Sea ice algae on which Arctic animals rely under threat from climate change

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Credit: AI-generated image (disclaimer)

Sea ice algae is an essential resource for the survival of many species living in the Arctic.

Traces of ice algae have been found in many animal groups from tiny filter-feeding shrimp to large predators like whales, revealing the critical

importance of algae and the sea ice on which it grows to the fragile Arctic ecosystem.

Plunged into constant darkness for several months of the year, the Arctic is a harsh environment where only those adapted to the extreme conditions are able to survive.

When sunlight finally returns to the region for a few months in early spring, algae blooms appear across vast areas on the bottom of the sea ice.

Arctic sea ice algae are among the best-adapted organisms on the planet to photosynthesize in low light levels, enabling them to survive in places where little else can grow.

A new study published in *Nature Communications* has now examined the extent to which animals in the Arctic rely on the algae as a food source, as its decline could have cascading effects across Arctic food webs.

To do this, researchers sampled 2,300 animals from 155 species, including invertebrates, fish, seabirds and marine mammals collected from across the Arctic shelves. They tested these specimens for a unique molecule produced by the algae to trace its presence throughout the food chain.

They found traces of the algae in 96% of the studied organisms and, despite the algae blooms only occurring in the spring months, found traces in species collected year-round from January to December.

Dr. Chelsea Koch, a scientist at the Museum and lead author of the study, says, "Despite sea ice algae blooms only occurring during this limited window in the early spring, it has pretty far-reaching impacts."

"Much of the algae gets stored on the sea floor because as sea ice starts to melt and break apart each year, the algae are released into the water column and sinks rapidly without much degradation."

There are diverse communities of animals such as sponges, crabs and worms that live on the sea floor which can feed directly on this resource throughout the year. Other animals, like diving seabirds, walruses and seals, then eat those animals, providing this year-round transfer of sea ice carbon into the food web to fuel the ecosystem.

"We think this might be one way in which Arctic environments can thrive despite having several months of little to no sunlight and no productivity," explains Chelsea. "These ice algae reserves are available to keep things going."

How were traces of algae detected in animals?

Arctic sea ice algae are primarily comprised of diatoms, which are photosynthesizing algae found in almost every aquatic environment. Certain species of diatoms produce a type of lipid called highly branched isoprenoids (HBIs).

Researchers found that HBIs appear not only in the tissues of animals that have eaten the algae, but also in animals that had eaten those animals. Therefore, these lipids could be used as a biomarker to trace their presence in species across the food web.

Animals collected between 1982 and 2019 were tested for these HBIs. Older samples were obtained from frozen specimens in museum collections or other management organizations and communities, where the biomarker could still be extracted from tissues.

The research team found the algae was essential for the majority of

species across the Arctic food web throughout the year.

"It was surprising to see it so widespread and just see the vastness of it presented in this way," says Chelsea.

"Other methods have been used to look at sea ice algae that mostly agree with our findings. So this adds another piece of evidence to show it's important for Arctic marine food webs."

What will happen to sea ice algae in the future?

The climate crisis is driving a rapid change in the Arctic. Current projections show that sea ice will decline significantly, with seasonal periods of an ice-free Arctic Ocean likely within this century.

Over the past few decades observations have shown that sea ice is already thinning. While initially this will enhance the potential habitat for sea ice algal growth in the short term as more light can penetrate the ice, changes to the distribution of sea ice could cause problems. Many organisms on the sea floor that eat the falling algae are relatively immobile and perhaps unlikely to move quickly enough to new areas covered by ice.

In the long term, as the sea ice rapidly melts, we could see fewer algal blooms on shallow shelf systems in the Arctic. Therefore, the loss of sea ice will likely have cascading effects within the food web and impact coastal ecosystem resources on which Indigenous Peoples rely.

The researchers also noted how different populations of species might be impacted in different ways.

"For this study, multiple researchers contributed datasets and we looked at everything broadly. However, there were a lot of interesting nuances

that came out within certain species," explains Chelsea.

"For example, we saw a population of beluga whales with higher sea ice carbon and one with lower sea ice carbon. We realized that the former population tends to stick around in icy waters, while the latter migrate further south to go foraging."

"We also saw similar patterns when looking at the Pacific walrus and the Atlantic walrus sub-species. These populations have different migratory behavior and proximity to sea ice throughout the year, so we saw differences in their sea ice carbon values to match."

"It raises more questions to explore within that data about what might be happening at a species or population level and how their life cycles might depend on sea ice in one location but not so much in another."

More information: Chelsea W. Koch et al, Year-round utilization of sea ice-associated carbon in Arctic ecosystems, *Nature Communications* (2023). DOI: 10.1038/s41467-023-37612-8