

PARTICLE PHYSICS
The Neutron
Enigma

ECOLOGY
Overrunning
the Galápagos

BIOENGINEERING
Compute with
Living Cells

SCIENTIFIC AMERICAN

APRIL 2016

ScientificAmerican.com

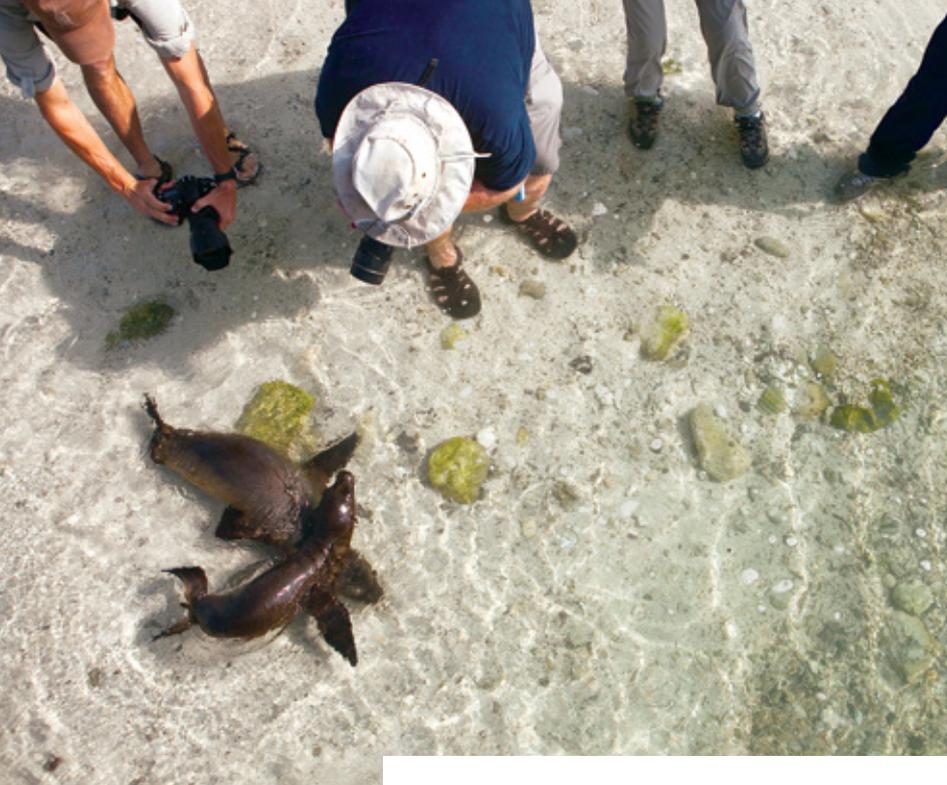
Stone Age Brains

Toolmaking shaped
how our minds
think today

SPECIAL REPORT

FUTURE OF
MEDICINE:
CANCER

- + IMMUNITY BOOSTERS
- + NEW VACCINES
- + GERM THERAPIES



TOURISTS ARE EVERYWHERE in the Galápagos Islands, disturbing exotic species and their habitats: young sea lions (above), a marine iguana (top right) and fragile plant life on Isabela Island (bottom right).



ECOLOGY

STAMPING OUT GALÁPAGOS

A relentless rise in visitors could ruin the famous biodiversity hotspot in only a few years *By Paul Tullis*

At the southern tip of the island of Santa Cruz in the Galápagos, a gorge known as Las Grietas is home to a species of parrot fish: a brilliantly colored creature about 18 inches in length. The pool where the fish live was created long ago, when large waves spilled over the island's raised edge and into a deep crevice. Today it is refreshed by rainwater that seeps

through the porous volcanic rock that forms the steep gorge. Through it all, the small parrot fish population has been evolving in the pool, its water so clear one can see through more than 65 feet to the vertebrates lurking at the bottom.

In August 2014 I arranged to hike there with naturalist Andrés Vergara. We met at the Finch Bay Eco Hotel and walked about



IDE

10 minutes over uneven earth and sand at an easy pace. But then we took the final stretch of the trail—up over jagged rocks, then down the gorge’s stony walls in a crablike clamber to the pool’s edge. This last part was hazardous enough to discourage the casual tourist; only a few adventurous individuals had actually reached the pool. It is a beautiful spot. Rock ledges up to 30 feet



above provide places from which a visitor with enough courage can leap into the water below.

We were lucky to visit when we did because Las Grietas was shortly thereafter closed for trail improvements. It reopened in December 2014. Vergara, who works as a guide for the Galápagos National Park Service, phoned me at that time and said the spot now has a boardwalk over the rocks, an elaborate staircase leading down to the water and a wood platform for the plunge into the pool. “It’s part of a plan of the Galápagos National Park to make things better for the community and visitors,” he said. The improvements have dramatically increased the number of visitors, which tripled between July 2014 and July 2015, when 7,109 people made the walk.

What all these humans mean for the viability of parrot fishes is unclear. Will increasing amounts of sandwich crumbs, washed-off sunscreen and the inevitable plastic wrappers pollute their unique habitat—and ultimately ruin the pool’s tourist appeal?

Ever since Charles Darwin visited the islands in 1835 and observed them as a living laboratory of natural selection, the Galápagos has become known the world over as one of the best places to see wildlife. The islands hold 14 species of tanagers (known as Galápagos finches) and 12 species of tortoise. Penguins and flamingos live within a few miles of one another. Sea lions are so well fed on abundant fish that they do not even bother with the penguins, which they readily hunt in other parts of the planet. The list of wildlife attractions, promoted on slick brochures and Web sites, is why a modicum of adventurous—and wealthy—tourists have been compelled for decades to make the long journey to the archipelago.

In recent years, however, the trickle of tourists has turned into a flood. In the early 1990s, 41,000 people a year visited the Galápagos. In 2013 the figure exceeded 200,000 for the first time. More than 224,000 visitors arrived in 2015, another record. This growth is fueled in part by need. Ecuador is struggling financially. It relies on oil for 44 percent of its export revenues. To bolster its finances and make up for the recent drop in oil prices, the government has turned to tourism, allowing industry to more easily develop the islands, and has chipped in with projects such as the one at Las Grietas.

“The government is clearly working to significantly increase tourism in the Galápagos; there’s no doubt about it,” says Swen Lorenz, who has a background in finance and who, from 2011 until 2015, was executive director of the Charles Darwin Foundation, which advises the government on ecological issues.

It is possible to conduct tourism in a way that preserves natural areas, benefits local people, and even finances conservation of habitats and species. But this responsible “ecotourism” still has an impact on habitat, and it is no longer the only kind that is happening in the Galápagos. The influx of travelers is on a collision course with the very thing that everyone comes to see: the wildlife. Of

Paul Tullis is features editor for TakePart, a digital news magazine. He has written for *Scientific American Mind*, the *New York Times Magazine* and *Slate*, among others.



20 endemic species that are critically endangered, 16 live on the four inhabited islands that get the most visitors. New invasive species, brought in large part by visitors, are already taking over certain ecological niches. A green iguana, which could spread disease from the mainland to endemic species, was captured in Puerto Ayora on Santa Cruz last August; no one knows how it got there or how many others may have come with it.

The Galápagos would not be the first ecologically sensitive place to be permanently damaged by tourists. Visitors lop off corals for souvenirs in the Great Barrier Reef. Fragile Antarctica is being discovered by cruise ships. There is now a Walmart at Teotihuacán, the ancient Mesoamerican city in Mexico that was carefully exhumed and restored. Ecuador, by letting the tourism industry develop unabated, may be presiding over the destruction of a jewel of biodiversity. If that happens, the islands could also lose the interest of tourists and the income they bring.

In 2013 Ecuador took a step toward putting the Galápagos on a sustainable path. President Rafael Correa ordered a study of the impact of growing tourism on the islands. The report that came

IN BRIEF

A steep rise in the number of tourists visiting the Galápagos Islands is threatening the very biodiversity people come to see. Ecuador has encouraged the increase to bring in revenue. But the former head of the Galápagos National Park, who was fired, and inde-

pendent wildlife experts say the country must set an annual cap on visitors or the islands will be ruined. **The experts** filed a report in early 2014 that recommended a cap of 242,000 people, but they say President Rafael Correa’s administration has ignored it.

In the meantime, the park service is building walkways and other infrastructure to make it easy for visitors to reach ecologically sensitive spots, which could be overrun. And small, illegal hotels have expanded to bring in more tourists than ever before.

PRECEDING PAGES: ERIC KRUSZEWSKI/Getty Images (sea lions); MATT MOYER/Getty Images (iguana); DOUG CHESEMAN/Getty Images (tourists)



NEW BOARDWALKS and stairs, like these on the island of Barotomé, make it easy for numerous visitors to reach pristine places, threatening the landscape and wildlife in the process.

back was dire: if Ecuador did not quickly set a cap on the number of visitors each year, continuing development would imperil the archipelago's biodiversity and its attractiveness to tourists. So far, however, Correa's administration has not heeded this warning.

CONTROVERSIAL CAP ON TOURISTS

THE MOVE TO ASSESS tourism's impact began in the late summer of 2013, when Arturo Izurieta received a surprise phone call from Lorena Tapia, at the time Ecuador's minister of the environment. Izurieta, a native of Ecuador who had lived more than 25 years in the Galápagos, was working as a conservationist in Australia. Tapia was offering him a chance to return home to the archipelago and a position he held there in the early 1990s: director of the Galápagos National Park and Marine Reserve.

What is more, Tapia wanted Izurieta to take on the problem of sustainable development, according to Izurieta. (Tapia, through a spokesperson, declined a request to be interviewed by *SCIENTIFIC AMERICAN*.) President Correa, she told him, had just requested a study of how many tourists the Galápagos could accommodate. How many sites could be safely opened? What was the general impact of human presence on the islands? The latter "was a very exciting question," Izurieta recalls. "She asked me, 'How are we going to figure this out?'" Correa wanted an answer within a year.

Izurieta got started in September. He quickly assembled a commission of experts, such as Stephen J. Walsh, a geographer who directs the Center for Galápagos Studies at the University of North Carolina at Chapel Hill, and Carlos Mena, who, with Walsh, co-directs the Galápagos Science Center, which is jointly run by U.N.C. Chapel Hill and Ecuador's University of San Francisco, Quito. His panel included biologists, geographers and a business school professor.

The team decided to define scenarios of tourism growth and

let the government decide which scenario it wanted to pursue based on its goal, be that revenue generation or conservation of the islands, or some balance between the two. "The scenario you choose is based on the amount of risk you're willing to assume," Walsh says, and on what the government values. If the government decided to double the number of tourists, for example, it had to accept greater risk that habitat would be trodden and that more diesel spills and pollution from incoming ships would occur. "Every time a decision about the human dimension is made, it affects what the Galápagos will look like in the future," Walsh explains.

Walsh and Mena developed mathematical models of the islands' ecosystems to determine how different levels of growth, for different categories of tourist, would affect various aspects of the environment. The 19 islands, and their roughly 145 protected sites, experience different impacts depending on whether a tourist is staying on land or on a boat anchored along the shore, for example. Even a visitor's nationality matters: waste production, for example, grows more quickly as the percentage of tourists from the U.S. rises. The team incorporated decades' worth of data and fed them into algorithms to plot how changes to any one factor affected the others.

As Walsh and Mena raised the number of annual visitors, the models revealed critical thresholds—points at which negative effects began to change the environment dramatically, sending certain species over the edge toward ruin. The models basically showed a death spiral from unchecked growth in tourism. Demand for private development to support that growth would destroy habitat, and plants and animals would go extinct. After a

decade or so, the decline in species would become so noticeable that the travel industry would diminish as a result. Tourism-funded programs to reestablish ailing species would then be left underfunded. “If we continue growing,” Izurieta says, “very soon we will reach the point of no return.”

How soon? Izurieta’s report, commonly referred to as *Scenarios for Sustainability*, puts the date at 2017. Allowing unlimited growth would bring more revenue to Ecuador over the next 10 years than the other scenarios. But revenue from tourism would peak in 2027 and then decline. “The number of visits will fall below what we have today,” Izurieta says.

The alternative stabilization scenario, which would cap visitors at 242,000 annually, would mean less revenue between now and 2027, but it would virtually guarantee ongoing revenue annually for decades beyond. The cap, Izurieta says, is based on the carrying capacity (the number of visits over a certain time period) of sites within the protected areas. It would undercut the market for giant hotels and reduce demand for small, illegal hotels as well, but it would allow the light-footprint, higher-priced ecotourism that sustained the islands for decades to continue more or less unimpeded.

Izurieta’s commission filed its report in February 2014. Through most of 2014, according to Izurieta and two other conservationists I spoke with, Tapia discussed the report with the current minister of tourism, the national director of planning, the head of the Galápagos governance council and the director of the national parks. The group “had various meetings to polish the presentation that would be made to President Correa,” Izurieta says. “In those meetings, there was a consensus that the stability scenario would be advised.”

It was hard for the group to get national politicians to focus on environmental policy in early 2015, however. The legislators were consumed with revising the 1998 Special Law for Galápagos, which determines things like the minimum wage and the number of boat licenses. The report group decided to delay presenting Izurieta’s study to President Correa until a new law was passed. That happened in June 2015.

Two months earlier, though, the environmental ministry fired Izurieta—without explanation, he says. Tapia, through a spokesperson, declined to comment. The report has been sitting on a shelf ever since, according to several sources.

ILLEGAL HOTELS, FOREIGN INVESTORS

IZURIETA FIRMLY BELIEVES that a cap on tourists is essential. The “Galápagos is the most carefully managed tourist destination in world,” says Matt Kareus, executive director of the International Galápagos Tour Operators Association. “While [Izurieta] was in charge [of the park], there was no increased impact on the protected sites—none. It was extremely well managed.” But any number of tourists, no matter how “eco” they are, carries risk.



CERTAIN GIANT TORTOISES have made a comeback thanks to conservation efforts funded in part by park entry fees. If managed tightly, tourism could coexist with native species.

Simply bringing in fuel to support even low-impact travel increases spills, carbon emissions and land degradation. Ecotourists can unwittingly bring invasive species into the islands just as well as anyone else. The parasitic fly that is wiping out the mangrove finch was probably introduced in the 1960s, when tourist visits were less than one twentieth of what they are today.

“We still have time to stabilize the number of tourists, but we need to start now,” Izurieta told me by phone in April 2015. “If we don’t, I don’t know what’s going to happen to the islands.” It is easy to see how the archipelago’s white sand beaches, 80 degree Fahrenheit ocean water, gorgeous views, and activities such as snorkeling and sea kayaking could make the Galápagos “a holiday destination like any other, with spa hotels and streets lined with T-shirt shops,” says Lorenz, former director of the Charles Darwin Foundation.

Correa’s government appears to be taking no measures to slow growth, relying instead on changes to the Special Law they hope will discourage tourism. By not choosing, Ecuador’s leaders are selecting unchecked growth by default. They continue to grant airlines additional flights to Seymour Airport, the archipelago’s biggest, on the barren island of Baltra. They give tourists park entry licenses even when the applicants are unable to show they have a reservation at a legal hotel, as is nominally required (unlicensed hotels are everywhere). Officials grant so-called temporary resident permits with no expiration date.

Close observers say a cap on visits is not forthcoming, because Correa’s advisers do not want to deliver the bad news that tourism will have to slow. “I don’t think a cap is going to be established,” says Juan Carlos Garcia, conservation director for the Ecuador branch of the World Wide Fund for Nature. “Everyone is afraid of giving any number.”

Two changes to the revised Special Law that were passed in April could invite more trouble. One eliminated the requirement that residents of the Galápagos must own the majority of any investment in the islands; now locals must only be “involved” in new development, a vague term open to wide in-

terpretation. The second change allows park boundaries to be altered. Technically, these two changes together would make it possible for foreign investors to rush in, develop what was once parkland and leave locals with little economic gain for the ecosystem losses.

Without a cap, the number of land-based tourists is almost certain to grow, says Kareus of the International Galápagos Tour Operators Association. They use more energy and leave more waste than travelers who spend their nights on boats along the shore. The Galápagos National Park Service regulates tourist visits to sensitive areas such as the island of North Seymour, where magnificent frigate birds and blue-footed boobies nest and raise their young, and Tortuga Bay, where sea turtles bury their eggs, through its management system. But the system was designed for a ratio of boat berths to hotel beds of between 1:1 and 1:2.

Today there are about five times as many hotel beds as boat berths, a ratio of 1:5, according to official statistics cited by Izurieta, who has taken over for Lorenz as director of the Darwin foundation. And that does not count many unlicensed hotels going up, especially on Santa Cruz. A moratorium on new hotels or hotel expansion was put in place about a decade ago but was never enforced, according to Felipe Cruz, deputy executive director of the foundation, who has lived in the islands for 30 years. A house in his neighborhood recently added two stories, he says, and he was surprised to see a “hotel” sign go up when construction was completed.

Much of the construction, Cruz and others say, is for cheap facilities catering to backpacking college students and weekenders from South America. For that region’s expanding middle class, a \$300 flight from Santiago or Buenos Aires to Baltra is within reach of more people than ever.

Izurieta applauded the recent lifting of the hotel moratorium because he believes it will lead to new construction that is better regulated. Legalizing what was going on anyway will put these facilities under the eye of authorities. Although the Ministry of Tourism says that new hotels will be limited to 35 rooms each, it will need to resist industry pressure, Izurieta says. Lorenz sent me documents produced by a financial consultant company called Stock & Fund Managers, which promised that it and an investment group had “secured two prime locations” for development of 39 “villas” and two hotels totaling 95 rooms, with one of the developments offering “restaurants, entertainment areas, meeting rooms, spas and swimming pools.”

Lorenz says that in 2014 Kempinski Hotels, headquartered in Germany, and Waldorf Astoria Hotels & Resorts presented plans to President Correa for large developments. The hoteliers said they have no confirmed projects in the islands, and Ecuador’s tourism ministry declined to comment, although the ministry issued a statement on September 9, 2015, avowing that the Galápagos governance council’s approval of three projects with 36 rooms between them “confirms once again that mega hotels are banned in the Galápagos.”

POLITICAL WILL

CONSERVATION AND TOURISM in the Galápagos are not incompatible; revenue from visitors can help protect habitat and wildlife. I visited a nursery working to recover a species of giant tortoise that had been nearly wiped out by rats, which devour their eggs. Soon

after my visit, a study in *PLOS ONE* reported that a similar captive breeding program for the giant tortoise population on the island of Española, along with goat-eradication efforts there, had been so successful that the population is now considered stable. Park entry fees financed much of this work, along with funds from environmental organizations. Wildlife conditions on the uninhabited islands, where invasive species such as goats had run rampant as well, are also improving thanks to other conservation programs financed by tourism.

Eliécer Cruz, a former Galápagos National Park Service director whom President Correa made president of the Galápagos governance council in April 2015, told me last October he was working on changes to the immigration system to limit the number of visitors. He also said he and the relevant ministers had been talking just the day before about presenting *Scenarios for Sustainability* to President Correa, at long last. He said a cap on visitors of 242,000 a year, the number that the report says is sustainable, is “really important.” But in February of this year, the current head of the Galápagos National Park System, Walter Bustos, confirmed that the report still had not been presented.

Bustos told me that the new minister of environment, Daniel Ortega, has decided to “update the information” provided in Izurieta’s report. When asked about this, Walsh wrote in an e-mail that the request “is not about changing the outcomes from the earlier model run” but to “look explicitly at the economics of tourism in the Galápagos.”

In any case, Bustos said, “it’s not so easy” to set a limit of 220,000 a year, adding that “I think we can achieve 220,000 through other policies.” He pointed to new hotels being restricted to 35 rooms and requiring the approval of the Galápagos council, as examples of measures that will “slow the rate of growth” of tourism on the islands. The question is whether this can be done before crossing the 242,000 line, which will happen in the first half of 2017 at current rates.

As for why Izurieta was fired, he will not give his opinion on the record. He wrote on Facebook a few days after losing his job in April that it was “a political decision” and that “though I respect it, I do not necessarily agree with it.”

In the meantime, tourism construction continues apace. A \$2.5-million infrastructure project is under way. Some of the funds will go to Tagus Cove on the island of Isabela, where, on September 29, 1835, Darwin encountered “great black lizards between three and four feet long.” It is not clear from his diary whether he arrived by boat or made the challenging climb down from the surrounding hills, but either way the cove is difficult to reach. The park service plans to build stairs. ■

MORE TO EXPLORE

- The Beak of the Finch: A Story of Evolution in Our Time.** Jonathan Weiner. Knopf, 1994.
- Plundering Paradise: The Hand of Man on the Galápagos Islands.** Michael D’Orso. Harper, 2002.
- Galapagos at the Crossroads: Pirates, Biologists, Tourists, and Creationists Battle for Darwin’s Cradle of Evolution.** Carol Ann Bassett. National Geographic, 2009.
- The Galápagos: A Natural History.** Henry Nicholls. Basic Books, 2014.

FROM OUR ARCHIVES

- Darwin’s Living Legacy.** Gary Stix; January 2009.

scientificamerican.com/magazine/sa