Drilling for life: Crispin Halsall, an environmental chemist, checks air and ice samples on the Beaufort Sea. Researchers aboard a converted icebreaker, the Amundsen, have been combing the Canadian Arctic for microscopic organisms.
George Tombs

Core findings: Sea-ice samples – such as one from the Beaufort Sea – offer scientists a chance to investigate microorganisms that could survive in icy environments in space.
george tombs

Beneath Arctic ice pack, teeming life holds extraterrestrial clues

Microscopic organisms thrive in polar-ice 'brine channels' whose conditions mirror some of those found in space.

By George Tombs | *Contributor to The Christian Science Monitor*
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Contributor George Tombs talks with CSMonitor.com's Pat Murphy about life in the Canadian Arctic ice.

CANADIAN ARCTIC - In the Beaufort Sea in the northwest Canadian Arctic, the sun rose Jan. 23 after a long polar night of round-the-clock darkness that had begun in late November. At this latitude (71 degrees north), the sun will be shining 24 hours a day by mid-May. With the wind blowing at more than 20 m.p.h. it feels like 53 degrees below zero F.

The bright-red bow of the 320-foot Canadian Coast Guard research icebreaker Amundsen looms above the frozen sea. While armed crewmembers stand on guard nearby, ready to fire a warning shot in case we encounter marauding polar bears, scientists snowmobile around on the three-to-15-foot-thick ice surface collecting ice and snow samples.

"It turns out the sea ice of the Canadian Arctic is not that dead after all," says Jody Deming, an astrobiologist from the University of Washington in Seattle and chief scientist on one of several three-week legs of the Amundsen's year-long Circumpolar Flaw Lead Project.

The $20 million project, led by Arctic climatologist Dave Barber of the University of Manitoba, is part of Canada's contribution to International Polar Year, a multinational effort aimed at researching the polar regions. Atmospheric chemists, physicists, oceanographers, and marine biologists from Asia, North America, and Europe are studying the place where the Arctic Ocean's multiyear sea ice meets one-year, land-fast ice in the Canadian Arctic archipelago.

With funding from the US National Science Foundation, Ms. Deming has been focusing on the nepheloid layer – clouds of water-borne particles above the ocean floor – as well as halophiles, tough, "salt-loving" microorganisms that thrive in superchilled liquid brine channels within the ice.

Microbes on Europa?

Deming believes the bacteria and viruses in these channels in polar sea ice could provide clues about possible life on Jupiter's ice-covered moon Europa.

"When we think astrobiologically, we think of the initial microbes, similar to ones that gained a foothold on Earth 3.8 billion years ago," she says. "Europa is a very promising situation because all the evidence points to an ocean under the ice cover and heat under the ocean."

Astrobiology is a decades-old scientific discipline bringing together astronomy, biology, and geology. It examines whether microorganisms living in extreme heat and cold on Earth could tell us what kind of life forms might exist on other celestial bodies.

"Humans have always thought that icy environments are 'harsh' and 'inhospitable'," says Jere Lipps, an astrobiologist at the University of California, Berkeley, who has done fieldwork in Antarctic sea ice and authored several scientific articles on possible life on Europa. In fact, he says, the diversity of the "sea-ice community" demonstrates that an icy environment can play host to a complete and complex ecosystem.

The ecosystem of polar sea ice includes larger halophile zooplankton – such as nematode worms – that are able to survive in brine channels so saturated with salt that they rarely freeze.

Maike Kramer, a marine-biology doctoral student at the Institute for Polar Ecology at the University of Kiel, in Germany, has been braving the extreme cold, taking ice cores from the ocean surface back onboard the Amundsen. She scrutinizes them under a microscope for signs of life.

High-stakes endeavor

Studying life in polar sea ice requires a major investment. The icebreaker Amundsen had to be retrofitted with innovative design features and state-of-the-art laboratories for polar research. Still, the ship has limits. According to the Amundsen commander, Lise Marchand, the ship has rammed a few times this winter into pressure ridges – where plates of sea ice ride up on top of one another. "We occasionally get stuck," says Captain Marchand. "The way to break loose again is to send ballast and fuel from one compartment to another, to lighten the ship's stem." Crew members and scientists then use gas-powered ice augers and chain saws to loosen the ice jam.

Deming has been doing fieldwork in the Arctic for more than a decade. Her work before this project was aboard a Canadian icebreaker off Greenland.

"We were focusing on organic polymers, a kind of gelatinous material released by microbes into the brine pores that acts like antifreeze," she says. "When temperatures are very cold, liquids become thin films. As the microbes produce this stuff to protect themselves, they change the physics of the ice, keeping the pores liquid. This is an unusual case where biology affects physics."

A eureka moment

Then, on returning to Seattle, she had her "eureka" moment. She was struck by images of Europa captured by the National Aeronautics and Space Administration's Galileo spacecraft mission, showing a lunar-ice surface full of lines, domes, and streaks. It reminded her of the Arctic and made her wonder about parallels. "If you allow life to have extraordinary capabilities of living in tiny patches of ice," Deming says, "then some astrobiologists would say that the moon and Mercury, as well as comets, have a likelihood of life."

If there is life out there, Mr. Lipps says, it could well be carbon-based. "Carbon is the only element that is interactive and will make long molecules under those conditions…. The elements of carbon-based life are everywhere in the universe," says Lipps, who thinks the possibility of "hydrothermal seeps" on the floor of Europa's oceans means that hot conditions could also exist there, raising the prospect of originating life.

The astrobiology community is hoping that a mission to Jupiter, currently being discussed by NASA, will provide more opportunities to look for life on Europa.

A number of frozen planets and moons have the potential to sustain microscopic life, scientists say. They include:

Mercury – The smallest planet of our solar system and the one closest to the sun is believed to have ice in permanently shaded craters at its poles.

The moon – Earth's satellite may have ice at its poles mixed in with regolith (a dry blanket of loose soil and rocky fragments).

Mars – Long the subject of speculation about life, this planet has water ice at both north and south poles and frost has been detected in higher elevations of the volcanic Tharsis region.

Europa, Ganymede, and Callisto – Three of Jupiter's ice-covered moons, discovered by Galileo in 1610, may have liquid-water oceans under the ice crust at the surface. If oceans exist below the ice, it may be kept warm by tidal heat.

Enceladus – This tiny moon orbiting Saturn appears to have spewing ice geysers on its surface.

"Jupiter's moon Europa is the outstanding target because of the water under its ice and the tectonically active icy crust," says Jere Lipps, an astrobiologist at the University of California, Berkeley. "Another of Jupiter's moons, Ganymede, is less likely but still a candidate, because it may also have water under its much older icy crust."

Saturn's moon Titan is another possible host, Mr. Lipps says, given the presence of many carbon compounds, "although that's not necessary, given the abundance of the elements of life in general in the solar system," he says