"They're rushing it." Others are also worried that the goals laid out by Congress—to lower the lake's salinity and stabilize its level—are skewed, when a more serious threat to ecology may be the high nutrient levels.

Some observers argue that the crisis has been overblown and that it might be better to allow the sea to grow even saltier. This strategy, coupled with efforts to draw off nitrogen and other nutrients, got major play in a report co-authored by Glenn and released last February by The Pacific Institute, a policy think tank in Oakland, California. Skeptics also point out that previous seas that formed centuries ago in the sizzling Salton basin all evaporated, in a natural cycle. "This is a situation where you're really fighting nature," says aquatic ecologist Eugenia McNaughton of the U.S. Environmental Protection Agency in San Francisco, who's overseeing the environmental assessment of Interior's evolving plans. She favors "a management strategy that takes into account the history of the place."

If the Salton's salinity increases and the fish disappear, the sea would turn into a brine shrimp lake—like Utah's Great Salt Lake—that would still support plenty of wildlife, says Glenn. Other birds, he contends, could find habitat if steps were taken to manage wetlands in the Colorado delta in Mexico. The Salton Sea, agrees grebe expert Joe Jehl of the Hubbs–Sea World Research Institute in San Diego, "wouldn't be a dead lake, it would be a different lake."

Arguments that nature should take its course "cause my blood to boil," says Friend, who contends that the disruption to wildlife would be far greater than Glenn and others believe. The Salton's birds may not do so well in Mexico's delta wetlands, adds Hurlbert, who points out that these waters have a different mix of vegetation, fish, and invertebrates. Friend argues that the issue of protecting important wetlands is larger than the Salton Sea itself, noting that an "explosion" of bird disease across North America in recent years has been linked to birds forced to live in close quarters. "We should be fighting for all the habitat we can sustain," he says. A Salton success story, Friend says, could set an example for how to use wastewater to provide needed wildlife habitat in other water-scarce regions in the world.

Although the Salton Sea's fate may remain as cloudy as its water—if Interior does opt for an engineering solution, Congress will have to find money to pay for it—scientists agree that steps must be taken to help the area's wildlife. Setmire recalls a visit to the sea during a die-off in August where he helped collect sick and dead birds and wound up holding an injured white pelican in a pillowcase. "I was holding this big bird. Not pretty, but majestic. It really gave you a feeling about wanting to save this ecosystem."

—JOCELYN KAISER

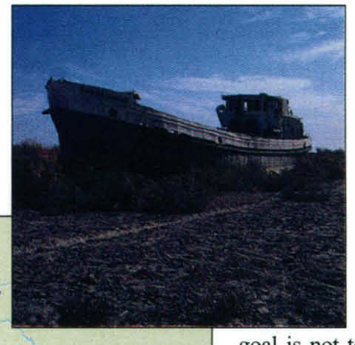
DYING SEAS
ARAL SEA

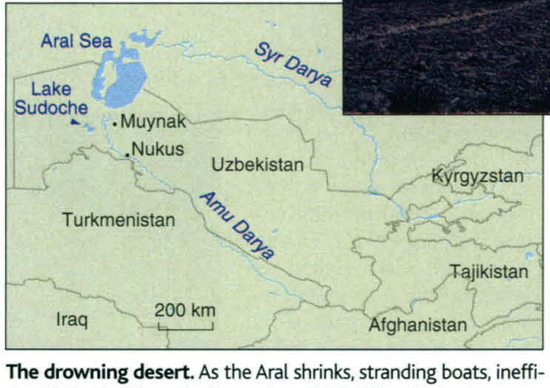
Coming to Grips With the Aral Sea's Grim Legacy

There's no undoing this sea's demise, perhaps the most notorious ecological catastrophe of human making. But scientists are hoping to soften the impact

NUKUS, UZBEKISTAN—Standing on the roof of the 10-story Uzbek Academy of Sciences (UAS) building, Yusup Kamalov has watched, more times than he would care to remember, the ground-hugging, dirty gray clouds that churn across the salt-streaked desert beyond the city's outskirts. Sometimes the chubby-cheeked engineer has to beat it indoors before one of these dust storms barrels into Nukus. The screaming grit blots out the bronze statue of famed 15th-century Uzbek astronomer Mirzo Ulugbek in front of the academy's local headquarters and chokes anyone unlucky enough to be caught outdoors.

Dust storms are common in deserts, but here in the Republic of Karakalpakstan, a province in the northwestern corner of Uzbekistan, they may also be harbingers of sickness and death. After decades of zealous Soviet efforts to yoke a huge swath of central Asia to the single-minded task of growing cotton, the locals are reaping an ill wind. It carries sulfates, phosphates, chlorinated hydrocarbons, and their ilk—fertilizers and pesticides whipped up from the bare floor of the shriveled Aral Sea and the poisoned land around it. According to the United Nations Development Program (UNDP), the death rate from respiratory illnesses in Karakalpakstan—167 per 100,000 people in 1993—is among the world's highest. "The level of health and the quality of life are profoundly poor, and deteriorating," says Ian Small, country manager for Doctors Without Borders (DWB), a medical relief agency (also known as Médecins Sans Frontières) that has logged high rates of anemia among Karakalpaks. "It is a tragic humanitarian disaster."





The drowning desert. As the Aral shrinks, stranding boats, inefficient irrigation from the Darya rivers is blighting the land.

The toxic dust storms are just one symptom of the environmental and social catastrophe that is engulfing this region. After decades of wanton irrigation, once-fertile fields produce next to nothing. And the shrinkage of the Aral Sea from a vast body of fresh water teeming with fish to a salty remnant has marooned ports and killed the fishing industry. Even local officials are resigned to the sea's eventual breakup: "We will be witnesses to the disappearance of the Aral Sea," says Karakalpak health minister Damir Babanazarov.

Ignored by Soviet planners for decades, the 35 million people who live in the Aral Sea's watershed have finally caught the attention of the rest of the world. A major campaign, spearheaded by the World Bank and the UNDP, is under way to improve the region's drinking water, revamp its agricultural practices, and sustain its biodiversity. The goal is not to turn back the clock and restore the Aral to its former grandeur. Rather, the massive cash infusion is meant to assuage the disaster's social consequences and avert a scramble—or even a war—over water among the fledgling democracies in central Asia.

Western water managers are hoping to learn lessons of their own. Central Asia is "attempting to implement many of the sustainable [agricultural] practices that the rest of the world is grappling with," says Daene McKinney of the University of Texas's Center for Research in Water Resources in Austin. Steps to mitigate the Aral's problems,

CREDIT: MUTSUMI STONE

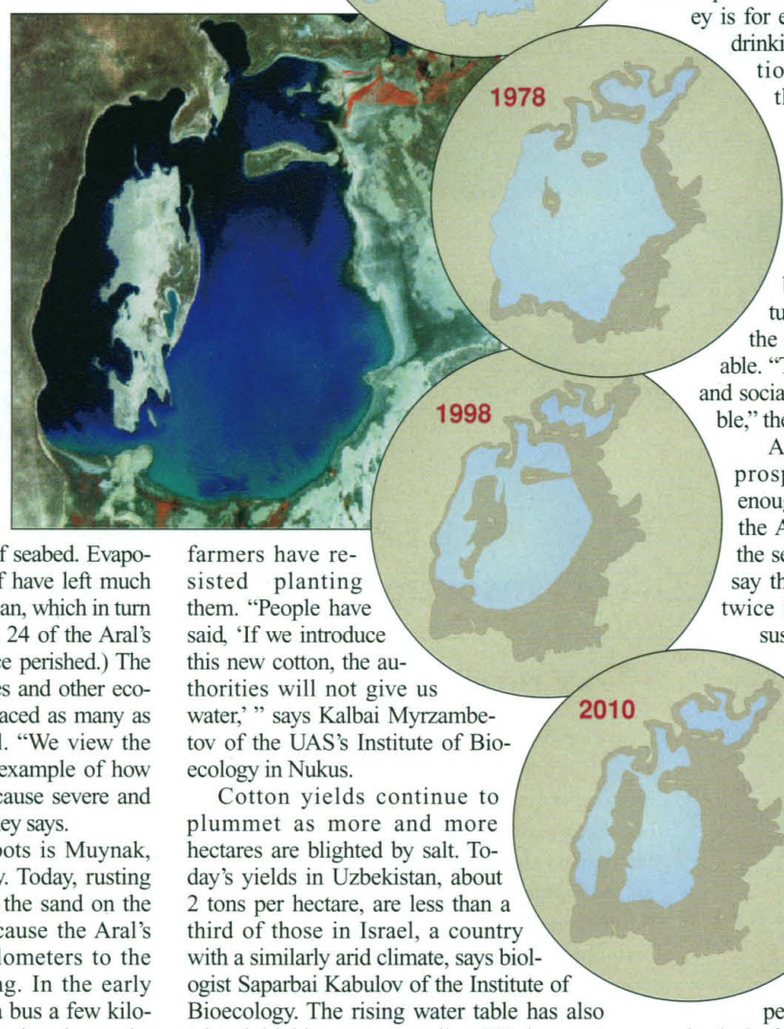
he says, "can teach us many things" about water management in the United States.

White gold. The Aral region's plight traces its roots to the early days of the Soviet Union, when communist authorities hatched a plan to grow all the cotton the budding superpower would need by irrigating vast plains in central Asia. The Soviets revved up cotton production in the mid-1920s, then 30 years later began carving hundreds of kilometers of unlined canals from the Aral's two tributaries—the Amu Darya and the Syr Darya—into the surrounding desert to nourish new cotton fields. The strategy paid dividends: The Soviet Union soon joined China and the United States as the world's leading cotton exporters. But by the early 1960s, the first signs of trouble began to appear: The Aral Sea was unmistakably shrinking as irrigation projects sucked billions of liters of water from its feeder rivers.

By now what was the world's fourth largest lake, slightly bigger than Huron, has lost 80% of its volume over the last 4 decades, exposing 3.6 million hectares of seabed. Evaporation and agricultural runoff have left much of the Aral saltier than the ocean, which in turn has killed off most fish. (All 24 of the Aral's native species have long since perished.) The collapse of the Aral's fisheries and other economic tribulations have displaced as many as 100,000 people, says Small. "We view the Aral situation as a real-life example of how unsustainable planning can cause severe and irreparable damage," McKinney says.

One of the grimmest spots is Muynak, the site of a former cannery. Today, rusting hulks of fishing boats litter the sand on the town's northern fringe, because the Aral's shores have shifted 70 kilometers to the north and are still receding. In the early 1980s, "we could still take a bus a few kilometers from Muynak to go swimming at the shore and watch the blue seagulls," recalls DWB's Valeria Slabolitskaya. Today, scores of unemployed people laze around on the dusty streets. Just outside town, says Small, "you can drive for kilometers and see nothing but thick white salt. It looks like snow."

Not even "white gold," as Soviet officials called central Asian cotton, can bail out the troubled region. Wasteful irrigation schemes that allowed farmers unlimited water have raised the water table, blocking drainage and clogging the fields with as much as 700 tons of salt per hectare, says Kamalov. Although Uzbek scientists have developed salt-resistant cultivars that require half as much water to grow as normal cotton, farmers have resisted planting them. "People have said, 'If we introduce this new cotton, the authorities will not give us water,' " says Kalbai Myrzambetov of the UAS's Institute of Bioecology in Nukus.



Water's end. The Aral Sea (1996 satellite shot below) has lost 80% of its volume since 1960. Philip Micklin predicts it will break up into three Aralets around 2010.

Cotton yields continue to plummet as more and more hectares are blighted by salt. Today's yields in Uzbekistan, about 2 tons per hectare, are less than a third of those in Israel, a country with a similarly arid climate, says biologist Saparbai Kabulov of the Institute of Bioecology. The rising water table has also tainted drinking water supplies. "We have not a single hectare in which the water is fresh," he says. After rainstorms in springtime, adds Kamalov, "that's when the water is the worst. We can't drink tea. It tastes bad."

Going, going ... After first acknowledging the ecological disaster during *glasnost* in the mid-1980s, the Soviets drafted grand plans for saving the imperiled Aral, perhaps by diverting water southward from Siberian rivers. Those plans were never realized, and after the Soviet Union dissolved in 1991, five new countries inherited the disaster. Since then, international organizations have tried to forge a game plan for helping central Asia tackle the legacy of Soviet-style cotton production.

The international community is now rallying around a series of initiatives approved last year, in which the World Bank, the Global Environment Facility (GEF)—an agency managed by the World Bank and the United Nations that funds projects on water, biodiversity, and other environmental issues in developing countries—and several other organizations plan to spend $600 million through 2002 to address a panoply of Aral problems. A large chunk of the money is for engineering projects to purify drinking water and upgrade irrigation and drainage systems throughout the Syr Darya–Amu Darya basin. The stakes are high: According to a 1997 World Bank report, if salt continues to leach into the fields and the water supply, much of the land "will be unfit for irrigated agriculture within a few decades" and the water will become undrinkable. "The economic, environmental, and social impacts would be incalculable," the report states.

As for the Aral Sea itself, the prospects are grim. In theory, enough fresh water flows through the Aral's watershed to replenish the sea, says Kamalov. But experts say that restoring the sea to about twice its current size—enough to sustain a diverse aquatic ecosystem—would require stopping all irrigation from the two Daryas for the next half-century. "There is no way to get the requisite water without destroying the countries' economies," says Aral expert Philip Micklin of Western Michigan University in Kalamazoo. Experts hope that constricting the massive leaks from the region's irrigation network will result in less water being siphoned from the Darya rivers and thus greater inflows to the Aral. More efficient irrigation should also lower the region's water table—a process that could take decades—and flush salt from croplands, boosting productivity and the region's economic vitality.

But at the present rate of shrinkage, Kamalov predicts, in a decade or so "the Aral will break up into three small lakes and disappear as an ecosystem." Two lakes,

CREDITS: (LEFT TO RIGHT) DLR; SOURCE: PHILIP MICKLIN/WESTERN MICHIGAN UNIVERSITY

mostly in Uzbekistan, likely would continue to shrivel. Kazakh officials hope to preserve the northern brackish lake by diking it off from the main water body to the south and allowing the Syr Darya to gradually refill it. They hope this will allow native fish to return to the north lake and revive its fisheries. There's a "real possibility" the Kazakhs will succeed, says Micklin.

A similar project, now gearing up, seeks to save an important wetland in the 28,000-square-kilometer Amu Darya delta, just south of the Aral Sea in Uzbekistan. Half of the delta's wetlands have already dried up. The project focuses on Lake Sudoche, a roughly 500-square-kilometer lake southwest of Muynak that, by international convention, has been designated a critical habitat for waterfowl. Together with the surrounding marshlands, Sudoche is home to several endangered species, including the Bukhara deer, the Dalmatian pelican, the Siberian crane, and the bastard sturgeon.

The $3.9 million project will include the construction of earthen dams between the dry Aral Sea bed and Sudoche, which is becoming saltier and more oxygen-poor every year. Once completed, the dams should corral as much as 600 million cubic meters of rainwater during the fall and winter. The fresh water is expected to flush the wetlands and raise oxygen levels, improving conditions for wildlife. If the project succeeds in saving Lake Sudoche, GEF managers hope it will stimulate the local economy through increased fishing and hunting.

Project managers acknowledge, however, that the first big flush could have unintended ecological consequences, such as water temperature changes, which could in turn harm native wildlife. "The level of risk is unknown," states a GEF report released last year. It points out, however, that "if nothing is done, Sudoche would become even more saline, the oxygen content of the waters would continue to drop, and the wetlands would lose much of [their] biodiversity and fish life." Adds Micklin, "It's hard to see how the project would make things worse."

The human dimension. As engineers and agronomists try to improve water management and stem the environmental destruction, organizations like DWB are focusing on human health. In one project, DWB staff members are collaborating with Muynak doctors to improve drug therapies at a local tuberculosis (TB) clinic. "We're building a brand-new dispensary," says DWB doctor Darin Portnoy. "They just didn't have any money to do something like this." Karakalpak officials welcome the foreign intervention. "We might not be able to save the Aral Sea," says health minister Babanazarov. "But we may be able to save the people living around it."

Karakalpakstan has dire health problems besides TB—rampant anemia and high infant mortality rates, for example—that also beg for resources. DWB epidemiologist Joost van der Meer is trying to ascertain the causes. "I'd bet on the toxic dust storms," he says. In Nukus, the frequency of major dust storms has increased from about one storm every 5 years in the 1950s to about five a year, says Kamalov. Toxic dust storms, van der Meer says, "are the one thing you can't find anywhere else." But few data exist on the dust's constituents. "I'm not sure of any reliable chemical analysis," says Ross Upshur of McMaster University in Ontario, who has analyzed the scant Aral health data. "This is one of the key areas for initial research."

Lifeline. The sea may be a lost cause, but saving the region's people, including this TB patient in Muynak, is not.

CREDIT: MUTSUMI STONE

Van der Meer acknowledges that it will take a lot of outside help to get to the bottom of the region's health woes. "We have no capacity to do this ourselves," in either labor or lab facilities, he says. Local experts are also appealing for foreign partners. Thus van der Meer hopes to become a matchmaker of sorts, hooking up Western and Uzbek scientists for projects on everything from tracking disease rates to probing the dust's toxicity. What the Karakalpak researchers lack in data or equipment, however, they compensate for in access to a unique research site. As Kabulov points out, "There's no experience for science around the world in which a whole sea has disappeared." **–RICHARD STONE**

PHYSIOLOGY

Heart Failure Simulated

New computer models suggest why failing hearts show diminished contractility and an increased susceptibility to fatal rhythm disturbances

Heart attacks may be the most feared heart ailment. But the most common is a slower but potentially equally deadly disorder, a steady weakening of the heart muscle known as chronic heart failure. Every year in the United States alone, more than 400,000 people develop the condition, which often causes fatal disturbances in heart rhythms. New results, some from computer simulations of the heart, are now helping clarify what causes heart failure and makes it so dangerous.

Heart failure occurs when the cardiac muscle cells contract less effectively, with individual beats becoming longer and less forceful. It often sets in after a heart attack damages the muscle, but exactly what causes the altered contractility has been hard to pin down. The new work, described in the 19 March issue of *Circulation Research* by a team led by Eduardo Marbán, Raimond Winslow, and Brian O'Rourke of The Johns Hopkins University School of Medicine, suggests that it's largely due to the altered production of two proteins that help control the concentrations of calcium ions in cells.

The simulations, which mimic the interplay of many different proteins controlling heart muscle contraction, testify to the power of studying cells as systems (see the special section on Complex Systems beginning on p. 79). They may also have important medical implications, because they show how the biochemical changes might trigger the fatal arrhythmias. "If that turns out to be true, that's important, because half of the people with heart failure die from arrhythmias," says Steven Houser, a cardiac cell specialist at Temple University School of Medicine in Philadelphia. It suggests, he says, that drugs capable of restoring the proper balance of calcium in cardiac cells could be used to treat heart failure and prevent the arrhythmias.

Researchers have known for some time that in heart failure, cardiac muscle cells produce abnormal amounts of key proteins, although they don't know why. For example, two of the proteins that form the membrane channels that funnel potassium ions in and out of cells drop by as much as 70%. Because potassium ions flowing out of muscle cells help reverse the electrical change, or action potential, that triggers muscle contraction, this discovery led to widespread speculation that reduced potassium outflow is what leads to the prolonged action potential and weaker heart muscle contraction in heart failure.

But the malfunctioning heart cells also contain higher than normal amounts of a shuttle protein for calcium, another ion that is important for muscle contractility, and less of a protein that helps store calcium within cardiac cells. "So many things are different in [these cells] that it's impossible to sort out the relative importance of one