



WHAT'S KILLING THE WORLD'S SHOREBIRDS?

Researchers brave polar bears, mosquitoes and gull attacks in the Canadian Arctic to investigate an alarming die-off.

BY MARGARET MUNRO

Four gun-toting biologists scramble out of a helicopter on Southampton Island in northern Canada. Warily scanning the horizon for polar bears, they set off in hip waders across the tundra that stretches to the ice-choked coast of Hudson Bay.

Helicopter time runs at almost US\$2,000 per hour, and the researchers have just 90 minutes on the ground to count shorebirds that have come to breed on the windswept barrens near the Arctic Circle. Travel is costly for the birds, too. Sandpipers, plovers and red knots have flown here from the tropics and far reaches of

the Southern Hemisphere. They make these epic round-trip journeys each year, some flying farther than the distance to the Moon over the course of their lifetimes.

The birds cannot, however, outrun the threats along their path. Shorebird populations have shrunk, on average, by an estimated 70% across North America since 1973, and the species that breed in the Arctic are among the hardest hit¹. The crashing numbers, seen in many shorebird populations around the world, have prompted wildlife agencies and scientists to warn that, without action, some species might go extinct.

Although the trend is clear, the underlying causes are not. That's because shorebirds travel thousands of kilometres a year, and encounter so many threats along the way that it is hard to decipher which are the most damaging. Evidence suggests that rapidly changing climate conditions in the Arctic are taking a toll, but that is just one of many offenders. Other culprits include coastal development, hunting in the Caribbean and agricultural shifts in North America. The challenge is to identify the most serious problems and then develop plans to help shorebirds to bounce back.

MALCOLM BOOTHROYD

In chilly summer conditions, Paul Smith surveys the Arctic landscape for shorebirds.

ecologist Paul Smith, a research scientist at Canada's National Wildlife Research Centre in Ottawa who has come to Southampton Island to gather clues about the ominous declines. He heads a leading group assessing how shorebirds are coping with the powerful forces altering northern ecosystems.

Researchers say it is now more crucial than ever to understand how conditions in the Arctic are altering breeding and survival. "This is high urgency," says ecologist Jan van Gils of the Royal Netherlands Institute for Sea Research in Texel, who is studying the decline of wading birds called red knots (*Calidris canutus*) that breed in the Russian Arctic. "It's indeed now or never."

GUNSHOTS AND PANCAKES

At his base camp on the island, Smith looks as if he could have walked out of a tech lab in Silicon Valley — except for the shotgun slung over his shoulder. He is constantly in motion, up before 7 a.m. and in the helicopter by 9, ready to head north to survey shorebirds. At 6 p.m., he's in the kitchen cabin, humming away as he cooks dinner for the hungry crew returning from their nest hunts. He deals with a computer glitch before bed, and then scrambles out of his sleeping bag at 2 a.m. when a curious polar bear wanders into camp. He deters it with several warning shots, which makes for animated conversation over the pancakes that he whips up later that morning. Then, he hikes off to set contaminant collectors in thigh-deep melt ponds to check for pollution that might be affecting the birds.

Smith has been coming to this site, known as East Bay, every year since 2000, when he was sent here as a biology student to help build a camp to study poorly understood shorebirds. He was soon intrigued by the birds — some no bigger than a sparrow — that fly across continents to lay eggs on the wide-open landscape. Sleet is not uncommon in June, cold winds blow in off Hudson Bay in July and snowdrifts can persist well into August.

Smith now heads studies at the 12-square-kilometre research plot at East Bay, one of the longest-running shorebird-research camps in the Arctic. He is also co-leader of a joint effort between Canada and the United States called the Arctic Program for Regional and International Shorebird Monitoring (Arctic PRISM). The project, which began in 2002, has dispatched crews to more than 2,000 sites, stretching from Alaska to Baffin Island in eastern Canada, to survey the 26 shorebird species that breed in the North American Arctic. Smith and his Canadian co-leader, Jennie Rausch, cover the central and eastern Arctic, and the first round of the

"It's inherently complicated — these birds travel the globe, so it could be anything, anywhere, along the way," says

massive PRISM survey is nearing completion.

It is a short, intense season for both the birds and the biologists. The East Bay site, several hundred kilometres north of the tree line, comes alive in June with the mating and territorial calls of a dozen shorebird species. Among them are the robin-sized red knot, which flies up from the tip of South America; several plovers and sandpipers; and the ruddy turnstone (*Arenaria interpres*) that winters in Latin and South America.

Shorebirds stream north on four main flyways in North America and Eurasia, and many species are in trouble. The *State of North*

peak abundance of insects, so the birds do not grow as big.

When those undersized knots migrate to their West African wintering grounds, they run into further problems because their short bills cannot reach deeply buried clams, their preferred food. "We show the smaller individuals live shorter lives and have lower survival than larger individuals," van Gils says.

He says that he had his first close-up look at the knots' Arctic breeding grounds last summer, when he joined a US team to study a subspecies that migrates to Alaska, where chicks' growth rates also seem to be slowing as tem-

"FOR KNOTS, THERE IS NO WAY OUT — THEY ARE ALREADY AT THE NORTHERN EDGE OF THE WORLD."

*America's Birds 2016 report*¹, released jointly by wildlife agencies in the United States, Canada and Mexico, charts the massive drop in shorebird populations over the past 40 years.

The East Asian–Australasian Flyway, where shorelines and wetlands have been hit hard by development, has even more threatened species. The spoon-billed sandpiper (*Calidris pygmaea*) is so "critically endangered" that there may be just a few hundred left, according to the International Union for Conservation of Nature.

Red knots are of major concern on several continents. The subspecies that breeds in the Canadian Arctic, the rufa red knot, has experienced a 75% decline in numbers since the 1980s, and is now listed as endangered in Canada. "The red knot gives me that uncomfortable feeling," says Rausch, a shorebird biologist with the Canadian Wildlife Service in Yellowknife. She has yet to find a single rufa-red-knot nest, despite spending four summers surveying what has long been considered the bird's prime breeding habitat.

The main problem for the rufa red knots is thought to lie more than 3,000 kilometres to the south. During their migration from South America, the birds stop to feed on energy-rich eggs laid by horseshoe crabs (*Limulus polyphemus*) in Delaware Bay (see 'Tracking trouble in the Arctic'). Research suggests that the crabs have been so overharvested that the red knots have become deprived of much-needed fuel.

In other cases, climate change might be the prime problem. Van Gils' team in the Netherlands has found that red knots that breed in the Russian Arctic produce smaller offspring during summers when the snow melts early². He suspects the reason to be malnutrition. During warm years, the red-knot chicks may miss the

temperatures climb. The data collected last year are still being analysed, but van Gils suspects another timing mismatch there — chicks miss the peak insect emergence.

Conditions are also changing rapidly at Smith's research site in Canada, where sea ice last year broke up more than a month earlier³ than it did three decades ago. But when it comes to the shorebird population declines at East Bay, says Smith, "there may be more immediate threats than climate change".

Snow geese (*Chen caerulescens*) are high on his list of suspects. The goose population has exploded in North America, and they have severely degraded wetlands along the coast of Hudson Bay that serve as key refuelling stops for millions of migrating shorebirds⁴.

Geese are also showing up in shorebird breeding territory, where they mow down the grasses that the shorebirds use to protect their nests on the wide-open landscape. Perhaps even more threatening, says Smith, is that the geese attract foxes and other predators that eat shorebird eggs and chicks.

Southampton Island is an ideal spot for gauging the impact because there are now about 1 million nesting snow geese on the island. A sister research site that Smith runs on nearby Coats Island — less than an hour away by Twin Otter aircraft — provides a control because the island does not have a snow-goose colony.

HIDDEN NESTS

One day in late June, biologist Lisa Kennedy calls out a warning as she surveys the East Bay research site. "Careful where you step," says Kennedy, sticking to the larger rocks for fear of crushing the speckled eggs of a plover. A doctoral student at Trent University in Peterborough, Canada, Kennedy led the six-person crew that combed for nests last summer.

Tracking trouble in the Arctic

Migrating shorebirds face a long list of hazards on their epic flights.

BY MARGARET MUNRO
AND RICHARD MONASTERSKY
DESIGN BY JASIEK KRZYSZTOFIAK

Many shorebird populations are declining steeply around the globe, and those that nest in the Arctic are among the hardest hit. On their long-distance migrations, they encounter a number of threats, including hurricanes and hunters, pesticides in croplands and human sprawl that is destroying wetlands used by the birds as refuelling stations. By tracking the journeys of each species, researchers can better understand the problems confronting these birds.

Shorebirds are vulnerable because their migrations are tightly tuned to the cycles of other species. The robin-sized red knot (*Calidris canutus*, pictured) that breeds in the Canadian Arctic times its northward migration so that it can stop and bulk up on the eggs of horseshoe crabs (*Limulus polyphemus*) in Delaware Bay. Western sandpipers (*Calidris mauri*) touch down every spring on Canada's west coast to feast on biofilm produced by algae along the expansive mudflats of the Fraser River delta. And all the Arctic breeders aim to have their chicks hatch at a time when there is a banquet of mosquitoes and other insects on the tundra.

But there is growing concern — and evidence — that the connections have begun to fray because of climate change and other human impacts on the environment and ecosystems.



Spy tech

MOTUS NANOTAG

Pearl-sized nanotags (shown here and on back of bird), that weigh as little as 0.25 grams are so light that they can be glued onto small birds, bats and insects. Batteries can last a couple of weeks to a year, powering coded transmissions that get picked up by a network of towers. Nanotags fall off when birds moult.

SATELLITE TAG

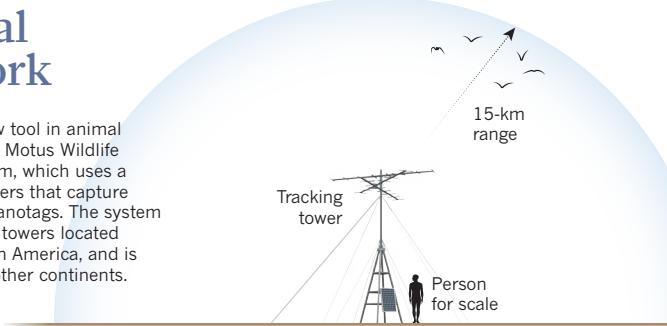
Tags attached to backs of birds send or receive signals from satellite networks to track the location of the birds as they migrate. These tags are bigger than Motus nanotags and geolocators and are worn until they can be removed from the bird, or fall off.

GEOLOCATOR

Long-lasting tags, typically attached to the leg, record sunrise and sunset, which can be used to establish rough estimates of a bird's latitude and longitude. Tags must be recovered to retrieve data.

Animal network

A powerful new tool in animal research is the Motus Wildlife Tracking System, which uses a network of towers that capture signals from nanotags. The system has some 300 towers located mostly in North America, and is expanding to other continents.



Population problems

STOLEN ARCTIC EGGS

Less than 7% of the shorebird eggs at East Bay on Southampton Island hatched successfully, whereas the rate at Coats Island topped 55%. The difference? Coats Island has no snow geese but East Bay is overrun. When shorebirds leave their nests to defend against encroaching geese, that provides an opportunity for predators to steal eggs.

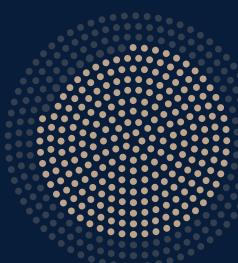
EAST BAY

20/296 eggs hatched



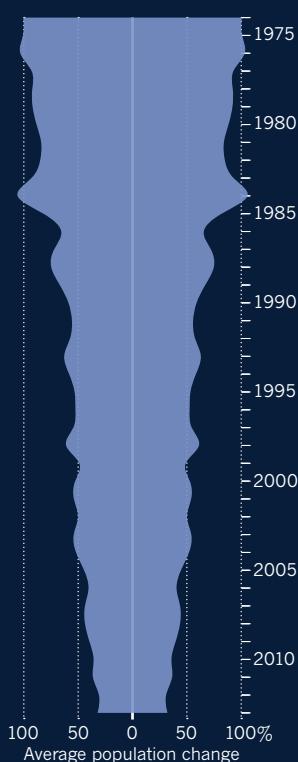
COATS ISLAND

247/448 eggs hatched



NEGATIVE NUMBERS

Since the 1970s, migratory shorebird species have experienced a 70% drop in population size, on average.



HYDROELECTRIC DAMS

Red knots wearing trackers revealed a previously unknown stopover site during their northward migration near hydroelectric dams along the Nelson River on the west coast of Hudson Bay. Researchers have raised concern that the dams can change water flow and temperatures in ways that might harm the birds.

Trials and trails

The red knot has a wingspan of about 50 centimetres, but it makes one of the longest animal migrations known, from the tip of South America to the Arctic. The rufa subspecies, which breeds in northern Canada, has been hard hit in recent decades and is listed as threatened by the United States and endangered by Canada.

SOURCES: POPULATION-DECLINE DATA, ADAM SMITH & REF. 1; GOOSE POPULATION REF. 4; MOTUS TOWERS, STUART MACKENZIE; BIRD FLIGHT PATHS, SJØERD DUJNS; STOLEN EGG DATA, PAUL SMITH

MAP KEY

Motus towers

- Active
- Inactive, temporary or seasonal stations

Flight paths recorded 2014–15

Threats

- Snow-goose population range

Nelson River hydroelectric plants

- Existing
- Planned



SNOW GESE

The population of snow geese (*Chen caerulescens*) and other geese in the North American Arctic has surged from about 1.5 million in the 1960s to as many as 20 million today because of changes to US farming that provide abundant food sources for the birds.

HORSESHOE-CRAB HARVEST

Red knots time their migration north to refuel on eggs laid by horseshoe crabs in Delaware Bay. Overharvesting of the crabs is thought to have contributed to the steep decline of the birds.



HUNTING

Hunting is a threat to shorebirds, particularly in several Caribbean islands and northern South America. Efforts are currently under way to better estimate the annual harvest, with an aim of preventing the loss of too many birds.

The young biologists instantly identify birds by their silhouettes, calls and behaviour. They are also quick to spot polar bears that can appear seemingly from nowhere, which is why shotguns are taken everywhere — even to the outhouse.

The biologists hike 10–15 kilometres a day across the tundra and melt ponds to find and monitor nests. They also spend a lot of time lying motionless on the soggy ground waiting for shorebirds that they spooked to return to their eggs. It can sometimes take days to locate the well-hidden nests — some are circular cups the birds dig in the ground; others just grass, moss and the odd feather pulled together.

The researchers weigh and measure the birds and their eggs and put the nests under surveillance. They also fit many birds with bling — bands around the legs and pearl-sized nanotags that are glued to their feathery backsides. “You have to be careful not to stick yourself to the bird,” says Kennedy, holding a nanotag in place on a semipalmed plover until the Krazy Glue sets.

Then the bird is off, the hair-like antennae on the tag emitting an electronic pulse that can be picked up by the receiving station on top of a cabin back at camp. This is part of the Motus tracking system, a network of some 300 receiving towers that is expanding across the Americas. The Motus nanotags weigh less than 0.3 grams — so light that they can be carried by the smallest shorebirds and their chicks. Their signals are picked up when the birds are within 15 kilometres of a receiving station.

On his computer, Smith has watched red knots make the 3,000-odd-kilometre flight to the Arctic from Delaware Bay on the US coast in three days. “They go ‘ding, ding, ding’ as they hit the towers,” he says.

Shorebirds make some of the longest migrations in the animal kingdom. One red knot, sporting leg band B95, journeyed to and from the southern tip of South America and the Arctic for more than 20 years.

The nanotags that Smith’s group uses in the Arctic are helping to fill in details about the ultramarathon migrations. In 2014, Smith and his colleagues discovered that red knots were stopping to refuel at a previously unknown spot along the coast of Hudson Bay.

Nanotags are also valuable on the breeding grounds because they enable Smith’s team to monitor how much time adults spend on their nests, and how far hatchlings wander in search of insects — two of many variables affected by geese. Nesting shorebirds will take flight to defend their nests from grazing geese, leaving their eggs and chicks vulnerable to the foxes and predatory birds.

This year, predators took most of the shorebird eggs laid on the East Bay research plot. Just 20 eggs out of 296 survived long enough to hatch. At the snow-goose-free site on Coats Island, more than half the eggs hatched. Smith says that the reproductive success of shorebirds



Some red knots (*Calidris canutus*) migrate to the Arctic from the bottom tip of South America.

on Southampton Island has dropped so low that the population can no longer sustain itself.

The research adds to long-standing concerns about North America’s goose explosion. The geese used to winter in the coastal marshes of Louisiana and Texas, but now spend the season feasting on leftover crops on farm fields in the southern and Midwest United States. In the spring, the geese fly to the Arctic to breed.

Robert Rockwell, a population biologist and ecologist at the American Museum of Natural History in New York City, says that it has been “pretty staggering” to watch the goose population explode from 1.5 million in the 1960s to what he estimates could be as many as 20 million today. He has run a decades-long monitoring project on La Pérouse Bay on the coast of Hudson Bay, where he and his colleagues first showed⁵ how geese can rip up lush green grass and marshland and render it inhospitable to both plants and animal species such as shorebirds. Subsequent work⁶ has shown that geese have triggered long-term damage that has reduced the biodiversity of plants, insects and birds at several other sites.

Whether geese have enough of an effect to be a major factor in the shorebird declines is still unclear. Rockwell says that the question of goose impacts is a crucial issue, and applauds Smith’s team for trying to answer it.

FIGHT FOR FLIGHT

Brad Andres, national shorebird coordinator of the shorebird conservation plan for the US Fish and Wildlife Service in Falls Church, Virginia, says that there is a huge need to understand how different threats and disturbances impact shorebird survival — be it snow geese in Arctic Canada, insect abundance in Alaska and Russia or the destruction of feeding grounds and refuelling stops caused by coastal development in the tropics and midlatitudes. Researchers are building models to pinpoint the biggest dangers and help managers

to develop the most efficient conservation actions. “But it’s a data-hungry system,” says Andres. “So until we have the sources of information, it is hard to do.”

Van Gils also stresses the need to find the mechanisms driving the declines, which he expects to worsen, given the unrivalled warming rates seen in the Arctic. “For knots, there is no way out — they are already at the northern edge of the world,” says van Gils, who predicts that many knot subspecies will collapse over the next 50 years because of warming and trophic mismatches.

For now, the shorebirds are back in the sunny southern climes, settled onto beaches and wetlands often shared with tourists, shrimp farmers and hunters. Rausch and Smith have hung up their waders and are back at their desks, drawing up plans for the camps and aircraft that they’ll use to catch up with the shorebirds in the Arctic again next June.

One priority is to send a nest-hunting crew to Prince Charles Island in northwestern Hudson Bay, which was alive with shorebirds when it was last surveyed in the 1990s. Rausch and Smith flew there to scope out locations for a research camp in late July, and as their plane came in to land, they spotted one species they had hoped not to see, says Smith: “The island was covered with breeding geese.” ■

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1. North American Bird Conservation Initiative. *The State of North America’s Birds 2016* (Environment and Climate Change Canada, 2016).
2. van Gils, J. A. et al. *Science* **352**, 819–821 (2016).
3. Canadian Ice Service. *North American Arctic Waters Spring 2016* (Environment and Climate Change Canada, 2016).
4. Flemming, S. A., Calvert, A., Nol, E. & Smith, P. A. *Environ. Rev.* **24**, 393–402 (2016).
5. Abraham, K. F. et al. *Arctic Antarctic Alpine Res.* **37**, 269–275 (2005).
6. Koons, D. N., Rockwell, R. F. & Aubrey, L. M. *J. Anim. Ecol.* **83**, 365–374 (2014).