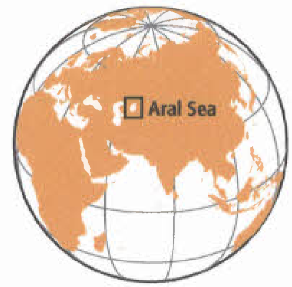


Reclaiming the Aral Sea

Recklessly starving the world's fourth-largest lake to irrigate crops turned rich waters into a barren wasteland. Now the northern part, at least, is coming back

By Philip Micklin and Nikolay V. Aladin

KEY CONCEPTS

- The Aral Sea in Central Asia was the fourth-largest lake on the planet in 1960. By 2007 it had shrunk to 10 percent of its original size. Widespread, wasteful irrigation of the deserts along the Amu and Syr rivers, which feed the Aral, cut the freshwater inflow to a trickle.
- The sea has shriveled into three major residual lakes, two of which are so salty that fish have disappeared. The once thriving fishing fleets have disappeared, too. Former shore towns have collapsed. Vast seabeds lie exposed and dried; winds now blow salts and toxic substances across populated areas, causing significant health problems.
- Nevertheless, a dam built in 2005 has helped the northernmost lake expand quickly and drop substantially in salinity. Fish populations and wetlands are returning—and with them signs of economic revival. The two big southern lakes could become dead seas, however, unless the Amu river, which once fed them, is substantially reengineered, a project requiring tens of billions of dollars and difficult political agreements.
- Other lakes worldwide are beginning to suffer similar fates, chief among them Lake Chad in Central Africa and the Salton Sea in Southern California. Lessons learned about the Aral's demise and partial resurrection could benefit these regions. *—The Editors*

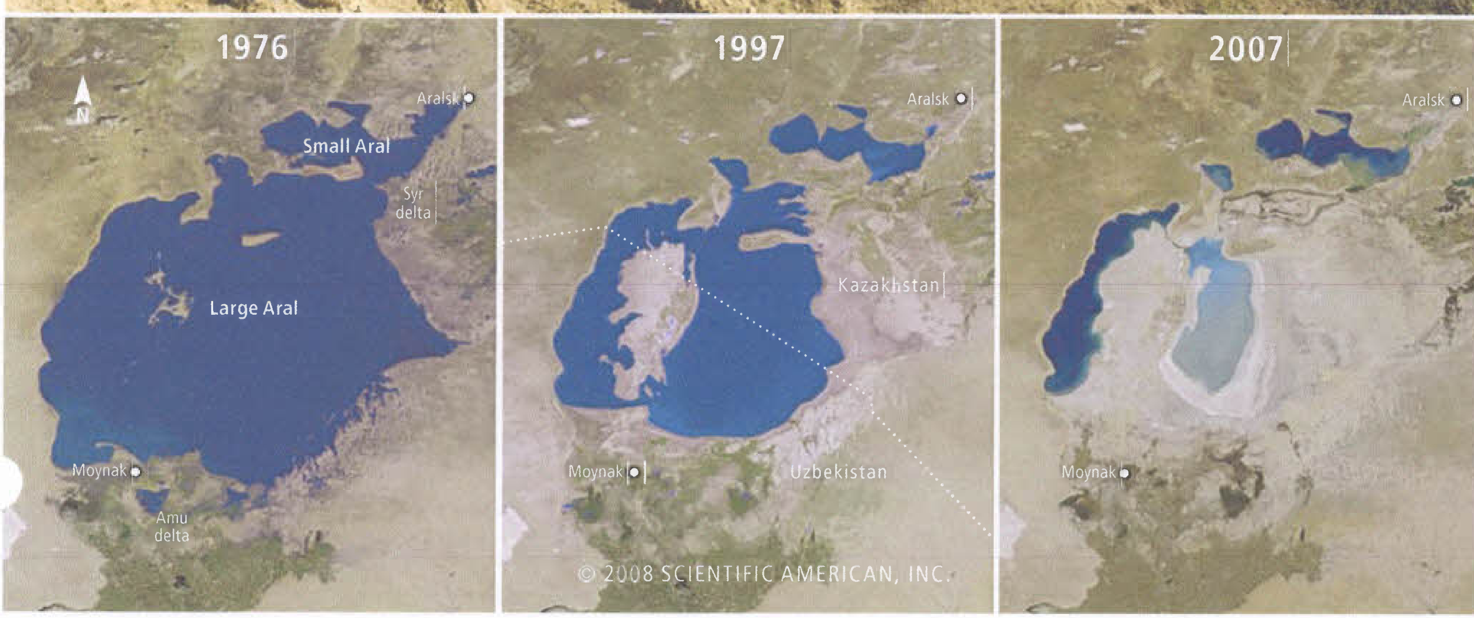
COLLAPSE

The Aral Sea gets almost all its water from the Amu and Syr rivers. Over millennia the Amu's course has drifted away from the sea, causing it to shrink. But the lake always rebounded as the Amu shifted back again. Today heavy irrigation for crops such as cotton and rice siphons off much of the two rivers, severely cutting flow into their deltas and thus into the sea. Evaporation vastly outpaces any rainfall, snowmelt or groundwater supply, reducing water volume and raising salinity.

The Soviet Union hid the sea's demise for decades until 1985, when leader Mikhail Gorbachev revealed the great environmental and human tragedy. By the late 1980s the sea's level had dropped so much that the water had separated into two distinct bodies: the Small Aral (north) and the Large Aral (south). By 2007 the south had split into a deep western basin, a shallow eastern basin and a small, isolated gulf. The Large Aral's volume had dropped from 708 to only 75 cubic kilometers (km^3), and salinity had risen from 14 to more than 100 grams per liter (g/l). The 1991 dissolution of the Soviet Union divided the lake between newly formed Kazakhstan and Uzbekistan, ending a grand Soviet plan to channel in water from distant Siberian rivers and establishing competition for the dwindling resource.

MATTHIEU PALEY *Corbis (waterless sea)*; WORLD SAT *(satellite images)*; MAPPING SPECIALISTS *(all maps)*; LUCY READING-IKKANDA *(all illustrations)*

▼ SHRINKING LAKE has receded 100 kilometers from this former shoreline near Moynak, Uzbekistan.

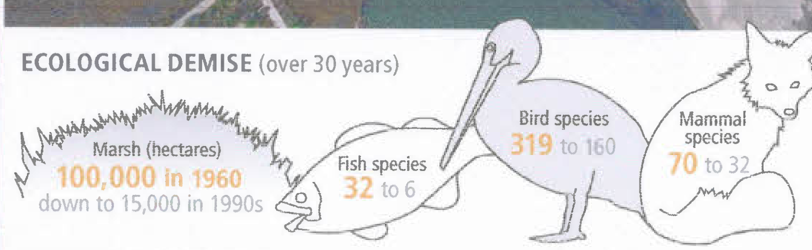


ROCK BOTTOM

Desiccation of the Aral Sea has wrought severe consequences. Greatly reduced river flows ended the spring floods that sustained wetlands with freshwater and enriched sediment. Fish species in the lakes dropped from 32 to six because of rising salinity and loss of spawning and feeding grounds (most survived in the river deltas). Commercial fisheries, which caught 40,000 metric tons of fish in 1960, were gone by the mid-1980s; more than 60,000 related jobs were lost. The most common remaining lake occupant was the Black Sea flounder (*kambala* in Russian), a saltwater fish introduced in the 1970s, but by 2003 it had disappeared from the southern lakes because salinity was more than 70 g/l, double that of a typical ocean.

Shipping on the Aral also ceased because the water receded many kilometers from the major ports of Aralsk to the north and Moynak in the south; keeping increasingly long channels open to the cities became too costly. Groundwater levels dropped with falling lake levels, intensifying desertification. By the mid-1990s meager stretches of halophytes (plants tolerant of saline soils) and xerophytes (those tolerant of dry conditions) struggled where lush expanses of trees, bushes and grasses had once flourished on the banks. Only half the number of native mammal and bird species could be found in the area. The climate also changed up to 100 kilometers beyond the original shoreline: today summers are hotter, winters are colder, humidity is lower (so rainfall is less), the growing season is shorter and drought is more common.

▼ VAST DRAINAGE BASIN (*top*) provides almost no water to the Aral Sea because irrigation channels, as shown in the photograph below, siphon water from the Amu and Syr rivers for hundreds of kilometers through several countries. Among other results, animal and plant species have disappeared (*bottom*).



▼ FREIGHT LINES that once transported manufactured goods and foods from the thriving port city of Aralsk lie in ruin, as does the city's economy.

KAZUYOSHI NOMACHI *Corbis* (*aerial irrigation*); PAUL HOWELL *Sygma/Corbis* (*train*)

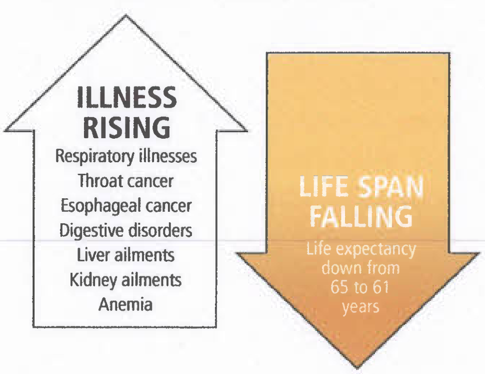
TOXIC SUBSTANCES

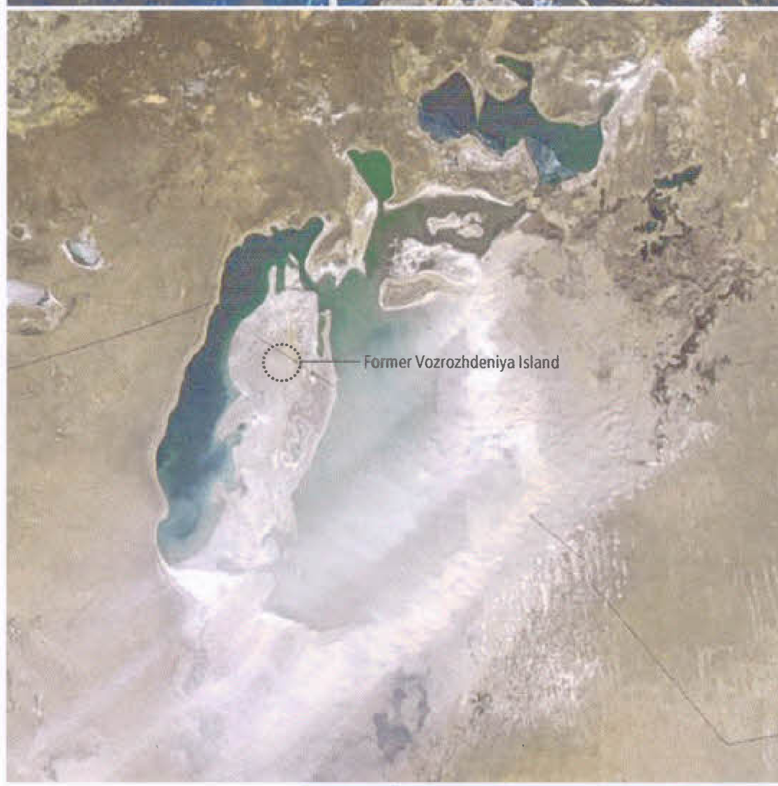
The receding sea has exposed and dried 54,000 square kilometers of seabed, which is choked with salt and in some places laced with pesticides and other agricultural chemicals deposited by runoff from area farming. Strong windstorms blow salt, dust and contaminants as far as 500 km. Winds from the north and northeast drive the most severe storms, seriously impacting the Amu delta to the south—the most densely settled and most economically and ecologically important area in the region. Airborne sodium bicarbonate, sodium chloride and sodium sulfate kill or retard the growth of natural vegetation and crops—a cruel irony given that irrigating those crops starves the sea.

Health experts say the local population suffers from high levels of respiratory illnesses, throat and esophageal cancer, and digestive disorders caused by breathing and ingesting salt-laden air and water. Liver and kidney ailments, as well as eye problems, are common. The loss of fish has also greatly reduced dietary variety, worsening malnutrition and anemia, particularly in pregnant women.

Vozrozhdeniya Island also poses a unique problem. When it was far out to sea, the Soviet Union used Vozrozhdeniya as a testing ground for biological weapons; anthrax, tularemia, brucellosis, plague, typhus, smallpox, and botulinum toxin were tried on horses, monkeys, sheep, donkeys and laboratory animals. But as a result of receding waters, Vozrozhdeniya united with the mainland to the south in 2001. Health experts fear that weaponized organisms have survived and could reach civilization via fleas on infected rodents or that terrorists might gain access to the organisms.

HEALTH TOLL (on area population)





▲ REFUSE and pesticides once dumped into Aralsk harbor are now exposed (*top*). Terrific windstorms (*middle*) blow the toxic substances and massive quantities of sand and dried salts across the region, killing crops and sickening local people.

▶ SOVIET PATROL BOAT, once used to guard bioweapons activity on Vozrozhdeniya Island, is now grounded on the dried seabed.

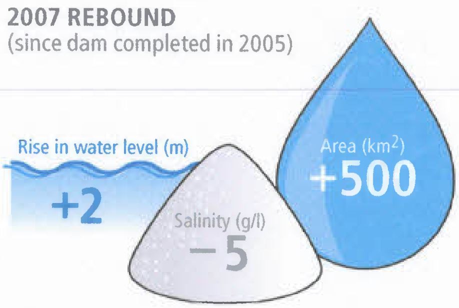
ANTOINE GYORI AGP/Corbis (*sea debris*); JACQUES DESCLOITRES *MODIS Land Rapid Response Team, NASA GSFC* (*aerial dust storm*); PHILIP MICKLIN (*boat*)

HOPE FOR THE NORTH

Returning the entire Aral Sea to its 1960s state is unrealistic. The annual inflow from the Syr and Amu rivers would have to be quadrupled from the recent average of 13 km^3. The only means would be to curtail irrigation, which accounts for 92 percent of water withdrawals. Yet four of the five former Soviet republics in the Aral Sea basin (Kazakhstan is the exception) intend to expand irrigation, mainly to feed growing populations. Switching to less water-intensive crops, such as replacing cotton with winter wheat, could help, but the two primary irrigating nations, Uzbekistan and Turkmenistan, intend to keep cotton to earn foreign currency. The extensive irrigation canals could be greatly improved; many are simply cuts through sand, and they allow enormous quantities of water to seep away. Modernizing the entire system could save 12 km^3 a year but would cost at least $16 billion. The basin states do not have the money or the political will.

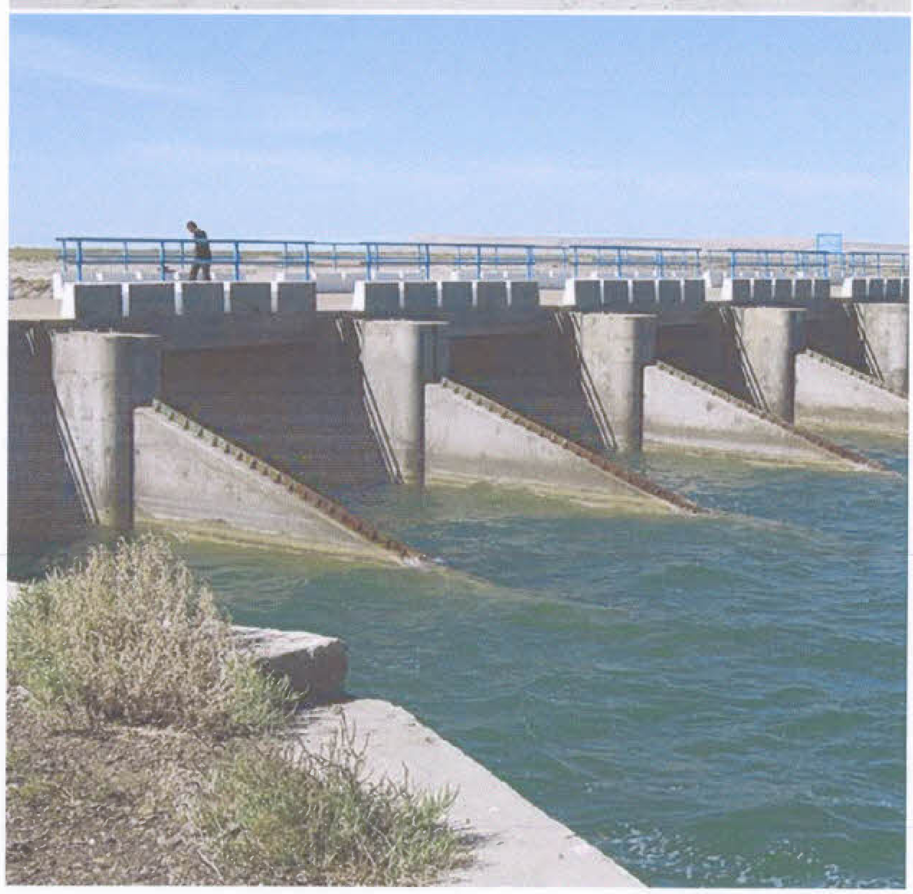
Kazakhstan has nonetheless tried to partially restore the northern Aral. In the early 1990s it constructed an earthen dike to block outflow to the south that was uselessly lost to evaporation, but a catastrophic failure in April 1999 destroyed it. The effort demonstrated that water level could be raised and salinity lowered, however, prompting Kazakhstan and the World Bank to fund an $85-million solution. The key element was a much heftier, 13-km earthen dike with a gated concrete dam for water discharge, completed in November 2005. Heavy runoff from the Syr River in the ensuing winter jump-started the Small Aral's recovery. The water rose from 40 to 42 meters—the intended design height—in only eight months. Area increased by 18 percent, and salinity has dropped steadily, from roughly 20 to about 10 g/l today. Fishers are once again catching several species in substantial numbers—most important, the highly prized pike perch (known as *sudak* in Russian) and *sazan* (a type of carp).

2007 REBOUND
(since dam completed in 2005)



▼ GATED DAM (*top*) and a 13-kilometer dike completed by Kazakhstan in 2005 saved the Small Aral by stopping outflow into dying channels that led nowhere. Since then water levels and fish populations have risen (*bottom*). The gates, which can release excess water to control lake level, were finished in November 2005—water, two meters deep, had returned by the following summer.

PHILIP MICKLIN (*top*); IGOR PLOTNIKOV (*bottom*)

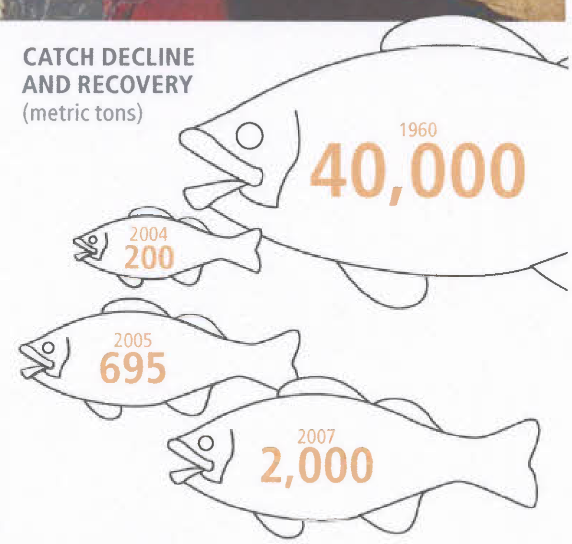


PROSPERITY RISING

We expect salinities in the Small Aral to settle at three to 14 g/l, depending on location. At these levels many more indigenous species should return, although the saltwater *kambala* would disappear from most places. Further restoration is possible. For example, if irrigation improvements raised the average annual inflow from the Syr to 4.5 km^3, which is entirely feasible, the lake's level could stabilize at about 47 meters. This change would bring the shoreline to within eight kilometers of Aralsk, the former major port city, close enough to allow redredging of an earlier channel that connected the city to the receding waters. The channel would give large commercial fishing vessels access to the sea, and shipping could restart. Marshlands and fish populations would improve even more because of a further reduction in salinity. Outflow to the southern lakes could also increase, helping their restoration [*see map on next page*]. Such a plan would require a much longer and higher dike, as well as reconstruction of the gate facility, and it is not clear that Kazakhstan has the means or desire to pursue it. The country is, however, now discussing more modest proposals to bring water closer to Aralsk.

SYLVAIN LIECHTI

FISH have returned to the Small Aral in rapidly increasing numbers, providing livelihoods for fishers from surrounding villages (*top* and *middle*). A processing plant in Aralsk has also reopened (*bottom*), boosting the local economy.



SPECIES CAUGHT
(autumn 2007, most to least)

1. Carp
2. Aral bream
3. Aral roach
4. Pike perch
5. Flounder
6. Aral asp
7. Aral white-eye bream
8. Crucian carp
9. Sabre fish
10. Pike
11. Perch
12. Rudd
13. Aral shemaya
14. Wels
15. Snakehead
16. Turkestan ide

LONG SHOT FOR THE SOUTH

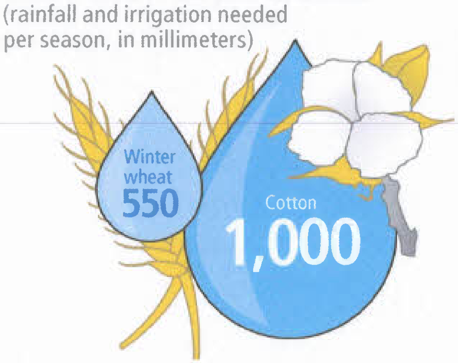
The Large Aral faces a difficult future; it continues to shrink rapidly. Only a long, narrow channel connects the shallow eastern basin and the deeper western basin, and this could close altogether. If countries along the Amu make no changes, we estimate that at current rates of groundwater in and evaporation out, an isolated eastern basin would stabilize at an area of 4,300 square kilometers (km^2). But it would average only 2.5 meters deep. Salinity would exceed 100 g/l, possibly reaching 200 g/l; the only creatures that could live in it would be brine shrimp and bacteria.

The western basin's fate depends on groundwater inflow, estimates for which are uncertain. One of us (Aladin) has noted numerous freshwater springs on the western cliffs. Our most reliable calculations indicate that the basin would settle at about 2,100 km^2. The lake would still be relatively deep, reaching 37 meters in spots, but salinity would rise well above 100 g/l.

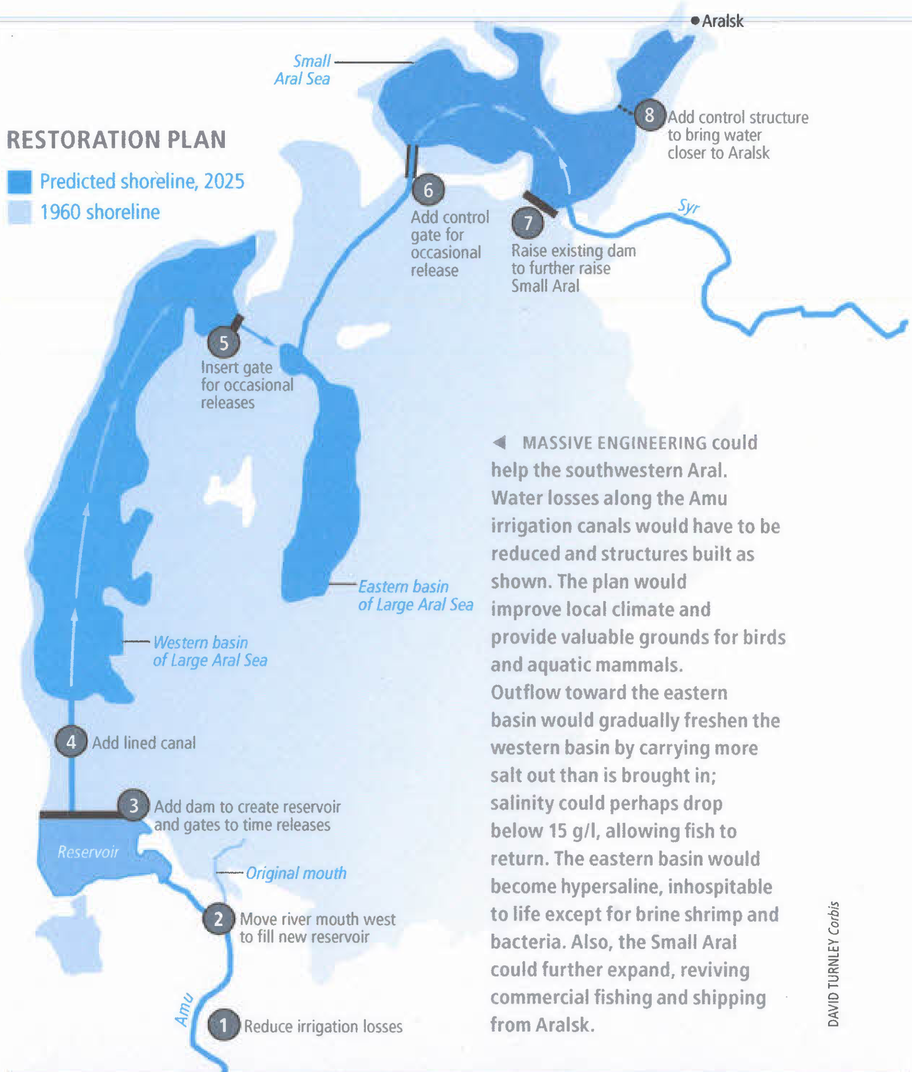
Large-scale engineering could partially rehabilitate the western basin. One early plan recently updated by one of us (Micklin) could help [*see map at right*]. It has received little evaluation, so costs are unknown, but it would be very expensive. It would require only modestly increased flow through the Amu, however, which could be attained with relatively reasonable irrigation improvements in the river's drainage basin. Rehabilitating wetlands is also a major goal.

The Soviet Union began such work in the late 1980s, and Uzbekistan has continued this effort with the help of international donors. Biodiversity, fisheries and natural filtering of wastewater by aquatic vegetation have marginally improved, but there is no quick fix. The Aral has been desiccated for more than 40 years; sustainable, long-term solutions will require not only major investments and technical innovations but fundamental political, social and economic change.

CROPS' EFFECT ON WATER USAGE
(rainfall and irrigation needed per season, in millimeters)



RESTORATION PLAN



◄ MASSIVE ENGINEERING could help the southwestern Aral. Water losses along the Amu irrigation canals would have to be reduced and structures built as shown. The plan would improve local climate and provide valuable grounds for birds and aquatic mammals. Outflow toward the eastern basin would gradually freshen the western basin by carrying more salt out than is brought in; salinity could perhaps drop below 15 g/l, allowing fish to return. The eastern basin would become hypersaline, inhospitable to life except for brine shrimp and bacteria. Also, the Small Aral could further expand, reviving commercial fishing and shipping from Aralsk.

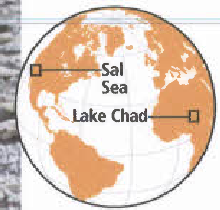
DAVID TURNLEY *Corbis*

▲ COTTON consumes much of the region's irrigation. A switch to less thirsty crops such as winter wheat could spare water badly needed to revive the Aral Sea, but countries rely on cotton sales for foreign currency.

GLOBAL IMPLICATIONS

Until recently, many observers considered the Aral Sea a lost cause. Progress in the north, however, convincingly demonstrates that sizable parts of the remnant sea can be made ecologically and economically productive. The Aral story illustrates the enormous capacity of modern, technological societies to wreak havoc on the natural world and their own people, and yet the story also demonstrates the great potential for restoring the environment. Other water bodies around the world are beginning to suffer Aral-esque fates, notably Lake Chad in Central Africa and the Salton Sea in Southern California. We hope the lessons learned will be heeded elsewhere. Among them are:

- Humans can quickly wreck the natural environment, but repairing it is a long, arduous process. Planners must cautiously evaluate the consequences of large-scale interference in natural systems before starting any action, which the Soviet Union did not do.
- Avoidance of serious problems at present is no guarantee for the future. Widespread irrigation took place in the Aral Sea basin for many centuries and did not seriously hurt the sea before the 1960s, but further expansion pushed the region's hydrologic system beyond the point of sustainability.
- Beware of quick fixes for complex environmental and human problems. Major cuts in cotton growing could send more water to the sea but would damage national economies, raise unemployment and contribute to social unrest. Sustainable solutions require not only money and innovation but must be politically, socially and economically practical.
- The natural environment is amazingly resilient, so do not abandon hope or efforts to save it. Many pundits wrote off the Aral Sea as doomed, but substantial parts of it are now being ecologically restored. ■



▲ DEAD TILAPIA choke the shore of California's Salton Sea (*above*), growing ever saltier because of botched irrigation. Various plans are being considered to freshen the lake before all the fish are gone. Africa's Lake Chad (*below*) has shrunk to one-tenth its size since the 1960s because of widespread irrigation. Farmers, herders and dwellers from the four border countries often fight violently over the remaining water (*bottom right, blue*), now only 1.5 meters deep.

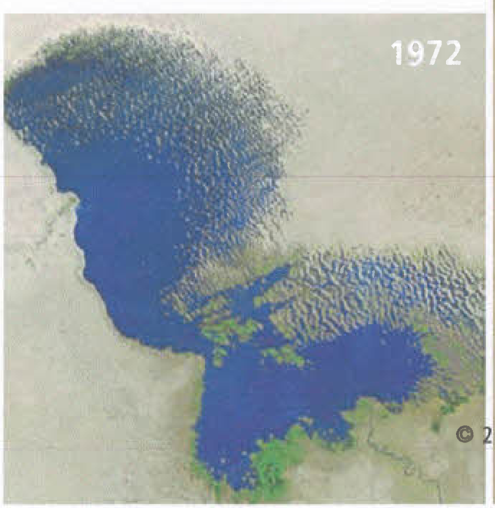
[THE AUTHORS]

Philip Micklin and **Nikolay V. Aladin** have conducted several on-site investigations of the Aral Sea over the past decade. Micklin is professor emeritus of geography at Western Michigan University. Aladin is head of the Brackish Water Laboratory at the Russian Academy of Sciences's Zoological Institute in St. Petersburg.

➡ MORE TO EXPLORE

Hydrobiology of the Aral Sea. Edited by Nikolay V. Aladin et al. *Dying and Dead Seas: Climatic vs. Anthropic Causes.* NATO Science Series IV: Earth and Environmental Sciences, Vol. 36. Kluwer, 2004.

The Aral Sea Disaster. Philip Micklin in *Annual Review of Earth and Planetary Sciences,* Vol. 35, pages 47–72; 2007.



WORLD SAT (*aerial Lake Chad*); JAY CALDERON *The Desert Sun* (*dead tilapia*)