San Francisco Estuary Partnership

ESTUARY NEWS

SCIENCE • RESTORATION • WATERSHED • POLITICS • SPECIES • BAY

DECEMBER 2017
VOL. 26, NO. 4

Promising Results from an Experimental Wedge of Grass, Mud, and Wastewater

Whether It's Wet or Dry this Winter Planners Still Prep for Floods

Shells as Camouflage for Nests?

Voracious Snails and Weevils in the Delta: Good and Bad Biology

Quelling Erosion Worries about Rain on the Burn

Intermittent Diablo Range Creek Rich in Biodiversity

Public Sediment Favors Mud

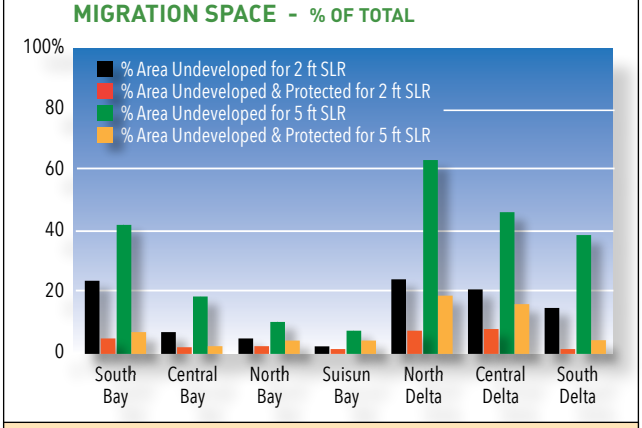
RESTORATION

Minding the Margins

David Thomson, the Habitats Program director for the San Francisco Bay Bird Observatory, studies transition zones between marsh and upland. The habitat is crucial for a properly functioning estuary, mainly because of the coverage and forage it can provide endangered and sensitive species looking to escape high tide events. Intact transition zones also help future-proof the estuary by giving marsh plant and animal communities the opportunity to migrate landward as the sea level rises.

But really understanding how the marsh to upland transition zones function in San Francisco Bay is challenging. Historically, marsh-upland transition zones were broad and gradually sloping. Nearly all of these historic zones have been developed, filled, put behind a levee, or otherwise impacted. "If you want to see a less impacted landscape you have to go to Suisun Bay," Thomson says. "A couple of researchers from UC Davis call those sites unicorns."

Another reason that studying marsh-upland transition zones is tricky is because they have also been poorly defined, both in terms of vocabulary and by maps and modeling (see new report link below). Often characterized by biologists or ecologists by changing plant communities, marsh-upland transition zones are actually physical structures that, according to Thomson, should be defined in relation to high tide events. Based on tides and topography, marsh-upland transition zones will have a different look and feel in different parts of the Bay.



For the State of the Estuary Report 2015, scientists developed an indicator of the "health" of the Bay Area's supply of migration space from tidal areas into uplands. The indicator assesses the current percent of undeveloped space in the area of transition zones and the percentage of that space that is protected from development.

Today, Thomson and his colleagues are applying what they have learned by recreating physical transition zones at places like Bair Island and Pond A17, which is part of the South Bay Salt Pond Restoration Project. While the long, gently sloping transitional habitats are no longer feasible at the Bay's edge because of space constraints, restorationists are making their best efforts to mimic transition zones with good site planning and careful earthwork.

But it's not all about soils and salinity. The plants covering the newly built transition zones are also crucial to their overall health and function. Without the right combinations of cover, it just becomes weed-filled slope and can't provide the ecological benefits for tidal marsh animal communities. Over the past several years, Thomson's SFBBO Habitats Program and a number of partnering agencies have worked to figure out how to best bring transition zones back to life. "We have seeded over 30 species of local native plants, and enhanced them with up to 10 species of natives grown in containers for outplanting, because not everything does well from seed," Thomson says about the Bair Island and Pond A17 sites.

Meanwhile, planning documents about marsh-upland transition zones are catching up with what ecologists have been documenting for decades: Marsh-bound communities need high ground in times of flood tides. The 2013 U.S. Fish and Wildlife Service Recovery Plan for Tidal Marsh Ecosystem of Northern and Central California, which provides guidance for marsh restoration, says that the marsh-upland transition habitat is a critical ecosystem component and just as important as the marshes themselves. "The language changed from should restore transition zones," Thomson says, "to must restore transition zones." DM

CONTACT
David Thomson, dthomson@sfbbo.org

New Mapping Methodology for Transition Zones
www.sfestuary.org/vision

WEATHERREPORT

Wet? Dry? Whatever

From the Oroville dam to Highway 37 to San Jose neighborhoods along Coyote Creek, last winter's unusual rainfall unearthed northern California's many flood vulnerabilities. It was a costly lesson for the Bay Area: in San Jose alone flooding forced the evacuation of 14,000 people – many of whom after nine months are still trying to recover – and caused over $100 million in damages.

So what's in store for the Bay Area this winter? Dr. Michael Dettinger, a research hydrologist with the United States Geological Survey, cautions against drawing conclusions based on the past winter's storms. "Last year was so unusual that it would be completely unexpected to get another like it this year," says Dettinger. "It would be like pulling an ace of spades twice in a row out of multiple card decks shuffled together."

According to Dettinger's research, past river levels in the Sierra Nevada show that last year's weak La Niña conditions most often result in normal winter precipitation. However, there is one big caveat: the really big rain event events in our historical records occurred during the same weak La Niña conditions that we saw last year and that are currently brewing in the tropics.

"I'm duty bound to point out that the four largest floods over most central Sierra Nevada rivers have historically happened when we were in weak La Niña status," says Dettinger. "So despite the low odds we can't take the possibility of another strong winter completely off the table."

continued page 4

C L I M A T E

Nudging Natural Magic

"Miraculous" isn't a term that comes easily to the lips of scientists and engineers. But the word, along with a quickly quelled gulp of incredulity, cropped up more than once in interviews concerning the preliminary results of the horizontal levee experiment on the San Lorenzo shore — including off the charts levels of removal of nitrogen and pharmaceuticals from wastewater passed through the system and growth of willows, cattails, and wet meadows.

This pilot sea level rise adaptation project, led by the Oro Loma Sanitary District, combines precision engineering, native plants, irrigation via treated household wastewater, and a hump of bay mud, sand, and gravel. The idea is to test which ingredients –liquid, solid, vegetable — in what doses and combinations make the levee bulk up and leaf out fastest, and best "polish" (clean) the wastewater.

As the Bay Area confronts a rise in sea level projected to accelerate rapidly as early as 2040, those charged with protecting drowning shorelines are exploring new options for how to help increase their elevation in relation to the advancing tides naturally. This closely-watched experiment goes beyond sea walls and sediment lifts to harness the productive power of plants, which as they go through cycles of growth and decay lay down new layers of organic matter over soils — adding much-needed inches to shoreline elevations.

"I've been drinking the restoration Kool-aid long enough to have seen lots of failures, surprises, and unplanned outcomes," says Save the Bay's Jessie Olson, who oversaw the collection of four million native seeds and thousands of rhizomes (root clumps) from wet meadows and creek zones in the East Bay to green the pilot project. "But I was stunned by how quickly and densely the plants came in at Oro Loma."

One magic ingredient is water. In this case, treated wastewater from the Oro Loma Sanitary District was drizzled and percolated through 12 experimental cells on the levee slope, each with their own flow meter, valves, and perforated pipes, and each with a different mix of soil types, ranging from coarse sand to fine Bay mud. "It's a very sophisticated watering system that allows us to test all kinds of different discharge rates," says ESA Associate's Mark Lindley, lead engineer for the project. "We can cycle between dry and wet days, and saturated and drained soils, mimicking the natural conditions these plants might experience in the transitional zone at the edge of Bay marshes."

Another magic ingredient is the diversity of species planted, with a particular emphasis on perennials that regenerate every year vegetatively via buds. Botanist and coastal ecologist Peter Baye chose each species in the mix to replicate the great range of conditions in a transitional zone where fresh water from local watersheds and aquifers would naturally seep into the back of our salt marshes — if we hadn't built so many levees, walls, and communities right up to their edge.

Participants in Resilient by Design challenge stand at the top of horizontal levee looking over an associated wet weather basin, with the jungle of growth on the new levee behind them.

"Creeping perennials give us an edge over seed-dependent weeds," says Baye. "They spread by creeping rhizomes and fill the soil space below ground and cover above ground, without the dicey seed and seed reproduction part of the life-cycle."

Even the planting sequence and arrangement of the species on the slope was micro-managed. "We planted the perennials in random clusters to mimic how they would occur in a natural system rather than enforcing our own bias as to where plants should go. They all soon sorted themselves out and found their place on the slope," says Save the Bay's restoration manager Donna Ball.

Some of the magic had to do with the intensity of the timeline too. The entire project had to be constructed within 15 months because of grant deadlines (the project was largely funded by the Oro Loma and Castro Valley Sanitary Districts and a Bay Area Proposition 84 Integrated Regional Water Management Grant from the California Department of Water Resources administered by the San Francisco Estuary Partnership).

The accelerated timeline prompted some innovative thinking by project partners. Lindley developed a way to speed up levee building on loose bay mud — which has a tendency to compress, settle, buckle, bubble, "heave," and flow back into any excavation area—by moving heavier material around as a compression weight to "surcharge the subsurface." Jason Warner, general manager of the sanitary district, shepherded multiple partners through design, permitting, construction and funding challenges with "phenomenal vision and leadership," according to Ball. Olson substituted labor and time intensive container plants from Save the Bay nurseries with rhizomes which her volunteers planted in nursery beds right at the experiment site — getting 10 root clumps for every one collected and nurtured within months not years. "We took advantage of the way species would propagate in the field, but helped them along, giving them better soil and more consistent irrigation that they would have had under wild conditions," she says.

continued back page

WET? DRY?, *cont'd from page 2*

Devin Mody, a Santa Clara Valley Water District Engineering Unit Manager, hopes for the best but is preparing for the worst. "Last year we had a deluge, and before that years of drought," he notes. "This winter, something in between those book-ends would be great."

The Water District is responsible for maintaining nearly a third of the 800 miles of creeks and channels in Santa Clara County. Mody's staff is racing to inspect creeks and levees for weak spots to shore up before the winter's first significant storms. They not only battle invasive arundo, pulling out tangled clumps of reeds which can trap debris and slow the water's race to the Bay, but also oversee maintenance for about 275 miles of creeks and water channels.

In the bigger picture, the Water District is attempting to address governance issues that exacerbated flood damage last February—namely approving a new joint Emergency Action Plan with the City of San Jose on November 3rd, and engaging the United States Army Corps of Engineers to try and solicit federal funding for long-term flood protection solutions.

In the meantime, as the days shorten and summer's latent heat evaporates into winter's chill, the Bay Area region waits to see what the Earth's climate has in store this winter. "The flood protection part of me doesn't want a lot of rain, but my water supply side would like some water," says Mody. "Ideally we get some rain spaced out enough to replenish our surface water reservoirs and groundwater basins, but not enough to flood."

Dettinger is a little more blunt on what to expect this winter in the Bay Area. "California has quantitatively the most variable year-to-year precipitation totals in the lower 48 states," he says. "It is largely unpredictable. The only reasonable thing to do in California is to always be prepared for almost anything, wet or dry. Or maybe I should more accurately say, be prepared for almost anything, wet AND dry." **IP**

I N F R A S T R U C T U R E

Worries Over Puny Pumps

When a section of Highway 37 in Novato flooded last winter, Caltrans brought in portable pumps to help clear the roadway. Marin County already operates a pair of permanent pump stations where tidally influenced Novato Creek intersects the four-lane thoroughfare; during storms, they help to stop flooding before it starts. But it wasn't enough during heavy rains last January and February to stop the bay from temporarily reclaiming this critical commuter connection.

In lieu of managed retreat or other "softer" solutions such as wetland buffers, flood-control and sea-level-rise planners throughout the Bay Area are poised to place growing faith in pumps, agrees Lindy Lowe, former Bay Conservation and Development Commission planning director. New pumps, which can cost more than $1 million, require regular maintenance for decades, and consume large amounts of electricity, are currently in the works in Marin and well beyond.

Photo: Nate Seltenrich

For Roger Leventhal, a senior engineer with the Marin County Department of Public Works, Highway 37's flooding woes are just one example of a far larger problem along Marin's bay-facing waterfront and throughout the Bay Area, where more than 100 stormwater and groundwater pumps keep streets and communities dry each winter — and in some cases year-round.

Pump capacity, reliability, and cost are already big concerns for flood-control managers today, Leventhal says, and given the rising tides and increasingly severe storms promised by climate change, these critical if under-appreciated pieces of local infrastructure will become increasingly problematic in the future.

"Gallon for gallon, it's easily the most expensive way to deal with water," he says. "It's not the ideal solution, but it's the one we're falling into, in the sense that it's a hard engineering solution."

"Right now we're using a system that is pretty energy-intensive and not always reliable," Lowe says. "It seems unlikely for us as a region to get away with increasing the number of pumps 100-fold, which is what we would have to do if we were to go with hard solutions like levees and tide gates. The water would accumulate behind these barriers, and you would have to find a way to get rid of it."

Given that many of the region's existing pumps are already undersized or at the end of their service lives, planners should consider the "lifecycle of responsibility" that comes with new walls and pumps, she says. "We don't tend to maintain our existing infrastructure." **NS**

PLANNING

All In for One Water?

As climate change threatens to upend precipitation patterns and disrupt water supplies, agencies are increasingly searching for ways to wring more benefits out of every drop. To that end, the Santa Clara Valley Water District is seeking to take integrated water management planning to the next level through its One Water initiative.

"The idea of One Water is to manage all water — treated water, groundwater, stormwater, flood water, water for habitat, species and Baylands — as one resource," says the District's Brian Mendenhall. The District is somewhat unusual in that, in addition to providing Santa Clara County's water supply, the agency is also responsible for flood protection and stream stewardship. "One Water allows us to coordinate the work of our different business areas and divisions," Mendenhall adds.

One Water includes an implementation plan that will comprise detailed plans and priority activities for each of the county's five watersheds. "We have often had difficulty prioritizing projects," says Mendenhall. To address this problem, the District has now identified a specific proven method for selecting those projects that achieve the most benefits. Projects will be selected through a scientifically informed process that combines input from stakeholders and staff regarding challenges in the watershed with analysis of geographic data.

The Coyote Creek watershed — the county's largest — is the first area staff are tackling. "We started with 300 concepts," says Mendenhall, "and then boiled it down to 100 site-specific projects." Projects that offer multiple benefits are particularly important, such as a stream restoration project in a flood-prone area that also may also include groundwater recharge basins and recreational trails. "Right there you've got four different things you could consider as either a single project or a portfolio of projects, all within a small area. The idea is try and look at the efficiencies of planning together like that," says Mendenhall.

The District developed ten specific objectives for One Water, along with metrics that measure progress toward each one. "We always start projects saying this is going to have this benefit or that benefit, but adding these up so you can see the overall benefit for the watershed is really new," says Mendenhall.

Santa Clara's water district is far from alone in embracing the principles behind One Water. The U.S. Water Alliance, of which the District is a member, has an initiative — also entitled One Water — that promotes similar programs nationwide. "We are seeing a lot of innovation around the country," says CEO Radhika Fox.

In the Bay Area, the Sonoma County Water Agency has been part of this wave of innovation for more than a decade. "We are still big advocates of integrated water management planning and looking at how whole watershed functions instead of just jurisdictions within a function," says Director Mike Thompson. Like Santa Clara's district, Thompson's agency provides multiple functions, including water supply, flood protection, sanitation and water recycling, as well as technical assistance to local groundwater management programs. "We take a holistic watershed approach because of the services we provide," says Thompson.

Localities where the different water-related services are provided by different agencies may find One Water-type programs more challenging, but there are intriguing efforts underway nevertheless. Michelle Selmon, coordinator of the Tulare Basin Watershed Connections Group, says the 2014 passage of Sustainable Groundwater Management Act, which requires groundwater-dependent regions to halt overdraft and bring basins into balanced levels of pumping and recharge, provided an impetus "to get people to think outside their traditional silos" for water management.

"Now we have the opportunity to get valley floor water managers, who traditionally don't think upslope much, to recognize the valuable resource they have in the Sierra Nevada watershed, and how investing in that watershed can benefit them and all of the folks downstream and explore all the possibilities." Selmon believes that encouraging valley floor water managers to think upslope will help reduce dependence on water from the Central Valley Project. "We want to turn their attention to local supplies and figure out how they can maximize benefits."

According to the national alliance's Fox, the main impediment to the development of one-water policies is a fragmented policy environment. "There are more than 25 federal agencies that have authority over some aspect of water," she says, " and then that fragmentation gets reinforced at the local level." CHT

CONTACT

BMendenhall@valleywater.org;
Michelle.Selmon@water.ca.gov;
RFox@uswateralliance.org

Draft One Water Plan, SCVWD:
https://onewaterplan.wordpress.com

Flooding in the winter of 2017 in Rock Springs, San Jose.
Photo courtesy Santa Clara Valley Water District

ESSAY

Resprout

Spending time in the burned zones is an almost overwhelming assault on the senses; this is a familiar world inverted. The colors, textures, shapes, and smells are all unfamiliar. That which should be green is black. That which should be inside is out. That which should be standing has fallen. Nothing, it seems, can be taken for granted.

From the freeway, a week after the fire, the magnitude is masked at 60 miles per hour. Instead of being a patchwork of green and gold, many eastern hills are brown and black. Sections of guardrail rest on the pavement atop burned-out supports. Some buildings are gone, abrubt gaps in the familiar architecture of the city I have known my entire life, the city my father was born in, and that his father was raised in. But it's a few blocks off Highway 101 that the devastation reaches a scale that is hard for the mind to process. Passing through eastern Santa Rosa on my way out of town, entire neighborhoods are turned to low heaps of ash and debris. Perfectly intact loops of tarmac wind past houseless intersections and cul-de-sacs. Driveways and paths lead from rubble to rubble. Partially recognizable appliances suggest kitchens, garages, dining rooms. Cars, trucks, RVs, motorcycles are all stripped down to their frames, fused into place, paint turned to colors of ash and earth and swirled into abstract designs.

Farther out of town, the landscape is less chaotic but equally unnerving. The ground is stripped bare. Everything small and flammable is gone—grass, flower, twig, stump. The blanket that usually covers the earth is ripped off. Soil and rock are crisped black and brown. Tree trunks, standing or fallen, are the same. Nearly all leaves are brown, unless they are black, or gone. It looks like autumn, but wrong because it touched every species alike: evergreen madrone, pepperwood, or Douglas-fir; poison oak or honeysuckle; the sedges along the rivers. What flame didn't devour, the heat baked.

And then there is the smell. The charred, dead-campfire stink of partially-burned wood and wetted charcoal permeates everything. After being in the burn zone for ten or fifteen minutes, I start to get dizzy. Really, really, dizzy, and a little bit frantic, as if some animal part of my brain is waking up and scrabbling around, wondering if it is time for fight-or-flight to kick in.

Photo: Jacoba Charles

This strange feeling is one I never encountered until a few days into the fires, when the smoke really started to get thick in my town—a comparatively safe 10+ miles from the western edge of the blaze, but still far too close for any kind of comfort. It echoes back quickly now, in both heart and lung—when I burn something in the toaster oven, or when I spend an hour walking through ash.

Despite all this, the burn zone isn't empty. Even well outside of town it teems with life, both human and wild. Cars commute on the roads like usual. Plenty of people are out on foot: homeowners, assessors, contractors, prison clean-up crews. Every soul stands out. More carrion birds than I have ever seen in one place—mostly vultures, but also a lot of ravens—wheel above the hills, doing their noble, dirty work of cleaning up the creatures that didn't survive the flames. There are a lot fewer songbirds, but some still sing along the streambanks. There are a lot fewer green plants, but each one shines like a beacon. Seedlings unfurl. Perfect buckeye seeds have dropped on the naked, charred soil of a riverbank, ready to sprout. The plastic pots and wooden frames of a garden were incinerated, but the soil still holds their shapes—and the plants within are already standing tall, ragged flags from a battered but heartful army.

This is what nature is made to do—resprout. What form recovery will take in this particular burn zone, where so many human works were incinerated alongside wild ones, is anyone's guess. With the earth stripped of so many trappings it is easy to see that this entire landscape is watershed. Parcel boundaries mean nothing; all containment is gone. Everything that the fire ravaged is flowing downhill now, into soil and stream, at the same time that people are planting acorns, shoveling ash, rebuilding, removing, restoring. This feels like uncharted territory; will more damage appear? How resilient is this patch of earth? We are in a raw time of hope and fear and beauty. But whatever unfolds, it is clear that life is not on its way back to these burned-out hills. It has been here all along. **JC**

PERUSE 25 BEAUTIFUL RESPROUT PHOTOS ONLINE

Reporter Jacoba Charles and photographer Amber Manfree ventured out after the October wine country fires in search of green shoots, clearing waters, and fresh starts. Review their intimate glimpses of a changed landscape two months later at www.sfestuary.org/estuary-news-resprout-fire-photos/

F I R E

After the Burn Comes the Rain

Nature dealt a case of whiplash to the North Bay this fall. The first rains came hot on the fires' heels, wetting black ash while smoke still billowed from holes in the earth and dead roots smoldered deep underground. Land managers and hillside homeowners quickly shifted from surveying the damage to planning for erosion, landslides, and toxic runoff. But when fire strikes upper watersheds along the wildland-urban interface as it did here in October, responses can vary widely depending on land use and ownership.

Interviews with various land agencies, a water utility, and an erosion consultant for private landowners reveal that post-fire management in the upper watershed depends a lot on how the land was used and managed prior to the fire, and how heavily the land had been altered or developed. Approaches may range from doing nothing to installing erosion controls like silt fences, sandbags, straw bale dikes, straw tubes called wattles, and mulch-like slash to digging ditches or building sediment-containment basins.

State-park officials hew to the former, more passive approach whenever possible, says Cyndy Shafer, a Petaluma-based Natural Resource Program Manager for California State Parks' Bay Area District. "We view wildfire as a natural process, and even erosion to some degree is also a natural process if it's in a relatively undisturbed landscape," she says. Indeed, soil transport through creeks can naturally help build wetlands at their base. Bay Area scientists now argue we'll need this sediment to help drowning shorelines adapt to sea-level rise.

Although significant portions of three state parks — Trione-Annadel, Sugarloaf Ridge, and Robert Louis Stevenson — burned in the North Bay fires, agency policy has dictated a rather limited response. Wildlands and backcountry areas have largely been left alone, including along creeks, and early evidence suggests the parks are well poised to recover. "The landscape saw variable intensity of fire and has plenty of natural seed source," Shafer says.

Only in developed areas such as campgrounds, around infrastructure including roads and structures, and, perhaps most urgently, where fire crews' bulldozer lines scarred the surface, did State Parks set out to control erosion and runoff. And even then, reseeding to hasten revegetation was off the table, Shafer says.

It's a different story when lands are managed not for ecosystems and natural processes but primarily for drinking-water quality, suggests Scott Hill, Manager of Watershed and Recreation for the East Bay Municipal Utility District (EBMUD). Even after small fires, which is all the agency's 28,000 acres of East Bay watershed lands have seen over the last 35 years, erosion is a significant concern.

"One of the things that we do, after any fire, is perform a review" to determine how it burned, he says, analyzing variables like slope, soil condition, fuel type, and density. Next the agency assesses proximity to drainages, water bodies, and reservoirs. It even considers projected rainfall for that area of the watershed. "Then we have a good understanding of what the environmental factors are that could influence the potential for erosion at the site after the fire," and of what the downstream impacts are likely to be, Hill says.

This, in turn, informs the development of an erosion- and sediment-control plan designed to retain as much soil on the burn area as possible. "We don't want sediment and nutrients getting in our storage reservoirs, because they cause problems," he says.

A middle ground comes from Monterey-based consultant and former United States Department of Agriculture natural resource conservationist Rich Casale. He came out of retirement immediately after the fires to advise private North Bay property owners on erosion control. "People were desperate," he says. "Because the fires happened so late in the fall, there wasn't much time to button things up before winter."

Yet what exactly that means must be considered on a case-by-base basis, Casale says, even within a single neighborhood. "In some cases doing nothing may be the best course of action. It's a site-specific plan as to what to do."

If not implemented properly, sandbags, straw bales, and ditches can do more harm than good in natural areas by concentrating runoff and "creating flows that are going to be way more destructive," he says. Spreading thick mulch or slash to stabilize soil this winter can likewise be counterproductive over the long term by inhibiting regrowth of the native seed bank and the gradual regeneration of plants.

"We have to think about at least two winters following fire, not one winter," says Casale. "We're really not out of danger for two or three years after fire." **NS**

CONTACT Cyndy.Shafer@parks.ca.gov; Scott.Hill@ebmud.com; RichCasale3@gmail.com

Soda Creek, Napa County, November 2017. Photo Amber Manfree

PROFILE

Searching for a Few Good Weevils

For Julie Hopper, heroism often takes an unlikely shape. She was drawn to marine biology as a child, but rather than dolphins and whales, she was fascinated with female parrot fish capable of changing their sex in the absence of males. Today, as a postdoctoral fellow funded by the Delta Stewardship Council, she studies another off-beat creature: The herbivorous weevil *Neochetina bruchi.*

"They're pretty charismatic," Hopper says of the tiny insect. "They have these long snouts that make them kind of cute." Hopper's project with the Stewardship Council has sent her to all corners of the Delta, studying how effectively *N. bruchi* manages the population of the invasive water hyacinth.

Native to Argentina, these weevils were first brought to North America to combat the spread of the aquatic weed in Florida, Louisiana, and Texas. The weevil feeds exclusively on water hyacinth, and with such voracity that lakes once covered by the invasive weed could sparkle clearly again. Later, the weevils arrived in the Delta to attempt the same.

Like the weevil, Hopper also started far from here. She left her hometown of Hershey, Pennsylvania to study marine biology at UC Santa Barbara. There she met Dr. Armand Kuris, a professor of parasitology who introduced her to biological control.

Dr. Kuris had employed a method of biological control in Kenya, where the disease Schistosomiasis was rampant. A parasitic flatworm was transferring the disease via freshwater snails to humans. Kuris controlled the population of snails by introducing crayfish into a number of lakes, substantially reducing occurrences of the disease across several Kenyan villages.

"This was a pivotal moment for me," says Hopper. "Biocontrol can make a huge impact, from reducing disease transmission to controlling invasive species, you name it."

Hopper is currently a postdoctoral fellow at UC Davis and works with Dr. Paul Pratt of the US Department of Agriculture. Pratt's expertise on the Delta's invasive species inspired her current study on the effectiveness of *N. bruchi* as a biocontrol agent.

Water hyacinth spreads quickly and creates dense colonies, clogging pumps and waterways. Mechanical methods of removal, such as herbicides and shredders, are expensive and can accidentally target other native species. The weevil, when effective, is far cheaper and does not intrude upon the local ecosystem. "They're like a fine-toothed comb," says Hopper, describing their precision relative to mechanical control methods.

However, *N. bruchi* has not been as effective in the Delta as it was in Texas or Florida. Hopper's project, done in collaboration with the labs at the USDA, is investigating if there is some underlying cause to their local ineffectiveness. Hopper thinks there is.

"Because they were brought from so many different places, you can imagine a lot of bottlenecks existed for the population," she explains. While the Mediterranean climate of California and southern Argentina are similar, the weevils currently inhabiting the Delta descend from those used in the muggy American South. "It's possible that they adapted to the warmer temperatures. We're exploring whether or not there is a cold bio-type of these weevils we can introduce in the Delta to increase genetic variation."

Hopper recently published a report of the first year of her project, but she doesn't limit herself to scientific writing. She is also working on a children's book that tells the story of the weevil and the water hyacinth.

"I consider them a kind of superhero," says Hopper. In her story, "a scientist named Kia figures out how to control the water hyacinth in Lake Victoria using the superhero weevils. She saves the day."

After her work with the weevils, she plans to head to the University of Southern California to study the harmful algal blooms responsible for domoic acid poisoning in marine mammals like the California sea lion. Perhaps there is some unlikely biocontrol superhero capable of saving the day. If there is, Julie Hopper is the kind of person to find it. **MHA**

Science Fellows www.deltacouncil.ca.gov/science-program/delta-science-fellows-program

Photos courtesy Julie Hopper.

INVASIONS

Table Set for Snails

Mike Moran, the supervising naturalist at the Delta's Big Break Regional Park, got a call several months ago about a cluster of unusual looking pink eggs. "It looked like a big wad of bubble gum," he says. "We thought we might be looking at this channeled apple snail thing."

Channel apple snails (*Pomacea canaliculata*) are a large freshwater species that are native to the Amazon and Plata River basins of South America. Introduced to the United States and elsewhere, beginning in the 1980s, first as a potential menu item at swanky restaurants and then as part of the aquarium industry, the snails are now established in a few states in the southeast and have been spotted in Ohio and Indiana. They've also set up shop in in Arizona and, since 1997, been present in California. With this discovery at Big Break, the US Geological Survey has now officially documented the species in northern California. The snail has also been added to the Survey's nonindigenous aquatic species list in four locations in San Diego county and one location each in Riverside, Kern, and Fresno counties. The sighting and identification of the channeled apple snails at Big Break is the newest front of the invasion.

"What we are worried about here," Moran says, "is the snail's voracious appetite for aquatic plants like the rice we grow in the Delta and the marsh plants that sustain native fish."

Channeled apple snails get their name from their physical characteristics. They can be large when fully grown — about the size of a child's fist Moran says — and they have deep grooves or channeled sections on their shells. They are frequently confused with other invasive snails, such as the Chinese mystery snail and the island apple snail.

Well-adapted to thrive in a range of environmental conditions, channeled apple snails also reproduce prolifically. That bubble-gum-wad-like mass that Moran saw at Big Break is likely to contain hundreds of eggs.

How, exactly, the snails ended up in California generally, or in the Delta specifically, is still unknown. There are a few guesses. It's likely they were released from aquariums or dumped when the culinary market for the snails never really developed. Either way, the species is heavily regulated in California. "The channeled apple snail are a restricted species — meaning no sale or possession within the state — because they are detrimental to agriculture, wildlife, or human health," says Martha Volkoff, environmental program manager with the California Department of Fish and Wildlife's invasive species program.

The California Department of Agriculture has taken a keen interest in the control of the channeled apple snail because the species has negatively impacted rice production in other places such as the Philippines and southeast Asia. So far, known control measures include pesticides, hand removal of the snails and eggs, and the release of carnivorous ducks. Health-wise, the snails are known to carry rat lungworm, which can be contracted by humans if the snail is eaten undercooked.

But the potential ecological impacts in the Delta are what have Big Break's Moran the most concerned. "They are freshwater animals and the Delta is managed to be fresh at all times, so we are setting the table for them nicely," Moran says. "There can be a broad horizon of impacts. We don't know what they are yet, but there's no reason to think that they'll be good." **DM**

CONTACTS mmoran@ebparks.org; Martha.Volkoff@wildlife.ca.gov

Photo: Wikimedia Commons

Freshwater seep by Peter Baye

Small Natural Features, Big Ecological Benefits

One of the beauties of the Bay Area is that the landscape, while densely urbanized, is also rich in remnants of the wilderness that was once here. And many have big ecological benefits, boosting native species far more than their size might suggest. Here are just a few of the small but key natural features to celebrate in and around the Estuary.

FRESHWATER SEEPS

While many tidal marshes in the Estuary are diked, natural marshes — which also tend to be ancient — are still connected to the land. In places where groundwater is barely beneath the surface, like small valleys between gentle hills, freshwater seeps out and trickles toward the salt marsh.

"You won't see the water flowing but you can see it in the plants," says Peter Baye, a coastal ecologist and San Francisco State University lecturer.

As water from a seep flows toward the Estuary, it becomes ever saltier and this gradient supports a fringe of brackish marsh between dry land and salt marsh. "Brackish zones are refuges for species that can't take salt," Baye says.

These zones also have a subtle beauty. Brackish marsh plants often grow in well-defined swathes, each a distinctive shade of green. As the freshwater from seeps mingles with salt water, the silvery green of willow groves on the land side contrasts with the dark olive-green of rushes and sedges, followed by the bright green of cattails or tules, and finally, on the salt marsh side, by the deep green of bulrushes topped with speckled brown seedheads.

Without freshwater seeps, plants like pickleweed and saltgrass dominate salt marsh edges. "Seeps increase diversity," Baye says. "They're especially important in extreme droughts." (See other seep stories pp. 2-3.)

ALCATRAZ CLIFFS

Alcatraz is only a third of a mile long and just a bit over 500 feet across at its widest point. But from late winter through summer, thousands of nesting seabirds are crammed on this tiny island. Birds that breed there include Brandt's cormorants, which have brilliant blue throat patches; double-crested cormorants, which have orange throat patches; and pigeon guillemots, auk family members with bright red mouths, legs and feet.

Most birds nest up and down the island's sheer sandstone cliffs, which are 140 feet high. "Seabirds like to be in inaccessible places away from mammalian predators," says Letitia Grenier, an ecologist with the San Francisco Estuary Institute (SFEI). Cliffs give breeding birds the freedom to dive into the Bay or wade along shorelines and in tidepools for fish, leaving their nests otherwise undefended.

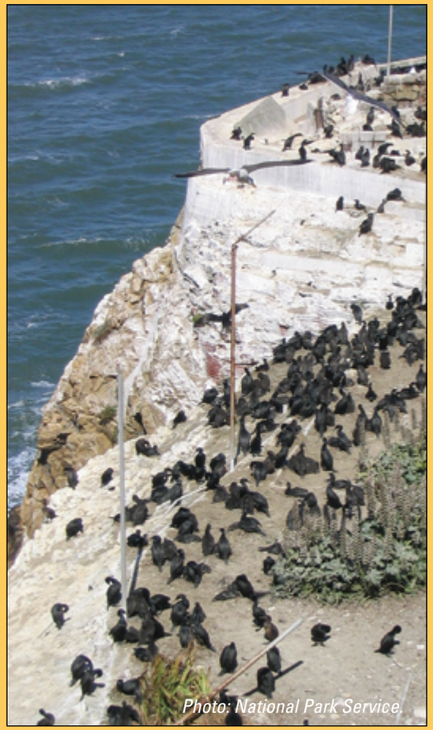


Photo: National Park Service.

The combination of safety and proximity to food for their chicks make cliffs critical to seabird reproduction. But many cliffs in the Bay Area have been impacted by people. "Seabirds usually breed on offshore islands like the Farallons," Grenier says. "What's cool about Alcatraz is you can see them easily."

GRAND OLD OAKS

Photo: Amber Manfree

Oak savannas once flourished in coastal valleys around the Estuary, and today remnant old trees — huge, craggy and enduring — are scattered across the landscape. Mostly valley and live oaks, these survivors predate the Gold Rush and can be several centuries old.

"Mature oaks are different from young trees," says Robin Grossinger, a historical ecologist at SFEI. "They have more acorns, more fissured bark, and more dead wood for nest cavities."

Old oaks feed and house thousands of species, and are essential to acorn woodpeckers and many insects. "They can be whole worlds in and of themselves," he adds.

Canopies of old oaks are vast, as much as one hundred feet wide. But on the ground, the trees take up just 10 square feet or so. This can make them compatible with other land uses — as long as they are in the right spot. Those people have spared were lucky to fit in yards, parking lots, and plazas or pocket parks.

Intrinsic adaptability is likely another factor in the survival of grand old oaks. "They're obviously very successful," Grossinger says. But urban oaks are often too isolated to pass on their ability to withstand change. To make acorns, oaks need to be close enough for wind to carry pollen between them.

He hopes re-oaking — planting young oaks nearby — will help preserve the genetic diversity of old oaks. "They're amazing living legacies," Grossinger says.

DEEP POOLS

Some Bay Area streams are ephemeral during the hot season, with dry stretches that could strand fish like the endangered steelhead trout. What saves them from low summer flows? Streams also have deep pools.

"They allow fish to survive hot summer months," says Michael Bowen, a project manager at the State Coastal Conservancy.

Bigger streams have bigger pools, and those in Alameda and San Francisquito creeks can hold hundreds of fish. Bowen isn't sure exactly how far down these pools go, but in other parts of Northern California they can reach depths of two to three meters.

Even when streams don't dry out, they can get too warm for salmonids in the summer — but the deepest pools are still cold at the bottom. Water there can be as much as 9 degrees C colder than on the surface.

Fish also use deep pools to escape predators like herons and raccoons, as well as rushing waters during heavy rains. "Fish can hunker down and survive," Bowen says. The slower water in pools is also less cloudy during the winter. As sunlight shines through the clear water, algae multiplies, nourishing the aquatic insects that fish eat. "They can hunt by sight," Bowen says. "Migrating salmonids can bulk up on their way to the ocean."

ANCIENT SALT MARSH

During high tides in the Estuary, animals that live in salt marshes — including at-risk species like the salt marsh harvest mouse and Ridgeway's rail — seek higher ground. But usually there's no place for them to hide.

"They get picked off by predators like northern harriers," says SFEI's Letitia Grenier.

Ancient marshes, which can be thousands of years old, offer a haven from rising water. Bit by tiny bit, fine sediments have built up along tidal channels that meander through ancient marshes, creating slightly higher elevations lined mostly by gumplant, a shrubby member of the daisy family with spectacular yellow flowers. Small creatures shelter in gumplants, where they are further protected by pickleweed and salt grass growing up around the edges. "Predators can't see in," Grenier says.

These ancient marshes are also home to plants that are now rare in the Estuary's younger salt marsh, including spring wildflowers called goldfields and owl's clover, as well as soft bird's beak, an endangered herb found only in California.

Today, ancient marsh remnants in the Estuary include Heerdt Marsh near Corte Madera, China Camp Marsh near San Rafael, Petaluma Marsh near Novato, Whittell Marsh near Richmond, and Laumeister Marsh in the Palo Alto Baylands. **RM**

CONTACT botanybaye@gmail.com; letitia@sfei.org; robin@sfei.org; michael.bowen@scc.ca.gov

Hana Moidu checks depth of deep pool in upper Coyote Creek watershed east of Morgan Hill (see p. 13). Photo: Stephanie Carlson

STATE OF THE ESTUARY

Smart Plover Predators

The South Bay's salt pannes—bleak unvegetated flats left behind by commercial salt works—seem inhospitable to life. To western snowy plovers, though, they look like home: a place to lay their speckled eggs and forage for beetles and brine flies. Tidal marsh restoration under the South Bay Salt Pond Project will shrink that habitat. As biologist Karine Tokatlian explained in her October 2017 State of the Estuary Conference presentation, efforts to do more with less by boosting the plovers' breeding success in the remaining salt pannes have encountered unexpected challenges, including coping with crafty predators.

Most of the coastal population of these small sand-colored shorebirds historically nested on ocean beaches, although some may have used small natural salt flats around the Bay. Over the last century, plover numbers increased in the South Bay as beach habitat diminished and salt production created alternative habitat. Overall, California's snowy plovers aren't doing well: the coastal birds are federally listed as threatened, their inland-nesting relatives a state species of special concern. One of the restoration project's goals is sustaining a South Bay breeding population of 250 snowy plovers, about as many as now nest Bay-wide.

According to Tokatlian, oyster shell has been spread on snowy plover nesting areas in Oregon and Washington State in the hope that the shells would camouflage their eggs and chicks from predators. Following small pilot projects, in 2014 Tokatlian, then with the San Francisco Bay Bird Observatory, tried this on a larger scale at Eden Landing Ecological Reserve, a state-managed portion of the salt-pond complex near Hayward used by over two-thirds of the South Bay's breeding plovers. The plovers' nesting density increased at the treated sites. But this didn't translate to more young plovers, because predation by common ravens depressed nest survival rates. (Of 42 documented predation events at the plover colony, ravens accounted for 41, a peregrine falcon for the 42nd.)

Tokatlian says the ravens—intelligent and opportunistic birds—may key on either the oyster shells or the higher density of nesting plovers. Resident peregrines may have deterred California gulls and other potential predators, but not the ravens.

Predator management resources for Eden Landing are limited, and some options have been ruled out. Exclosure—fencing nests to exclude predators—works better against mammals than avian predators, and has been associated with increased death rates for adult plovers. Relocated predators find their way back. In another location, Humboldt State University wildlife scientists Sara Peterson and Mark Colwell took a creative approach to repelling ravens from a coastal snowy plover colony, acting out the killing of a raven with a taxidermied specimen as a prop and recorded gunfire and distress calls for sound effects, then hanging the carcass nearby. Ravens subsequently avoided the crime scene, at least for one nesting season. Closer to home, the Hayward Regional Shoreline has succeeded in hazing predators away from a site used by snowy plovers and California least terns—but that required a lot of volunteer hours.

Other colony-nesting shorebirds and waterbirds—black-necked stilts, American avocets, Forster's terns—use the salt pannes. Last year, endangered California least terns joined them at Eden Landing for the first time. Tokatlian says research on the shorebirds' and waterbirds' basic habitat needs and ways to accommodate them continues. Restoration has its paradoxes, requiring an adaptive process in which managers weigh the disparate needs of different focal species and stay alert for unintended consequences. **JE**

CONTACT
ktokatlian@openspace.org

Conference Abstracts
www.sfestuary.org/state-of-the-estuary-conference/

Photo: Karine Tokatlian

SCIENCE

Coyote's Cache of Intermittent Riches


Photo: Nate Seltenrich

Robert Leidy and Stephanie Carlson show the way along the stony bed of Coyote Creek. Even after last winter's record-setting rains, much of it is bone-dry in late September. The main waterway in Morgan Hill's 87,000-acre Henry W. Coe State Park has been reduced to a series of rapidly drying pools.

But as Leidy, an Environmental Protection Agency ecologist, and Carlson, a UC Berkeley professor and fish ecologist, have learned through research along a 2.5-mile stretch of Coyote Creek over the last four summers, the protected waterway's extreme annual swings above Coyote Dam — from flood to fragmentation and back — also make it a bastion of native biodiversity. "It's almost a reference state," Leidy says of the creek's undisturbed condition.

There's a common perception in California that more water is always better for fish. Yet many native species possess traits that allow them to persist through harsh, dry summers and cyclical drought. Over the long run, summer releases from reservoirs and urban runoff can harm local fish by laying out a welcome mat for non-native species adapted to perennial flows, Leidy says. "In areas where streams have been altered by humans, where the natural hydrograph has changed, that's where you see invasives take a foothold."

Coyote Creek's strictly seasonal flows, and those of other naturally intermittent streams in the state, by contrast, are so extreme in the winter and so sparse in the summer that non-natives simply can't cope. "It's physically too much for them, and they just can't get established," Leidy says.

What's more, intermittent streams that fragment or "disconnect" during summer offer both creek and pond habitat, likely supporting a greater diversity of aquatic and terrestrial species than even a naturally perennial stream.

Leidy and Carlson's latest visit to Coyote Creek is part of an ongoing effort they launched in 2014 with former Berkeley postdoctoral scholar Michael Bogan to better describe and quantify summer intermittency along Coyote Creek and its relationship with the distribution of aquatic species. Before heading to the University of Arizona, where he's now an assistant professor, Bogan identified some 170 species of invertebrates in the creek's remnant pools, seeps, and springs — predominately insects but also including sponges and the imperiled California floater freshwater mussel.

Today's task: sampling fish populations in a series of larger pools along the mostly still creek. Wearing waders, Leidy and Carlson enter a waist-deep pool with a fifteen-foot seine, which looks something like a heavy-duty badminton net. They begin pulling it slowly through the water toward a sandbar on the other side where Pablo Rodriguez-Lozano, a postdoctoral researcher in Carlson's lab, and Megan Fitzgerald, an EPA biologist, await with half-full buckets of water at the ready. The seine comes ashore wiggling with dozens of tiny fish, mostly chunky California roach and torpedo-shaped Sacramento pikeminnow, and all four researchers set to quickly picking them up with their fingers, one-by-one, and dropping them in the buckets.

As Rodriguez-Lozano and Fitzgerald begin the time-consuming task of recording each fish's species, length, and weight, Leidy and Carlson return to the pool with hand nets to search for riffle sculpin, which tend to live along stream banks and are difficult to catch with a seine.

Over the course of the summer Rodriguez-Lozano has led similar surveys up and down Coyote Creek, sampling fish every month in ten predetermined pools of various sizes to study the relationship between fish size and pool connectivity. Preliminary results show that fish condition (a measure of the relationship between weight and length) does decrease, particularly for roach and sculpin, once pools disconnect, suggesting that the harsh conditions stress our native species just as they support them.

Rodriguez-Lozano's study builds on Leidy and Carlson's larger long-term effort to map and measure stream connectivity here during the summer and fall, from May until the first significant rain, to better understand patterns of biodiversity and population persistence in drying pools. Now in its fourth year and planned to continue for many more, the project already includes a historic drought and a historic deluge — but no "normal" years, which both complicates and enriches the dataset.

What the researchers can say so far is that although this 2.5-mile stretch of Coyote Creek shrunk to

continued next page


Photo: Stephanie Carlson

Rob Leidy, Pablo Rodriguez-Lozano, and Stephanie Carlson (L to R) pulling a seine net through a larger pool in Coyote Creek for a fish survey in September 2017. Credit: Nate Seltenrich

just six to eight small pools at the end of each summer during the drought, a contraction rate of about 80 percent, what remained was enough to support the survival of native species including the roach, pikeminnow, and sculpin, as well as the Pacific brook lamprey, the California floater mussel, the rare foothill yellow-legged frog, and the threatened California red-legged frog. Only the Western pond turtle seemed to truly suffer, as team members frequently observed empty shells scattered along the creek throughout the drought.

Last summer was a different story, with the creek contracting only 35 percent by November after a soaking-wet winter. Most species appeared to appreciate or at least tolerate the extra water, Carlson says — apart from the Sacramento sucker, whose numbers were way down. She suspects the fish, which tends to be quite tolerant, was hurt by unusually high flows during winter storms.

Other research projects led by Berkeley students and postdocs at Coyote Creek under the tutelage of Carlson and Leidy seek to understand how intermittent streams help feed terrestrial organisms like racoons, snakes, and birds over the course of the summer, as pools get smaller and fish become more vulnerable to predation; why "sanctuary" pools exist where they do, including the influence of large boulders from landslides on pool persistence; and how long Pacific brook lamprey can survive in the gravel of pools whose surface water has evaporated.

Although findings to date are limited, the message behind all this work is that organisms native to intermittent streams, in California and around the world, are well suited to harsh conditions and severe seasonal swings — a fact that could have implications for conservation and land management in the coming decades. "With climate change, they'll be more threatened," Leidy says. "But they also may be more resistant, as we've seen in Coyote Creek where organisms persist in pools that are somewhat decoupled from annual rainfall. These could be important refuges to protect biodiversity." **NS**

CONTACT Leidy.Robert@epa.gov; smcarlson@berkeley.edu

More of this story online at www.sfestuary.org/estuary-news-coyote-cache-riches

California red-legged frogs. Photo Rob Leidy

Non-Sticks Stick Around

Though levels of some kinds of stain and water repellant chemicals in Bay seals and seabird eggs have declined in the last decade of monitoring, other kinds of fluorinated chemicals have not, according to data from the Regional Monitoring Program (RMP).

"The reason for the lack of declines is not clear," says researcher Meg Sedlak, a senior scientist with the San Francisco Estuary Institute (SFEI).

Over 3,000 fluorinated chemicals, known as PFASs (per and polyfluoroalkyl substances), are used in textiles for clothing and furniture, grease and waterproof coatings for paper, and aqueous firefighting foams. Thanks to their stability, as well as their unique ability to repel oil and water, they've been used in product manufacturing for decades. Ironically, their very stability is also why some PFASs are considered chemicals of concern to public health and the environment. Data collected since 2006 by SFEI and the RMP has found these common coatings and repellants in San Francisco Bay water, sediment, and wildlife.

The most well known PFAS is PFOA, which despite the awkward acronym is familiar to many as one of several ingredients in the non-stick pan coating Teflon – now banned. Studies had detected perfluorinated chemicals (which include PFOA and PFOS) in human blood, and linked their accumulation to health risks such as cancer and liver damage. As the largest manufacturer of PFOS in the U.S., 3M phased out the chemical in 2002; PFOA was phased out by DuPont, 3M and other manufacturers by 2015. And in 2016, the U.S. Environmental Protection Agency finalized health advisories for levels of PFOS and PFOA in drinking water.

Based on the detection of PFOS and similar chemicals in animals around the globe in the early 2000s, the RMP conducted a small study to see whether these compounds were in the Bay. A recent paper links those results to later data and presents temporal trends in PFASs in San Francisco Bay's fish, bird eggs and seals over the last 13 years.

"In 2006 and 2009, the levels of PFOS we found in cormorant eggs were some of the highest observed concentrations in the world," says Sedlak.

During the same time period, the RMP also detected high concentrations in seals located in the South Bay. By 2016, though, PFOS concentrations dropped substantially in cormorant eggs and seals — likely due to the phaseout, says Sedlak, though the eggs still exhibited levels associated with reduced egg hatching success in tree swallows.

Though PFOS and PFOA (known as C8s because their molecules contain eight carbons) aren't made domestically anymore, they are still manufactured in other countries. And in the U.S., the phase out has meant that the longer-chained PFASs have just been replaced by shorter-chained versions (dubbed C4s and C6s), as well as by fluorinated ether compounds.

Dr. Erika Houtz, an environmental engineer and PFAS expert who monitored their levels in San Francisco Bay stormwater and wastewater for most of the past decade, says that the shorter chain PFAS substitutes detected in the environment today are much less bioaccumulative.

"But shorter chain PFASs are more mobile in water," Houtz says. "They're also less responsive to many of the technologies a water treatment plant might use to remove or separate the [longer chain C8] compounds."

Is anything being done about PFASs in a more public sphere? In January 2017, the California Department of Toxic Substances Control's Safer Consumer Products Program held a one-day workshop to share knowledge about PFASs. Industry, academic researchers, NGOs, U.S. EPA and the Centers for Disease Control and Prevention (CDC) all participated.

"We were able to bring all these players together and have an actual dialogue," says Dr. Simona Balan, a senior environmental scientist with the Safer Consumer Products Program. "There was no disagreement about whether the longer chain PFASs needed to be phased out."

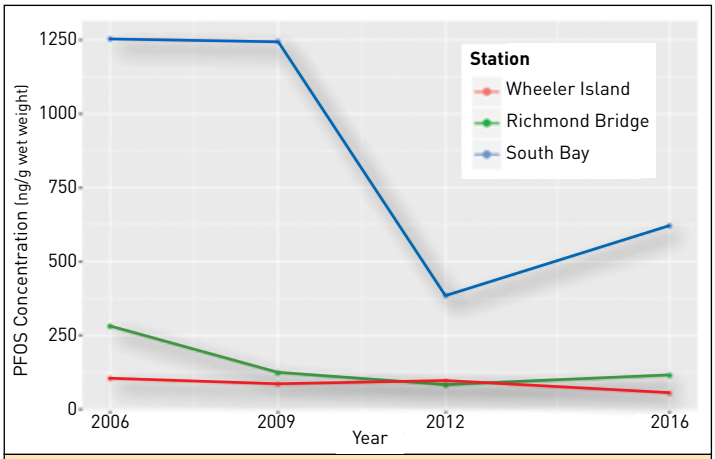
For shorter chain PFASs, though, opinions varied. "Generally, the academic community [felt there wasn't] enough information to make a formal safety assessment, whereas the product and chemical manufacturers have embraced the shorter chains as an alternative," Balan says.

But there was also a higher purpose for the workshop. "Our program was developed with the intention of preventing regrettable substitutions," she says. "If we decided to focus on a class of chemicals found in a certain type of consumer products, manufacturers would have to identify potential alternatives and determine if the product can be made safer."

In the meantime, the RMP will continue to monitor PFASs in cormorant eggs every three years, and in sport fish every five years. KrW

CONTACT Meg Sedlak meg@sfei.org, Erika.Houtz@arcadis.com, Simona.Balan@dtsc.ca.gov

Read the paper - M.D. Sedlak et al. *Chemosphere 185* (2017): www.ncbi.nlm.nih.gov/pubmed/28477851



PFOS concentrations in cormorant eggs from three stations in the Bay. From SFEI (2017). The Pulse of the Bay: The 25th Anniversary of the RMP. SFEI Contribution #841. Cormorant photo above: Mark Rauzon

E N D A N G E R E D

Cold Curtain

For infant Chinook salmon, cold water is the elixir of life. Only chilly water can deliver the levels of oxygen their eggs need to hatch and their fry need to mature. But by the end of California's scorching summers, snowmelt frigid enough to raise goosebumps is all too often in short supply in the Sacramento River.

To keep endangered salmon comfortable, water managers have added an elaborate series of hydraulic structures to the channels, dams, and reservoirs of the upper Sacramento River system. The hack involves two rivers, two floating rubber sheets, and a set of 9,000-ton steel gates, all of which are critical to maintain the dwindling Chinook runs of the Central Valley.

The system received its latest tweak this fall, when one of the rubber curtains was replaced with an upgraded design. This winter, engineers will evaluate how well the new set up is conserving cold water for native fish.

In the Sacramento River, cold water for salmon flows from two main sources. Most comes from Shasta Lake, formed by a massive concrete dam that blocks the river's main stem 15 miles north of Redding and collects water from cool upper Sacramento tributaries. Lake water reaches the river via the dam's power plant or its main spillway.

For dam operators struggling to keep river waters cool in autumn, the power plant posed a major problem. As designed by the U.S. Bureau of Reclamation in the 1940s, it could only pull water from 300 feet below the lake surface.

"That's where all the cold water is. So when we started releasing water in spring, it let cold water out too early. Little volume is left by fall, when salmon really need it," says USBR hydraulic engineer Tracy Vermeyen.

Photo: Mike Wigle

The solution: a 300-foot-tall, 250-foot-wide, $80 million set of hydraulic gates. Completed in 1997, the device consists of a series of metal shutters installed at three levels along the upstream face of the dam. The shutters are positioned in front of the penstocks, the pipes that feed the power plant. The so-called multi-level intake structure enables plant operators to draw from different water depths to meet downstream water temperature objectives.

In spring, operators open the top level of gates, which draws surface water that has been cooling all winter. In late spring or early summer, when surface waters grow too warm for salmon, the midlevel gates are opened for a month or so. When conditions heat up further, the lowest set of gates, located right over the original intakes, are opened until winter.

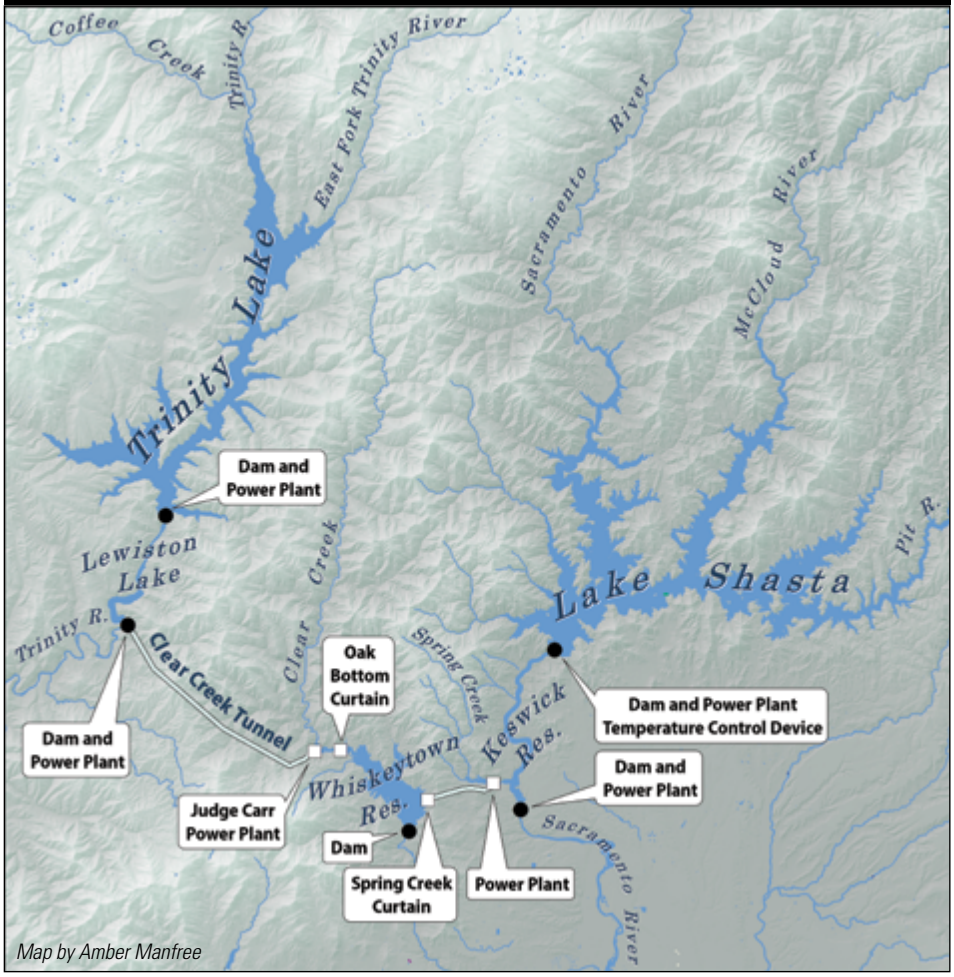
"We're managing where we're taking water out of Shasta Lake and leaving as much cold water as possible for the fall run of Chinook, who need it," Vermeyen says.

The second source of supplemental cool water comes from an entirely different waterway, the Trinity River. Every step in this water's journey to the Sacramento River includes measures to keep the water cool.

The first leg involves transferring water from Lewiston Lake below Trinity Dam three miles through a tunnel to supply Judge Francis Carr Powerplant in the northwest corner of Whiskeytown Lake.

The water gains a considerable amount of heat as it's conveyed from the Trinity River, through a long tunnel and pipeline, then flows through the power plant. This warm outflow is problematic for engineers looking to keep Whiskeytown cool.

Shasta & Trinity Water and Power Infrastructure



Map by Amber Manfree

"When the Carr Powerplant water hits the lake, a lot of mixing goes on, just like below the faucet in a bathtub," Vermeyen says. Turbulence causes the warm surface waters to mingle with the cool Trinity River water discharged into Whiskeytown Lake.

To minimize hot and cold mixing, Reclamation installed a floating impediment a few miles below the power plant, in the Oak Bottom arm of the lake. Known as a flexible curtain, it consists of a 40-foot-tall rubber sheet suspended at the surface by buoys and anchored by weights. The curtain blocks all but the deep, cold water from entering the main body of Whiskeytown Lake.

"It's a clever idea and it's been fun to work on all these years," Vermeyen says.

At the eastern end of Whiskeytown Lake, the water enters a conduit used to feed Spring Creek Power Plant, below which it is considered Sacramento River water. Spring Creek pulls water from one end of Whiskeytown to the other. Deep lake water remains cool as it travels because it is insulated by the layers of warmer water above.

Here, a second curtain ensures only cold lake water leaves Whiskeytown for Spring Creek Power Plant and the Sacramento River.

When the curtains were first installed in the early 1990s, Vermeyen studied how well they worked. Temperature probes suspended up and down both sides of each curtain indicated the dams could maintain up to a two- to three-degree temperature differential — not inconsiderable given the volumes of water involved.

In 2011, Reclamation replaced the Spring Creek curtain, which had developed a number of holes, with a newer model featuring fabric cut at lengths mirroring lake bottom contours and better-sealing flotation booms. Temperature sensors added to both faces of the new curtain this fall will enable Vermeyen to compare its performance to the old curtain as soon as this winter. The results will be used to minimize hot and cold water mixing as water is imported to and exported from the reservoir.

How the power plants are operated complicates matters further. The plants are typically run when their electricity can be sold at a premium — generally when demands peak in the evening and early morning. That schedule, however, may not always be the best method to keep lake water cool.

In general, the more water that's moved through Whiskeytown, the higher the temperature differential between the sides of the Oak Bottom curtain. This helps Whiskeytown Lake fill with cooler water available when the Spring Creek plant turns on.

How much difference these measures make in a future that promises longer droughts and hotter heat waves remains to be seen. If the supply of cold is limited, no amount of human engineering may be able keep salmon out of hot water. **KMW**

SMARTGROWTH

Trees No Slouch

Want to save the planet? Go plant a tree. Forest restoration and other land management methods can play a larger part in curbing climate change than previously thought, according to two studies published by The Nature Conservancy scientists in the last few months.

The first study examined the potential contribution that "natural climate solutions" can make toward achieving global Paris Climate Accord goals. Up to 37% of the necessary emissions reductions could be provided by a suite of conservation, restoration, and land management methods. Forestry-related practices—including reforestation, preventing forest conversion, and improving forest management—could make the single largest potential contribution identified by the study, published in the Proceedings of the National Academy of Sciences in September by Bronson Griscom and numerous co-authors.

Changing grasslands and other agricultural practices—such as limiting excess fertilizer, increasing soil carbon sequestration, and integrating more trees into croplands—would make the next largest contribution toward reaching Climate Accord goals. Other changes that would play a part include preservation and restoration of wetlands and peatlands.

The second study looked specifically at how such efforts could help California reach our own regional climate goals, which are some of the most ambitions in the world. Up to 17% of the state's goals could be met through conservation and changes in land use and management, according to the article, which was also published in the Proceedings of the National Academy of Sciences in October. **JC**

Forest Studies online at
www.pnas.org/content/114/48/12833.abstract and www.pnas.org/content/114/44/11645.abstract

ACCLIMATEWEST

Canal Communities Prep for Wet Feet

Madeleine King is on the water several times a week. Tanned and fit, she'll step atop her board at 101 Surf Sports and soon disappear down the San Rafael Canal, paddling with gusto toward its mouth and the San Francisco Bay. She sees a waterway in a state of constant flux: tides pushing or pulling, water levels rising or falling, winds blowing or resting. "We see so many changes out here," King says. "That's what's so beautiful about it — it's always changing."

However, the incremental march of sea-level rise is essentially invisible to King, just as it goes unnoticed by many residents, workers, and business owners along the 1.25-mile waterway's densely developed shores. The creep of rising rides — a mere eight inches over the last century — is easy to miss, especially amid the canal's daily and seasonal flows and the bustle of city life that, for the most part, has its back turned to the canal. Yet San Rafael and Marin County will soon be forced to face the canal head-on, as projections for sea-level rise place it at the center of an alarming scenario. By the middle of the century, Bay tides are expected to infiltrate well into the urban center of the county's most populous city. Such tidal flooding could have drastic impacts on the predominantly Latino immigrant residents of the southern bank's Canal neighborhood — one of Marin's poorest and densest — and for the regional economy that depends on their contributions...**NS**

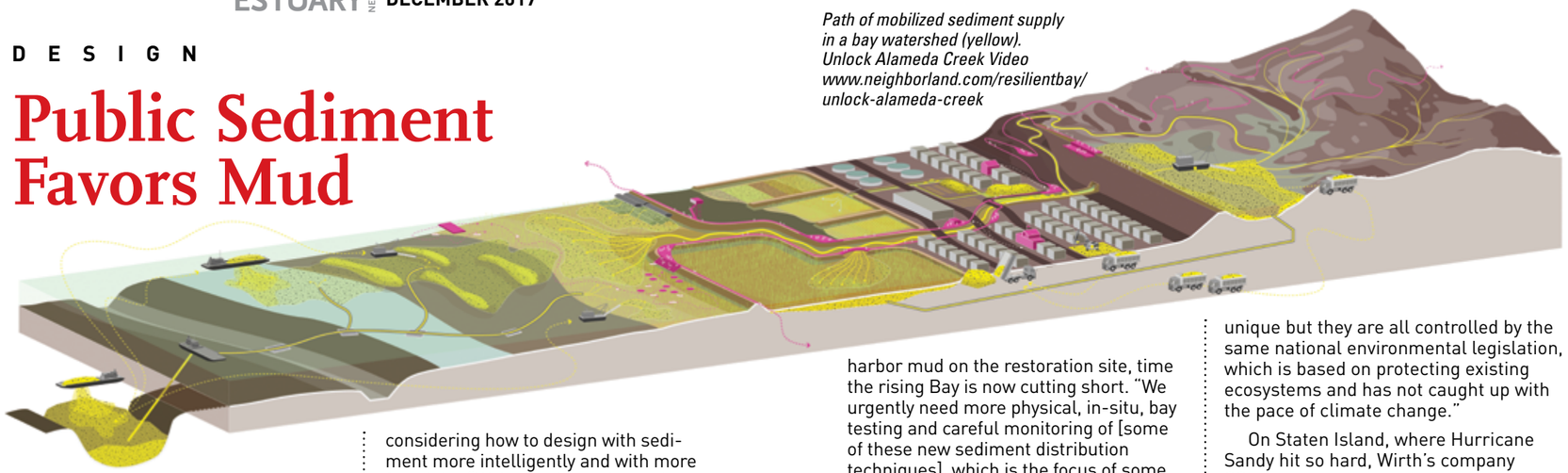
Continued www.acclimatewest.org/san-rafael-san-rafael-canal

Got some Leftover Pennies in Your Budget? Fund Journalism

If you'd like to see this kind of baseline story (excerpt above), which links real experience on the ground with local and regional efforts to prep for sea level rise, written about your creek, cove or waterway, we can help you clean out your coffers. AcclimateWest is a start up project of the ESTUARY news team, and we'd love that unspent $3,000 in your annual budget to underwrite investigative journalism and graphics for Damon Slough, Alameda Creek, Walnut Creek, San Francisquito Creek, Wildcat Creek, the Guadalupe River, and more. Help us flesh out this great place-based storytelling site on www.acclimatewest.org
Questions? editor@acclimatewest.org

DESIGN

Public Sediment Favors Mud



Path of mobilized sediment supply in a bay watershed (yellow). Unlock Alameda Creek Video www.neighborland.com/resilientbay/unlock-alameda-creek

Louisianans don't stumble over the word "sediment." According to Brett Milligan of the Dredge Research Collaborative, it's a dream for their group to work in the southern state "because the entire population knows how important sediment is to their future." Of course, residents of New Orleans felt the consequences of living at the sinking mouth of one of the most altered, dammed, leveed, and flood controlled river systems worldwide during hurricane Katrina. In the absence of hurricanes, the West Coast has been a little slower to moon over mud. But a new bi-coastal team of innovators, already working on coastal infrastructure design and mud mobilization in New York, New Orleans and other harbors, is doing their best to shift the Bay Area mindset.

"We went all in on sediment," says Gena Wirth of SCAPE, who leads one of ten teams invited to design shorelines more adaptive to rising sea levels as part of the Bay Area Resilient by Design Challenge. Launched in early 2017, Resilient by Design is the latest of several disaster-triggered international design competitions but the first to take place before the disaster.

"Public Sediment," the name of Wirth and Milligan's team, is a collaborative of seven firms and groups including UC Davis. Together they are proposing mud rooms, mud berms, mud pathways, and top-to-bottom mud management to better build up Bay Area shorelines and keep them above rising water. "As we looked into designing with a sediment focus, we realized how it connects to so many other aspects of resilience, not just wetlands, but also social vulnerability and aging urban infrastructure. It's a really useful lens for the conversation," says Wirth.

Milligan's collaborative, part of the team, organizes DredgeFests around the country but more recently began considering how to design with sediment more intelligently and with more foresight. "We're finally seeing a change in paradigm, from treating it as waste to valuing it as a resource," he says.

The team began their research by reviewing the existing science on the Estuary's sediment supply, and which corners of the Bay it collects (USGS), and also more fine-tuned analysis of how mud moves through three Bay Area creeks and builds up wetlands at their mouths, or not (Flood 2.0, SFEI & SFEP). What was missing, says Wirth, was the total amount needed to sustain marsh elevations, which her team sees as the Bay Area's best buffer against sea level rise, into the future.

According to their calculations, the region needs 300 million cubic yards more than it has. "We're not scientists, so it was great to have SFEI's Scott Dusterhoff confirm the order of magnitude of our numbers during his Sediment Savy presentation at the October 2017 State of the Estuary conference," says Wirth. "Assuming 3.5' of sea level rise, we have a sediment deficit equivalent to three Olympic size swimming pools full of mud, every day, from now until 2100."

As part of fulfilling the next step of the Resilient by Design challenge, the team recently completed three proposals on three different scales for how their approach to mud might deploy in specific places around the Bay. Their first proposal is to establish small pilots to more aggressively push the envelope of how to build a marsh where there never might have been one before, or how to place mud in the Bay and let it distribute naturally ("mud berms") without raising all the usual red flags over benthic smothering and harm to environment.

"Look at how long it took to complete the Hamilton restoration project," says Wirth, referring to the 15-year timeline for planning, approval and placement of harbor mud on the restoration site, time the rising Bay is now cutting short. "We urgently need more physical, in-situ, bay testing and careful monitoring of [some of these new sediment distribution techniques], which is the focus of some of our pilots," says Wirth.

The team's second proposal is to expand on the regional flood risk reduction contribution of the 11,000-acre South Bay Salt Ponds restoration project to make it even more of what the team calls a "Bay Cushion." "Most people view the ponds as an ecological restoration project but we can't help seeing it as so much more because the shape of the bay bottom down there amplifies tidal forces throughout the Bay," says Wirth. "We'd like to see the cushion get bigger and softer."

The team's third proposal is to "Unlock Alameda Creek." The unlocking would involve sediment harvesting steps from top to bottom in this largest of Bay watersheds. The team has ideas for everything from mobilizing sediment trapped above and below dams to breaching levees to raise marshes. They'd also like to install sediment sensing stations along the creek and invite communities and kids to educational "mud rooms."

"It's everyone younger than us that will have to deal with the more dire consequences of climate change, and investing in their education is a lot cheaper than moving mud around," says Wirth.

"It might seem ambitious to retrofit dams to release more sediment now, but as California's dams age, retrofits down the road become more plausible," adds Milligan. He also sees a lot of potential for upstream sediment management support in Measure AA. "Our proposals try to make the point that spending some of it in the uplands could benefit the baylands."

No matter what the proposal, all of these kinds of innovations – current or proposed – are sure to encounter regulatory road blocks that Wirth says are universal: "Every place we work is unique but they are all controlled by the same national environmental legislation, which is based on protecting existing ecosystems and has not caught up with the pace of climate change."

On Staten Island, where Hurricane Sandy hit so hard, Wirth's company SCAPE has a contract to design some highly structured habitat breakwaters that could help buffer the island and build habitat for oysters, juvenile, fish, and other marine life. The project displaces a small amount of sandy bottom habitat, however, which Wirth says isn't scarce or ecologically valuable in New York harbor: "It's all been dredged." Yet SCAPE is now in the fifth year of "very in-depth conversations" with local officials on their breakwater project.

"In New York, I've seen many projects scrap their ecological infrastructure components and only build the hard infrastructure, because of regulatory context. We have to reframe our whole thinking, in terms of how we do this work. The Bay Area is already showing signs of becoming a leader on this front, but we all have to be prepared for some very long conversations," says Wirth. In the meantime, a Resilient by Design committee is scheduled to announce its decisions about which team will tackle which site with what approach in mid-December. **ARO**

EDITORIAL

Can the Region Get it Together to Be Resilient?

The last time the region really lined up its ducks was when it saved the Bay in the 1960s. Today we face an even greater threat than the filling of the Bay – rising oceans. The challenge to all our turf ahead, no matter what interests you represent, demands unprecedented collaboration and some difficult, forward-thinking decision-making. Someone has to decide what we should protect and where we should retreat, and it can't all be on local shoulders. The highways and airports are going under, and no matter what level of sea level rise you embrace, many of the little people and rich and poor communities along our shores will soon be getting wet feet, so it's no time for cold feet on the part of those we look up to.

Recently I participated in what might be called a sign of progress in regional collaboration around turf-testing decisions – editing a report called "Raising the Bar on Regional Resilience." The report debuts this winter on the web site of the Bay Area Regional Collaborative. For anyone who isn't really aware, the collaborative is a joint entity of our regional transportation, urban planning, bay conservation, and air quality districts (MTC, SFBCDC, ABAG, and BAAQMD).

The report is a self-proclaimed call to action – for the agencies themselves — to develop an integrated regional resilience plan. It's the best foot forward yet of some higher level staffers and leaders in each agency to merge priorities, identify gaps, and promote stronger leadership as a group on merging both climate change adaptation and mitigation. The report recommends six steps for a more resilient region and presents four case studies summarizing some of the legwork already done in San Rafael, East Palo Alto, Hayward, and Oakland. Finally, it includes some strong language on equity and even acknowledges water and estuary interests (long in a separate silo) in the regional planning mix.

If we can really pull this off as a region – integrate the whole shebang of prep for sea level rise, from elevating bridge onramps to saving affordable housing and buffering wetlands and providing flood control, into a single piece of regional cloth – I'll be impressed and even hopeful about at least one part of the country pulling together. Will you? It's your turn for public comment. **ARO**

Comment by January 15, 2018
barcadmin@bayareametro.gov

Raising the Bar: http://mtcmedia.s3.amazonaws.com/files/Resilience-report-final_draft-20171113a_HI_RES.pdf

San Francisco Estuary Partnership
1515 Clay Street, Suite 1400
Oakland, CA 94612

www.sfestuary.org

San Francisco Bay and the Sacramento-San Joaquin River Delta comprise one of 28 "estuaries of national significance" recognized in the federal Clean Water Act. The San Francisco Estuary Partnership, a National Estuary Program, is partially funded by annual appropriations from Congress. The Partnership's mandate is to protect, restore, and enhance water quality and habitat in the Estuary. To accomplish this, the Partnership brings together resource agencies, non-profits, citizens, and scientists committed to the long-term health and preservation of this invaluable public resource. Our staff manages or oversees more than 50 projects ranging from supporting research into key water quality concerns to managing initiatives that prevent pollution, restore wetlands, or protect against the changes anticipated from climate change in our region. We have published *Estuary News* since 1993.

ESTUARY News
December 2017, Vol. 26, No. 4
www.sfestuary.org/estuary-news/

MANAGING EDITOR Ariel Rubissow Okamoto
SENIOR EDITOR Cariad Hayes Thronson
ASSISTANT EDITOR Michael Hunter Adamson

CONTRIBUTING WRITERS
Jacoba Charles, Joe Eaton, Daniel McGlynn, Robin Meadows, Isaac Pearlman, Nate Seltenrich, Kristine Wong, Kathleen Wong

DESIGN Darren Campeau
COVER IMAGE Nicholas Coley
Water Moves Beneath Us, oil on canvas

MAGIC, *cont'd from page 3*

But perhaps the most extraordinary early result is coming from an examination of the quality of the treated wastewater that passes through the levee and all its elaborate hardware, soil zones, and root systems. Researcher Angela Perantoni is one of a team intensely monitoring exactly what gets put into pipes at the top of the experimental levee and what comes out at the bottom, or what engineers call the "toe" of the slope. "A lot of constructed wetlands designed to polish wastewater are monocultures made up of pea-sized gravel and common reeds," says Perantoni. "This project took the time to create a more diverse, native situation."

Perantoni is measuring levels of pharmaceuticals (anti-viral, anti-bacterial, anti-epiletic drugs and beta-blockers) as part of a UC Berkeley team led by David Sedlak. Another graduate student, Aidan Cecchetti, is following what happens to nutrients (nitrogen, ammonium, phosphate) – a new priority for water quality regulators. The team is also tracking organic carbon (TOC) – a key indicator of biological breakdown in the formation of peat soils.

"It's early to say yet, but the results are excellent," says Perantoni. "We expected the levee system to work well for nitrate, but we didn't expect it to remove recalcitrant trace pharmaceuticals so well." Cecchetti's results for nitrate removal were far better than conventional blackwater polishing systems – removing 95% as long as the wastewater moved through the subsurface, where it stays longer, rather than over the top of the slope.

The hydraulics are also of keen interest to the sanitary district's Jason Warner, but more in terms of how much water could efficiently pass through such systems in the long term. Currently 70,000 gallons per day are passing through the experimental levee to spur plant growth, but the district processes 12 million gallons per day. Based on the preliminary results, Warner isn't sure enough treated wastewater could be run through such systems if scaled up along the 17 miles of shoreline where East Bay dischargers operate a system of transport and deep Bay discharge pipes they may soon need to replace. But levee engineers remain optimistic that design parameters could be tweaked to pump more water through such natural treatment systems –whether it's salty brine, oily runoff, or tainted with traces of human consumption.

Though these preliminary results are just beginning to be tested under colder, wetter, more wintry conditions, planners and engineers are already thinking about bigger, longer versions of the horizontal levee in Palo Alto, Richmond, Novato, as well as along the Hayward shore near the prototype.

"The results emphasize the power of natural treatment systems, and natural systems in general," says Perantoni. "We have a tendency as engineers to just build something, a grey solution, but sometimes the best solutions are green." **ARO**

Don't Miss the Details in ESTUARY's Online Extended Story
www.sfestuary.org/estuary-news-nudging-natural-magic/

CONTACT dball@savesfbay.org; jolson@savesfbay.org; MLindley@esassoc.com; jwarner@oroloma.org; angela_perantoni@berkeley.edu; acecchetti@berkeley.edu; botanybaye@gmail.com