MIGRATION

The Golden Age of Tracking

HOW TINY DEVICES KNOWN AS GEOLOCATORS ARE UNLOCKING

SONGBIRD-SIZE: Contributing editor Julie Craves placed this geolocator on a Gray Catbird in Michigan in September 2011. The stem at top holds a light sensor, while the watertight casing below encloses a clock, battery, and microprocessor. A leg-loop harness made of Kevlar holds the device in place on a bird's back. Each geolocator carries a unique number.

BEJEWELED: A Northern Wheatear rests in a researcher's hand in Alaska. Bands adorn its legs, and the stem of a geolocator (arrow) peeks out between its wings. Studies employing geolocators have confirmed that wheatears make the longest known migration of any songbird.

Heiko Schmaljohann; Julie Craves (far left)

THE BIGGEST SECRETS OF BIRD MIGRATION

by Anne Murray

The steep headland at Point Reyes, California, is wrapped in mist and salt spray, and heavy surf pounds the rocks below. Monterey cypresses once planted as a shelterbelt stand bent and twisted by the prevailing breeze.

You might not expect to find songbirds here, at one of the windiest points on America's Pacific coast, yet several hardy Golden-crowned Sparrows are foraging among shrubs on the cliff top.

Common in winter in the western states and clearly accustomed to bleak weather, the species was until recently almost unstudied. Its nest was one of the last among North American songbirds to be described scientifically, and the breeding location of the Point Reyes birds remained a mystery until researchers at nearby Palomarin Field Station fitted the birds with a revolutionary new tracking device, one that is rapidly changing our knowledge of bird migration.

The breakthrough came thanks to a tiny battery-powered gizmo known as a geolocator. Embedded in an innocuous tag that sits harmlessly on the back of owls, warblers, swifts, and other far-flying birds, as well as sparrows, it does a simple task very, very well: It records sunlight levels at regular intervals.

The data it logs permit the position of a bird to be calculated, since day length varies with latitude and solar noon varies with longitude. Plotted over time, the

positions offer researchers fascinating insights into migratory connectivity — how different locations are linked within a bird's lifecycle. Even more important, by revealing the winter, stopover, and breeding locations of different species and subspecies, the geolocator promises to be a powerful bird-conservation tool around the world.

A major development

Ever since humans noticed the comings and goings of birds through the seasons, we've wanted to know more. Bird banding has been a remarkable information source for more than a century, yet only a small fraction of banded birds are ever re-encountered. Satellite telemetry has been the gold standard of tracking in the space age, but transmitters are expensive and too heavy for songbirds. Consequently, the invention of small, archival, light-sensing geolocators is a major development.

Engineer James Fox, formerly of the British Antarctic Survey, was the first to adapt geolocators for songbirds. He credits his British Antarctic Survey colleague Vsevolod Afanasyev with the invention of the technology, which was initially used to track Wandering Albatrosses and other seabirds in the southern oceans. "It took a long time for the technology to go across from the marine community," Fox told me.

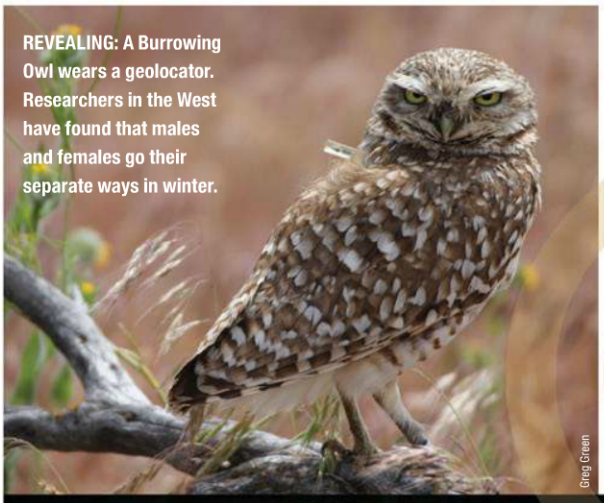
Bridget Stutchbury, Canada Research Chair in Ecology and Conservation Biology at York University in Ontario and author of the 2009 book *Silence of the Songbirds,* realized the potential for songbird tracking and collaborated with Fox on the development of miniaturized geolocators. To be successful, Fox had to squeeze a clock, battery, light sensor, and microprocessor into a tiny package, lightweight enough for a small bird to wear without distress and with no impact on flight performance.

His latest models weigh only 0.018 oz. (0.5 g). Seabirds and shorebirds generally carry a geolocator on a leg, but that does not work for small birds. "The first breakthrough for songbirds was putting the light sensor on a stalk," he says. This allows the geolocator to be carried in a backpack harness on the rump, held in place by flexible loops around the legs. The light sensor pokes out from the back feathers.

The primary limitation now is expense. Each geolocator costs $200, and recovery rates are generally less than 20 percent of tags per study.

Opening the door

Ornithologist Nat Seavy, a research director with PRBO Conservation Science, a nonprofit research group formerly known as Point Reyes Bird Observatory, led the effort to track the Golden-crowned Sparrows of Point Reyes. "When Bridget



REVEALING: A Burrowing Owl wears a geolocator. Researchers in the West have found that males and females go their separate ways in winter.

Greg Green

"TRACKING THEIR MIGRATION SHOWS WHAT A SMALL WORLD IT IS TO THE BIRD."

TIME TO GO: In Utah, Markus Mika, science director of HawkWatch International, holds a Flammulated Owl that has just received a geolocator. He released the owl moments later.

Mike Shaw

Stutchbury's first paper was published [in February 2009], everyone was blown away," he says. "Until recently, migration tracking was limited by transmitter size, which meant the birds had to weigh 400 to 9,000 grams (0.9 to 20 pounds). Bridget's work was the first opening of the door to a large number of other birds, such as sparrows, in the 30- to 400-gram (1- to 14-oz.) size range."

Stutchbury fitted 14 Wood Thrushes and 20 Purple Martins with geolocators. Five thrushes and two martins were recaptured the following spring. The data they logged revealed that their return flights from the tropics had been two to six times faster than their fall trips.

Other researchers quickly put the new technology to use, and the mysteries of migration began to unravel. The Amazonian wintering grounds of Black Swift and Eastern Willet were located; the amazing, transoceanic, loop migration of Pacific Golden-Plover was discovered; and Red Knots were tracked from the Arctic to Atlantic Oceans. (See the sidebar, page 23, for more.)

Behavioral information also emerged: Spring migrants show an urgency that contrasts with a much more relaxed pace in fall, and shorebirds make long detours to avoid tropical storms and Atlantic headwinds. Subspecies variation in thrushes is being explored by finding differences in migratory stopover locations.

Joe Smith, a biologist with the Nature Conservancy, is one of the many investigators who are excited by the new technology. "This is the golden age of tracking," he says. "Everyone is learning, success is hard won, and the technique has not evened out into standard practice."

Smith is using geolocators to investigate the eastern semipalmata subspecies of Willet, a long-lived, medium-size shorebird with a characteristic broad white wing stripe. The subspecies is virtually unstudied, and its wintering range is not well understood.

Willets mate for life. Once close to extinction, populations have slowly rebounded, and they now have a good rate of return to nest sites, which makes refinding birds possible. For three years, Smith has been fitting geolocators on nesting Willets in southern New Jersey and trying to catch them when they return. The birds, however, soon learn what he is up to and change their habits to avoid him. Consequently, he and his colleagues spend a lot of time wading in salt marshes with large nets, trying to outwit the Willets.

"Tracking their migration shows what a small world it is to the bird," he says. In late June, after nesting in a salt marsh on the shores of Delaware Bay, the Willets move south, avoiding hurricane season. Strong fliers with long, narrow wings, they travel direct and nonstop for four days, over 2,000 miles (3,200 km) of Atlantic Ocean. After a brief stop in Surinam, the birds continue on for 800 more miles (1,290 km) to the north coast of Brazil.

They spend eight months of the year in remote mangrove forests along the coast. Smith has a hunch that the Surinam stop may coincide with a food-availability event akin to Delaware Bay's horseshoe-crab spawn, providing a source of energy to be used when the birds molt. Their return flight is equally direct and fast — nonstop from Brazil to the Florida or Georgia coast, then a hop to New Jersey on trade winds — taking a week to 10 days and arriving at the nesting grounds in late April.

The discovery that Eastern Willets converge on a relatively small area in Brazil illustrates the important conservation value of tracking. Smith worries that the mangrove swamps they frequent could be at risk from the spread of shrimp farms along the coast. He has also detected mercury in their feathers, perhaps from upstream mining operations.

> "BY REVEALING THE WINTER, STOPOVER, AND BREEDING LOCATIONS OF DIFFERENT SPECIES AND SUBSPECIES, THE GEOLOCATOR PROMISES TO BE A POWERFUL BIRD-CONSERVATION TOOL AROUND THE WORLD."

Destinations vary

Not all birds congregate on their wintering grounds. Where Swainson's Thrushes that breed in the Pacific Northwest spend the winter depends on the subspecies. Kira Delmore, a graduate student at the University of British Columbia, has spent the last three years studying them.

I met Delmore on a damp autumn day, long after the last Swainson's Thrush of the year had departed for warmer lands. She explained that the thrushes are a good size for geolocator studies, as they weigh just over an ounce (30 g) and can carry a 0.03-oz. (0.9-g) instrument without aerodynamic disadvantage. Delmore uses only adult males for her studies, attracting the reclusive birds to her mist nests by song playback.

Thrushes are not the easiest birds to handle, she says. Placing tags on them is a challenge because they have "feathers everywhere," and like Eastern Willets, they become wary after being handled once. Although new birds can be caught within half an hour, recapturing them the following year took Delmore an average of four days. Of the 40 birds originally fitted with geolocators, she managed to catch 10, although one had lost its tag. "It can be very depressing when you spend days catching a bird," she says, "and he doesn't have the light sensor."

Fortunately, the remaining birds gave clear results. Coastal and inland populations of Swainson's Thrush winter in totally different areas, and the two subspecies follow separate routes to their wintering grounds. Birds of the russet-backed Pacific population from Vancouver's damp forests migrate to Central America down the west coast. In contrast, the olive-backed subspecies from east of the Cascade Mountains flies inland to Alabama and then over the Gulf of Mexico to Columbia. In spring, the subspecies flies north around the Gulf.

As an evolutionary ecologist, Delmore is curious whether hybrid birds take an intermediate route. Since this would

require the birds to cross barren deserts and high mountain peaks, it might result in fewer survivors returning to nest the following year, thus perpetuating the subspecies separation.

At Point Reyes, I watched Palomarin Field Station interns working the mist nets. The coastal scrub is a hotspot for sparrows, kinglets, and other songbirds that have flown south for the winter. "The rate at which knowledge of migratory connectivity is growing is absolutely exploding," Seavy told me.

The shelves in his office overflow with banding records dating back decades. He chose to study Golden-crowned Sparrow because "most geolocator work has been done on neotropical migrants breeding in North America and wintering south. It's exciting to look at a species on its wintering ground and track it to its breeding area."

Being able to work with a bird with good recovery rates was also an important consideration. Seavy and his team tagged 33 Golden-crowned Sparrows the first year and recaptured 11 birds the following winter. He was surprised to retrieve only four geolocators, however; it turns out that the sparrow's thick bill is powerful enough to peck through the Kevlar binding of a leg-loop harness. Nonetheless, he was pleased with the initial data. "With these 30 birds, we have learned more in one year than since we started banding in 1965."

He learned, in fact, where the Point Reyes sparrows breed. The geolocator data showed that they traveled more than 2,000 miles (3,200 km) south from the Gulf of Alaska. Their northern breeding locations spanned 750 miles (1,200 km) of coastline from the panhandle to the Alaskan Peninsula, a surprisingly wide distribution for birds that forage close to each other all winter.

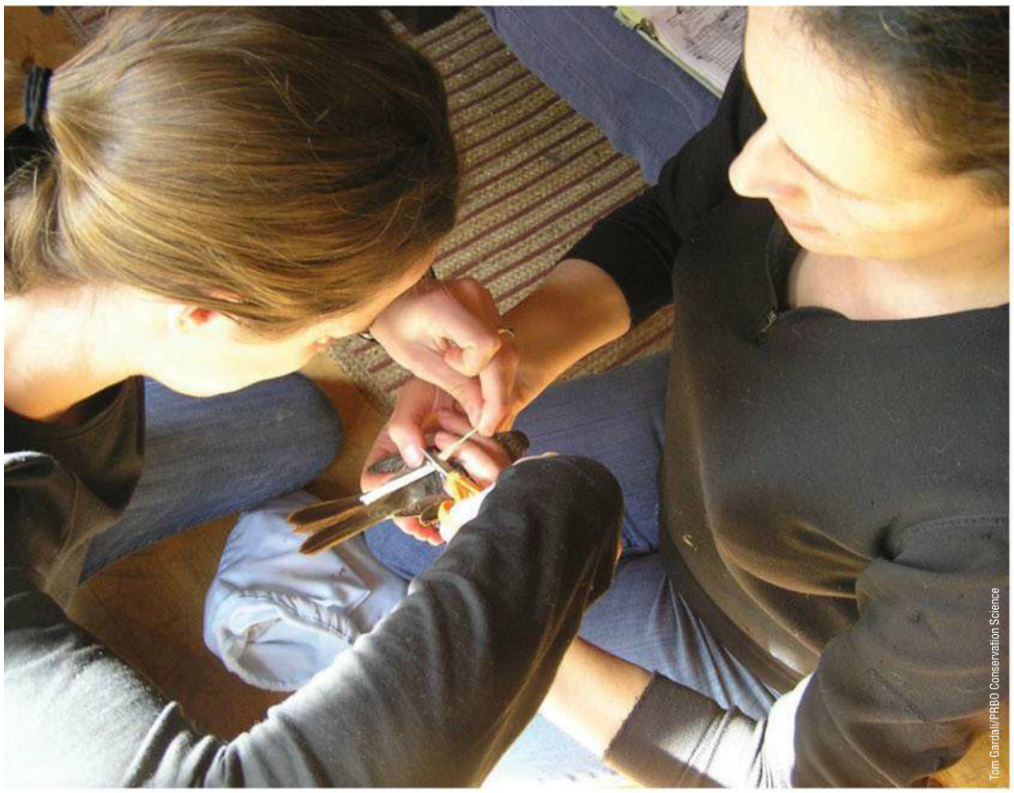
HEADED TO ALASKA: A Golden–crowned Sparrow in California pauses, its geolocator barely visible on its back.

The geolocators also revealed new information about the sparrows' route north. Three of the birds stopped at Cape Flattery in Washington State, a noted migration hub and the northwesternmost point of the lower 48 states, while the fourth flew farther inland. "What makes it amazing is how quickly we are finding out more," Seavy says. He is now working with an inland population of the sparrow, as well as wintering Hermit Thrush, a softer-billed bird that cannot peck through Kevlar.

Geolocators do have limitations. Light-level data can be obscured by cloudiness, foliage, and other sources of shade. Latitude readings can be uncertain, especially during the spring and autumn equinoxes, when day and night are the same length. And shrinking the size of the geolocator to fit smaller birds increases the risk of water damage.

Nonetheless, the technology's ability to deliver new information on numerous species will continue to teach us about the amazing migrations of birds. The Eastern Willets of New Jersey, Vancouver's Swainson's Thrushes, and the Golden-crowned Sparrows of Point Reyes all make astounding migratory journeys. Tracking them has opened a fascinating window on the world of birds.

Anne Murray is the author of A Nature Guide to Boundary Bay *and* Tracing Our Past: A Heritage Guide to Boundary Bay *(Nature Guides B.C.). She described Drayton Harbor in Blaine, Washington, Hotspot Near You No. 149, in December 2012.*



HOLD STILL: Reneé Cormier (left) and Diana Humple (right), researchers with PRBO Conservation Science, place a geolocator on a Golden-crowned Sparrow. The tracking devices revealed the bird's breeding area in Alaska.

10 huge discoveries uncovered with small geolocators

1. Northern Wheatear

Three birds have confirmed the astonishing migratory routes of Northern Wheatear. A bird from Baffin Island in northeastern Canada crossed the Atlantic to winter in western sub-Saharan Africa, and two wheatears tagged north of Fairbanks, Alaska, flew over the Bering Sea and through northern Russia and Kazakhstan before crossing the Arabian Desert to wintering areas in Sudan, Uganda, or Kenya. The Alaskan birds' average round-trip distance — 18,640 miles (30,000 km) — is the longest known migration of any songbird.

2. Burrowing Owl

Males and females that breed in Washington and Oregon spend winters far apart. In a study in which 25 geolocators were recovered from 93 tagged owls, researchers found that most females flew south to California for winter, while most males wintered in eastern Washington; males that nested in Oregon flew *north* in fall. The scientists say males choose to stay close to their breeding areas so they can get back to their territories quickly in spring.

3. Rusty Blackbird

A previously unknown migration route was uncovered when three tagged blackbirds were recaptured in 2010 at nesting areas near Anchorage, Alaska. The birds migrated through the central provinces and states and used stopover sites in Saskatchewan, the Dakotas, and Iowa. Fall migration lasted 72 to 84 days, while the spring trip was completed in 16 to 30 days.

4. Wood Thrush

Tagged thrushes that were recaptured two years in a row at breeding sites in Pennsylvania did not follow the same migration route from their wintering areas in Costa Rica each year, possibly due to the effects of wind, stopover habitat, and each bird's physical condition. The date they began migrating didn't change much, however. Each bird departed within about three days of the date it left the year before, suggesting that a strong internal schedule drives the urge to fly north.

5. Gray Catbird

Birds tagged in parks near Washington, D.C., spent the winter in southern Florida or Cuba. Researchers reported that the finding supports data accumulated over decades of banding work: that catbirds breeding near the East Coast winter in Florida and the Caribbean, while catbirds breeding in the Midwest winter in Mexico and Central America.

6. Flammulated Owl

A long-suspected wintering area in southern Mexico was confirmed in 2011, when four tagged owls were recovered near their breeding areas in central Colorado. The birds covered the 1,500-mile (2,500-km) distance in one to two weeks in fall; the return flight took a month or more. In northern Utah, HawkWatch International tagged 24 owls in 2012; when the birds return this spring, their geolocators should provide more information about wintering areas and migration routes. Stay tuned.

7. Snow Bunting

Spring migration lasts about 12 days longer than fall migration, according to new data from geolocators worn by 13 Snow Buntings that nest on East Bay Island in northern Hudson Bay. The finding is highly unusual because most songbirds fly north in spring much faster than they fly south in fall. Scientists say the birds appear to make long stopovers, possibly in large groups that enable individual buntings the best chance to avoid predation by Peregrine Falcons.

8. Black Swift

Winter records of northern Black Swifts were nonexistent until researchers at the Rocky Mountain Bird Observatory tracked them with geolocators. They discovered that the birds fly 4,350 miles (7,000 km) south, from Colorado to lowland rainforests in western Brazil, at an average speed of 212 miles (341 km) per day.

9. Pacific Golden-Plover

The large shorebirds set ground-speed records of 60 mph as they flew 9,900 to 14,900 miles (16,000 to 24,000 km) on a previously unknown circular migration route around the Pacific Ocean. The birds flew from American Samoa in the South Pacific to a stopover in Japan before completing their trip to Alaska. The return flight from Alaska to American Samoa lasted just six and a half days.

10. Purple Martin

Birds of the eastern subis subspecies were tagged in far-flung breeding sites in Pennsylvania, New Jersey, Minnesota, Virginia, South Dakota, Oklahoma, and Texas. When their geolocators were retrieved, the data revealed a surprise: The birds share a broad, overlapping wintering area along the Amazon River in northern Brazil. In contrast, martins from the western arboricola subspecies appear to have a distinct wintering region in southeastern Brazil, approximately 1,800 miles (3,000 km) from the core wintering region of the eastern subspecies.

More online

Find links to research papers describing these discoveries, as well as links to our past articles about geolocators.
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➔Have you found a bird with a geolocator? Check for an email address on the device to notify the researchers.