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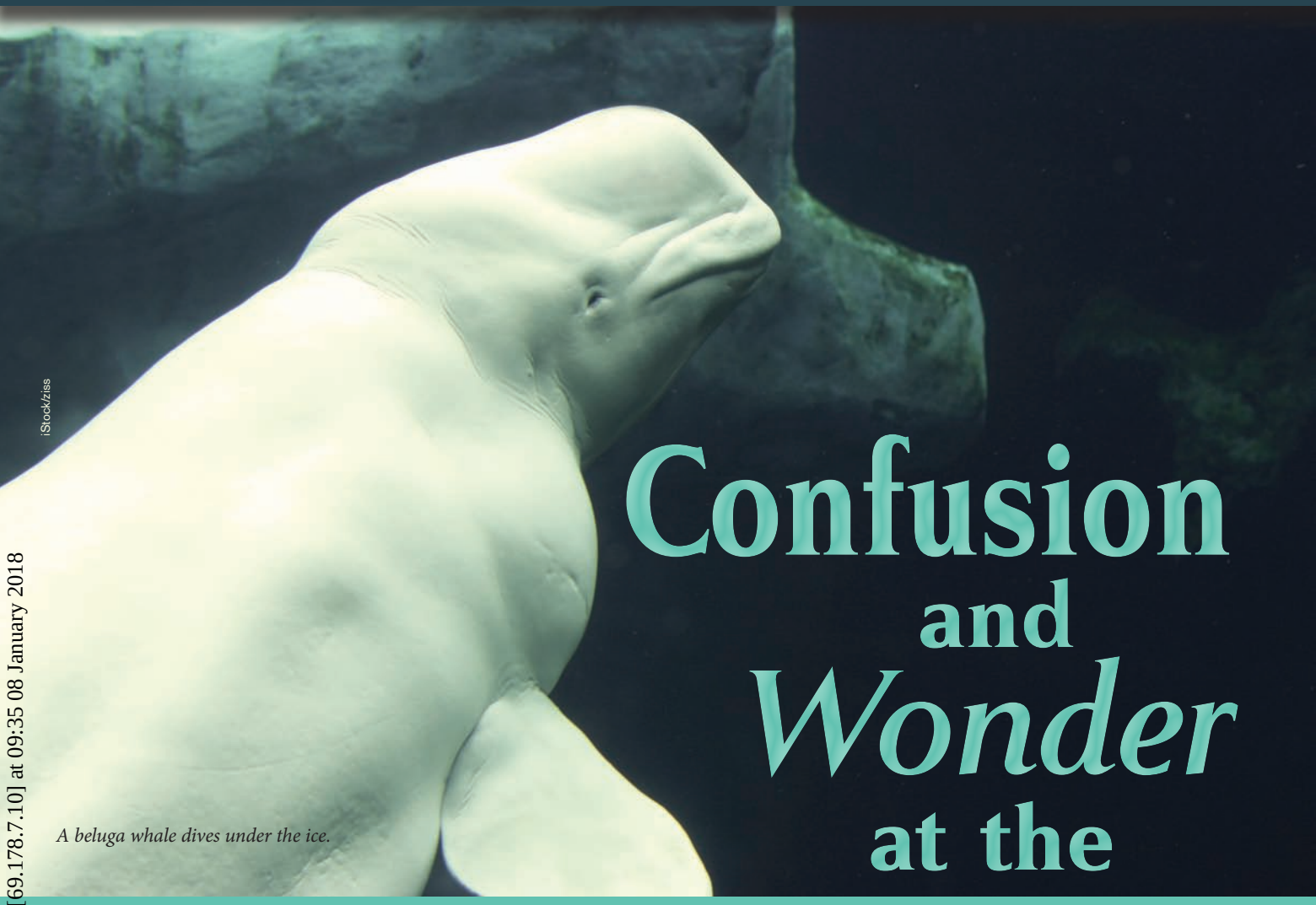

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A beluga whale dives under the ice.

Confusion and *Wonder* at the Limits of Our Knowledge

by Henry P. Huntington

The Arctic is a beautiful, fascinating place. It can also be frustrating and confounding, as we pursue one thread of inquiry and discover how that thread branches in many directions and disappears in knots. It is scary to think of the myriad ways Arctic climate systems and ecosystems can go off the rails. Still, there is wonder in learning that bowhead whales can live two centuries, the longest life span of any mammal on Earth. There is a fearful awe in making the connections that show how a snowstorm in New York City may have its origins in the loss of sea ice in the Chukchi Sea. And there is a certain joy in knowing that there is much yet to do to understand and to conserve a region that has for so long excited so many imaginations.

We do in fact know many things about the Arctic. Indigenous peoples have been living there for thousands of years and rely on accurate understanding of the cycles of the seasons, the habits of animals, and the nature of the ice

and snow on which they travel. Scientists have been studying the Arctic for centuries, classifying species and identifying habitats and quantifying food-web dynamics. Satellite-borne sensors tell us about sea ice extent, about primary productivity, and about the movements of animals.

There is therefore much we can say with confidence. Arctic species have numerous adaptations to an environment that is cold most of the time and has prolonged darkness in winter months. Arctic peoples are closely connected to their environment, relying on it for food, shelter, clothing, and a deep sense of identity and belonging. And of course the Arctic is changing rapidly due to global climate change, the effects of which are amplified in polar regions.

And there is much we do not know, not yet and perhaps not ever. While justly proud of the knowledge gained from the latest study, scientists are often quick to move from what we have just learned to what we need to study next. This habit can give the impression of an endless treadmill in which hypotheses lead to research, which leads to further hypotheses, leading to more research. Such is the progress of knowledge, but it is good from time to time to remember how far we have come, to consider both the wonder we experience in learning and the fear and confusion that may remain in the face of what remains unknown.

Let us consider a few examples. Through art, story, dance, and testimony, the Arctic's peoples have long expressed their ties to the environment and its animals. Studies done in collaboration with indigenous peoples have documented the high harvest of fish, mammals, birds, and plants across the North. Scientists who stop to listen may find among hunters, fishers, and herders a shared depth of understanding of the complexities of Arctic ecosystems and a shared concern for their well-being.

But we also find that Arctic peoples do not respond as we might expect to changes in their environment. Coastal communities threatened by erosion have seen their populations increase in recent years. The same people whose subsistence harvests have increased may report that their waters are in trouble from many stressors. On the one hand, these findings emphasize the innovative, flexible capacity of Arctic residents to make good use of what is available rather than dwelling on what cannot be found. On the other hand, we have a great deal to learn about the complex suite of factors that shape people's lives, and the equally or more complex ways that people respond to change.

As another example, the loss of sea ice is rightly understood as a threat to Arctic marine mammals. Seals use sea ice as a platform for resting and for

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An ancient Saami cave painting of a nautical vessel from northern Norway.

Ted Schuur

Technician Justin Ledman standing in front of eddy covariance equipment measuring carbon balance—the difference between carbon uptake by plants and carbon release by plants and animals (all the way to tiny microbes). This equipment is monitoring the change in a tundra environment near Denali National Park in Alaska where permafrost is degrading, and scientists are measuring net carbon release to the atmosphere (more is lost than plants re-gain).

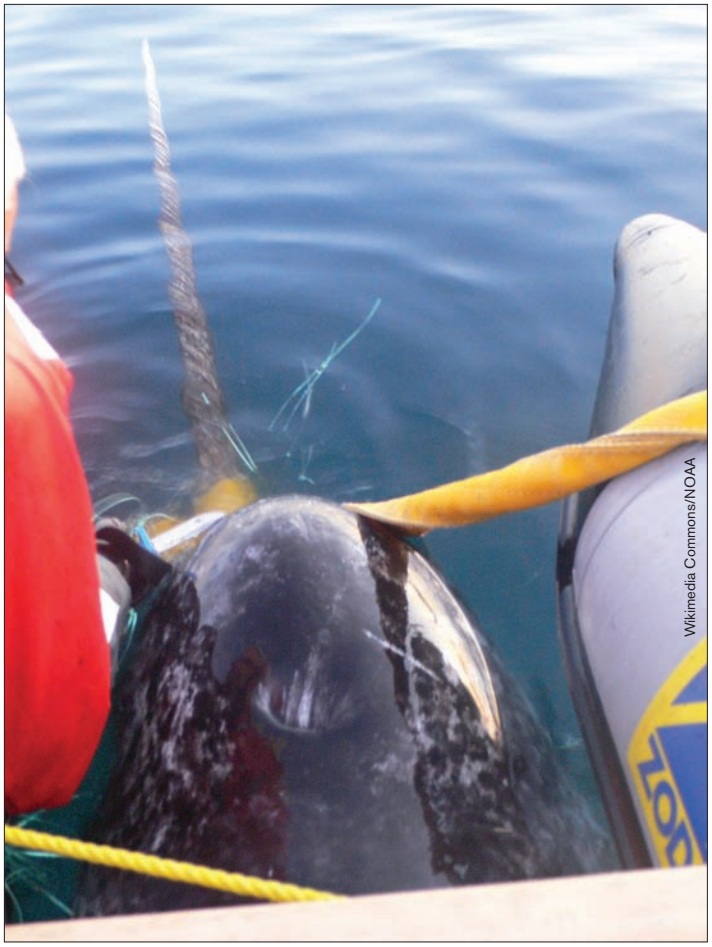
building birthing lairs. Walrus use ice to rest and give birth. Polar bears hunt atop sea ice and make dens in deep snow that accumulates next to high pressure ridges. Beluga, narwhal, and bowhead whales find food amid the ice and refuge from the predation of killer whales or competition from other species. The affinity for ice is one of the remarkable adaptations of Arctic marine mammals.

So why do these same animals appear to be flourishing in some of the places where sea ice is retreating? The short answer is that we do not really know. The longer answer is that sea ice is retreating on a different timeline than that on which ecosystems appear to be responding. Summers may be warmer with less ice, but winter is still cold and dark. Mammals follow age-old patterns of migration and habitat use, which may not change quickly. We will simply have to wait and see how these influences play out in the years to come, and we will have to design management strategies that are robust across a range of scenarios, some of them dire views of what the future holds.

A final example is that of methane emissions from Arctic permafrost. Frozen ground keeps vast quantities of dead plant material from decomposing. As the permafrost thaws in a warming climate, this organic matter releases carbon dioxide and methane. In some wetlands, methane emissions are rich enough that the bubbles can be lit on fire when they burst at the surface of the water. Methane is especially worrying because it is many times more powerful a greenhouse gas than carbon dioxide. If a warming atmosphere leads to more methane emissions, those emissions in turn will create more warming, a vicious cycle that could exacerbate climate change and undermine efforts to reduce human-caused emissions.

The questions are, what is the volume of methane being emitted from the Arctic today, and how is that likely to change in the future? The problem is that two ways to measure methane emissions give very different answers. If we measure the methane in Arctic air and work backward to figure out how much is being emitted, we get a quantity several times lower than if measure emissions from the ground up. It appears we are missing something crucial in the way methane emissions work and in the ways methane behaves once it is in the atmosphere. Such uncertainty leaves a big and worrisome gap when trying to project what is in store for us.

An uncertain future for the Arctic, as for the rest of the globe, should keep us up at night. Yet we face that future not in ignorance but with a depth of hard-won knowledge and insight. We know things are changing fast. We know what is driving those changes. In broad terms, we know what can and should be done to avoid further stress on cultures and ecosystems. We must continue to build our knowledge and we must work to put that knowledge into action. Only then can we tame our fear, act amid our uncertainty, and leave to our children an Arctic as wondrous as the one that has inspired so many of us for so long.



A male narwhal is captured and satellite tagged before being released.

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