

# Atlantic Crossings

by

Sorcha McDonagh

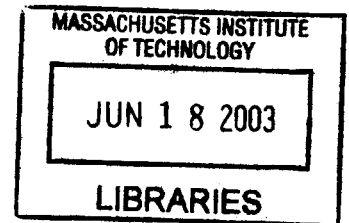
B.A. Communications Studies  
Dublin City University, 1995

SUBMITTED TO THE PROGRAM IN WRITING AND HUMANISTIC  
STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF

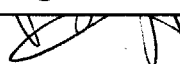
MASTER OF SCIENCE IN SCIENCE WRITING  
AT THE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SEPTEMBER 2003

© Sorcha McDonagh. All rights reserved.



The author hereby grants to MIT permission to reproduce  
and to distribute publicly paper and electronic  
copies of this thesis document in whole or in part.

Signature of Author: Signature Redacted  
 Department of Writing and Humanistic Studies  
June 9, 2003

Accepted by: Signature Redacted  
Robert Kanigel  
Advisor/Professor of Science Writing  
Director, Graduate Program in Science Writing

**ARCHIVES**



# Atlantic Crossings

by

Sorcha McDonagh

Submitted to the Department of Writing and Humanistic Studies  
on June 9, 2003 in Partial Fulfillment of the  
Requirements for the Degree of Master of Science in  
Science Writing

## ABSTRACT

Since 1999, I have crossed the North Atlantic 36 times. Eighteen times westbound, flying through daylight to an American afternoon; eighteen times eastbound, flying through darkness to an Irish morning. It is a short and easy journey, only five to seven hours each way, made in the comfort of a heavy jet.

For most of us, the Atlantic is no longer the awesome barrier that it was for our ancestors. For animals, the birds and fish who have been crossing the ocean for thousands of years, the journey has changed little with time. The Atlantic embodies the power and elegance of nature. In its stillness and storms, the ocean wears the successes and failures of human endeavor.

“Atlantic Crossings” is the story of three journeys by people and creatures over the water; contemporary journeys that are rooted in history. It is part of what I hope will eventually be a book.

Thesis Supervisor: Robert Kanigel  
Title: Director, Graduate Program in Science Writing



## *Acknowledgements*

---

I am grateful to everyone who spoke with me and shared their expertise for *Atlantic Crossings*.

Captain Lou Burns, formerly with TWA and American Airlines.

Dr. Bill Grider, aviator and owner of Kokomo Dental.

Bill Cox, ferry pilot and senior editor at *Plane & Pilot* magazine.

At the Communications Control Center in Ballygirreen, County Clare: Ruairi Ó'Brolacháin, Tony Woods, Frankie Rice, John Finan, and the many other radio officers who made me feel welcome; and especially John Power, for being so generous with his time and knowledge.

At Shannon Airport, County Limerick: Lilian Cassin, Jim Murphy, John Fitzgerald, and Dan Ryan.

James Orr and Dr. James Robinson of the Wildfowl and Wetlands Trust.

Jill Crosher of Birdwatch Ireland.

Dr. Molly Lutcavage of the New England Aquarium.

Lieutenant Marshall Stelzriede who served in the 96<sup>th</sup> Heavy Bomb Group, 338<sup>th</sup> Squadron, Eighth Air Force, during World War II.

I send my love and heartfelt thanks to family, friends, and mentors who have helped me over the years and during my time at MIT: Elizabeth Cronin; Professor Alan Lightman; Professor Boyce Rensberger; Professor B.D. Colen; Christina Starodoj Cosgrove; my classmates; Sarah Merrow; my parents, Anne and Pat; my brothers, Richard and David; Lorcan; Finny; and Professor Robert Kanigel.

Sorcha McDonagh  
June 9, 2003



*For my parents, Anne and Pat*





**I**t is mid-August, and the weather is beginning to change on Ellesmere Island in the northeast reaches of Canada. A pair of geese, their four feisty offspring close by, are feeding on grass, moss, and lichens, the rich vegetation of the Arctic tundra. With eyes like black pearls the birds look upon a breathtaking landscape: the rocky ground above the timberline; the lakes of glacial water; the plant life of burnt umber and dark green. A pure wind ruffles the birds' gray-brown feathers and fleeting circles break on the water as a light rain falls.

The pair of light-bellied Brent geese came here in early June to breed. They made a nest in a shallow depression out on the open tundra and lined it with moss, grass, and plenty of down to keep their eggs warm. Within a month, four goslings emerged from the yellow-white eggs. As a precocial species—one that is highly independent soon after birth—the newly-hatched goslings were capable of walking within hours and quickly followed their parents to feeding areas to graze for themselves. They have since been growing steadily, smooth flight feathers replacing fuzzy gosling down. The family has survived the short Arctic summer, avoided the bullets of Inuit hunters. Now, with the onset of fall, they know it is time to leave.

Ellesmere Island is part of Nunavut, a vast archipelago in northeastern Canada. Like all of the Nunavut islands, Ellesmere lies inside

the Arctic Circle, the cap-like section of Earth's sphere that sits above 66 degrees north of the Equator. During the summer, these islands are home to the millions of migratory water birds that come here annually to breed: hardy little waders like the knot and turnstone, raucous seabirds like the ivory gull and snow goose. They are visitors from around the world and, now sensing the arrival of fall, they are all preparing to fly home. The species will disperse by hundreds of routes, all heading south to warmer winters—some to the United States, some to Japan, some to Caribbean islands. But the light-bellied Brent geese will make one of the most hazardous journeys of all, the longest and most dangerous migration of all goose species: to reach Ireland, their winter home, they will cross the North Atlantic.

Of all the goose species nesting in the Canadian Arctic, only the light-bellied Brent goose makes the transatlantic journey. This population of 20,000 birds spends seven months of the year in Ireland and two and a half months in the Arctic tundra. The remaining time is spent traveling between these wintering and breeding grounds, which are about 2,500 miles apart. They follow an ancestral route, taught by parents to offspring for thousands of generations, and have an innate sense of when to prepare for departure. In what is known as the hyperphagia phase, they eat massive amounts of grass to build up their body fat—the fuel for the journey—increasing their weight by 25 to 50 percent. When they feel that their body mass is right, when the weather begins to change, and when the winds are with them, it is time to go. The urge to take flight is irresistible.

That day has come for the light-bellied Brent family. Only a month ago, the pair's offspring were bumbling goslings; now, almost fully grown, they are taking on a colossal journey. With wingspans of just over three feet, the six geese take to the air. They head off in a southeast direction, quickly climbing to an altitude of 3,000 feet, juveniles following parents. If

everything goes well, the family—flying in a sloppy V-formation—will arrive at their final destination, Northern Ireland, one and a half months from now. They will have crossed the Atlantic on nothing but their own power, their own black feathered wings.



The Kokomo Dental Center is a low, red-brick building by a highway in Kokomo, Indiana, about 60 miles north of Indianapolis. “You can sit up now and spit,” Dr. Bill Grider says to his patient. Grider is rotund, with a buzz cut, his cheeks slightly flushed, and he speaks kindly in a Midwestern accent. A small motor burrs as he raises the dental chair to a sitting position. It was a nice job—the last filling of the day. The last filling he’d do before taking *Tweety Bird*, his single-engine, four-seat airplane, across the North Atlantic. “She’s a cutie. She’s a cream puff,” Grider says. “I love my *Tweety Bird*.” He was planning to fly from Kokomo to Paris, to eat chocolate éclairs in a sidewalk café, to cross the Atlantic and make what he calls “the granddaddy of all aviation trips.”

It is a trip Grider has been planning for six years, and he is marking his departure with a huge party. On June 15<sup>th</sup>, 2002, the day before his flight, three hundred people arrive at his private hangar at Kokomo Municipal Airport. The airport is small, with no control tower or scheduled services; it mostly serves privately-owned light aircraft like Grider’s. His hangar is impressive, the walls covered with World War II memorabilia—army-green airplane parts painted with logos: “Cripes-a-mighty,” “Snooks 2<sup>nd</sup> Fresno California,” and “Lazy Lady,” a curvy poster girl with red lipstick. A dummy dressed as a soldier is suspended from the ceiling, his silky parachute hanging above him. Photos of aviation heroes like the Wright brothers and Eddie Rickenbacker are on the walls, and here and

there are pilots' jokes: "Remember when sex was safe and flying was dangerous?" "Pilots believe in clean living—they never drink from a dirty glass." The place is a pilot's haven, a private museum for aviation buffs.

The Mayor of Kokomo is at the party. So are the media—ABC affiliates, CBS affiliates, *The Kokomo Tribune*, *The Indianapolis Star* (the *Star* would later run the headline, "Tweety Bird to Carry Dentist Across the North Atlantic"). Ice sculptures of the Statue of Liberty and the Eiffel Tower melt slowly in the heat. Grider's twelve-strong ground crew—including a chief mechanic, pastor, director of communications, and French attaché—are all wearing yellow *Tweety Bird* shirts and North Atlantic Crossing baseball hats. Grider's mother, who has Alzheimer's disease, is Air Boss for the day. "Everybody at the party was kind of nervous," Grider would say later. "A lot of people didn't know what to say because they figured I was going to die and that'd be the last they'd see of me. They wanted to shake my hand, look me in the eyes and say it's good to know you and good luck. Then others had a twinkle in their eye because they thought they were in my will." The departure rites are far more elaborate than those of Charles Lindbergh, who remarked that his send-off was like a "funeral procession" on that gloomy morning in 1927 when he took off from New York. It is sunny today in Kokomo as the town Mayor declares June 16<sup>th</sup> "Official North Atlantic Crossing Day" and the 300-strong audience applauds.

Someone asks Grider if he will be scared. "Well heck yes," he replies. "You'd be a fool to cross the North Atlantic in a single-engine small airplane and not be scared."

The morning after the party, Grider and his hired co-pilot, Bill Cox, get ready to go. Cox is a senior editor at *Plane and Pilot* magazine, and he is also a professional ferry pilot—he gets paid to transport light aircraft on often-dangerous, long-haul journeys. Ferry pilots have a reputation for

being cavalier, but Cox simply seems relaxed, with no hint of bravado. At 62 years of age, he has 12,000 hours in his pilot's log book and has crossed the Atlantic 120 times in light aircraft. This is one of three "hand-holding" trips that he will make this summer—but Grider is firm on the matter of who is captain. Cox is the co-pilot, there for support, and his expertise will only be needed if there is an emergency. "I'm a low-time pilot," Grider explains. "If the weather gets bad, a man of experience might make the difference between... living or dying."

After steak and eggs, the traditional astronauts' breakfast, Captain Grider gets suited up for the flight. He lies down on the tarmac beside *Tweety Bird* and wriggles into his bright red Gumby suit, an outsized rubber suit for flotation and warmth in the event of ditching. In the breast pocket of his flight suit is the vacuum-packed Bible his father gave him years ago—protected in case Grider lands in the water—and around his neck is a six-foot-long white silk scarf. He bundles himself into *Tweety Bird*, like the Stay Puff marshmallow man squeezing himself into a Formula-1 racing car. Once Grider has sat down and peeled the Gumby suit off to his waist, Cox climbs in to sit in the right-hand seat. It is snug in the cockpit.

*Tweety Bird's* turbo engine starts with a gutsy rumble. Because of the extra fuel tank and survival gear on board, the plane is 350 pounds heavier than the normal permissible weight, putting it barely inside the flyable range. But *Tweety* performs well and leaves the ground at a gentle angle. Shortly after take-off, Grider tucks in the plane's wheels and makes a low-pass buzz to please the press. Flat Indiana lies below, with its grid of highways and neatly plowed fields, its Applebees, Cracker Barrels, and strip malls. One thousand miles to the east, Grider will cross the coastline and head out over the Atlantic Ocean. There, his real journey will begin.

Captain Lou Burns always carries his digital camera when he's traveling, and today he has decided to take some photographs of his crew by the Boeing 767. Three of the flight attendants stand on the rim of the plane's port-side engine—women in navy suits, framed by a thick metal circle, a black turbine fan behind them. The two first officers, Ian Duncan and Jim Taft, stand beaming in the foreground. "I'll take one of you," Taft says, taking the camera from Burns. They walk around to the starboard side and Burns stands by the front landing gear, the airplane's nose looming over him. The 59-year-old pilot looks smart in his night-blue uniform. Four silver bands are embroidered on each cuff of Burns' jacket, a sign of his rank, and a simple pewter wings badge is pinned on the breast. He is relaxed and smiling, speaking in those husky tones, the seasoned pilot's voice of reason and cool. It is a mild September day at Gatwick Airport, just outside London, England; a fine morning for flying. The crew is bound for St. Louis Airport, Missouri—a nine-hour journey from Gatwick under today's conditions with just a light headwind forecast for their cruising altitude. It should be a smooth flight.

None of his crew knows it, but today is a special occasion for Burns. It will be his 2,137th time crossing the Atlantic Ocean—and the last time he makes the journey at the helm. With 24,000 flight hours in his pilot's log book, clocked up in 38 years of transatlantic flying, he is taking early retirement from American Airlines. For him, the crossing is routine, his workplace a jetliner barreling from one continent to another, six and a half miles above the Atlantic Ocean. He has been flying the St. Louis-Gatwick route for a year, making a return trip four times a month. He has never thought much about how much time he has spent over the water, but it is something on the order of a thousand days, almost three years of his life.

When Burns addresses his 165 passengers over the intercom, he does not tell them that this is his last crossing. He wants “to go out quietly, to sneak away,” he says. So it is with little sense of ceremony that he pushes back from the gate and makes the slow, jouncing taxi to runway 26L, the left-hand one of a pair of runways that has a roughly westerly heading, 260°. A faded orange wind sock nods and bobs, flaccid on this calm morning, and rabbits darting around on the grass between the taxiways ignore the giant 767 rolling by.

Burns steers onto the runway, a gray, jewel-lined strip. Sparkling white lights on the edges and center line give way to ruby warning lights near the runway’s threshold, over a mile and a half away. As Burns opens the throttle, an ear-splitting bass noise bursts from the engines and the plane courses down the runway, the tremendous thrust pushing all aboard back into their seats. At 155 knots, or roughly 190 miles per hour, a lifting force is generated by the movement of air over the wings and the difference in pressure between the wings’ upper and lower surfaces. The plane leaves the ground, 180 airborne tons about to make the Atlantic crossing.

There is nothing unusual about any of this. Every day, about 900 commercial aircraft go through the same routine as they depart to cross what some call “the pond.” Several months later, when he looks back on the flight, Burns will say that it was just like every other trip he’s made: “It was less dramatic than I ever thought it would be. It was just another day at work.” In the back of the airplane, passengers read, look out the window, bless themselves, yawn widely to counteract the popping in their ears, or wait for the in-flight entertainment to begin. They are among the 160,000 or so passengers who will spend the afternoon this way, aloft over the Atlantic, the busiest transoceanic route in the world.

Past Penzance on the southwestern tip of England, where the English Channel meets the Atlantic Ocean, Burns looks out at the water, an

opalescent-gray flat before him. It will be the last journey in which he sees the Atlantic through the cockpit window. He switches off the seatbelt sign and takes out his newspaper.

From Captain Burns' window, six and a half miles above Earth's surface, the ocean looks smooth and constant with a fixed silver skin. But those who sail on the water, who fly low over its whitecaps, who live on its diverse coastlines—all know an ocean of moods.

I first took notice of the Atlantic when I was fourteen years old. I was on a summer holiday on Inis Mór, one of a family of three islands that sits just outside Galway Bay on the west coast of Ireland. On a blustery afternoon, I lay down on a cliff top on the island's west side, my head hanging over the edge, fingers gripping the ground for fear I'd blow away, watching the ocean hammering the rocks 200 feet below. Tipping my head up a little, I could see the subtle arc of the horizon in the distance. The ocean seemed endless and aggressive, instilling feelings of fear and longing—a nagging desire to face up to the distance, to have it somehow figure in my life. I suppose it was a hope for my future, a hope to one day live in the *world*, and not just in the confines of my neighborhood.

Ten years later, I moved from my home in Dublin to Boston. The crossing seemed too easy, 3,000 miles belittled by a heavy jet, the ocean looking subdued below. Now I go back to Ireland three times a year—even if only for a few days—ensconced in an airplane's cabin, eating a warm meal from a plastic tray, to stumble off jet-lagged but happy after five hours. I can stay close to Ireland and America. I do not have to give up one for the other.

I marvel at that. Only 150 years ago, Irish people who were starved by the potato famine and forced to immigrate to North America never saw



home again. It took them four to eight weeks to sail across the water—often in ramshackle vessels, the coffin ships, so named because of the thousands who died in the desperate conditions on board. For the 1.5 million people who survived the journey and made their way in North America, the ocean would remain a barrier separating them from Ireland for the rest of their lives.

Every American and European schoolchild knows the name of the “first” to discover the New World: Christopher Columbus, the Italian explorer who reached San Salvador in 1492, in his search for a new spice-trade route to the Orient. But it was the Viking Leif Eriksson who settled in North America long before Columbus arrived. Far north in the tenth century, Eriksson and his crew rowed and sailed their wooden longships to Newfoundland by way of Iceland and Greenland. Some believe that an Irish monk crossed the ocean in a boat covered with ox hides four centuries before the Vikings. The medieval manuscripts *Navigatio Sancti Brendani Abbatis* tell of the voyages of Saint Brendan, and some scholars have interpreted the details as suggestive of an Atlantic crossing: the pillars of crystal he saw might have been icebergs on the Labrador Sea, the fountains of fire volcanic activity on Iceland.

Whoever may have crossed the water first, it was not until after Columbus’ voyage that the volume of traffic between Europe and the New World began to grow. The ocean bore the thousands of Europeans who would surge across North America and the Africans who would be their slaves. It was a frontier in World War II, with gray military ships moving across in their droves. Five hundred years of Atlantic crossings have left hundreds of vessels on the ocean floor, the “treasury of human history” of which explorer Robert Ballard often speaks; the saltwater has absorbed the bodies of thousands, those drowned in wrecks or thrown overboard after dying of starvation or disease. In the past century, the ocean has carried a

new breed of adventurers: the Spanish aristocrat who spent four months crossing on a jet ski; the Frenchman who swam 3,700 miles in flippers; the Welsh school teacher who kayaked across; the American artists who took their three dogs over on a boat made of junk.

While we have fumbled, groped, sank, persisted—and ultimately prevailed—in our attempts to get across the ocean, animals carried on with the transatlantic journeys they had been making for tens of thousands of years. Migrating bluefin tuna travel between the Caribbean and Mediterranean seas. The Atlantic ridley, a gray turtle that is found in the Gulf of Mexico, is known to follow the warm Gulf Stream current east to Europe. Migratory birds like the light-bellied Brent goose spend summer and winter on opposite sides of the ocean. What they have long known how to do, we humans have just learned.

This is the chronicle of three journeys across the same great water.



With their long necks extended and feet tucked under their bodies, the geese have been flying for 16 hours without stopping. This massive effort has taken the family 800 miles across Baffin Bay to the west coast of Greenland, a fractal line where hundreds of fjords meet the North Atlantic water. It is summer and the snow has melted along the coast, revealing the fjords' high, rocky walls—but Baffin Bay is still a mosaic of light-blue ice floes. More than a mile deep at its deepest point, the bay is a frozen arm of the North Atlantic that reaches up into the Arctic Circle, meeting the Arctic Ocean in the narrow pass between Greenland and Ellesmere Island. It is a fractured seascape, so hostile that it is only fished—usually with traditional methods—by the native Inuit people. Few icebreakers pass through this stretch of ocean. It is remote and unspoiled.

The geese have propelled themselves across the ice-laden ocean at an average speed of 50 miles per hour. Like all migratory birds, the geese are especially strong fliers, making deep, measured wing beats. Their pectoral muscles (the breast meat), which power the wing movement, are larger than those of non-migratory birds. The pectoral muscle is often referred to as the “flight engine.” With its rich supply of blood vessels and mitochondria, the body’s energy-producing cells, this flight engine is highly efficient at utilizing the fuel from fat stores. (Fat is the ideal fuel because it is the most energy-rich storable substance, having twice as much energy as carbohydrates or proteins.) Even migrants’ wings tend to be longer and more pointed than those of sedentary birds, species that do not migrate.

Flying in a V-formation helps to reduce the overall workload for the family in flight. Cyclists in a pack know that the leader makes the greatest effort; the same principle applies for a flock of geese in the air. On their flight to Baffin Bay, the parents are taking turns in the lead position while the youngsters follow. The lead goose cuts through the air, reducing the amount of air resistance for the trailing birds. The lead goose also leaves turbulence in its wake, in the form of vortices, providing a boost for the birds in tow. Because of the complex aerodynamic forces in the V-formation, flying behind the lead bird saves an average of 17 percent of a goose’s energy compared with flying solo. The size of the flock is also a factor: a study of 56 Brent geese flying in formation found that the geese at the very back needed about 40 percent less energy to propel themselves than the leader.

After a full day and night of flying, the Brent family is ready to break formation and take a day’s rest before continuing on their southeasterly journey to Ireland. They settle on a rocky outcrop on Qeqertarsuaq, the largest island off Greenland’s west coast, inhabited by about a thousand people. This is old Viking territory, first explored a

thousand years ago by Eric the Red. For the Brents, the island is the first of several “staging areas,” the chain of stopover points that they will use on their migratory route. As they rest, they are vulnerable to hunters—according to the World Wildlife Federation in Canada, game accounts for 12 percent of the local people’s diet. Shooting light-bellied Brents is illegal, but ornithologists know that some birds are lost here each year. They are not sure how many.

As the Brents potter around with their webbed feet turned inwards, they do not look much like high-powered, long-distance fliers. They are small, stocky sea geese, about a foot tall, and they have a gentle nature—not rowdy or bossy like a swan, but hardy enough for the transatlantic migration. Their North-American name, “Brant,” is derived from the Norse word “brand,” which means “burnt,” a clue to the bird’s coloration. Its neck, head, and breast are black, its back is gray-brown, and its belly ranges from pale gray to nearly black, depending on the subspecies.

The color of the belly feathers is the primary means of classifying Brent geese. There are three subspecies: the light bellies, gray bellies, and dark bellies. These subspecies are divided among seven populations—groups that have separate migration routes—all of which breed in the Arctic Circle. After breeding, each population migrates to a different part of the globe: Ireland, the United States’ Pacific and Atlantic coasts, regions of the North Sea, Japan, Korea, and China.

By taking different migratory routes, the geese are exploiting global resources well; they are not putting too much pressure on any one area. This is one of the benefits of migration which has ensured the behavior’s perpetuity. Among birds, migration is the norm rather than the exception—it is a way of finding new food supplies and staying in comfortable temperatures year-round. The behavior has its roots in the end of the Ice Age, some 11,000 years ago. Picture the northern hemisphere, for instance.

As Earth began to warm and the ice caps receded northward, birds began to fly farther north in spring, searching for new feeding areas where there would be more space and less competition for food—better conditions for raising their young. When winter arrived, some species were able to cope with the lower temperatures and the winter food supply, so they stayed in their new territory, becoming year-round residents. But others had to return to the south in search of warmth and suitable nourishment. When summer—the breeding season—came around the next year, the southern birds were once again compelled to fly northward in search of good nesting conditions. It proved a successful routine, continuing through generations. Evolution selected for the successful migrants.

This theory, now largely supported by the ornithological community, is only about 200 years old. Until as recently as the late 18<sup>th</sup> century, Aristotle's theory about bird migration prevailed. Working around 350 BC, the Greek philosopher and naturalist postulated that some bird species disappeared in winter because they were hibernating. He also suggested that birds changed their appearance from one season to the next—so winter's robin became summer's redstart. Even Carolus Linnaeus, the Swedish botanist who gave us the binomial nomenclature for plants and animals in the 18<sup>th</sup> century, accepted the Aristotelian theory, suggesting that swallows hibernated beneath swamps during winter. Neither Aristotle nor Linnaeus imagined that birds might be involved in a massive annual cycle of movement around the globe, that a country might have summer and winter visitors.

For the light-bellied Brent geese, winter in Ireland offers a moderate climate and decent eating on mudflats and golf courses, while summer in the Arctic offers isolated breeding grounds with rich vegetation and comfortable weather. The transatlantic journey has continued because it has proven profitable for the species; it is now part of their life cycle. The urge

to migrate is driven by hormonal changes that occur in response to changes in the environment—the seasonal change in the weather, for example, or the change in the number of daylight hours. Both of these changes are called *zeitgebers*, the stimuli for setting the bird's biological clock. Ornithologists have found that migratory birds kept in captivity become restless around migration time, beating their wings as they sit on their perches, and even darting around in their cages. The term for this migratory drive is *Zugunruhe*, an amalgam of two German words: *zug* means “pull,” and *unruhe* means “restlessness.”

While the Brent geese know to migrate, the specific migratory route must be taught by parents, passed on from generation to generation. Young light-bellied Brent geese thus learn to get to Ireland by making stepping stones of Greenland and Iceland. They learn to take on the North Atlantic a piece at a time.

Having rested for a day on Qeqertarsuaq island, it is time for the geese to take on the 500-mile marathon across the Greenland ice sheet. Ice fields are among the six main barriers for migratory birds, as ornithologist Peter Berthold describes them, with the other five being mountain ranges, deserts, rain forests, bad-weather fronts, and oceans. Greenland is the largest island on Earth, with an area of 840,000 square miles, roughly one-fifth the area of the United States. Eighty-five percent of the island is covered by the largest single ice mass in the northern hemisphere. This is hostile territory, uninhabited, without roads; the only way to get across—should you want to—is by dog sled.

It took a satellite tracking project to find out exactly how the geese manage to traverse the ice sheet. In populous areas, networks of birdwatchers can build up a picture of a bird's migratory path—but parts of the light-bellied Brents' route are so remote, there are no people around to watch the geese pass. In 2002, researchers at Britain's Wildfowl and

Wetlands Trust tagged six geese and found that the birds got across Greenland by exploiting the ice sheet's topography: they took the low road, a depression between the sheet's northern and southern domes where the maximum elevation is 7,900 feet. The geese make a spectacular ten-hour journey through a valley of ice. Once through to the other side, on Greenland's east coast, they rest again for a day before setting out across the next stretch of ocean: 400 miles of the Denmark Strait, which lies between Greenland and Iceland.

Over the course of their journey, the light-bellied Brents avoid setting out over vast stretches of ocean. Staying as close to land as possible is the same strategy that pilots of small aircraft must use, for rest and refueling stops, and for somewhere to go in case of an emergency.

Bill Grider is at 11,000 feet over the Gulf of Saint Lawrence—between Quebec and Newfoundland—when *Tweety Bird's* engine stops. "Oh, shit," Grider says, his heart suddenly belting in his chest. Cox, his co-pilot, scans the instrument panel. There is no sound but the wind rushing over the wings; the plane begins to sink gently. They quickly figure out that the auxiliary fuel tank behind them has run dry sooner than expected, and that they need to switch over to the tanks in the wings. "I never had an engine quit before," Grider would say later. "That was a good experience. Not a big deal."

He and Cox are en route from Maine to Newfoundland, where they will set off on their first leg across the ocean. To reach the southern tip of Greenland, they will fly farther south than the geese did, 760 miles across the Labrador Strait—a journey that should take about seven hours at most. The route is a function of *Tweety Bird's* range. Because the airplane cannot carry enough fuel to make a journey straight across the ocean from the U.S.

to Paris, Grider and Cox will stop off in Greenland and Iceland. Today, the weather is perfect: the propeller and wings bite into cold, dense air, and visibility stretches to the horizon. There is not even a bump. Below is a landscape of cloud, pearly canyon lands with gulches, peaks, and veiny furrows. Through a cloud gap, Grider sees a ship cutting through the water below—but he would happily forgo the ocean view. “It’s goofy,” he says, “but over clouds I feel more relaxed and comfortable than looking down and seeing huge whitecaps and waves. Seeing fluffy clouds makes me think of being back home.”

Cox says that many pilots feel more nervous flying over water than over land: being out over the ocean makes them suddenly lose confidence in their airplane. “The airplane doesn’t know the difference; only the pilot does,” Cox says. Even so, if the engine does quit over land, it is often possible to glide to Earth and make a smooth landing—whereas over water, the only option is to splash down. “The big problem on the North Atlantic is the temperature of the water,” Cox explains. “If you go in, the chances of survival are minimal.” The temperature of the ocean is about 40 degrees Fahrenheit in summer and as low as 25 degrees in wintertime. Without a survival suit, you will die of exposure within minutes. Most of the souls lost when *Titanic* sank died not of drowning, but of hypothermia in the water, because the nearest ship in the area, the *Carpathia*, could not get to them quickly enough. Cox soberly reflects on losing over fifty friends in ferrying accidents over his 26 years of flying. “I accept that if everything goes against you,” he says, “there’s a really good chance that you’re not going to make it.”

Grider has different ideas, believing that he can improve his chances by carrying some 300 pounds of survival gear. “I decided that I was going to be the best-equipped, best-trained person to ever cross the Atlantic,” he says. “I wanted a fighting chance if I went down in the water, or on land, or



an iceberg. I was going to fight like hell to survive.” Most of the six years he spent preparing for the flight were taken up with selecting safety equipment. His obsession with it is striking. He has a military crash helmet, oxygen supply, Gumby survival suit, three kinds of Global Positioning equipment, a life raft (which he spent 1 ½ years researching before buying), a two-man tent, satellite telephone, flares, smoke bombs, laptop hookup, a survival vest with umpteen pockets for gadgets—including a safety-belt cutter, the world’s loudest whistle, toilet paper, fishing tackle, food rations, and an Emergency Locater Transponder. A marine going into battle carries less gear. Grider even took courses to learn how to escape an airplane that’s upside-down in the water and in complete darkness. Wearing a blindfold and with no oxygen supply, he practiced breaking his way out of a mock-up cockpit immersed in a cold swimming pool.

Cox, on the other hand, has brought an old Gumby suit which he is not wearing; instead, he’s wearing his cotton jump suit, black sneakers, and Ray-Bans for the whole trip. Despite his ferrying work, he has never taken a ditching survival course. “When you’ve done it 120 times as I have, there’s not a whole lot that you worry about much,” he says. “You come to a certain level of acceptance of the risk. Everyone still has a small amount of fear, but we get well paid for what we do.” In the nine hand-holding trips Cox has been paid to make across the North Atlantic so far, two of his employers changed their minds when they got to the coastline. Those that did make it across were usually jittery, he says. He tells of the South-African surgeon who threw up all over himself twice when he realized he was 600 miles away from land out over the North Atlantic; and the ABC cameraman who kept rigidly still, chalk-faced, for an entire flight once he realized what he’d gotten himself into.

They need not have been so afraid. “The perception of risk is out of proportion with the actual risk,” Cox says, “primarily because general-

aviation engines today are so reliable that it's unlikely you'll experience any kind of a failure going across." Cox compares the engine service time today with Lindbergh's time: where an aircraft engine today would need servicing only every 1,500 hours or more, a machine like Lindbergh's *Spirit of St. Louis* would have required maintenance every three- or four-hundred hours.

Bad weather, rather than engine failure, is much more likely to bring an airplane down on the crossing. In March 2001, two pilots from Provincetown, Massachusetts crashed just off the southwest coast of Iceland. They were on their way to London to compete in a round-the-world competition when their airplane succumbed to a combination of high winds and icing. Icing occurs when moisture collects on the plane's surface and freezes, forming an irregular crust of ice that disrupts the air flow around the aircraft; it can even jam the moveable wing- and tail-parts that enable a plane to turn, climb, and descend. The plane can become hard to control and the wings may even lose their ability to generate lift, causing the plane to drop out of the sky. Larger aircraft have deicing equipment, such as heated wings, but small planes like the Commander the Provincetown pilots were flying—and *Tweety Bird*—usually don't. They must avoid icing conditions altogether.

Icing is probably the greatest hazard facing pilots of light aircraft over the span of the North Atlantic, because both water vapor—in heavy cloud cover—and freezing temperatures are frequently found at their flight altitudes. High winds over the Denmark Strait and southern Greenland also present a problem. For example, pilots can misjudge the weather and end up with headwinds they hadn't bargained for. With a headwind, the plane does not cover as much ground, so the pilot runs the risk of running out of fuel well short of land. Grider sought to avoid this by planning to have three hours of fuel reserve by arrival at each destination, and by having strict weather "minimums" to begin with: for him to take off, the sky should be

clear of clouds and the headwind no greater than 30 knots. If the weather is below these minimums, Grider will not go. Migrating geese will also wait for bad weather to pass: they simply sit on the water's surface, riding the rolling waves until conditions are good enough for them to take to the air again. For pilots, waiting for conditions to improve can prolong the crossing, with only a couple of days' flying being tallied in weeks.

Grider and Cox have had no such delays so far. Having departed Goose Bay in Newfoundland seven hours ago, they have flown *Tweety Bird* 760 miles across Baffin Bay—a few hundred miles south of the goose family's route—and are now getting close to Narsarsuaq Airport on the southern tip of Greenland. The airport is in one of the most stunning locations in the world. It sits in a valley, at the foot of a glacier, and light aircraft reach it by flying through 48 miles of fjords—serene seawater-filled valleys with high, dusky walls. Because there is no air traffic control in the region, it is up to pilots to keep clear of other planes, which they do by communicating their position and intentions over a common radio frequency.

Sometimes a thick, milky fog obscures the fjords completely. When that happens, the Narsarsuaq approach becomes one of the six most difficult approaches in the world: it is like flying blind through a narrow corridor—usually no more than  $\frac{1}{4}$  of a mile wide—forcing pilots to depend exclusively on their instruments to navigate safely. The local aviation forecast, broadcast from Narsarsuaq Airport, tells pilots what conditions to expect in advance; those unfamiliar with the area are advised not to try making the fjord approach if visibility is less than five miles.

Fortunately for Grider, the weather is fine as he guides *Tweety Bird* through the fjords, 1,000 feet above the water, an azure, flat-calm surface speckled with ice shards. He says he didn't know what a fjord was before reading about Narsarsuaq. Now he is breathing heavily, concentrating on

keeping *Tweety* level—the plane is out of balance because of uneven fuel distribution in the wings—and staying on the right course. The display on Grider’s Global Positioning System receiver shows *Tweety Bird* as a small airplane icon on a meandering green line, the route through the fjords. It is a breathtakingly beautiful flight, more exhilarating than anything Grider has ever done.

Convoys of B-17 bombers and P-38 fighter planes followed the same path over fifty years ago during World War II. Narsarsuaq Airport, which went by the codename Blue West One in wartime, was the convoys’ first stop after crossing Baffin Bay. The airport was one of a string of military bases constructed in Newfoundland, Greenland, Iceland, and Scotland, all serving as refueling stops for fighter aircraft, troops, and armaments being ferried from the United States to Britain. This hop-skip-jump route across the North Atlantic, with no leg longer than 850 miles, was used by about 950 aircraft in 1942 and some 5,900 in 1944. The Allies regarded air transit as safer because the Atlantic shipping lanes were dogged by German U-boats. Establishing the northern air route was part of Operation Bolero, the run-up to Operation Overlord, the invasion of western Europe that began when Allied soldiers rushed in their thousands onto the beaches of Normandy.

Narsarsuaq is an especially pleasing destination for a WWII- and aviation-history buff like Grider. Lieutenant Marshall Stelzriede, a B-17 navigator who guided his crew to a safe landing at the remote military base, recalls what life was like there during the war: “The attitude of the GIs at Blue West One was the worst I have ever seen anywhere in the service, because of the poor environment there, with all of the snow and ice and the small area of the base,” he says. “The story was that two of the men there had walked over the hill to the ice cap at different times, and were never heard from again.”

Tonight, Grider and Cox are resting easy at Narsarsuaq, now a quiet airport used by ferry pilots and private pilots on their transatlantic adventures—a stopping point on what Cox likes to call “the usual milk-run route.” Following this route matters to Grider, as he says it is important for him to frame his journey in the history of aviation. He wishes to emulate the bravery of the Lafayette Esquadriille; the attention to detail of the Wright brothers; and the flamboyance of Roscoe Turner, a pre-WWII barnstormer. “Turner called himself a colonel though he was never in the military,” Grider explains. “He made himself his own little uniform: he always wore his britches, flying boots, a fancy hat. He was like a showman.” Turner thought it was important to dress the part. Grider concurs. He designed his own flight suit with seven patches, including a space-shuttle-mission-style patch for the North Atlantic crossing. “I’ll just say it like this: when I’m doing dentistry I dress like a dentist, I try to think like a dentist, and I perform like a dentist. When I’m a pilot I like to dress like a pilot, think like a pilot, and perform like a pilot,” Grider explains. “Getting in a uniform gets you to concentrate on what you’re doing.”

Silk stockings also help. Grider stuffed a pair into his flight helmet, borrowing a good-luck charm from the Lafayette Esquadriille, a group of American pilots who fought for the French during World War I. The stockings were procured from Paris by the French attaché on Grider’s ground crew—it was the attaché’s sole assignment. “I didn’t trust my fate to luck; on the other hand, I took every little bit of good luck with me I could,” Grider says. Apart from one incident of engine stalling, not much luck has been needed so far. The flight from Goose Bay to Narsarsuaq was the smoothest of Grider’s life.

After a night’s rest, he and Cox are ready to take *Tweety Bird* across the Greenland ice sheet to Reykjavik, Iceland. Narsarsuaq’s 6,000-foot runway has a six-degree slope: at its westerly end, its elevation is 112 feet,

while its easterly end, which faces a looming iceberg, is at just 11 feet. Grider takes off to the west, a downhill roll away from the glacier and towards the fjord. Before turning east to cross Greenland, pilots in light aircraft climb in a tight spiral to gain sufficient altitude to clear the glacier at the runway's end. The Greenland ice sheet, its southern dome at an elevation of 10,000 feet, lies ahead. They will cross just a thousand feet above it, staying within the comfortable breathing zone of the atmosphere. Another thousand feet up and the pilots will need their oxygen masks.

With their spiraling turns complete, Grider looks out at the frozen wilderness now laid out before him. The view reminds him of Superman's Fortress of Solitude, a glassy palace in a landscape of ice.

"Coffee, Lou? Ian?" a member of the cabin crew asks over the intercom. Burns puts down his copy of the *Herald* and pulls down the visor on the windshield, softening the glare of the Sun. He notices that there is newsprint on his fingers. First Officer Duncan is adjusting the high-frequency radio, bringing crackle, siren-like whoops, and occasional distant voices in and out of phase. They are relaxed, six and a half miles above Earth's surface, roaring along at 550 miles per hour, aloft in a world that extends to the horizon curving softly all around. The view is gorgeous, but it is not of the Atlantic; it is a topography of clouds that changes abruptly from torn cotton to smooth, vapor dunes.

The Boeing 767's wings flex lightly, up and down, buffeted by speed. Burns sips his coffee and listens to Duncan calling air traffic control. "Shanwick Radio, this is American 272I on 556I. Good afternoon."

"American 272I, good afternoon, go ahead," comes the reply through static and hum.

The voice is coming from a radio communication station in the countryside in the west of Ireland. Because there is no radar coverage over most of the ocean, air traffic controllers use radio to keep track of where the hundreds of aircraft are. Duncan and Burns are about to leave the Shanwick Oceanic control area of the North Atlantic, a one-million-square-mile airspace—one of four quadrants into which the North Atlantic is divided for air traffic control. The northwest quadrant is monitored from Gander, Newfoundland; the southwest, from New York; the southeast, from the Azores; and the northeast, from Prestwick, Scotland.

Prestwick is home to the air traffic controllers for Shanwick Oceanic, but these controllers do not communicate directly with the aircraft in their airspace. Instead, all communications are relayed to pilots by radio officers in the Shannon region of the west of Ireland (hence, “Shanwick”). The division of labor between radio officers and traffic controllers is the same in all the North Atlantic airspaces. This is because the high-frequency radio they use for talking to pilots can be temperamental; organizing traffic and trying to decipher often-garbled messages is too much work for one person to do quickly.

Only for the Shanwick quadrant, though, are the radio officers and controllers in different countries. This unusual arrangement came about because of an agreement between the British and Irish governments in 1966, when they decided to merge their separate North Atlantic air traffic control operations. Radio communications were based in the west of Ireland because high-frequency signals transmitted from there reach farther across the ocean than they would from Scotland. With the Irish taking care of communications, the Scots choreograph the traffic.

The Irish radio officers speak in an assortment of accents—Clare, Tipperary, Dublin, Limerick—lilting, flat, and soft. But all enunciate carefully. “You absolutely have to get the message right,” says officer

Gabriel Creeney, “or there’s disaster.” Creeney is one of sixty Shanwick radio officers, all men who began their careers at sea with the Irish Merchant Marine. Many of them spent months out on the Atlantic Ocean, in vast, open space with clean salt air. Now, they work eight-hour shifts in a low, pebbledash-covered building in the countryside, the Communications Control Center in Ballygirreen, County Clare. All of the officers are long-term staffers—some for more than thirty years. There is a sense here of a warm enclave, of bucolic ease, where everyone is settled and calm. Yet these officers are the link to Earth for hundreds of jets sawing noisily through the Atlantic sky.

“As communicators, the officers have to suppress the urge to be creative, because they don’t have the broad picture of what’s going on,” explains watch manager Ruairi Ó’Brolacháin, a jovial man in his early forties who speaks proudly of his line of work. “You want them to take the messages they get from the controller, pass them to the aircraft—and vice versa—and to do it accurately, quickly, and efficiently.” The controllers and radio officers communicate with each other through coded text messages exchanged on a computer network called the Automatic Fixed Telecommunications Network—a kind of tailor-made e-mail system.

Controlling the traffic is made easier by the fact that aircraft are not flying on a complex web of airways as they might be over Europe or the United States. Instead, they follow a neat set of tracks, invisible roads that lie side by side in the sky, each road at least sixty miles from the next. Every track is defined by about six waypoints, sets of coordinates which, over the water, are spaced at intervals of ten degrees of longitude. Today, Captain Burns is following an unusually southerly track: SOMAX, 50N20W, 50N30W, 49N40W, 46N50W, BANCS. Mark these waypoints on a map, join the dots, and you have an air highway connecting the English Channel and southern Newfoundland.



“Somax” is the name of the entry point onto the highway, at 50N15W, southwest of Ireland, and “Bancs” is the end of the highway, at 45N52W, just south of Newfoundland. All tracks’ beginning and end points have five-letter names rather than just coordinates, introduced in 2001 to help reduce errors. On the eastern side of the Atlantic, the waypoint labels were all computer-generated so that no label sounded too much like another—weighty words like DOGAL, MALOT, LIMRI, and NIBOG. Over by Newfoundland, the waypoint labels were hand-picked and given names of marine life, like SCROD, OYSTR, and CARPE.

Traffic is carefully arranged on each track. The aircraft might be following each other, ten minutes apart, at the same altitude—or they may be stacked at different altitudes, always with a vertical separation of 1,000 feet. (The separation minimums are smaller than they used to be, because today’s navigation equipment enables an airplane to hold a precise course.) Separation is critical because if one plane gets too close to another, it might catch the first plane’s wake: just as a speedboat churns water that can upend a water skier, a plane slicing through the air leaves fast-moving vortices behind that can flip a trailing aircraft on its back. It is the same sort of turbulence that geese flying in V-formation produce—but where the slow-moving wake turbulence of a goose gives a boost to the trailing birds, an airplane moving at 550 miles per hour causes potentially catastrophic disturbance. By placing the aircraft ten minutes apart, each plane’s wake turbulence dissipates long before it can cause a problem.

The invisible threat of wake turbulence makes it critical for pilots to follow proper procedure on their tracks. They have to get permission to change speed and altitude, and when they make a request, it is up to the controller to calculate whether or not it is feasible. Usually, pilots will ask to speed up or to get out of clear-air turbulence, fluctuating air currents that are sometimes found at cruising altitudes. When the request is processed,

the radio officer passes the response back to the pilot. Captain Burns has sometimes found the pass-the-baton system frustrating. He has gotten into rough turbulence and instead of being immediately granted permission to get out of it, the communication system meant waiting a few minutes. “If you’re getting into really heavy turbulence, you want to slow the airplane down,” he explains. “But you can’t talk directly to a controller—you have to talk to Ballygirreen, which has to communicate with Prestwick, and then come back to you with the message. By this time you’re really getting banged a lot.” Moderate turbulence, which Burns mostly experienced, is not serious, but severe turbulence can cause an airplane to bounce as much as hundreds of feet, putting massive stress on the plane’s structure, and sometimes causing serious injury to those on board. On the North Atlantic Track system, pilots are entitled to take evasive action themselves and move to the space between tracks using formal contingency procedures—like driving on the shoulder of a highway. They communicate their intentions over the emergency frequency for all nearby traffic to hear and then try to get out of the rough air. Once they are out of harm’s way, they can get back on track with the controller’s assistance.

Most transatlantic traffic, whether in the air, on the ocean’s surface, or beneath the water, is organized in tracks. Leviathan cargo ships plow the water in fixed shipping lanes, with separate furrows for east- and westbound traffic. Blue whales have migration corridors. Birds, like the light-bellied Brents, follow a loose track each year. Sea turtles propel themselves through long-established tunnels across the ocean. All of the traffic ebbs and flows—some in daily patterns, some annually—waves of creatures, people, and machines moving across the water, all at their own paces.

For the officers at Ballygirreen, the cycle of movement is a daily one. It gets busy at 3 am, when the first wave of eastbound traffic arrives in the Shanwick Oceanic air space. The rush continues until about 8 o’clock in the

morning, by which time all 450 or so flights will have passed through, filtered into different airspaces in Europe. For a time, their piece of sky is quiet. The traffic then begins to build again by about noon, when the westbound flights start piling into their airspace. On radar, the movement looks almost organic: watching the air space above and to the west of Ireland, the airplanes are small green markers, hoofing towards their tracks like cattle being herded through narrow gates, one by one. They must arrive at the gate at the expected time. If they don't, they'll be asked to make a wide, 360-degree turn, and re-enter. Once through the gate, the hardest work is done.

The aircraft will not be herded through the same gates every day, because the tracks are not fixed; instead, they change with the jet stream, the high-altitude, global wind system that races around the world in a generally westerly direction. The jet stream can make a difference of two to three hours between the lengths of west- and eastbound flights. On the way to North America, aircraft sometimes have to beat against a mighty headwind; on the way to Europe, they're riding surf that can travel at hundreds of miles per hour.

North Atlantic airspace controllers try to lay out tracks to get airplanes across in both directions with the greatest speed and least fuel consumption. In general, jet-stream patterns put flights from Europe to North America much further north than flights in the opposite direction. Every twelve hours, the controllers map out between five and eight tracks. The resulting "North Atlantic Track Picture" is distributed to all air traffic control centers that send traffic into the North Atlantic airspace, and to the airlines, so they can request the most economical tracks for their flights. The chart is labeled for the day of the year: 011 indicates January 11; 364 indicates December 30—unique identifiers to ensure that nobody uses the wrong chart. Taking the wrong track could lead to disaster.

While on the Atlantic crossing, some aircraft can transmit their position information to a satellite. But most pilots have to radio in a position report every ten degrees of longitude, about every 40 minutes for a heavy jet. Apart from these occasional communications with air traffic control, there normally isn't any need for the crew to pay close attention to the radio—but there has to be a way for radio officers to quickly get the crew's attention. Every plane in the world has a unique four-letter identification code. The radio officers at Ballygirreen punch in the four letters on a console, like dialing a telephone number, making a chime sound and a light flash in the plane's cockpit, getting the pilots' attention. The code is called the SELCAL, for Selective Calling. Early in the flight, the pilots and radio officers do a SELCAL check to make sure it is functioning. If it is defective, they'll have to listen closely to the radio for the entire flight—and that can be tiring, especially with a medium as temperamental as high-frequency radio.

“It's an old technology, and it's pretty rough and raspy at times,” says John Power, a watch manager at the Communications Control Center in Ballygirreen. As he stands in the center of the control room, he hears interference from the radio officers' work stations—a ceaseless, high-pitched fizz and warble that makes the Atlantic pilots sound as though they are communicating from the moon. It's the kind of noise that could put you in a bad mood. “But high-frequency radio is always there,” Power says. “It doesn't require satellites—it utilizes the ionosphere, so you might say it's a gift from nature.”

High-frequency signals are in the shortwave band, familiar territory for HAM radio operators. The signals travel long distances because they are refracted by the ionosphere, about 60 to 250 miles above Earth's surface. This atmospheric layer contains particles that have been charged by energy from the Sun. These charged particles, called ions, are the cause of the

signal refraction: they bend the signals back down towards Earth's surface, thousands of miles from the source. How the signals are refracted depends on the time of day, because the number of charged particles in the ionosphere varies with the amount of sunlight the layer is receiving. The variable nature of the ionosphere can lead to dire reception, complete blackouts, and anomalies. "Once, in the 'seventies, I thought I was being called by a Clipper [Pan Am] flight and I told it to go ahead," Power says. "But I received a position report with waypoints I didn't recognize. It turned out to be a Clipper all right, but it was over the Indian Ocean on its round-the-world trip. Both the pilot and I were surprised when we realized our unexpected communication was the result of freak radio conditions."

Some aircraft already have the Automatic Data Surveillance equipment that would replace HF radio. The technology has been available for ten years, but establishing standards necessary to get it on all airlines will be a chore, and the cost of installing ADS in airplanes is high (as much as \$100,000 per plane). In the long run, it would be less expensive for the airlines, because they are charged about \$36 each time they enter Shanwick Oceanic, a small fee that adds up when scheduling thousands of flights per year. For the Irish Aviation Authority and the British National Air Traffic Service, it is a good business: each year, they collect fees from as many as 330,000 flights.

The radio officers at Ballygirreen believe that most of them will lose their jobs—that only a few officers will be needed to monitor the emergency frequencies—but they do not agree on when. The estimates run from two to twenty years. Outside the center, watch manager Ruairi Ó'Brolacháin points out the new antennae that are being built, their support wires like faint pencil-drawn lines against the blue sky. There is no sound but birdsong and a breeze brushing reeds, no hint of the hundreds of voices coming in from the ocean. Ó'Brolacháin ponders his future. "I find the

transition difficult,” he says. “You’re used to doing one thing, and you’ve been doing it for a long period of time... I’m 48 now, and the thought of having to become as skilled as I am in this environment in something else...” His voice trails off. “I fear the future,” he says. Another officer, 32-year-old John Finan, describes his colleagues’ fate allegorically. “You remember how the musicians kept playing on the *Titanic* as it went down?” he asks. “Well, we are like that orchestra. We will be here until this place closes.”

Captain Burns has long since left Finan’s and Ó’Brolacháin’s airspace. For the last couple of hours Burns has been in the Gander Oceanic quadrant, in the hands of controllers in Newfoundland. With the Atlantic sparkling below him and the coastline of the United States in sight through a break in the clouds, Burns is ready to make a turn to the southeast towards St. Louis. “There’s Boston,” he says to his first officer, Ian Duncan. “That pisses me off, because it’s going to take me another seven hours to get back there!” They have been flying over the ocean for six hours; there are now another three hours to go to St. Louis. They cross the Atlantic coast and leave the ocean behind.

It is a still night, and to the north of the Greenland ice cap, the emerald veils of the aurora borealis are fluttering like ghosts. The Brent family is flying southeast, breaking the silence with the steady beating of their wings, with their panting, and with an occasional honk at one another. The sound races out into the night and echoes off the ice-canyon walls. This is the second leg of their journey to Ireland, a 500-mile flight across the ice sheet that will take the geese about ten hours to complete. They are bound for the fjords and bays near Ammassalik, an island on Greenland’s east coast.

Natives refer to the east coast as “Tunu,” the back side of the country, because it is so sparsely populated compared with the western seaboard.

The adult geese recognize the terrain below and know their way through the icy valley. They know the look of Baffin Bay, too, with its bluish ice floes; the jagged outline of Qeqertarsuaq; and the patchwork fields of Northern Ireland with the Mountains of Mourne to the south. The geese may even pick out the city lights of Reykjavik and Derry. This method of navigating by landmarks, known as piloting, is one of the first things that pilots of light aircraft learn. On cross-country flights, they look for landmarks that are easy to pick out from the air: intersecting highways, reservoirs, mountains.

Ornithologists think that birds form mental maps, much as people remember the prominent features of an oft-made journey. Even the stars feature in these maps—they are cosmic landmarks, familiar, sparkling arrangements on the velvet hemisphere above. Lindbergh and Columbus referred to the constellations on their Atlantic crossings, and there are yachtsmen who still navigate by the stars; some say it is more authentic, the mark of a true sailor. In his book, *Sea Change*, Peter Nichols writes with pride about using a sextant on his solo Atlantic crossing in a small yacht.

As well as using the stars as landmarks, birds use them to establish direction. The distinction between navigation and orientation is an important one: navigation means using landmarks and bearings to find something—like staging grounds or a food source—whereas orientation means knowing north from south. In the 1960s, behavioral ecologist Stephen Emlen released Indigo buntings in a planetarium, the northern sky displayed on its dome, and found that the birds turned to face the direction of their migration. When he rotated the dome image by 180 degrees, the buntings changed direction too. But when Emlen excluded the North Star and the region around it from the planetarium’s display, the birds became

confused. To test the birds' reliance on the North Star, Emlen blotted out the star itself and some other constellations from the rest of the sky. The birds all turned to face the right way, suggesting that the constellations *around* the North Star, which include *Draco* and *Ursa Minor* (of which the North Star is a part), mattered most to the buntings. This region of the night sky is their reference point, the anchor around which the sky seems to revolve.

The "star compass," as it is known, is one of three compasses that birds employ on their travels. The first one to be discovered was the Sun compass, over fifty years ago, when German ornithologist Gustav Kramer observed the behavior of caged starlings around the time they would normally migrate. The birds were restless, agitated by the migratory drive, the *Zugunruhe*. When they could see the Sun, they all tended to face in the direction of their migratory route. When the Sun was hidden by clouds, they did not all face the same way. But when Kramer used mirrors to change the direction of the Sun's rays, the birds all turned to face what they thought was their direction of migration, relative to the reflected light.

Kramer concluded that the starlings used sunlight as a directional reference. The theory made more sense when some of Kramer's colleagues found that birds' circadian rhythms enabled them to compensate for the Sun's changing position over the course of a day: they know where the Sun should be, and when. Starlings and carrier pigeons can use the Sun compass at the poles—even when the Sun does not set—and penguins use it as they slowly make their way across Antarctica's ice fields. Even the orange monarch butterfly orients itself by the Sun's position on its annual migration from the United States to Mexico and back.

The third compass birds have is magnetic, one that gives them a sense of north and south that is as natural as our sense of up and down. Biologists had long thought that birds could perceive Earth's magnetic field,



but it was not proven until 1968, by ornithologist Wolfgang Wiltschko and some European robins. By placing electrical coils in a bird cage, Wiltschko shifted the direction of the magnetic north inside the cage, fooling the birds.

Over thirty years later, we still don't know how birds perceive Earth's magnetic field. One theory is that a bird's photoreceptors, the light-sensitive cells in its eyes, may double as magnetoreceptors—cells that are sensitive to magnetic fields. It is likely that crystals of an iron ore called magnetite, found in the back of a bird's mouth, have some connection to birds' magnetic sense. Because Earth's magnetic field varies with location, getting stronger at the poles and weaker at the Equator, birds may be able to construct mental maps based on the planet's magnetic topography.

Together, the innate orientation skills and the acquired knowledge of the landscape—geographic, stellar, and magnetic—enable thousands of migrating species to cross Earth's diverse terrains every year. When the light-bellied Brent geese are flying over the ocean, where there are no landmarks, they depend entirely on their compasses. Which compass they use depends on the weather: on a cloudy day, for example, they are more likely to take directional cues from Earth's magnetic field than from the position of the Sun.

Beneath the choppy, North-Atlantic surface are ocean dwellers that also find their way with magnetic compasses. Sea turtles, which writer Deborah Cramer calls "itinerant mariners" in her book *Great Waters*, use Earth's magnetic field on their journey around the Sargasso Sea, the elliptical, seaweed-laden stretch of the North Atlantic between Florida and the Azores. Just as Wolfgang Wiltschko fooled robins by altering the magnetic field around them, in 2001 marine biologist Kenneth Lohmann tricked baby loggerhead turtles as they swam through a ring of electric coils, indicating their awareness of the magnetic field. Sharks, rays, and tuna

roaming the oceans all use lines of magnetic variation as signposts in their blue world. Some are transatlantic migrants: the bluefin tuna, for example, has swam 3,000 miles across the ocean in as little as forty days. Bluefins' migratory habits are not as predictable as those of the light-bellied Brents, though. Marine biologists are not sure what percentage of North Atlantic bluefins migrate across the Atlantic—or how often they make the journey.

Bluefin tuna, *Thunnus thynnus*, are rigid-bodied fish with smooth and shimmering gray-blue skin. They are the biggest, fastest, and strongest of all tuna species. About ten feet long when fully grown, they can reach speeds of 50 miles per hour—as fast as a migrating Brent goose—though 2-5 miles an hour is their more usual pace. They prey on small schooling fish, silver swarms of hakes, anchovies, mackerel, and sauries; and on red crabs and squid. The bluefin's flesh is deep pink, fatty, and succulent, favored by the Japanese for sushi and sashimi. In the Tokyo fish market, Tsukiji, where most of the world's bluefin catches are sold, a tuna can fetch between \$50,000 and \$80,000.

North Atlantic bluefin tuna are divided into two populations, east and west, with the dividing line 45 degrees west of the prime meridian. This artificial boundary was set in 1982 by ICCAT, the International Conservation Commission for Atlantic Tuna, for controlling bluefin fishing quotas at a time when the populations were in dangerous decline. The barrier reflects the old assumption that the east- and west-side populations are largely separate, with very little mixing between the two groups—seven percent at most—and that there is one spawning area on each side of the ocean. The eastern population apparently stayed close to the Americas, spending winter in the Gulf of Mexico, their warm spawning grounds, and traveling north near New England and Canada from June to November. On the western side, the winter spawning grounds are in the Mediterranean, and

the fish were said to spend summer off the coast of northern Europe, in the Bay of Biscay and as far north as Norway.

In reality, North Atlantic bluefins do not adhere to such neat migration routes, and they pay no heed to the ICCAT boundary line. In 1996, researchers from Stanford University in California began a five-year project to track the movements of bluefins and to learn more about their physiology. Dr. Barbara Block and her team put electronic tags on 377 tuna over the course of five winters and, by the end of the study in 2001, they had collected data from about one-third of the fish. Many of the bluefins were western residents. Others crossed the ocean, from west to east and back in the same year; or they headed east for the breeding season after spending a couple of years in the west. Some of these transatlantic travelers swam into the Mediterranean Sea. In the words of National Public Radio reporter Christopher Joyce, bluefin tuna “treat the entire Atlantic as their backyard.”

Research by Dr. Molly Lutcavage of the New England Aquarium in Boston complicates the picture further. In tracking data gathered from twelve bluefins between 1997 and 1999, four of the fish migrated from New England to the central and eastern ocean. During breeding time, the bluefins were not in known spawning areas, leading Lutcavage to believe that there may be spawning grounds biologists don't know about.

In all, the data suggests that bluefins have a range of migratory options: some on the north-south axis, on either side of the ocean, and some on the east-west axis—either to somewhere in middle of the Atlantic, or clear across it. These à-la-carte migrations are quite different to the routine journeys of the light-bellied Brent goose. Lutcavage thinks that gathering in schools to forage probably affects where the tuna end up. “Dispersal patterns associated with schooling pretty much guarantee that not all the

fish will do the same thing,” she says. The bluefins probably linger in areas when the feeding is good, and move on when supplies run low.

There is still not enough tagging data to know where all the bluefins go from year to year. Even so, Lutcavage and Block think they already have enough information to know that the fishery-management strategy is outdated. Because western bluefin stocks are thought to be more depleted than eastern stocks, the western quota is one-twelfth the size of the eastern quota (about 6 million pounds versus 70.5 million pounds). But if stocks fished by U.S. fishermen also visit the Mediterranean—and vice versa—then U.S. and European fishermen have a stake in each other’s fisheries. Block thinks the European quota exerts too much pressure on North Atlantic bluefins as a whole, and that it should be reduced for the health of tuna throughout the ocean.

Understanding animals’ migration patterns is necessary to protect them. To ensure the safety of the light-bellied Brent population on its 2,500-mile range, the British Wildfowl and Wetlands Trust is organizing a flyway management plan that involves the nations the geese fly over and where they stop to rest: Canada, Greenland, Iceland, and Ireland. Right now, the researchers are not sure how many of the 20,000 or so light-bellied Brents are lost on their migration, but a satellite tagging project in 2002 gave them a better idea of the dangers the birds face. They also learned more about the birds’ route, staging areas, and breeding sites.

The WWT tracked six geese over a period of about four months, covering their spring migration to the Nunavut Territory and their fall migration back to Ireland. All were robust-looking males, captured as they rested on their Icelandic staging grounds west of Reykjavik. The team secured a lightweight transmitter on each goose’s back, a device for uploading data about the goose’s location to a satellite at regular intervals.

The geese, named Kerry, Oscar, Arnthor, Austin, Hugh, and Major Rutledge, became minor celebrities. Their exploits were widely reported by the media, and thousands of British schoolchildren watched their progress through the WWT's Web site. There was no shortage of drama. Oscar never left Iceland; two children collecting eiderdown found him in Hjörsey, a small island in the north of the country. He was probably killed by a gyrfalcon. Kerry was found hanging upside-down in an Inuit hunter's fridge in the town of Resolute Bay on Nunavut's Cornwallis Island. The bird was still wearing its satellite transmitter, as the bemused hunter did not know what the device was. Arnthor and Austin are missing. Because Arnthor's transmitter stopped working very suddenly on Qeqertarsuaq island, off the west coast of Greenland, he may have been shot there by subsistence hunters. The batteries on Austin's transmitter ran out, and he has not been seen since.

Two of the Brents made it to Nunavut and then back to Ireland. But when spotted in Ireland in October, Hugh and Major Rutledge did not have mates or youngsters in tow. Dr. James Robinson, an ornithologist at the WWT's center in Slimbridge, England, says he is not sure whether the birds had been behaving like breeding birds in Nunavut or whether they were "just acting like adolescents, going up there for the first time and feeling their way around."

Robinson says he figured Brents were being shot in Greenland, but that neither he nor the Canadian Wildlife Service had known about hunting in the Nunavut Territory. The hunter there who shot the tagged goose Kerry, for example, told ornithologists how he seeks out the birds when they are molting and flightless, and thus easy to shoot. If the take by subsistence hunters is not too great, then it will be allowed to continue—but shooting the birds for sport is forbidden. The purpose of the flyway

management plan is to limit the impact human activity has on the geese, keeping the population stable at 20,000 birds.

The tagging project gave the WWT a much better understanding of the geese's migration routes, and the locations of some of their staging grounds. But Robinson realizes that because they only tracked six birds, they may not have the full picture of light-bellied Brent migration. "As scientists, we know we are biasing the results because we tagged birds in only one year," he says. He is looking for more funds for future tagging projects, to see if the geese stick with the exactly same flyway and staging grounds year after year—and to get a better sense of how many Brents are lost on their migration. Right now, they have no way of knowing how many goslings don't make it through their first Atlantic crossing, because the breeding grounds in Nunavut are difficult to access.

By tagging more geese, Robinson might get to follow some of the birds that get blown off course, or lost, each year. "There are quite a few light-bellied Brent geese that travel beyond Ireland and head for the Channel Islands," he says. "There are some that head to Brittany in northern France. We've recently found out from some Spanish colleagues that the Brents are even going down to northern Spain." The birds that arrive in Spain show up there around the same time as most of the Brents reach Ireland. Robinson thinks this could mean that the geese have two migratory routes: instead of crossing the Greenland ice cap, a small number of birds may fly down the coast to the southern tip of Greenland, and then try to make their way to Ireland—without stopping off in Iceland. They either hit County Kerry, on Ireland's southwest coast, or they miss completely and wind up in northern Spain. "They seem to be able to make it," Robinson says, sounding incredulous. "The ocean crossing between the south tip of Greenland and northern Spain is absolutely amazing." The flight is about 1,800 miles long.

It has been four days since our light-bellied Brent family left the Nunavut Territory. After a day's rest on the east coast of Greenland, they flew 400 miles across the Denmark Strait, and have now arrived in Iceland. The birds spend a month Alftanes peninsula to the southwest of Reykjavik—where as many as 10,000 Brents can stop at a time—eating well and taking life easy, replenishing the fat stores they used on the journey from Nunavut. When they are ready to leave Iceland, they have only one more flight to make, southeast to Northern Ireland across 800 miles of the North Atlantic Ocean. Home, and a winter of rest, is less than a day away.

Grider has got crumbs on his Gumby suit from the Snickers bar he's been sharing with Cox. The flight across the Greenland ice cap to Reykjavik has been boring; they've been listening to Clint Eastwood movie soundtracks and playing tag with the heating system. Grider, stuffed into his heavy flotation suit, wants the heat off. Cox, dressed in a light jump-suit, wants it on. "It's almost a cliché in aviation," Cox says, "but the Atlantic crossing is hours and hours of boredom punctuated by brief instances of stark terror." Grider describes a panoply of emotions and sensations: mild fear, tedium, claustrophobia, aching shoulders, intimidation, anxiety, a "sore butt." He is watching the gauges closely, making sure *Tweety* is in good shape, that the engine temperature and oil pressure are in the right range. Out on the ice cap, there is no radar coverage and radio communication is poor. Every so often, Grider imagines himself down on the ice, marooned in a frosty wasteland with Cox and a disabled airplane. He doesn't much like the idea.

Grider is free to speculate, because *Tweety Bird* is flying itself over the ice sheet. A Global Positioning System (GPS) receiver is hooked up to the plane's controls, keeping the auto-pilot on a steady course towards Reykjavik. The GPS device enables Grider and Cox to pinpoint their

location on Earth at any time. The Global Positioning System consists of a network of 24 satellites that are in orbit about 11,000 miles above Earth's surface—positioned so that a GPS receiver can always pick up signals from six of them from anywhere on Earth. The GPS receiver figures out where it is by calculating its distance from the satellites. The satellites rain down high-frequency, coded radio signals that give information about the time the signal was transmitted to within the nanosecond, which is one-billionth of a second. The receiver calculates the difference between the time of transmission and the time of reception and multiplies it by the speed of light—the rate at which the signal traveled to Earth—to figure out how far away the satellite is. By cross-referencing the location data from at least four satellites, the GPS receiver can pinpoint its exact location in terms of latitude, longitude, and altitude.

Many GPS receivers used in aviation can be augmented with maps and airport locations around the world. Grider is using such a device to find his way to Reykjavik: he selects his destination, the course is plotted, and *Tweety* follows. The technology has made the Atlantic crossing much less risky for private pilots. “Most of the people that went down over the Atlantic did so because they got lost and ran out of gas. With the advent of GPS, that doesn't happen too frequently,” Grider says. Some pilots still go across without GPS, though, opting for dead reckoning instead, a navigation technique that depends entirely on mathematical calculations. It enables pilots to find their way over featureless terrain, ocean, or clouds, without any reference to landmarks. You begin by plotting your course on an aviator's map of the areas you plan to cross. Next, record the distance and direction of flight between each turning point on your route. Finally, find out the direction and strength of the wind at your cruising altitude for each stage of the journey, because the wind will influence your speed and course. With all this information, you can calculate your speed over ground,



how long the journey will take you, and how much fuel you will consume—and by watching the clock during your flight, you will know when to make turns.

Crucially, you will also calculate in which direction to *make* those turns. A stiff wind can blow a light aircraft off course just as easily as it relocates a goose. The plane may be pointing east, for example, but it is being blown to the northeast by a tailwind. This is known as wind drift, and it means that you are not really flying the course indicated on your compass. To compensate, you need to make a wind correction: point the nose in a more southeasterly direction to maintain an easterly course. Without making such an adjustment, you might get blown well north of Scotland and end up on the west coast of Norway.

It is possible to make rough guesses of how much to compensate for the wind, but it is better if you can get the wind speed and direction from an aviation forecast. Over the North Atlantic, there is not much traffic at the flight levels of light aircraft—between 5,000 and 11,000 feet—so there is no specific forecasting for those altitudes. Shipping forecasts don't help because the winds aloft are often different from surface winds; similarly, jets five miles overhead are coasting along in very different conditions, immersed in the jet stream. In an effort to assist light-aircraft pilots, the Canadian Weather Service makes estimates of the wind conditions for their typical flight levels. In his years of flying, Cox has found their predictions to be reliable—occasionally so accurate that it was “unbelievable, right on the point of eerie,” he says. Cox used their forecasts to make successful dead-reckoning crossings for thirteen years before the advent of GPS.

Establishing the wind direction and staying on course was one of the biggest problems for Charles Lindbergh on his solo Atlantic crossing in 1927. In his day, there was no weather forecasting at altitude, and he was flying an open-ocean route, far south of Grider's and Cox's path. “I've got

to get under these clouds where I can see waves and wind streaks,” Lindbergh wrote in *Spirit of St. Louis*, recalling the sleepy nineteenth hour of his flight. “I *must* find out how much the wind has changed. I *must* take hold—begin to grapple with problems of navigation.” If the sky had been perfectly calm for Lindbergh’s journey, finding Paris would have been simple: he could just fly the headings he had plotted on his chart. But the winds influenced his course and speed, making him uncertain of his exact location. In daylight, he flew close to the ocean surface to observe the direction of the waves and the blasts of spray off the whitecaps—the wind streaks—to get a sense of where the wind was coming from and how strong it was. He felt that he was a poor judge of it. By night, he observed the position of the stars. He worried about navigational errors and made many course corrections based on intuition rather than strict calculation. “I can’t possibly miss the whole continent of Europe,” he wrote. “What difference does it make if I strike the shore line a little farther from course than I had planned?” When he finally saw the Irish coastline, two and a half hours ahead of time and very much on course, he was stunned. He arrived in Paris later that day, after a 3,600-mile, 33 ½-hour flight from New York.

Lindbergh is synonymous with the Atlantic crossing, but he was not the first to make the journey non-stop. A far more elegant-looking aircraft than the *Spirit of St. Louis*, a biplane of fabric and wood, had managed it eight years earlier, with two British aviators in command. Captain John Alcock, the 26-year-old pilot, and Lieutenant Arthur Whitten Brown, the 33-year-old navigator, were both veterans of the recently-ended Great War. Bundled into heavy flight suits and Eskimo-style boots, they set out in their open-top plane from St. John’s, Newfoundland, on June 14<sup>th</sup>, 1919, and flew through sixteen hours of fog to the west of Ireland. Like Lindbergh, they found their way with a combination of dead reckoning and celestial navigation. They drank coffee and ale, communicated with each other by

shouting, and were uncertain of their exact location for much of the 1,880-mile journey.

It ended with an awkward landing in a bog near Clifden, a town in the west of Ireland, on the morning of June 15<sup>th</sup>. After circling around in search of a good landing spot, they mistook the flat bog for solid ground and dug their Vickers Vimy plane nose-first into the morass. Officers from the nearby Marconi wireless station—most of whom were still in their pajamas—ran out to greet the pilots. “That’s the best way to cross the Atlantic,” the *Daily Mail* reported Brown as saying when he clambered out of his airplane. But as the *Daily Express* told it, Brown had “had enough of flying for a bit.” When other locals arrived, Alcock and Brown signed autographs and distributed rain-soaked cigarettes and souvenirs they had had on board. Gripped by post-war jingoism, the *Daily Mail* saluted the flight as an “all-British triumph,” with “the honour secure in British hands.” Like Lindbergh in New York, Alcock and Brown received an enormous welcome when they returned to London.

They made the crossing in pursuit of a prize, £10,000 offered by the *Daily Mail* as an incentive to further aviation—ideally, British aviation. “Aeroplane, waterplane, or airship? That is the principal problem for these islands today,” the editors of the *Daily Mail* newspaper wrote in April 1913, when they first announced their Atlantic-crossing competition. “Our problem is not the French problem or the German problem.” Before the war, the British saw supremacy in the air as an important aim, and crossing the Atlantic in a single flight would be a milestone in aviation. Alcock and Brown’s only opponents in the competition had taken off eight weeks before them, had crash-landed in the ocean, and were rescued.

All told, 1919 was an eventful year for crossing the Atlantic. One month before Alcock and Brown made their journey, a flying boat made the first ever transatlantic flight—but with one stop on the way. It was one of

the “Nancies,” three aircraft that the U.S. Navy had commissioned from one of the best aircraft designers of the time, Glenn Curtiss. Because ships on Atlantic shipping lanes had been so threatened by German submarines during the war, the U.S. Navy was looking for a way to get all the way across the ocean on wings alone. The trial began when NC-1, NC-3, and NC-4—three clunky-looking flying boats—took off from Newfoundland in May of 1919, bound for the Azores, the isolated family of nine major islands at about 40 degrees north in the Atlantic. The Nancies’ final destination was to be Plymouth in England.

While Alcock and Brown had found their way through fog by dead reckoning and occasional glimpses of the stars, the Nancies looked for ships’ lights. Forty-five U.S. Navy destroyers were positioned at intervals of 50 miles along the airplanes’ route to the Azores. Five battleships, one every 400 miles, acted as weather stations. Picture it: military vessels strung out like dark beads across the water, a path of ship light for the Nancies to follow. The elaborate set-up could do nothing to prevent engine problems, however, and only one of the airplanes made it across. The NC-4, with its five-man crew, took almost two weeks to get to Plymouth. On a refueling stop at Lisbon, Lieutenant Commander Albert C. Read sent a telegram to home: “We are safely on the other side of the pond. The job is finished.”

In the collective memory, though, it is Lindbergh who finished the job. The stories of Read, Alcock and Brown, and many other transatlantic aviators—apart, perhaps, from Amelia Earhart’s—have been overshadowed by Lindbergh’s. His arduous solo crossing, his good looks and youth, and the fact that he connected two major cities, all added to his appeal. Where others had taken northerly routes from obscure departure points in the cold north to remote destinations in western Europe, Lindbergh let people see how flying across the Atlantic might be part of their lives. Instead of landing nose-down in a bog, he arrived with great flourish in Paris, his

aircraft set upon by thousands of souvenir-seekers. Part of the 25-year-old pilot's legacy was to imbue the Atlantic crossing with a certain mystique among private pilots—whether they take the milk-run route or not.

Grider and Cox are coming to the end of the second leg of their journey across the Atlantic Ocean. As they make the approach to Reykjavik through heavy clouds and sheets of rain, *Tweety Bird* leaks water, soaking the pilots. “The problem with Iceland is that you have what’s called a perpetual low,” Grider explains. “It’s just crappy all the time.” The Gulf Stream, a warm river of water that runs from the Gulf of Mexico to northern Europe, passes south of Iceland, as does the typical track of North Atlantic storm systems. The result is that Iceland is quite windy and cloudy all year round.

The pilots are forced to wait in Reykjavik for four days due to persistent bad conditions between Iceland and Scotland, over the stretch of North Atlantic that reaches up to the Norwegian Sea. “The only time I was really scared was when I was on the ground, trying to decide whether I was going to back out and go home, or fly through this crap,” Grider would recall later. “I finally decided no. I’m not totally stupid.” The weather is hanging well below the minimums he had set for himself: there is solid cloud from 1,800 to 23,000 feet, freezing levels at 4,000 feet, and a 30-knot headwind. The combination of cloud and freezing temperatures is perfect for aircraft icing.

If it were up to Cox, he would probably brave it and take off for Scotland, but Grider does not want to fly in marginal conditions. He tells Cox that he would sooner let *Tweety Bird* “sit on the ramp and rust to pieces” than take off into bad weather. With or without Cox, Grider wants to play it safe, and so they wait. Grider goes to the Blue Lagoon geothermal spa and lounges in milky-blue pools; he listens to the pipe organ at the Reykjavik Cathedral, a grand building that looks like a wedding cake; and

then he and Cox take *Tweety Bird* on a day trip to Akuryeri, a town on Iceland's northern coast. Grider notes that it's very clean, drug-free, with no bubble gum on the streets. He says he doesn't care if anyone back home is wondering why he is not on his way to Scotland. "If they think I'm chicken, they can catch a jet over and take my seat," he says.

The weather is still poor in Iceland on the morning they leave. Grider is worried, unable to eat his breakfast, and feeling a long way from Kokomo. Cox is optimistic that conditions will be better once they clear the mainland and head across the water to Scotland. He is right: at 7,500 feet, they break out of the clouds and keep climbing, leveling off at 11,000 feet, their airplane's wings blazing back sunshine. They find themselves carried by a galloping, 50-knot tailwind, constant and smooth. It pushes *Tweety Bird* so hard that they cover almost 800 nautical miles in four hours and 31 minutes, the speed record for this journey and this type of airplane. At one point, they are traveling at a speed of about 216 knots—exceptional for a plane that normally cruises at 144 knots. "What are you flying?" Edinburgh air traffic control asks them over the radio. The controller is incredulous when he hears that they are in a Piper Arrow. "Are your wings still attached?" Grider's appetite returns and he bites into a candy bar. Scotland is just ahead and, as he courses toward it behind *Tweety Bird's* control wheel, he is feeling pleased.



Three hundred miles southwest of Grider's route to Scotland, the Brent geese see home. It is Strangford Lough, a 30-mile-long sea inlet ten miles south of Belfast, the capital city of Northern Ireland. From the air, the lough is an unmistakable blue crescent set in low hills, a landmark the geese have looked for year after year. In an undulating, loose V-formation, the

family comes about to land into the wind. Heads low, bodies and feet forward, wings held back high, they splash down into the cool water, their webbed feet acting as brakes. It is the end of August and their 2,500-mile journey is over.

Other family groups and stragglers will keep arriving until late September, until finally all 20,000 or so geese will be gathered on and around the lough. They will stay for six to eight weeks, exhausting the supplies of eelgrass and algae on the glossy mudflats before dispersing to sites around Ireland. People come to watch them from the shelter of the Wildfowl and Wetlands Trust's bird hide—a low, wooden building on the east side of the lough that smells like cedar, its walls lined with wildlife murals. Little kids in red Wellington boots run up and down, screaming for all they're worth, while birdwatchers look out through the narrow windows at the flats below. Oblivious to the observers, a community of birds busies itself between the advancing tide and the shelter: heavy birds with thick legs, dainty birds with slender legs—avian allsorts. Alongside the geese are shelducks, dunlins, oystercatchers, knots, gulls, curlew, turnstones, pinkfoots, and redshanks. They have a variety of songs and calls to match: the curlew's liquid warble, the piping of the oystercatcher. James Orr, the director of the WWT's center here at Strangford Lough, squints through his binoculars, sets them down on the ledge, and offers a suggestion for cooking a Brent goose. "You get a big pan of boiling water, put the Brent goose in it, put in one of those old irons, and after three hours you throw away the Brent goose and eat the iron," he says, laughing softly. "Because they're eating eel grass, they're very salty. But when they come back from Canada and Iceland, they've been eating tundra grasses—very sweet grasses—and their flesh tastes totally different. So at the end of the winter they're pretty horrible to eat, but at the beginning they're gorgeous." The problem, though, as Orr points out, is that when they arrive at the

beginning of winter the geese are very lean, having used all of their body fat to get here.

Even so, Brents were probably eaten by the earliest settlers in Ireland, some 9,000 years ago. Evidence of Neolithic, Celtic, early Christian, and Viking dwellings have been found on the numerous islands that dot the lough and on the surrounding agricultural land. Looking across at Rough Island, Orr says, “You can see why people came up Strangford Lough—this would have been all wooded. There’s a causeway linking Rough Island to the mainland, so it was an easy place for settlers to defend and protect themselves. And plenty of food around—plenty of geese.”

Goose hunting on Strangford Lough has been banned for the past fifty years. The most significant threat now, Orr says, is human recreation on the lough. If the geese decide to start feeding on surrounding agricultural land, as they sometimes do when they disperse to the Republic of Ireland, there might be conflict with local farmers. In 1995, the WWT established an annual Brent festival to make people more aware of the geese’s epic migration, and the importance of Strangford Lough to their life cycle. The festival takes place in the fall, to welcome the geese home: a beacon is lit in Scrabo Tower as a signal to the birds; children have made a giant outline of a goose on Rough Island; local women helped make a totem pole with Celtic and Inuit carvings, which now stands on the island; and each year there is a carnival. “I’d like to see a cultural change in the way we perceive wildlife,” Orr says. He thinks the Brent festival has helped, because more and more people have been attending the festival each year. “I think it’s particularly resonant in Northern Ireland, you know—generally we never look beyond the six counties. We’re very narrow, conservative, insular people,” Orr explains. “I think it’s good to see we live in a global context; we’re part of a planet.” Instead of being complacent about the Brents’ migration, he wants locals to recognize that the geese have come from a



different country, that “they’re part of a seasonal thing that has been going on for thousands of years.”

Northern Ireland has been convulsed by sectarian violence for the past eighty years. Republicans and Loyalists alike have expressed themselves in massive protest murals, many of which can be found in cities such as Derry and Belfast. The tone of the murals varies: from skeletal angels of death, bearing Union Jacks, to benign images of Mother Ireland, a Celtic beauty. But probably the most famous mural is the Free Derry Wall in the Bogside community, a Republican stronghold in the city of Derry. The ten-foot-high wall bears a message painted in black letters against a white background: “You are now entering Free Derry”—a proclamation against what the community sees as the occupying British forces. Now a national monument, in these more peaceful times its reverse side is often used by local groups fighting for other causes such as gay rights. James Orr has his own message to get across: he has gotten permission to paint the Brent goose on the back of the wall, as a symbol of peace and hope, and he plans for local children to do the artwork. “It’s just another way of communicating.” Orr says. “So you’re now entering Free Derry with a Brent goose. It’ll turn heads, you know.”

It is fitting, in a sense: for the Irish, “the wild geese” is a potent cultural and political symbol that emerged over three hundred years ago in the struggle against British Protestants. In the late 1600s, a Roman-Catholic soldier named Patrick Sarsfield led an army of thousands of Irish men against the oppressive rule of Britain’s Protestant king, William III. When finally forced to surrender, the Irish signed a treaty with the British in which Sarsfield and his army agreed to leave Ireland for France. Their mass departure became known as the flight of the wild geese. In the next hundred years, the flock grew larger still: an estimated half a million more Irishmen went to France, then ruled by a Roman-Catholic king, all to serve for

France in the fight against protestant England. When Sarsfield died, he is reported to have said, “Oh, that this were for Ireland.” The poet William Butler Yeats echoed Sarsfield’s regret in “September 1913,” one of his best-known verses. He lamented the despondence of the Irish as their country remained under British control, despite earlier heroic uprisings by Sarsfield and others: “Was it for this the wild geese spread the grey wing upon every tide?” the poet asked. “Romantic Ireland’s dead and gone; it’s with O’Leary in the grave.”

The wild geese, spreading the gray wing upon every tide, have since come to represent emigration from Ireland as a whole: some seven million people departed for the New World from the 1600s to the 1950s. The most acute phase was in the 1850s, when about two million people left because of the Irish potato famine. These “wild geese” were driven across the North Atlantic to escape starvation, just as geese depart en masse with the change of seasons to sustain their life cycle. Over 100 years later, in the 1980s, tens of thousands left Ireland during a period of severe economic depression with a 15-percent unemployment rate. “The Irish are citizens of the world,” author Thomas O’Hanlon writes in his book *The Irish*. “When the time is propitious, they migrate with the natural instincts of wild geese, traveling ancient routes to Boston, London, Vancouver...” Emigration is part of the Irish culture. Only in the past ten years, more prosperous times for the country, have emigrants been able to return home.

For the Brent geese, the mild winter in Ireland is enough to ensure that they follow their ancient routes home year after year. Although it is on the same latitude as frigid Newfoundland, between 45 and 60 degrees north, Ireland has a temperate climate—an effect of the prevailing westerly winds that blow over the North Atlantic Current, a source of heat in an otherwise cold ocean. The current is like a river within the ocean, a warm extension of the Gulf Stream, which originates in the Gulf of Mexico; it

travels in a clockwise direction in the ocean. It is this influence that lets Ireland be the winter destination of the hundreds of bird species that make their way from northern Russia, Norway, Eastern Europe, Scandinavia, Iceland, and North America—and some birds that, like the Brents, fly down after summer in the Arctic Circle: the redshank, knot bar tail godwit, shelduck, and wigeon. “Ireland isn’t well known for its wildlife, but probably the most significant wildlife it has are the birds that come here in the wintertime from the Arctic,” James Orr of the Wildfowl and Wetlands Trust says. “That’s what makes Ireland internationally important for different species. The thing about the Brent goose is that it’s the only goose whose population is totally dependent on Ireland.”

By November, almost all of the 20,000 birds on Strangford Lough disperse to some 1,800 sites around Ireland to avail themselves of new food sources: the groomed grass at golf courses; the rough sod of Gaelic football fields; the seaweed in salt marshes all around Ireland’s coast. Their locations and numbers are checked each January by the coordinated effort of hundreds of birdwatchers around Ireland. One person who has watched their comings and goings over the years is Jill Crosher, an amateur birdwatcher involved with Birdwatch Ireland. A fit-looking woman in her fifties, Crosher is breathtakingly energetic, her cheeks ruddy from being outdoors. She describes how Ventry Harbor in southwest Ireland, where she lives, is a superb harbor for sea grass, seaweeds, and algae. “It has one of the largest diversities of seaweed of any section of Atlantic shore anywhere,” Crosher says. With this kind of vegetation, Brent geese are apt to dine there. “We only ever get sixty or seventy geese, but it’s important to us—it’s locally significant,” she says. “We keep an eye on them; we like to know where they’re feeding. The geese are part of our experience of the place.”

Crosher goes on to tell a story of arrival at Ventry Harbor. “A couple of years ago a group of about twenty geese came in in early

September, over the Atlantic, and landed in front of me. And I thought, gosh, these may have just come from the far north. They were all fighting and squabbling and arguing just like families do when they've had a long journey. As if the kids are all saying, 'Are we here yet?' I imagined, rightly or wrongly, that they had just arrived and that we were their first landing spot before they moved on to collect in another place. I might be quite wrong about that. But it doesn't matter whether you're right or wrong about these things; what matters is your feeling, seeing them coming over the Atlantic. You think"—she gasps—"they're here. It's fantastic."

Captain Burns has arrived. It is 1 a.m. as he steps into his house in Newport, Rhode Island, after the hour-long drive from Boston. Finnegan, Fiona, Kate, and Luciano, Burns' four Maine-Coon cats, sleepily acknowledge him as he pours himself a Jameson whiskey. It is his usual ritual when he finishes a roundtrip; on this September night, after he has parked a Boeing 767 for the last time, it is no different.

What Burns loved about flying the Atlantic was not so much the crossing itself as the destinations. "Those of us who started when I did really saw the best of it because we flew all around the world—almost every place in Europe we went to, and down to East Africa. It was wonderful," he says. "The last couple of years weren't much fun; it was a slide downhill." When American Airlines acquired TWA, the company Burns had been with for most of his 39-year career, they chose to keep TWA operations separate. This left the TWA employees on an ever-diminishing number of routes; Burns, for example, spent the last two years of his career bouncing between Gatwick and St. Louis—bland destinations, he thinks, compared with Cairo or Milan.

The job of crossing the Atlantic Ocean has changed dramatically since Burns made his first trip in 1964. Where once he was occupied with just staying on course for the entire flight, by the end of his career there was not much to do once out over the ocean. Automatic navigation equipment took much of the work out of his hands. This gave Burns time to read the newspaper, but he says that activity in the cockpit is a sensitive subject. "Different captains run different ships," he explains. "Some would be aghast that anyone would read a magazine or do a crossword puzzle in the cockpit, but it is usually pretty boring, and some diversions are welcome." One of the first officers Burns flew with prefers the relaxed, newspaper-reading captains, because they usually look up every two or three minutes to scan the gauges and check that everything is in order. The ones who do not read newspapers, the first officer jokes, sometimes just stare out the window, mesmerized.

Burns did not have time for the view on his first Atlantic crossing. It was a frenetic training flight, with the 22-year-old pilot learning to find his way across the ocean using the Doppler-Loran system, a combination of two navigation techniques that together enable accurate dead reckoning. It was far more involved than the navigating airline pilots do today. "There was such complicated paperwork," Burns says. "I thought, 'I'll never figure this out. This is awful.'" He worked hard throughout the flight, keeping track of the airplane's course by cross-checking two kinds of data, Doppler and Loran. The former relied on the Doppler effect, a property of waves that you can observe when an ambulance passes by. As the ambulance moves towards you, the pitch of the siren seems higher; as it moves away, the pitch seems to drop. The frequency of the sound waves varies with the vehicle's velocity relative to you. This is the Doppler effect and, when Burns was first learning to navigate the Atlantic, it was used to calculate an airplane's direction of flight and its speed over Earth's surface. An on-board Doppler

unit emitted four microwaves down to the ocean and tracked their shift as they came back. The minuscule difference was enough to measure the airplane's groundspeed, enabling Burns to keep track of where the airplane should be on its course.

Keeping track of his groundspeed and direction of flight helped Burns to figure out his position over the water, but for accuracy, he checked his calculations using data from Loran stations. These radio stations were located on the Faroe Islands, southern Iceland, the southern tip of Greenland, and on the east coast of Newfoundland. At all times on the North-Atlantic crossing, an airplane could pick up pulsed radio signals emitted from at least two of the Loran stations. By measuring the time interval between the arrival of the signals, Burns could draw two lines of position on his chart, pinpointing the airplane's location. The average error at the end of the crossing, Burns says, was to be 20 miles off course—inaccurate by today's standards, but relatively precise back then, when pilots using celestial navigation might have found themselves as much as 100 miles off target at the end of an Atlantic crossing.

When the Boeing 747 arrived in 1969, bringing inertial navigation with it, navigational errors all but disappeared. "It was a whole new world," Burns says. "It was so much easier—you just programmed the latitude and longitude of every waypoint along the route. It was very accurate." Inertial navigation instruments are sensitive to changes in direction and acceleration. Devices like the gyroscope and accelerometer keep track of the distance and direction a plane has traveled from its starting point by measuring changes in velocity during its journey. When Burns first flew the 747, he used its inertial navigation system to check to see how far he was from his house, out over the ocean; or how far it was to the North Pole. Many aircraft flying today, including 747s, still have inertial navigation—less

sophisticated equipment than the GPS devices Bill Grider has on *Tweety Bird*.

Burns likes to keep an open mind about new technology. In aircraft built in the 1990s, the cockpit's analog array of standard instruments, with its myriad switches and gauges, gave way to a bank of computer screens—designed to condense the information from many instruments into an easy-to-read, graphic display. A lot of Burns' colleagues did not welcome this "glass cockpit," as it became known. Some resisted it, in the manner of adults who refuse to try programming a video recorder. "Oh, flying a 757, they'd say, all you have to do is learn how to type. Which is true, in a way—there are a lot of keystrokes," Burns says. "When the glass-cockpit airplanes came along, guys used to say the two most frequently used phrases in the cockpit used to be, 'What is her name?' or 'What did he just say?' And now the phrases are, 'Why is it doing that?' or 'Where is it going now?'" He laughs. "I understood the system, I could get it from point A to point B okay, but I didn't understand everything it did. Fortunately we could always just disconnect it and do it the way we were used to doing it."

Having made over 2,000 Atlantic crossings in a jet, Burns is now coming full circle in his flying career. He is going back to flying a small, single-engine airplane similar to the plane he first trained on forty years ago—something like Bill Grider's *Tweety Bird*. Burns will be working for Air Newport, a new light-aircraft charter company, taking passengers from Newport to places like Nantucket and Martha's Vineyard, pretty vacation islands off the coast of Massachusetts. He is now preparing for his "check ride," the pilot's equivalent of a driving test, on the Beech Bonanza he will be flying. It feels different from a jet, Burns says, like sailing a dinghy over high seas instead of a cargo ship. The Beech Bonanza is easily buffeted by Newport's fresh, afternoon winds.

Burns will not stray far in his single-engine plane; he has no desire to take it across the Atlantic, Grider-style. “It was long enough going over in a jet,” he says. “That was all the time over the ocean I wanted to spend. Too long.” Whenever Burns flies a plane now, he will keep the broad Atlantic at his wing.

Back in his hangar in Kokomo, Dr. Bill Grider sips a can of Diet Coke, puts it down on the roof of the old, red Porsche Carrera parked in the corner, and continues flicking through a slide show of photographs from his trip. He visited the Royal Air Force base at Biggin Hill, which played a major role in the Battle of Britain in World War II; he stopped for a pint at the Grasshopper on the Green Pub in Westerham, the village where Winston Churchill grew up. Grider and Cox then flew south, 2,400 feet over the English Channel, past the White Cliffs of Dover on England’s west coast, to set *Tweety Bird* down in an airport outside Paris, France. “I flew my airplane past the Eiffel Tower,” Grider says. “I’ll probably never get over that.”

It had been twelve days since they left Kokomo. At the memorial for the Lafayette Esquadrielle outside Paris, Grider laid down a bunch of roses and pondered a question that still preoccupies him: how do we conquer fear? He is captivated by the bravery of the millions of soldiers in the World Wars. “They went into battle knowing the odds, that they wouldn’t come back alive,” he says. “Some day I’d like to write a book about fear.” On the Atlantic crossing, Grider tried to manage his own odds of survival by spending eight years preparing, loading up on survival gear, getting extensive training, and bringing a renowned ferry pilot along for the ride. If the worst were to happen, he had left instructions on how to sell his dental practice, how to liquidate his assets, who should get his “toys.”



It never came to that. And for all Grider's talk of fear—his own fearfulness and Cox's lack of it—an interesting irony emerges. "Bill Cox is not scared of flying," Grider says. "But he is scared to death of going to the dentist. He went into a full-blown panic attack just telling me about the dentist—he had to put on the oxygen mask. So I said, OK, we won't talk about that anymore. He's not afraid to die by himself over an ocean in a storm, but he comes unglued at the thought of going to the dentist. You're not going to get killed at the dentist, are you? Unless I happen to have a bad day."

But even Cox has become a little more cautious about flying. "I'm not exactly an old fart, but I'm not a young man anymore either," he says. He is 62. "You get to the point where you don't want to make seventy trips a year no matter how much anybody's willing to pay you. Nine or ten is plenty for me; I'm happy with that. There's also the factor of fear. . . as you get older, you get a little more nervous. I am more conservative now than I was fifteen years ago. But I still get the job done."

*Tweety Bird's* return trip, from Scotland to the United States, called on Cox's strong side. Because the weather forecast was poor, Grider opted to fly home in a jet instead of taking *Tweety Bird*, leaving Cox to travel alone. On the flight between Scotland and Iceland, Cox climbed to 6,000 feet on three occasions, got iced up, and had to come back down to 2,000 feet to allow the ice to melt. He ended up spending six hours in the clouds, at 3,000 feet, en route to Reykjavik. The leg from Reykjavik to Narsarsuaq was not much better: instead of flying over the ice cap, Cox had to fly around the southern tip of Greenland to keep *Tweety Bird* low enough to avoid icing. The fjords on the approach to the airport were shrouded in fog. He flew the 48-mile fjord approach with zero visibility, fifty feet above the water, using just the GPS graphical display to navigate—something like playing a video game. *Tweety Bird's* tail was shimmying a little, a sure sign

of icing. Cox could not see the Narsarsuaq Airport runway until he was right on top of it, but he managed to make a smooth landing. “The bottom line was that I got in OK and didn’t get killed even once,” Cox says. Grider thinks this is miraculous. “He’s a pretty gutsy guy. He’s got more than nine lives.”

Several months after his Atlantic odyssey, Grider is still doing root canals at his practice in Kokomo, still taking *Tweety Bird* on short hops to local airports at the weekends, and he is assembling a train set for his newborn son. When Grider gives talks to aviation interest groups around Indiana—the Indy Flying Club, the Rotary Club—he tells the audience that he does not regret missing out on the adventure of Cox’s journey home. He does not feel bad about not making a solo crossing. Listening to Grider, you get the feeling that he was satisfied with just crossing the ocean once, that he’s glad to be done with it, glad to be able to say he did it. He admits that he got more fun out of the preparation for the journey than the journey itself. “The landscape, the scenery, the glaciers—all of that’s memorable. But probably the biggest thing that will stand out in my memory, the thing I’m most proud of, is the preparation, the discipline, the commitment,” he says. “To some extent, I am a better person because of the trip.”

At the end of December 2002, the *Kokomo Tribune* listed Grider as the third biggest people story of the year. “I got beat out by two other people that died,” Grider says. “I didn’t have to die to make the biggest people story of the year. That’s kind of cool.” For a dentist whose great obsession was just surviving the Atlantic crossing, living to tell the tale is about the coolest thing there is.



## *A Note on Sources*

---

My most important sources for *Atlantic Crossings* were people. In some cases, I was telling their stories. In other cases, they were subject matter experts, patiently answering my questions. I spent a considerable amount of time with most of my sources either in their homes or workplaces, talking and reviewing documents, photographs, and other memorabilia. Generally, we carried on exchanging emails and speaking on the phone after first meeting. I recorded all face-to-face interviews on micro-cassette and did full transcriptions afterwards. During telephone interviews, I typed notes.

I based the story of the Brent family on what ornithologists know about the species. Much of the information, particularly about the route of flight, came from the Wildfowl and Wetlands Trust's satellite tagging project in 2002.

For facts, such as the area of Greenland or the nature of tundra vegetation, I always referred to the online edition of *Encyclopedia Britannica*, available through an annual subscription. This is a worthwhile investment for every science writer.

I found a huge amount of information on the Web, usually through Google, but needed a lot of time to cross-check facts found on random web pages. The National Oceanic and Atmospheric Administration and National Geographic offered some of the most helpful and reliable resources on their Web sites.

The only text I depended heavily on was *Bird Migration* by Peter Berthold. All of the information on pages 39-41, regarding bird orientation and navigation, comes from Berthold's definitive summary of the research on avian migration.

Reference books I recommend are Dorling Kindersley's *Aviation Year by Year* and National Geographic's *Atlas of the Oceans*.

Peter Nichols' *Sea Change* is a lovely account of his solo journey across the Atlantic Ocean in a small wooden yacht called *Toad*.

SMcD

June 9, 2003

## References

---

“Atlantic Bridge—1919-1999.” History of Air Traffic Control. UK National Air Traffic Services. October 22 2002  
<<http://www.nats.co.uk/library/history8.html>>

Aviation on the Shannon: A History of the Foynes seaplane base and of the early days of Shannon Airport. Limerick: Irish Air Letter, 1985.

“Baffin Bay.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2 2003  
<<http://www.britannica.com/eb/article?eu=11873>>

Bairlein, Franz. “How to get fat: nutritional mechanisms of seasonal fat accumulation in migratory songbirds.” Naturwissenschaften. Vol 89 (2002): 1-10.

Berthold, Peter. Bird Migration: A General Survey, 2nd edition. New York: Oxford University Press, 2001.

Blacklock, Mark (ed.) International Civil Aviation Organization: 50 Years Global Celebrations 1944-1994. London: ICAO, 1994.

Block, Barbara *et al.* “Migratory Movements, Depth Preferences, and Thermal Biology of Atlantic Bluefin Tuna.” Science. Vol 293 (2001): 1310-1314.

Boorstin, Daniel J. The Discoverers. New York: Vintage Books, 1985.

“Brant.” Audubon Watchlist. Audubon. March 1 2003  
<<http://audubon2.org/webapp/watchlist/viewSpecies.jsp?id=44>>

“Brent goose.” Royal Society for the Protection of Birds A to Z of UK Birds. Royal Society for the Protection of Birds. March 2 2003  
<<http://www.rspb.org.uk/birds/brentgoose/?page=b>>

Buck, Eugene H. “Atlantic Bluefin Tuna: International Management of a Shared Resource.” CRS Report for Congress. March 8 1995. National Library for the Environment. April 2003  
<<http://www.ncseonline.org/nle/crsreports/marine/mar-5.cfm?&CFID=7961169&CFTOKEN=59598148>>

- Canadian Shark Research Laboratory Web site. 16 May 2003. Bedford Institute of Oceanography, Nova Scotia. May 2003  
<<http://www.mar.dfo-mpo.gc.ca/science/shark/english/index.htm>>
- Cramer, Deborah. Great Waters: An Atlantic Passage. New York: Norton, 2002.
- Deinlein, Mary. "Have Wings, Will Travel: Avian Adaptations for Migration." Smithsonian Migratory Bird Center. Smithsonian National Zoological Park. March 2003  
<[http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Fact\\_Sheets/default.cfm](http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Fact_Sheets/default.cfm)>
- Delany, Simon and James Orr. "Conservation of a Transatlantic Migrant." Birdscapes. Spring/summer 2001: 17.
- Department of Biological Rhythms and Behavior. Max-Planck Research Centre for Ornithology. March 2 2003  
<<http://erl.ornithol.mpg.de/research/I.html>>
- Diebel, Carol *et al.* "Magnetite defines a vertebrate magnetoreceptor." Nature. Vol 406 (2000): 299-302.
- Doppler Loran and International Procedures. TWA Flight Operations Training Center, 1970.
- Earle, Sylvia. National Geographic Atlas of the Ocean. Washington DC: National Geographic, 2001.
- Fergus, Chuck. "Canada Goose." Pennsylvania Game Commission Web site. Pennsylvania Game Commission. May 14 2003  
<[http://sites.state.pa.us/PA\\_Exec/PGC/w\\_notes/c\\_goose.htm](http://sites.state.pa.us/PA_Exec/PGC/w_notes/c_goose.htm)>
- Fowle, Barry. Ed. Builders and Fighters: US Army Engineers in World War II. Fort Belvoir, Virginia: Office of History, US Army Corps of Engineers, 1992.
- "Goose." Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 1 2003  
<<http://www.britannica.com/eb/article?eu=38144>>

- “Greenland.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2003  
<<http://www.britannica.com/eb/article?eu=38741>>
- “Greenland Ice Sheet.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2 2003  
<<http://www.britannica.com/eb/article?eu=38743>>
- Gugliotta, Guy. “Butterflies Guided by Body Clocks, Sun.” The Washington Post. 5 May 2003: A03.
- “Gulf Stream.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. February 23 2003  
<<http://www.britannica.com/eb/article?eu=39270>>
- Gunston, Bill (ed.) Aviation Year by Year. New York: Dorling Kindersley, 2001.
- Handwerk, Brian. “Satellites Help Reveal Secrets of Epic Goose Migration.” National Geographic News. December 27 2002. National Geographic. March 2 2003  
<[http://news.nationalgeographic.com/news/2002/12/1219\\_021227\\_geese.html](http://news.nationalgeographic.com/news/2002/12/1219_021227_geese.html)>
- Henson, Robert. The Rough Guide to Weather. London: Rough Guides, 2002.
- Holden, Peter and Mike Langman. Migrants and Migration. London: Hamlyn Books, 1994.
- Illman, Paul. The Pilot’s Handbook of Aeronautical Knowledge, 4<sup>th</sup> edition. New York: McGraw Hill, 2000.
- Irish Aviation Web site. The Irish Aviation Authority. December 2002  
<<http://www.irishaviation.net/shanwick.htm>>
- “Jetstream.” National Weather Service Southern Region Weather School. 2003. National Oceanic and Atmospheric Administration. April 24 2003 <<http://www.srh.weather.gov/jetstream/global/jet.htm>>
- Knights, Edwin M. “Navigation before Netscape.” History Magazine. May 18 2003  
<<http://www.history-magazine.com/navigation.html>>

Laxton, Edward. The Famine Ships: The Irish Exodus to America.  
New York: Henry Holt and Company, 1998.

Lincoln, Frederick C. and Steven R. Peterson. Migration of Birds.  
Washington DC: U.S. Department of the Interior, U.S. Fish and  
Wildlife Service, 1979.  
<<http://www.npwrc.usgs.gov/resource/othrdata/migratio/migratio.htm>>

Lindbergh, Charles A. The Spirit of St. Louis. St. Paul: Minnesota  
Historical Society Press, 1993.

Lohmann, Kenneth *et al.* "Regional Magnetic Fields as Navigational  
Markers for Sea Turtles." Science. Vol 294 (2001): 364-366.

"Longlining, Overfishing, & Atlantic Bluefin Tuna." Empty Oceans,  
Empty Nets. 2002. Public Broadcasting Service. February 10, 2003  
<<http://www.pbs.org/emptyoceans/tuna/>>

Lutcavage, Molly *et al.* "Results of pop-up satellite tagging of spawning size  
class fish in the Gulf of Maine: do North Atlantic bluefin spawn in  
the mid-Atlantic?" Can. J. Fish. Aquat. Sci. Vol 56 (1999): 173-  
177.

Magnani, Edward. "Journey of NC-4: First Across the Atlantic." November  
2002. Aviation History Magazine. March 2003  
<[http://history1900s.about.com/library/prm/bljourneyofnc4\\_1.htm](http://history1900s.about.com/library/prm/bljourneyofnc4_1.htm)>

Magnuson, John *et al.* "Whose Fish Are They Anyway?" Science. Vol 293  
(2001): 1267-1268.

Marconi Calling Web site. February 2003  
<<http://www.marconicalling.com>>

Mather, Frank J. *et al.* Historical Document: Life History and Fisheries of  
Atlantic Bluefin Tuna. National Oceanic and Atmospheric  
Administration.

Marshall Stelzriede's Wartime Story. 2003. May 2003  
<<http://www.stelzriede.com/warstory.htm>>



- Martin, Rick. "Living loadstones." Reefquest Centre for Shark Research Web site. 1994. Reefquest Centre for Shark Research. May 2003 <<http://www.elasmo.com/martin/loadstone.html>>
- "Migration." Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 1 2003 <<http://www.britannica.com/eb/article?eu=119302>>
- Miller, Kerby and Patricia Mulholland. Journey of Hope: The Story of Irish Immigration to America. San Francisco: Chronicle Books, 2001.
- Montgomery, M.R. and Gerald Foster. A Field Guide to Airplanes of North America, 2<sup>nd</sup> edition. New York: Houghton Mifflin, 1992.
- Nichols, Peter. Sea Change. London: Profile Books, 1999.
- "Northern Ireland." Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. May 2003 <<http://www.britannica.com/eb/article?eu=128224> >
- Nugent, Walter. Crossings: The Great Transatlantic Migrations, 1870-1914. Bloomington: Indiana University Press, 1995.
- "Northwest Territories." Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2 2003 <<http://www.britannica.com/eb/article?eu=119773>>
- "Nunavut." Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2 2003 <<http://www.britannica.com/eb/article?eu=131614>>
- O'Hanlon, Thomas J. The Irish: Portrait of a People. New York: Harper & Row, 1975.
- Operation Migration Web site. 2003. February 17 2003 <<http://fathergoose.durham.net/index.html>>
- Orr, James. "Brent Geese." Castle Espie, Northern Ireland: The Wildfowl and Wetlands Trust, 1998.
- Orr, James. "Strangford Lough: Brent Geese and Other Species." Castle Espie, Northern Ireland: The Wildfowl and Wetlands Trust, 1998.

- Pisano, Dominick A. and F. Robert Van Der Linden. Charles Lindbergh and the Spirit of St. Louis. New York: Harry N. Abrams, 2002.
- “Profile: Biologist’s Study of Bluefin Tuna.” National Public Radio Web site. August 17 2001. National Public Radio. February 10 2003  
<no longer available online free of charge>
- “Qeqertarsuaq.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 2003  
<<http://www.britannica.com/eb/article?eu=63692>>
- “Recommendation by ICCAT concerning conservation of western Atlantic bluefin tuna.” ICCAT. October 2002.
- “Recommendation by ICCAT concerning a multi-year conservation and management plan for bluefin tuna in the east Atlantic and Mediterranean.” ICCAT. October 2002.
- Reeder, Allan. “The Wonder in the Bog.” Atlantic Abroad. October 15 1998. The Atlantic Monthly. February 23 2003  
<<http://www.theatlantic.com/unbound/abroad/ar981015.htm>>
- Robinson, James A. *et al.* “Irish Light-Bellied Brent Goose *Branta bernicla hrota* Research Program, 2001-2005.” Slimbridge, UK: The Wildfowl and Wetlands Trust, 2001.
- Robinson, J.A. and M.J. O’Connell. “Flyways of the East Canadian Light-bellied Brent Goose.” Slimbridge, UK: The Wildfowl and Wetlands Trust, December 2002.
- “Satellite tracker finds goose in freezer.” BBC News World Edition. 26 August 2002. BBC. February 17 2003  
<<http://news.bbc.co.uk/2/hi/science/nature/2216858.stm>>
- Schwartz, Mark and Ken Peterson. “Electronic tags reveal stock boundaries ignored by bluefins.” Stanford Report. August 22 2001. Stanford University. February 10 2003  
<<http://www.stanford.edu/dept/news/report/news/august22/tunastudy-822.html>>
- Seago, Michael J. “Brent Goose.” Birds of Britain Bird Guide. May 9 2003 <<http://www.birdsofbritain.co.uk/bird-guide/brent-goose.htm>>

- “Sea Turtle.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. May 2003  
<<http://www.britannica.com/eb/article?eu=68181>>
- Severin, Tim. The Brendan Voyage. New York: The Modern Library, 2000.
- Terres, John K. How Birds Fly. New York: Stackpole Books, 1994.
- “The Glass Cockpit.” NASA Facts Online. June 2000. NASA. May 2003  
<<http://oea.larc.nasa.gov/PAIS/Glasscockpit.html>>
- Tirion, Wil. The Cambridge Star Atlas, 3<sup>rd</sup> edition. Cambridge, UK: Cambridge University Press, 2001.
- Titanic: A Special Exhibit from Encyclopædia Britannica. Encyclopædia Britannica. April 22 2003  
<<http://search.eb.com/titanic/>>
- “Tracking Bluefin Tuna.” National Public Radio Web site. August 17 2001. National Public Radio. February 10 2003  
<no longer available online free of charge>
- Trivedi, Brian. “‘Magnetic Map’ Found to Guide Animal Migration.” October 12 2001. National Geographic Today. National Geographic. May 2003  
<[http://news.nationalgeographic.com/news/2001/10/1012\\_Tvanimalnavigation.html](http://news.nationalgeographic.com/news/2001/10/1012_Tvanimalnavigation.html)>
- “Tuna.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. February 10 2003  
<<http://www.britannica.com/eb/article?eu=75684>>
- “Tundra.” Encyclopædia Britannica. 2003. Encyclopædia Britannica Premium Service. March 1 2003  
<<http://www.britannica.com/eb/article?eu=75686>>
- Weldon, Niall G. Pioneers in Flight: Aer Lingus and the Story of Aviation in Ireland. Dublin: The Liffey Press, 2002.
- Wernham, Chris (ed.) *et al.* The Migration Atlas: Movements of the Birds of Great Britain and Ireland. London: T & AD Poyser, 2002.

Whiteman, Lily. "The High Life." 2000. Audubon Magazine. November 2000: 13 pars. March 1 2003  
<<http://magazine.audubon.org/birds/birds0011.html>>

Whitfield, John. "Tagged geese text home." Nature Science Update. June 10 2002. Nature. March 20 2003  
<<http://www.nature.com/nsu/020603/020603-9.html>>

Wright, Karen. "Winging It." Discover magazine online. December 2002. Discover. May 2003  
<<http://www.discover.com/search/index.html>>

WWT Satellite Tracking Brent Geese 2002 Web site. 2002. Wildfowl and Wetlands Trust. March 2003  
<[http://www.wwt.org.uk/brent/brent\\_goose.asp](http://www.wwt.org.uk/brent/brent_goose.asp)>

## *About the Author*

---

Sorcha McDonagh is from Kilsallaghan, a rural area in north County Dublin, Ireland. She graduated from Dublin City University with an honors degree in Communications Studies in 1995. For one year following her graduation, she produced and presented talk-radio programs for Dublin Weekend Radio, a specialized station for the academic community. Sorcha's next stop was Irish educational software company Riverdeep Interactive Learning, where she spent six years designing multimedia math tutorials for middle- and high-school students. Sorcha also edited Riverdeep's online magazine for the same audience, *The Riverdeep Current*. In the fall of 2002, she joined MIT's Graduate Program in Science Writing. Sorcha likes music, dogs, flying, Mexican food, and going for nice long walks o'er hill and dale.