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NATIONAL GEOGRAPHIC



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the edge and pushing
beyond what
I think is possible."*

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U.S. OLYMPIC
CHAMPION

▶ **BUILDING A BETTER ATHLETE**



SIR EDMUND HILLARY AND TENZING NORLAY, EVEREST, 1953



UNDER THE POLE EXPEDITIONS



TRIESTE, 1960

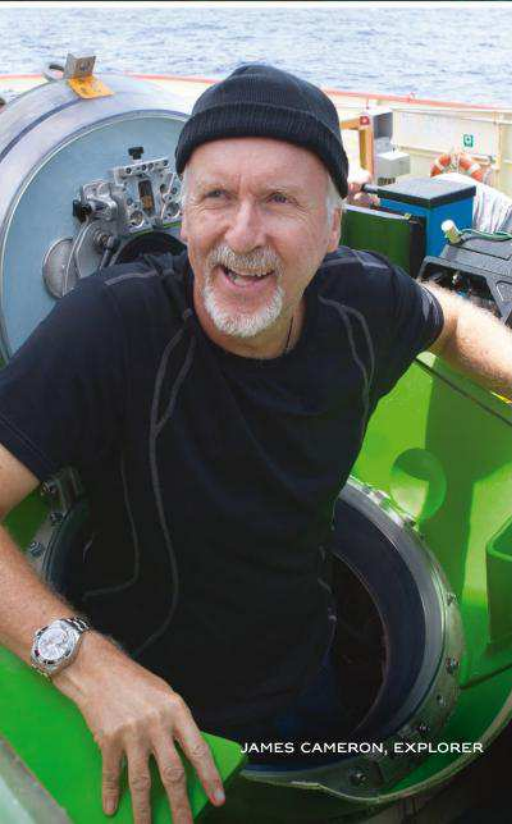




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C O N T E N T S



On the Cover

Swimmer Katie Ledecky, a five-time Olympic gold medalist, is known for her tough work ethic, but she also relies on sports science to improve performance.

PHOTOS BY JOHN HUET

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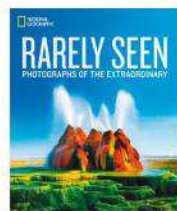
Get a Good Look at Giant Carnivorous Bats

Award-winning National Geographic photographer Anand Varma ventured deep into the Mexican jungle to find and photograph one of the continent's most elusive creatures: giant carnivorous bats. For centuries their lives have remained a mystery. Varma and renowned biologist Rodrigo Medellín teamed up to uncover the bats' secrets and capture images never seen before. *Giant Carnivorous Bats* airs June 22 at 8/7c on Nat Geo WILD.

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BOOKS

Extraordinary Images Wherever You Go

National Geographic's dazzling book of visual wonders—a *New York Times* photography best seller—now comes in a compact form. *Rarely Seen: Photographs of the Extraordinary* is available where books are sold and at shopng.com/books.

NAT GEO WILD

Back to the Barn With Dr. Pol

With more than 40 years in veterinary practice treating countless farm, pet, and exotic animals, Jan Pol is back for a 13th season of his reality TV show. Starting July 7, *The Incredible Dr. Pol* airs Saturdays at 9/8c on Nat Geo WILD.

BOOKS

Tips for How to Love Your Age

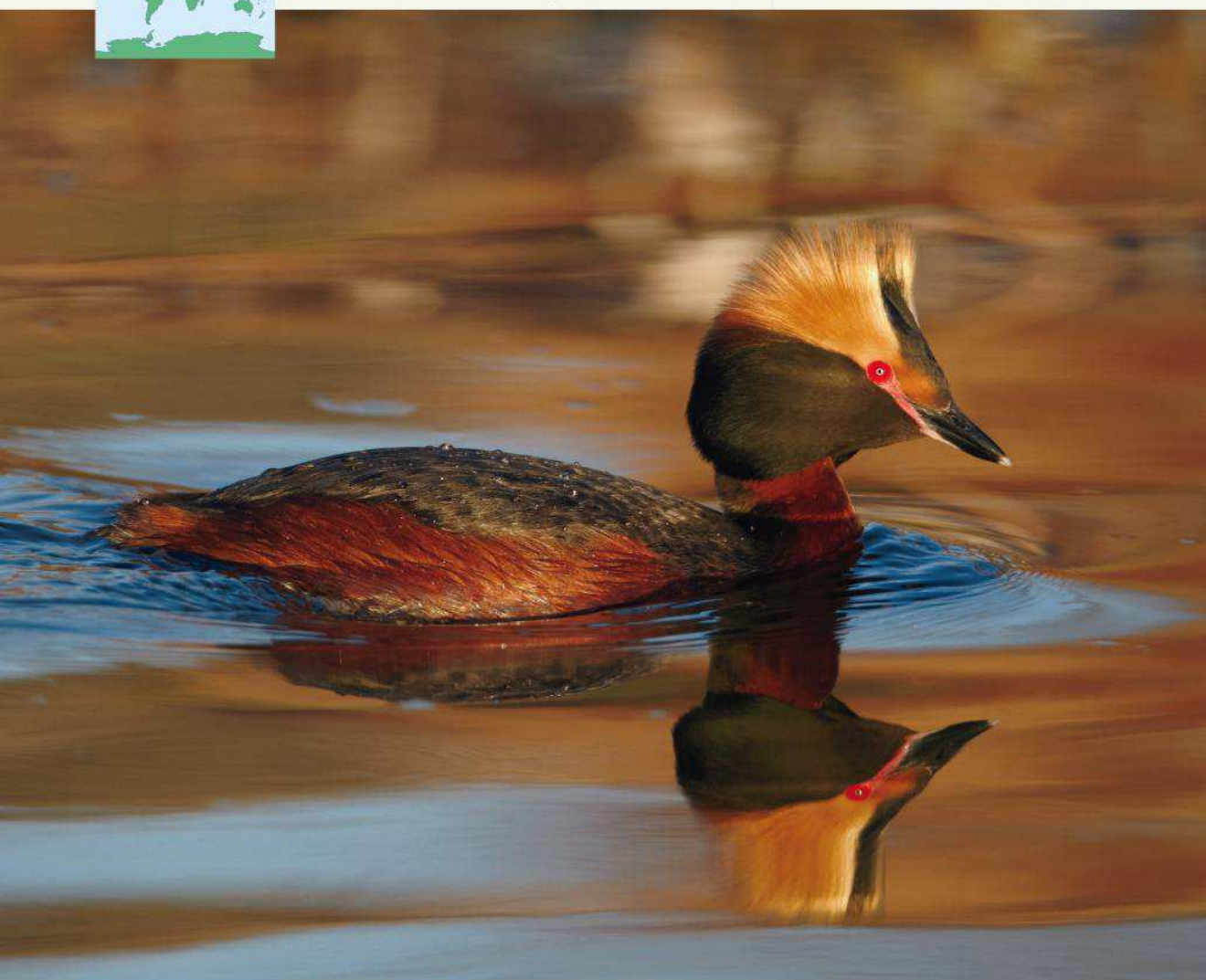
In an inspiring new book, positive-aging advocate Barbara Hannah Grufferman reveals easy-to-adopt steps that she says will lead to "a better, longer, happier life." *Love Your Age* is available where books are sold and at shopng.com/books.



Horned Grebe (*Podiceps auritus*)

Size: Body length, 31 - 38 cm (12.2 - 15 inches); wing length, 13.1 - 15.8 cm (5.2 - 6.2 inches)

Weight: 300 - 515 g (10.6 - 18.2 oz) **Habitat:** High northern latitudes; breeds in small, shallow fresh water bodies or inlets **Surviving number:** Estimated at 239,000 - 583,000



Photographed by Markus Varesvuo

WILDLIFE AS CANON SEES IT

Dance master. The horned grebe uses complex behavioral displays during courting and aggression, with choreography ranging from a "penguin dance" to swimming side by side in a hunched posture while trilling in duet. The grebe is also graceful in its foot-assisted takeoffs, which make it look as if it's running on water. But a multitude of dangers are

catching up to it, including human disturbance at breeding sites, fluctuating water levels, introduced predators and toxic chemicals. Will the dance continue?

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.



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PUERTO RICO

Everyone Has a Story

INTERVIEW BY SUSAN GOLDBERG PHOTOGRAPH BY CAROL GUZY



CAROL GUZY, 62, has won four Pulitzer Prizes for photography—more than any other photojournalist. Among her peers she's known as much for her big heart as for the images she makes in places as different as Iraq, Haiti, and New Orleans. We sent Guzy to cover Puerto Rico (above) after Hurricane Maria. I talked with her about that experience and storytelling.

Susan Goldberg: I learned as a young reporter writing obituaries that everyone has a story...

Carol Guzy: Yes! Everyone has a story, and it's almost cathartic for people to tell it. But it's their story—not my story—and it's amazing to me that people have the courage to open up their lives to the camera.

In nearly 40 years as a photographer, what changes have you seen?

Now there's such mistrust of the media. It makes it more important than ever that what we portray is as accurate as we, as subjective beings, can make it.

What was it like in Puerto Rico?

I'd never been; my first trip was the day of the hurricane. People were just getting by, yet not one didn't welcome me into the rubble that was left of their home. They had almost no water but

offered us some. There are few places I've been where people were so gracious.

You've made a career of going into difficult places. What have you learned from what you've seen?

When I was covering the refugee camps in Kurdistan, people were living in terrible limbo, and yet there was such an amazing spirit. In Mosul, Iraq, there was horrific urban fighting. People were battered and maimed and yet had this grace. I feel so privileged and so guilty to get on a plane and leave, and they are stuck. People forget them.

Is that why you take pictures—so people won't forget?

I take pictures to enlighten people to something they are not aware of. If we keep taking the pictures and keep telling the stories, we can make it better. I really believe that.



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P R O O F

NATIONAL GEOGRAPHIC



Russia's troubled environmental history hides a surprise:

LOOKING AT THE EARTH FROM EVERY POSSIBLE ANGLE

Sunset falls on a young arctic fox framed by reindeer antlers, on Wrangel Island in the Chukchi Sea. Wrangel is one of 105 Russian *zapovedniks*—"strict nature reserves" to which all human access is tightly regulated.

THE WILD GEMS OF RUSSIA

85 million acres of highly protected, pristine lands.

PHOTOGRAPHS BY **SERGEY GORSHKOV**

VOL. 234 NO. 1



**ABOVE**

The Dulismar River begins to freeze in Putoransky Zapovednik in the Siberian Arctic. The roadless reserve, which stretches from boreal forests north into ice deserts, receives just a few hundred visitors a year.

RIGHT

Lava streams converge (right to left) near the snowy summit of Ploskiy Tolbachik, a volcano in Klyuchevskoy Nature Park on the Kamchatka Peninsula.





LEFT

Lake water welling up through a central hole radiates in branching fingers through the algae-tinted snow and ice on Lake Lama, one of thousands of lakes and waterfalls on the Putorana Plateau. When spring comes to this nearly inaccessible region, "water is the main artist," photographer Sergey Gorshkov says. The area pictured is about 30 feet across.



In Putoransky Zapovednik, Kandinsky Falls and a lower cascade drop 700 feet from the Putorana Plateau to the canyon below. A reindeer migration route crosses part of the reserve, which is also home to Eurasian elk, wolves, wolverines, Putorana bighorn sheep, and brown bears.



THE BACKSTORY

RUSSIA'S CENTURY-LONG APPROACH TO PROTECTING NATURE
IS TO KEEP HUMANS OUT OF LARGE PARTS OF IT.

A LITTLE-KNOWN LEGACY of Russia's tumultuous 20th century is a profusion of protected lands, some so remote and restricted that few Russians have ever set foot in them.

In the final months before Nicholas II, the last tsar, was forced to abdicate in 1917, he created the country's first *zapovednik*, or "strict nature reserve," near Lake Baikal in Siberia. Nicholas was soon executed by Bolshevik revolutionaries. He never knew that his reserve had succeeded in saving the Barguzin sable, long prized by the imperial family for its fur, which was nicknamed "soft gold."

In the United States the first national parks had been conceived as "pleasuring grounds" for the people. Early Russian conservationists, such as Grigory Kozhevnikov, had different dreams. They wanted to keep Russia's new reserves *from* its people, as pristine labs of primordial nature. "No need to remove anything, to add anything,

to improve anything," Kozhevnikov argued. "One should leave nature to itself and observe the results."

Today, countless environmental battles (and a few environmental disasters) later, Russia has 174 million acres of federally protected lands. They include 85 million acres in 105 *zapovedniks*, which meet the highest protection standards of the International Union for Conservation of Nature, category Ia—"...where human visitation, use and impacts are strictly controlled and limited." No other country has as much highly protected land.

Sergey Gorshkov has been photographing these wilds for nearly two decades, capturing rare volcanic eruptions, intimate moments with wildlife unused to humans, the seasonal thaw of untouched Arctic waterways. His work is a timely reminder of the beautiful results we observe when we heed Kozhevnikov's plea and leave nature alone. —EVE CONANT



Dark clouds gather over icebergs off Franz Josef Land, in the Russian Arctic National Park.

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Birds Predict Quakes
Soccer Players' Roots
Resilient Landscapes



THE DISCOVERIES OF TODAY THAT WILL DEFINE THE WORLD OF TOMORROW

NATIONAL GEOGRAPHIC

VOL. 234 NO. 1

Climate: The More Things Change...

IN THE TIME IT TOOK TO BUILD THE CASE THAT CLIMATE CHANGE IS A POLLUTION PROBLEM, IT'S BECOME UNNERVINGLY MORE THAN THAT.

BY ANDREW REVKIN

T

HIRTY YEARS AGO, the potentially disruptive impact of heat-trapping emissions from burning fossil fuels and rain forests became front-page news.

It had taken a century of accumulating science, and a big shift in perceptions, for that to happen. Indeed, Svante Arrhenius, the pioneering Swedish scientist who in 1896 first estimated the scope of warming from widespread coal burning, mainly foresaw this as a boon, both in agricultural bounty and “more equable and better climates, especially as regards the colder regions of the Earth.”

There were scattered news reports through the decades, including a remarkably clear 1956 article in the *New York Times* that conveyed how accumulating greenhouse gas emissions from energy production would lead to long-lasting environmental changes. In its closing the article foresaw what's become the main impediment to tackling harmful emissions: the abundance of fossil fuels. “Coal and oil are still

IN 1988 A VARIETY OF FACTORS—INCLUDING SEVERE DROUGHT AND HEAT AND VAST FIRES IN PARTS OF THE WORLD—HAD PUSHED THE GREENHOUSE EFFECT INTO THE SPOTLIGHT.

plentiful and cheap in many parts of the world, and there is every reason to believe that both will be consumed by industry so long as it pays to do so.”

The Intergovernmental Panel on Climate Change was established in late 1988, after a variety of factors had pushed the greenhouse effect into the spotlight. That year there was severe drought and heat in the United States and vast fires in the Amazon rain forest and in Yellowstone National Park. The outline of a solution had been forged just one year earlier as the world’s nations agreed on the Montreal Protocol, which set steps to eliminate certain synthetic compounds imperiling the atmosphere’s protective ozone layer.

The crystallizing moment came on June 23, in unnerving Senate testimony. James E. Hansen—a climate scientist who’d turned his attention from studying the searing conditions on Venus to Earth’s human-changed atmosphere—concluded bluntly that “the greenhouse effect has been detected and is changing our climate now.”

MY JOURNALISTIC JOURNEY to learn about climate change science, impacts, and related energy choices began in earnest later that month in Toronto, at the first World Conference on the Changing Atmosphere. It’s never stopped, weaving from the North Pole to the White House, from solar-tech labs and nuclear plant fuel pools to the Vatican. Details changed, but in many ways the main issues remain roughly as I and other journalists found them in 1988.

That October, my *Discover* magazine cover story touched on the flooding threat to Miami, the potential amped-up power of hurricanes, China’s predicted emissions surge, the vulnerability of California’s snowpack and thus its water supply, and more. It also described vexing uncertainties in warming projections that remain today. It ended with this quote from Michael B. McElroy, then, as now, a Harvard University professor: “If we choose to take on this challenge, it appears that we can slow the rate of change substantially, giving us time to develop mechanisms so that the cost to society and the damage to ecosystems can be minimized. We could alternatively close our eyes, hope for the best, and pay the cost when the bill comes due.”

That warning probably sounds familiar. Scientists, climate campaigners, and concerned politicians have been making similar statements ever since. Their

warnings have not kept emissions from increasing. Glen Peters, a scientist at the Center for International Climate Research in Oslo, Norway, charted the rise of the carbon dioxide level in the atmosphere from the year 1870—and found that nearly half that rise has come from human emissions in the past 30 years.

Plenty is happening with renewable energy technologies, with soaring growth in solar and wind systems and in performance of the batteries necessary to keep lights on when the sun is down and the air is still. But the world remains more than 85 percent reliant on fossil fuels to satisfy its thirst for energy. Gains in energy efficiency and renewable energy have been swamped by rising demand for fossil energy as poverty ebbs. In the U.S. and much of Europe, low-carbon nuclear power is in retreat as communities, recalling past scares, press to close aging plants, and high costs hinder the development of new ones.





WHAT EXPLAINS the lack of decisive progress on human-driven climate change? Having invested half of my 62 years in reporting and writing climate-related stories, blog posts, and books, I've lately found it useful—if sometimes uncomfortable—to look back for misperceptions or missed opportunities that let the problem worsen.

Can we name the main culprits? There are almost as many theories and targets as there are advocates of one stripe or another. Among them: lack of basic research funding (I was often in that camp), industry influence on politics, poor media coverage, and doubt-sowing by those invested in fossil fuels or opposed to government intervention. There's also our "inconvenient mind"—my description for a host of human behavioral traits and social norms that cut against getting climate change right.

For years I thought the answer was like the

Visible beyond a vineyard in Napa County is one of at least a dozen fires that ravaged Northern California in October 2017. The area had been plagued by years of extreme heat and drought.

conclusion in Agatha Christie's *Murder on the Orient Express*: that all suspects were guilty. But there's another possibility. Maybe climate change is less an environmental wrong to be set right and more an emerging source of risk—a case of humanity's planet-scale power outrunning, at least for now, our capacity for containing our momentous impacts. In a 2009 piece called "Puberty on the Scale of a Planet," I toyed with this notion, suggesting that our species was in a turbulent transition from adolescence to adulthood, resisting admonitions to grow up—with fossil fuels standing in for testosterone.

But the situation is even more tangled. The more

I reported in unlit Kenyan slums and Indian villages where people cook on illicit charcoal or hand-gathered twigs, the clearer it became that there's no single "we" when it comes to energy, nor for vulnerability to climate hazards. The rich "we" can afford to convert to clean energy and cut vulnerability to heat, floods, and more. But the rest of humanity is still struggling to get the basic economic benefits that we've gotten from burning fossil fuels.

Research by an array of scientists and scholars supports a daunting conclusion: Climate change is unlike any environmental problem we've ever faced. We can't "fix" it the way we've started to fix smog or the ozone hole, with circumscribed regulations and treaties and limited technological changes. Climate change is too big in space, time, and complexity; the emissions that cause it are too central a consequence of the effort of some 7.5 billion people now, and some 10 billion within several decades, to prosper on Earth.

THE REAL SHAPE of what's happening to Earth emerges only when the greenhouse emissions surge is considered alongside other metrics for human activity. A 2015 scientific report titled "The Great Acceleration" included a planetary dashboard of graphs charting signals of human activity, from tropical forest loss to paper manufacturing to water use. Most have the same shape as the curve for CO₂ emissions. Pollution and climate impacts, then, are symptoms of a broader situation: the human-Earth mash-up moment that's increasingly called the Anthropocene.

Adam Frank, an astrophysicist at the University of Rochester, has begun assessing possible outcomes for our planet under different scenarios. He draws on the rapidly expanding body of knowledge about other planets outside our solar system that could harbor life and plots possible trajectories for Earth-like planets inhabited by sentient species.

While the mathematical models are fairly simple, three broad scenarios emerge, which Frank describes in a new book called *Light of the Stars*. The first scenario is the "soft landing," in which a civilization and its planet come smoothly to a new, steady state. The second is "die off," in which a planet's environmental conditions degrade and populations drop precipitously but seem to survive. "It's hard to know if a technological civilization could survive losing something like 70 percent of its population," Frank says.

And there's a third scenario: collapse. "The

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population rises, the planetary state 'heats up,' and at some point the population crashes down to zero," Frank says. "We even found solutions where the collapse could happen after the population changed from a high-impact energy source—fossil fuels—to a lower-impact one, solar."

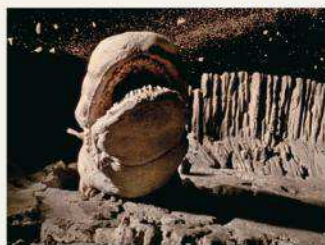
Frank's interplanetary perspective makes clear that the climate crisis is really more of a grand challenge, like the wars on cancer or poverty, that people work on over a lifetime, even generations, with a mix of urgency and patience. The change in perspective is troubling but also liberating: It means anyone with motivation and perseverance can make a difference—as a teacher or engineer, an artist or investor, or simply as an engaged planetary citizen.

In looking into space to assess Earth's prospects, Frank has circled back to James Hansen's starting point—his early research on our superhot neighbor, Venus. Earlier this year, I asked Frank what he sees in Earth's future: Are we destined to be more like a struck match, flaring bright but briefly? Or could we glow on, like, say, a solar-powered LED?

Frank thinks it may be hard for any biosphere that evolves a planet-scale industrial civilization to avoid great disruption. "The question is, how often does the civilization make it through the transition to emerge as a still important part of the now changed biosphere," Frank said. "Much may depend on the evolutionary heritage the species gets," he says—whether populations can think and act as needed to adapt to, and responsibly manage, a new reality.

It's a question for Earth, he says: "Do we have what it takes? I hope so, but I guess we'll see pretty soon."

Andrew Revkin recently joined the National Geographic Society staff as strategic adviser, environmental and science journalism, after three decades of environmental reporting, mostly for the *New York Times*. With environmental educator Lisa Mechaley, he co-wrote the 2018 book *Weather: An Illustrated History, From Cloud Atlases to Climate Change*.



The Force of Climate Change

To explain how the enormity of climate change affects our grasp of it, Rice University's Tim Morton cites a scene from the *Star Wars* movie *The Empire Strikes Back* where the *Millennium Falcon* flies into a "cave" that's actually a giant worm's maw. Living with climate change is like that, he says: "Because the worm is 'everywhere' in your field of vision, you can't really tell the difference between it and the asteroid you think you landed on. For a while, you can kid yourself that you're not inside a gigantic worm—until it starts digesting you." —AR

SEE THE CAT SHE WAS BORN TO BE

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DISPATCHES
FROM THE FRONT LINES
OF SCIENCE
AND INNOVATION

Origami Challenge

What started in 2015 as an ambitious project for paper artist Cristian Marianciuc—to fold an origami crane a day for 100 days—became a personal quest. He ended up making 1,000 gorgeous cranes over as many consecutive days.



ENVIRONMENT

Bugs: They're in the House

Freeloaders come in all sizes. A study of 50 houses in the Raleigh, North Carolina, area, reported in the journal *Peer J*, found hundreds of species of arthropods living with unwitting homeowners. Most (73 percent) were flies, spiders, wasps, ants, and beetles, like the varied carpet beetle below. Also found: moths, earwigs, cockroaches, and millipedes.

—LORI CUTHBERT



TECHNOLOGY

WINGED PREDICTIONS

CAN TAGGED BIRDS DETECT COMING EARTHQUAKES?

Scientists are betting on a new system to alert us to impending earthquakes: birds wearing tiny backpacks.

Though no one knows precisely why, animals often act atypically before an earthquake or other disaster. Flocks of birds might migrate off course or be active at unusual times, says Martin Wikelski, an ecologist at Germany's Max Planck Institute for Ornithology and a fellow of the National Geographic Society. He directs a satellite tracking project called International Cooperation for Animal Research Using Space. ICARUS will use lightweight electronic tags—affixed as backpack harnesses, leg bands, or even hats—to monitor the activity patterns of tens of thousands of birds, bats, and other creatures for irregularities that suggest an earthquake is imminent.

A global network of volunteers has started to tag animals with the devices—Wikelski calls them “wearables for wildlife”—which will track and beam their movements and other data to the International Space Station. There Russian astronauts will install the ICARUS data-gathering hardware during an upcoming space walk. The result, Wikelski hopes, will be a disaster-prediction network akin to an “internet of wings.”

—LINDSAY GELLMAN



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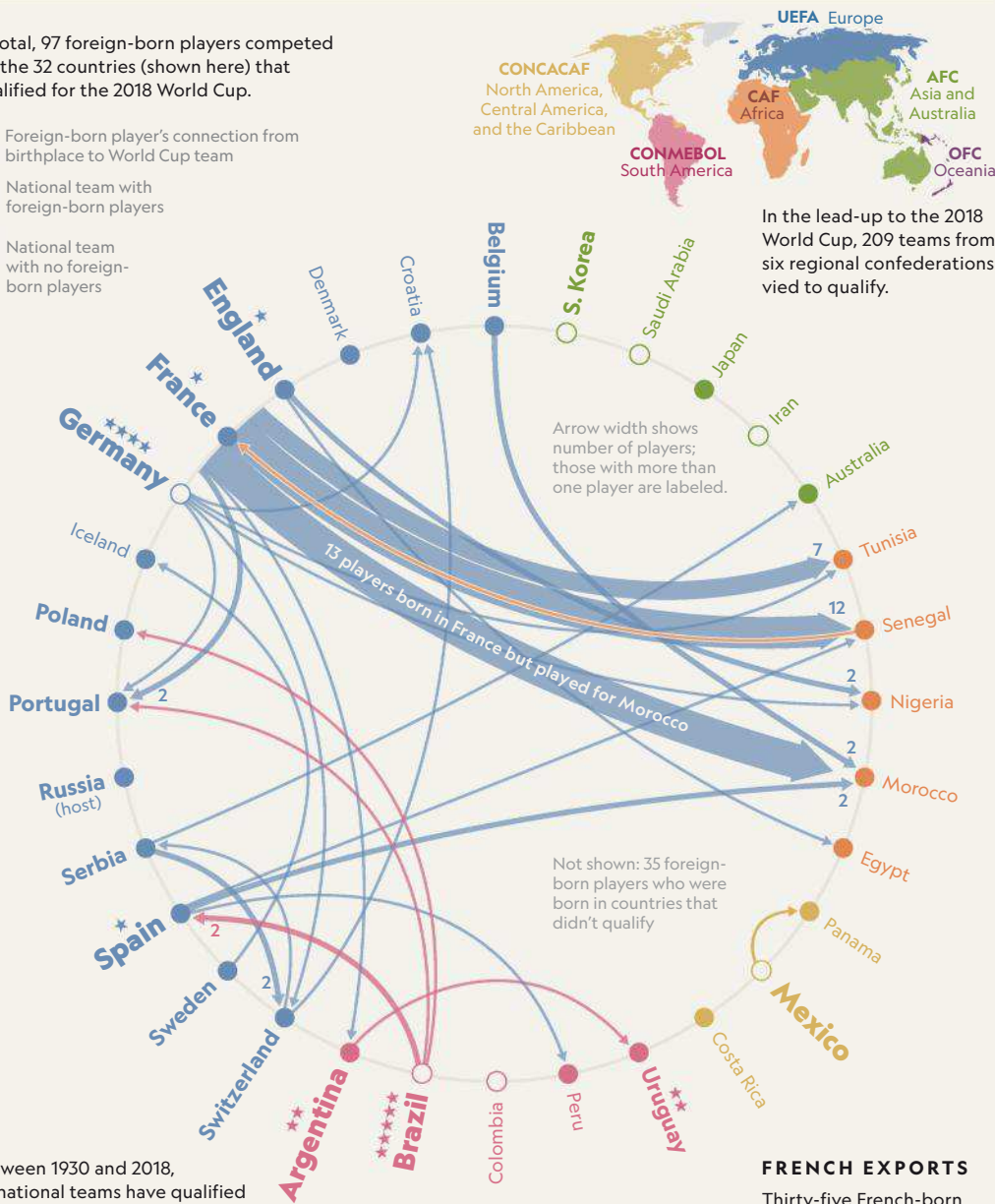
SOCCER WITHOUT BORDERS

THE 2018 FIFA WORLD CUP in Russia will feature 32 soccer teams from around the world. But just because a team represents a country doesn't mean all its players were born there. Family heritage and dual citizenship are factors that players consider when choosing which country to represent. Of the 32 teams, 25 of them fielded at least one foreign-born player during qualification for the world's most watched single-sport tournament—covered this summer by National Geographic in partnership with Fox Sports.

BY RILEY D. CHAMPINE

In total, 97 foreign-born players competed for the 32 countries (shown here) that qualified for the 2018 World Cup.

- Foreign-born player's connection from birthplace to World Cup team
- National team with foreign-born players
- National team with no foreign-born players



In the lead-up to the 2018 World Cup, 209 teams from six regional confederations vied to qualify.

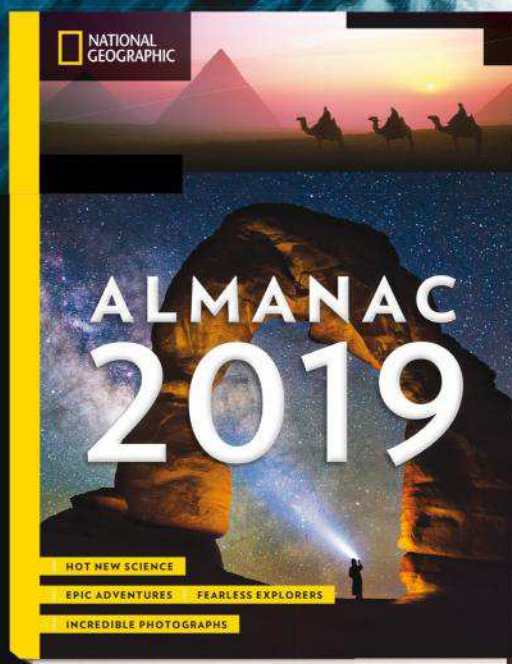
Between 1930 and 2018, 79 national teams have qualified for a World Cup tournament. Only eight have been champions.

★	World Cup win
Country	15 or more appearances
Country	7-14 appearances
Country	6 or fewer appearances

FRENCH EXPORTS

Thirty-five French-born players will likely compete for other countries, such as Senegal, Tunisia, and Morocco—a legacy of French colonialism in Africa and waves of immigration.

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GENIUS

KATE ORFF

BY RACHEL HARTIGAN SHEA PHOTOGRAPH BY BENEDICT EVANS

**Designing Landscapes
for the Anthropocene**

Making places beautiful is not enough for Kate Orff. The landscape architect also wants to make them adaptable to climate change and its extreme effects. "Every square inch of the planet has been impacted, intentionally or not, by human agency," she says. "My goal is to translate that into something positive."

Scape, her design studio, has partnered with New York State (with federal funding) to create what they're calling "living breakwaters" along the south shore of Staten Island, which was pummeled by Hurricane Sandy in 2012. The breakwaters will do triple duty—protect the coastline from future storms and erosion, restore marine habitat in Raritan Bay, and provide places along the shore for residents to learn about the ecosystem and to engage with it.

Orff, who also directs Columbia University's new Center for Resilient Cities and Landscapes, approaches landscape design from what she calls "a stance of activism." She wants the places she designs to "bridge nature and culture, sociology and ecosystems." A proposed project to restore Alameda Creek in the San Francisco Bay Area exemplifies that goal: People would be invited to interact with nature along the creek's banks, while the water's improved flow would bring sediment to the bay, protecting the area from extreme flooding.

Orff urges people to be activist designers in their communities. In these times of dramatic ecological change, she says, it's dangerous to "look passively upon the Earth as an aesthetic backdrop."



For people with unresectable Stage III non-small cell lung cancer (NSCLC) whose disease has not progressed following concurrent chemoradiation therapy

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*In a clinical trial, the median time that people lived without their tumors growing or spreading was 16.8 months for the 476 patients receiving IMFINZI compared with 5.6 months for the 237 patients receiving placebo (no medication). Median is the middle number in a group of numbers arranged from lowest to highest. Overall survival comparison is not yet available. The trial is still ongoing.

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WHO IS IMFINZI FOR?

IMFINZI® (durvalumab) is a prescription medicine used to treat a type of lung cancer called non-small cell lung cancer (NSCLC). IMFINZI may be used when your NSCLC has not spread outside your chest, cannot be removed by surgery, and has responded or stabilized with initial treatment with chemotherapy that contains platinum, given at the same time as radiation therapy. It is not known if IMFINZI is safe and effective in children.

IMPORTANT SAFETY INFORMATION

What is the most important information I should know about IMFINZI?

IMFINZI is a medicine that may treat a type of lung cancer by working with your immune system. IMFINZI can cause your immune system to attack normal organs and tissues and can affect the way they work. These problems can sometimes become serious or life-threatening and can lead to death.

Call or see your healthcare provider right away if you develop any symptoms of the following problems or if these symptoms get worse:

Lung problems (pneumonitis). Signs and symptoms may include new or worsening cough, shortness of breath, and chest pain.

Liver problems (hepatitis). Signs and symptoms may include yellowing of your skin or the whites of your eyes, severe nausea or vomiting, pain on the right side of your stomach area (abdomen), drowsiness, dark urine (tea colored), bleeding or bruising more easily than normal, and feeling less hungry than usual.

Intestinal problems (colitis). Signs and symptoms may include diarrhea or more bowel movements than usual; stools that are black, tarry, sticky, or have blood or mucus; and severe stomach-area (abdomen) pain or tenderness.

Hormone gland problems (especially the thyroid, adrenals, pituitary, and pancreas). Signs and symptoms that your hormone glands are not working properly may include headaches that will not go away or unusual headaches; extreme tiredness; weight gain or weight loss; dizziness or fainting; feeling more hungry or thirsty than usual; hair loss; feeling cold; constipation; your voice gets deeper; urinating more often than usual; nausea or vomiting; stomach-area (abdomen) pain; and changes in mood or behavior, such as decreased sex drive, irritability, or forgetfulness.

Kidney problems, including nephritis and kidney failure. Signs of kidney problems may include decrease in the amount of urine, blood in your urine, swelling of your ankles, and loss of appetite.

Skin problems. Signs may include rash, itching, and skin blistering.

Problems in other organs. Signs and symptoms may include neck stiffness; headache; confusion; fever; chest pain, shortness of breath, or irregular heartbeat (myocarditis); changes in mood or behavior; low red blood cells (anemia); excessive bleeding or bruising; muscle weakness or muscle pain; blurry vision, double vision, or other vision problems; and eye pain or redness.

Severe infections. Signs and symptoms may include fever, cough, frequent urination, pain when urinating, and flu-like symptoms.

Severe infusion reactions. Signs and symptoms may include chills or shaking, itching or rash, flushing, shortness of breath or wheezing, dizziness, fever, feeling like passing out, back or neck pain, and facial swelling.

Getting medical treatment right away may help keep these problems from becoming more serious. Your healthcare provider will check you for these problems during your treatment with IMFINZI. Your healthcare provider may treat you with corticosteroid or hormone replacement medicines. Your healthcare provider may delay or completely stop treatment with IMFINZI if you have severe side effects.

Before you receive IMFINZI, tell your healthcare provider about all of your medical conditions, including if you have immune system problems such as Crohn's disease, ulcerative colitis, or lupus; have had an organ transplant; have lung or breathing problems; have liver problems; or are being treated for an infection.

If you are pregnant or plan to become pregnant, tell your healthcare provider. IMFINZI can harm your unborn baby. If you are able to become pregnant, you should use an effective method of birth control during your treatment and for at least 3 months after the last dose of IMFINZI. Talk to your healthcare provider about which birth control methods to use. Tell your healthcare provider right away if you become pregnant during treatment with IMFINZI.

If you are breastfeeding or plan to breastfeed, tell your healthcare provider. It is not known if IMFINZI passes into breast milk. Do not breastfeed during treatment with IMFINZI and for at least 3 months after the last dose of IMFINZI.

Tell your healthcare provider about all the medicines you take. This includes prescription and over-the-counter medicines, vitamins, and herbal supplements.

What are the possible side effects of IMFINZI?

IMFINZI can cause serious side effects (see earlier).

The most common side effects in people with non-small cell lung cancer (NSCLC) include cough, feeling tired, inflammation in the lungs (pneumonitis), upper respiratory tract infections, shortness of breath, and rash.

Tell your healthcare provider if you have any side effect that bothers you or that does not go away. These are not all the possible side effects of IMFINZI. Ask your healthcare provider or pharmacist for more information.

Call your healthcare provider for medical advice about side effects. You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/MedWatch or call 1-800-FDA-1088.

Please see Brief Summary of complete Prescribing Information on adjacent page.

If you cannot afford your medications, AstraZeneca may be able to help. Visit AstraZeneca-us.com to find out how.

 **IMFINZI™**
durvalumab
injection for intravenous use 50 mg/mL



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IMPORTANT INFORMATION ABOUT IMFINZI® (im-FIN-zee) (durvalumab) INJECTION



WHAT IS THE MOST IMPORTANT INFORMATION I SHOULD KNOW ABOUT IMFINZI?

IMFINZI is a medicine that may treat a type of lung cancer by working with your immune system.

IMFINZI can cause your immune system to attack normal organs and tissues and can affect the way they work. These problems can sometimes become serious or life-threatening and can lead to death.

Call or see your healthcare provider right away if you develop any symptoms of the following problems or these symptoms get worse:

Lung problems (pneumonitis). Signs and symptoms of pneumonitis may include:

- new or worsening cough
- shortness of breath
- chest pain

Liver problems (hepatitis). Signs and symptoms of hepatitis may include:

- yellowing of your skin or the whites of your eyes
- severe nausea or vomiting
- pain on the right side of your stomach area (abdomen)
- drowsiness
- dark urine (tea colored)
- bleeding or bruising more easily than normal
- feeling less hungry than usual

Intestinal problems (colitis). Signs and symptoms of colitis may include:

- diarrhea or more bowel movements than usual
- stools that are black, tarry, sticky, or have blood or mucus
- severe stomach area (abdomen) pain or tenderness

Hormone gland problems (especially the thyroid, adrenals, pituitary and pancreas).

Signs and symptoms that your hormone glands are not working properly may include:

- headaches that will not go away or unusual headaches
- extreme tiredness
- weight gain or weight loss
- dizziness or fainting
- feeling more hungry or thirsty than usual
- hair loss
- changes in mood or behavior, such as decreased sex drive, irritability, or forgetfulness
- feeling cold
- constipation
- your voice gets deeper
- urinating more often than usual
- nausea or vomiting
- stomach area (abdomen) pain

Kidney problems, including nephritis and kidney failure. Signs of kidney problems may include:

- decrease in the amount of urine
- blood in your urine
- swelling of your ankles
- loss of appetite

Skin problems. Signs of these problems may include:

- rash
- itching
- skin blistering

(continued)

Problems in other organs. Signs and symptoms may include:

- neck stiffness
- headache
- confusion
- fever
- chest pain, shortness of breath, or irregular heartbeat (myocarditis)
- changes in mood or behavior
- low red blood cells (anemia)
- excessive bleeding or bruising
- muscle weakness or muscle pain
- blurry vision, double vision, or other vision problems
- eye pain or redness

Severe infections. Signs and symptoms may include:

- fever
- cough
- frequent urination
- pain when urinating
- flu-like symptoms

Severe infusion reactions. Signs and symptoms of severe infusion reactions may include:

- chills or shaking
- itching or rash
- flushing
- shortness of breath or wheezing
- dizziness
- fever
- feel like passing out
- back or neck pain
- facial swelling

Getting medical treatment right away may help keep these problems from becoming more serious.

Your healthcare provider will check you for these problems during your treatment with IMFINZI. Your healthcare provider may treat you with corticosteroid or hormone replacement medicines. Your healthcare provider may delay or completely stop treatment with IMFINZI, if you have severe side effects.

WHAT IS IMFINZI?

IMFINZI is a prescription medicine used to treat:

- a type of lung cancer called non-small cell lung cancer (NSCLC). IMFINZI may be used when your NSCLC:
 - has not spread outside your chest
 - cannot be removed by surgery, **and**
 - has responded or stabilized with initial treatment with chemotherapy that contains platinum, given at the same time as radiation therapy.

It is not known if IMFINZI is safe and effective in children.

Before you receive IMFINZI, tell your healthcare provider about all of your medical conditions, including if you:

- have immune system problems such as Crohn's disease, ulcerative colitis, or lupus
- have had an organ transplant
- have lung or breathing problems
- have liver problems
- are being treated for an infection
- are pregnant or plan to become pregnant. IMFINZI can harm your unborn baby. If you are able to become pregnant, you should use an

(continued)

effective method of birth control during your treatment and for at least 3 months after the last dose of IMFINZI. Talk to your healthcare provider about birth control methods that you can use during this time. Tell your healthcare provider right away if you become pregnant during treatment with IMFINZI.

- are breastfeeding or plan to breastfeed. It is not known if IMFINZI passes into your breast milk. Do not breastfeed during treatment and for at least 3 months after the last dose of IMFINZI.

Tell your healthcare provider about all the medicines you take, including prescription and over-the-counter medicines, vitamins, and herbal supplements.

HOW WILL I RECEIVE IMFINZI?

- Your healthcare provider will give you IMFINZI into your vein through an intravenous (IV) line over 60 minutes.
- IMFINZI is usually given every 2 weeks.
- Your healthcare provider will decide how many treatments you need.
- Your healthcare provider will test your blood to check you for certain side effects.
- If you miss any appointments, call your healthcare provider as soon as possible to reschedule your appointment.

WHAT ARE THE POSSIBLE SIDE EFFECTS OF IMFINZI?

IMFINZI CAN CAUSE SERIOUS SIDE EFFECTS, INCLUDING:

SEE "WHAT IS THE MOST IMPORTANT INFORMATION I SHOULD KNOW ABOUT IMFINZI?"

The most common side effects of IMFINZI in people with NSCLC include:

- cough
- feeling tired
- inflammation in the lungs (pneumonitis)
- upper respiratory tract infections
- shortness of breath
- rash

Tell your healthcare provider if you have any side effect that bothers you or that does not go away.

These are not all the possible side effects of IMFINZI. Ask your healthcare provider or pharmacist for more information. Call your healthcare provider for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

GENERAL INFORMATION ABOUT THE SAFE AND EFFECTIVE USE OF IMFINZI.

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. If you would like more information about IMFINZI, talk with your healthcare provider. You can ask your healthcare provider for information about IMFINZI that is written for health professionals.



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EXPLORE

IN THIS SECTION

Shaping the Globe
Moving Mountains
She Stalks Sharks
Armadillo Amour



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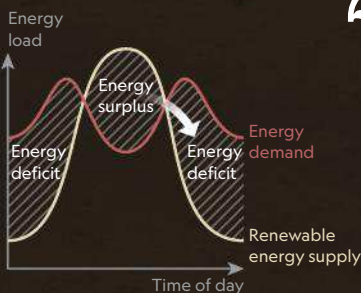
NATIONAL GEOGRAPHIC

VOL. 234 NO. 1

CLEAN ENERGY IN A COAL MINE

THE CHALLENGE: Renewable energy from the wind and sun is abundant; storing it for future use has been a persistent puzzle. An Australian project uses a giant lithium-ion battery, while one in Nevada employs molten salt. Germany, which aims to run on 80 percent renewable power by 2050, is turning to the infrastructure of the very industry the country aims to replace—coal. The plan: Transform the Prosper-Haniel mine in Bottrop into a battery. This would be among the first underground projects using pumped hydropower, which has proved to be an efficient energy storage technology. But even if clean, it's expensive—and still in search of funding.

Without energy storage, renewable energy is wasted when demand is low.



1 On the surface, wind turbines and solar panels generate renewable energy. The coal mine, which is set to close this year, is underneath.

Water pumped to surface

2 When there is more energy supply than demand, excess power is used to pump water upward from the underground reservoir through existing shafts to the surface reservoir.

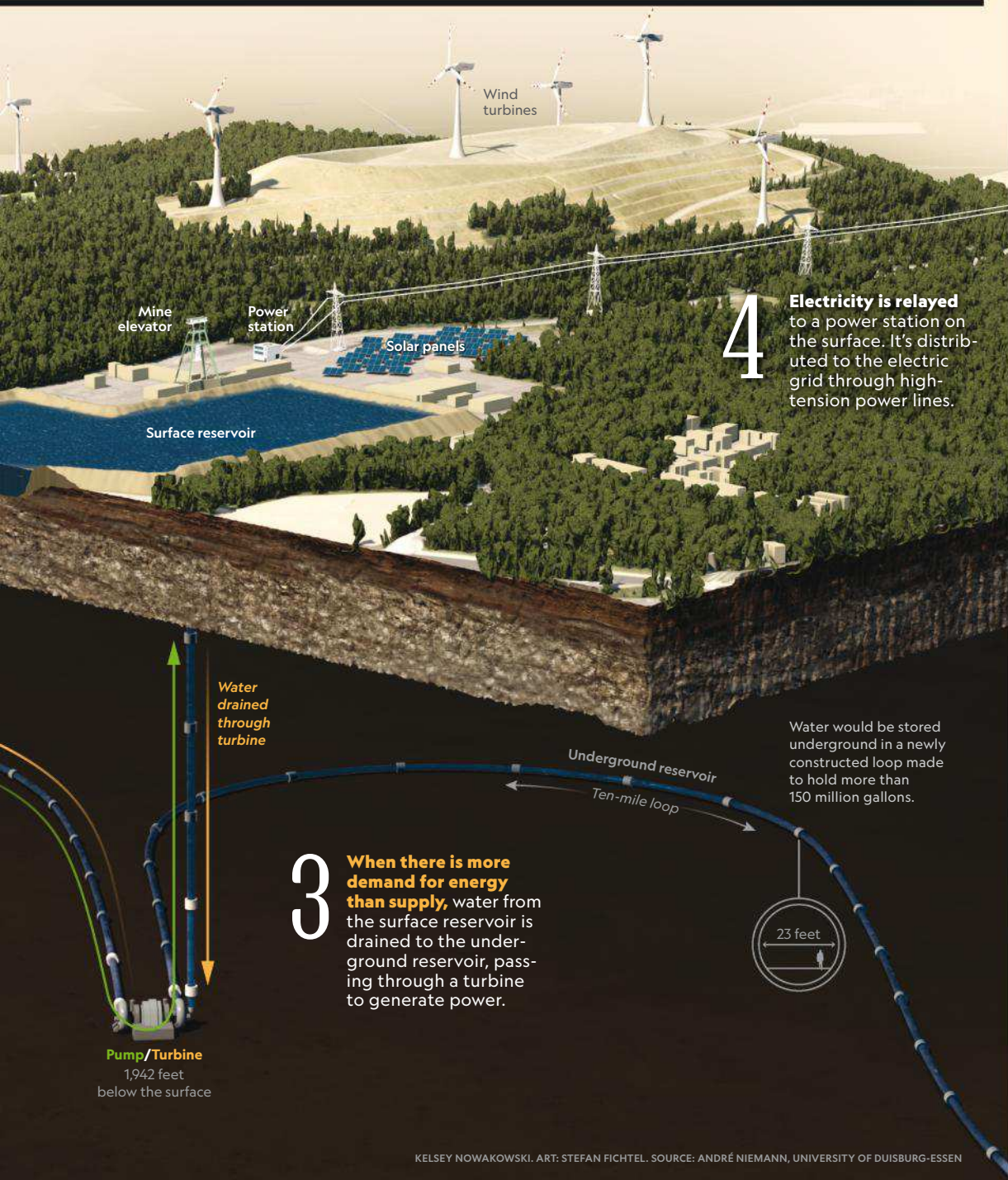


PLACE Prosper-Haniel coal mine

LOCATION Bottrop, North Rhine-Westphalia, Germany

DISTINCTION A soon-to-be-closed coal mine may find new life as a storage facility for renewable energy.

DECODER BY JASON TREAT



4

Electricity is relayed to a power station on the surface. It's distributed to the electric grid through high-tension power lines.

3

When there is more demand for energy than supply, water from the surface reservoir is drained to the underground reservoir, passing through a turbine to generate power.

Water would be stored underground in a newly constructed loop made to hold more than 150 million gallons.



CREATING THE WORLD



PHOTOGRAPH BY AARON TILLEY

PETER BELLERBY WANTED TO MAKE A GLOBE for his father's 80th birthday. By the time he delivered the gift, two years later, Bellerby had sold his house and car to launch one of the world's only bespoke globemakers. In the 15th century, artisans etched their maps into brass printing plates in reverse. It's still delicate work for the London-based Bellerby & Co. team. Each surfboard-shaped map section is hand-painted and stretched—a process known as goring—and many tools must be custom made. "There are no globemaker supply stores," jokes Bellerby. —NINA STROCHLIC

1. Spherical measure

A tool for accurately plotting latitude lines.

2-4. Watercolor supplies

Small pots of hand-mixed watercolors and a palette for testing them.

5. Desk globe

A mini, nine-inch globe in mint green. The biggest are 50 inches in diameter.

6. Paintbrush

For applying washes of color on large globes.

7. Engraving tools

Sharp metal tools for engraving personal messages on the base.

8. Large compass

Used for drawing latitude lines on the big globes.

9. Inner spindle

Allows a globe to spin on an axis. The bottom holds the globe on the base.

10. Gore

A hand-cut strip of the map painted with the first wash of color.

11. Calipers

For measuring sphere circumference.

12. Calligraphy pen and paintbrushes

The pen is used to write personalized messages on the globes, the paintbrushes to apply watercolors.

13. Blotting paper

One drip could mean starting over—so the paper absorbs excess paint from brushes.

14. Wooden base

Ball bearings on the wood base allow the globe to spin 360 degrees.

15. Head artist's book

The lead artist stores color references from past globes in a notebook.

16. Drop cloth

Fabric branded with the Bellerby logo.

BY THE NUMBERS

20°F

NIGHT TEMPERATURE AT
13,000 FEET

15,893

SUMMIT OF MOUNT BAKER
(FEET)

22

DAYS ON MOUNT BAKER



The Rwenzori
span Uganda
and the Demo-
cratic Republic
of the Congo.

AN

Three weeks on one of Africa's highest peaks to

'AS WE CLIMBED, THE
VEGETATION KEPT CHANGING:
FROM TROPICAL RAIN FOREST
TO MOUNTAIN FOREST TO
OPEN GRASSLAND.'

—Christian Ziegler

T MINUS SIX MONTHS PLOTING THE COURSE

I was invited to photograph a group of German geologists who were using very detailed GPS readings to measure how tectonic-plate movement is shifting the Rwenzori Mountains. Months before our departure I bought waterproof clothing and bags to protect my equipment from the wet climate. Then we planned our strategy. The range is on the border of Uganda and the Democratic Republic of the Congo. At my urging the team decided to travel on the Ugandan side to avoid rebel activity in the DRC.

T MINUS TWO WEEKS ESSENTIAL PACKING LIST

At the base of Mount Baker, the temperature was in the 80s. As we climbed, it became cold, wet, windy—and then snowy. We went from sweating to freezing in just a few days.

- A warm sleeping bag
- Four waterproof bags
- A GPS device
- Chocolate (not enough)
- Polarizing filter for camera lens to diffuse the mountain light
- A backup hard drive for downloading photos every night
- Aspirin for altitude sickness

T MINUS 48 HOURS READY FOR LAUNCH

Climbing to such a high altitude in the Rwenzoris was a dream, and I couldn't wait to get there. I flew from my home in Panama to New York, then on to Amsterdam and finally to Entebbe, Uganda. I met the geologists there, and we drove together to the western border. In a town at the base of the Rwenzori Mountains, we arranged for 15 porters and cooks, as well as one armed guard, to accompany us up Mount Baker.

ALL-TERRAIN CLIMB

measure how the Rwenzori mountain range is shifting.

STORY AND PHOTOGRAPH BY **CHRISTIAN ZIEGLER**
AS TOLD TO NINA STROCHLIC



HOW TO SAVE A PREDATOR

AFTER HELPING TO BAN THE SHARK TRADE IN THE COOK ISLANDS, JESSICA CRAMP WANTS TO KNOW: CAN A LAW PROTECT SHARKS?

BY NINA STROCHLIC PHOTOGRAPHS BY ANDY MANN

THEY ARE ON A BOAT DOCK, hands coated with the innards of a yellowfin tuna, when Konini Rongo and Bella Smith learn that they live in one of the world's largest shark sanctuaries.

The girls, both 17, are chopping up scraps next to a row of fishing boats at a port on Rarotonga, the biggest of the 15 Cook Islands. They volunteered to help American marine biologist Jessica Cramp place underwater cameras to spot sharks. But first comes the messy task of making bait, as Cramp—whose work is supported by National Geographic and Rolex—tells them the story of the 484-million-acre protected area.

In 2011 Cramp moved to the South Pacific islands, where the reefs teem with sharks, to help launch a campaign for the sanctuary. Eighteen months later it was law, with a minimum \$73,000 fine levied on

any boat found selling or transporting shark parts in the Cook Islands' exclusive economic zone.

Now Cramp plans to insert satellite tags into the backs of 28 sharks so she can follow their movements. Little is known about the region's sharks. Cramp wants to find out where and how far they're traveling—vital data for designing better protections.

On the boat Cramp shows the teens the drill: how to attach a GoPro camera and bait stick to a device that will moor them to the ocean floor, how to log the GPS coordinates so they can pull it up later. If a shark is drawn to the area by the bait, she explains, they're going to hook the animal, rope it to the side of the boat, cut a slit at the base of its dorsal fin, and slide in a satellite tag. The girls look horrified.

"It sounds brutal, but it's going to give us

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Above: Silky sharks (pictured here in the Bahamas) were among the species being killed around the Cook Islands before marine biologist Jessica Cramp helped launch a sanctuary there. Now she's gathering data to evaluate if it's working. Previous page: Cramp free dives off Rarotonga, the largest of the Cook Islands.

information to make policies that protect them," Cramp says. "One of the reasons we're studying sharks is because they're in trouble, and we want to know if the laws we have in the Cook Islands work."

Before the sanctuary was created, a vessel could easily catch five or six sharks a day, says Josh Mitchell, who oversaw commercial fisheries for the Ministry of Marine Resources. His inspectors could smell ammonia, which seeps out of sharks' skin, as soon as they boarded a boat. Often the crew would sell the fins in parts of Asia where shark-fin soup is a delicacy.

When the zero-tolerance policy went into force in 2012, the inspectors were relieved, Mitchell says, because it left no room for interpretation. Since then four boats have paid a total of \$247,000 in fines (one lower fine was levied on a local boat).

A college professor once told Cramp that the best scientists spend their entire lives trying to disprove their own theories. So for three years Cramp has been crunching global data to evaluate whether large-scale protected areas like the one she helped design are keeping sharks alive. She hopes this information will help conservationists and lawmakers develop more effective policies. "I just know sharks are still dying within sanctuaries," says Cramp. "And if they don't work, then all the political will, all the kudos, all the momentum, is for nothing."

She's come to realize that even when the law seems absolute, there are gray areas. In multiple

instances Cook Islands authorities haven't fined a boat with shark parts on board because it was just passing through the nation's waters or had entered to request medical assistance.

Traditionally sharks were an animal guardian, a *taura atua*, to Cook Islanders. But to modern-day commercial fishermen, they're the competition. Fishermen lure their catch with devices that dangle under buoys a few miles offshore—but they also attract hungry sharks. This has become a battlefield for Cramp's conservation efforts. "The mentality here is, if you're getting sharked, go catch a shark," says a local skipper.

A few days before the camera-drop trip, Cramp stops by the port looking for bait. "You guys catching anything today?" she asks a group of fishermen gathered around a picnic table. "Seen any sharks?" The answer is no to both, but Cramp has heard that one of them recently killed a shark, and she confronts him. "It was messing with me!" he hollers back.

Cramp has a reputation in the port; fishermen call her the shark lady. She tries not to lecture this one about the kill—just say enough that it sticks in his head. "He will start to kill fewer sharks," she says, "because he'll feel bad."

On boat rides to place and retrieve the GoPros, Cramp's young helpers don't see any sharks to tag. The next day they watch the GoPro footage: fish sucking on the bait stick, eels battling in front of the camera. Two hours in, Cramp spots something circling in the background: "There's a shark!" High fives all around. "That was my camera drop," Rongo says proudly.

Cramp envisions someday passing her work on to a Cook Islander. Rongo and Smith, both high school seniors, are considering going to college for marine biology. "Instead of saying, 'I work in an office,' you'd be like, 'I'm a shark lady,'" Smith muses. "That'd be such a cool name to have."

Marine conservationist and shark researcher **Jessica Cramp** is a participant in the new partnership that longtime allies Rolex and National Geographic formed in 2017. Its motto, "Committed to a Perpetual Planet," reflects its mission: to promote conservation and exploration of Earth's oceans, poles, and mountains. Learn more at nationalgeographic.com/environment/perpetual-planet.



Cook Islands Sanctuary

In 2012 the Cook Islands became one of the world's 17 shark sanctuaries, which protect a collective 7.5 million square miles of ocean. Its regulations, including those listed at right, attempt to curtail the killing of sharks, estimated at tens of millions annually.

Forbidden Fishing

Bans vessels operating within the nation's exclusive economic zone from targeting sharks.

Fines

Levies a fine of \$73,000 to \$182,000 on any boat found with shark parts on board.

Wire Ban

Forbids trace wire, a type of fishing line that often ensnares sharks.

You may be entitled to replacement solar panels and/or a new inverter from a BP Solar Settlement

*Para una notificación en Español,
llamar 1-844-360-2767 o visitar nuestro
website www.BPSolarSettlement.com*

On December 22, 2016, the Court approved a Settlement in a class action lawsuit against BP Solar and Home Depot involving solar panels manufactured between 1999 and 2007 with an S-type junction box ("Class Panels"). You may be entitled to benefits from a \$45.33 million common fund or a separate \$20 million claims-made settlement.

The lawsuit claims these panels are defective and prone to junction box failures, which could cause burn marks at the junction box, shattered glass, and be a potential fire hazard. BP and Home Depot deny these claims.

Who's Included?

The Settlement includes anyone in the United States who: (1) purchased certain BP solar panels for installation on a property, or (2) currently owns a property on which these panels are installed and, in either case, who still owns some or all of the BP solar panels.

The panels were sold through various distributors and retailers, including but not limited to Solar Depot and Home Depot.

What does the Settlement provide?

The Court approved a \$45.33 million Common Fund to pay for the removal and replacement of a subset of Class Panels (Category 1), and to pay administration, attorneys' fees and costs, and Class Representative awards. The Court also approved the separate \$20 million Claims Made Fund for the remaining Class Panels (Category 2), which have a lower failure rate. Category 2 claimants will be entitled to a free visual inspection to identify any failed panels, a replacement of failed panels, and a free inverter with arc fault detection; **or** if over 20% of panels have failed, replacement of all panels. Nonresidential class members with 400 or more Class Panels will be invited to commercial negotiations.

How can I receive benefits?

You must file a claim to receive benefits. You can file a claim online at www.BPSolarSettlement.com or call 1-844-360-2767. Category 1 claims will be paid until the Fund is spent. The deadline to submit Category 2 claims is February 6, 2020 or until the \$20 million fund is spent.

This is only a summary, so please visit the website for complete information.



| DIVE DEEPER |



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THE JOY OF THE CHASE—OR SEX AT HIGH SPEEDS

PHOTOGRAPH BY JOEL SARTORE

THE MAMMAL LINEAGE of Xenarthra—sloths, anteaters, and armadillos—has inhabited the Western Hemisphere since Paleocene times, some 65 million years ago. Clearly, they’ve been perpetuating their species, but scientists rarely catch them in the act.

Brazilian ecologist Nina Attias has. She’s spent years studying three of the 20 species of armadillos. Her doctoral research focused on *Euphractus sexcinctus*, aka the yellow, or six-banded, armadillo (below), whose courtship rituals she has observed and filmed.

In the Pantanal wetlands of Brazil, yellow armadillo *amour* blooms year-round. When males catch the scent of a female in estrus, they approach, and “she just starts running,” Attias says. “You’ll see a female running like crazy and a bunch of males chasing her.” Once a swift suitor manages to mount the female, “coitus actually happens while they’re running,” Attias says.

Even as other males chase them, the couple stays coupled. It helps that among mammals, armadillos have one of the largest penises relative to body size; an *E. sexcinctus* male may have a 13-inch-long body and a six-inch-long penis. And if on-the-run sex succeeds, 60 to 65 days later the female may bear one or two pups.

Just procreating won’t ensure armadillos’ survival; they need human help. Brazil has a national plan for conserving three-banded armadillos. The state of Piauí has set aside parkland with the animals’ protection in mind. And with support from the Institute for the Conservation of Wild Animals, where Attias works, the state of Mato Grosso do Sul plans to track giant armadillos as an indicator species, whose presence will help measure the success of habitat conservation efforts. —PATRICIA EDMONDS

Know Your Armadillos

1. THREE-BANDED

Only two armadillo species, the southern three-banded and the Brazilian three-banded, roll into a ball if threatened. The International Union for the Conservation of Nature assesses the Brazilian (*Tolypeutes tricinctus*) as vulnerable, and the southern (*T. matacus*) as near threatened, chiefly due to habitat loss and hunting.

2. NINE-BANDED

The armorlike carapace of *Dasyus novemcinctus* may actually have up to 11 bands, bony plates connected by flexible tissue. The only armadillo whose ranks seem to be increasing, it also has the largest range—in South, Central, and North America—which is expanding as climates warm.

3. GIANT

Found across South America, *Priodontes maximus*, the largest armadillo, can exceed five feet long and 110 pounds. The IUCN assesses the species as vulnerable. Indigenous peoples hunt it for meat, and some local farmers kill it because of a myth that says seeing one brings bad luck.



PHOTOARK
JOEL SARTORE

These yellow armadillos were photographed at the National Mississippi River Museum & Aquarium, Dubuque, Iowa.



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FEATURES



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'THE OVERALL SEABIRD
POPULATION IS ESTIMATED TO
HAVE FALLEN BY 70 PERCENT,
AND A DISPROPORTIONATE
NUMBER OF SEABIRD SPECIES
ARE AT RISK OF EXTINCTION.'

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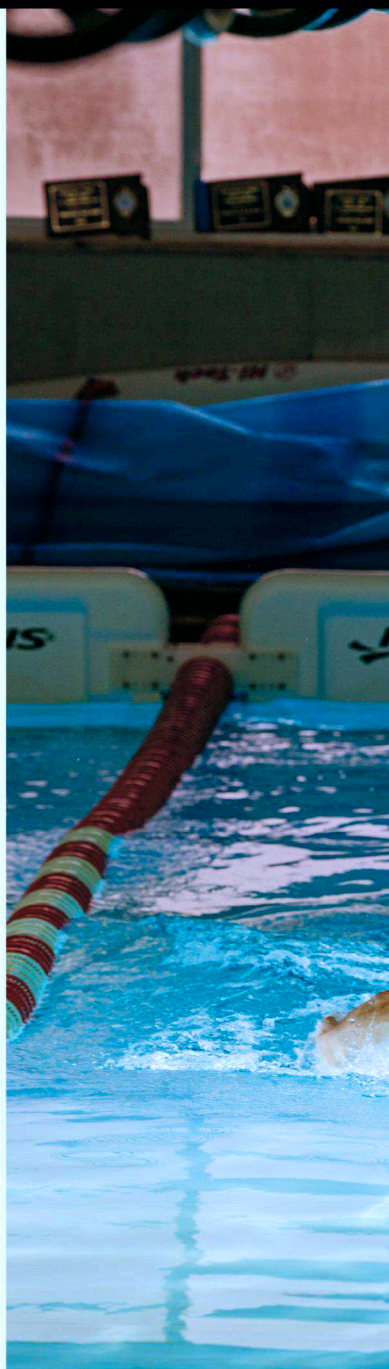
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Technology and science are helping athletes shatter records. How much further can we push the limits of human performance?

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Olympic hopeful Michael Andrew trains with his father and coach, Peter, in a pool at their home in Lawrence, Kansas. He swims short, fast distances in a program that challenges traditional training methods.

MARK THIESSEN



Swim prodigy Andrew's training program of high-intensity distances conditions his mind and muscles to swim at race pace. Andrew, 19, holds 22 USA Swimming records.
MARK THIESSEN (ALL)



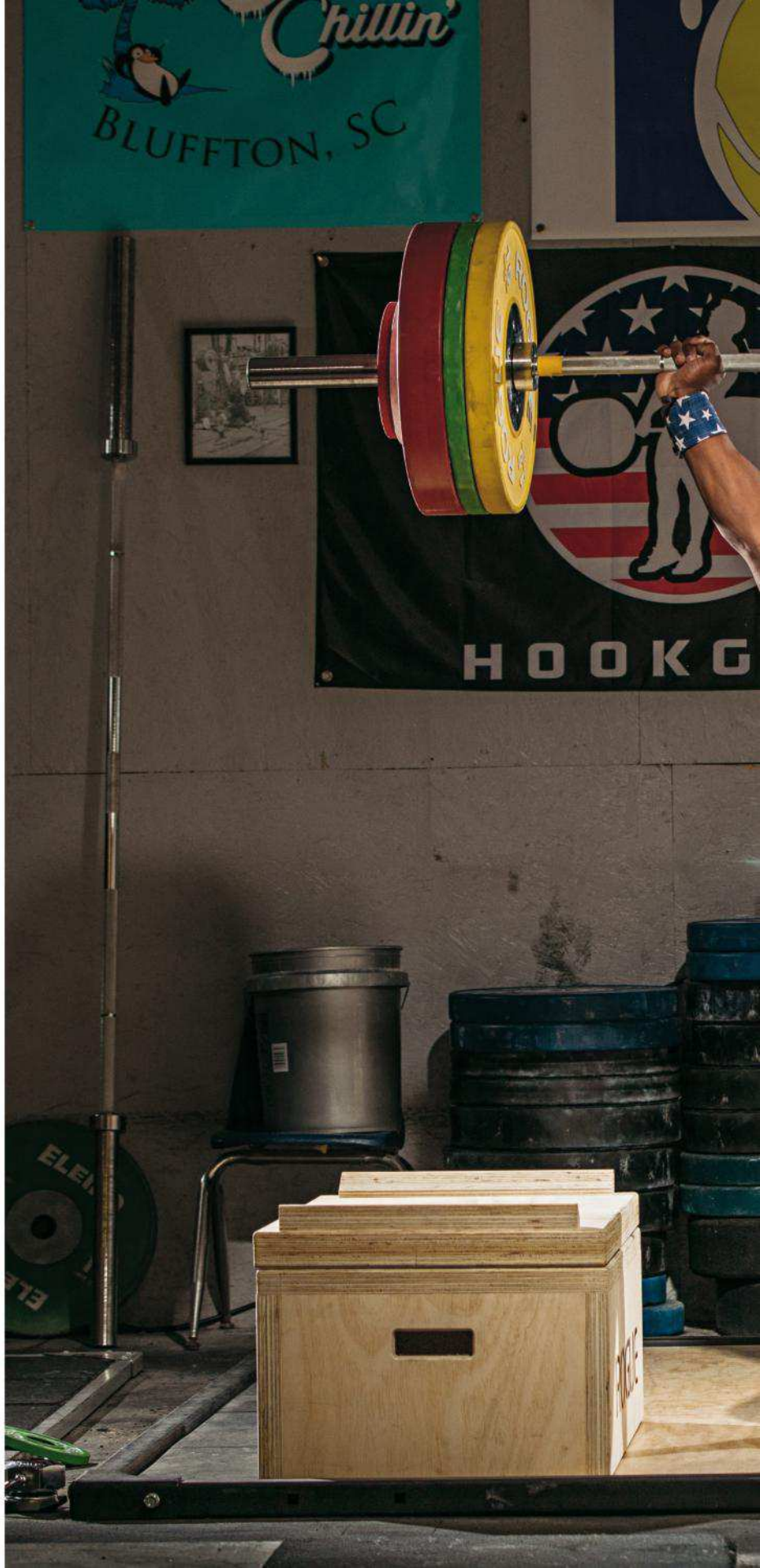
Record-breaking weightlifter CJ Cummings, 18, defended his Youth World Championship in 2017 and broke his own world record for the "clean and jerk" by lifting 407 pounds.



Classical ballet dancers such as Esmiana Jani, 25, from the Washington Ballet, put enormous force on their ankles and knees when landing jumps. They are the only athletes in the world who must point the foot to its absolute extreme while bearing weight. To help recover more quickly, they use inflatable "boots" that massage their leg muscles from the toes to the top of the thighs.

Cummings's body type and his technique—he pulls the bar faster than other lifters and maintains this speed as the lift progresses—separate him from the competition. Bob LeFavi, while head of health sciences and kinesiology at Georgia Southern University in Savannah, analyzed Cummings's biomechanics. Researchers found that a “perfect storm” of attributes—strength, speed, body structure, and technique—all contribute to his success. Still a teenager, Cummings should reach his full potential in his mid to late 20s, LeFavi says.

MARK THIESSEN



Physical Therapy

& Sports Rehabilitation



ROGUE

THE RACE FOR THE AGES CAN BE RUN ONLY IN OUR IMAGINATION: USAIN BOLT VS. JESSE OWENS.

Bolt is in his 21st-century lane, a smooth, slip-resistant rubber surface spread out for 100 meters, designed to quickly return energy to his legs as he races across it.

Then there's Owens in his pre-World War II lane, an uneven bed of cinders, a soft surface that actually steals energy from his legs as he runs.

Bolt, the Jamaican sprinting legend who has eight Olympic gold medals and has held the world records in the men's 100- and 200-meter sprints for nearly a decade, is wearing lightweight shoes made specifically for running on high-tech surfaces. For his entire competitive life, he has received the finest training the world has ever seen. He jets to competitions and has his own cook, who makes him lean, nutritious meals. Bolt also has been at his peak during the height of the steroids era in sports. He has never tested positive, but suspicion follows many top Olympic athletes of his time. Bolt had to forfeit a gold medal he won as part of a relay in the 2008 Olympics after a teammate tested positive.

Owens, who won the 100 meters with a time of 10.3 seconds in the 1936 Olympics—one of four gold medals he claimed in Berlin—is wearing leather running shoes. Bolt is able to get a quick launch from state-of-the-art starting blocks, but Owens must dig his own “starting blocks” out of the cinders with a gardening trowel.

Owens grew up in a segregated America, with

RIGHT

A lightweight shoe like the one that Usain Bolt wore to set the world record in the 100-meter sprint in 2009 is shown on a piece of Mondotrack, similar to what he ran on that day in Berlin. The surface is designed to return energy to runners, making them faster.

MARK THIESSEN

BELOW

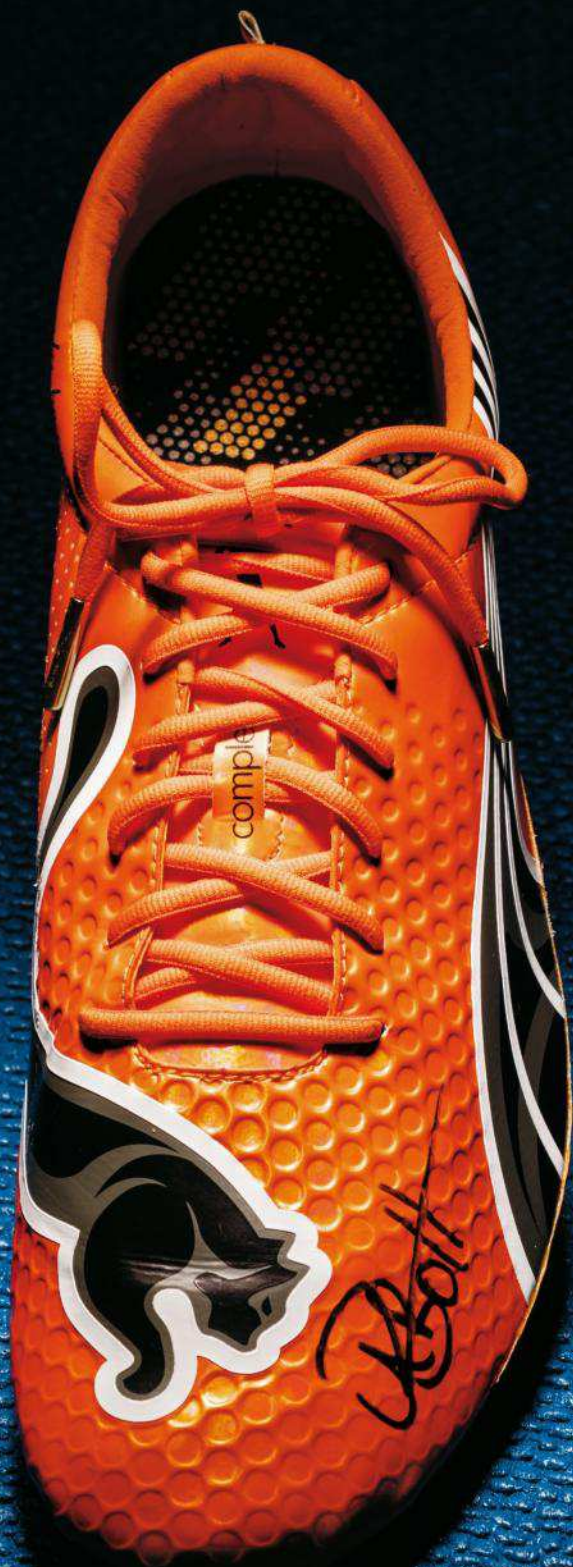
Jesse Owens won the 100-meter race at the 1936 Olympics in 10.3 seconds. Usain Bolt, shown in 2016, holds the record, 9.58 seconds. With a better running surface and lightweight shoes, Owens could have been significantly closer to Bolt's times.

ULLSTEIN BILD VIA GETTY IMAGES (OWENS); KAI PFAFFENBACH, REUTERS



World Cup 2018

National Geographic will partner with Fox Sports for the FIFA World Cup. Beginning June 14, our reporter Sergey Gordeev will cover Russian culture during match-day broadcasts.

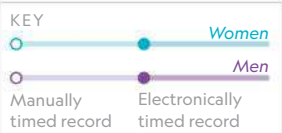


Duration of record

13.6 seconds

Marie Mejzlíková II,
Czechoslovakia
August 5, 1922

**Progression of 100-meter
dash world record,
1910-2018**



THE SPEED OF INNOVATION



Stronger starts

Early racers dug holes into the tracks, which were usually laid with cinders. The introduction of solid starting blocks in the late 1920s led to new world records.



Lighter shoes

The first running shoes were simply leather dress shoes, with nails to provide grip. Today's shoes boast nylon, fiberglass, and single-use spikes.

10.6 seconds

Donald Lippincott, U.S.
July 6, 1912

10.2

Jesse Owens, U.S.
June 20, 1936

few of the perks of modern athletes. To get to Berlin, he and other U.S. athletes spent several days crossing the Atlantic on an ocean liner.

Bolt, who ran the 100 meters in a record 9.58 seconds in 2009 and retired last year, is still widely recognized as the world's fastest man. But how much faster was he, really, than elite sprinters of previous generations like Owens?

Setting aside the questions about performance-enhancing drugs, how far have we come in our never ending quest to go faster, higher, and farther? And what are we learning about how technology and new training methods can help us push the limits of human performance?

A demonstration included in a 2014 Ted Talk given by sports journalist David Epstein showed that if Owens had run on the same surface as Bolt, Owens's best time in the 100 meters (10.2 seconds)—accomplished shortly before the 1936 Olympics—could have been within one stride of Bolt's performance in the 100 meters (9.77 seconds) at the 2013 World Championships.

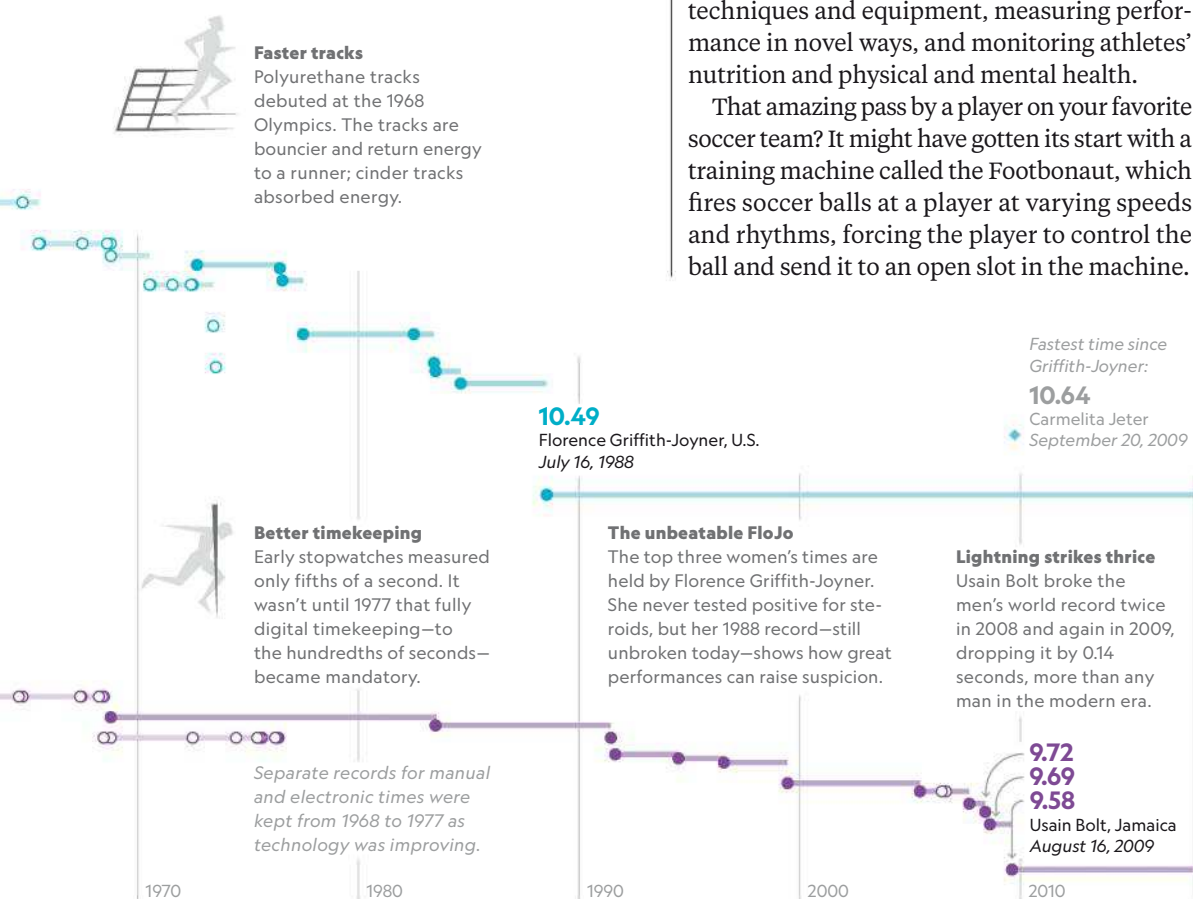
In the eight decades since Owens's historic victories, improvements in training, testing,

technique, clothing, and equipment have helped athletes become better, faster, stronger, and more precise. But researchers believe we have not yet reached the limits of human possibility.

Peter Weyand, who runs the Locomotor Performance Laboratory at Southern Methodist University in Dallas, Texas, and is one of the world's leading experts on the biomechanics of sprinting, says that the potential for significant improvement in the 100- and 200-meter sprints and in marathons is not out of the question. His lab uses high-speed video analysis to study sprinters' techniques, looking for ways to make them more efficient—and faster. Weyand is part of a team led by United Kingdom sports scientist Yannis Pitsiladis that's focused on breaking the two-hour marathon barrier. (A similar Nike effort fell short in 2017.) To help athletes shatter records, researchers are focusing on such key areas as physiology, nutrition, biomechanics, medical support, real-time monitoring, and coaching. This kind of scientific knowledge "allows performance to be improved," Weyand said.

To help athletes legally push the limits of performance, scientists are experimenting with new techniques and equipment, measuring performance in novel ways, and monitoring athletes' nutrition and physical and mental health.

That amazing pass by a player on your favorite soccer team? It might have gotten its start with a training machine called the Footbonaut, which fires soccer balls at a player at varying speeds and rhythms, forcing the player to control the ball and send it to an open slot in the machine.





That curveball your favorite baseball pitcher threw? Fifty years ago, coaches would simply watch a pitcher to see how he was throwing. Now coaching is a mixture of reviewing video and statistics on big-screen TVs, cell phones, tablets, and laptop computers—with old-fashioned intuition thrown in. And coaches can instantly measure the speed of a pitch.

T HIS CONVERSATION about human performance comes with a strong note of caution. Can we believe what we're seeing? In 1988 we marveled at the world record 100-meter dash of Canada's Ben Johnson—until he tested positive for using a performance-enhancing drug, was stripped of his gold medal, and was sent home from the Summer Olympics in Seoul. The steroids era in sports is going strong 30 years later: U.S. cyclist Lance Armstrong, U.S. track star Marion Jones, Russia's Olympic delegation—the list of violators goes on.

But let's focus on the good in sports technology, which has upended training for paralympic athletes as well.

Visually impaired skier Danelle Umstead, a three-time Paralympian and three-time bronze medalist in a sport where athletes can reach speeds of 70 miles an hour, has trained in a wind tunnel that allowed her to work on aerodynamics with a sight guide. During races she follows her partner through the course as they communicate via headsets. Training in the tunnel helped her tweak her technique to go faster.

Meanwhile, coaches and athletes are challenging long-held assumptions about training.

Michael Andrew, 19, has broken the most national age-group swim records in USA Swimming history and holds 22 national records. He and his father-coach, Peter, swear by a non-traditional training method called Ultra-Short Race-Pace Training, or USRPT. Andrew swims at short high-speed distances, conditioning his mind and body to constantly swim at race pace.

Traditionally, elite swimmers have built endurance through workouts that involve a slower pace with more yardage. The much debated approach has helped make Andrew an Olympic hopeful for 2020 and is gaining traction among top swim coaches in the U.S. and elsewhere.

"Everything we do is science-based; there is data to back up what we're doing in the pool," Andrew says. "Our brain and our body will code these movements like a computer would. It doesn't make sense to train slowly when you're trying to swim fast."

A MERICAN DISTANCE SWIMMER Katie Ledecky, who recently announced that she is leaving the Stanford University team to become a professional swimmer, has a more traditional training method. But Ledecky, 21, has used sports science to become one of the best women's freestylers in the world. The five-time Olympic gold medalist, who set two world records at the 2016 Olympics in Rio de Janeiro, Brazil, eagerly digests readouts about her nutrition and blood work, and studies videos of her workouts and races, looking for ways to improve her arm and hand movements. Ledecky's success often is attributed to her work ethic; her real secret could be that she has one of the most efficient strokes in swimming.

That wouldn't have mattered, though, if she had not been willing to work hard, says Bruce Gemmell, who coached Ledecky to the 2016 Olympics. In the three years before the Rio Olympics, Ledecky's weekly workload was usually 60,000 to 65,000 yards, spread over nine practices in six days. "I give speeches about coaching Katie," Gemmell says. "One day, I'm tempted to put up just one slide saying, 'Katie works her ass off, and she's tough as nails,' and then say: 'Any questions?'"

Two things during those practices made a difference for Ledecky in Rio. She wanted to pay attention to the start of her races—how she dived into the pool. For sprinters, this obsession would make sense. Every 10th of a second matters in races that are decided by hundredths of a second.

But Ledecky is a distance swimmer, known for finishing far ahead of her competitors. "She studied a video of her starts, hoping to gain a 10th of a second," Gemmell says. Ledecky's second practice obsession involved the finish of the 200-meter freestyle. As she would finish a series

During workouts, Taylor Fletcher, 28 (left), and other members of the U.S. ski team wear headphones that electrically stimulate their motor cortex. Research

suggests that targeted brain stimulation may improve muscle memory and reduce an athlete's ability to perceive fatigue.

DAVID BURNETT





Paralympic visually impaired skier Danelle Umstead, 46, tests her aerodynamics in a wind tunnel to learn better techniques for drafting behind her sight guide (not shown), who skis in front of her. Paralympic skiers can reach speeds of 70 miles an hour.

MARK THIESSEN

PREVIOUS PHOTO

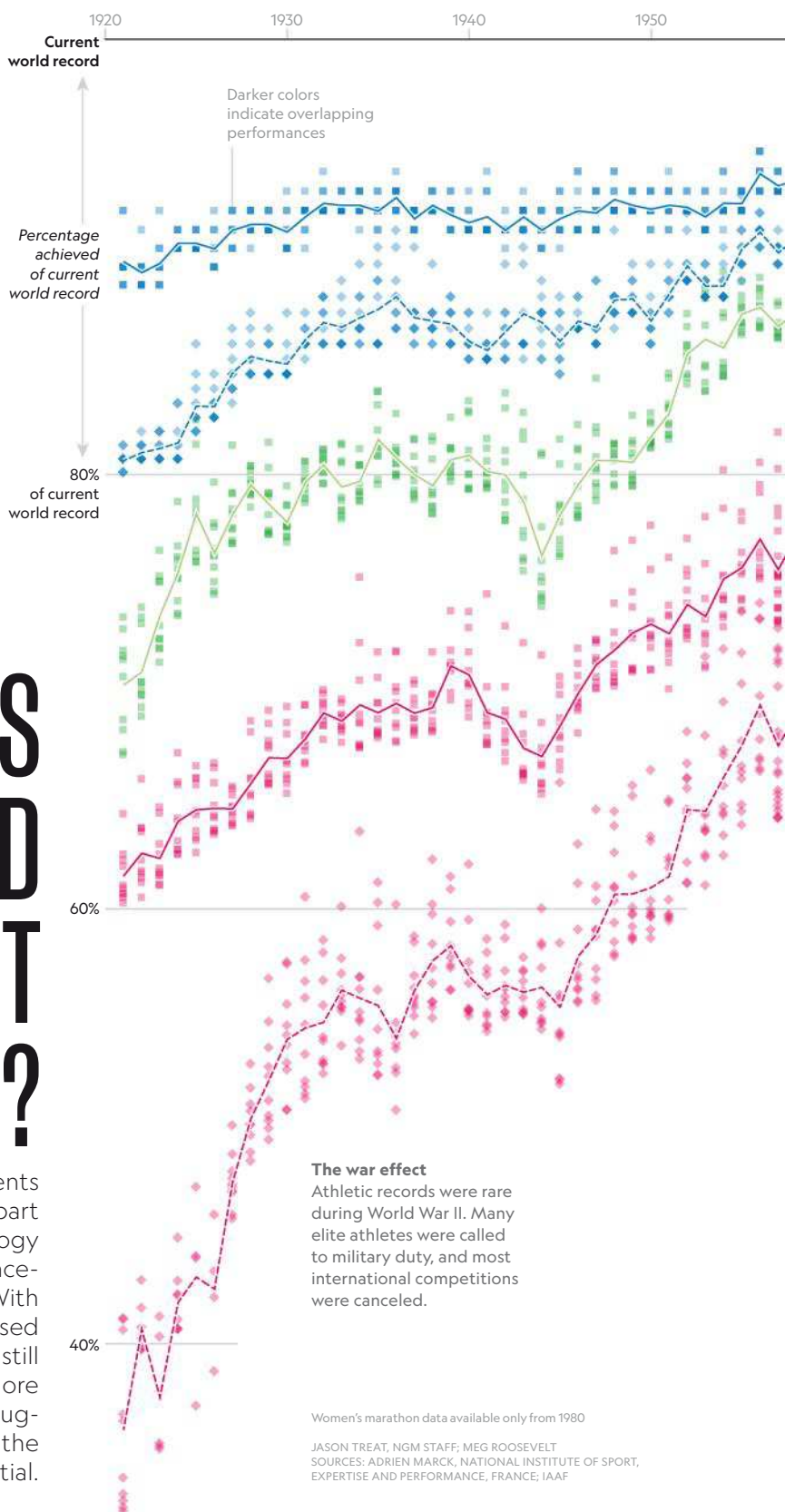
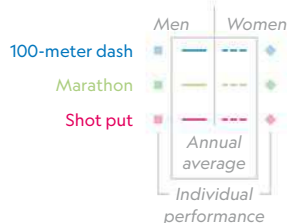
Paralympian sprinter Jarryd Wallace's biomechanics are analyzed at the Southern Methodist University Locomotor Performance Laboratory in Dallas, Texas. "There was a lot I was doing wrong," says Wallace, 28. The four-time world record holder, whose lower right leg had to be amputated because of a muscle disorder, uses the lab's analysis of his stride to run even faster.

ROBERT CLARK





World's 10 best performances by year 1921-2016



AS GOOD AS IT GETS?

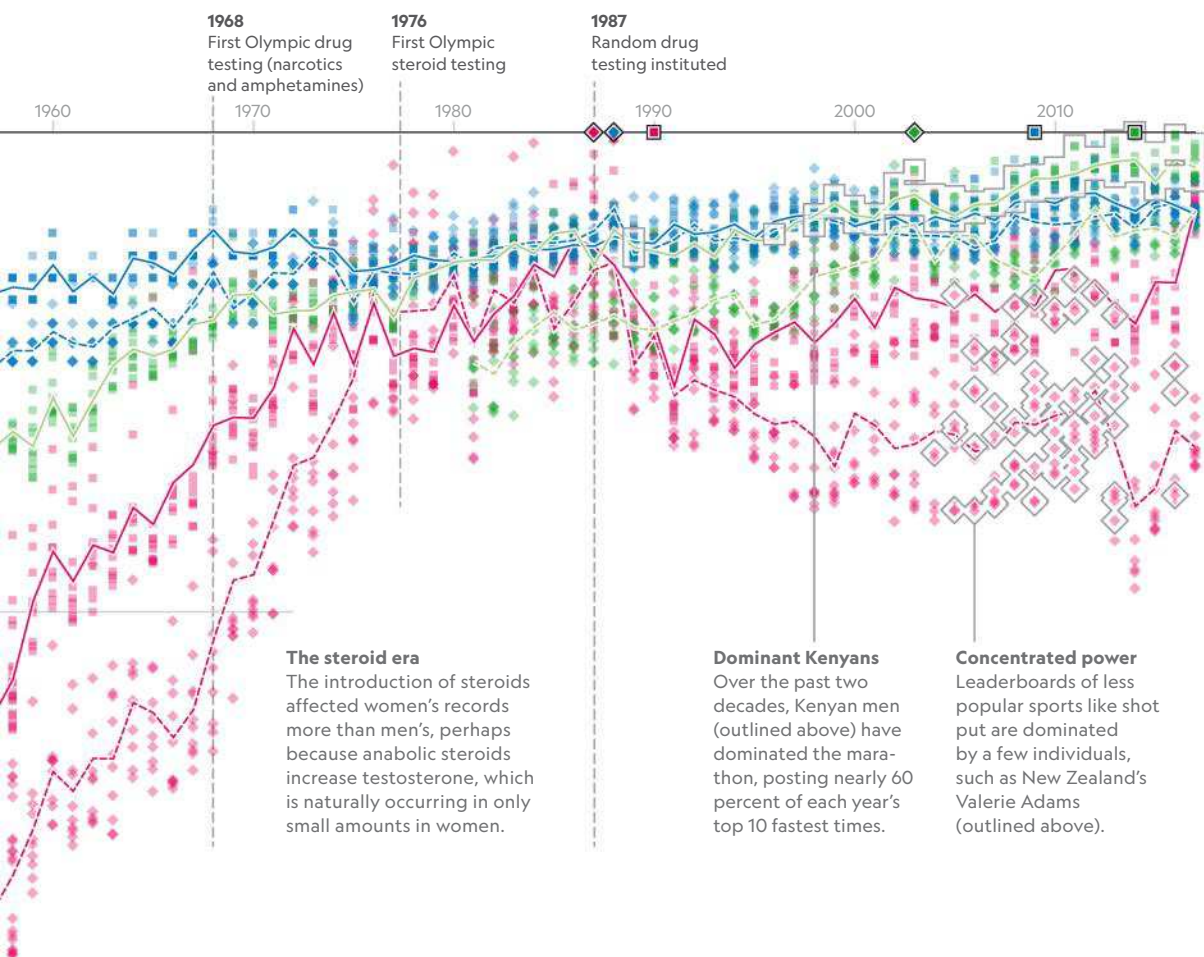
Athletic achievements improved for decades, in part because of new technology and the use of performance-enhancing steroids. With athletes under increased scrutiny, world records are still getting broken—but more incrementally. This could suggest that we are pushing the limits of our athletic potential.

The war effect

Athletic records were rare during World War II. Many elite athletes were called to military duty, and most international competitions were canceled.

Women's marathon data available only from 1980

JASON TREAT, NGM STAFF; MEG ROOSEVELT
SOURCES: ADRIEN MARCK, NATIONAL INSTITUTE OF SPORT, EXPERTISE AND PERFORMANCE, FRANCE; IAAF



of laps during practice, she would suddenly pick up the tempo at the end, in the last 15 meters or so, increasing her kick furiously, Gemmell says.

"In the midst of this most mundane work, she did that, two to three times a week, for 15 minutes to a half hour, finishing every rep that way."

Move ahead to the 200 freestyle in Rio. Because it was her shortest individual race, it would be her closest. She couldn't put other swimmers away so decisively in such a short race, just four lengths of the pool. She knew the finish would matter most. Sure enough, as swimmers neared the finish in the 200-meter finals, Ledecky's top rival, Sarah Sjöström of Sweden, closed fast and drew even with Ledecky with 15 meters to go. It looked like Sjöström had the momentum and would win.

But Ledecky wouldn't lose. Why? It was all that practice for the end of the race. "When Sarah pulled up even, I thought, I've seen Katie finish that race more than a thousand times. She's going to get her hand to the wall first."

And she did. "No wonder she can do that in the pressure cooker at Rio," Gemmell says. "She

knew exactly what she was doing in practice, over and over again."

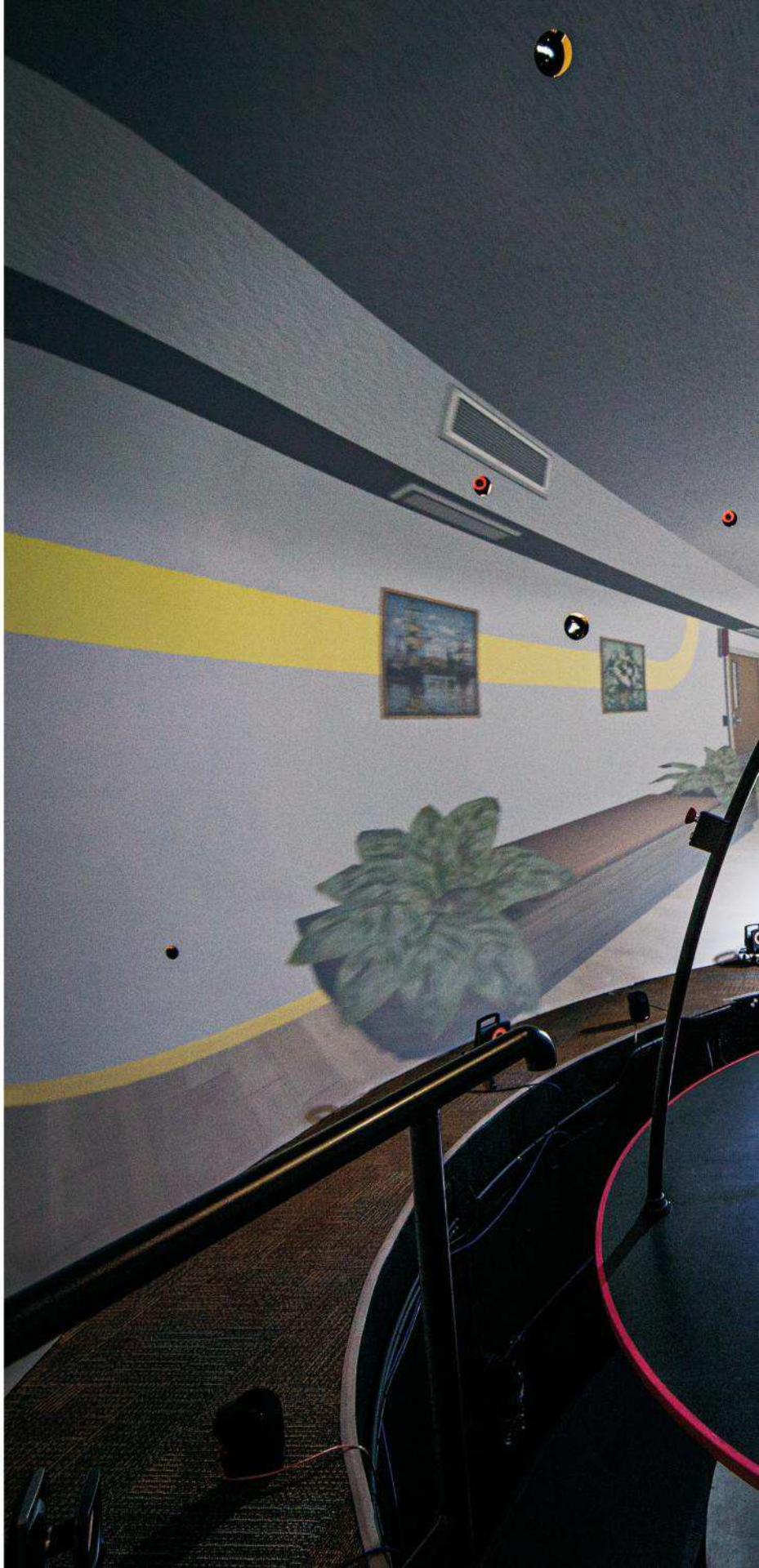
Ledecky's overall performance in Rio was one for the history books. But she and Gemmell had foretold it three years earlier, after she broke the 800-meter freestyle world record. They were musing about how much faster she wanted to go in the 800- and 400-meter freestyles in 2016, and Ledecky wrote down her goals on a Styrofoam float she used in practice and carried with her to meets around the world. Her new world record for the 800 freestyle was 8:13.86. Ledecky's goal? 8:05. It seemed crazy: Breaking her own world record would be one thing, but by almost nine seconds?

During the next three years, Ledecky kept lowering her world record in the 800 freestyle. By early 2016 she had dropped her record to 8:06.68. In Rio she crushed the field and set another new world record: 8:04.79.

This made Gemmell wonder: "What if we had said eight minutes flat? We don't know where the limit is. We set goals that were unheard of three years before Rio. Once Katie reached them,

Research volunteer Yunna Sinskey walks on a treadmill mounted on a motion base inside a 360-degree virtual reality dome, which includes wall-mounted cameras and projectors at MIT Lincoln Laboratory. Reflective markers are placed on her body, allowing the 18 cameras mounted in the dome to capture her movements for a study on improved diagnosis and treatment of mild traumatic brain injury. Tracking movement patterns can also help diagnose injuries in athletes.

DAVID BURNETT





I couldn't help but wonder in the back of my mind: Why didn't we set them faster?"

L EDECKY AND OTHER TOP ATHLETES today have the advantage of the march of time in their sport. Look at a photo of swimmer Mark Spitz from the 1972 Olympics, and you'll see the difference: no goggles, no cap, no state-of-the-art, water-repelling swimsuit. He even had a mustache. Pools then didn't have the improved gutter systems and wave-reducing lane ropes that competition pools use now to absorb much of the splash from nearby swimmers. It all slowed Spitz down, but we didn't know that then. He still won seven gold medals in 1972.

Health science has played a big part in the lives of generations of swimmers since. Gemmell tells a story about a minor ankle injury Ledecky suffered while practicing at the U.S. Olympic Training Center in late spring 2016, just a few months before Rio.

"Within two hours, we had the opinions of two doctors, we had an ultrasound, we had a physical therapist, a strength and conditioning coach, a swim coach—that was me—and like three other people, who had already reviewed the data, consulted with each other, and formulated a plan."

Alan Ashley, the U.S. Olympic Committee's chief of sport performance, says the key to breaking performance barriers is to "keep athletes healthy. If they stay healthy, everything else falls into place."

I N THE LATE 1960S, figure skater Audrey King Weisiger finished third in the U.S. women's novice division one year and third in the junior division the next. She learned to jump high and quickly—not because it was the right way to do it but because she was training on a small rink in Falls Church, Virginia, that was one-third the size of a regular rink. "If I went the distance, I would have smashed into the wall," she says.

Coming up in the sport about the same time as 1976 Olympic champion Dorothy Hamill, Weisiger was surrounded by young women doing double-revolution jumps, so she did only doubles in competition, although she did successfully do triple jumps in practice. Unlike today's skaters, she didn't train with weights, she didn't take Pilates, and she wasn't concerned about nutrition. "We did have ballet," she recalls.

Move ahead to the late 1980s and 1990s. Weisiger, by then a top-ranked international

coach, taught her pupil Michael Weiss how to land doubles and triples—and finally, quadruple jumps. He was the first American to attempt a quad toe loop at the U.S. national championship in 1997. Weiss went on to compete in two Olympic Games and won three national titles and two world championship bronze medals.

Unlike Nathan Chen, a 2018 Olympian whose slim body and tiny waist and hips help him rotate quickly in the air, Weiss had a muscular build, so he relied on upper-body strength to power himself through the air.

Weisiger would record Weiss's jumps on what would now be a vintage video camera, put the VHS tape into a VCR hooked to a TV monitor, and then wheel the TV onto the ice so she and Weiss could watch it together. Then they'd get back to work.

"We could see it, but we had no way yet to measure it," Weisiger recalls with a laugh. "I'd say, 'I think it's high enough,' and off we'd go, trying it again."

Today, chatting over dinner at a restaurant, Weisiger touches her iPhone and opens an app called Vert. "If I put a belt with a sensor on you, and you jumped, I could tell you with my phone how high you jumped, which would be the beginning of our conversation about trying a quad," she says.

Later Weisiger sent me a dozen text messages showing photos of a skater's first, second, third, and fourth revolution of a quad jump, with a timer under them that showed the process lasted little more than half a second—0.68 of a second to be precise—from takeoff to touchdown.

Trying these difficult jumps can be dangerous. Crashing on the hard ice over and over again can cause career-ending injuries. So for several decades, figure skating coaches have been able to strap a skater into a harness at the end of what looks like an elaborate fishing pole. In 50 years

Katie Ledecky, a world-record-breaking athlete who won four gold medals and one silver at the 2016 Olympics, has the latest scientific and technological resources and training available. The U.S. distance swimmer

studies readouts about her nutrition and blood work, reviews video of her technique, and is equipped with innovative gear. Ultimately, her success is attributed to grit, hard work, and a near perfect stroke.

JOHN HUET



Lu Mingjing, nine, practices her diving technique at an athletics center in China's Jiangsu Province, where she lives, studies, and trains. Girls as young as four are selected to train at schools like this. Does training so young boost performance later? Researchers say early training can lead to success but may increase the risk of injury, stagnation, or burnout.

DAVID BURNETT









Weisiger had progressed from learning organically how to land high, tightly spiraled jumps because otherwise she would run into a wall at the rink, to using her phone to tell how high and long a skater was in the air while doing a quad.

Advances in technology give coaches the ability to help their skaters understand the physics of these jumps, but something more is at work here, Weisiger says.

“Why wasn’t Dorothy Hamill doing triple jumps?” she asks. “She didn’t have to. Once women started to try triples, everyone had to do them. It’s like anything else: Competition pushes you along.”

In February in Pyeongchang, South Korea, women’s Olympic figure skating champion Alina Zagitova of Russia landed seven triple jumps in her free skate. Chen became the first man to attempt and land six quads in his free skate, finishing fifth overall after a poor short program.

SOMETIMES THE MARCH of progress in sports is simply the result of an athlete’s competitive fire.

To my unaided eye, a jump at the 1991 world track and field championships in Tokyo’s National Stadium looked monstrous. I had been watching the best long jumpers in the world for more than an hour, and American Mike Powell’s jump clearly was different. Technology would confirm what my eyes were telling me, but I already knew. The most legendary and seemingly untouchable individual record in Olympic sports, which had stood for a stunning 23 years, had just been broken.

My fascination with the advancement of sports performance didn’t start on that warm, humid August evening, but it certainly got quite a boost. Two inches here and there might not seem like much in our daily lives, but that was almost exactly the distance between Bob Beamon’s landmark leap of 29 feet 2.39 inches, set at the 1968 Olympics in Mexico City, and Powell’s 29-foot, 4.36-inch jump that night in Tokyo.

All these years later, that moment fascinates me. Why? With everything science and computers and great minds can devise to help humans perform faster, higher, and stronger—and because a sport like track and field has progressed from cinder tracks to synthetic surfaces, from rudimentary footwear to famous shoe companies trying to outdo one another—record-breaking progress still came down to the



work of one human being. Sports is now filled with scientists, coaches, and athletes who measure progress through analytics. But that night, the march of human performance had a face and a name: Mike Powell.

The story behind making sports history sometimes really isn’t that momentous. In this case, one athlete just became angry with the success of another and wanted to beat him.

I called Powell recently in Southern California to ask him to relive that moment. There was no particular science to that night, he told me.

Powell said he broke the record because he was pushed by a competitor: The great Carl Lewis, widely considered the best long jumper ever, was also in the field. Lewis never broke the



Acclaimed distance runner Nancy Kiprop, 39, dances with students at the school she founded near Iten, a tiny corner of western Kenya where many of the world's fastest distance runners train. The local government allowed her to establish the school, which she named in honor of her father. Kiprop subsidizes the children's school fees with income from her shoe sponsorships and race earnings.

NICHOLE SOBECKI

PREVIOUS PHOTO

Runners from Iten practice together. Distance running is a proud tradition in Kenya, where many of the best runners take advantage of the region's high altitude and challenging terrain. Kenyan men have nine of the 10 fastest times in the marathon; four of the 10 fastest women's times were run by Kenyans.

NICHOLE SOBECKI

world record himself. Unwittingly, though, he helped Powell do it. "I love Carl now, but back then I hated him," Powell said. "So when we competed, he brought my energy level way up."

Right before Powell uncorked the record jump, Lewis leaped farther than anyone ever had, beating Beamon by a quarter inch. But the wind was blowing too hard at his back, so it didn't count.

Powell can't get the image out of his head nearly three decades later. "He ran past me, pumping his fist. That got me mad. It made it real personal. I had always been the skinny guy, the one picked on. It was happening again, right there. But I could do something about it this time. My body just took over and did what I needed to do." Powell's amazing jump is still the

world record. "Carl raised the bar so high," Powell said. "I knew I had to break a world record just to beat him."

That's the school-yard view of human performance—and a testament to the mind's ability.

"I don't think we have really tapped into the power of the brain," says Gemmell, Ledecy's Olympic coach. "That's the next frontier over the next 30 years: how we train the brain like the body. That's where the breakthroughs are going to come next." □

Christine Brennan is a national sports columnist for *USA Today*, a commentator for CNN, ABC News, PBS NewsHour, and NPR, and a best-selling author. She has covered 18 consecutive Olympics, starting with the 1984 Los Angeles Games.



Predators in the Night

BY VIRGINIA MORELL PHOTOGRAPHS BY ANAND VARMA



AN ANCIENT MAYA TEMPLE IN MEXICO SHEDS LIGHT
ON THE MYSTERIES OF RARE, MEAT-EATING BATS.

A woolly false vampire bat flaps into a moonlit night. The mission: Get dinner. For rodents and other small creatures of Mexico's Yucatán Peninsula, the night is an especially dangerous time, as carnivorous bats leave their roosts seeking prey.



A spectral bat in a cage targets a laboratory mouse in leaf litter on a table. Scientists studying these carnivorous bats in Mexico haven't yet seen them take prey in the wild, so they film them and record sounds related to the pursuit. Watch this controlled hunt play out in a video at ngm.com/Jul2018.



They hang from the cold, stone ceiling of an ancient Maya temple like a bunch of fuzzy gray fruits, staring down at us with eyes that shine golden in the red glow of our headlamps.

The toothy, hungry bats have long, nearly transparent bunny-like ears and wrinkled, wolfy faces with a lance-shaped nose leaf—an appendage that bats use for echolocation—on top of their snouts.

These mysterious bats just outside the Calakmul Biosphere Reserve, in the Yucatán Peninsula, don't roost in the thousands like some other species, said Rodrigo Medellín, the country's leading expert on the flying mammals and a professor at the National Autonomous University in Mexico City. "They're always in these small groups—they're very protective of one another."

Medellín swung his butterfly net at one of the six bats, catching it. He held the animal in a leather-gloved hand so we could examine the bat's thick, woolly fur, which made it look sweet and cuddly, and its protruding snout and sharp teeth, which made it look anything but. This was a female, and she chattered her jaws at us, protesting. Medellín gently stretched out one of her wings and pointed to the bat's thumb, which curved out from the edge. It was armed with a pronounced claw, shaped like a saber and just as sharp.

"That's what they use to lock their prey," he

said. From the size of this weapon, you know these hunters of the night aren't slashing mosquitoes—they're after rodents, songbirds, even other bats.

Carnivorous bats, known collectively as false vampire bats because they don't drink the blood of animals, as true vampire bats do, are found throughout the tropics, although in low numbers: Less than one percent of all bat species eat other vertebrates.

Two species are found from southern Mexico to Bolivia and Brazil, with one even extending farther south into parts of Paraguay and Argentina: the woolly false vampire bat (the ones in the Maya temple) and the spectral bat, also called Linnaeus's false vampire bat. The latter are the largest of the New World bats, some with wings spanning up to three feet. Threats to their rain forest habitats are putting pressure on Mexico's bats—and adding urgency to efforts to understand their ways.

Little is known about woolly false vampire bats, so Medellín caught all six and brought

 The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.



them outside the temple in soft, white cotton bags to weigh and measure them. Four were male, and two female, one pregnant. To learn more about the bats' relationships, the researchers punched out a tiny skin sample from one wing of each bat to send to a laboratory for genetic analysis. Small GPS tracking devices were attached to the backs of three of the bats (including the pregnant female) to provide information about their hunting habits.

"Look," Medellín said, pulling a male from a bag and turning him on his back. "The males have tiny testicles—that correlates with monogamy." In the animal world, monogamy is rare. "It could be that two of these males are the females' mates, and the other two are their offspring from last year and are in the process of becoming independent," he explained. One female was nursing a four-month-old pup, and the pregnant one's swollen belly indicated that she would give birth soon.

On the floor of the bats' room was the partially eaten carcass of a spiny pocket mouse. "Look at that—a fresh meal, and probably the last prey of the night," Medellín said. "We think they eat some prey outside, and after they're full, they bring the last one back." The catch often goes


A spectral bat, or Linnaeus's false vampire bat, bites down on a researcher's glove. These bats weigh about six ounces and have gossamer wings that extend up to three feet. Sharp, hooked claws on the thumbs are used to snag prey.

to bats that may not be able to hunt, such as nursing mothers. "We want to know what time they leave their roost, where they go, who feeds whom, and who they travel with," he said.

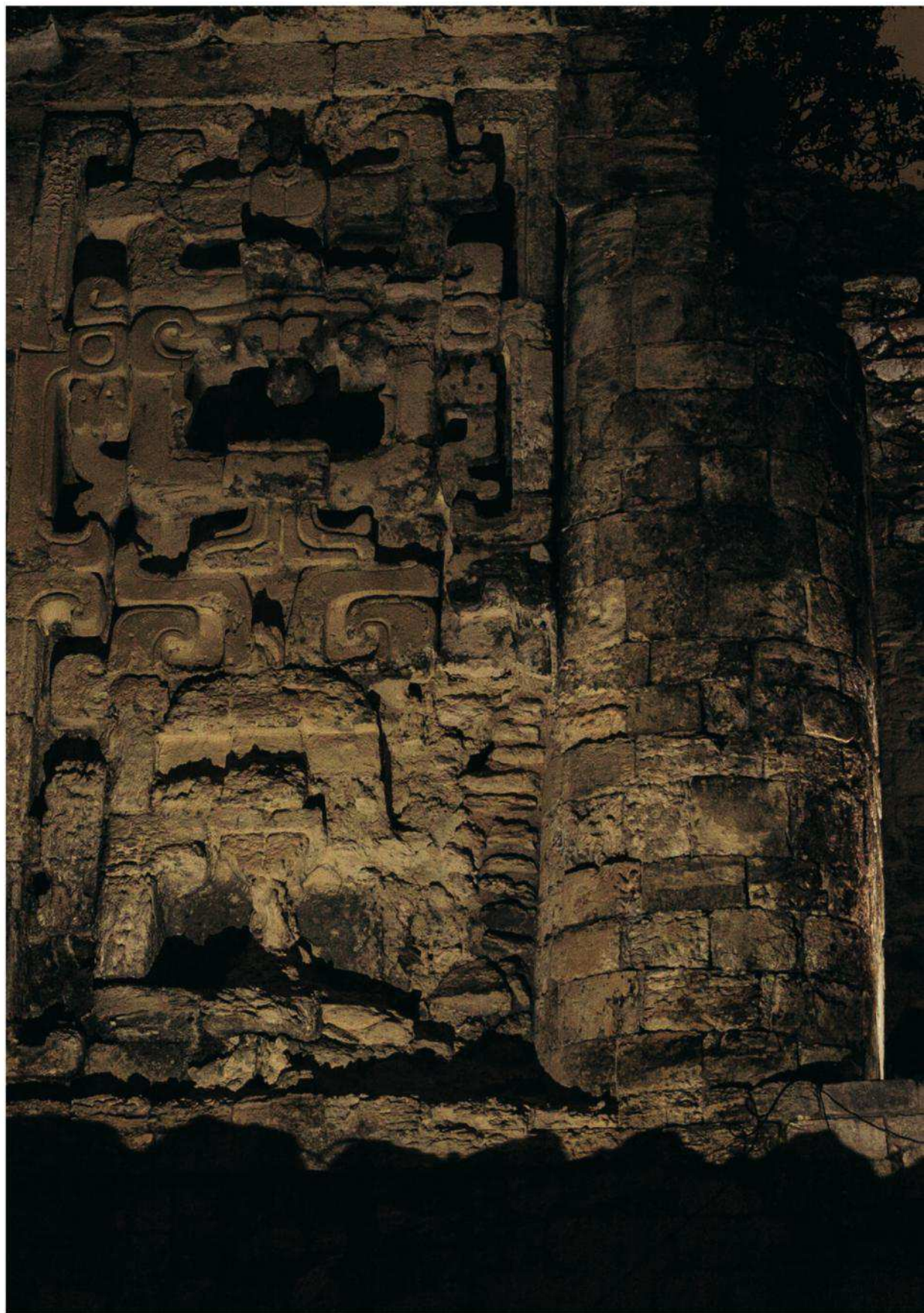
Clues to the bats' diets were gleaned from dinner leftovers and feces in the temple. "Look," Medellín exclaimed again, holding up the tiny, decaying carcass of the juvenile mouse. "I'm surprised they didn't eat it all, because usually they eat every bit—even the bones, toenails, and tail, sometimes." They'd also eaten a yellow butterfly, forgoing the wings; a cicada; and a bird, possibly a woodcreeper, judging from a cluster of russet feathers. "Usually we find the wings of other bats." They eat a lot of one uncommon species that is difficult to find. Medellín is now studying why this species is highly favored and how the woolly false vampires find them.

According to Medellín, woolly and spectral bats "are likely the bats described in the Maya



A photograph of a biologist, Rodrigo Medellín, in a dark forest at night. He is sitting on a blue tarp, wearing a dark t-shirt and dark pants. He is holding a small, light-colored bat in his gloved hands, examining it with a small tool. A white plastic container is visible on the tarp next to him. The background is filled with the dark trunks and leaves of trees.

After collecting data and genetic samples from a woolly bat, biologist Rodrigo Medellín (at left) and researcher Ivar Vleut will release it back into its cave. GPS devices help scientists learn about the bats' preferred habitat for hunting.





Casting a shadow on the ruins of a temple at the archaeological site of Hormiguero, a woolly false vampire bat returns to its roost after hunting for dinner. Bats may bring food back for members of the group that aren't able to hunt, such as females with pups.



origin myth, Popol Vuh.” In that tale the Maya hero twins are placed inside a “bat house”—a cave filled with death bats, called Camazotz by the Maya. The bats had snouts like blades, which they used to kill people and animals. To escape, the twins crawled inside their blowguns, and all night long the bats terrorized them. Toward dawn, one of the twins said he would check to see if it was safe to leave. He raised his head out of his gun—and promptly had it cut off by a Camazotz.

“These bats do the same thing,” Medellín said. “They stalk their prey, land on them with half-spread wings, locking them with the thumb claws, and deliver a death bite to the back or top of the head. Camazotz was not an invention.”

LIKE WOLVES, LIONS, most bird species, and some cetaceans, insects, and primates—including us—woolly and spectral bats share food, but only with their roost mates. Scientists consider food sharing to be a sign of altruism, although the behavior is most often found among animals that are closely related to one another—and then it’s more indicative of a close genetic relationship than a kind heart. Giving food to individuals outside of one’s genetic relatives, as humans often do, is seldom seen in other species. That’s another reason Medellín and his students want

to clarify the genetic relationships among the woolly bats. They know the bats are bringing prey back to their temple roost (“It’s the soft side of their nature,” Medellín said), but they’re not yet sure which ones are sharing and which receiving. They expect to get answers from video recorders deployed in the roost by Ivar Vleut, Medellín’s postdoctoral researcher, to capture footage of feedings.

Vleut played some food-sharing clips for me on his laptop. “You can see the mother with her pup hanging here, and now another bat has arrived with a mouse,” he said. The bat, most likely one of the males, flies in and roosts close to her, grabbing an overhead beam with his feet. Hanging upside down, she shakes her furry forearms at him much as a baby bird does when begging from its parents. She bites the prey and removes it from the hunter; the mouse is already missing its head, which the male probably ate. Grasping the mouse’s body by its neck and chewing vigorously, she devours everything but the tail, which drops to the floor. The hunter bat hangs quietly beside her, grooming his wings by licking them. “That’s the usual behavior,” Vleut said. “They often seem to be full, satiated, when they return, which is why we think they’ve been hunting for a while and then bring back their last catch to share.”

The scientists have yet to see the bats hunting in the wild, but they have a good idea of their technique because Medellín kept two woolly false vampire males captive for two weeks in

Anand Varma and Rodrigo Medellín team up to capture never before seen images in *Giant Carnivorous Bats*, airing June 22 at 8 p.m. on Nat Geo WILD.

his hotel room and let them hunt for mice he released. He scattered leaves for the rodents to rustle through, sounds the bats quickly detected as they rotated their giant ears like satellite dishes to target their prey. “The bats flew inside a cage and hung from its wire sides or a branch,” Medellín said, “and just stayed there, perfectly still. But as soon as they heard the tiniest sound from the mice, they pounced.” The bats were easy to train, he added, quickly learning that a certain sound on his cell phone meant they’d soon have a chance to hunt. Medellín suspects that woolly bats in the wild hang out on tree trunks when hunting, listening for the scuttling footsteps of rodents or reptiles, or the sound of another bat’s wings.

ONE DAY WE TREKKED through the rain forest hoping to find spectral bats. Vleut had first

of ropes and carried the camera to the uppermost part of the trunk, where the hollow opened. He slipped the camera inside and inched it farther down.

For several minutes the computer monitor on the ground was dark. Then: “We see them! There they are! Look, look! Right there!” Three pairs of eyes shone in the camera’s light, an adult female with a juvenile and an adult male. Surprised by the strange intruder in their home, they were protesting. We couldn’t hear their sounds, but the bats’ faces were contorted, their teeth chattering furiously, their long ears vibrating.

“They do that when they make the *burr* sound, which tells you to back off,” said Medellín, who kept his eyes fixed on the screen. “Now what’s that down there?” he said, looking past the bats at what appeared to be the floor of the tree’s interior. “That’s a bat’s wing!” one

‘I WAS COMPLETELY CONFOUNDED WHEN I SAW THIS GIANT BAT CHEWING HIS WAY OUT OF OUR NET. I WAS SURPRISED AND A BIT SCARED BECAUSE OF ITS SIZE.’

Ivar Vleut, bat researcher

encountered one in 2009. “They’re very rare, and I knew nothing about them,” he said as we hiked along a trail. Once he trapped a spectral in a net while doing a bat survey. “I smelled it before I saw it—I thought something had died in our net. I was completely confounded, without words, when I saw this giant creature chewing his way out of our net. I was so surprised and a bit scared because of its size.” After removing the bat from the net, Vleut put on two pairs of leather gloves to handle it.

Fascinated, Vleut read everything he could find about the bats—which was very little—and discovered that no one had looked into their ecology. He contacted Medellín, and the two launched their study. “Right now we’re trying to determine how many of these bats can live in an area,” Vleut said. “We give rewards to people who find their roosts and tell us.”

That was how they’d located several roosts. They found another one after netting a spectral bat and attaching a transmitter to its back. Our group followed the signal to a hollow tree, where Medellín and Vleut hoped to be able to observe spectral bats at home. The scientists attached a GoPro camera to a cable. Vleut fixed a set

of his students replied. It was the remains of a recent meal, perhaps, lying there like part of a discarded Halloween costume. The bats continued to glare and chatter at the GoPro, and finally in what was surely a desperate protective gesture, one of the adults turned and spread its wings around the pup.

“Ohhh,” we said in unison, and then: “Take the camera out—get it out of there!” Vleut pulled on the cable, and the bats disappeared from the screen. An animated discussion ensued about how the scientists might put an unobtrusive camera into the tree to get images of the lives of bats without disturbing them.

Undoubtedly these carnivorous bats were terrifying to the Maya, just as they must be today to the animals they hunt. But we saw their softer, vulnerable side when they were huddled in their roosts or being handled by the scientists. Strange-looking creatures—a winged mix of mouse and wolf—as gentle and caring of their own as any other mammal. □

Virginia Morell is the author of the *New York Times* best seller *Animal Wise: How We Know Animals Think and Feel*. **Anand Varma’s** story on hummingbirds appeared in the July 2017 issue.



How Latinos Are Shaping



America's Future

BY HÉCTOR TOBAR

PHOTOGRAPHS BY KARLA
GACHET AND IVAN KASHINSKY

Latinos came to Wilder, Idaho, as migrant farmworkers in the second half of the 20th century; today they're 76 percent of the population. Miguel Arredondo arrived in 1972 and still has his first American car, this scarred Chevy. His grandkids also live in Wilder; the bouncy castle is for their baptism celebration. Guests include Santiago Rojero and his son, Santiago Jr.

PREVIOUS PHOTO

Members of the Palmer Society, a campus women's organization, celebrate their graduation from Whittier College in California. The school—Richard Nixon's alma mater—now ranks among the most diverse colleges in the United States, and the town of Whittier is predominantly Latino and increasingly affluent.





Ismael Fernandez grew up in Wilder, Idaho, a town of 1,700 souls surrounded by tall hop plants and stubby alfalfa fields.

He lived with his grandparents in a home built on land where his grandfather, a Vietnam War veteran, once picked beets and onions.

When Fernandez was 19, he was elected to the city council. On his first day in office, in 2015, he stepped up to the short dais in Wilder City Hall and sat alongside the four other council members. A local reporter noticed something no one else had: There were five Spanish surnames on the council members' nameplates.

Elvis Navarrete, wearing a hat that his father brought from Nayarit state, Mexico, looks for weeds as he walks through an onion field. The children of those who arrived in Wilder as migrant farmworkers now work the same fields—but to them it's just a summer job.

Almazan. Rivera. Godina. Garcia. Fernandez. The story soon went national. For the first time ever in Idaho—a state where non-Hispanic whites make up 82 percent of the population—voters had elected an all-Latino city council.

Born in 1996 to farmworkers with roots in Mexico, Fernandez grew up hearing people describe him as Latino. The term spread in the last decades of the 20th century as a means of grouping together ethnically diverse peoples of Hispanic heritage: immigrants from Cuba and Guatemala, U.S.-born citizens with roots in Puerto Rico and Peru, and many others.

“Wilder is a small town, and it's a sleepy





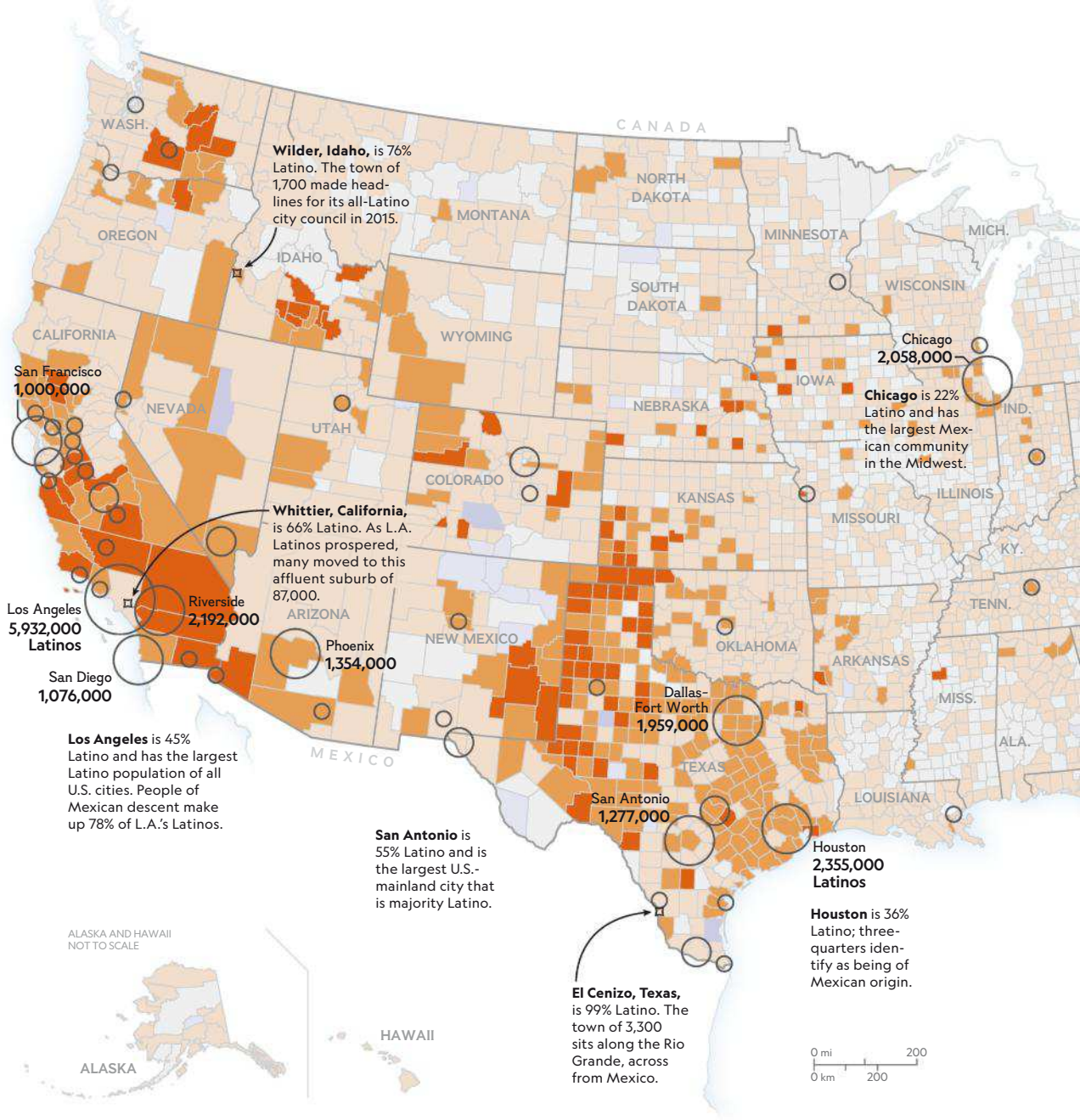
town,” Fernandez explained to some of the out-of-town reporters who visited. “Early in the morning and late in the evening, no matter what direction you go...north, south, west, east, you’re going to see fields and...people working. Mainly Latino, mainly of Mexican descent.”

Wilder, where Latinos now make up three-quarters of the population, has become an unlikely symbol of the rising influence of Latinos nationwide.

Every day the rest of the United States becomes a little more like Wilder. The nation’s Latino population has grown sixfold since 1970, reaching an estimated 57.4 million in 2016, or

nearly 18 percent of the population, according to the U.S. Census Bureau. In most places where the locals say a community “feels” different from what it did a generation ago, Latinos are the reason: They account for more of the nation’s demographic changes than any other group.

Because of this increase, the United States will become a “minority majority” country by the middle of this century. This dramatic reordering of the nation’s demographics has spawned anger and conflict, which some opportunistic politicians and media commentators have helped fuel by portraying whites as victims in an increasingly diverse United States. Such



critics, including President Donald Trump, often have cast Latinos as violent gang members, job stealers uninterested in learning English, and undocumented immigrants who come to the United States and have so-called anchor babies, children who are U.S. citizens at birth. Resentment about immigration—most of the estimated 11 million undocumented immigrants in the U.S. are Latinos—helped fuel the political shifts that sent Trump to the White House.

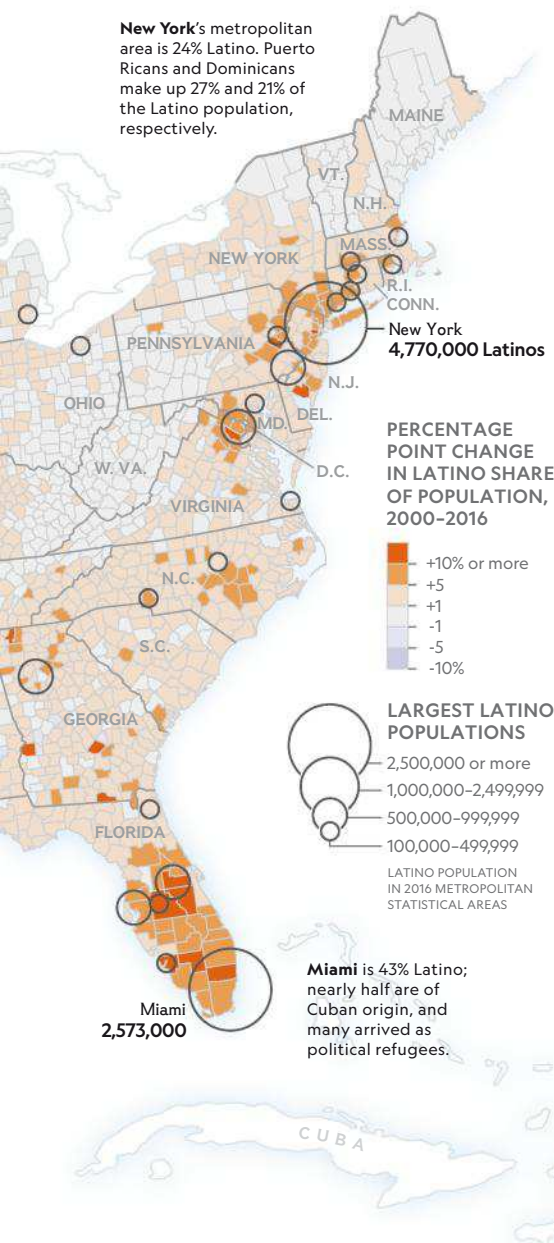
Most Latino people in Wilder will tell you they've always gotten along well with their white neighbors. Things haven't changed much since

Trump was elected in 2016, they say. People with roots in Mexico are appreciated here because the farm economy couldn't exist without them.

"This has always been known as the Mexican town," Adrián González, 40, told me from the front yard of his Wilder home, a block from a field where hop vines rise on V-shaped trellises. He was born in Texas, grew up speaking Spanish at home and English at school, and came to Idaho to join Mexican-American relatives working in the fields: "We topped onions, detasseled corn, blocked sugar beets."

A similar need for laborers is reshaping the

New York's metropolitan area is 24% Latino. Puerto Ricans and Dominicans make up 27% and 21% of the Latino population, respectively.



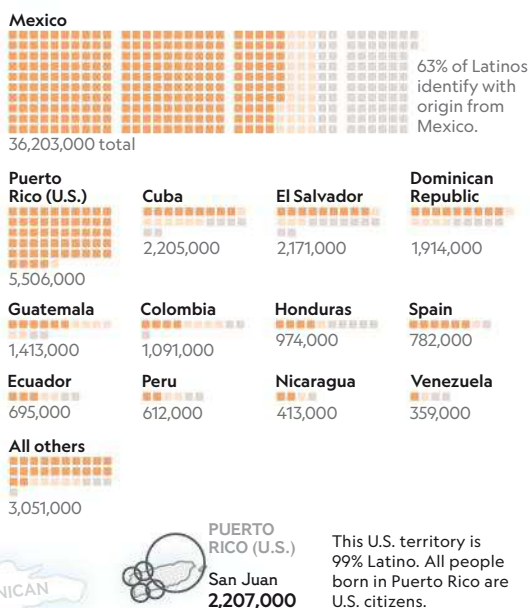
Expanding Latinidad

The Spanish word "Latinidad," which loosely translates as "Latino-ness," is a term that strives to encompass the shared cultural identity of millions of Latinos who are of different races and national origins and who live in the United States. According to the U.S. census, the terms "Latino" and "Hispanic" represent the 57.4 million who hail from a host of countries south of the U.S. border and in the Caribbean, as well as Spain. Latinos officially became the largest U.S. minority in 2000. Since then their Latinidad has continued to thrive in urban and rural areas.

Diverse origins

Many Latinos prefer to identify with the place of their family's origin, rather than with terms such as "Latino" or "Hispanic."

- Native-born U.S. citizens
 - Foreign-born U.S. citizens
 - Non-U.S. citizens
- EACH SQUARE REPRESENTS 100,000 PEOPLE.



demographics and culture of rural areas nationwide. And big cities such as Miami, New York, Houston, Chicago, and Los Angeles are now home to millions of Latinos who reflect a broad economic spectrum and, as in Wilder, are taking on leadership roles in their communities.

I GREW UP as the son of Guatemalan immigrants in Los Angeles, which now has a Latino plurality. Like people in Wilder, L.A. residents of Latino descent pepper Spanish into their speech, even if English is their native tongue. They make comfort food from beans and corn masa; they go to church

to praise Dios, and they call their daughters *mija* (a portmanteau of *mi hija*, my daughter).

Latinos in Los Angeles vote too, electing pro-immigrant representatives and helping make California (a state that once elected Ronald Reagan governor) among the most pro-Democrat of the 50 states. The mayor of Los Angeles and the leaders of both houses of the state legislature are of Latin American descent.

Over the decades I've seen traditions such as Cinco de Mayo spread across the country to heartland towns such as Garden City, Kansas; Lexington, Nebraska; and Wilder, Idaho.

Ceremonial dancing is part of the Anahuacalmecac International University Preparatory's graduation-day celebration in downtown Los Angeles. The K-12 public charter school emphasizes knowledge of indigenous culture. Students learn Nahuatl (Aztec) in addition to English and Spanish. As part of their math lessons, they study a traditional computation system called *nepohualtzintzin*.

NEXT PHOTO

Philanthropists Rebecca (center) and Richard Zapanta (left), a surgeon, founded Los Compadres, a charity that supports Children's Hospital Los Angeles. Each year they fund events for very ill patients, often coming-of-age parties such as *quinceañeras*, which commemorate a girl's 15th birthday.









After sitting through a long Mass for their first Communion, these girls in La Puente, California, get to play outside. Nearly half of Latinos in the United States identify as Roman Catholic, while a fifth identify as evangelical Protestants.





The city council in Wilder meets in a former bank that serves as city hall. Members say they rarely, if ever, discuss questions of cultural identity.

“People ask me, ‘As a Hispanic, how are you going to help Hispanics?’” says Mayor Alicia Almazan, a hair stylist who grew up working alongside her father in Idaho fields. “This is not what we’re about.” Her mission, she explains, is to help all of Wilder’s residents.

At the same time, the mayor is proud of her heritage. Her Spanish-speaking father taught her “to stand up for yourself no matter what...and never back down.” She repeats a phrase he’d say in Spanish: “*Nunca se va a rajar, ninguno de mis hijos.*” None of my kids will ever break.

LIKE OTHER PLACES in the United States, western Idaho is a cultural crossroads. Spanish-surnamed people first came from Mexico and South Texas to live in Wilder in large numbers during the second half of the 20th century. They were following annual migrant-worker routes, and each

year most would leave once the snow began to fall. When a few decided to stay, the local Latino community was born.

“We were very cold—in a trailer, without heat, and with a baby boy,” Alejandro Bravo, 40, says of his family’s first winters in Wilder. Bravo works full-time for a local farmer during the week. On the weekends he’s a pastor who leads a Spanish-language service in Wilder’s Methodist church. The lessons he’s learned on his journey to Idaho from Guadalajara, Mexico, are reflected in his sermons. “*Sufrimos, batallamos,*” he says. We suffered, we battled.

Among the major ethnic or racial identities in the United States—white, black, Asian, Native American—Latino is the most amorphous. Latino people can be African, Mesoamerican, Asian, or white. They are evangelical, Roman Catholic, and Jewish. I am of Maya Indian heritage, but like many Latino people over 50, I have “white” listed as my race on my birth certificate.

What “Latino” means, more than anything, is that you are part of a story that links you to other



people with roots in a southern place: Ecuador or El Salvador, for example. Or maybe an old Southwestern town founded by Spaniards, such as Española, New Mexico. More than likely this story involves the journey a migrant made in search of work and opportunity.

IN LOS ANGELES, the great sprawling metropolis centered on what was once an outpost of the Spanish Empire, Latino people still think of labor, migration, hardship, and resilience as the qualities that define them and tie them together.

I grew up with my parents' stories of their journey from Guatemala to the one-room apartment in Los Angeles, where I was born and raised. We slowly rose into the middle class, moving eastward every few years—from crowded East Hollywood to newer, roomier suburbs such as Whittier.

Countless Latino residents of Greater Los Angeles followed in my family's footsteps. Once confined to barrios in East L.A. and Boyle Heights, Latino communities have spread to almost every corner of the metropolis.

**WHAT 'LATINO' MEANS,
MORE THAN ANYTHING,
IS THAT YOU ARE PART
OF A STORY LINKING YOU
TO OTHERS WITH ROOTS
IN A SOUTHERN PLACE.**

LEFT

Mariachi Negrete performs at a birthday party in Compton, California. The group, founded by Guillermo Negrete from Michoacán, Mexico, and now led by his son, Rodrigo, has been playing together for 20 years. On some days the band performs at multiple house parties in the Los Angeles area.

RIGHT

Laura Sermeño and her baby boy celebrate the end of her *cuarentena*, or quarantine. The tradition, common throughout Latin America, requires new mothers to rest under the care of their relatives for some 40 days after childbirth. The period ends with a mother-child herbal bath and a massage.



At the southern end of Los Angeles, in the oil-refinery and port community of Wilmington, I met the family of Luz Gomez. Three languages are spoken at the Gomez home: English, Spanish, and Zapotec. Luz, 17, is a U.S. citizen who's grown up following Zapotec Indian traditions. At celebrations in Los Angeles, she dons the woven skirt and blouse worn by women in her parents' hometown—San Bartolomé Quialana, in the Mexican state of Oaxaca, a place she first visited this year. "When people say 'Latino,' they think 'Mexican,'" Luz told me. "I call myself Oaxacan."

Her father, Fidel, came to the U.S. as a teen. When his first American daughter was born, he gave her two names: Luz, which is Spanish for "light," and Zithviani, Zapotec for "far away." "So my name means 'light from far away,'" she says. And each fall Luz's mother, Lola, marks the Day of the Dead, el Día de los Muertos, with traditions of her Oaxacan ancestors: cooking special dishes and building an altar in the living room with marigolds, votive candles, and photos of the departed.

IN SOUTHERN CALIFORNIA el Día de los Muertos is a modern symbol of Latinidad, or Latino-ness, for millions of people. Many are lifelong Americans like me who grew up speaking English.

In Whittier fifth-grade teacher Yolanda Garcia noticed her students did better when their lessons had Latino themes. Learning about their culture and history made them feel smarter. She sensed that this hunger for Latino culture had commercial potential too—so she started a store, Casita del Pueblo, in Whittier's Uptown in 2004.

Later, with the blessing of Whittier officials, Garcia launched a Day of the Dead festival in a nearby park. The festival now takes up a dozen city blocks on an October weekend.

Whittier has become a mecca of the Latino middle class, a transformation few locals could have imagined a generation ago. I grew up in South Whittier—an unincorporated, down-market community nearby—and knew Whittier as a place where white people lived. Richard Nixon went to high school there.

These days some very affluent Latino families live in Whittier, including Richard and Rebecca Zapanta. Their 12,000-square-foot home in the city's Beverly Hills Estates resembles an Italian villa. They've filled it with paintings and other works by many of Mexico's master artists, including Rafael Coronel and Frida Kahlo.

Richard grew up in the barrios of East Los

WHITTIER HAS BECOME A MECCA OF THE LATINO MIDDLE CLASS, A TRANSFORMATION FEW COULD HAVE IMAGINED A GENERATION AGO.

Angeles in the 1950s and 1960s, but he had no real, living connection to Mexico. "I'm fourth-generation Mexican American," he told me. After he became a successful surgeon, he traveled to the land of his ancestors again and again. His Spanish improved, a skill that was useful when he met Mexican artists.

The Zapanta home is also filled with photographs of Latino politicians they know, many of whom have risen to national prominence. Among them: Antonio Villaraigosa, who was Los Angeles's mayor for two terms, and Hilda Solis, a former U.S. congresswoman who was labor secretary during President Barack Obama's second term.

When Rebecca was first dating Richard, she says, "We started off with \$10, eating menudo at Ciro's," a humble Eastside eatery. Before Obama left office, Secretary Solis invited Rebecca to a state dinner at the White House.

IN THE LATINO communities of Southern California, it is the best of times, and the most difficult.

I live in a hillside home with beautiful views near the Los Angeles River, where the real estate boom has pushed the value of some properties past one million dollars. A short downhill walk from my home, undocumented immigrants live and work.

In February 2017, less than a mile from my neighborhood, Romulo Avelica-Gonzalez was driving his U.S.-born daughter Fatima to school when immigration agents suddenly descended upon the family. Her mother told Fatima, then 13, to record the arrest on her cell phone. "I was sad, and at the same time I was mad, because they were taking my dad away from me," she told me.

The Avelicas have roots in a seaside town in the Mexican state of Nayarit, but they've lived in Los Angeles for a quarter century. For months after Romulo's arrest, Fatima and her family visited him in an immigration facility. In the meantime the video she'd shot of her father's

arrest had gone viral. “Now people know what the president is doing,” she says, referring to the Trump administration’s aggressive deportation policies. “He’s tearing families apart because he thinks they’re criminals.”

Romulo was released from detention six months later. He returned to the Eastside and made tacos for the friends and strangers who’d fought for his release and had won—thanks in large measure to Fatima’s video.

Romulo has lived in the U.S. long enough to have grandchildren born in America. With plans to revamp the nation’s immigration system stalled in Congress, the presence of millions of undocumented Latino men and women is becoming a permanent feature of American life; they are now as much a part of the nation’s social fabric as softball and summer camp. But the ever stricter enforcement of immigration laws has changed the feel of daily life in many Latino communities. The impact is seen most dramatically along the 1,900-mile U.S.-Mexico border.

THE SLOW RIVER that separates Mexico from the United States is a mirror of calm water less than 100 yards wide when it passes the quiet border town of El Cenizo, Texas—population 3,300. If Trump’s proposed border wall were built here, it would run past a city playground near the riverbank and the open field where Fermín Longoria stopped recently to feed his brother’s horses.

“I don’t think that wall will ever be put here,” Longoria told me in Spanish.

El Cenizo is 99 percent Latino. People of Mexican descent have long lived here and crossed easily back and forth between the two countries. In 1999 the city passed a sanctuary law protecting undocumented immigrants. “Two Cultures, One Great City” is El Cenizo’s motto. The local school is named for two heroes, one U.S.-born and one Mexican: Kennedy-Zapata Elementary.

El Cenizo gets its name from a sagebrush that grows along the Rio Grande Valley. People here used to work on the onion and melon farms nearby, but those crops were abandoned years ago, forcing many to travel hundreds of miles in search of jobs. And yet many residents remain proud to call the mostly Spanish-speaking town home. “You never have to lock your doors here,” Salomon Torres-Martínez, 63, told me. He built a home in El Cenizo from scratch, assembling materials gradually, “like a bird building a nest.”

When immigrants pass by his house after

crossing the river on rafts, Torres-Martínez responds the way most other El Cenizo residents do: He looks the other way.

In recent years tougher enforcement has made immigrant smugglers a more dangerous, desperate breed. “Now they’re starting to carry guns,” resident Carlos Coronado told me. An increased U.S. Border Patrol presence also has frightened many in El Cenizo: Mayor Raul Reyes estimates one in five residents may be undocumented.

In 2017 Reyes filed suit to stop enforcement of a new Texas law that would force local police to cooperate with immigration authorities. Reyes, a registered Democrat, announced he would be willing to take the fight all the way to the U.S. Supreme Court.

Reyes first ran for office in El Cenizo at age 19—just like Ismael Fernandez, the young city councilman in Wilder, Idaho, except Fernandez ran as a Republican.

Growing up in rural Idaho, Fernandez once told his grandmother that he might be the first Latino president. It didn’t seem impossible, given how driven he was. He often engaged in political debates with his more liberal older sister, Mariza. “I want to change people’s minds by doing stuff,” he told her.

He studied practical things such as sewer and water systems. A state legislator appointed him her alternate; he was empowered to cast votes when she was absent from the Capitol in nearby Boise. It was a great honor for a 20-year-old, and more seemed sure to follow. But just days after the appointment, on January 27, 2017, Ismael Fernandez died in a car accident outside Wilder. His sister and grandmother chose a small obelisk as his grave marker—it reminded them of the Washington Monument. “You know he would love that,” his sister says. Young Ismael had been a history buff who put a framed copy of the U.S. Constitution on his bedroom wall. “I want to be talked about for ages to come,” he once told her. “I want to leave something behind.”

Today that obelisk stands as a monument to a local hero of the Latino community: a young man who went to city hall to make his hometown a better place to live and who believed a Latino family with roots in Mexico could leave a permanent mark on the United States of America. □

Héctor Tobar is a veteran journalist and the author of four books. Photographers **Karla Gachet** and **Ivan Kashinsky** have worked throughout the Americas. All three are based in Los Angeles.

A woman with curly hair, wearing a teal patterned tank top and shorts, is crouching on a grassy area. She is washing a white cloth in a large white bucket filled with water. To her left, a large black metal pot sits on the ground. In the background, a large blue plastic water bottle hangs from a tree branch. The scene is set outdoors with lush greenery and a clear blue sky with some clouds.

DISPATCHES | PUERTO RICO

Power Struggle

MONTHS AFTER HURRICANE MARIA, PUERTO RICO IS STILL
RECOVERING FROM THE LONGEST BLACKOUT IN U.S. HISTORY.

BY **DAVID BRINDLEY** PHOTOGRAPHS BY **CAROL GUZY**



18°01'34" N, 65°49'58" W

"THE FISHERMEN HERE are suffering," says Yamary Morales Torres, 41, standing in her yard overlooking the pounding surf on Puerto Rico's southeastern coast. Setting out before daybreak, Yamary and 14 other fishermen in her neighborhood have to prepare their boats and fishing gear in the dark. "There's no place to refrigerate the fish we catch," she adds. "So we need to sell them immediately."

On September 20, 2017, Hurricane Maria struck land not far from Playa El Negro in Yabucoa, where Yamary and her extended family live. The storm knocked out power to the entire island, a United States territory that is home to 3.3 million citizens. Five months later this neighborhood of only 14 homes—all damaged and flooded by the storm—still had no electricity and no sense of when it would be restored.

A third-generation fisherman, Yamary lives with her elderly parents in their dilapidated concrete home. The house next door was all but leveled in the storm. Her twin sister, Yasmin, lives two houses down, next door to a brother and his family. They all had to evacuate before the storm, but with no other options the family returned to their homes. "Life is very sad now," Yamary says. "But I'm not leaving. I'm staying right here."

That spirit of resilience is helping Puerto Rico rebuild from the massive destruction left in the storm's path. Power and water were restored within weeks to the island's major urban areas, but with spring approaching, more than 100,000 residents—all in rural, poor areas much like Playa El Negro—remained in the dark. It's going to take more than determination by the island's population to fully recover, if that's even possible.

The strongest storm to hit Puerto Rico in 89 years, Hurricane Maria battered the island with tornado-force winds. Massive rains brought catastrophic flooding, washing out bridges and inundating neighborhoods. The island's infrastructure, already shaky after years of neglect, was devastated.

Running water was cut off for much

of the population. Communications to and from Puerto Rico were nearly impossible for days. Airports were shut down, delaying recovery efforts, since supplies had to be airlifted or shipped in. And the Federal Emergency Management Agency, charged with disaster relief, was stretched thin after two other major hurricanes had recently hit the U.S. in less than a month.

The result was the longest major power outage in U.S. history, and many communities on the island were left without running water for months. Toilets couldn't flush; there was no water for showers, baths, or washing clothes. People had to rely on bottled water, but supplies were limited. Useless electric stoves had to be replaced with propane ones. Without refrigeration, food rotted and vital medicines spoiled. Only those with generators for their homes could ward off darkness after dusk—for a few brief hours. Forget about air conditioners to relieve the sweltering heat. All the modern conveniences we take for granted were left behind.

ON FEBRUARY 19 the power finally came back on for a neighborhood on the outskirts of Morovis, a small town in the island's north-central highlands. When the lights turned on in her house, Marysol Rivera Rivas, 51, jumped up and down, hugged her neighbors, and hoisted a can of beer. "There's the last clothes I have to wash by hand," she exclaimed, pointing to a line of laundry flapping in the wind in her yard. "This is the first time in five months we're able to celebrate. We're alive now!"

Even after power and water are restored across the island, people will still be dealing with the aftermath. "The storm takes away the foundations of society. Everything you thought gave you certainty is gone," says psychologist Domingo Marqués, 39, an associate professor at Albizu University in San Juan. "You see people anxious, depressed, scared." Marqués estimates that 30 to 50 percent of the population is experiencing post-traumatic stress disorder, depression, or anxiety.

Still, Marqués is guardedly optimistic. "We saw a lot of resiliency. We're not going anywhere. We're rebuilding," he says. "We'll be OK. But we shouldn't try to get back to normal, because things will never be normal again." □

TOP RIGHT

Two days after Hurricane Maria struck Puerto Rico in September 2017, flooding continued in the northeastern town of Loíza, where Liz Maríes Bultron (at left) and her neighbor Alana Bepizarro live.

CAROL GUZY, ZUMA PRESS

BOTTOM RIGHT

Power lines and palm trees lean ominously over the road leading north from Punta Santiago, Humacao, five months after the storm. Punishing winds and a massive storm surge crippled the coastal area.

PREVIOUS PHOTO

Yasmin Morales Torres, 41, washes laundry by hand in her yard in Playa El Negro, a beach community in Yabucoa. As of March the area still had no power, six months after the devastating storm.



SEPTEMBER 2017

FEBRUARY 2018



TOP LEFT

Without electricity Irma Torres Rodríguez, the 75-year-old matriarch of Playa El Negro, relies on lanterns as she does nightly chores in her kitchen. She and her husband have lived in their home since the 1960s and have nowhere else to go.

TOP RIGHT

Dawn breaks over all that remains of a home in Playa El Negro. Hurricane Maria made landfall not far from this once Edenic beach community.

BOTTOM LEFT

Carmen Torres Rivera, 56, fishes off the destroyed pier in Punta Santiago. "This is a hobby; it helps time pass," she says.

BOTTOM RIGHT

The stress of living without power in a badly damaged house wears at Berenarda Martínez Morales, 64. She shares her two-room home in Playa El Negro with her three adult children.





LOST AT SEA



Seabirds are suffering
devastating losses.
Saving them begins
with knowing
more about them.

By JONATHAN
FRANZEN

Photographs by
THOMAS P.
PESCHAK







Fishing vessels offer a bonanza of food for seabirds, but they proved fatal to these albatrosses and white-chinned petrels (black birds on perimeter) caught in 2017 on tuna longlines off South Africa's coast. Thanks to sustainable fishing practices, annual bird bycatch off South Africa now numbers only in the hundreds. Globally, however, more than 300,000 seabirds are killed by longlines alone.

PREVIOUS PHOTO

In Peru's Lobos de Afuera Islands, a century of loss from guano harvesting, overfishing, and—recently—climate change lies between a 1907 photograph of a Peruvian pelican breeding colony and the landscape of littered bones on the same spot in 2017. Starvation, coupled with El Niño rains, likely killed most of the chicks in the preceding breeding season.

ROBERT E. COKER, NATIONAL GEOGRAPHIC CREATIVE (ARCHIVAL IMAGE)

A scalped gray-headed albatross chick on sub-Antarctic Marion Island gruesomely conveys the threat seabirds face from invasive species. For reasons not entirely understood, mice brought to the island by humans 200 years ago have begun feeding on birds at night. With no instinctual fear of this new danger, a bird will sit passively while mice nibble into its flesh, until it succumbs.



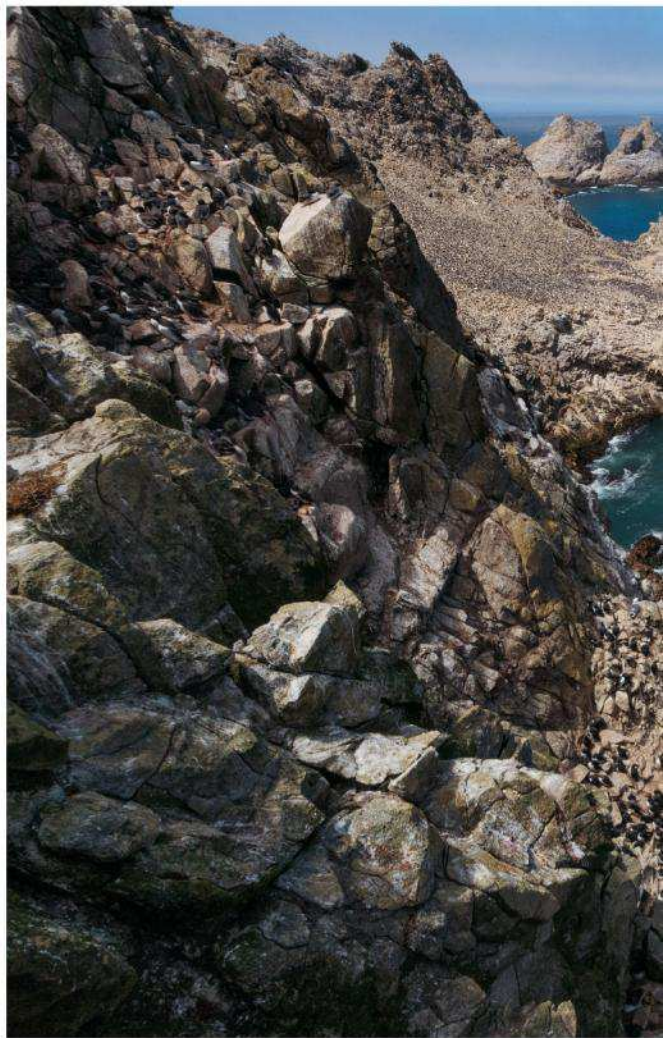


Imagine
a slender,
mouse-gray
bird, no bigger
than a starling,
that spends
most of its life
on open ocean.

In cold water and all weather, the ashy storm petrel—a warm-blooded animal that weighs less than an ounce and a half—forages among the waves for tiny fish and ocean invertebrates. Fluttering with dangled legs, its toes skimming the surface, it gives the impression of walking on water, like the biblical Peter.

Although storm petrels as a group are among the world's most abundant and widespread birds, ashies are rare and found only in California waters. They have a distinctive strong musky odor; you can smell them in the fog. They're most at home on the water, but, like all birds, they need to be on land to lay eggs and raise their young. For this, they prefer undisturbed islands. To escape the attention of predators, they nest underground, in rock crevices or burrows, and come and go only at night.

In the Farallon Islands National Wildlife Refuge, 30 miles west of San Francisco's Golden



Gate, a local artists' collective has built a kind of sloppy igloo out of chunks of concrete from the ruins of old buildings on the main island. A small door in the sculpture allows access to a crawl space lined with Plexiglas. If you go in on a summer night and shine a red light (less disturbing to birds than white light), you might see an ashy storm petrel sitting patiently on an egg at the bottom of a crevice, looking even smaller and frailer than it would on the water. You might hear the nocturnal song of one of its hidden neighbors, a soft and tuneful purr that emerges from the rocks like a voice from another world: the world of seabirds, which encompasses two-thirds of our planet but is mostly invisible to us.

Until recently, invisibility was an advantage for seabirds, a cloak of protection. But now,



The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.



CELEBRATING THE YEAR OF THE BIRD

National Geographic is partnering with the National Audubon Society, BirdLife International, and the Cornell Lab of Ornithology to celebrate the centennial of the Migratory Bird Treaty Act. Watch for more stories, books, and events throughout the year.

A lone common murre flies above thousands more tending eggs and young in the Farallon Islands off California. Decimated in the 19th century by egg hunters supplying San Francisco's markets, the population suffered another collapse in the early 1980s because of gillnetting—the use of large nets that trap seabirds and other wildlife as well as the target fish. Since the mid-1980s, restrictions or outright bans on gillnetting have allowed the Farallon murrelets to thrive again.

as invasive predators and commercial fishing threaten their existence, they need people to protect them; and it's difficult to care about animals you can't see.



THE FARALLONS TODAY are a small portal to the past, when seabirds were abundant everywhere. More than half a million birds were nesting in the refuge when I visited the main island in June 2017. On steep slopes and sparsely vegetated level ground, surrounded by deep-blue water roiling with seals and sea lions, were puffins and guillemots and cormorants, tiny plump Cassin's auklets, weirdly horned rhinoceros auklets, and, in my opinion, way too many western gulls. The gull chicks were hatching, and it was impossible to walk anywhere without enraging their parents, which screamed at

ear-hurting volumes and jumped into the air to strafe intruders with evil-smelling excrement.

The gulls were a gantlet worth running to reach the island's colonies of common murrelets. One morning, Pete Warzybok, a biologist with Point Blue, the conservation group that helps the U.S. Fish and Wildlife Service monitor wildlife on the Farallons, led me up to a plywood blind overlooking a murrelet metropolis. Like a blanket of coarsely ground pepper, 20,000 black-and-white birds covered a sloping spit of rock that bottomed out in surf-splashed cliffs. The murrelets were standing shoulder to shoulder, pointy billed, penguin-like, and incubating an egg or guarding a tiny chick on territories as small as a few square inches. The colony had an air of quiet industry. There were occasional outbursts of gentle clucking, and the menacing gulls kept sailing over, scanning for breakfast opportunities, and sometimes a murrelet landing awkwardly



NGM MAPS

ALGOA BAY SOUTH AFRICA

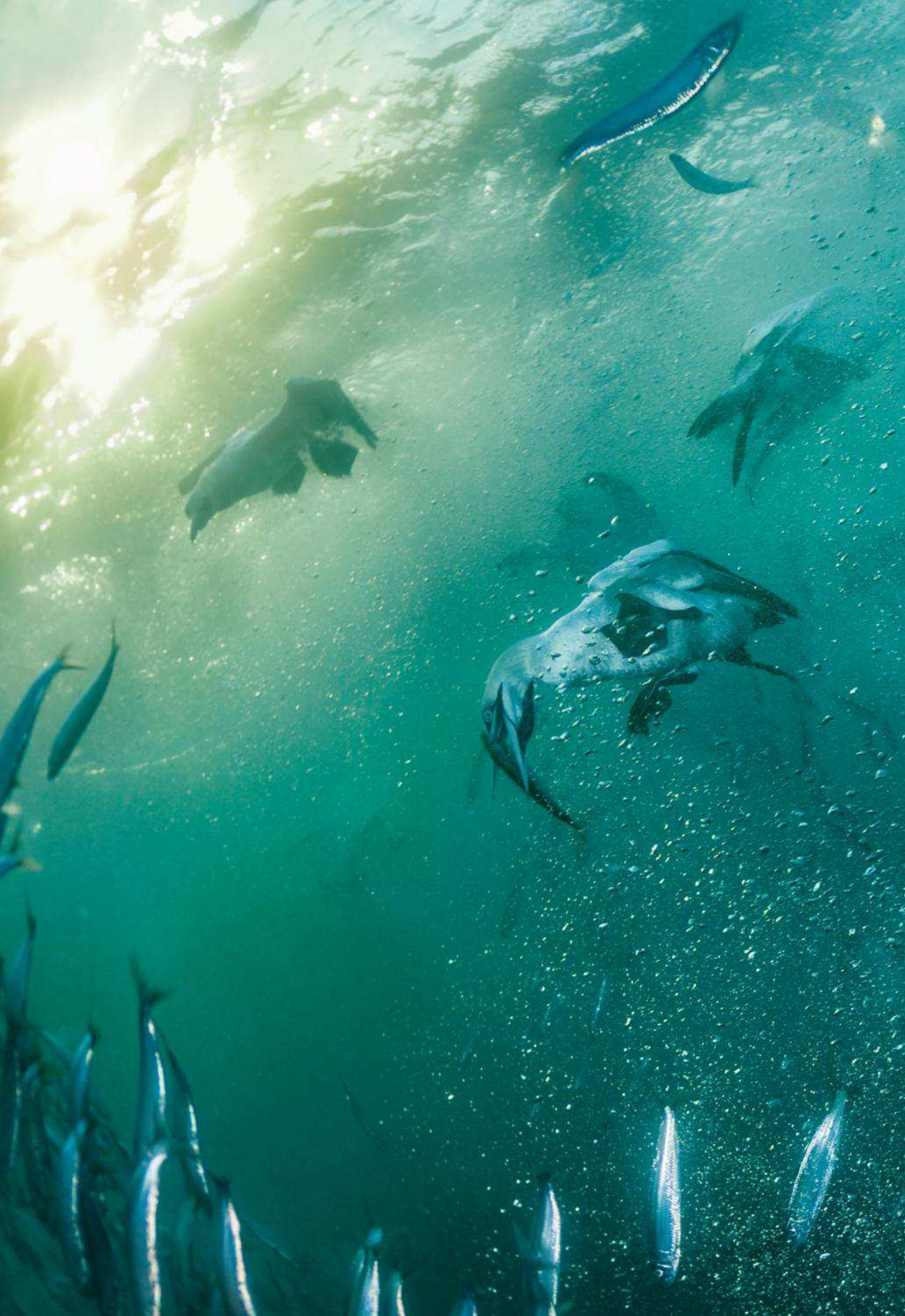


A national park along South Africa's southern coast protects key breeding grounds for more than a dozen seabird species. But dangers remain.

On Bird Island in Algoa Bay, puddled water from heavy rains makes a messy landing for a Cape gannet. Climate change models predict more frequent and intense rainfall in the region, and flooding can cause large-scale loss of eggs. An altered climate can affect other birds by moving their fish prey farther from their breeding grounds.

NEXT PHOTO

After hitting the water at 60 miles an hour, plunge-diving Cape gannets feast on high-calorie sardines, their preferred prey. This photograph captures the first evidence (top right) of underwater kleptoparasitism among Cape gannets: one bird caught heisting a fish from another.





or scrambling to take flight would scuffle with a neighbor. But the disputes ended as suddenly as they started, the birds resuming their grooming as if nothing had happened.

“Murres do what murres do,” Warzybok remarked. “They aren’t the brightest birds.”

What murres do is exercise devotion. Although divorce is not unheard of, they form strong pair bonds and may live for 30 years or longer, returning every year to the same tiny territory and raising one chick. Parents share incubation duties equally, one of them remaining in the colony while the other ranges over the ocean and dives underwater for anchovies, juvenile rockfish, or whatever else is available. When a bird returns from a long foraging trip, the parent that has stayed behind—increasingly hungry and streaked with guano—is still reluctant to leave the egg. In the local lore of murres, there’s an anecdote of a mother whose egg rolled downhill as soon as she laid it. A gull came by and swallowed it, stood for a moment with an enormous lump in its throat, and then regurgitated the egg, which rolled farther downslope and hit a standing murre, which promptly climbed onto it and began to incubate it.

“If they don’t have an egg,” Warzybok said, “they’ll incubate a stone or a piece of vegetation. They’ll lay a fish on an unhatched egg, trying to feed it. And they won’t give up. They’ll sit on a dead egg for 75 or 80 days.”

Murre chicks take to the water when they’re barely three weeks old, too young to fly or dive. Their fathers go with them and stay by their side for months, feeding them and teaching them to fish while their mothers, which have made a heavy caloric investment in producing eggs, go off by themselves to recover. Parental devotion and the equal division of labor pay dividends. The reproductive success rate of Farallon murres is very high, typically above 70 percent, and they’re one of the most abundant breeding seabirds in North America. Immense though it was, the colony that Warzybok and I were visiting held less than 5 percent of the islands’ murres.

**Seabirds
breed on
forbidding
islands and
live in
inhospitable
waters. If they
disappeared,
how many
people would
even notice?**

The murre population today represents a provisionally happy ending to a long, sad story. Two hundred years ago, as many as three million murres bred in the Farallons. In 1849, when the gold rush made San Francisco a boomtown, the islands became an inviting target for a city without a poultry industry. By 1851, the Farallone Egg Company was gathering half a million murre eggs a year for sale to bakeries and restaurants. Its eggers arrived by boat in the spring, crushed the eggs that had already been laid, and proceeded to collect every freshly laid one. Over the next half century, at least 14 million murre eggs were harvested on the Farallons. The birds’ fidelity to their nest sites kept them coming back, year after year, to be robbed of the objects of their devotion.

By 1910, fewer than 20,000 murres remained on the main island. Even after eggging stopped, they fell victim to the cats and dogs introduced by the keepers of the island’s lighthouse, and large numbers were killed at sea by oil flushed from the tanks of ships entering San Francisco Bay. The murre population didn’t seriously recover until after 1969, when the main island became a federal wildlife refuge. And then, in the early 1980s, the population plunged again.

The problem was the indiscriminate fishing method known as gillnetting. Hauling a huge net to the surface of the ocean sweeps up not only the target fish but also porpoises, otters, turtles, and diving seabirds. Today at least 400,000 seabirds are killed worldwide every year in gill nets—murres and puffins and diving ducks in northern waters, penguins and diving petrels off the coast of South America. The annual toll on murres alone may equal the 146,000 killed in the 1989 *Exxon Valdez* oil spill in Alaska.

Beginning in the mid-1980s, many American states, including California, took note of the ecological havoc and imposed severe restrictions or outright bans on gillnetting. The result, in the Farallons, was a surge in seabird numbers. In the past 15 years, safe from gillnetting, and free to do what they do, the murres have quadrupled their population. The only threat to their survival in the Farallons now is the disruption of their food source by climate change or overfishing.

Pete Warzybok, perched in the blind, was writing down the species of fish that the murres in his study plot brought back to their nests. To a California fisherman asked to share the ocean’s bounty with seabirds—Farallon murres consume more than 50,000 tons of fish every summer—the



argument for murre conservation isn't just ethical or aesthetic. The birds that Warzybok studies function like airborne fishery-monitoring devices, a fleet of living research drones. They scour thousands of square miles of ocean and are expert at finding where the food is. Using only binoculars and a notebook, Warzybok can gather better data about current anchovy and rockfish populations, for much less money, than California's fishery managers can gather from a boat.



FARALLON MURRES are the lucky ones. They've survived most of the major threats to seabirds, and a case can be made for their economic utility. Elsewhere, globally, in the past 60 years, the overall seabird population is estimated to have fallen by 70 percent. This figure is even worse than it sounds, because a disproportionate number of seabird species are at risk of extinction. Of the world's 360 seabirds, a larger percentage is listed as endangered or threatened than of any comparable group of birds. Parrots, as a group, have troubles of their own, but they're also widely admired. Game birds are valuable to hunters; eagles and other raptors are conspicuous and iconic. Seabirds breed on remote, forbidding

African penguin chicks nest in guano on Mercury Island off the coast of Namibia. On most southern African islands, where guano has been harvested down to bedrock, scientists must provide artificial nests. Mercury Island's remoteness and forbidding slopes have discouraged intensive guano harvesting, and seabirds have clustered here in recent years, giving chicks a natural layer to burrow into.

islands and spend most of their lives in waters inhospitable to us. If they disappeared entirely, how many people would even notice?

Imagine a young albatross in the South Atlantic Ocean. It's following the circumpolar winds, gliding 500 miles a day on its 10-foot wingspan, using its nose to track the smell of fish or squid or crustaceans near the water's surface. Often the best place to find food is in the wake of a deepwater fishing vessel. The albatross glides in circles around a trawler and eyes the chaos of smaller seabirds tussling over the fish scraps thrown overboard. When it plunges into the scrum, it brings a size advantage: a massive bill and a wingspan that announces, *I am huge!* The other birds scatter, but as the albatross hits the water, something goes terribly wrong. Its outstretched wings have wrapped around the cable of the trawler's net, which drags the bird under and swiftly pulls it deeper. No one sees

SEABIRDS IN CRISIS

The global population of seabirds has dropped by nearly 70 percent since monitoring began in the 1950s. Each of the nine orders of these birds—from transoceanic voyagers such as albatrosses to shore-hugging penguins—is facing at least one of four key threats.

360 species of seabirds
(630 million birds)

110 species under threat
(80 million birds)

Range and number of seabird species in danger of extinction



Threatened seabird species on islands



LEADING THREATS

ORDERS

Number of species Under threat

3

PHAETHONTIFORMES
Tropic birds



White-tailed tropic bird
Phaethon lepturus
Length: 30 in



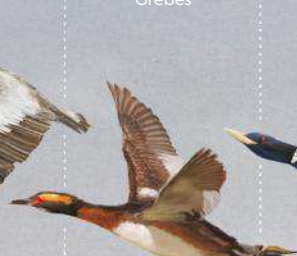
PELECANIFORMES
Pelicans



Peruvian pelican
Pelecanus thagus
57 in



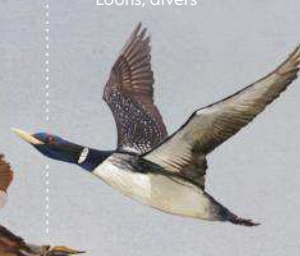
PODICIPEDIFORMES
Grebes



Horned grebe
Podiceps auritus
14 in



GAVIIFORMES
Loons, divers



Yellow-billed loon
Gavia adamsii
33 in



HABITAT DISTURBANCE
Invasive species and human activity ravage nests. Light pollution can fatally disorient fledglings.



POLLUTION
Spilled oil fouls feathers, making them less waterproof. Oil and plastics cause a buildup of toxins.

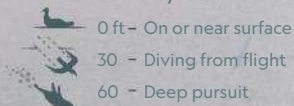


CLIMATE CHANGE
Sea-temperature rise forces birds to forage farther, abandoning nests; severe weather can be fatal.



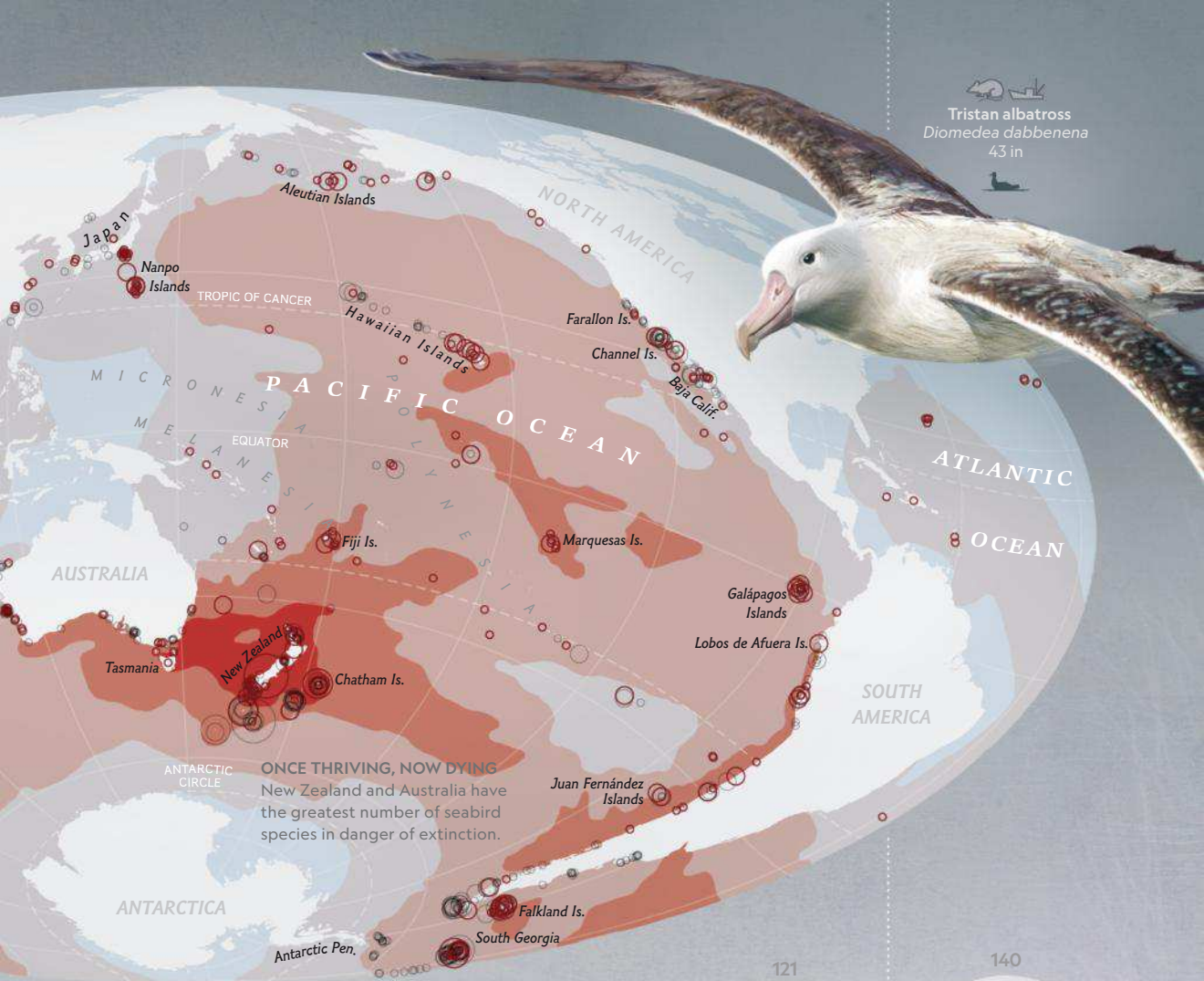
COMMERCIAL FISHING
Fishing depletes seabird food sources; birds feed at different depths and can drown when caught in nets or hooked on longlines.

How they feed



Trawl fishing





SPHENISCIFORMES
Penguins

African penguin
Spheniscus demersus
26 in



ANSERIFORMES
Ducks, eiders, mergansers

Velvet scoter
Melanitta fusca
22 in



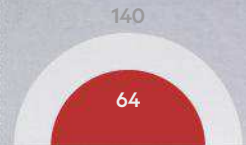
SULIFORMES
Frigatebirds, cormorants, boobies, gannets, shags

Abbott's booby
Papadula abbotti
31 in



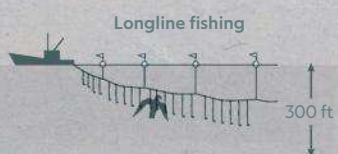
CHARADRIIFORMES
Gulls, terns, skuas, puffins, murrelets

Atlantic puffin
Fratercula arctica
12 in

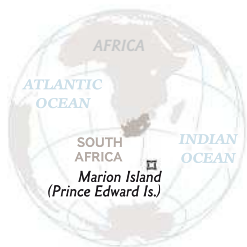


PROCELLARIIFORMES
Albatrosses, shearwaters, petrels, fulmars, storm petrels

Magenta petrel
Pterodroma magentae
16 in



BIRDS NOT SHOWN TO SCALE. THE NUMBERS FOR PELECANIFORMES, PODICIPEDIFORMES, ANSERIFORMES, AND CHARADRIIFORMES ARE FOR SEABIRD SPECIES ONLY. FERNANDO G. BAPTISTA AND MATTHEW W. CHWASTYK, NGM STAFF; PATRICIA HEALY. SOURCES: MARIA DIAS, BIRDLIFE INTERNATIONAL; JAY W. MCGOWAN, CORNELL LAB OF ORNITHOLOGY; DENA SPATZ, ISLAND CONSERVATION; DENG PALOMARES, SEA AROUND US; THREATENED ISLAND BIODIVERSITY DATABASE PARTNERS; JANOS HENNICK, UNIVERSITY OF HAMBURG



MARION ISLAND SOUTH AFRICA



Coats fresh from molting, a column of macaroni penguins trudges up the ridge of an old volcano crater on Marion Island. Behind them is “the Amphitheatre,” a series of terraces in the crater worn down over eons by nesting and molting macaronis. “The sound of all the penguins reverberating from this multitiered half crater is really impressive,” says ecologist Otto Whitehead.

NEXT PHOTO

King penguins, most returning from hunting at sea, congregate in shore break in Marion Island’s Kilda Ikey Bay. The birds normally come ashore in small groups, the better to avoid orcas and other predators. On this day, heavy surf slowed their landing at the beach, leading to a rarely observed traffic pileup.

A thousand miles from any shore and rarely visited except by scientists, sub-Antarctic Marion Island is a singular paradise for seabirds.





this happen. No one is out on the cold, choppy water except the trawler's crew. Even if the crew had time to be looking, the bird has disappeared in the blink of an eye, and its dead body won't float to the surface until the ship has moved on.

Every year, thousands of albatrosses are killed invisibly by trawlers. Tens of thousands more die on the hooks of longline fishing vessels, along with even greater numbers of petrels and shearwaters. Accidental death in the world's fisheries is one of the two most grievous threats that seabirds face, and it's a tough one to address, because deepwater fishing boats typically operate under intense financial pressure and minimal oversight. Only a few countries seriously regulate their fleets' seabird bycatch.

In one of those countries, South Africa, I met a successful longline tuna-boat captain named Deon van Antwerpen. With me, at a small harbor in Cape Town, was Ross Wanless, a biologist who manages the seabird conservation program of BirdLife South Africa. Wanless had come to the harbor to hear about the problems that van Antwerpen was having with the government's seabird regulations. Van Antwerpen, a beefy and voluble man, gestured unhappily toward a basket of pale green fishing-line weights at the back of his vessel.

"We've lost 3,000 of these things," he said.

Longline fishing kills albatrosses differently than trawling does. A smaller seabird dives down and brings a baited hook to the surface and tries to pull the bait off, and then an albatross barges in and swallows the whole thing, hooking itself and drowning. One solution is to weight the line, so that the baited hook quickly sinks out of reach of the birds. But a bare metal sinker can become a bullet to a crew member's forehead when a hundred-pound tuna is hauled in and the line recoils. BirdLife recommends sinkers with a loosely attached casing of luminescent plastic (light attracts fish), and van Antwerpen had been eager to try them on his vessel. "Every bird I catch," he said to Wanless, "is potentially a fish I didn't catch. But you need to

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get legislation that's practical. If you don't, then most guys will just ignore it."

There ensued an intricate discussion between an exceptionally conscientious boat owner and a conservationist whose goal is to bring bird-safe methods to the entire world's deep-sea fishing fleet. Van Antwerpen's chief complaint with the plastic sinkers was that BirdLife wanted them too close to the baited hook—"if a shark snaps the line, we lose the sinker." Would it be OK if he increased the separation between sinker and hook to four meters? Wanless frowned and pointed out that this would make the hook sink too slowly to protect seabirds. But maybe increasing the weight of the sinker would compensate for a greater separation? Van Antwerpen said he'd be happy to do the experiment—he really didn't want to catch albatrosses. He just wanted to catch tuna without losing all his sinkers.

Fishing vessels can further reduce seabird bycatch by dragging a "bird scaring" line, which consists of a brightly tasseled rope with a plastic cone at the end of it. They're inexpensive, easy to use, and highly effective at keeping birds out of a vessel's wake. A trawler, by using only a bird-scaring line, can reduce the number of albatrosses it kills by as much as 99 percent. Because a longline vessel's hooks remain close to the surface beyond the bird-scaring line, South Africa requires it to take one additional protective measure, either weighting its lines or setting them after dark, when the birds are less active and can't see the bait.

Wanless and his wife, Andrea Angel, who is the leader of BirdLife South Africa's Albatross Task Force, have been working with South Africa's government and fishing fleet for more than a decade. Any commercial vessel fishing in South African waters now has to practice seabird bycatch mitigation, and Wanless and Angel are attempting to forge relationships with every longline tuna skipper. "The way to achieve something," Wanless told me, "is not to present a fancy technical solution but to engage with human beings." As a result of his team's efforts, the annual toll on seabirds in South Africa has fallen from an estimated 35,000 in 1996 to as few as 500 today.

But protecting seabirds takes more than regulations. It also requires independent monitoring of fishing vessels and, ideally, a financial incentive for the industry to reduce seabird bycatch. Although long-liners have one straightforward reason to catch fewer birds—"They'd rather catch



\$10,000 bills, which is what a bluefin tuna represents,” Wanless said—a potentially stronger incentive is the market for sustainably harvested fish. Pursuit of this premium market, particularly in Europe, has already led many South African fishing vessels to pay for independent observers, to ensure compliance with bycatch rules. Without an observer on board, even a captain like van Antwerpen may be tempted to break the rules.

The best way for a government to ensure compliance is to mandate that every vessel be outfitted with a digital camera to monitor its catch and bycatch. When Australia did this with its tropical tuna-fishing fleet, in 2016, ship captains placed panicked calls to Australian regulators, asking where they could buy bird-scaring lines. “Once there’s a camera on board, the game’s over,” Wanless said. “You’re risking losing your license for failing to buy a hundred dollars’ worth of gear.”

Another promising technological advance is the Hookpod, which consists of a hard plastic case that snaps around a baited hook, protecting the bait from birds and birds from the hook, and doesn’t spring open until it has sunk to a safe depth. It is theoretically possible, by making the Hookpod standard equipment on all long-line vessels, and by requiring all trawlers to run bird-scaring lines, and by simply banning gill net

As the sun sets on Marion Island’s western shore, a quartet of wandering albatrosses breaks out in the species’ ritual dance, a complex suite of calls and gestures, including a “sky calling” display from the bird at right. Wandering albatrosses mate for life, and the dancing behavior, typically performed by subadults, helps individuals size up prospective partners.

fishing (as South Africa has done), to render the world’s oceans safe for seabirds. For now, though, the global situation remains atrocious. Wanless and Angel have expanded their outreach to the fisheries of South America, Korea, and Indonesia, with not altogether discouraging results, but the fleets of China and Taiwan, which together account for two-thirds of fishing vessels on the high seas, operate with little or no regard for seabird mortality, and they sell their catch in markets mostly indifferent to sustainability.

Wanless estimates that 300,000 seabirds, including 100,000 albatrosses, continue to be killed annually by long-liners alone. This is hard enough on the abundant species, like sooty shearwaters. But many species of albatrosses, which are slow to reach maturity and typically breed only in alternate years, are threatened with extinction. And, as harmful as modern fishing practices are, there’s an even deadlier threat that seabirds face.



PACIFIC COAST PERU



Scientists survey tightly packed nests of guano left behind by guanay cormorants at Punta San Juan, a peninsula in southern Peru transformed into a virtual island by a six-and-a-half-foot-high concrete wall built by the guano industry to protect the breeding site from predators. With three or four nests per square yard, guanays are among the densest nesting seabirds in the world.

NEXT PHOTO

Farther north, guanay cormorants make room for a few Peruvian pelicans to roost on Isla Gualaño Norte, one of Peru's most productive guano islands. This colony of over 80,000 guanays leaves the island at midmorning to preen in offshore waters before flying farther out to sea to forage for anchovy and other prey in the Peru Current.

The capes and offshore islands washed by the fertile Peru Current are home to millions of seabirds. Their guano once supplied fertilizer to the world.







GOUGH ISLAND, a 25-square-mile mass of volcanic rock in the South Atlantic Ocean, is home to millions of breeding seabirds, including the entire world population of the Atlantic petrel and all but a few pairs of the critically endangered Tristan albatross. Ross Wanless first went to Gough in 2003, as a doctoral candidate, after other researchers had reported that alarmingly few petrels and albatrosses were fledging chicks. It was known that rats and cats, which humans have introduced on islands all over the world, prey heavily on seabirds. But there were no rats or cats on Gough, only mice. Using video cameras and infrared lights, Wanless recorded what the mice were doing to the petrel chicks. “The sun went down,” he said, “and a mouse came out in the petrel burrow. It hesitated and then started nibbling on the chick. Other mice came, and I witnessed this insane, disgusting attack. As the blood started to flow, the mice got more and more excited. At times, there were four or five of them competing for the wound, lapping up blood and going inside to eat the chick’s internal organs.”

Having evolved without terrestrial predators, seabirds have no defense against mice. A petrel in its inky-dark burrow can’t even see what’s happening to its chick, and an albatross on its nest lacks the instinct to recognize mice as a threat. In 2004, Wanless noted 1,353 breeding failures among Gough’s Tristan albatrosses, most of them from predation, and only about 500 successes. In more recent years, failure has been as high as 90 percent. Among all seabird species on Gough, mice now kill two million chicks every year, and many of these species are also losing adults in the fisheries. Annual mortality among adult Tristan albatrosses at sea has risen to 10 percent—more than triple the rate of natural mortality. Ten percent adult mortality plus 90 percent breeding failure is a formula for extinction.

The calamitous decline in seabird populations has many causes. Overfishing of anchovies and

other small prey fish directly deprives penguins and gannets and cormorants of the energy they need to reproduce. Overfishing of tuna, schools of which drive smaller fish to the ocean’s surface, can make it more difficult for shearwaters and petrels to forage. Climate change, which alters ocean currents, already appears to be causing breeding failure among Iceland’s puffins, and birds that nest on low-lying islands are vulnerable to rising sea levels. Plastic pollution, particularly in the Pacific Ocean, is clogging the guts of seabirds and leaving them hungry for real food. And the resurgence of marine mammal populations—in other respects, an environmental success story—has resulted in more seals to eat young penguins, more sea lions to crowd cormorants out of their breeding sites, and more whales to compete with diving birds for prey.

The number one threat to seabirds, however, is introduced predators: rats, cats, and mice overrunning the islands where they breed. This is the bad news. The good news is that invasive species are a problem with achievable solutions. Organizations such as Island Conservation, a nonprofit based in California, have perfected the use of helicopters and GIS technology to target predators with poisoned mammal-specific bait. Animal lovers may grieve at the mass killing of small furry mammals, but human beings have an even greater responsibility to the species they’ve threatened with extinction, however inadvertently, by introducing predators.

The most ambitious rodent-eradication effort to date was mounted by the South Georgia Heritage Trust. South Georgia island, 900 miles from the Antarctic Peninsula, is the breeding ground of perhaps 30 million seabirds; without rats and mice, the island could easily host three times that number. From 2011 to 2015, at a cost of more than \$10 million, three helicopters traversed every ice-free area on South Georgia, dropping bait. No living rat or mouse has been detected on the island since 2015.

Similar efforts are now planned for Gough Island, in 2019, and for South Africa’s Marion Island in 2020. Mice came to Marion with whalers and sealers in the 19th century. In the 1940s, the South African government introduced cats to control them, and the cats quickly went feral. Instead of killing mice, they proceeded to decimate the smaller seabird species nesting on the island. (“Mice know exactly what a cat is,” Ross Wanless explained. “Seabirds don’t.”) Marion’s

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seabirds were expected to recover after the last cats were removed, in 1991, but they didn't. "The mice are the only explanation," Wanless said.

Seabirds are a poignant combination of extreme vulnerability and extreme toughness. A 20-pound Tristan albatross can't stop a one-ounce mouse from eating its young, and yet it thrives in frigid salt water and brutal winds and can bully a large gull. Because of its longevity, it may survive 20 years of breeding failure and still produce chicks, once the danger to its nest is eliminated.

"Seabirds respond well to restoration," Nick Holmes, the science director at Island Conservation, told me. "Addressing the terrestrial threat bolsters their resistance to all the other threats." When Island Conservation and its partners eliminated rats from California's Anacapa Island, south of Santa Barbara, the hatching success rate of the Scripps's murrelet (a small cousin of the common murre) immediately jumped from 30 percent to 85 percent. The murrelets are now secure on Anacapa, and ashy storm petrels have been recorded breeding there for the first time.



TO PREVENT THE EXTINCTION of a species, you first have to know that it exists. You

On Isla Guañape Norte, two Inca terns protest a third's attempt to eke out a little roosting space between them. With their fire red beaks and white handlebar mustaches, Inca terns are the most flamboyant seabirds sharing the Peru Current's plethora of fish. They roost in large numbers, and in late afternoon there is constant squabbling as they compete for the best overnight perches.

need ocular proof, and seabirds are especially adept at withholding it. Consider the story of the Magenta petrel. In 1867, an Italian research vessel, the *Magenta*, shot a single specimen of a large, gray-and-white petrel in the South Pacific. For more than a century, this remained the only scientific evidence of the species. But invisibility is enticing, and in 1969 an amateur ornithologist named David Crockett went to New Zealand's Chatham Islands to search for the bird. Although much of the Chathams' main island had been cleared for pasture by European and Maori farmers, its southwest corner was still forested, and there were piles of unidentified petrel bones in the middens of a Polynesian people, the Moriori, who had settled the islands centuries earlier. Crockett had read accounts of latter-day Moriori collecting and eating a large petrel, known locally as *taiko*, as late as 1908. He suspected that the *taiko* was the Magenta petrel, and that it might



CHATHAM ISLANDS NEW ZEALAND



New Zealand's Chatham Islands include Te Tara Koi Koia (the Pyramid), the only breeding ground of the vulnerable Chatham albatross. Some 5,000 breeding pairs nest there each year. During April and July, most fly 6,000 miles to the southwest coast of South America, following the current north to Peru.

NEXT PHOTO

The most sheltered nesting site is a natural cave high up on Te Tara Koi Koia. Inside, nests protected from erosion from wind and rain form pedestals tall as top hats. The downy gray chicks will fledge in five months' time.

Some of the most endangered albatross and other seabird species breed in only one place: a rocky archipelago 500 miles east of New Zealand.





still be nesting in burrows in the forest.

The tract of forest where the Moriori had collected taiko was owned by a sheep farmer of Maori descent, Manuel Tuanui. Inspired by the prospect of discovering a lost native bird on their land, Tuanui and his teenage son, Bruce, helped Crockett conduct a series of arduous searches for the taiko, scouring the forest for burrows and setting up spotlights to attract seabirds flying in at night. To Bruce, Crockett was “this strange guy who was chasing a *taipo* [a Maori word for ‘ghost’].” When Bruce married a young woman from a neighboring island, Liz Gregory-Hunt, she was swept up in his family’s quest. “You get sucked into the vortex,” Liz told me, “and it becomes your life.”

On the night of January 3, 1973, Crockett was rewarded with a spotlighted look at four birds that matched the description of Magenta petrel: ocular proof. But he also wanted to capture taiko and find where they nested, and this was even harder than seeing them. It was another five years before Bruce and Liz, driving into town from the farm, were stopped on the road by an uncle of Bruce’s who gave them the news: “They’ve just caught two taiko.” It was a further ten years before a team of scientists was able to locate two active taiko burrows in the forest, by radio-tracking captured birds.

For the Tuanuis, this was still only the beginning. The taiko’s single known breeding site was on their land, and the bird needed to be protected from the threats that had already nearly driven it extinct. Lines of traps were set around the burrows for cats and opossums, and Manuel Tuanui, in a move considered “mental” by his neighbors, donated 2,900 acres of bush to the New Zealand government, which fenced most of the land against sheep and cattle. Within a few years, because of the family’s efforts, the number of pairs of taiko known to breed in the forest began to rise; today it stands at more than 20.

On a hot day in January, I joined a British seabird specialist, Dave Boyle, and a British volunteer worker, Giselle Eagle, on a long trek to the burrow of a female taiko known to them as S64. She was incubating an egg fertilized by a male that had lived in the area for 18 seasons before attracting a mate. Boyle wanted to examine S64 before her egg hatched and she began to spend more time foraging at sea. “There’s no way of knowing how old she is,” he said. “She could have been breeding somewhere else with a different partner, or she could be very young.”

The terrain was rugged, the forest dense and intermittently boggy. S64’s burrow was tucked into a steep hillside covered thickly with ferns and tree litter. Boyle knelt down and removed the lid of an underground wooden nest box previously installed at the back end of the burrow. Peering in, he shook his head sadly. “It looks like the chick got stuck hatching.”

Chick death is not uncommon, especially if the mother is young and inexperienced, but every breeding failure is a setback for a species whose total population is still only about 200. Boyle reached into the box and lifted out S64. She was big for a petrel but seemed small in his hands, and she had no idea how rare and precious she was; she squirmed and tried to bite Boyle until he slipped her into a cloth bag. To discourage her from hanging around the burrow any longer, he removed the dead chick and the crumpled shell that had trapped its legs. Working with Eagle, he then fastened a band to S64’s leg, stuck her with a needle to draw a DNA sample, and shot a microchip under the skin on her back.

“She’s not having a good day,” Eagle said.

“Once she’s got a microchip in,” Boyle said, “we never have to handle her again.”

The few taiko that survived after centuries of predation and habitat loss nested deep in the forest because it was relatively safe, not because it was an optimal site. To get airborne, even adult taiko need to climb a tree, and it can take a new fledgling several days to fight its way out of the forest, a struggle that may leave it too weak to survive on the ocean. When the Tuanui family created a formal organization, the Chatham Islands Taiko Trust, in 1998, one aim was to raise off-island money for a predator-proof enclosure closer to the water. The enclosure, called Sweetwater, was completed in 2006, and many of the chicks now born in the forest are transferred there before fledging, to “imprint” the location on their memory and encourage them to return there to breed. The first Sweetwater-imprinted taiko returned in 2010; many more have come back since then.

The Taiko Trust has also transferred chicks of the Chatham petrel, a bird smaller and scarcely less endangered than the taiko, from a nearby island to Sweetwater, to create a secure alternate nesting site for the species. To bolster the population of the Chatham albatross, a species whose only colony is on Te Tara Koi Koia, a constricting offshore cone of rock also known as the Pyramid, the trust has ferried 300 chicks to a second



predator-proof enclosure on the main island, above the majestic sea cliffs on the Tuanui farm. “For the trust to survive,” Liz Tuanui said, “we knew we had to diversify to other species.”

Liz has now spent four decades in the vortex. She chairs the Taiko Trust, and she and Bruce have fenced 13 tracts of forest altogether, seven at their own expense. This has benefited both seabirds and native land species—the splendid Chatham pigeon, once near extinction on the main island, now numbers more than a thousand—but Bruce prefers to emphasize the synergy between conservation and farming. Fencing the forest, he told me, also protects his waterways, shelters his stock during storms, and makes it easier for him to muster his sheep. When I pressed him to account for why a sheep-farming family had shouldered the burden of saving three of the world’s rarest seabirds, at such a cost of labor and money, he demurred with a shrug. “If we didn’t do it,” he said, “no one else was going to do it. Finding the taiko was a huge effort. It was part of us but part of the Chathams, too.”

“It’s awesome,” Liz said. “We have tenfold the number of people protecting their bush than 25 years ago.”

“If we don’t do it,” Bruce said, “it’s going to be even harder for the next generation.”

Wary of the Chatham albatrosses’ reliance on a single breeding ground, Dave Boyle (above) and colleagues in the Chatham Islands Taiko Trust have set up another on the main island. Chicks are relocated from Te Tara Koi Koia, placed on flowerpot nests among decoy adults, and fed fish until they fledge. If all goes as planned, the birds will return one day to lay the foundations for a new colony.

The crucial difference between the Chatham Islands and the world in which most of us live, it seemed to me, is that islanders don’t need to struggle to imagine seabirds. From the trust’s predator-proof cliffside enclosure, to which young Chatham albatrosses will soon be returning to court their mates, it’s only a two-hour boat trip out to Te Tara Koi Koia. There, on vertiginous slopes, above blue ocean swells heaving against kelp-covered rocks, stern-browed albatross parents tend to their downy gray chicks. Overhead, in such numbers that they confuse your sense of scale and seem no bigger than seagulls, the albatrosses circle and ride the wind on their immense wings. Very few people will ever see them. □

Novelist **Jonathan Franzen** wrote about why birds matter for the January 2018 issue. This is photographer **Thomas P. Peschak**’s ninth assignment for *National Geographic*.



YOUR SHOT

HANS-MARTIN DÖLZ

PHOTOS FROM OUR COMMUNITY

WHO

Hans-Martin Dölz, a retired financial controller and now a fine art photographer

WHERE

Stuttgart, Germany's municipal library, known as the Stadtbibliothek

WHAT

A Leica M9-P camera with a 35mm lens

A photo taken in Stuttgart's Stadtbibliothek inspired Dölz to visit the library with his own camera. Designed by architect Eun Young Yi, the sleek building opened in 2011. Dölz, who lives near Stuttgart, chose the vantage point with maximum light and waited for a balanced composition: a woman walking, some people seated in the cafeteria upstairs. Back at his computer, he increased the contrast and exposure and reduced yellow saturation to make the image white and bright.

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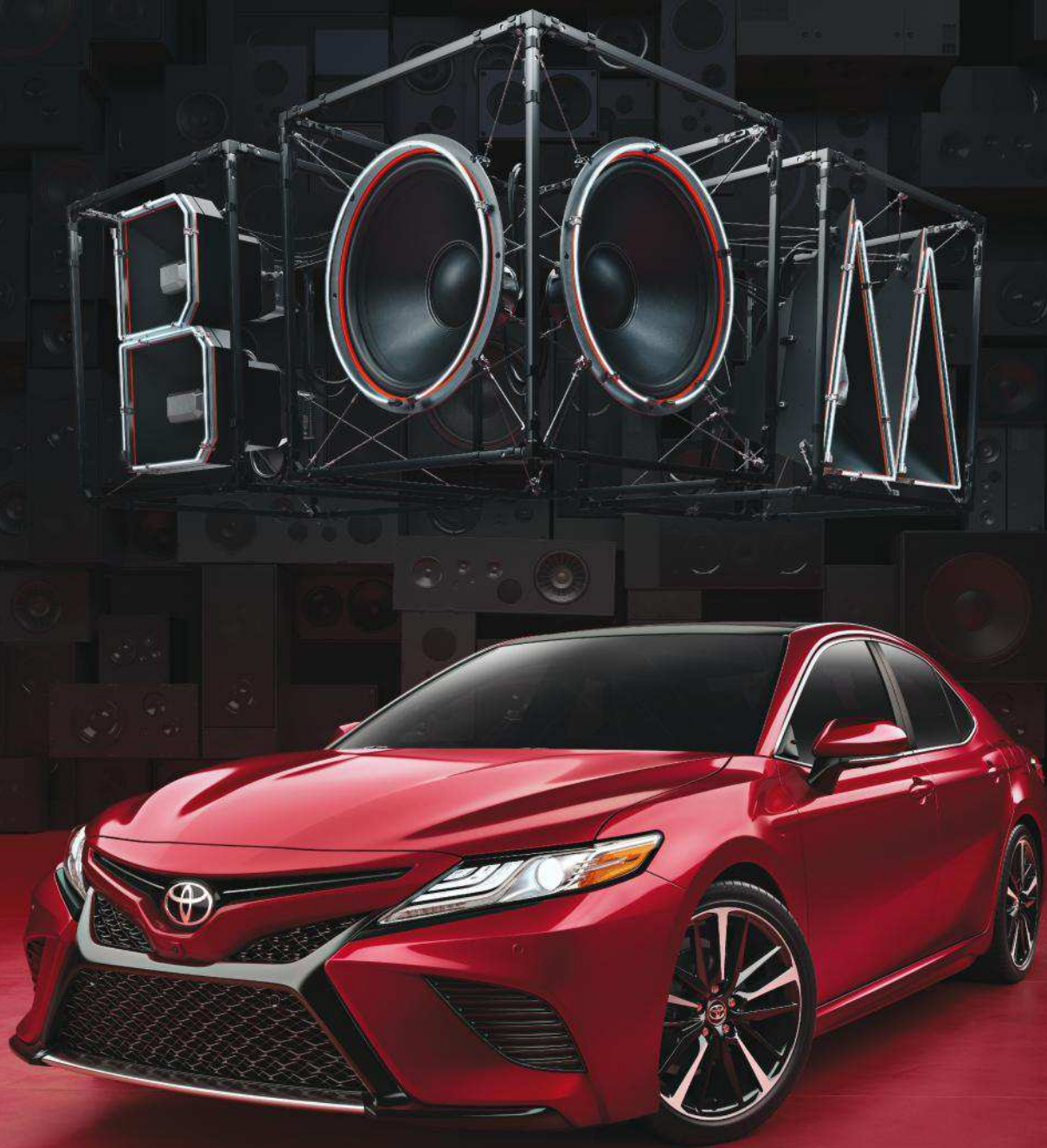


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