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SCIENCEINSHORT

The Hullabaloo About HABS

An Interview with Keith Bouma-Gregson, US Geological Survey

ARIEL RUBISSOW OKAMOTO, REPORTER

Dead fish belly up in Lake Merritt and San Francisco Bay this past August sent scientists like Keith Bouma-Gregson scrambling to pinpoint the cause. A harmful bloom of marine algae had taken up residence in the Bay, and while many of the fish died from the resulting lack of oxygen in the water, toxins produced by the algae could have played some role, says Bouma-Gregson, a biologist with the US Geological Survey and regional expert on HABs. The Delta is no stranger to HABs, which in recent years, with warming temperatures and drought, have been on the rise. But an event like the one in San Francisco Bay — a different kind of algae with different impacts but a harmful bloom nonetheless — hadn't occurred in a decade.

Galvanized by visible loss of life, from bat rays to leopard sharks, citizens started taking pictures and making counts, while local science groups and government agencies scrambled to create a digital place to collect their observations. "When an event like this is so large, it can be hard to cover every location being impacted," says Bouma-Gregson. "But that's one of the really amazing things about the 21st century. With GPS and cameras on our phones, you can really transfer information very quickly!"

Despite the increasing alarm over HABs, there is no coordinated or funded strategy to monitor them in the San Francisco Estuary. To explore prospects, the Delta Stewardship Council is holding a two-day workshop November 8-9. Meanwhile, Bouma-Gregson covers a few basics on harmful algal blooms in this brief Q & A and longer online audio interview.

Q: What are HABs?

A: Harmful algal blooms occur when algae grow rapidly and accumulate in the water column. When the abundance of algal cells is high it can negatively impact ecosystem health and human health.

Q: Why are they a problem for Delta fish, dogs, and people?

A: HABs are a problem for people and pets primarily because many HAB species can produce toxins which are harmful to humans, mammals, and other animals. In the Delta, HABs are formed by a group of photosynthetic bacteria called Cyanobacteria. Not all cyanobacteria produce toxins, but if a bloom is producing toxins and the concentrations become elevated then that could result in negative symptoms or an illness. The primary exposure route is ingestion, which involves accidentally, or in the case of animals or small children, intentionally drinking water with cyanobacterial cells.

Q: Can HABs get into our drinking water?

A: Cyanotoxins can be treated by drinking water plants but require additional treatment considerations and staff time to deal with their presence. Besides toxins, cyanobacteria produce compounds which cause taste and odor and clogging issues for drinking water providers.

Q: How are the recent fish kills in San Francisco Bay different than Delta blooms?

A: The organisms that bloom in the Delta and the Bay are very different. In freshwaters, like the Delta, HABs are primarily formed by cyanobacteria, a group of photosynthetic bacteria. In coastal waters or estuaries, like the Bay, HABs are usually formed by eukaryotic algae, which are more complex than cyanobacteria.

Unlike most Delta blooms, the HAB in the Bay had a major impact on dissolved oxygen concentrations. When a bloom starts to decline, the algal cells die and sink to the bottom. Bacteria then begin decomposing the algal cells, this process uses oxygen and can deplete the oxygen in the water column. When this occurs, other animals do not have enough oxygen to survive, and suffocate in the water.

Q: How do you monitor HABs?

A: For citizens, a few tell-tale signs are water that is discolored, or has streaking at the surface. For scientists and water quality managers, we use both images from satellites orbiting the earth as well as on-the ground collection of water samples and measurements of different constituents in the water. Blooms are quite dynamic, changing over the course of days to weeks, and also being moved by currents and winds. Intensive monitoring can be challenging and costly, but some areas have been able to train community members to identify HABs in the field or under a microscope. These community scientists then alert relevant agencies when they begin to see signs of a HAB developing.

Q: Are HABs worse now because of climate change?

A: If winters become milder, then that would extend the time-period favorable for freshwater HABs to occur in the Delta. Any phenomenon that increases one of these four factors — light, temperature, nutrients, and water-column dynamics — would increase the chance of HABs formation. Our water- and land-use policy and management decisions will be important in offsetting any potential climate impacts so we can minimize HAB formation California's rivers, lakes, Delta and other waterways.

Science-in-Short Podcast

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ENDANGERED

Of Mice and Marshes: Surveying Salties to Save Them

KATHLEEN WONG, REPORTER

It's five in the morning, and Don Edwards San Francisco Bay National Wildlife Refuge remains in the tight velvet grip of night. All is peaceful and quiet, despite the fact that the toll plaza of the Dumbarton Bridge is less than a quarter-mile away.

By 5:15, car dome lights and slamming doors have transformed this lonely spot at the watery edge of Newark into a hub of activity. People are taking last sips of coffee, strapping headlamps to their foreheads, and swapping civilian footwear for rubber muck boots. The occasion that's roused everyone from bed more than an hour before sunrise? The first survey of the salt marsh harvest mouse conducted across the rodent's entire San Francisco Bay-centered range.

In 1970, *Reithrodontomys raviventris* became one of the first animals added to the federal endangered species list. Found along the damp fringes of San Francisco Bay, the salt marsh harvest mouse is the only mammal entirely restricted to coastal marshes — specifically, those found in the San Francisco Estuary. The loss of more than 90% of historical tidal marsh since Gold Rush times, compounded by future expected sea-level rise, puts the species in danger of extinction. Yet this tenacious rodent hangs on in remnant pickleweed-dominated marshes along the Petaluma River, Suisun and San Pablo bays, and Alviso north to Hayward and the Peninsula.

No one, however, has a good sense of how the species is faring. That includes the U.S. Fish and Wildlife Service, the agency responsible for managing the recovery of all listed species. This August 2022 expedition to Dumbarton Marsh and the north shore of Mowry Slough is part of a seven-week effort to obtain a comprehensive picture of this at-risk rodent's entire population. The project would ultimately survey mice at 55 sites around the Bay, and collect scat samples from bait stations at an additional 29 sites to confirm the presence or absence of the species.

A tagged mouse in pickleweed. Photo: Marisa Ishimatsu

Leading today's survey is biologist Katie Smith of WRA, Inc., an environmental consulting firm. Having trapped more than 4,000 "salties" since 2008 — 2,000 for her doctoral dissertation alone — Smith is the leading expert on a species she considers to be charismatic minifauna.

Critical Baywide Data

Surveys in previous decades have generally been one-offs, limited to a handful of sites on the rare occasion that scientists have had time and funding. But such a scattershot approach is inadequate to get a read on the population as a whole. "The populations can vary a lot from month to month and rain year to rain year," Smith says. "If you trap here this year during this month, and a different spot next year in a different month, we can't necessarily compare them."

Surveying the entire Bay at one time is the only antidote. "The idea here is we trap everywhere all at once, and we can have a baseline. More mice here, less mice there," Smith says.

Funding for the study comes from the National Fish and Wildlife Foundation, the nation's largest private provider of conservation grants. One of the survey's thorniest tasks proved to be gaining permission to trap. On top of his regular duties as operations manager of Suisun Resource Conservation District, John Takekawa helped coordinate the survey and spent nearly three years tracking down the myriad, often mysterious, landowners of tidal marsh properties, as well as petitioning government agencies for trapping permits.

Additional preparations included gathering records of as many previous trapping efforts as possible. Many of those accounts were missing basic data such as the date or numbers of traps set. Even so, the information has allowed Smith to start modeling habitat characteristics such as the marsh elevations where the highest numbers of mice were trapped.

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Despite its complicated logistics, the survey finally promises to yield the baseline data to guide future salt marsh harvest mouse conservation. Determining where the species is present, absent, or struggling with problems such as low numbers or inbreeding is the first step toward finding solutions.

It's still pitch-dark in the parking lot, but Smith wastes no time marshaling her seven volunteers into the field. All are biologists, from WRA as well as a variety of regional, state, and federal agencies. "We're always racing the sun," Smith explains while steering our convoy of three vehicles over a rutted levee road. Last night, Smith and colleagues left 100 Sherman traps baited with birdseed in these marshes. We need to get to any animals trapped inside before the aluminum boxes get too hot.

The sky has brightened to blush with a smear of tangerine over Mission Peak by the time we pull up at Dumbarton Marsh. Weathered plank walkways suspended over a sea of pickleweed will take us into the heart of the wetland. We climb rickety wooden ladders over massive decommissioned water supply pipes, pass beneath towering electric pylons, and step gingerly over exposed nails and rotted boards to reach the trap grids.

Before anyone touches a trap, Smith fills out the pre-survey site assessment. The form asks about types and height of vegetation and cover, whether the marsh is connected to nearby habitat, and the likelihood that competitor species such as rats and voles are present. The information will help reveal what features make some marshes better for salties than others. At present, that's not entirely clear; Smith has seen plenty of places that look like lousy habitat yield many mice, and vice versa. "Having this large dataset will give us a lot more analysis power to say, for example, areas with this cover or pickleweed of a certain height consistently have more animals across the species range," she says.

Complicating matters further, location also affects a site's suitability as mouse habitat. For example, shorter pickleweed in Suisun Bay can offer good shelter because the tidal range there is smaller, while plants of the same height in the Central Bay could offer inadequate refuge against inundation. And though low marsh is more vulnerable to tides, "it's kind of like a hideout for salties," Smith says; other species are less competitive in areas subject to frequent inundation.

Hair samples are collected for lab analysis. Photo: Marisa Ishimatsu

What Kind of Mouse?

The form completed, it's time to check the traps. Walking across dense pickleweed takes some getting used to; the fluid-filled stems are just springy enough to affect balance. An occasional shout erupts from those who get mired in a hidden pothole or channel. For our all-female group, Smith considers these happenings "marsh maiden" initiations.

The first few traps are open. Then Smith picks up one that has its door sprung shut. Holding the trap inches over the bottom of a bucket, she carefully pushes the door open. A fuzzy ball roughly the size of a chicken egg tumbles out. Smith scoops up the zippy little animal up by the base of its tail and places it on her gloved hand.

With satisfaction, Smith declares it to be a salt marsh harvest mouse. Most people, however, couldn't say that with certainty. To the untutored eye, salties look nearly identical to the common and plentiful Western harvest mouse, which can also live in tidal marshes. Dimensions of tail and body, plus hair length and color, are the best ways to distinguish the species by sight.

Smith flips the animal over to examine its reddish belly fur, a characteristic of South Bay mice, and records the number code for the matching hue and pattern. North Bay mice tend to have a

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Volunteers preparing to check traps. Photo: Kathleen Wong

C L I M A T E

Drought Strains Stormwater Monitoring

NATE SELTENRICH, REPORTER

When it rains, it pours. This old saw passes for an apt description of the new precipitation regime that climate change has wrought for the Bay Area: larger winter storms, but fewer of them. The implications of this shift for ecosystems, infrastucture, and water storage are widespread, and often highly visible. But behind the scenes, it is also complicating efforts to monitor pollution inputs to the San Francisco Bay and other local water bodies from stormwater runoff.

The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) has been collecting data in Bay water, sediment, and biota since 1993. RMP monitoring of stormwater flows after rain events, which began in 2006, has shown that runoff is a major pathway to the Bay for "legacy" contaminants like PCBs and mercury, as well as contaminants of emerging concern like PFAS and chemicals used in automobile tires.

Only through careful monitoring during and immediately after storm events can RMP scientists accurately characterize — and thus inform efforts to mitigate — the contribution of stormwater runoff to Bay pollution that may harm wildlife and humans alike. But with fewer, more severe storms, this job is becoming increasingly difficult — and costly.

"Literally every single one of our projects has been impacted, and we just keep having to roll forward funds and scope of work to future years, because we don't get the data that we need," says San Francisco Estuary Institute's Alicia Gilbreath, who leads the RMP's stormwater monitoring team. "So every year we just keep piling on more and more, both what we're supposed to do in a given year and all the work from the previous years."

For example, a pilot study last winter of pollutants entering the Bay at creek mouths was to include data from just two storms, a relatively low bar. But not low enough: "We were able to sample one really early-season storm," says Gilbreath, referring to the record-setting deluge that hit the region in late October and early November 2021. "We fully expected in February to get another storm, but it never came."

Another study to screen for a wide variety of emerging contaminants in stormwater flows — including PFAS, organophosphate ester flame retardants, bisphenols, ethoxylated surfactants, and tire ingredients — was supposed to be completed over the course of two wet seasons, from fall 2018 to spring 2020. But it ended up running for twice as long as a result of insufficient sampling opportunities, especially during the second winter. This in turn delayed the launch of a more targeted, longer-term program informed by the preliminary study.

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Sampling at the outflow of a stormwater conveyance in Berkeley. Photo: Don Yee

Sampling a green infrastructure installment. Photo: SFEI

"We had so few storms that were suitable for monitoring that we had to stretch our study out longer than expected in order to get enough data to really have a meaningful conversation about next steps," says Rebecca Sutton, a senior scientist with SFEI who leads the RMP's emerging contaminants work.

Adapting to this new reality will entail a greater reliance on remote monitoring where possible — using small devices that automatically sample stormwater when flows reach a certain threshold — and more careful deployment of field staff where required, notes RMP program manager Melissa Foley.

"Storms may hit on weekends or at night, and it's sometimes hard to mobilize multiple teams to get out there and to hit as many sites as possible," Foley says. "In the past, it's been, 'We'll, that's okay, we'll get the next storm.' Now it's at the point where we can't take that for granted anymore. This might be the last storm we get."

But storms aren't only rarer; they're also bigger. Extreme rainfall events can pose additional risks to field staff collecting stormwater samples: roadways can be dangerous, creeks can flood, trees can topple. Crew members often must be on site for several hours at the storm's peak, and their safety takes priority, Foley says. This may require additional planning, prioritization, labor, and equipment — all avenues that the RMP is exploring to ensure it can continue its critical work in an era of megastorms. "We can't squander any opportunity to collect data at this point," she says.

Filling bottles for many different contaminants of interest in stormwater. Photo: SFEI

In some cases, larger storms may also overwhelm green infrastructure such as bulb-outs, swales, and rain gardens intended to capture and filter stormwater before it runs to the Bay, adds Sutton: "They're designed with a certain sort of storm in mind. If it's too intense, the water will bypass. If we end up with bigger, less frequent storms, it might mean you have to redesign that infrastructure or it won't operate as effectively as you want."

Ironically, efforts to evaluate the effectiveness of green infrastructure at removing legacy and emerging contaminants from stormwater have also been stymied in recent years. But this is one area where automated sampling could play an important role going forward, says Chris Sommers, a stormwater monitoring consultant who works with both the RMP and county-level agencies throughout the Bay Area.

"[Remote samplers] are helpful to not miss storms, or to not spend money on storms that never appear, which is a big issue," Sommers says. "Our records show that about 25% of all predicted storms that you are ready to go out and mobilize for end up not producing enough rainfall that is sample-able."

Reducing the number of such "false starts" through automated samplers integrated into green infrastructure could free up funding and personnel for labor-intensive manual sampling required at other sites like creek mouths. And it's just this sort of innovating and prioritizing that will be required for stormwater monitoring programs to continue meeting regulatory requirements and helping protect water quality in the San Francisco Bay going forward, Sommers says.

"There are requirements to sample a minimum number of events per year, but if you only have five storm events that come through, then you gotta get those five storm events," he says. "There's no room for error here. Even if it's the middle of the night, even if it's Christmas, that's what the expectation is."

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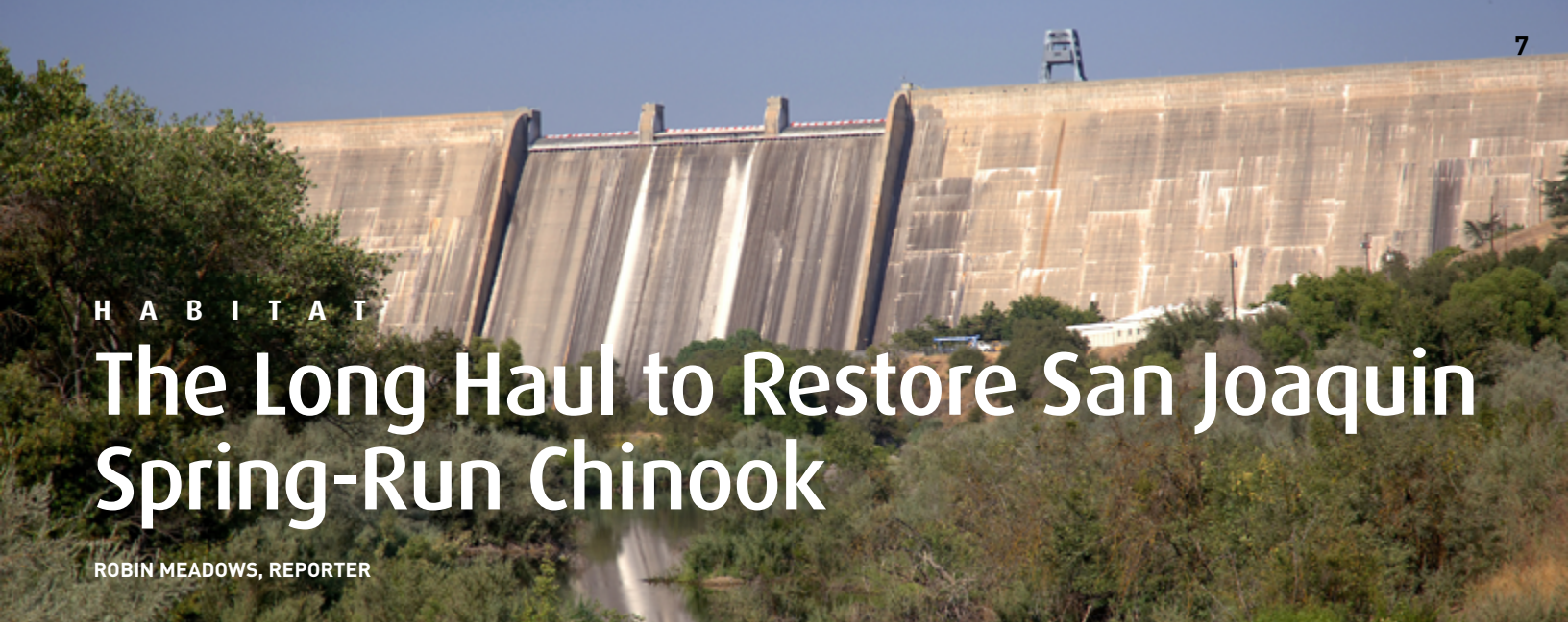

HABITAT

The Long Haul to Restore San Joaquin Spring-Run Chinook

ROBIN MEADOWS, REPORTER

When a team of fish biologists was tasked with restoring spring-run Chinook salmon in the San Joaquin River in 2006, none of them quite knew where to begin. The thirsty farms that crowd the river on both sides had taken almost all the water out of it most years since the mid-1900s, leaving a nearly 60-mile long stretch below Friant Dam near Fresno completely dry. The riverbed had been parched for so long that someone even built a house in it. The salmon that once thronged up-river by the hundreds of thousands had vanished, and there was no precedent for jumpstarting a population from scratch.

Then one of the team members joked that they should just write a white paper saying it wasn't going to work. "That broke the tension," recalls Gerald Hatler, who manages the California Department of Fish and Wildlife's Central Region Fisheries Program. "We all laughed — and then we sharpened our pencils and got to work."

That was shortly after a Natural Resources Defense Council (NRDC)-led coalition prevailed in its 18-year lawsuit against the Friant Water Users and the U.S. Department of the Interior seeking to restore threatened spring-run Chinook and other fish in the San Joaquin River. The settlement guaranteed water releases of up to 4,500 cubic feet per second for fish from Friant Dam and established the San Joaquin River Restoration Program, which is charged with restoring a naturally spawning, self-sustaining population of 30,000 spring-run Chinook while minimizing adverse impacts on agriculture and other water users.

The restoration program, which launched in October 2009, is a mix of spectacular success and drawn-out delays. Adult spring-run Chinook from test releases of young are already returning to the San Joaquin River after their decades-long absence. But key settlement target dates for officially reintroducing salmon and reestablishing fish passage by 2012, and releasing full restoration flows by 2014 have come and gone. Now, the program is finally on the cusp of major milestones on both the reintroduction and passage sides. The timeline for full restoration flows, however, remains uncertain.

Spring-run have a distinctive life cycle among Chinook. "Fall-run come up in the fall, spawn, and die," Hatler says. "Spring-run come up in the spring and stay the summer." The San Joaquin River used to be perfect for summering adult spring-run. The river starts near the crest of the Sierra Nevada; salmon would shoot upstream as high as 3,300 feet, where snowmelt kept the water cool in deep pools that sheltered these three-foot, 30-pound fish through the summer. Historically the San Joaquin River's spring run was one of the largest Chinook runs on the Pacific Coast with as many as one million returning as adults every year, according to California Trout.

Today the San Joaquin River has 27 dams, six reservoirs, and nine hydropower plants along its 366 miles, making it among the most heavily dammed and diverted rivers in California. It's all but impossible for fish to swim up the river. Salmon can only migrate to their remaining spawning grounds below Friant Dam in the wettest years, when the river runs at its highest. Most years the fish only make it as far as the San Joaquin River's confluence with the Merced River. The restoration program focuses on the usually inaccessible 152 mile stretch between the Merced River confluence and the 319-foot Friant Dam.

Although spring-run Chinook were long gone from the San Joaquin River when Hatler and his fellow fish biologists set out to restore them, there were still a few small populations in the Sacramento River. So the team decided to pool fish from those remnant populations and raise their young in a new conservation hatchery near Friant Dam. "We wanted to increase the genetic diversity so we could get a population uniquely adapted to the San Joaquin River," Hatler says. The conservation hatchery has been much delayed by construction troubles but is now on track to be operational in 2023, capable of producing upwards of one million young spring-run Chinook annually.

In the meantime, the restoration program began test releases of young spring-run from the Feather River Hatchery in 2014, starting with 60,000 and now exceeding 200,000 per year. These releases are experimental, designed not to restore the population but rather to inform the eventual large-scale reintroduction of conservation hatchery fish. So it was a thrill when these experiments had the remarkable result of producing 23 spring-run Chinook that completed their lifecycle and made it back to the San Joaquin River to spawn in 2019. Spring-run have continued to come back every year since, with 57 adults returning in 2020, 93 in 2021, and 11 in 2022.

"When I first got involved, I had a healthy amount of skepticism," Hatler says. "I've been pleasantly surprised."

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But his shift toward optimism is tempered by the fact that in all but the wettest years salmon still can't make it to the spawning grounds themselves. "We have to put them there," he continues. "Adults that come up the river get stuck well before Friant Dam so we truck them the rest of the way."

Even though they often need trucking, it's amazing that spring-run Chinook have begun returning to the San Joaquin River at all. "People were kind of shocked — we weren't expecting them to come back yet," says Trout Unlimited California science director Rene Henery, who has served on the restoration program's Technical Advisory Committee for a decade.

The odds against the salmon seemed too great. The experimental releases are quite small, fish get a mere trickle of the restoration flows they were promised in the settlement, and there are still major barriers to adult migration.

Donald Portz is doing his best to change that. "Wet years are few and far between," says Portz, who has been with the San Joaquin River Restoration Program almost since the beginning, first as the fish biologist and now as the program manager. "We need to improve passage in normal and dry years." In the driest years, adults will still need to be trucked upstream even after fish passage is improved.

Salmon swimming upriver run into three major barriers, which are at 18, 64, and 86 miles past the Merced River confluence. The first is a five-foot vertical drop at the downstream end of the Eastside Bypass, part of a 52-mile flood-control channel that conveys excess water from the San Joaquin River during very wet years. Water sheets down this drop too fast for salmon to withstand; the fix includes building a rock "ramp" that salmon can climb.

Next comes the nine-foot Sack Dam. Here, the fix includes bypassing the dam with a fishway designed to mimic a natural river channel. This project has been held up because the land around Sack Dam is sinking so fast due to groundwater pumping that it's literally a moving target. "It's very hard to come up with a design that will work with high subsidence for years to come," Portz explains, adding that program engineers think they've finally done it.

The last major obstacle is the 23-foot Mendota Dam and the adjacent Mendota Pool, a water-delivery hub with diversion channels radiating from it like spokes on a bicycle wheel. The channels are hazards for salmon, which can get diverted along with the water. This fix is more complex and includes a fishway around the dam as well as setback levees around the pool, which will create more than 800 acres of floodplain nurseries for young salmon migrating downstream toward the ocean.

While Portz initially intended to stagger these three fish passage projects, he now expects them all to be complete in 2026. This will allow salmon to swim the entire length of the restoration area in all but the driest of years. But for that, of course, they also need water.

Restoration flows are limited by factors the settlement didn't account for, such as seepage from the San Joaquin River into the almond and pistachio orchards planted in its former floodplains. Seepage can raise the water table, making soil too soggy or salty for these high-value crops.

This unforeseen consequence of restoring flows to the long-dry river has also delayed fixing the barriers to salmon migration. "Fish passage improvements were supposed to be the biggest expenditure, but the biggest expenditure to date has been buying seepage easements," says Doug Obegi, NRDC's director of California River Restoration. "These limits on restoration flows to prevent naturally occurring seepage is wasting taxpayer money — it's the biggest impediment to the success of the program."

The program is also hampered by the region's frontier mentality towards water. "It's still quite a bit like the Wild West on the San Joaquin River," Obegi says. People reportedly carry shotguns while adjusting valves, and agricultural water rights are fiercely defended.

Take the San Joaquin River Exchange Contractors Water Authority, called Exchange Contractors for short, which has some of the oldest water rights in the state and whose mission statement includes "maximize local water supply." When Friant Dam was constructed in 1942, nearly one-quarter million acres of farmland on the west side of the valley could no longer draw

SAN JOAQUIN RIVER RESTORATION AREA

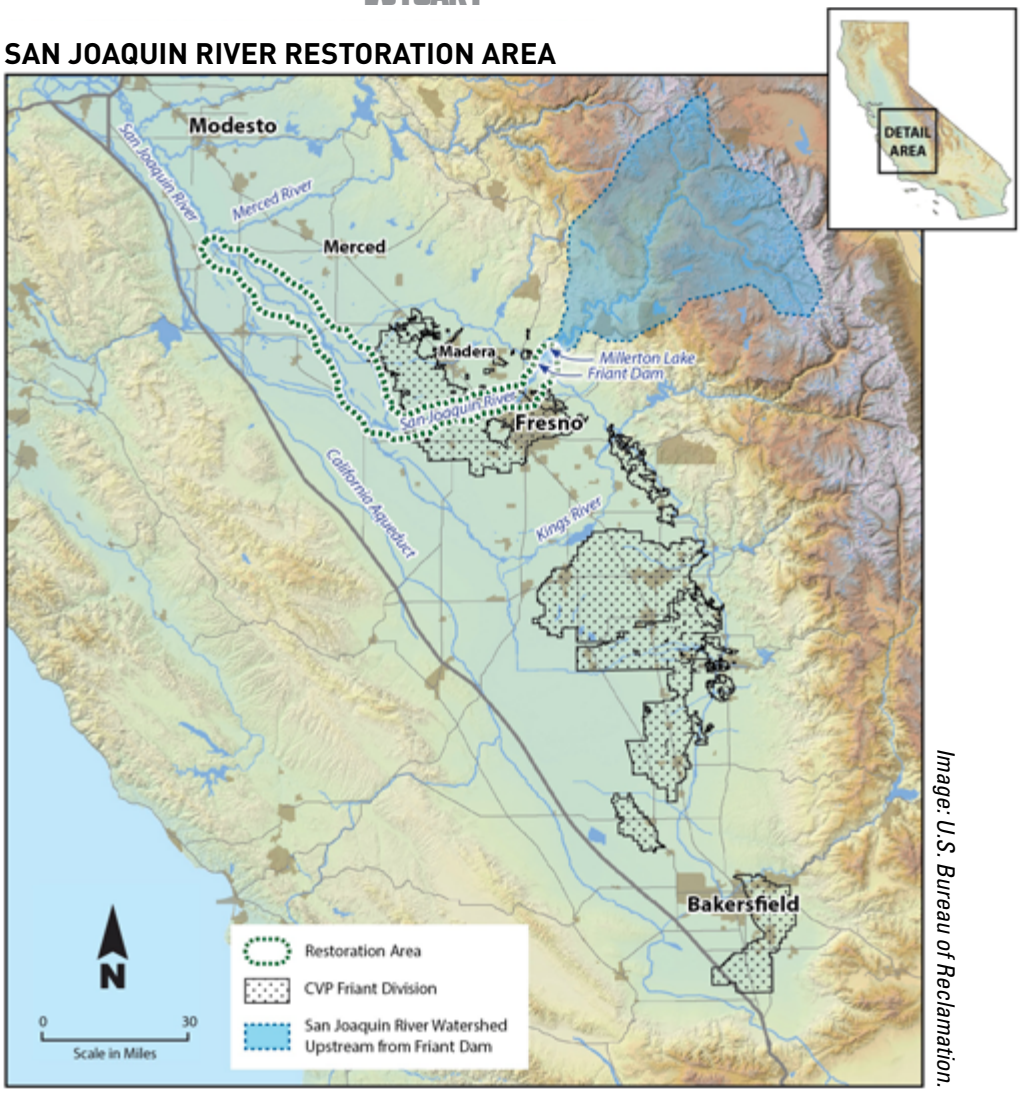

Image: U.S. Bureau of Reclamation.

water from the San Joaquin River. In exchange, west side farmers were allocated water from the Sacramento River via the Delta.

The catch is that when the Exchange Contractors are shorted on water from the Sacramento River, they make up the difference by reverting to their former water rights from the San Joaquin River. And the Exchange Contractors are not part of the restoration settlement, so they get this water at the expense of fish.

NRDC wants this exchange contract to be renegotiated. "In six of the past 10 years the Bureau of Reclamation has allocated as much or more water to the San Joaquin River Exchange Contractors than the entire flow of the San Joaquin River," NRDC wrote in May 2022 letter to the Bureau. "In several recent years (2014 and 2022) the San Joaquin River has been dewatered and dried up as a result of water deliveries from Friant Dam to the Exchange Contractors."

Exchange Contractors' releases are a double whammy for spring-run Chinook in the San Joaquin River. Besides decreasing the water available to salmon, these releases are drawn from the bottom of the reservoir behind Friant Dam and so deplete the coldest water. Adult spring-run need this cold water to survive the Central Valley's intense hot season.

LEFT: Hatchery-raised juvenile spring-run Chinook salmon are released at the Freemont Ford State Recreation Area. RIGHT: Program biologists monitor for returning spring-run Chinook salmon in the Eastside Bypass. Photos: U.S. Bureau of Reclamation/Josh Newcom.

These days most Central Valley Chinook are fall-run. But there used to be as many spring-run as fall-run, and the commercial fishery for the former once surpassed that of latter, with the California Fish Commission reporting catches of 567,000 and 213,400, respectively, in 1883.

But even though salmon fishermen once depended on Central Valley water for their livelihoods as much as farmers did, they were left out of the equation when people divvied up San Joaquin River flows. "When decision-makers replumbed the San Joaquin Valley to suit agricultural interests, salmon fishermen lacked political muscle," says John McManus, president of the Golden State Salmon Association. "We're living with the legacy of that to this day."

The success of the San Joaquin River restoration will depend on whether the salmon ever get the water they were promised in the settlement. "We've shown the naysayers that it is very much possible to bring back this population," Portz says. "But you've got to have water." If they get it, says Trout Unlimited's Henery, "Spring-run Chinook are totally recoverable in the San Joaquin River. There's tons and tons of reason for hope."

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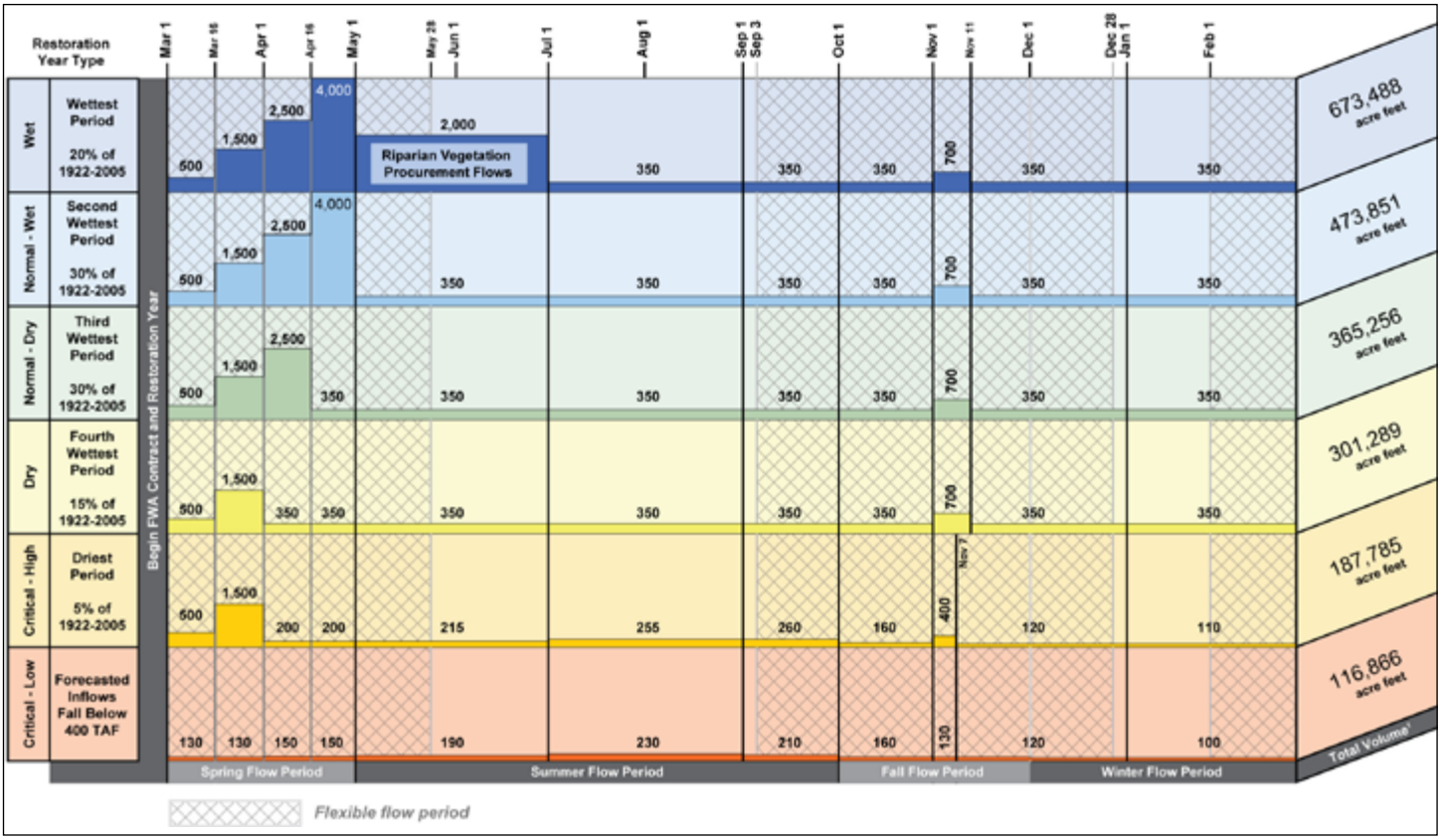

SJR Restoration Program Flow Schedule. Image: U.S. Bureau of Reclamation.

MAMMALS, *cont'd from page 4*

lighter or white underside. "These ones in the South Bay, the coloration and the shape of their faces, are especially cute," Smith says. With the deftness of long practice, she repositions the mouse to measure the length of its body and tail, determines its sex and breeding condition, and pops it into a plastic bag for a weighing.

After collecting samples for lab analysis — hair and a tiny snip of ear tissue — and attaching a numbered silver tag to its ear, Smith sets the little male on the ground. It freezes for a heartbeat before vanishing beneath the gray-green stalks of its pickleweed kingdom. By 9:30, Smith and the team have captured a respectable 16 salties and one house mouse at Dumbarton Marsh and Mowry Slough.

The ear tissue samples will be sent to Mark Statham, a UC Davis expert on salt marsh harvest mouse genetics. His analyses, also funded by the survey grant, will verify whether the rodents that were caught were salties or Western harvest mice, yielding more accurate population size estimates.

Beyond confirming species identity for the survey, the DNA sequences will provide nuanced insight into population divisions and robustness. The most important factor is genetic diversity, says Statham: "Diversity is sort of a measure of genetic health. The lower the diversity, the fewer genetic tools the animals have to deal with whatever they're getting hit with, such as climate change."

Marshes where mice are especially distinctive might, for example, merit extra preservation efforts. Similarly, populations with substantially lower diversity might need an influx of new genes.

"The longer the genetic divergence between two populations, the more evolutionary distinct they are. If we find populations that are very recently separated because of something humans have done, say a road, we can tell we have stopped the gene flow between them," Statham says. Here, removing the physical barriers isolating marshes, or creating novel linkages, could enable them to breed with neighbors again, bolstering their genetic diversity.

Among the most interesting puzzles awaiting Statham's attention is the geographic dividing line between the two recognized subspecies of the mouse. Currently mice in Suisun and San Pablo bays are grouped into a northern subspecies, while those from Point Pinole to the southern end of San Francisco Bay belong to the southern subspecies.

"Looking at the genetics of these animals across the range, we'll be able to figure out where the real break between the different subspecies is, and whether we have got additional distinct units within," Statham says.

By the time the survey wrapped at the end of August, it had amassed an astonishing trove of mouse-oriented information. Out of 50 traps set out for three nights apiece at 55 sites, the survey netted about 575 salties (a number that awaits genetic confirmation). Such statistics on trapping success can serve as estimates of population density — necessary for the federal government to declare where, when, and if the species merits delisting.

As for Smith, she is beyond pleased with the results. "We hit almost every site we wanted to get to, a lot of people got to participate and learn about the mouse, and we know a lot more already than we did before the survey," she says. "We will be able to do a lot of really cool analyses with the data, and answer some of the questions that we haven't really been able to address over the past 50 years. It should go a long way toward helping the species recover."

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2022 SALT MARSH HARVEST MOUSE REGIONWIDE SURVEY SITES

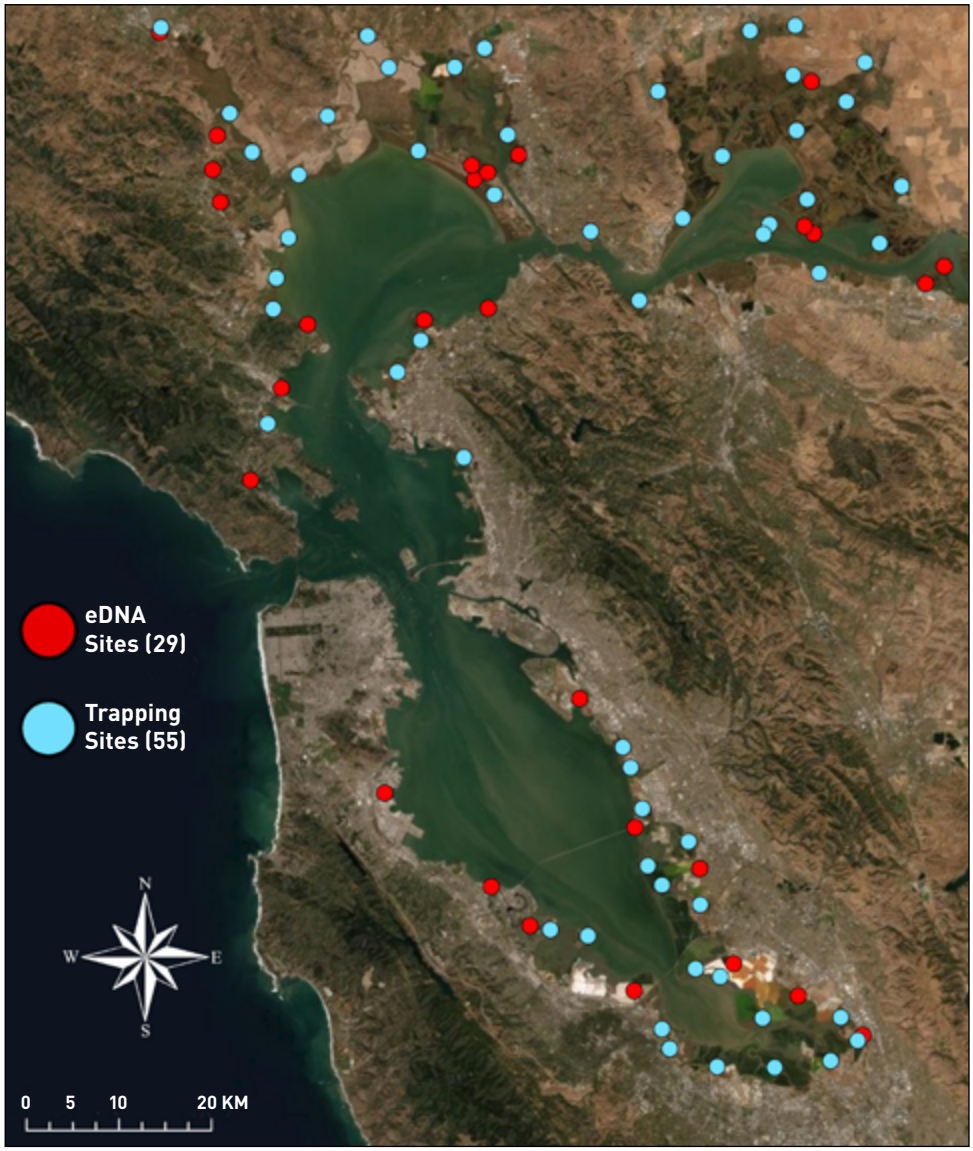


Image courtesy of Suisun Resource Conservation District

RESTORATION

Resurrecting the Carmel River Floodplain

SIERRA GARCIA, REPORTER

When the storm hit, it was lucky that my parents had a habit of leaving one car on each side of the Carmel River as they commuted from Big Sur into Monterey each day. The 1995 El Niño rainfall had pushed the Carmel River into hundreds of homes, and destroyed the Highway 1 bridge that connected Big Sur with the rest of the world. Most Big Sur residents were trapped during the week it took the Federal Emergency Management Agency (FEMA) to repair the freeway bridge.

But in the era before Zoom, my mother couldn't just stay home from nursing school. So my parents trekked past the mud of submerged artichoke fields on the river's south bank and onto the flooded Rancho Cañada golf course, where my dad was "surprised as hell" to find an intact wood-slatted suspension bridge. They crossed it with the river seething around their ankles, then backtracked past the flooded homes and parking lots on the north bank to where my mom's old blue pickup truck was waiting safely just above the floodwaters to carry them to school and work.

The Carmel River of the late 20th century was a tale of California water extremes writ small. In 1998 it flooded homes again, but in most years, the river was largely reduced to a trickle as it was siphoned off to water the blooming tourist mecca of the Monterey Peninsula. Endangered steelhead trout, members of the southernmost surviving population, would often find their attempts to swim upriver and spawn thwarted by strandings in low water before they could even reach the impassable dams upstream. The national advocacy group American Rivers even included the Carmel on its infamous "Most Endangered Rivers" list in 1999.

But in the last decade, the river has staged a surging comeback, with a high-profile dam removal in 2015 presaging a new wave of restoration about to break ground. The river's degraded floodplain is now poised for a transformation born of decades of advocacy — just in time, many hope, to turn the fortunes of the fish, frogs, and people who are threatened by the river's status quo.

Life After Dam

On a breezy July afternoon, I retraced my parents' path upriver from Highway One along the southern edge of the Carmel River floodplain. The artichoke fields my parents slogged through decades ago had long since given way to a flat, sun-baked pasture dotted with grazing cattle, with only a distant line of trees hinting at where the sunken river flows beneath the freeway bridge that replaced the one it destroyed in 1995. Just on the other side of the freeway, where the river flows into the Carmel River Lagoon, I could see a slice of white beach where the lagoon meets the sea. Several leaders of the Carmel River Floodplain Restoration and Environmental Enhancement project (CR-FREE) walked alongside me.

Cows graze on the Carmel River floodplain, where the CR-FREE project will soon break ground. Photo: Sierra Garcia

"The river will once again be connected to the floodplain, and the floodplain will be connected to the lagoon in a way that hasn't happened since the levees were built," Rachel Saunders explained as we gazed across the yellow landscape toward Carmel River Beach. Saunders is director of conservation at the Big Sur Land Trust, one of the core members of what she describes as the "Rubik's cube" of groups enmeshed in the decades of planning for the CR-FREE project.

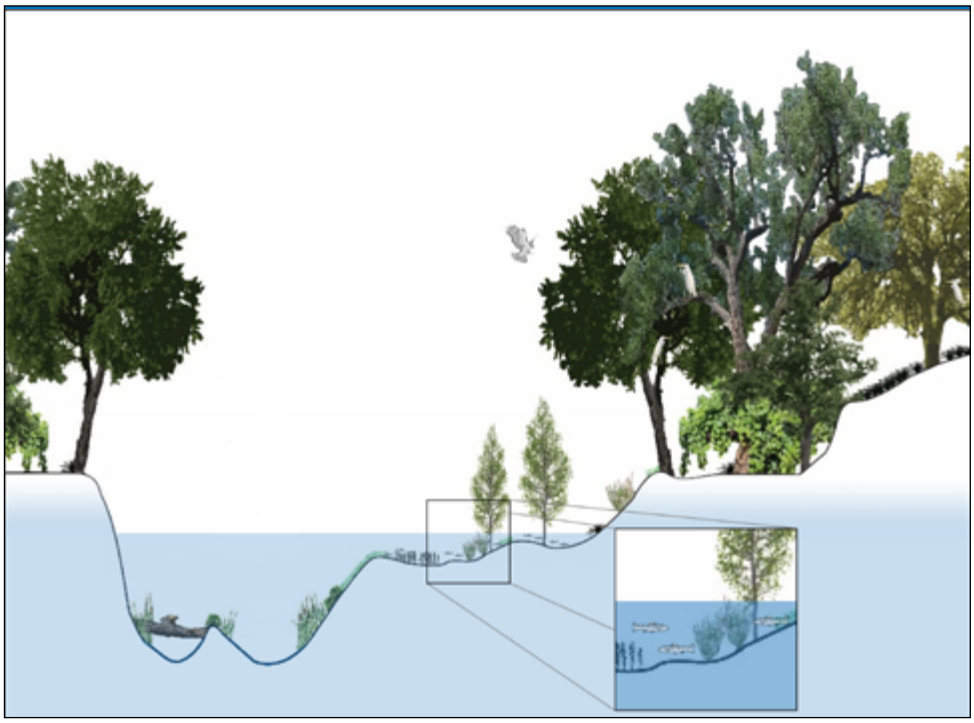
continued on next page

Left: The Carmel River South Lagoon looking east. Photo: Monterey Peninsula Water Management District.
Right: The Carmel River near Garland Park. Photo: Lorin Letandre

So far in the 21st century, the river's biggest claim to fame has undoubtedly been the 2015 toppling of the San Clemente Dam, the largest dam-removal project ever completed in California. Saunders describes the ambitious floodplain plans now in motion as a "bookend" to that event, with the restoration leaving as monumental a mark on the river's fate as destruction of the century-old dam.

Today, the hundreds of people who have invested time, money, and expertise into returning the floodplain to some semblance of its original self fall into two camps: those working on the CR-FREE site, which abuts the freeway where the surging river once washed the bridge seaward, and those involved in a separate, more recent, project on county-park property just upstream called Rancho Cañada. Both projects boast similar aims: restoring floodplain habitat for threatened species like steelhead while diminishing future flood damage to homes and businesses.

The CR-FREE restoration plan hinges on punching a series of holes in the century-old levees along roughly a mile of the river's south bank. The levees were originally built to protect the farmland on the south bank, and in most years, they accomplish that — but they have also corralled the river over time into a sunken incision, like a canyon. The holes in the levees will allow smaller channels of water to spill onto the floodplain when the river fills.



The Rancho Cañada project will lower the floodplain by up to 15 feet. Image: California Coastal Conservancy.

The broad vision of reshaping the lower floodplain, where the river flows seaward beneath the freeway, has existed since the catastrophic El Niño floods of the 1990s. Planning began moving "in earnest" a decade later, Saunders tells me, and by the mid-2010s, efforts to make what became known as the CR-FREE project a reality were fully underway. CalTrans had come on board for the eventual construction of a second causeway bridge under the freeway, and actor-cum-local-politician Clint Eastwood, who had acquired the old artichoke farmland decades previously and committed part of it to CR-FREE, had agreed to donate his remaining acres of that property to the project.

But decades of coming out on the losing end of local water politics was still straining the river and its denizens, especially as chronic drought gripped the state. The historic San Clemente Dam removal upstream brought hope for the river to conservation groups, and steelhead advocates in particular, but nobody expected the water windfall that was to come.

A Confluence Upstream

For decades, the Rancho Cañada golf course was one of the largest water guzzlers drawing from the river, second only to the residential and industrial users of the Monterey Peninsula. It was a plum parcel on the lip of Carmel Valley, an area known less for its eponymous river than for its

tennis courts, boutique wineries, and vacationing millionaires escaping the fog of Pebble Beach. So for Christy Fischer, then the executive director of the local Santa Lucia Land Trust, it was a shock when the sprawling property went up for sale in 2016, after nearly half a century of operation.

Fischer was desperate for the land trust to acquire the parcel not only for the prospect of new public access trails, but because the alternative could have shifted the ecology of the area from bad to worse. The land going up for sale meant the water rights were for sale as well. The golf course was at least open space, and she feared that the choice location — and the water that came with it — would inevitably lead any other buyer to erect "a wall of development" beside the riverbed.

Right away, recalls Fischer, "I knew I needed to bring that price down. I couldn't compete with five developers."

She obtained an agreement from the Monterey Peninsula Regional Park District to eventually take over managing the parcel, and then asked property owner the Hatton family to consider accepting a more modest price, in exchange for leaving a legacy of land to the wider community. To her surprise, they agreed. The California Coastal Conservancy, California Natural Resources Agency, California Department of Fish and Wildlife, and Wildlife Conservation Board (to name just a few) all chipped in to fund the acquisition, and the golf course became public land.

"Given the [proximity] to popularized, urban areas, it's really incredible that that many hundreds of acres are set aside," says John Bair, a restoration ecologist with McBain Associates who consults on the Rancho Cañada restoration. "That makes it a really unusual opportunity." (Of the nearly 200 total acres that were acquired from the former golf course and converted to public space, the floodplain at Rancho Cañada will be restored on 40 acres; the CR-FREE project will restore 100 acres of floodplain.)

Tom Gandesbery, project manager at the California Coastal Conservancy — which has invested $2 million in the Rancho Cañada restoration — agrees that holds true for both projects. "There are these two very fairly large pieces of real estate that weren't completely paved over and turned into houses or shopping malls," he noted. "In a lot of parts of California, you can find rivers like the Guadalupe River in Santa Clara County that goes through San Jose. The upper watershed might be intact ... but when you go down to the lower watershed, where the floodplains were historically, they've all been developed."

Sandbar willow switches, center, are among the plants essential to local native cultures that will be planted along the restored Carmel River floodplain. Photo: Sierra Garcia

Projects for the People

Linda Yamane says she "almost jumped out of [her] chair with excitement" when she learned that sandbar willow will be among the species planted along the restored Carmel River floodplain. The ancestors of the Rumsen Ohlone master basketweaver and tribal scholar lived along the Carmel River a mile upstream from the Rancho Canada project, and relied on tender willow shoots, earthy sedge rhizomes, and fibrous dogbane to craft everything from ceremonial baskets to jewelry and practical tools of everyday life.

"[Sandbar willow] is the one willow species with all of the attributes needed for fine basketry work — and it's very difficult to find in this area any more," she explained to an audience of restoration practitioners at a conference in May 2022. "The plant list could make the difference between life and death of certain local traditional native practices."

When Yamane's many-greats grandmother (seven generations back) was baptized in the Rumsen Ohlone village of Tucutnut in 1773, the Carmel River would still have been densely vegetated, and a lifeblood — as it remains today — for species such as steelhead and California red-legged frogs. The river was important to native people beyond Yamane's tribe as well, including the Esselen Tribe of Monterey County and Ohlone Costanoan Esselen Nation.

Returning culturally relevant species to the floodplain, including one that has been completely eradicated from the riverbank for at least a century, is one of many community benefits that both restoration projects hope to provide. The former golf course land is already crisscrossed with hiking paths that continue on into the Big Sur hills, and the CR-FREE project will eventually provide trail access that connects to the same network — and beneath the freeway, to the ocean. Unlike the admiring crowds that throng many scenic hikes near the Monterey coastline, the folks strolling across the old putting green are locals: dogs returning contented from long walks, pairs of gossiping friends, families with children.

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But the most important project benefit in the community psyche remains flood protection. Once the CR-FREE project is finished, the county estimates that a hundred-year flood would surge through the restored floodplain two to three feet lower than it would today. The restoration will save Monterey County $14 million in levee repair costs it would otherwise need to shoulder to protect the homes and businesses along the river from catastrophic flooding; it is also likely to reduce insurance costs for some homes. Both restoration projects have received floods of support rarely bestowed on unglamorous engineering proposals, including hundreds of public comments in favor of the CR-FREE project during its environmental impact review phase. Margaret Robbins, a constituent who delivered 18 pages full of signatures in support of the project to the County in 2019, summed up the prevailing sentiment: "I can't imagine how anyone could object to CR-FREE. Let's get it approved and built as soon as possible."

Timing Is Everything?

Although the San Clemente Dam existed almost 18 miles upstream of the present-day restoration sites, it offered some lessons for the floodplain project planners. After the dam was dismembered, engineers refashioned the riverbed around it with meticulous care (and millions of dollars) to create a variety of natural-looking pools that would nurture endangered steelhead traveling upstream to spawn.

The river had other ideas. The first heavy rains after the project's completion rearranged boulders, branches, and embankments at will. This time, says Rancho Cañada project consulting hydrologist Ben Snyder, the plan is to stay hands-off after the excavation and planting and "[allow] the river to do river things."

"Our whole approach that we're taking to rewilding this river is really taking the shackles off … [and] helping to create a safe space for river processes," he added. "By [removing enough earth to] lower the floodplains as much as 13 to 15 feet, we're going to be creating these nice open spaces where this channel can meander and occupy new parts of the floodplain."

The CR-FREE planners downstream don't have as much leeway to let the river freely flood and meander — although they hope and expect it to do so some years, within the limits of the land currently used for cattle grazing. If the river's primary channel under the freeway were to migrate, it could jeopardize the wastewater treatment plant that sits precariously near the lagoon where the river runs into the sea. Still, the river will have far more leeway than at any point in the last century to wander and carve new paths through the surrounding landscape.

Both the Rancho Cañada and CR-FREE projects will need years to realize their fullest benefits. The final heavy-lifting steps of the downstream CR-FREE project, constructing the second causeway bridge beneath the freeway, could be completed by 2027. But even then, it will take years for the native saplings and sedges to form the rich riparian canopy around the expanded riverbed with enough root structure to withstand stronger flood flows.

One certainty is that the floodwaters will rise again, and much higher than the ones that my parents forded in the 1990s. Based on historical modeling, a 100-year flood is overdue. But climate change's altering of precipitation patterns may make a "100-year" flood of the last century more likely in this one. An atmospheric river in 2017 came close to overtopping the levees, Saunders points out, and climate change is stacking the odds of more extreme rain higher than past records would suggest.

"People who live on the other side still have very clear memories of what it was like on their second floors looking down at the water that filled their garages," Saunders says. "So every year it's a concern. We're living on borrowed time."

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The CR-Free Project site. Inset: Rendering of completed project. Photo: guru.foto. Rendering: Big Sur Land Trust

L E G A L

South Bay Fish Fight

ALASTAIR BLAND, REPORTER

Two decades after the South Bay's main water supplier agreed to restore aquatic habitat in the streams that flow from its reservoirs, fish in the region remain in dire straits, and local river advocates say it's the Santa Clara Valley Water District's fault. The agency, which serves the taps and toilets of 1.9 million Santa Clara County residents, has made some improvements on fish habitat along miles of stream and increased the amount of water it releases from its reservoirs. Yet Chinook salmon and steelhead in Coyote Creek, Stevens Creek, and the Guadalupe River remain about as scarce as ever.

Several environmental organizations want Valley Water to do more, and last month one of them, San Francisco Baykeeper, sued the district, alleging it was neglecting its responsibilities to protect public-trust resources. Baykeeper accuses Valley Water of violating state laws and the California Constitution while making feeble effort to help restore ailing species. At the heart of the suit, filed September 27, is water: not enough, Baykeeper argues, is being allowed out of the district's reservoirs to support healthy fish numbers, which state law requires that dam owners do.

"Once you build a dam, you're responsible," says Ben Eichenberg, an attorney with San Francisco Baykeeper. "The law says you have to keep the fish in good condition."

The fish populations in the South Bay's watersheds are unquestionably in poor condition, but Valley Water biologists say that's no fault of their agency. The district, they argue, has completed more than 20 projects to facilitate fish migration and spawning throughout the county in the past two decades, and has collaborated with a collection of organizations and agencies on improving stream flow conditions for migratory fish.

While Baykeeper's lawsuit demands that Valley Water "increase releases of freshwater flows to provide habitat connectivity that is unavailable under the current flow regime," the water district's staff say they're already releasing flows described in the "Fish and Aquatic Habitat Collaborative Effort," which Valley Water produced with a handful of agencies and environmental groups in 1997. The FAHCE plan outlined a variety of needed habitat-improvement measures that would ostensibly help disappearing fish species.

Guadalupe River at Foxworthy Blvd. overpass, May 2021. Photo: Baykeeper

"Valley Water has been implementing the FAHCE ... on Stevens Creek and Guadalupe Creek for the past two years," Valley Water's John Bourgeois wrote in an August 25 letter to Baykeeper, shortly after the environmental group threatened to sue. He noted that because of drought-related supply issues, "Valley Water has been able to release only a few ... pulse flows for fish during this two-year period."

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LEFT: Placing spawning gravels on top of creek bottom to improve fish habitat, Los Gatos Creek, 2019. Photo: Valley Water.
RIGHT: Woody materials attached to bank by cables, Feb. 2022. Photo: Baykeeper.

But much restoration work that Valley Water has committed to completing remains undone. While the district has proposed spending $126 million on habitat-improvement projects, it could be decades before major stream revisions are completed.

"They're just dragging this out indefinitely," Eichenberg says. "They've already had 20 years to do this. It shouldn't take 40."

Valley Water's biologists say they have been hard at work to restore Chinook and steelhead habitat for the past 20 years. The district is also collaborating with the National Marine Fisheries Service, California Department of Fish and Wildlife, and U.S. Fish and Wildlife Service to improve available flows for salmon and steelhead while preserving enough reservoir water to maintain supplies for people. Recharging groundwater basins is another responsibility weighing on the district, Bourgeois says.

He says the whims of nature are making the district's job difficult. Creeks run dry during periods of extended drought, which challenges the agency to meet its responsibilities.

"We have multiple objectives at Valley Water," Bourgeois says. "We have flood risk management to take into account, we've got water supply for the two million residents of Silicon Valley, and we've got sensitive aquatic habitats."

The current regulatory fight stems back more than a quarter century. In 1996, the Guadalupe-Coyote Resource Conservation District filed a complaint against the State Water Resources Control Board and Valley Water to contest the district's management of Stevens Creek, Coyote Creek, Guadalupe River, and their tributaries. The complaint alleged that Valley Water had, since initiating its operations in 1928, degraded fish habitat and violated Fish and Game laws and the public trust. The FAHCE plan was produced the following year. Six years after that, Valley Water codified the FAHCE measures in another document, the 2003 "settlement agreement" — what Valley Water's website calls "a roadmap for resolving water rights complaints and for improving habitat conditions for fish in the three watershed areas." In 2021, Valley Water produced a draft Environmental Impact Report outlining implementation of the remaining settlement agreement measures.

What concerns Eichenberg, among others, is how the draft EIR, 18 years after the settlement agreement, proposes to reset the clock on the timeline for fish recovery. It describes a decades-long, phase-by-phase plan "to support fish passage, spawning and rearing habitat, and hydrological enhancements."

"Phase 1 would be implemented over a 10-year term ..." the report reads. "If program objectives are not being met, Valley Water would implement Phase 2 for a 10-year period, potentially followed by Phase 3. If during the 10-year program evaluation Valley Water determines that program objectives are not being met, they would transition to Phase 4."

Patrick Samuel, the Bay Area director of California Trout — one of the groups that initialed the settlement agreement in 2003 — says the draft EIR was released more than six years later than he and others had expected. It was also, he says, "pretty disappointing." For one thing, Samuel says, the draft report failed to describe any population-recovery targets for migratory fish species.

"We were shocked that more had not been done to link stream flows to habitat-restoration opportunities so we could determine whether Valley Water's proposal would provide enough habitat to support fish in good condition," he says. Samuel also says the document pushes into the future watershed restoration actions that should already be completed.

"We anticipated the agreement would go into effect in 2005 and that all Phase 1 measures would be completed in the first 10 years," he says. "There's a whole host of things that were supposed to have been done basically right away that still have not been done."

Whether the South Bay's imperiled fish species can last much longer isn't clear. A 2017 study from San Jose State University professor Jerry Smith even concluded that seagoing steelhead might already have been extirpated from Coyote Creek and its tributaries during a five-year spell of inadequate flow conditions resulting from drought and reduced reservoir releases. In a summary of the findings, Smith, now retired, wrote that Valley Water's reservoir management led to numerous periods when the water in the creek was either too scant or too warm to support steelhead migration and rearing.

Lisa Porcella, an environmental services manager at Valley Water, disputes the theory that steelhead have vanished, explaining that these seagoing fish are well adapted to survive droughts. Genetically identical to rainbow trout, steelhead can reside in freshwater for years if passage to saltwater has been lost due to

drought or diversions. That, Porcella says, is what steelhead have done in the South Bay.

"These fish populations, while they may not be thriving due to drought conditions, they're hanging on, and they're hanging on because of the diverse life history," she says.

Chinook numbers have also reportedly crashed in the Guadalupe River, though baseline population levels are unknown. Research published last year in the journal PLoS ONE identified Chinook salmon bones from an ancient Native American village in the Guadalupe River valley, and a 1904 newspaper account refers to San Jose locals fishing for salmon in the stream. As late as the 1990s the fish reportedly returned to spawn in large numbers. Roger Castillo, a lifelong San Jose resident and naturalist who has spent countless hours observing and filming local watersheds, says he counted "thousands" of adult Chinook in the Guadalupe River in 1994 and again in 1996. The fish, he says, were congregated in lower estuary waters as well as deep upstream pools.

"I saw them with my own eyes," says Castillo, an associate director of the Guadalupe-Coyote Resource Conservation District, which withdrew from the FAHCE agreement in 2020 partially due to the slow pace of implementation.

Porcella, however, says "there is no documented credible scientific evidence to support" claims that the South Bay ever supported abundant Chinook runs. Both camps agree that the fish today are scarce.

Eichenberg commends Valley Water's staff and field crews for improving structural habitat throughout the watersheds, but says such work will be ineffective without additional water. "If you walk these creeks, you'll find these really nice gravel beds and woody debris that's been artfully arranged, and it's all a foot above the waterline," he says.

Rick Lanman, who led the PLoS ONE study and is president of the Institute for Historical Ecology in Los Altos, recognizes the work Valley Water has been doing but thinks the projects completed to date are too few and far between to make a positive dent in ecosystem function. "They've done a patchwork of good things," he says, "but that hasn't made any single watershed more viable."

Valley Water biologists say their restoration efforts have made miles of habitat accessible again — but what caused local fish declines in the first place is a source of contention. Water district staff direct the blame toward climate change and drought, which have limited the amount of water available for streams and rivers. Others, though, blame Valley Water. Baykeeper alleges that the water supplier has violated California's Fish and Game Code, which prohibits owners of any dam in the state from harming fish downstream. Specifically, code 5937 states that "[t]he owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around, or through the dam to keep in good condition any fish that may be planted or exist below the dam."

Fluctuations in local salmon numbers could also be due to the changing overall abundance of the species on the West Coast. Isotopic and DNA analyses of South Bay Chinook tissue samples have confirmed that the fish that swim up the Guadalupe River are primarily — but not entirely — born in Central Valley fish hatcheries. Because many of these fish are trucked to saltwater for release and thereby deprived of the olfactory homing system that leads most wild salmon back to their natal streams, the fish often stray into other rivers and creeks — like those of the South Bay.

Steven Holmes, executive director of the South Bay Clean Creeks Coalition, believes the decline of Chinook through much of their West Coast range makes it imperative to protect any watershed where the fish are taking refuge, whether or not they are native. And Lanman agrees that the South Bay's creeks could be vital to the species' future. "We really need to protect Chinook at the southern end of their range," he says. In warmer, drier watersheds, he explains, natural selection may create drought-tolerant genetics that could prove valuable to the species' adaptation as salmonids are squeezed northward by warming.

Holmes is hopeful that improved river conditions will allow Chinook from other regions to naturally recolonize South Bay watersheds. With the goal of rebuilding South Bay Chinook and steelhead runs, his group has removed more than a million pounds of trash from local watersheds in the past decade, and next year they plan to add gravel and woody debris to a section of Los Gatos Creek to help spawning fish.

Samuel, at California Trout, feels the South Bay has a unique opportunity to set a precedent for fish recovery in urban watersheds. You used to be able to walk to a Sharks game and look down at the water and see Chinook salmon spawning in the heart of downtown — that's unbelievable, but it was real," he says. "I think the opportunity for recovery is huge, but if we can't do it in Silicon Valley, in the heart of innovation, where can we do it?"

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Salmon in Los Gatos Creek. Photo: Mike Tamaro

DROUGHT

Rocky Road to a Fresh Enough Delta?

ARIEL RUBISSOW OKAMOTO, REPORTER

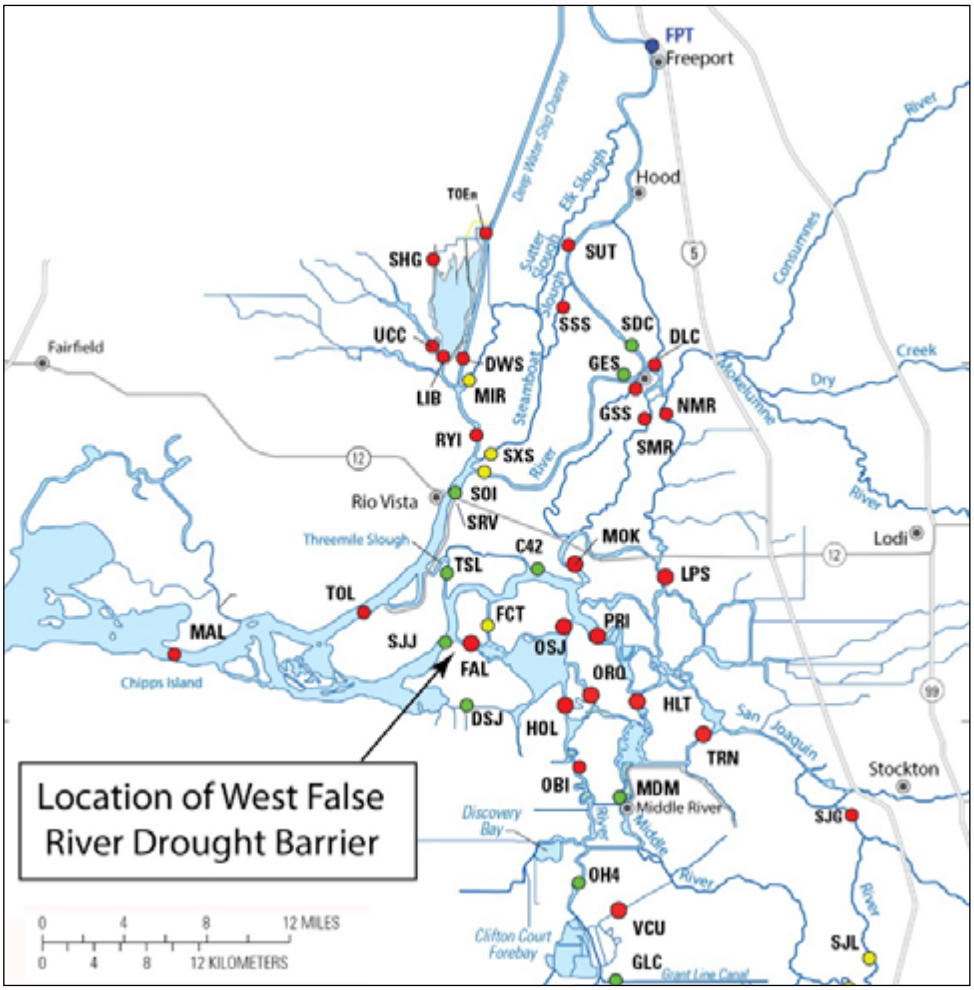
Nothing reveals just how much the upper Estuary's seesaw of tides and freshwater flows is micro-managed than prolonged drought, and the resulting fiddling with barriers, gates, and water quality standards to prevent the ocean tides and salinity from intruding too far upstream. Come summer, managers begin to talk fearfully of "losing control of the Delta" and the dreaded outcome: salt water too near the export pumps that supply tap water for millions of Californians.

The ominous language is also reflected in the nickname of a new monitoring station at channel marker 42: "the point-of-no-return" station. Installed this August on the San Joaquin River just downstream of the Mokelumne River, the station joins a network of about 40 others at key Delta locations operated by the US Geological Survey (USGS) and the Department of Water Resources (DWR, see map). These stations send real-time data on water velocities, flow rates, salinity movements, and other water quality constituents swirling around the Delta to a computer platform every worried water manager can't help keeping an eye on.

"It's an early-warning location," says USGS hydrologist Jon Burau.

Last year, water managers got dangerously close to letting the salt all the way up the San Joaquin River near the northern confluence with Old River. "Once it comes in that back door, you're in real trouble," says Greg Gartrell, a consulting engineer and former assistant general manager of the Contra Costa Water District at the edge of the Delta. The new monitoring station tells managers exactly what's going on at that critical backdoor. An intensive series of workshops spearheaded by the Delta Stewardship Council this year is also bringing increased attention to the challenges of, and options for, salinity management.

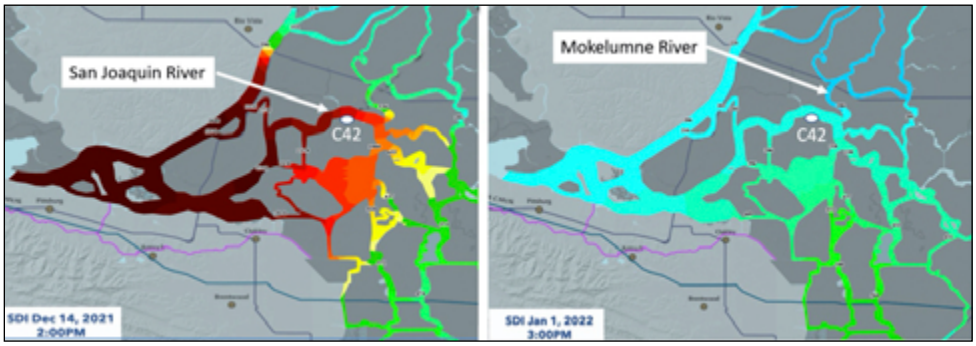
For the last few decades, the one physical thing keeping that back door shut has been a 30-foot-tall wall of rocks placed intermittently in the West False River. Conditions have been so dry that the barrier has been in place since June 2021, but removal is due to start this October and finish by the end of November. The last time the Department of Water Resources placed a barrier here was in 2015.



Locations of the flow and water quality stations of the core monitoring network operated by the USGS and DWR, the "point-of-no-return" station (C42), and the West False River Drought Barrier. Source: USGS

SALINITY STARTING TO INTRUDE INTO FRANKS TRACT

SALT FLUSHED OUT OF SYSTEM DUE TO ATMOS. RIVER



Heat maps of the Central Delta salt field in on December 14, 2021 and January 1, 2022. Image at left shows salinity intrusion at the Delta's backdoor and the Channel Marker 42 station - the point of no return just downstream of the Mokelumne/San Joaquin River confluence. Images: Bay Delta Live

"We've had these horrible, horrible dry periods that were unprecedented in the prior record," says Gartrell, only four wet years from the last 20. In the past, that might have been enough wet years to get by, for water supply managers and users, but now climate change is making it much hotter and dryer, says Gartrell. "If we rely on what's happened in the past, we're going to get burned."

In an Environmental Impact Report released this summer, DWR requested a permit for two more barrier placements in the next ten years. "It's so unpredictable, and very situational, what Mother Nature is going to give us, but we need to be prepared in the event we don't get the rain or snow we need," says DWR engineer Jacob McQuirk.

Barrier Basics & the Toolbox

Here's a brief lesson in the purpose of the barrier for the uninitiated. Two big rivers flow through the Delta to the Bay, the Sacramento with its high-quality freshwater and reserves behind Shasta and Oroville Dams, and the San Joaquin, which has historically produced less runoff and water of poorer quality, especially as the drought persists. Water managers use several physical tools to keep the choice Sacramento River water in the central Delta flowing toward the pumps, via the so-called "freshwater corridor," including closing and opening the giant metal gates of the Delta Cross Channel, releasing water from reservoirs to push salt water back downstream, and tapping alternate supplies like groundwater. "In severe droughts we simply don't have the water to keep the freshwater corridor open" says Burau.

As the ocean tides push salty water further and further upstream during dry conditions, the salty water eventually reaches West False River, historically a dead-end slough but now a channel from the San Joaquin River into the vast flooded island of Franks Tract. On the other side of the tract is a dangerous opening to that mainline to the pumps, Old River.

False River is where DWR occasionally builds a physical rock barrier to plug this pathway for saltwater intrusion, avoiding water supply Armageddon: "losing the Delta." If the drought gets worse, they may also add smaller barriers in Steamboat and Sutter Sloughs, which helps redirect additional Sacramento River water into the Central Delta.

"If you push water out of one area it pops out somewhere else," says Gartrell, which complicates salinity management.

Beyond the physical controls, there are policies that protect the various beneficial uses of Delta waters: fish habitat, water supply, agriculture, recreation, and the like. Many standards are pegged to salinity levels and specific time periods: For example, an agricultural standard requires water to be fresh enough for irrigation until the end of the growing season (August 15), while the estuarine habitat standard (also known as X2) requires the salt/fresh mixing zone to be in a specific place in the western delta between February and June, when young fish benefit from it most. Each year, and especially during drought, managers juggle all these standards, as well as various approved reasons for relaxation, such as temporary urgency change petitions (TUCPs) from DWR. A variety of federal and state pumping permits also come into play.

"Things are a lot better than they were in 2015; we're learning to coordinate the barrier and flow management to save the most [fresh]water," says DWR engineer Eli Ateljevich.

According to Gartrell, the barrier saved the state about 400,000 acre-feet of water in 2021, water that would have had to be used to push salinity downstream, if that pile of rocks wasn't sitting in False River.

Fish Loss, HABs & Other Effects

Last winter, when they decided to keep the barrier in place rather than removing it in November, managers notched it to allow vessels and juvenile salmon to exit Franks Tract. But managers found the notch acted like a high-pressure nozzle, more harmful than helpful to salmon caught in the flow or trapped in eddies (where they might be eaten for dinner). They still aren't sure, however, if the river is an important migratory pathway for fish.

"Their chances of survival go down once they get into Franks Tract and into the interior Delta," says McQuirk. In the coming years, DWR and other agencies plan to conduct more intensive acoustic telemetry monitoring of tagged fish to better understand which life stages of salmon use False River and how it affects their survival. Last year DWR

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West False River Barrier, looking northwest, near the confluence with the San Joaquin River. Photo: Florence Low, DWR

completed a study evaluating predation at the barrier and will determine if any tagged salmon were detected by acoustic receivers (early estimates suggest at least 40 were detected last year). Acoustic telemetry will continue into 2023. "We want to pin down if passage is an important thing for West False River," says McQuirk.

Another question in barrier management is how to prevent it from contributing to harmful algal blooms (HABs) and the already excessive growth of invasive weeds in Franks Tract. Neither of these are good for native fish, recreational water quality, or drinking water supply (see p.2).

HABs were not a problem when the barrier was in place in 2015, but they were in 2021 and 2022. It is not known what caused the change. Since the barrier impairs flows, it can increase the residence time of water in Franks Tract, possibly exacerbating HAB problems.

To flush the HABs, concerned observers proposed inserting some culverts with flap gates to block flood tides but allow ebb tides through the rock barrier. While initially it seemed like a good fix, modeling suggested otherwise. "It would have taken 48, forty-inch-wide culverts to make a dent in the residence time," says DWR's Ateljevich. "When you look at culverts and notches, it's hard to make a difference without ruining the salinity intrusion protections afforded by the barrier. Trying to change the barrier design is like working in handcuffs, shackles, and ankle bracelets." A smaller-scale approach to culverts could possibly help with localized stagnation in the future, however, suggests Gartrell.

Permanent Plug

The new point-of-no-return monitoring station reflects growing recognition that with drought, changes in snowpack and runoff, climate change, and sea-level rise, managers will have less and less freshwater at their fingertips to push the nasty saltwater out of the way. Sea-level rise, in particular, is going to push the entire system of salinity standards and physical barriers to the mat.

There may come a time soon when all the usual antidotes to "losing control" might not be enough in climate-changed Delta to keep water flowing to our faucets and irrigation intakes. There is a more permanent solution waiting in the wings however: plugging the West False River with a tidal marsh.

Crews make a notch in the drought barrier in January 2022 to allow fish and vessels to pass through. Photo: DWR

Since 2017, a collaborative group of scientists, engineers and planners led by Cal Fish & Wildlife has been working with residents of the communities around Franks Tract (such as Bethel Island) to redesign this 3,000-acre flooded island.

"In its current state, Franks Tract is a really big, really bad actor in the central Delta," says USGS's Jon Burau. "It's like Mount Shasta in terms of salinity intrusion. It creates its own weather."

The most recent "Franks Tract Futures" proposal is for a multi-benefit project that would deepen some areas of the tract to prevent invasive weed growth and use the dredged material to create new land masses. Some masses would offer recreational amenities like boat docks and beaches, and others tidal marsh and native fish habitat. About 213 acres of tidal marsh (of 1,300 total planned for the project) would be placed in the West False River, creating not only excellent native fish habitat but also a permanent natural drought barrier.

Even better, "The restoration remains resilient as sea level goes up," adds the agency's Eli Ateljevich. "It's also a bit more energetically balanced than a big pile of sharp rocks that the tides deflect off. It's a softer, squishier, more energy-absorbent solution."

Changing the Landscape

Franks Tract is just one example of many steps we could take to change the landscape of the Delta to better manage tidal intrusion and create more habitat for fish.

"The tides are lazy, they take the least path of resistance," says Burau. Manipulating the tides by changing the landscape could not only help mitigate the salinity intrusion problem in the Central Delta, he says, but also provide myriad ecosystem benefits, including increasing the production of fish food from shallows and marshes, connecting habitats that produce organic carbon (such as the Deep Water Ship Channel) with those habitats that accumulate it (lower estuary mixing zones), and as a result, improving juvenile salmon survival.

"One of biggest advantages of manipulating the tides is that these solutions do not depend on freshwater to create positive outcomes, increasing the resiliency of water deliveries and ecosystem services during droughts," says Burau.

Global forces such as sea-level rise will also spur some other landscape changes, whatever we do. But as Gartrell points out, there could be some interesting side benefits we should pay more attention to: "Sea-level rise increases the depths of channels, which increases salinity intrusion, but if we let the channels fill in by not dredging, so the depth change is less, we can reduce the salinity increase."

In the long run, Delta planners will have to think more about how to combine temporary interventions like rock barriers and long-term landscape changes like the creation of new marshes, floodplains, and fish habitats. Unfortunately, most of these projects are carried out in isolation and could negatively interact, says Burau: "We need numerical modeling to ensure these large-scale projects act synergistically to improve Delta conditions."

The Delta Stewardship Council's science program recognizes the need for "anticipatory, creative planning" to manage salinity under future stressors such as recurring drought and sea-level rise, which is why it is hosting the intensive workshop series this year.

"Any action to manage salinity in the Delta during drought — be it regulatory, demand reduction, nature-based solutions like wetland restoration, or traditional engineering — will be associated with tradeoffs, and we don't yet have a good handle on what those tradeoffs of existing and possible future strategies are for human communities and ecosystems," says the Council's lead scientist Laurel Larsen.

As of today, we haven't quite reached the point of no return. But it's looking dicey.

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Callie Rhoades contributed to reporting for this story.

RESEARCH

Key Facility's Fuzzy Future

JOHN HART, REPORTER

There are 14 marine laboratories in California. Just one of them is on San Francisco Bay: the Estuary and Ocean Science Center (EOS), on the rugged eastern shore of the Tiburon Peninsula in Marin County. EOS has trained generations of leading figures in estuary science and management. It possesses a site and facilities that no possible alternative could match. The research community swears by it. And in two years it might close.

In the 1970s, after decades as a U.S. Navy property, the 53-acre parcel was considered for inclusion in the Golden Gate National Recreation Area. Instead, in 1977, it passed — for one dollar — to San Francisco State University (SFSU). But the bargain has devolved into a burden, and today a budget crisis threatens to shut the Center down. Even a land sale, for considerably more than one dollar, is among the options the school is considering.

Approached by car from Highway 101 along winding Paradise Drive (don't even think about transit), the site seems a little remote. Viewed from a ship or boat, its strategic position is obvious. This is one of three natural deep-water anchorages in the Bay system (the others being Cal Maritime in Vallejo and far inland at Collinsville). In early Navy days the facility supplied coal to a world-traveling fleet; later it built and serviced anti-submarine nets strung under the Golden Gate. Today the center deploys a smaller flotilla: half a dozen research boats that motor out to study sites throughout the Bay and on into the Delta.

Reaching out to the Bay, the Center also brings the Bay ashore. Pumps and pipes feed a living current of turbid water into barrels and tanks called mesocosms, little worlds where ideas about the behaviors of an intricate ecosystem can be tested on the cheap.

I walk down the steep hill from Paradise Drive toward the glittering Bay. Not far offshore, the Larkspur ferry skims by. I track down one of the newest "mesocosmonauts," graduate student Jivan Khakee. Manhattan-born, educated on several shores, he is impressed by the Bay Area's efforts in preserving nature. "I come from a place where it's all concrete," he says.

His first experiment also involves concrete. He will help test the functioning of a new style of oyster reef anchor, developed right here. Unlike the heavy structures sometimes used to encourage colonization by the native but sadly diminished Olympia oyster, the new units, a couple of feet high and more or less triangular, are light enough for two people, or one husky one, to heft. He demonstrates without a grunt, and shows me how such units interlock to form a structure that won't shift in the Bay's fierce currents.

Khakee wants to find out what kind of interspecies dance will form around these structures once in place. Along with the oysters themselves, they will inevitably draw the Atlantic oyster drill, an inch-long carnivorous snail that first reached the Bay in the 1800s. The drills use sulfuric acid and an abrasive organ called a radula to bore their way through to oyster-flesh. But the snails themselves are prey: for native red crabs of the Cancridae family. Khakee hopes that the new reef components will attract the crabs as well, providing a kind of Praetorian Guard for the oysters. Also bound to show up is another non-native, the omnivorous European green crab. Little submersible cameras will watch how all these critters live, and die, together.

Estuary and Ocean Science Center is located at one of three natural deep-water anchorages in the Bay system. Photo: Keith Merkel

Moving to an active tank, Khakee lets in some Bay water from a spigot, then plunges a hand into the murk to retrieve a "cancrid" crab. "Ouch!" says. "They don't like being picked up." Brick-red, filling the palm, it can pinch hard even through a glove. The animals aren't bred here but are brought in by the boats; he needs a few more to get his experiment running.

Khakee is the newest recruit to the team of Katharyn Boyer, who doubles as the center's interim executive director. When not fighting to keep the operation alive, she works to understand and restore the Bay's eelgrass beds. Alongside revived oyster reefs and tidal marsh, these can help buffer shorelines from erosion and inundation by rising tides. The flow-through Bay water system is vital to this work. "Without it, we wouldn't be doing our restorations," she says.

Another member of Boyer's group, Christian Tettelbach, is testing whether eelgrass is just eelgrass. Do plants plucked from different parts of the Bay, and propagated here at the Center, show different responses to variations in acidity, salinity, and light? If so, it may matter which

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Graduate student Jivan Khakee displays a "cancrid" crab. Photo: Tessa Filipczyk

strains are planted where as restoration proceeds. If not, not. A CO_2 tank infuses different doses of the acidifying gas; a simple windowscreen over one tank mimics duskier water. To what extent can the grass itself help counter acidification? Answers are sought both here in the "mesocosms" and out in the field.

Unlike Khakee, Tettelbach has been at this for several years. I give it a try: Does he have any conclusions? None, he says, that he can share yet.

For researchers here the key habitat structure is Delta Hall, a handsomely refurbished warehouse. It houses about ten subsections, or laboratories, run by senior scientists. Boyer's is one. Wim Kimmerer, among the perennial names in estuary science, heads another. Several belong to the San Francisco Bay National Estuarine Research Reserve, a partner agency headquartered here. The Smithsonian Environmental Research Center, working especially on invasive species such as the oyster drill, rents its own building nearby.

Though united in praise of what they have, the denizens of the center ache to see fuller use of the expansive site. For every modernized and well-maintained building like Delta Hall, there is a Navy structure that can't be used without expensive restoration; one I walked by is visibly falling down. "You have to drive through a kind of ghost town to get to our main facilities," Boyer acknowledges.

But if two old barracks, already getting seismic upgrades, could be outfitted as dormitories, undergraduates could spend weeks instead of hours at the site, and grad students could find housing here (both Khakee and Tettelbach commute from Oakland). If the old wharf were rebuilt, the Center would gain a new and more welcoming front door. Water taxis could bring in students from the city (many of whom lack cars) and local youth learning the restoration trade. Empty spaces could host new research partners, perhaps as incubators or "maker labs" for compatible private firms.

The Center's hope for survival now seems to lie in just such a flowering. The present difficulties stem from a mismatch of scale: a facility of statewide importance (at least) became the ward of a single campus of an overtaxed state university system. When SFSU president Paul Romberg took charge of the former Naval land in 1977, he had to agree that the facility would have no separate budget of its own; like other school functions, it would live by state funding tied to total enrollment. Though the center itself has never lacked for recruits, the parent school's population, even before the Covid shock, was trending downward. The Smithsonian and the Estuarine Reserve chip in in different ways, but the latter's presence depends on a funding match that the school can ill afford.

The decision has already been made: the university will step out of its role as the center's prime support. By next June, a committee, including Boyer, is to come up with a better plan. Could several universities join in sustaining the Tiburon campus? Could new research tenants be found? Will foundations come to the rescue? Shouldn't the state resource agencies, with their multitude of EOS alumni, have a stake? Though it's the last thing anyone wants, "the nuclear option" — closure — is also on the list.

Stuart Siegel, interim director of the Estuarine Research Reserve, hopes that the Center will come out of its crisis as something even grander. "Expand the place up to what it's really capable of!" he says. "It should be the Bay Area's focus of research and training for climate change adaptation."

"It's the university's problem," Boyer notes, "but it's the whole scientific community's problem. I can't think we'll just fall apart. Where would you find another place like this? How could you replicate it? How would you even start?"

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"Mesocosms" permit cost-effective investigation of intricate ecosystem behaviors. Photo: John Hart

CLOSEUP

Sharing Science Across Barriers

KATE RAPHAEL, REPORTER

Growing up on Chicago's South Side, an urban landscape of metal and concrete, Miguel Mendez had limited access to open spaces, and always dreamed of traveling. Yet there in the city, he got first introduction to environmentalism.

"In some of the places I lived in Chicago, environmental activists are fighting air pollution and the limitation on parks," Mendez says. Many of those groups have been there for years, and as he grew up, Mendez internalized the importance of preserving and advocating for a safe environment for all communities.

When he was about to enter ninth grade, Mendez applied for a scholarship to an environmentally focused high school. So instead of walking into a classroom his freshman year, he found himself trekking into the Sylvania Wilderness, an expanse of pristine, protected lands within the Ottawa National Forest on Michigan's Upper Peninsula.

Everything about wilderness school was different from the urban life he had left in Chicago, from where he slept — Mendez spent one night in an igloo on a frozen lake — to the community that surrounded him. "The only other people of color that I knew were the students who were also part of my scholarship program," Mendez says.

Still, he welcomed the opportunity to immerse himself in nature. "I think of that time at boarding school as where I got my spark for the environment," Mendez says.

That spark caught fire as Mendez went on to study chemistry at Williams College, focusing much of his academic coursework and senior thesis on environmental justice. His chemistry thesis examined mercury and arsenic paper sensors designed to be low cost and user friendly. Mendez explored the applications of these sensors with the hope that they could serve as a tool for communities to easily assess their own water quality and advocate for change.

Miguel Mendez speaking to a reporter on Spanish language network Telemundo. Photo: Telemundo

Mendez went on to earn his master's degree in environmental engineering at Stanford before beginning working at the San Francisco Estuary Institute (SFEI) in 2020. At the SFEI, Mendez focuses primarily on PFAS, or per- and polyfluoroalkyl substances, manufactured "forever" chemicals that do not break down easily in the environment. PFAS occur in many consumer products, including cosmetics and cookware. Mendez is currently analyzing the levels of PFAS in wastewater treatment facilities in the Bay Area.

Mendez and his fellow researchers found relatively low amounts of PFAS in municipal wastewater and biosolids, byproducts of the wastewater treatment process. However, "one of the key problems with PFAS is that even though we may be seeing them at low levels, they're extremely persistent" and pose a health risk to humans, potentially causing damage to the liver and immune system, he explains.

Mendez is currently attempting to identify potential sources of PFAS to Bay Area wastewater treatment facilities by zooming in on specific wastewater discharges. Laundromats, food waste industries, and semi-conductor manufacturing could be contributing to elevated PFAS levels, Mendez explains. He is also beginning to analyze PFAS concentrations in wastewater flows in residential areas. "That will give us an indication of how much of this might be coming directly from our faucets."

Recently, as part of a larger report produced by the SFEI, Mendez helped develop conceptual models that illustrate how plastic moves through the environment. "The pandemic increased our dependence on single-use plastics," Mendez says, in turn increasing plastic waste. In one of the models Mendez and his team developed, single-use plastic foodware ends up on land as litter, where rainfall or runoff then carries the plastic and other pollutants into the stormwater system. In most cases, stormwater is not treated before being discharged into urban waterways or directly to the ocean. Through this pathway, plastic may be degraded, forming smaller plastics pieces including microplastics. The report Mendez and his colleagues produced helped inform California's strategy for addressing address microplastics, a

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SHARING, *cont'd from page 23*

two-pronged approach that includes immediate solutions to manage plastic waste and a longer-term research agenda.

Though Mendez focuses on particles and chemicals smaller than the naked eye can perceive, he never loses sight of the larger context. Witnessing how environmental hazards like PFAS, microplastics, and other contaminants disproportionately affect certain communities, Mendez makes a concerted effort to reach and educate these audiences.

As California launched its microplastics plan, Mendez partnered with the Spanish-language network Telemundo to provide Spanish language interviews and share the science across language barriers. "As a person of color in the environmental field, it's really important to highlight these types of studies...to a wider audience," he says.

Mendez knows firsthand that communities of color are often exposed to environmental dangers that are under-researched and unaddressed by government and policy organizations. Reflecting on his childhood in Chicago, Mendez describes a massive smokestack he walked by every day.

Mendez's corgi, Coco, often accompanies him to the beach. Photo: Areli Valencia

"Now I look retrospectively and can see the different environmental hazards [around me] when I was young."

From a young age, Miguel Mendez learned about the value of the natural world from environmental activists in his own community, and he continues to push that work forward today.

"I ask the science to speak for itself," Mendez says. "Through science we can find avenues to make an impact."

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