

easy to use, and confers robust gut immunity that helps stop polio transmission. But where immunization rates are low, the vaccine virus can continue to spread from person to person and over time acquire enough mutations to regain its ability to paralyze, just like the wild virus. As few as six nucleotide changes in the region encoding a viral capsid protein named VP1 are enough to transform a harmless Sabin virus into what is known as a vaccine-derived poliovirus (VDPV). That's why wealthy countries instead use Jonas Salk's inactivated polio vaccine (IPV), which must be injected. That vaccine cannot revert.

Most VDPV outbreaks are caused by one of the three polioviruses, type 2. Because type 2 has been eradicated in the wild, that component of the vaccine has been removed from general use and is deployed only to fight type 2 outbreaks. Both Afghanistan and Pakistan used type 2 OPV during mass campaigns in December 2021.

The viruses that arrived in New York, London and Israel did not come as full-fledged VDPVs; they were only part way along their journey, with just a few genetic changes from the Sabin type 2 virus. In London, Grassly says, sequence analysis of virus samples collected from wastewater shows a gradual evolution to a VDPV between February and June. Through retrospective analyses, New York state health authorities have found traces of a type 2 Sabin-like virus in wastewater collected to hunt for SARS-CoV-2 as early as April. The virus that paralyzed the young man in June had 10 nucleotide changes in the critical VP1 region. New York officials keep finding Sabin-like viruses in a growing number of counties, some with a few nucleotide changes, others full-fledged VDPVs.

Vaccination rates are high in the U.S. and the U.K. overall, but low in some communities. In Rockland County, where antivaccination sentiment runs high, just 60% of children under age 2 had received the full three doses of IPV in August. In one zip code, coverage is just 37%. (Rockland was also the site of a huge measles outbreak in 2019 that almost cost the United States its measles-free status.) The June polio case is “tragic but totally predictable and preventable,” Pallansch says.

The state has launched an all-out push to get children vaccinated with IPV. Although excellent at preventing paralysis, IPV is not as good as OPV at stopping outbreaks, but U.K. and U.S. experts think it can probably do the job. The idea is to build a wall of immunity around the virus then evaluate how well it works, says Andrew Pollard, director of the Oxford Vaccine Group and chair of the

U.K. Joint Committee on Vaccination and Immunisation. “There is reason to think it will [work]. So end of story.”

New York state has so far had limited success vaccinating the most resistant communities, says Rockland County Health Commissioner Patricia Schnabel Ruppert. But even in pockets where vaccine coverage remains low, the virus may burn itself out because the susceptible population won't be large enough to sustain spread, Grassly says.

Besides, “The kind of sanitation issues that we see [in poor countries] simply don't exist” in wealthy ones, says Aidan O'Leary, head of the Global Polio Eradication Initiative. The poliovirus spreads easily through fecal-oral contact and thrives in places where sanitation is lacking and clean water scarce. In high-income countries, the primary route of transmission is respiratory, which is less efficient, Pallansch says.

If vaccination with IPV isn't enough, contingency planning is underway in both the U.S. and the U.K. to evaluate the possible use of a new vaccine, known as novel OPV2 (nOPV2), designed to be just as good at stopping outbreaks as OPV but significantly less likely

to revert to its neurovirulent form (*Science*, 13 November 2020, p. 751). The vaccine is now being used in 22 low-income countries fighting polio outbreaks under a World Health Organization emergency use authorization. But the U.S. and U.K. would have to jump through big regulatory hoops to get approval to use nOPV2. “We are a long way from reaching for” nOPV2, says Janell Routh, who is leading CDC's investigation into the New York case.

Vaccine-derived polioviruses are not the only threat to the global eradication effort. Cases caused by the wild poliovirus are also up: Pakistan has already reported 17 this year, up from one in all of 2021. After being confined for years to Afghanistan and Pakistan, the wild virus leapt to Africa in 2021, where it was last seen 5 years ago. It has already paralyzed six children in Malawi and Mozambique. The risk of further spread is high, O'Leary says. Mozambique is also battling outbreaks of type 2 and type 3 vaccine-derived strains.

The global priority remains to “stop polio at the source,” while New York state and London deal with the “spillover” effects, O'Leary says. With ramped up surveillance and catch-up vaccination campaigns in place, “They are doing everything right at the right time,” he says. ■

Leslie Roberts is a science journalist in Washington, D.C.

**“This case is tragic but totally preventable and predictable.”**

**Mark Pallansch,**  
polio virologist



## ENVIRONMENTAL SCIENCE

# Record salinity and low water imperil Great Salt Lake

## Drought spurs efforts to restore shrinking lake's water supplies

By **Eli Kintisch**

Utah's Great Salt Lake is smaller and saltier than at any time in recorded history. In July, the U.S. Geological Survey (USGS) reported that the world's third-largest saline lake had dropped to the lowest level ever documented. And this week researchers measured the highest salt concentrations ever seen in the lake's southern arm, a key bird habitat. Salinity has climbed to 18.4%, exceeding a threshold at which essential microorganisms begin to die.

The trends, driven by drought and water diversion, have scientists warning that a critical feeding ground for millions of migrating birds is at risk of collapse.

“We're into uncharted waters,” says biochemist Bonnie Baxter of Westminster College, who has been documenting the lake's alarming changes. “One week the birds are gone from a spot we usually see them. The next week we see dead flies along the shore. And each week we have to walk further to reach the water.”

After years of inaction, the prospect of a



A runner traverses reeflike structures, called microbialites, exposed by the receding waters of the Great Salt Lake. They provide important habitat for insects that feed millions of migrating birds.

dying lake, plus the risk of harmful dust blowing from the dry lakebed, is galvanizing policymakers to find ways to restore water to the shrinking lake.

The Great Salt Lake is really two lakes, divided in 1959 by a railroad causeway. Over time, the northern arm, which has few sources of fresh water, became saltier than the southern arm, which is fed by three rivers. Historically, salinity in the northern arm has hovered around 32%—too salty to support more than microorganisms—and about 14% in the southern arm.

Although the southern part is about four times saltier than seawater, it supports a vibrant ecosystem characterized by billions of brine shrimp and brine flies, which feed on photosynthetic cyanobacteria and other microorganisms. Birds, in turn, devour prodigious numbers of flies and shrimp when they arrive at the lake to nest, molt, or rest during migrations. A diving waterbird called the eared grebe, for example, needs 28,000 adult brine shrimp each day to survive.

The low water and rising salinity threaten to destroy the base of this food web, researchers say. The receding shoreline has already dried out many reeflike mats of cyanobacteria, known as microbialites, that dot the lake bottom. Baxter fears the saltier water now threatens even the microbialite communities that remain submerged. “In laboratory tests, when the salinity passes 17% we see the cyanobacteria start to die off,” she says.

Loss of the mats could also harm brine fly populations, Baxter says. The flies lay eggs on the lake surface, producing larvae that swim down to the microbialites, where they pupate before maturing into adults. Some bird species feed on the larvae or adults, whereas others eat the pupae—which have been showing up dead by the billions during this fall’s migration season.

Soon the brine shrimp could dwindle as well. “The fear is that in some future year, [the lake] will become so salty that its

populations ... will collapse,” a pair of state ecologists wrote recently.

In the meantime, researchers are mobilizing to track the unfolding crisis. Baxter is bringing in a brine fly expert to assess the situation. Conservation groups are tracking shorebird populations across the intermountain West. And USGS has established a program to monitor hydrology and ecology at other saline lakes in Oregon, California, Nevada, and Utah, which are facing similar stress.

The shrinkage of the lake threatens people as well as wildlife. In a 2019 state-funded report, atmospheric scientist Kevin Perry of the University of Utah estimated that 9% of the exposed lakebed sediments contain problematic levels of arsenic or metals, thought to be derived from industry, wastewater treatment, or agriculture. Winds are likely to erode the crust that holds the sediment

in place and carry dust far and wide. With more than 1 million residents living near the lake, in Salt Lake City and its suburbs, the worst-case scenario would be an air pollution disaster—akin to those experienced by communities in Iran near other saline lakes. Even Utah’s famed ski slopes are imperiled by the dust; scientists have documented how storms are already dumping lakebed particles onto the snow, darkening it and hastening the melt.

For years, conservationists have urged policymakers to reduce the water that farmers and other users divert from streams that flow into the lake. But, “Conventional wisdom has been it’s just a salty lake—we should be using the water upstream,” says Utah State Representative Tim Hawkes (R). “For many in Utah the lake’s been a little bit out of sight, out of mind.”

This year, however, policymakers sprang into action. In April, Utah Governor Spencer Cox signed a landmark series of bills aimed at rescuing the lake and addressing the drought. They include new rules that allow farmers to sell water rights they are not using to groups that will allow the water to flow to the lake. The state earmarked \$450 million for water infrastructure and conservation projects, including a \$40 million fund that could acquire water for the lake in the future.

Such policies could take years to have a noticeable impact, especially if the current drought continues. Baxter, for one, wonders: “Is any of this enough?” But Marcelle Shoop, who heads the Saline Lakes Program for the National Audubon Society, says she is “optimistic, because there are so many people trying to develop solutions.”

In the meantime, the lake may get temporary relief from a different source: the upcoming winter wet season. If it produces a good snowpack in nearby mountains, the runoff could help refill the region’s parched streams. ■



A NASA satellite image taken in July shows the Great Salt Lake has shrunk since a high water mark in 1985.

PHOTO: NASA EARTH OBSERVATORY IMAGES BY JOSHUA STEVENS, USING LANDSAT DATA FROM THE U.S. GEOLOGICAL SURVEY AND DATA FROM THE NATIONAL WATER INFORMATION SYSTEM, ADAPTED BY K. FRANKLIN/SCIENCE

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