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HEALTH

SICK N IN THE ARCTIC

As the far north heats up, its inhabitants—
from musk oxen to residents of growing
cities—are getting ill

By Christopher Solomon



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MUSK OXEN, huddled together to face a snowstorm, are powerless against a lungworm parasite that is threatening their ranks.



Christopher Solomon writes often about the environment and the outdoors for the *New York Times* and *Outside* magazine, among other publications.



THE SEA OTTERS SPLASHING OFF ALASKA'S ALEUTIAN ISLANDS SHOULD HAVE THRIVED IN THEIR HOME FAR FROM CIVILIZATION.

Instead the furry little creatures were in trouble. Their population throughout the Aleutians and southwestern Alaska had crashed by 70 percent in less than 10 years.

Trying to decipher the decline, Tracey Goldstein of the University of California, Davis, and her fellow researchers went looking for disease. What they found chilled them: evidence of a distemper virus usually found in seals. The virus had already killed more than 50,000 seals along Europe's shores over two decades. It had also been linked to seal deaths on the eastern coasts of Canada and the U.S. Yet seal distemper virus had never been found in the North Pacific. How did it get there?

The sleuthing soon pointed to Arctic ice—or the lack of it. The year of the last big seal distemper epidemic in northern Europe—2002—was also a time of extremely little summer sea ice in the Arctic. Goldstein theorized that a melting Arctic opened the fabled Northwest Passage to disease transmission, allowing an infected Atlantic marine mammal such as a ringed seal, or its feces, to mingle somewhere with marine animals from the North Pacific, spreading the virus to sea otters there. The fragment of virus found in the Aleutian otters was identical to that in Europe's 2002 outbreak.

The theory has some skeptics, but if it is correct, marine mammals in the Arctic and Pacific oceans, particularly harbor seals, may be threatened by the virus's spread, according to Goldstein, who directs the university's Marine Ecosystem Health Diagnostic and Surveillance Laboratory. What is more, other species are now encountering one another or their effluents in the Northwest Passage, possibly leading to new exchanges of disease. In the summer of 2010, for instance, bowhead whales from

the Atlantic and the Pacific, which had been tagged and tracked by satellite, met there, a union that probably had not happened since the start of the Holocene epoch 12,000 years ago.

As climate change heats the world's highest latitudes faster than almost anywhere else, animals on land, as well as in the sea, are getting sick. Temperatures across Alaska increased by 1.9 degrees Celsius on average over the past 50 years, compared with 0.7 degree C worldwide. Alaskan winters are heating up even more quickly than summers, rising an average of 2.6 degrees C. That warming can create more hospitable conditions for pathogens and parasites and encourage northward migration of many animals and pests, such as ticks, that often carry disease. New life is also crawling and swimming toward a warmer north, carrying microbes to populations that have not seen them before.

The migration could spell trouble for humans, too. In a shrinking world where old barriers are sometimes literally melting away, animal diseases can spread to humans more readily. Indeed, more than 60 percent of the new infectious diseases emerging in humans worldwide since 1940 have been transmitted from animals to people—including those caused by Ebola virus and severe acute respiratory syndrome (SARS) virus. Simply put, says Michael Grigg, chief of molecular parasitology at the National Institute of Allergy and Infectious Diseases, "if the animals are sick, we can get sick."

A shift in disease could also alter animal populations and therefore threaten ecosystems and food supplies for indigenous peoples. It is not quite clear if the rising number of diseases being observed is simply the result of scientists looking more widely, and no one is ready to claim that Arctic life will collapse because of

IN BRIEF

Rising Arctic temperatures are helping pathogens spread and thrive where they had not been before.

Parasites in the far north are sickening musk oxen,

ticks are transmitting viruses to people, and Atlantic seals may have transmitted a lethal virus to Pacific seals as vanishing sea ice allows their worlds to mix.

Changing climate could help some species, but researchers fear it will hurt more of them, raising the need for nations to find ways to improve biosecurity.

PRECEEDING PAGES: NORBERT ROSING National Geographic (musk oxen); COURTESY OF PHATAP KATLE University of Calgary (lungworm)

Pathogens Move Northward

Researchers are finding surprising ailments in surprising places across the far north. Ticks and other parasites that carry pathogens from temperate zones are hitching a ride on animals that are migrating north with advancing forests. Mosquitoes are transmitting diseases at higher latitudes. Seals from the Atlantic and Pacific oceans are swapping illnesses. A few of the many discoveries appear here.

Aleutian Islands, Alaska

A distemper virus that infects seals in the North Atlantic Ocean now attacks sea otters in the North Pacific.

Saint Lawrence Island, Bering Sea

Avian cholera 200 kilometers off the Alaskan mainland has killed hundreds of northern fulmars, murres and crested auklets—seabirds that had not been afflicted before.

Sahtu, Northwest Territories

Ticks, never observed here before, have been discovered on moose hides.

Victoria Island, Arctic Archipelago

Lungworm has spread several hundred kilometers northward across the musk oxen population.

Hay Island, Nova Scotia

Ringed seals have passed a parasite to gray seals that killed 400 pups in 2012.

Sweden

Mosquitoes have spread the tularemia bacterium to people across the country.

Arkhangelsk Oblast, Russia

Tick-borne encephalitis cases in humans rose 50-fold from the decade 1980–1989 to the decade 2000–2009.



contagion. But changing dynamics, says Claire Heffernan, a specialist in global health at the University of Oxford, makes the Arctic “the Pandora’s box of infectious disease and climate change.”

PARASITES MATURE FAST

ONE WAY THAT A WARMING CLIMATE is promoting disease in the northern reaches of the planet is by helping parasites mature. A startling example is *Umingmakstrongylus pallikuukensis*, a lungworm that lives inside musk oxen, those shaggy, smelly Ice Age relics in Canada’s upper Northwest Territories. The lungworm has evolved a fascinating relationship with its hosts: Female worms, which can be up to 65 centimeters (25.6 inches) long, lay eggs in large cysts in the lungs of musk oxen. After the eggs hatch, a musk ox coughs up the larvae, swallows them, then passes them out through its feces. The larvae are picked up by the feet of Arctic slugs and snails, eventually passing back into the ox when the bovine eats the gastropods.

The Arctic’s modest summer temperatures always kept the lungworms in check. It rarely got warm enough for the larvae to grow to their final, infective stage in the slugs and snails, so they had to overwinter in their immature state and continue development the next summer.

But a “tipping point” has been reached, says Susan Kutz, associate professor of ecosystem public health at the University of Calgary. The warmth is lasting longer, allowing the parasite to mature in one summer instead of two. “They’re far more likely to get taken up by a musk ox and complete the life cycle” in that time frame, Kutz says, and thus have more opportunities to thrive and spread.

Invigorated, the lungworm is on the march. In 2008 Kutz and others found that its range had expanded north several hundred kilometers, to Victoria Island in Canada’s western Arctic Archipelago, home to as much as 30 percent of the global population of musk oxen. Today it is in all the oxen that live

in places on the island where the parasite has established itself.

The parasite's incursion is part of a double whammy. In a perfect world, *U. pallikuukensis* would not cause the animals much grief. The oxen "might have a smoker's cough or something," Kutz says. But toastier summers are also affecting the animals. "Remember," she says, "for a musk ox, warm weather is bad weather." If a musk ox is stressed by heat and its lungs are compromised because they are full of cysts, the animal can weaken, lose vital energy and become predisposed to various infections. "That can affect whether you live or die," Kutz says.

Sure enough, the population is declining dramatically. Indigenous peoples are worried, too, because they rely on a healthy population of the animals for food and natural materials.

TICKS AND MOSQUITOES SPREAD

WARMER TEMPERATURES are also allowing plant and animal species to migrate northward, bringing their infections with them. In Russia, for example, forests are advancing into tundra areas at about a kilometer a year. The field mouse, brown hare, hedgehog, wild boar, moose and a dozen new species of bird now occupy the growing northern taiga.

Ticks are among the invaders moving up with their hosts. In North America the winter tick survives the frigid months by attaching in autumn to animals such as moose and using the hosts' body warmth to endure. In 2013 researcher Cyntia Kayo Kashivakura found ticks on five of 30 moose hides in the Sahtu, an aboriginal region high up in Canada's Northwest Territories, the first time the bugs have been seen there.

Ticks and other threats are not just an animal problem in the Arctic. Roughly four million people now inhabit the far north, and they are at risk as well. About 10 percent of them live in smaller villages, but many other residents live in expanding cities as large as 300,000 (Murmansk, Russia). Energy exploration and tourism continue to bring newcomers. Sweden is one place already feeling the effects. The country saw a record number of tick-borne encephalitis (brain swelling) cases in 2011 and again in 2012. A warming climate and longer growing season have allowed roe deer, the main host for female ticks there, to expand their ranges northward. Lab data also suggest that the virus they carry may multiply to high concentrations in a tick's salivary glands during warm weather, so the virus is primed to infect when the tick attaches to a host.

Mosquitoes are expanding across Sweden, too. The insect is distributing *Francisella tularensis*, an infectious bacterium that is the primary agent of tularemia, which can cause severe fever, inflammation and death. The bacterium can be so lethal that during the cold war of the 1950s the U.S. and the U.S.S.R. weaponized it. The version now in Sweden causes about a week of flulike symptoms. Researchers have not pinpointed the mechanism allowing the mosquitoes and tularemia to thrive, but higher late-summer temperatures seem to be key, says researcher Anders Sjöstedt of Umeå University in Sweden. The threat is



WINTER TICKS, which burrow into moose to survive harsh temperatures, are being found much farther north, weakening the animals there.



only going to get worse. According to models built by Sjöstedt and others, by this century's end the time period during which outbreaks will occur will lengthen by three and a half weeks to more than six and a half weeks in high-risk counties.

Humans are also in peril from other quarters. A warmer climate can alter the habitats of local animals in ways that can foster disease transmission to people. In the winter of 2006–2007 northern Sweden experienced a sudden explosion of nearly 500 cases of a hantavirus infection, transmitted to humans when they inhale feces or urine of infected rodents. The hantavirus causes nephropathia epidemica, a sometimes lethal viral hemorrhagic fever. Up to 30 percent of the sick were hospitalized; at least three people died.

Pathologists eventually figured out the odd but likely reason: Record-breaking warmth that winter caused rain and ice to fall instead of snow. The hantavirus is endemic in bank voles, a rodent that relies on snow cover during winter to hide from predators and cold. When the ground in northern Sweden had no snow cover for 25 of 31 days, voles probably sought refuge in barns and homes, thereby transmitting the infection to humans. Warmer, wetter winters are Sweden's future.

ONE SEAL KILLS ANOTHER

IT IS NOT ONLY MIGRATIONS on land that are worrisome. Fish and marine mammals are moving en masse toward the poles, seek-

DON JOHNSTON: Corbis (moose); COURTESY OF RON MOEN: University of Minnesota Duluth (ticks)

ing cooler waters as midlatitude oceans warm. Researchers are finding more and more seaborne pathogens farther and farther north. For example, stocks of cod—one of the world's most important fisheries—continue to push up into the Arctic and now occur at record levels in the Barents Sea, northeast of Norway. The fish carry hitchhiker viruses. Predators follow, bringing more of the same.

Sometimes the reverse happens: a pathogen established in the north finds fertile ground in the new inhabitants. Gray seals, for example, are following fish stocks that are heading that way, in pursuit of a meal. In February 2012, 400 gray seal pups died on Hay Island off the coast of Nova Scotia, about a sixth of all pups typically born there each year. The killer, scientists think, was a parasite that is similar to *Sarcocystis canis*, a single-celled organism related to the one that causes malaria. The *S. canis*-like parasite is not always lethal, but in some populations it causes massive disease and death.

Researchers tested nearly a dozen species of Arctic marine mammals and found a likely culprit: the ringed seal. The seal spends most of its life on sea ice and is common in the Canadian Arctic. Soon-to-be-published research suggests that ringed seals either carry the parasite and pass it on, unchanged, or serve as its “definitive host”—one in which the parasite undergoes sexual reproduction and is passed through feces into the environment as an infective egg, or oocyst. Those oocysts can then enter and infect other animals such as gray seals, causing active disease, according to Katie Haman, a veterinarian and doctoral candidate at the University of British Columbia. For the first time, ringed seals are mingling with gray seals, says Grigg, who is Haman's adviser. Fishers in Newfoundland confirm the mixing. Researchers next hope to find ringed seal scat with those oocysts in it, which would confirm that the animals are the definitive host of the parasite.

Ominously, in every Arctic marine mammal that Grigg's team has examined, the group has found species of microbial pathogens not seen before. The Arctic is like an unread book, one that we ignore at our peril, according to Grigg.

BIOSECURITY NEEDED

FOR EONS THE ARCTIC's frigid temperatures, its snow and ice and lack of crowds, essentially kept a cap on infection. Native wildlife has grown accustomed to a place that is relatively free of disease and diversity. Some scientists even say that birds evolved to pursue taxing migrations north every year so they can focus their springtime energy on breeding instead of fighting off parasites and predators.

Now a chaotic reshuffling of factors affecting disease is under way, which scientists drily call “ecosystem reorganization.” Species are mingling in strange and previously unobserved ways, such as polar bears seen fighting and mating with grizzlies in Kaktovik, Alaska. An unprecedented 20,000 walrus hauled themselves onto a beach off the coast of Alaska in 2011, when their usual summer home—ice floes in the Chukchi Sea—simply vanished. Out-of-towners, plus crowds, plus stress, all add up to a greater possibility of illness spreading, researchers say.

The sickening Arctic is the product of a broader trend—an entire world saddled with more disease under climate change. Viruses, fungi and parasites are invading not only the north but also tropical ecosystems such as coral reefs and rain forests.

Tropical pathogens, in turn, are advancing into temperate zones; dengue fever is cropping up in Florida and Texas.

To be fair, the Arctic is not being crippled by contagion. Outbreaks to date have been relatively restrained. Some wildlife may even benefit from warmer times. Black brant geese that favor salt-marsh areas are starting to find more of that habitat on Alaska's North Slope as permafrost thaws and coastland subsides. It is possible, too, that some afflictions might decrease. Rabies persists in Alaska only in areas where Arctic foxes are present; as red foxes proliferate and displace Arctic foxes, rabies cases could ease, suggests Karsten Hueffer, associate professor of microbiology at the University of Alaska Fairbanks.

Still, researchers seem to find surprising illnesses in northern wildlife almost monthly: polar bears with alopecia (hair loss); seabirds with avian cholera. Whether these instances are multiplying or are just being discovered as more investigators look northward is still a bit hard to say. What is badly needed, researchers agree, is more baseline information about the state of disease. That goal is challenging. The Arctic is vast and remote, it is expensive to get around and it can be dangerous to study. Yet researchers say that in their gut, based on years of experience, they think a widespread problem is emerging.

More study would also help countries agree on solutions to spreading diseases as they are revealed. “What we're doing now is negotiating over resources up there,” Oxford's Heffernan says of nations planting their flags on the seabed and scrambling for oil. “What we really should be doing is negotiating about biosecurity.” Agreements need to be made about how to lower exposure to disease threats and prevent the inadvertent introduction of new pathogens to both human and wildlife populations at risk, she says. Nations need to forge collaborative actions “now.”

The Arctic “has been cut off from the rest of the world for a large number of years,” adds Grigg, the parasitologist. “It's got its own dynamic, so the pathogens that are in the hosts, and the hosts, have come to some balance.” But when pathogens are liberated by a new environment, he says, big changes can sweep through populations.

Sometimes those changes drive a new balance fairly quickly, without too much distress, Grigg continues, citing the modest consequences of West Nile virus in the U.S., which raised major fear when it was first discovered. But then Grigg mentions rats and bubonic plague, and the devastation wrought by smallpox when it was introduced to the native populations of the New World. “Sometimes,” he says, change “is catastrophic.” ■

MORE TO EXPLORE

Phocine Distemper Virus in Northern Sea Otters in the Pacific Ocean, Alaska, USA. Tracey Goldstein et al. in *Emerging Infectious Diseases*, Vol. 15, No. 6, pages 925–927; June 2009. www.cdc.gov/eid

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Local Environmental Observer Network for northern communities: www.anthrc.org/chs/ces/climate/leo

FROM OUR ARCHIVES

Arctic Plants Feel the Heat. Matthew Sturm; May 2010.

How Kitty Is Killing the Dolphins. Christopher Solomon; April 2013.

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