A project backed by the World Bank aims to reverse the Aral Sea's rapid decline, but it could also increase traffic to an abandoned bioweapons testing site

To Save a Vanishing Sea

AKESPE, KAZAKHSTAN—Amid a parched landscape, Denis Zhakupov draws his hand across his chest, recalling how shoreside reeds grew "up to here" in his childhood. The air was full of birds, and the sea was full of fish. "We had everything," the 60-year-old medic recalls. But his community, like many other towns near the coast of the Aral Sea, has lost its shoreline and its easy fishing. They are victims of an avoidable environmental catastrophe that has devastated this region and given Akespe a problem all its own.

As the sea withdrew several kilometers to the south, it bared a bottom of fine, alluvial sand. The winds picked it up and blanketed the village, piling up dunes higher than houses that now make the place look like a Saharan oasis—without the palms. Some houses have collapsed under the pressure of drifts. "We have to dig ourselves out every day when the wind blows," Zhakupov complains.

Desiccation has been eating at the Aral Sea for 30 years, turning a bountiful source of fish into a salty, inhospitable body of water. The sea shrank by 75% and split into two parts joined by an isthmus: the Small Aral in the north, which includes Akespe, and the Big Aral in the south.

A regional governor in the north decided to do something about the crisis a dozen years ago and built a primitive dike to prevent the Small Aral from completely draining away. But the dike quickly breached. Workers rebuilt it again and again—seven times in all—finally giving up in 1999.

After years of monitoring the local efforts, the World Bank agreed to finance a properly engineered dike that includes a sluice to release excess water. The bank also committed to major works aimed at doubling the flow of the Syr Darya, the main river that feeds into the Small Aral. The $85 million project, now under way, "is the biggest attempt to repair a damaged lake that we've seen so far," says Philip Micklin, an Aral Sea specialist at Western Michigan University in Kalamazoo.

The new dike and sluice are to be completed this summer. Within 3 years, the Small Aral is expected to rise at least 3 meters and cover about 1000 square kilometers of now-dry former seabed, extending its surface by 25%.

The water's rise is also expected to increase rainfall, improve pastureland, and cut down on dust storms. The sea's salinity, now at 15 grams per liter, is predicted to fall to 10 grams, a third of the concentration of the ocean and roughly that of the Aral Sea before desiccation began. Fish and other freshwater aquatic life forms that retreated into the Syr Darya delta when the sea became too salty are expected to return, perhaps including the commercially valuable caviar-yielding ship sturgeon. If it succeeds, the restoration will partly undo the damage wrought by 3 decades of Soviet policy. But the dike may also decrease water flow to the south and expose land in the Big Aral that was partially submerged. This in turn is likely to increase traffic across a land link to Vozrozhdeniye (Renaissance) Island, a remote site where the Soviet military once did field tests of plague and other bacteria whose lethality had been artificially increased. Thus the paradox: Reviving the Small Aral could worsen problems around the Big Aral.

Beached. A Soviet decision to divert river water to cotton farming hastened the Aral Sea's retreat.

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Sacrificed to cotton

The recent disruption of the Aral Sea began in the 1940s with Josef Stalin's decision that the Soviet Union needed to become self-sufficient in cotton production. This could be done, he declared, by massively increasing the amount of water diverted for irrigation from Central Asia's two big rivers, Uzbekistan's Amu Darya in the south and Kazakhstan's smaller Syr Darya in the north. The sea, which got most of its water from these, would shrink, and a 50,000-ton-a-year fishery would be lost, but the Kremlin calculated there was plenty of seafood coming in from its Pacific and Atlantic fisheries. Today, the skeleton of a huge fish cannery towers over the town of Aralsk, Kazakhstan, once the main port on the northern part of the sea, now 80 kilometers away.

Since the heavy irrigation began in 1961, the Aral Sea has dropped 22 meters and lost 90% of its volume (*Science*, 2 April 1999, p. 30). Dust storms have picked up millions of tons of salt and scattered it over neighboring areas, spurring desertification. Pesticides, herbicides, and chemical fertilizers used with abandon during the Soviet period were also picked up by winds, resulting in steep increases in respiratory diseases and cancers—one consequence the Soviets hadn't expected.

As the sea level dropped, the sea's only nature preserve, located on an island called Barsa Kelmes, became accessible by car in

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2000. It had been a primary research center for Soviet-era university studies of desert botany and zoology. Hundreds of saiga antelopes once grazed there; poachers have decimated all but a few, and the park administration no longer bothers keeping wardens there. A summer visitor, after driving for hours on the caked mud of the former seabed, found the scientific station deserted and partly in ruins. Because the water table had dropped, even the sturdy saxaul trees that form the region's biggest vegetation were dying.

This wasn't the first time irrigation had damaged the Aral Sea region. The Zoroastrian civilization built a vast agricultural network that collapsed in the 3rd century. In the 16th century, the British traveler Anthony Jenkinson noted that abuse of irrigation by Islamic settlers had caused "the great destruction" of the Amu Darya. Both civilizations discovered a simple fact of nature: The region is steeped in plant-stunting calcium sulfate, which is why very little grows, even near rivers. This salt leaches to the surface when land is excessively irrigated and requires increasing amounts of water to wash it away. The modern ecosystem collapse differs from earlier ones in two ways: It happened faster and was accompanied by chemical contamination from fertilizers, herbicides, and pesticides.

As the crisis deepened, Soviet scientists and policymakers drew up grandiose plans for digging huge canals to divert and bring southward the waters of two of Siberia's northward-flowing great rivers. But when Mikhail Gorbachev came to power in 1985 with a mandate for change, he tossed out the plan as environmentally dangerous and ordered a reduction in the use of river water for irrigation. Uzbekistan, for whom cotton is the main export, ignored him.

The Amu Darya was still pouring some water into the Big Aral when Uzbekistan gained independence in 1991. To rescue the wetlands around its delta, Uzbek authorities, with international support, built a half-dozen more dikes. As a result, the Big Aral dropped another 7 meters and became so salty that today only brine shrimp survive in it.

The economic collapse brought one positive change, however: The use of agricultural chemicals plummeted. Residues seem to have settled or dissipated; the remaining fish in the Small Aral have fewer poisons in their fatty tissues than those in Europe, says Sergei Sokolov, a hydrochemist monitoring the project for the World Bank.

CREDIT: C. PALA

From Samizdat to Celebrity—and Back

Portly, pony-tailed, and richly opinionated, Russian zoologist Nikolai Aladin has been infatuated with the Aral Sea for nearly 3 decades. The affair began in 1978 when he decided to take a break after defending his thesis at the St. Petersburg Zoological Institute, a part of the Russian Academy of Sciences. Aladin's adviser suggested that he go diving in the Aral's exceptionally clear and pleasant water. But when the 25-year-old reached the port of Aralsk, the sea was nowhere in sight: It had receded more than 30 kilometers—something the adviser had failed to mention.

Crusader. Zoologist Nikolai Aladin points to where the first dike was built.

Aladin did eventually reach the water, though, and observed that its salinity had increased from 10 grams per liter to nearly 20 in just 18 years—possibly the fastest such rise on record. Yet the sea was alive. He set out to study how salinity impacts aquatic ecosystems.

But back in St. Petersburg, his proposals were met with evasive refusals. Soviet leaders had decided in the 1950s to sacrifice the fish-rich, closed sea by diverting its source waters to cotton irrigation; they did not wish to publicize the toll on the environment.

Aladin found a way around them. "My father was relatively well-off as a naval doctor," Aladin recalled in an interview. "He offered to pay for my field trips." But it wasn't easy to share his findings. "To publish my first paper in the *Soviet Journal of Hydrobiology*, which was the first paper on the subject ever, I had to wait for 4 years and agree that all precise geographical coordinates be deleted," Aladin recalled. He went on to read papers at scientific meetings but had to print and circulate them himself. "It was a soft form of samizdat," he said, referring to the underground literature of the Soviet days. During official hours, he studied how variations in salinity affect crustaceans in other seas.

Aladin's Aral research did not go unnoticed. "Not only is his scientific work impressive, but he has done more than anyone to make people aware of the problems in the region," says Dietmar Keyser, an Aral Sea specialist at the University of Hamburg in Germany. "He is something of a crusader."

Western scientists knew from satellite photographs that the sea was shrinking, but they were unable to gain access to it. "In 1987, I flew over the Aral Sea with a map on my knees," recalled Rene Letolle, then a professor of geochemistry at Pierre and Marie Curie University in Paris. "I asked my Russian colleagues when I got to Tashkent if it was possible to visit the sea. But they said no, it was a military zone." He didn't get there until 1995.

Things began to change in 1986 when Mikhail Gorbachev initiated a policy of glasnost (openness) to expose and improve the sort of policies that had led to the Aral Sea catastrophe. Outrage followed. "It was the Russians who made it a huge public issue, and that's what got the Western attention," recalled Philip Micklin, an Aral Sea specialist at Western Michigan University in Kalamazoo.

Aladin, his work now recognized, was handed his own lab, the Laboratory of Brackish Water Hydrobiology in St. Petersburg, which he still heads. He led or participated in many expeditions to the Aral, including one in 1988 involving 100 scientists and intellectuals and a major scientific trip in 1990. "I had lots of funding, and I thought I was making a difference," he says. He takes credit for impressing upon the Aralsk governor in 1992 the need for a dike to save the Small Aral and for bringing in World Bank officials to see it, which helped prompt the bank's current investment in the area (see main text).

But when the Soviet Union broke apart, the Russian Academy of Sciences stopped funding Aral Sea research on grounds that it might appear materialistic. International scientific and educational institutions, according to Micklin, also began to "feel that the Aral Sea is not in Russia, so why should we give money to Russians?" Aladin says he was "lucky" to get good support during the early 1990s, but donors since then have favored citizens of Kazakhstan and Uzbekistan.

For Aladin, there's a sense of déjà vu: "I feel in the same situation as I was in the '80s, except that my father passed away, and I now pay for my field trips from the salary I earn from research of other seas." **–C.P.**

Grim legacy. Abandoned buildings on Vozrozhdeniye Island, a former bioweapons testing facility.

But the risk isn't gone, Sokolov says. As Kazakhstan's economy improves, the use of fertilizers has been rising. They flow into the river in the fall, after the harvests of rice and cotton, when farmers rinse the ground to wash out salt. "There needs to be a system under which, for 1 month a year, this water is not sent into the river but into special lakes," Sokolov argues. If not, he warns, "the Small Aral will become polluted." But Masood Ahmad, the World Bank official in charge of the project, disagrees: He says pollutants will be diluted to a safe level by the river's increased flow.

New prospects

Standing atop the smooth, new, 13-kilometer dike financed by the World Bank, most of which is already completed, Aitbai Kusherbayev, the dam's chief engineer and a former governor of the Aralsk region, says he's confident the barrier will work this time. It stands 6 meters high, 3 meters above the planned new sea level, and slopes gradually for about 120 meters toward the water. The seaside will be covered with gravel to resist the waves and the winter ice that dislodged the previous dike in 1999.

The structure will indisputably benefit the Small Aral. But the three-times-larger Big Aral will suffer as water from the Syr Darya is retained in the north for several years to raise the Small Aral by 3 meters.

Already, desiccation around the Big Aral has caused Vozrozhdeniye to grow from a 33-kilometer-long island into a 145-kilometer peninsula attached to the coast of Uzbekistan. Until last year, this southern end was too wet even in summer for any vehicle to pass. But access may soon be possible.

Because of its remoteness, Vozrozhdeniye was used as the main Soviet center for testing bioweapons, antidotes, and vaccines in complete secrecy. In the 1970s and 1980s, the only town, Kantubek, had a population of 2000 in the summer when experimenters were busy. Researchers exposed monkeys, horses, and other animals to weaponized anthrax, tularemia, brucellosis, plague, typhus, Q fever, smallpox, botulinum toxin, and Venezuelan equine encephalitis.

Biowarrior. Former lab supervisor Gennady Lepyoshkin worries that lethal plague bacteria may have survived among the island's rodents.

In 1992, Uzbekistan acquired the southern part of the deserted island; Kazakhstan, the northern part. But neither country bothered posting guards, so Kazakh scavengers were able to travel there episodically in small boats to take away pipes, wires, and other materials and sell them on the mainland.

To a visitor 2 years ago, Kantubek presented a rare glimpse of the world's biggest bioweapons program in ruins. Cages and lab equipment were piled haphazardly, and unused germ suits still could be found in boxes. Most of the equipment in the "hot zone" had been evacuated.

Russian and Kazakh scientists agree that one potential hazard remains: Military-grade, antibiotic-resistant plague bacteria—very different from the strain endemic in Central Asia—may have survived among the rodents in the testing range, 16 kilometers from Kantubek, despite attempts to minimize risk. Gennady Lepyoshkin, who spent 18 summers supervising a laboratory testing weaponized bacteria such as plague and brucellosis, recalls: "Before we tested, we would spray a poison over the area to kill all wildlife. Then we would bring in our testing animals and release the aerosol with the germs. But there's a good chance that some rodents had stayed in their burrows when the poison gas was released and came out when the germs were passing around them." Rodents and camels are natural carriers of plague; they don't die of it but spread it through fleas.

Lepyoshkin says Uzbeks will eventually cross the land bridge to Vozrozhdeniye, and the weapons-grade plague, if it has indeed survived, will spread when island and mainland populations of rodents begin to mingle. "An environmental catastrophe is inevitable," he claims.

There is a solution, according to Nikolai Aladin, a professor at the Zoological Institute of the Russian Academy of Sciences in St. Petersburg. Aladin, 51, has been studying the Aral Sea for 27 years, perhaps longer than any other scientist (see sidebar on p. 1033). He proposes building a dike from the northern part of Vozrozhdeniye to the Kazakh mainland that would cause the shallow water on the eastern side to rise and return the foot of the peninsula to marsh, making it impassible for vehicles.

"There has been talk about it," says the World Bank's Ahmad, "but so far no work has been done to investigate its feasibility or find financing for it."

Micklin, while acknowledging the bioweapons threat, calls the dike project backed by the World Bank "a reasonable approach" for now. He says, "You can't restore the whole sea, given the amount of water you have available now, so restoring the Small Sea and bringing back the fishery is a wise idea, even though it may speed up the decline of the Big Aral." It boils down to a tradeoff between the clear benefits of restoring part of a devastated ecosystem and the uncertain risks of resurrecting an old threat.

—CHRISTOPHER PALA

Christopher Pala is a writer based in Almaty, Kazakhstan.

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