Saving the Salton Sea

Researchers work to understand its problems and provide possible solutions

JEFFREY P. COHN

Steve Horvitz stands on a desert hilltop overlooking the Salton Sea in southern California. He shakes his head and points to a large, greenish mat of algae that covers the inland lake's northern end. Strong winds over the past few days have stirred up the sea and brought nutrient-rich water from the bottom to the surface, producing the bloom. The algae will die within a few hours, he says, robbing the sea's warm summer waters of dissolved oxygen as they decompose. That, in turn, will kill tons of fish.

"We'll have dead and dying fish everywhere by tomorrow," says Horvitz, superintendent of the Salton Sea State Recreation Area, a 16,000-acre preserve along the lake's northeastern shore. Indeed, even as he spoke, a crew was already out picking up dead fish. Six weeks earlier, in August 1999, an even more massive algal bloom had killed 8 million fish in 1 week.

Dead and dying fish—and often birds as well—symbolize both the problems and opportunities of the Salton Sea. Various newspaper and magazine articles have called the Salton Sea a "sinkhole consumed by a downright Biblical plague," an "environmental invalid," the "weirdest body of water in America," "a sewer," and a "dying ecosystem." Maybe so, but the sea is also one of the most productive ecosystems in North America. It hosts an incredibly large and diverse population of birds that live, nest, or winter there or spend time there during fall and spring migrations.

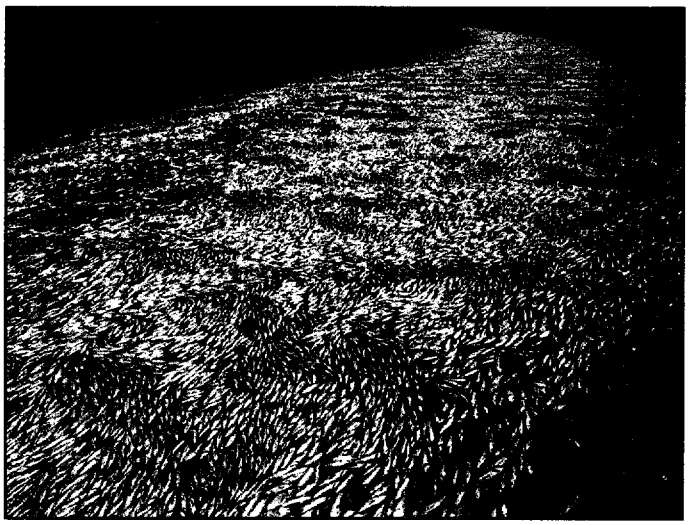
In all, 3.5 million birds may use the Salton Sea and its surrounding lands on any given day, especially in winter. Biologists have counted more than 380 bird species on or around the sea—nearly half of all North American bird species. Ninety percent of the North American population of eared grebes winters there. The number of white pelicans in some years totals 33,000, representing more than 80 percent of the entire western US population. Nearly half of the US population of Yuma clapper rails, an endangered subspecies, is found there. The sea is also one of only two nesting areas in the western United States for gull-billed terns, a bird proposed for listing as threatened.

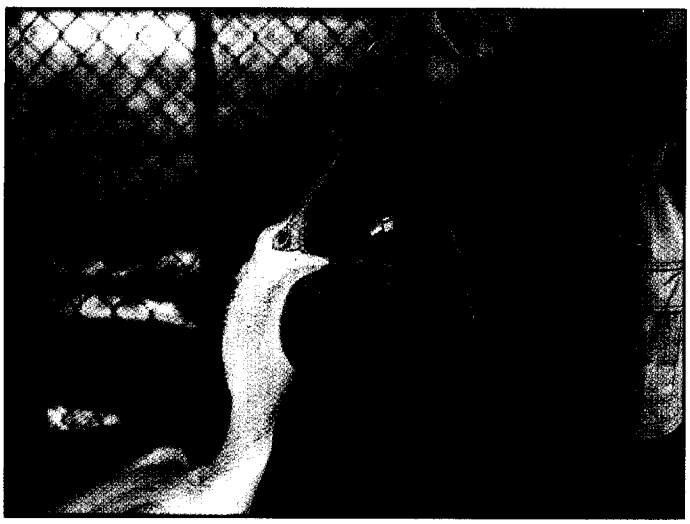
For many birds, especially migratory waterfowl, shorebirds, and fish eaters, there are few, if any, alternatives to the Salton Sea. More than 90 percent of California's wetlands have disappeared in the last century due to human development, according to a 1990 US Fish and Wildlife Service report. As a result, the sea has become "a critical link in the Pacific flyway," says Thomas Kirk, executive director of California's Salton Sea Authority, a state agency created in 1993 to help restore the sea and surrounding area. "The Salton Sea serves millions of birds, not because it is the best habitat but because it is the only one left," Kirk says.

Birds are not the only animals to thrive in the Salton Sea. An estimated 100 million fish, mostly tilapia, live in its waters. The tilapia are an exotic species introduced from Africa in the 1960s to control mosquitoes and weeds in agricultural drains that flow into the sea. Other fish in the Salton Sea include sargo, orange mouth corvina, and croaker—all imported from the Gulf of California after native fish died out because of rising salt levels—as well as the endangered desert pupfish. "It is the most productive body of water of its size in the world," states Barry Costa-Pierce, director of the Mississippi–Alabama Sea Grant Consortium. "You can catch more than 100 kilograms of fish in an hour, where the normal catch elsewhere would be less than 1. It is absolutely phenomenal. Nothing else comes close."

To address the sea's problems and to make the most of its opportunities, the federal government and the state of California have proposed a joint, multi-agency program to stabilize and restore the Salton Sea ecosystem. Although Congress has not yet decided whether or at what level to proceed, the Clinton administration has proposed both immediate and longer-term restoration efforts that could rival those underway in the Everglades. But any plan will have to overcome criticism from some scientists, who argue that a less costly remediation program could yield a valuable, if different, ecosystem.

Meanwhile, federal and state agencies are sponsoring the first systematic studies of the Salton Sea ecosystem. Earlier studies had addressed mostly





An estimated 100 million fish thrive in the Salton Sea, but problems such as algal blooms caused by excess nutrients in the water have led to massive die-offs, such as this one (left) affecting gulf croakers. In 1996, thousands of white and brown pelicans in the Salton Sea were killed by avian botulism, marking the first time that fish-eating birds succumbed to this disease. Here (right), a white pelican is being given fluids to help its recovery from an attack of botulism. Photos: Milton Friend.

engineering and technical issues involving water and salt levels. The new research is designed not only to advance knowledge of the sea's ecosystem, but also, and more important, to guide restoration efforts, says Milton Friend, executive director of the group overseeing the scientific studies of the sea and former director of the National Wildlife Health Laboratory, in Madison, Wisconsin.

A sea of contrasts

The Salton Sea sits in a low-lying rift valley in the Sonoran Desert southeast of Los Angeles and northeast of San Diego. It is the third largest saltwater lake in North America. In the United States, only the Great Salt Lake is bigger. Although its size has fluctuated over the years, the sea is currently 35 miles long and 9–15 miles wide, and it holds 7.5 million acre-feet of water (one acre-foot equals 325,851 gallons). Lying at 227 feet below sea level, it is the second-lowest point in North America, after Death Valley.

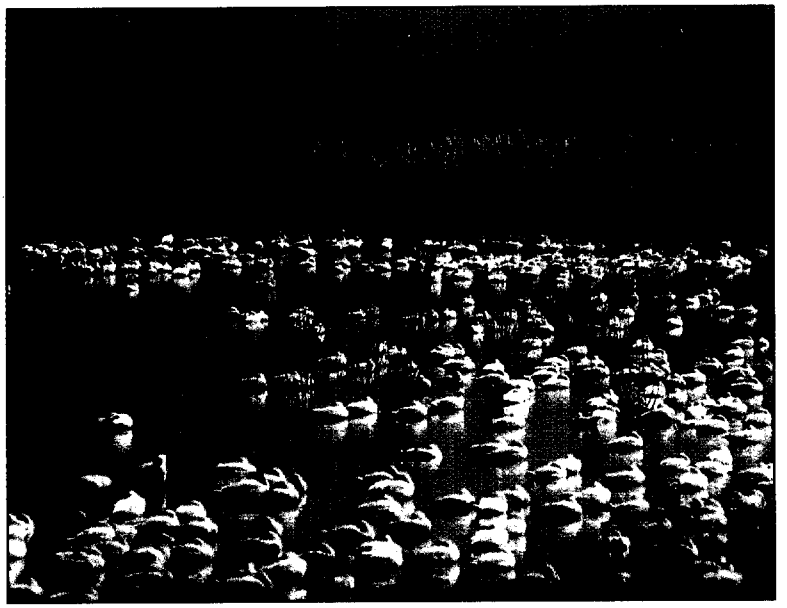
The Salton Sea is a place of contrasts. The long, flat basin it occupies contrasts with the massive Santa Rosa and Vallecito Mountains to the west and the Chocolate Mountains to the east. The sparse salt bush, pickle weed, creosote, and occasional ocotillo and palo verde of the desert stand in sharp contrast to row after row of lush irrigated fields that are scattered around the otherwise barren basin. And the dead and dying animals contrast with the sheer numbers of living geese, ducks, pelicans, cormorants, grebes, herons, egrets, stilts, avocets, and other birds that make the area a birdwatcher's paradise.

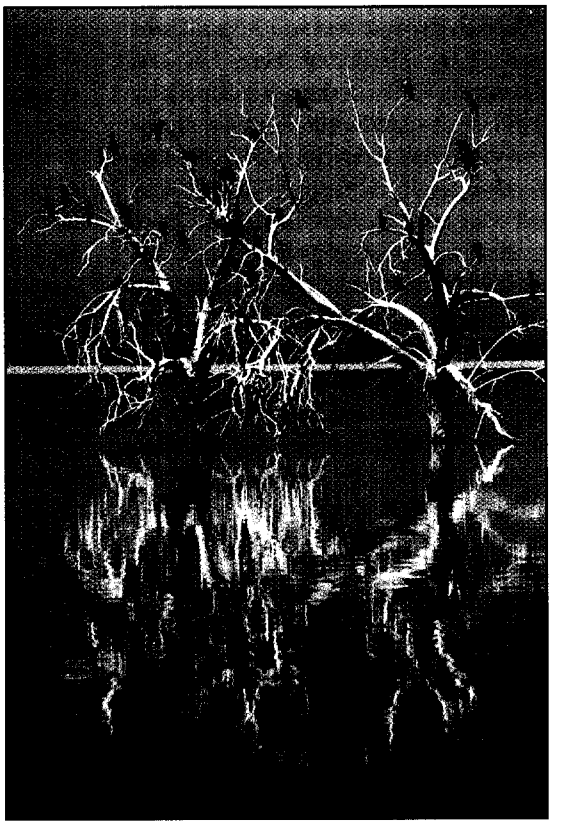
Birds of many species, including snowy egrets, are abundant in and around the Salton Sea. Photo: Milton Friend.

The Salton Sea was created accidentally in 1905, when the Colorado River flooded and broke through temporary gates built to control water flowing into irrigation canals for farms in California's Imperial Valley. For nearly 2 years the river spilled most of its water into the California desert.

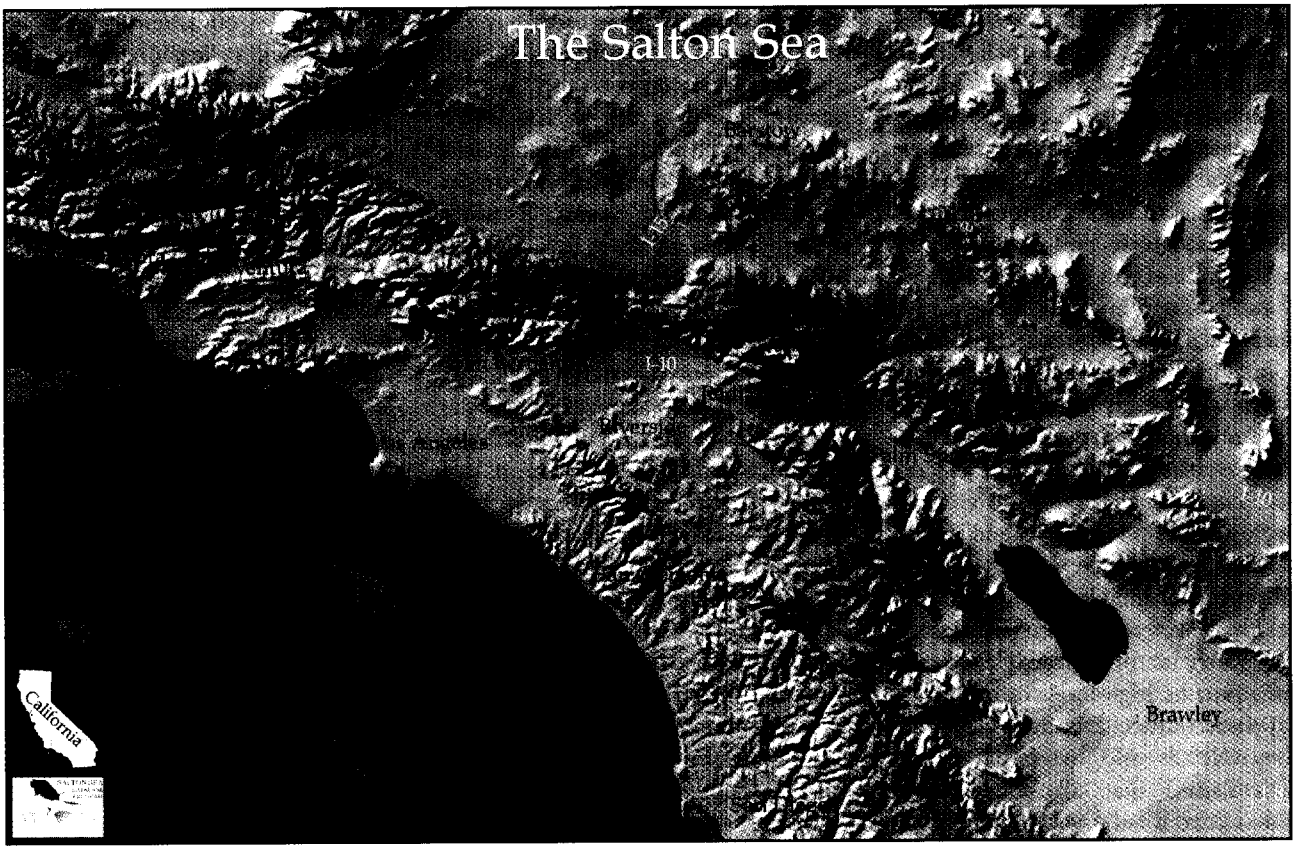
It was no accident, however, that water should occupy the Salton Basin. A much larger freshwater body, Lake Cahuilla, covered the area in the sixteenth century, leaving bathtublike rings on the nearby Santa Rosa Mountains. Earlier in geologic time, an arm of the Gulf of California extended to the Salton Basin and beyond. More recently, the Colorado River flooded the area eight times in the nineteenth century, although each time the water evaporated within a few years.

The current Salton Sea would likely have disappeared too, were it not sustained by irrigation water. Some 1.3 million acre-feet now flow into the sea each year—approximately the same amount of water that evaporates annually. Most comes from the 475,000 acres of farms irrigated with Colorado River water in the Imperial





A flock of snow geese (left) rests on an upland habitat adjacent to the Salton Sea that is part of the Salton Sea National Wildlife Refuge. Double-crested cormorants (right) roost in dead trees in an area that has been flooded as a result of excess irrigation water flowing into the Salton Sea. In 1998, an entire nesting colony of these birds was killed by Newcastle disease. Photos: Milton Friend.



The Salton Sea occupies a long, flat basin in the Sonoran Desert southeast of Los Angeles. This body of water has been called the "accidental sea" because it was created inadvertently in 1905, when the Colorado River flooded and broke through temporary gates built to control water flowing into irrigation canals in California's Imperial Valley. Today, excess irrigation water continues to sustain the Salton Sea, which has no outlet. Map courtesy of Salton Sea Database Program, University of Redlands, Redlands, California.

Valley to the east and south, and from the 75,000 irrigated acres in the Coachella Valley to the north. In effect, farmers use the Salton Sea as a dump for the excess irrigation water used to flush agricultural fields of salts picked up naturally by the Colorado River from the surrounding rock formations as it flows seaward. If fields were not flushed, salt levels would soon build up in irrigated fields and kill any crops. Water also flows north into the sea from wastewater treatment plants and irrigated fields in Mexico via the New River.

Because irrigation water flows into the Salton Sea, the lake is larger now than it was in the 1920s. In fact, the sea has flooded half of the 24,000 acres owned by the Torres Martinez Indian tribe on the northwestern side and more than 80 percent of the 45,000-acre Salton Sea National Wildlife Refuge on the southeastern corner, further complicating the sea's problems.

The Salton Sea's problems

Flooded lands are only a small part of the Salton Sea's problems, though. For starters, the sea has no outlet. Any water that flows into the sea remains there until it evaporates in the hot, dry desert of southern California. The water flowing into the sea carries 5.2 million tons of salt a year, enough to fill a mile-long freight train every day. As a result, the sea is already 25 percent more saline than the Pacific Ocean and getting saltier every year. Within a few decades it may be too salty for all fish and most invertebrates.

Along with the salt, more than 15,000 tons of phosphorus and nitrogen flow into the sea yearly. These nutrients fuel the algal and plankton growth that feeds invertebrates and fish, which in turn provide food for birds. But the high levels of nutrients may also contribute both to depleted oxygen levels and to outbreaks of avian diseases that kill thousands of birds a year. Dead and dying animals often combine with decomposing algae and hydrogen sulfide given off by the sea to create a stench that has driven away most hoped-for residents, tourists, and businesses.

Further complicating matters, the Salton Sea may soon lose much of the water now flowing into it. The Imperial Irrigation District, which governs water use in southeastern California, has expressed its willingness to sell 200,000 acre-feet of water a year to San Diego to meet that city's growing needs, instead of selling the water to local farmers. Also, water from the Imperial Valley might be sold to Los Angeles. Even more water could be lost when Mexico starts using water from municipal treatment plants in Mexicali to irrigate its own fields instead of releasing the water directly into the New River. In all, the Salton Sea could lose 500,000 acre-feet or more of water a year.

Additional water losses are likely as California is forced to reduce its use of Colorado River water to 4.4 million acre-feet a year, as required by the complex set of laws and agreements governing water use in the West. California now draws approximately 5.2 million acre-feet from the Colorado. But rising demand for water in such rapidly growing cities as Las Vegas, Phoenix, and Tucson has led to political pressure on California to cut its water use. Reducing California's water use will mean less water for irrigating fields in the Imperial and Coachella Valleys and, thus, less water flowing into the Salton Sea.

If the proposed water transfers go through, not only the size but also the topography of the sea would change. Demonstrating the point, Chad Karges, the former deputy manager of the Salton Sea National Wildlife Refuge, who is now at Malheur National Wildlife Refuge in Oregon, points to cattails ringing a large inlet only an inch or two deep formed behind a long mud flat. The cattail marshes and inlet are the habitat of the endangered Yuma clapper rail and numerous other birds.

"As the sea recedes, we will lose this habitat," Karges says from the captain's seat of a refuge air boat. "The slope will become steeper, and the new shore will be dry. The sea will look more like a fish bowl." Not only would the clapper rail lose habitat, but brown pelicans and double-crested cormorants on Mullet Island, a large rock outcrop in the sea, would find their roosting and nesting sites connected to the mainland, with its coyotes, foxes, and other predators.

A call for action

Although the Salton Sea's problems had been known to at least some scientists for years, they received little attention from the news media, policymakers, or the public until birds began dying in the early 1990s. "Dead birds are nothing new here," says Clark Bloom, the Salton Sea National Wildlife Refuge's manager. What shook people were the numbers: 150,000 eared grebes died in 1992 and another 20,000 died in 1994, both times of unknown causes. In 1995, 3000 waterfowl died of avian botulism, followed by another 14,000 in 1996. The 1996 outbreak of avian botulism also killed 8500 white pelicans and 1100 brown pelicans, the first time fish-eating birds had succumbed to the disease. In 1998, 8000 birds died of avian cholera and 6000 cormorants were killed by Newcastle disease, an avian virus that causes tremors and other neurological problems.

The result was a flurry of adverse publicity and political concern, led by then-Rep. Sonny Bono (R–CA), who recalled water-skiing at the Salton Sea as a teen. Secretary of the Interior Bruce Babbitt visited the sea in 1997, launching a federal effort to assess the sea's problems and possible solutions. Following Bono's death in 1998, Congress passed the Salton Sea Reclamation Act. The law provided formal support for Babbitt's feasibility studies and scientific research, with the goals of preserving the sea as a repository for agricultural drainage waters, making the environment safe for birds and endangered species, restoring recreational uses, maintaining a sport fishery, and providing opportunities for economic development.

Restoration efforts will not be easy, in part because of the bureaucratic

maze of government agencies, authorities, committees, and private groups involved. The Interior Department's Bureau of Reclamation is the lead federal agency for restoration, but the US Fish and Wildlife Service, US Geological Survey, Bureau of Land Management, US Army Corps of Engineers, and Environmental Protection Agency all have a role to play. In California, The Salton Sea Authority, which is governed by representatives of local county governments and irrigation districts, is the lead agency; it shares responsibility for the restoration effort with the US Bureau of Reclamation.

To run the scientific effort, Babbitt created a research management committee made up of high-level officials from the Interior Department, the California governor's office, the Salton Sea Authority, the Torres Martinez tribe, and the University of California Centers for Water and Wildland Resources. Babbitt also appointed a science subcommittee, headed by Friend, to decide what research projects to fund, judge proposals, evaluate the findings, and advise government agencies. So far, $5 million—out of more than $20 million allocated for all Salton Sea activities—has been spent on scientific studies.

New findings

The research, much of which is still underway, has already yielded some surprises. For one, more than 200 invertebrate species have been identified that no one knew were in the Salton Sea. "It's a rich lake," says Stuart Hurlbert, professor of biology and director of the Center for Inland Waters at San Diego State University. "It's not just a lot of a few species. Our findings should tell people that this place has not been studied to death [as some congressmen and critics of restoration have claimed]. Millions of dollars have been spent here, but we haven't learned anything from them about the biology."

The newly identified species include algae and protozoa previously unknown to science, says Hurlbert, who coordinates San Diego State University's field studies at the Salton Sea. Many of those species may exist in low numbers in the ocean, but they experienced a population explosion in the Salton Sea's warm, highly saline waters. They probably arrived at the sea either on the feet of birds or in water from the Gulf of California that was added along with stocked fish in the 1950s.

Researchers have also found that toxic algae are often present when large numbers of fish die. One algal species, *Prymnesium* sp., has been associated with fish kills elsewhere. Although the organism is barely detectable in the Salton Sea now, experiments show that it becomes more abundant as salt levels rise from the current 44 parts per thousand to 48 parts per thousand or higher. "It's something to be aware of for the future," Hurlbert warns.

Conversely, researchers have found that pile worms, abundant 2–3 inch long invertebrates, could be devastated if salinity continues to rise. High salt levels kill the worms' eggs and juveniles, which are particularly sensitive to salt. The loss of the worms would have cascading effects on the fish and birds that eat them. "They're a pretty juicy meal," Hurlbert says of the adult worms. "They're like floating hamburgers. There aren't any other large invertebrates to replace them as food sources." The worms also have an important role as scavengers, eating dead algae, protozoa, and bacteria.

Still another study has identified a bacterium in the guts of tilapia that may be a vital link to the spread of avian botulism in pelicans and other fish-eating birds, says Tonie Rocke, an epidemiologist at the National Wildlife Health Center. The bacterium, *Vibrio alginolyticus*, is thought to weaken the fish and create anoxic conditions in their guts that allow botulism spores to develop. Researchers hypothesize that the fish, ill from both the vibrio and botulism, swim so slowly that they are an easy catch for birds, which in turn develop botulism. Studies are underway to test whether fish are indeed the source of botulism in these birds.

In yet another study, Costa-Pierce has found another reason—beyond plentiful food resulting from all the nutrients in the water—that tilapia are so abundant in the Salton Sea. They reproduce like cockroaches, he says. Adult females can lay eggs every month for 7 or 8 months a year. By going through several generations annually, tilapia quickly replace any of their numbers that die.

Finally, research suggests that contaminants once thought to be widespread in the Salton Sea may not be as serious a concern after all. Previous studies had found high levels of DDT, selenium, and other contaminants in some marshes and agricultural drains along the margins of the sea and in tissue samples from some birds. But a 1999 study of sediment samples from 73 sites around the sea itself found that only a few sites had significant levels of pesticides or other contaminants, says Richard Vogl, a hydrologist who headed the study by Levine Fricke, Inc., an Irvine, California–based environmental engineering firm.

Proposed remedies

Nevertheless, problems relating to salt, water, and nutrient levels remain. After 2 years of study and more than 100 meetings, workshops, symposia, and other sessions, the US Bureau of Reclamation and the California Salton Sea Authority jointly submitted possible remedies in a draft environmental impact statement and a draft California state environment impact report, both of which were sent to Congress in January 2000. And at a January meeting in California, David Hayes, Acting Deputy Secretary of the Interior, announced the Clinton administration's program to stabilize and restore the sea, which is based on the reports sent to Congress.

In terms of immediate actions, the proposed steps outlined by Hayes are aimed at improving the sea's image as well as its environment. These include fixing boat ramps, docks, parking lots, and other recreational facilities; creating a commercial fishery; and cleaning up dead fish and birds in a more timely manner.

"This is the largest unfished tilapia population in the world," says William Steele, the Bureau of Reclamation's project manager for the Salton Sea, of the commercial fishery idea. "It's a neat opportunity to get jobs and money into an economically depressed area." It could also reduce the sea's nutrient levels.

Hayes also proposed a program to monitor and study wildlife diseases at the Salton Sea. Indeed, the Salton Sea Authority has already hired a wildlife biologist to do just that.

To reduce the sea's salt levels, Hayes proposed a pilot project to assess a system of evaporation ponds and high-pressure towers with sprinklers that would concentrate and precipitate excess salt in small walled-off portions of the sea. The salt that accumulates in the ponds as the water evaporates could then be removed or capped. The result would be a somewhat smaller sea with a reduced salt load. If the pilot project succeeds, two evaporation ponds large enough to handle nearly 100,000 acre-feet of water will be built. Bureau of Reclamation planners hope that the ponds and evaporation towers will reduce salt levels in the sea to 35 parts per thousand, equivalent to levels in the Pacific Ocean.

Beyond the immediate actions proposed by Hayes, the Bureau of Reclamation and Salton Sea Authority report lays out longer-term alternatives that might be used to restore the sea. One involves diverting 300,000 acre-feet of Colorado River waters to the Salton Sea when the river floods, approximately every 5 years or so. This water would be needed if the proposed transfers from the Imperial Irrigation District to San Diego occur and if California is required to reduce its use of Colorado River water to 4.4 million acre-feet a year.

Another approach to maintaining current water levels would be to send treated wastewater from Tucson or Phoenix to the Salton Sea. At 4–5 parts per thousand of salt, the water is too salty for drinking or agriculture, but it is fresher than water now entering the sea. "It's hard to find good water in the desert," Steele notes. "If Arizona has to get rid of it, we'd like to take it."

To deal with the threatened loss of shore marshes and mud flats that is likely to occur if the water transfers and water-use reductions take place, dikes could be built on the Salton Sea's northern side to protect shorebird habitat along the Whitewater River on land owned by the Torres Martinez Indians. FWS is also considering buying 7500 acres of farm land on the sea's southeastern side or using easements and other legal means to manage that land, says Richard Zembal, a wildlife biologist in FWS's Carlsbad, California, field office. The land would be used to create new marshes to replace those lost as sea levels drop.

If water levels do drop, a series of artificial islands could be built to replace Mullet Island. The islands would provide nesting and roosting spots for pelicans, cormorants, herons, egrets, and other birds. A less costly approach might be to fill old barges with soil and dead trees and anchor them in the sea, Zembal says.

Looking farther into the future, the Bureau of Reclamation and Salton Sea Authority may consider proposals to pipe treated municipal wastewater from San Diego to the Salton Sea. That would give the sea another source of fresh water. And, to give the sea a flushing mechanism, water from the sea could be piped to the Pacific Ocean near either San Diego or Oceanside; to Palen Lake, a dry basin east of Joshua Tree National Park in California; or to the Gulf of California in Mexico.

The ultimate cost to restore the Salton Sea will depend on which proposals are adopted and how they are implemented, Steele says. The cost of the cheapest fixes—sprucing up recreational facilities, cleaning up dead fish, and creating a commercial fishery—would total $4.5 million, he says. Bringing Colorado River flood water to the Salton Sea would cost another $10 million. And building dikes to create shallow waters would cost $15 million. On the more expensive side, building evaporation ponds would cost approximately $400–450 million, and an enhanced evaporation system would cost another $300–425 million. A pipeline to the Gulf of California would total $470 million, and one to San Diego would come to $1.2 billion ($2.8 billion if a return pipe is included). The San Diego route would cost more, Steele says, because it would require tunneling through mountains or pumping water over them.

Questions and consequences

Not surprisingly, given the size, complexity, and potential cost of the proposed remedies, a number of scientists have raised questions about both the environmental consequences and the financial costs of restoration. Edward Glenn, for example, is concerned about diverting Colorado River flood waters to the Salton Sea. "The sea is not alone," says Glenn, a professor of environmental sciences at the University of Arizona. "It is part of a larger ecosystem that includes the Colorado River delta." He notes that the delta, located at the head of the Gulf of California, supports a riparian habitat that has only recently recovered from decades of getting too little water from the Colorado River as a result of heavy use in the United States. However, Interior's Hayes says that his department "is not taking a position that favors" diverting flood waters from the Colorado.

Glenn's view is supported by two recent reports, one from the University of California's Institute for Mexico and the United States (MEXUS) and the other from the Pacific Institute, a private think tank in Oakland, California. Both reports urge the Bureau of Reclamation and the Salton Sea Authority to at least consider letting the sea become saltier, even if that would kill most fish and invertebrates. Such a no-action alternative "would change the sea, but [the sea] wouldn't go away," says John Letey, a professor of soil physics at the University of California–Riverside and director of its Water Resources Center. Letey, a coauthor of the MEXUS report, says that a saltier sea would create a habitat similar to those at Mono Lake in California

and the Great Salt Lake. In both lakes, the millions of brine shrimp that replaced pile worms and fish as salt levels rose provided food for thousands of grebes and other birds. Brine shrimp are already present in the Salton Sea, but in very low numbers.

The MEXUS report also urges that a series of marshes and other wetlands be built on the Alamo and New Rivers, which flow into the Salton Sea from the south; on the Whitewater River to the north; and on some agricultural drains. The man-made wetlands would replace lost habitat for some species if water levels drop. They would also filter out at least some of the nutrients that now reach the sea and lower overall restoration costs, Letey says. A $3-million Bureau of Reclamation pilot project is creating marshes along the New River near Brawley, south of the Salton Sea.

But letting the Salton Sea become saltier would significantly reduce the area's biodiversity, counters Friend. "It would eliminate critical nesting colonies of some birds," he argues, adding that "the displaced fish-eating birds may not be able to find suitable replacement habitat." Moreover, Hurlbert contends that artificial wetlands may be of "doubtful" use in reducing nutrient levels. Still, Steele says, the Bureau of Reclamation may recommend building them if the Brawley pilot project works.

Yet another criticism involves the proposed restoration measures' focus on water and salt levels. "We are paying far too much attention to salinity and elevation [water levels], to the exclusion of nutrients," says Eugenia McNaughton, an environmental scientist in EPA's San Francisco regional office.

But, Steele replies, "salinity will kill the fish before we can deal with the nutrients." He also points to ongoing studies to develop ways to reduce nitrogen and phosphorus levels in the Salton Sea as well as to efforts by the US Department of Agriculture and other agencies to develop new farm practices that reduce the amount of nutrients flowing into the sea.

McNaughton also questions the validity of studies showing the sea to be less contaminated than was thought. She is particularly concerned about selenium, which was found at high levels by a USGS study in the 1980s.

A continued scientific presence

At the same time that the US Bureau of Reclamation and the California Salton Sea Authority submitted their reports to Congress, the science subcommittee, in a separate report, proposed an ongoing research program to help guide restoration, Friend says. Needed, according to this report, are continued monitoring, computer modeling, focused research on problems related to managing restoration, and technical assistance for policymakers, project managers, and researchers. Toward that end, scientists at the University of Redlands, in Redlands, California, have developed a database and compact disk atlas of political, environmental, economic, physical, and other information on the Salton Sea.

The database and atlas have "created a common ground for viewing and using information drawn from different sources," says Timothy Krantz, a professor of environmental studies at the University of Redlands and director of the university's Center for Environmental Management, of the $3.4-million, 4-year data project. "Anyone who uses the atlas will be given a virtual flyover of the sea," Krantz says.

In the end, Friend says, restoration will have to overcome not only technical, environmental, and political problems, but also the fact that the Salton Sea cannot be made pristine. "What we have is a human-altered ecosystem," Friend states. "Our challenge is to make that human-altered ecosystem work for wildlife. This is too big and important a place to kiss off." ❑

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