. "There simply are no radiocarbon dates more recent than 3,000 years before present," said Jeffries. This ice shelf, in existence for at least three millennia, has now encountered conditions it can no longer survive.

In just the last century, scientists have discovered dramatic changes in the Ward Hunt Ice Shelf. Changes became apparent in the 1950s when ice-shelf investigators examined early 20th-century records of Arctic explorer Robert Peary. "It was already clear there was a vast region — much greater than today — of thick, ancient ice floating on the ocean. We estimate that this ice has now retreated by about 90 percent relative to Peary's observations," said Vincent.

Drainage of the epishelf lake worries Jeffries and Vincent as much as the loss of the ice shelf. Although the fresh water in Disraeli Fiord floated on top of denser salt water, a small amount continually flowed out of the fiord under the ice shelf. Because the Ward Hunt Ice Shelf is not fed by glaciers, its existence depends on snow and ice accumulation on top and freshwater freezing on the bottom. "Some of our earlier studies indicated that the most likely source of freshwater freezing was water flowing out of Disraeli Fiord," Jeffries explained. "The freshwater freezing was important because it was happening at the same time that ice was melting off the top, but now that source of fresh water is gone." Without the freshwater freezing on the bottom of the ice shelf, Jeffries fears that the shelf may start to thin, or thin at a faster rate.

The Ward Hunt Ice Shelf breakup comes at the same time as news of unprecedented melting of sea ice in the Northern Hemisphere. “Sea ice cover has been shrinking about 3 percent per decade over the past few decades. We saw a record minimum in September 2002, and the summer of 2003 almost set a new record,” said Mark Serreze, a research scientist at the National Snow and Ice Data Center in Boulder, Colorado.

Loss of sea ice can have major implications for global climate. Because of its light appearance, sea ice reflects most of the Sun’s energy back into space, whereas darker seawater absorbs most of the incoming radiation and could potentially warm Earth’s climate. As sea ice continues to melt, more radiation will be absorbed by the ocean.



Scientists study a luxuriant microbial mat on the Markham Ice Shelf, one of the last remaining ice ecosystems on the northern coast of Ellesmere Island. (Image courtesy of Warwick Vincent, Université Laval)

Biodiversity loss concerns Vincent as much as potential climate change. Both the ice shelf and the epishelf lake it dammed hosted uncommon microenvironments. “As you fly over in a helicopter, you see these beautiful Mediterranean-blue lakes on the ice. Within these lakes are remarkable microbial communities. A lot of them are bright orange because they’re rich in carotenoids, a pigment that protects them from UV radiation. They look like alien life forms, but they’re actually micro-worlds of bacteria, and microscopic plants and animals. As we’re losing sections of the ice, we’re losing portions of these communities,” he said.

Another type of community also disappeared with the epishelf lake. Disraeli Fiord’s combination of fresh, brackish, and salt water created a rare ecosystem of cold-adapted, salt-tolerant organisms. According to Vincent, further research on the epishelf lake’s microbial community might have discovered brand new species. “Unfortunately, we didn’t have enough time for the molecular techniques needed to identify new species,” he said.

Beyond improving knowledge of modern biodiversity, polar communities may help scientists understand Earth’s past. A hypothesis that has gradually developed since the 1960s postulates that between 800 and 600 million years ago, the Earth underwent a series of global glaciations, a time nicknamed the Neoproterozoic “Snowball Earth.” It was after this period of worldwide freezing that multicellular life forms began leaving a rich fossil record. “One of the arguments against the Snowball Earth hypothesis is that life might not have survived the massive freeze-ups,” said Vincent. “But those of us working in the polar regions see incredible opportunities for life in surprising places.”

One of the oldest fossils of multicelluar oganisms is *Dickinsonia*. Estimated at 560 million years old, *Dickinsonia* may have evolved after the end of the last Neoproterozoic global glaciation. (Image Copyright © University of California Museum of Paleontology, 1994-2004. All rights reserved.)

Unfortunately, researchers may not get the chance to test their hypotheses by examining modern life forms. "We're really running out of time to understand these unique environments and their biota before they disappear," Vincent said.

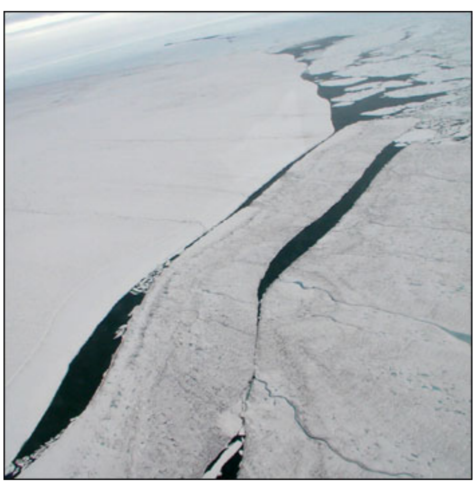
Understanding the impact of declining sea ice on marine wildlife may be easier to assess, though the news is not encouraging. Microbial ecosystems in sea ice comprise the base of much of the food chain in the Arctic Ocean. Directly or indirectly, zooplankton, fish, whales, seals, and polar bears depend on the energy provided by those microbial ecosystems. "In western Hudson Bay, satellite data reveal a significant change in sea ice cover, and we know from studies by the Canadian Wildlife Service that polar bears have been adversely affected by changes in their habitat that limit their access to seals," said Jeffries.

Some paleontologists suspect that the extreme conditions of the Snowball Earth may have jump-started evolution, ultimately giving rise to complex organs like this calcite-crystal eye of the trilobite *Phacops*. (Image courtesy of An Enlightened View of Calcite in the Ocean with MODIS from the GES Earth Sciences DAAC)

Ice shelf decline may affect humans as well as wildlife. During its breakup in 2002, the Ward Hunt Ice Shelf calved a number of ice islands, and the heavily fractured ice shelf now has the potential to release many more. Ranging in sizes up to tens of kilometers, these ice islands could eventually drift into the Beaufort Sea and jeopardize shipping and offshore development, such as oil rigs. "An ice feature of this size could exert tremendous force on an offshore structure, and there wouldn't be much we could do to divert it," said Jeffries.

Although researchers wouldn't be able to divert ice islands, they could use satellite data to track ice island movement. RADARSAT data was instrumental in tracking the movement of the giant B-15 iceberg that calved from the Ross Ice Shelf in Antarctica in March 2000, and the data may have similar applications in the Northern Hemisphere.

Big as the ice islands are, the Ward Hunt Ice Shelf breakup does not approach the scale of ice shelf deterioration observed in Antarctica. "The Ward Hunt Ice Shelf is a fairly small feature, and in terms of global climate impact, the breakup of this ice shelf is trivial. Yet it's another indication of what's happening in the Arctic," said Serreze. Among the changes in the Northern Hemisphere that Serreze has recently reported are earlier spring breakups of river ice, increased freshwater runoff, shrinking glaciers, and trees and shrubs invading Arctic tundra. "The Arctic is changing. This is fact," he said.



An ice island about 1.5 kilometers long, 250 meters wide, and 30 meters thick moves into the Arctic ocean after the fracturing of the Ward Hunt Ice Shelf in August 2002. (Image courtesy of Warwick Vincent, Université Laval)

Changes observed in the Arctic confirm climate model predictions. “We know from global circulation models — the results of which are broadly accepted among the polar climate and global climate community — that if global change is occurring, the effects will be felt first and amplified in the polar regions, particularly the Arctic,” said Jeffries. “We’ve seen changes in the Arctic, and in recent years, the changes seem to be occurring faster.”

Vincent agrees. Prior to the Ward Hunt Ice Shelf breakup, his team monitored Disraeli Fiord for five years. Though he had observed gradual decreases in the lake’s fresh water, its sudden disappearance caught him off guard. “I think it underscores a fundamental problem we have in climate change research,” he said. “Climate change models usually predict gradual, continuous change, but real-life impacts are not continuous. Changes can be relatively small, and then suddenly you can move to a new threshold. This ice shelf survived 3,000 years of human civilization, but now it’s gone.”

Reductions in sea ice cover have put polar bear populations at risk. Here, two orphaned cubs await transport to a zoo. (Image courtesy of the NOAA Photo Library)

How much change can be attributed to human activity is difficult to estimate. “We know the climate can vary on many different time scales due to natural processes,” said Serreze. “But when we look at the longer-term record of paleoclimate information, the warming we’re seeing does appear to be very unusual. Carbon dioxide concentrations in ice cores today are probably the highest they’ve been in 400,000 years. There’s a growing consensus between the things we’re observing and climate model projections of change. I’m still a fence-sitter, but I’m leaning more to the side of human causes for at least some of what we’re seeing.”

Jeffries and Vincent plan to continue monitoring the Ward Hunt Ice Shelf and Ellesmere Island. “It’s at the northern limit of North America, right in the bull’s-eye of the region that climate models predict will change most rapidly, most abruptly, and most severely,” said Vincent. RADARSAT data will continue to play a role in that monitoring. “We have been especially impressed with RADARSAT imagery resolution. In combination with our field measurements, it’s provided an unprecedented time series showing the magnitude of change.”

“I think this ice shelf breakup is another example of how valuable remote sensing is, and how important it is that scientists have easy access to these data on a frequent basis,” said Jeffries. “Otherwise, we miss things we really need to know.”

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For more information, visit the Alaska Satellite Facility DAAC.