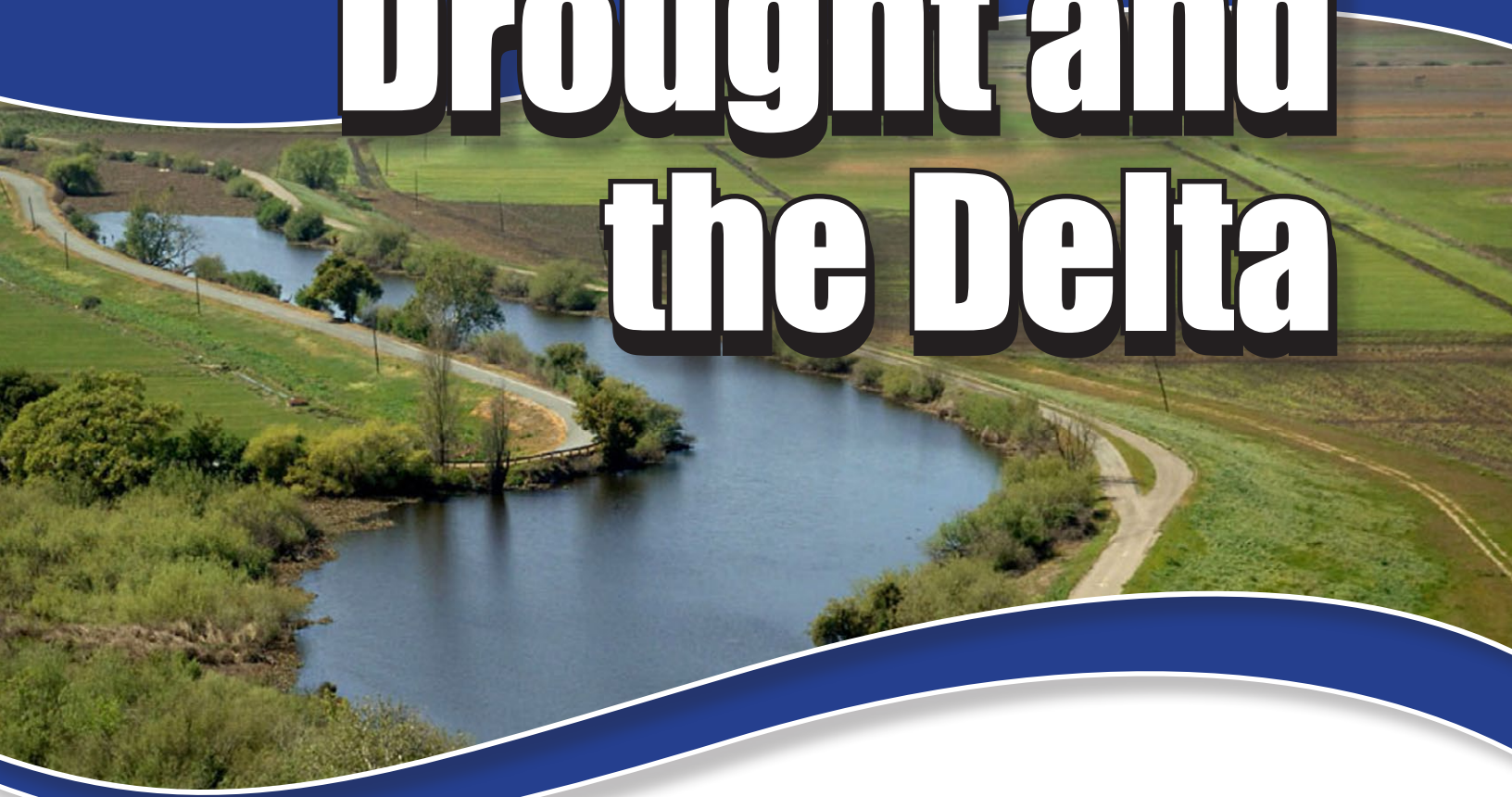
Drought and the Delta



– A "Deep Dive" into Impacts –

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WATER EDUCATION FOUNDATION

SACRAMENTO - SAN JOAQUIN DELTA CONSERVANCY
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Watch all of the presentations here
https://www.youtube.com/playlist?list=PLgiZsPcvQ9XWTFYUSdnIjXr7yz9l2hn1B

View the speakers' PowerPoint presentations here
http://www.watereducation.org/foundation-event/drought-and-delta-0

INTRODUCTION

California has endured five years of drought, and the state has paid a price. There's been a high toll on the state's rivers, reservoirs, groundwater and all the life water supports. Impacts have included water shortages and a decrease in water quality, which have impaired water systems and challenged agriculture, businesses and communities.

The Sacramento-San Joaquin Delta (Delta) is important to include in discussions about drought impacts because the region is an agricultural center, crucial ecological resource and the hub of California's water supply. What happens in the Delta has a ripple effect across the state.

The Delta drains the state's largest watershed – 45,600 square miles – and just south of Sacramento, two of the state's largest rivers, the Sacramento and San Joaquin, converge, directing about half of the state's total runoff through the region. These flows provide all or part of the water supply to more than 25 million Californians and 4.5 million of acres of farmland.

During a one-day briefing, cosponsored by the Water Education Foundation and the Sacramento-San Joaquin Delta Conservancy (Delta Conservancy) on Oct. 25, 2016, water experts discussed the drought impacts to the Delta region, how the Delta has responded and what is being done to prepare for future droughts.

Campbell Ingram, executive officer of the Delta Conservancy, welcomed the 120-plus people attending the event to what he called a "deep dive on Delta-related drought impacts."

"It's not a good situation. But fundamental to how we manage our ecosystem and our water, as well as natural resources in the future, is really understanding what are the impacts we are experiencing," Ingram said. "Our purpose today is to vet and better understand how is the Delta responding to the drought and how does that inform us as we move forward."

This paper presents a summary of the discussions at the event, which was held in Stockton.

The Sacramento-San Joaquin Delta

The Delta is formed by the Sacramento River flowing south to meet the north-flowing San Joaquin River a few miles south of Sacramento. The region is one of California's most crucial water and ecological resources.

The Sacramento River begins in the Cascade Mountains and flows south for 445 miles. The San Joaquin River begins in the Sierra Nevada and flows west and north for 330 miles. The rivers mingle and merge with smaller tributaries and tidal flows, and water then moves out through the Delta into the San Francisco Bay.

More than a century ago, farmers began building a network of levees to drain and "reclaim" what was then a series of marshes in the Delta. The lands were pumped dry and the marshes transformed into productive island farms, albeit mostly below sea level.

Today, the Delta is a 700-mile maze of sloughs and waterways surrounding more than 60 leveed tracts and islands. Of its total 1,153 square miles, nearly 73 percent of the land – or about 841 square miles - is agricultural. Dozens of small towns and cities are scattered throughout the Delta with about 100 square miles zoned for urban uses, and 117 square miles are undeveloped. The population of the region was 515,264 in 2000, according to the California Department of Water Resources (DWR).

In addition, the Delta serves as the hub of California's two largest surface water delivery projects, the State Water Project (SWP) and the federal Central Valley Project (CVP). Pumps located at the southern end of the Delta send water south for irrigation in the San Joaquin Valley and municipal water supply for the Bay Area, Central Coast and Southern California.

An aerial view shows Sherman Island with the Sacramento River above and San Joaquin River below.

The Bay-Delta estuary is the largest on the west coast of North America with more than 738,000 acres in five counties. An estimated 80 percent of the state's commercial fishery species live in or migrate through the Delta, and at least half of its Pacific Flyway migratory water birds rely on the region's wetlands.

Jennifer Bowles, executive director of the Water Education Foundation, noted, "The Delta is a region of many interests and many issues. The Sacramento-San Joaquin Delta – the hub of California's water supply, an agricultural center and a crucial ecological resource – hasn't been immune from the impacts of the prolonged drought. We want to take a close look at the Delta today and look at what those impacts are – from the farmland to the native fish to the water quality."

Jay Lund, director of the Center for Watershed Sciences at the University of California, Davis, pointed to additional challenges in the Delta, because it is a thriving region unto itself and also plays a vital role for California's water systems.

During the briefing, Lund used the analogy of Sacramento's new, large downtown arena, the Golden One Center, to describe the plight of the Delta. The stadium hosts concerts, conventions and entertainment events, as well as serving as home to the Sacramento Kings professional basketball team. On any given night when there is an event, the arena draws up to 19,000 people.

"People living in downtown Sacramento put up with Kings' games in the new stadium. They are going about their daily lives and then all these people come flushing in, disrupting traffic patterns, their restauranting, raising the cost of their land, everything," Lund said. "Now think about the Delta. It's a similar problem. The people of the Delta want to live their lives, but they are in the middle of this interchange – the water interchange for the entire system (in California). You can't escape that. It's like living in downtown Sacramento with the new arena," he said.

Jay Lund, Director, Center for Watershed Sciences, University of California, Davis

The Bay-Delta Watershed and Major Water Projects

Drought

In general, periods of drought are marked by significantly below-average precipitation that falls as rain and snow. This results in less water flowing in streams and rivers, reduced levels in lakes and reservoirs, overall warmer water temperatures and a lower water table in wells. In addition, vegetation dries out, and trees and plants are stressed by lack of water. As drought conditions linger, longer-term impacts mount, such as land subsidence (the settling or sudden sinking of the Earth's surface), seawater intrusion and damage to ecosystems.

For the most part, California depends on surface water – the water in rivers, lakes and reservoirs. The recent drought conditions have meant there is less snowfall in the Sierra Nevada, which typically provides about one-third of the water used by California's cities and farms once it melts in the late spring, according to the United States Geological Survey (USGS).

Michael Dettinger, USGS Research Hydrologist

Fast Facts

- California endured drought conditions from 2011-2016
- On Jan. 17, 2014, Gov. Jerry Brown declared a drought state of emergency
- 2014 was the warmest year on record in California with 2015 the second warmest ever
- 2015 saw record-low statewide mountain snowpack of only 5 percent of average
- The 4 driest consecutive years of precipitation on historical record were in 2012-14
  http://www.water.ca.gov/waterconditions/index.cfm

DWR and other state, federal and local agencies track precipitation throughout the "water year," which runs from Sept. 30 of the current year to Oct. 1 of the following year. A water year differs from the normal calendar year to reflect precipitation patterns – rain and snow that fall in late autumn and winter and snowmelt the following spring or summer. http://ca.water.usgs.gov/data/drought

In a "normal" year, about 40 percent of the state's water supply is provided by groundwater. That increases to a 60-percent reliance during drought years due to reduced surface water availability.

Surface water and groundwater are interconnected. Rivers, lakes and wetlands are fueled by precipitation flowing as surface water. Groundwater also plays an important role in feeding these waterways from below. When groundwater is depleted or pumped at a faster rate than an aquifer can be recharged, water levels drop, resulting in less water to meet demand and a deterioration of water quality.

During the briefing, Michael Dettinger, USGS research hydrologist, noted precipitation was at a mere 35 percent of normal between January 2013 and January 2014, beating the next lowest stretch by almost 20 percent. From 2012 through 2015, the reduced rain and snow translated into 313 million acre-feet less water flowing into the Delta catchment (an acre-foot equals 326,000 gallons and can meet the annual indoor and outdoor needs of one to two households).

In 2015, for example, the Sierra Nevada experienced a record-low snowpack, which meant less runoff flowed into reservoirs as the snow melted. Storage in all of the state's major reservoirs plummeted far below historical averages. In late May the state's largest reservoir, Shasta Lake, was at 62 percent of average; Lake Oroville was at 53 percent, and New Melones Reservoir held only 30 percent of its historic late-May average.

Historic Droughts in California (since 1900)

1917–1921	1943–1951	1987–1992
1922–1926	1959–1962	2007–1909
1928–1937	1976–1977	2011–2016

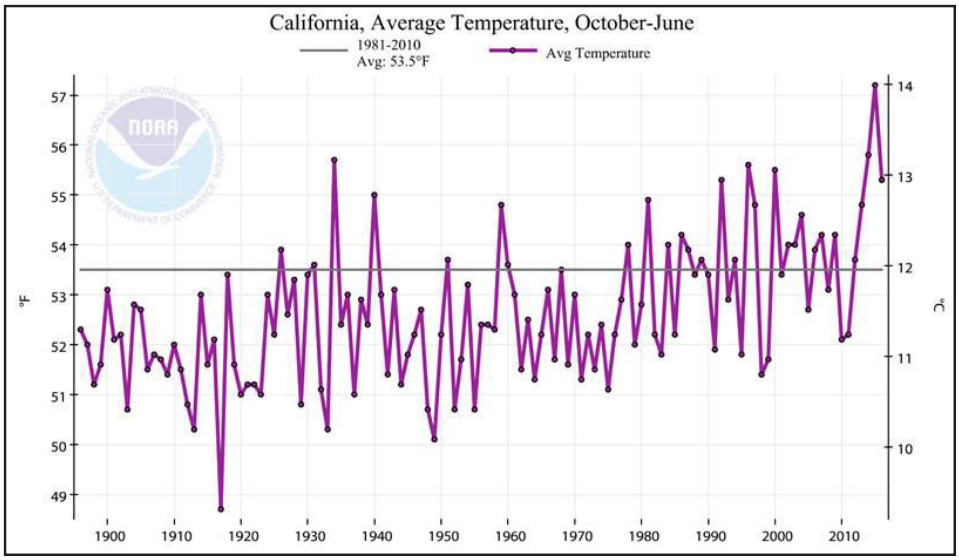
Sources: DWR and U.S. Geological Survey

Lack of precipitation also has taken a toll on groundwater supplies, because less water has been available to replenish aquifers. Compounding the problem, more groundwater is being pumped to compensate for reduced supplies of surface water. In total, Lund estimated groundwater is down 10-plus million acre-feet from before the drought.

In addition, and significantly, Dettinger said, the recent drought years have been exceptionally warm. Overall, 2015 was the warmest year ever on record in California, while June 2015-May 2016 was the third warmest year on record, according to USGS. The warming temperatures have drawn moisture from vegetation and the ground through a process called evaporative demand.

Plus, as a result of the warmth, Sierra snowpack melted more quickly and filled the reservoirs prematurely.

"In this drought, precipitation and temperature aspects have been vying with each other to determine



Records show a continued rising average temperature through the decades. Source: National Oceanic and Atmospheric Administration

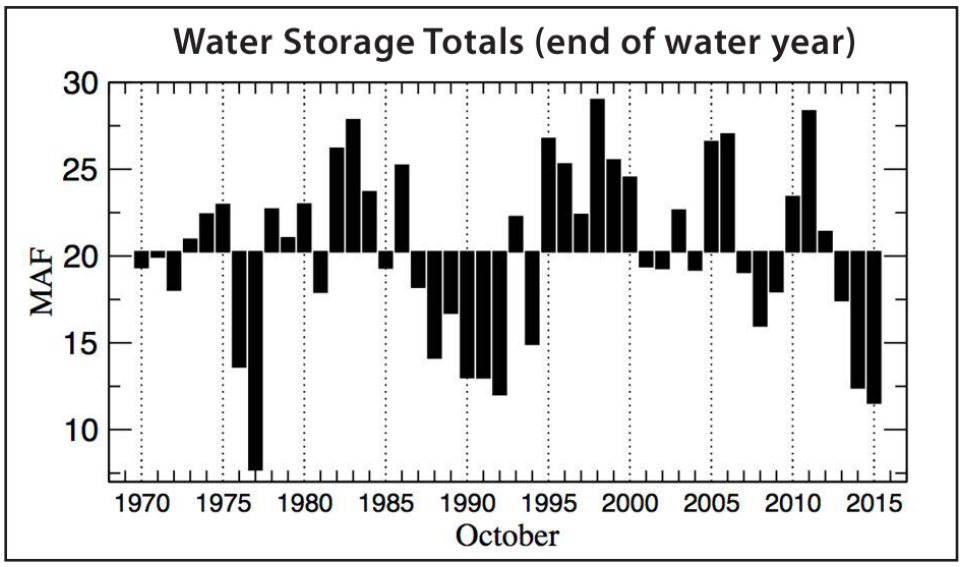
drought severity in absolute million acre-feet terms," Dettinger said.

In 2016, precipitation in Northern California was nearly a "normal" year combined with warming temperatures that meant the state's reservoirs filled quicker – "much better than in 2015," Lund observed – yet the stored total water for the state still was 3.5 million acre-feet below historical average.

The drought has impaired rivers and tributaries flowing into the Delta. The Sacramento River has had depleted flows in past years, although in 2016 the total flow was slightly above average. Of more concern for the Delta is the San Joaquin River, which typically is a drier river and more portions of the Delta are fed by the tributaries of the San Joaquin River than the Sacramento. For the past five years, San Joaquin River flows have been at or below average, with many of them close to being the driest on record, Lund said.

Another problem caused by the drought has been moving water across the Delta. Reduced precipitation has hindered flows, and, in addition, the state system has been managed to keep colder water in Lake Shasta to benefit the ecosystem, especially fish. The result has been a cutback of how much water has been pumped through the hub.

Lund said that even as conditions have improved in 2016, the state still has struggled to move surplus water south across the Delta.



This graph shows how much water (in million acre feet) has been left in California reservoirs at the end of each water year.

Summary of Impacts

The drought has created a laundry list of impacts for the Delta, which was addressed during the briefing by water experts. The topics included:

- Delta water operations and management of the resource
- Ecosystems – waterfowl and fish
- Water quality - salinity, algae and aquatic vegetation
- Delta agriculture - fallowing programs, salinity
- Policy and science implications

RESOURCE MANAGEMENT

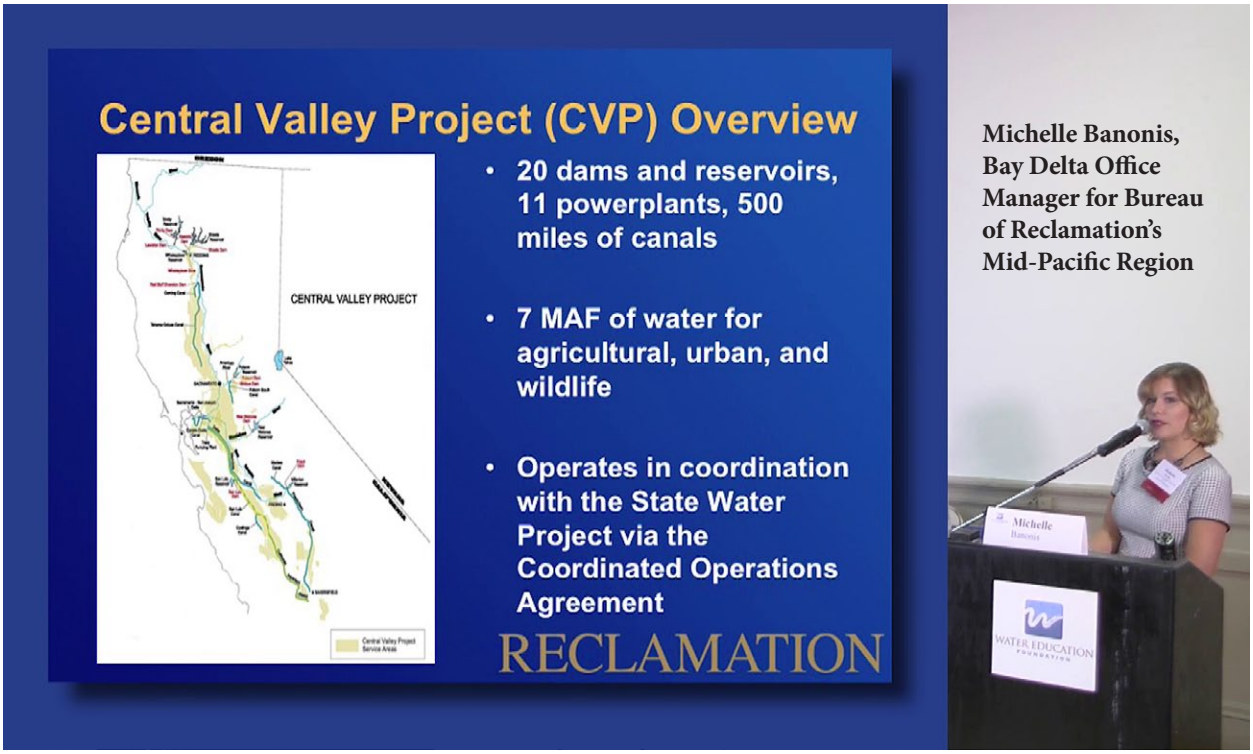
Both the CVP and the SWP rely on upstream dams and reservoirs to capture and store water that is strategically released through the Delta and redistributed via canals mostly to San Joaquin Valley farms and Southern California cities. In the Delta, water is drawn to the southern reaches by two massive pumping facilities, which can move millions of gallons per minute. The drought reduced that flow and hampered project operations.

Both water projects base their deliveries on who has priority water rights. During the drought, the SWP provided the same annual allocation percentages to all of its 29 contractors, which comprise both cities and farms. In 2011, a wet year, SWP allocations were 80 percent. Once drought set in, the annual allocations diminished. For example, the SWP delivered 65 percent of allocations in 2012, 35 percent in 2013, 5 percent in 2014, 20 percent in 2015 and 60 percent in 2016.

The Bureau of Reclamation (Reclamation), which operates the CVP, has a priority system on which it bases its total 7 million acre-feet of water allocation for farms, cities and the environment. Most of its allocations are delivered to the Central Valley, San Joaquin Valley and the San Francisco Bay Area, including to six of the top 10 agricultural counties in the state. The CVP is the largest single source of irrigation water in the state. It also delivers 800,000 acre-feet per year to fish and wildlife, pursuant to the 1992 Central Valley Project Improvement Act.

In addition, the system must adhere to regulatory requirements, such as the Endangered Species Act (ESA) and the State Water Resources Control Board (State Water Board) Decision 1641 (D-1641), which establishes that beneficial uses to be protected include fish and wildlife, agricultural, municipal and industrial. This includes an action program to achieve water quality objectives and salinity standards that must be adhered to.

The operational demands and regulatory constraints "and how those things intermeshed this year created some unique situations," said Michelle Banonis, Bay Delta Office Manager for Bureau of Reclamation's Mid-Pacific Region, detailing those challenges at the event.



Who Gets What

Every year, except for critically dry water years, 3.5 million acre-feet of CVP water is allocated to three recipients: 2.2 million acre-feet is delivered to the Sacramento River Settlement Contractors, which had pre-existing water rights dating to well before the construction of the CVP; 880,000 acre-feet to the San Joaquin River Exchange Contractors, which entered an exchange contract when Friant Dam was built in 1942 to replace that irrigation water with water flowing through the Delta. In addition, 422,000 acre-feet is dedicated to refuges. What is left goes to the municipal, industrial and other agricultural contractors.

In 2016, a nearly average water year in Northern California meant the CVP had more water available than in the prior four years. "It still wasn't ideal and storage gains weren't uniform over the system," Banonis said. For example, New Melones Reservoir suffered with less inflow from the Stanislaus River. "We were coming off of four years of drought, and species had really declined, specifically smelt and there were concerns over winter-run chinook."

For 2016, allocations for prioritized settlement and exchange contractors, as well as refuges, were at 100 percent. South-of-Delta and M&I water service contracts received 55 percent of their historical use, and South-of-Delta agricultural water service contractors got 5 percent. One contractor, the Friant Division, had fluctuations – first receiving 30 percent, updated to 65 percent, and finally at 75 percent as of July 18, 2016.

Above that, additional requests – in the form of new action plans - came in during spring and summer, which complicated operations.

In July, the state released its Delta Smelt Resilience Strategy that requested voluntary supplemental water of up to 250,000 acre-feet during spring and summer months of 2016-2018 to protect the endangered fish.
SEE P.15 FOR MORE

"Normally we have a lot of water storage in Shasta – we pick that up in the South Delta and use it for exports. Yet Shasta was still surprisingly low in August (of 2016)," Banonis said. "Reclamation worked with contractors to secure a supplemental 85,000 acre-feet for the Delta smelt. That fell short of the 250,000 acre-feet goal because the request didn't come until spring and summer."

The state also released its Sacramento River Water Temperature Management Plan on March 31, 2016 that addressed the need to protect winter-run Chinook salmon, which depend on cold water for spawning. The salmon were nearly completely lost during the earlier drought years because of a lack of cold water storage. The plan was revised later in the year after the National Marine Fisheries Service (NMFS) expressed concern about maintaining cold water carry-over in Shasta Reservoir for the following year of the winter run.
SEE P.17 For more about the temperature plan

The two fish strategies overlapped seasonally and both made their specific requirements and requests during the spring and the summer.

Overall, the many needs placed a pressing demand on CVP operations that had a ripple effect. Part of the issue was reduced releases out of Shasta, which meant fewer exports to the south-of-Delta contractors. There also were issues with contractors in the upper watershed who weren't able to divert their water from the Sacramento River. In addition, high salinity in the Delta and unusually high tidal movement meant higher outflows were required to meet D-1641 salinity objectives.

The fish strategy requests that came later in the season compounded the challenges. "By then Reclamation had already made its allocations. The water contractors had already used those allocations to plan their planting and their crop cycles. So trying to find water that late in the season was very difficult," Banonis said. "We were able to get through the season, but it was touch and go there for a while."

The struggles produced some valuable lessons. Even though there was more water available in 2016, it didn't mean there fewer resource conflicts – "we had more resource conflicts than the previous four years when there was less water," she said.

In addition, the late requests for water created problems. "The requests for additional needs absolutely must come before the water year commences [on Oct. 1]. Smelt came in spring and summer and by then planting and decisions had been made, and it was very hard for us to try to back into those species' needs," she said.

Finally, and most importantly, "We need to tie water management actions to specific and measurable biological objectives, not just numerical targets that may or may not achieve the desired effect of the species, especially given on the ground conditions," she said.

Going forward, Banonis said these lessons will be incorporated. Those include:

- Development of specific and measurable biological objectives, monitoring protocols, operational criteria
- Early coordination with regulatory agencies
- Continued coordination among State and Federal water and regulatory agencies to minimize or eliminate resource overlaps

In-Delta Water Rights

Within the Delta, the drought further illuminated water rights' challenges, as users have overlapping demands and water rights, and water was limited, said Michael George, the Delta watermaster appointed by the State Water Board. George is responsible for overseeing day-to-day administration of water rights in the Delta.

Landowners possess appropriative, riparian and overlying water rights, each with a different set of rules. Many growers have riparian rights, meaning their land borders waterways in the Delta and they have rights to tap into the water. The priorities of riparian right holders generally carry equal weight, so if water is not available, the growers share the shortage. All feel the pain, yet all still receive some water.

Other landowners with property located away from waterways have appropriative rights. Under that system, during water shortage conditions, growers with senior rights get water, while those with junior rights are cut off. Riparian rights still have a higher priority than appropriative rights.

Still other landowners only have access to groundwater on their properties. They are permitted to pump percolating groundwater without approval from the State Water Board or a court. If their wells run dry, they can deepen their well or drill a new well on their property to get to the water.

Michael George, Delta Watermaster

"My view is we must work really hard to administer the priority system intelligently, predictably, transparently and honestly so we can keep a system that can work for allocating all the water we get when we need it or when we get it and know how to cut back when we don't get it," George said.

CASE STUDY – Contra Costa Water District Operations

The Contra Costa Water District (CCWD) completed the Los Vaqueros Reservoir in northeastern Contra Costa County in 1998. In 2012, the reservoir was expanded to 160,000 acre-feet to provide more reliability during drought.

The offstream reservoir is unique in that it was designed to ensure water quality – specifically to address salinity issues - and not necessarily for water storage. However, during the most recent drought, the district needed to alter its normal protocol for the first time to tap the supply to meet the needs of its 550,000 customers.

CCWD's water conveyance system is the 48-mile Contra Costa Canal, which starts at Rock Slough and ends at the Martinez Reservoir. Water is taken from four intakes located at Rock Slough, Old River, Victoria Canal and Mallard Slough. Water is mostly supplied by the Central Valley Project (CVP) and, in fact, the district is the CVP's largest municipal customer.

"We are an in-Delta diverter. Most of our water comes from the Delta as surface water supplies with some groundwater and recycled water that our wholesalers use. Basically we live off of our CVP water contract and a few local waterway rights," said Lucinda Shih, senior water resources specialist at CCWD.

Salinity in the water has always been a challenge, and operational rules were designed around water quality. For example, CCWD typically fills the Los Vaqueros Reservoir in late winter and early spring when Delta water salinity is low. Then the district releases stored supplies to blend with Delta diversions in summer and fall when Delta salinity is high.

"We divert and pump water up from the intakes into storage when the water is fresh. That actually allows us to operate for water quality and not water supply. That makes us unique," Shih said. "We always have water at our intakes. But depending on

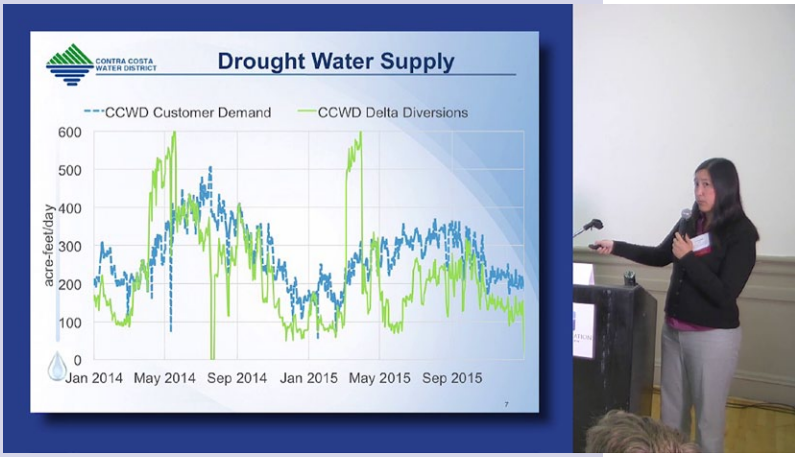
The Los Vaqueros Reservoir is located in the northern Diablo Range in northeastern Contra Costa County.

how much it's rained or not, and depending on the time of year, the water at the intakes is either salty or fresh."

During the recent drought, lack of rain increased salinity in the Delta: "What we were seeing was lack of rain. Also there were temporary urgency change petitions that relaxed some of the Delta water quality objectives that maintain Delta water quality that CCWD really depends on," she said. "We didn't protest because we knew this was such an extraordinary drought that it wouldn't be a permanent change. As a result, we relaxed some of our water quality delivery goals in order to maintain storage."

Compounding matters, CCWD had unprecedentedly low CVP allocations of 50 percent (85,000 acre-feet) in 2014 and 25 percent (50,500 acre-feet) in 2015.

Without the expansion of the reservoir to 160,000 acre-feet, water would have dropped to emergency storage levels of 44,000 acre-feet. "We would have been down to our emergency storage level at 44,000 acre-feet, which is a level in case the Delta goes out because of a levee failure – that sort of emergency," Shih said. "The drought did affect us, but also gave us a chance to see that our investments did pay off."



Lucinda Shih, Senior Water Resources Specialist, Contra Costa Water District

ECOSYSTEM EFFECTS

The Delta is an important habitat for more than 750 animal and plant species, including waterfowl, birds of prey, sport fish and species listed as threatened or endangered. These include Delta smelt, Chinook salmon and steelhead. The 1,153 square-mile estuary supports 80 percent of California's commercial salmon fisheries.

In general, drought conditions cause environmental impacts, such as:

- Losses or destruction of fish and wildlife habitat
- Lack of food and drinking water for animals
- Increase in disease in wild animals, because of reduced food and water supplies
- Migration of wildlife
- Increased stress on endangered species or even extinction
- Lower water levels in reservoirs, lakes, and ponds
- Loss of wetlands
- More wildfires
- Wind and water erosion of soils
- Poor soil quality

In the Delta, the drought has taken its toll, according to Peter Moyle, distinguished professor emeritus, Department of Wildlife, Fish and Conservation Biology and the associate director of the Center for Watershed Sciences at the University of California, Davis.

"When you are working in the Delta, it's hard to recognize there is a drought, because there are tides. You don't see the drought's effects. It's not like when I work in streams where you can see a dry streambed," Moyle said.

Still, inflows from tributaries have been reduced. "There are 1,440 large dams in the state, and each one is taking a slice of the water. That means less for the Delta." And, the current state of native fish is "horrible, and worsening."

In the Delta, overall, there have been three major causes of fish decline: habitat alteration, alien invasions (non-native species that are better adapted to the local Delta environment) and natural environmental variation, such as drought, according to Moyle.

"Drought in the Delta makes conditions worse. It means less fresh water in system, changed hydrology with cross-Delta flows, changes water quality – higher clarity, less food, saltier in places and warmer water – and the spread of non-native species," he said.

Native fish in the Delta have already adapted to drought through time: "Most of California fish evolved in a situation where long-term drought was present," Moyle said. They have the physiological

Peter Moyle, Professor Emeritus, Department of Wildlife, Fish and Conservation Biology and the Associate Director of the Center for Watershed Sciences at the University of California, Davis

tolerances and life-history adaptions. "A lot of them just get the hell out when it gets too dry - they go out to sea. There are a lot of ways these fish survive drought."

Even though the fish have endured worse droughts than now, the difference is the competing interests for water by people. "The difference is we are here. The fish did not have to experience that as well," he said.

"From a fish perspective, these long-term droughts are already in place," added Moyle, citing examples that streams are dewatered; the water is warmer;

dams block access to historic refuges; competition has increased from invasive species, "which are better adapted for the conditions we create."

"When you have a real drought, like we have now, and it just makes conditions worse. These fish are already in a drought, and we are just pushing them harder," he said.

Delta fish include: Chinook and Coho salmon, steelhead trout, sturgeon, splittail, longfin and Delta smelt, sculpin, chub, and pupfish.

Fish in Decline

- Native fishes in decline statewide - 63 species
- Fish Species of Special Concern in California (2015 California Department of Fish and Wildlife) - 30 species
- California fish listed under state and federal Endangered Species Acts - 93/122 extant species

"That means about 80 percent of all fish species in California need some sort of formal protection. That's not a very good record. And it tells you that the environment in California, in general, is not a great place to be a native fish," Moyle said.

The Delta Smelt Resiliency Strategy

Delta smelt are among the top endangered species in the Delta. Moyle said many species are under duress in the Delta, but the smelt is "the classic one where extinction in the wild is likely if present trends continue." For example, the first index from 2015 found six Delta smelt. The first index from 2016 counted zero.

The Delta Smelt Resiliency Strategy was prepared by the state to find a way to improve the smelt's resiliency to drought conditions and variations in habitat conditions. The strategy proposed 13 actions, including outflow recommendations for spring and summer for up to 250,000 acre-feet of outflow augmentation above the D-1641 requirements. D-1641 was revised in 2000 as an amendment to the water right license and permits for the SWP and CVP to meet certain objectives in the Bay-Delta Plan. D-1641 places responsibility on DWR and Reclamation to ensure that specified water quality objectives are met.

Besides augmented flows, other strategy actions include:

- Aquatic weed control to improve overall smelt habitat during 2017–2018 in locations permitted by the U.S. Fish and Wildlife Service (USFWS). Likely

treatment areas are Franks Tract, Sherman Lake, Decker Island and Cache Slough

- North Delta management to improve the food web for juvenile and young smelt by increasing food production and exporting food into areas where smelt frequent. This action requires DWR to augment flows in the Yolo Bypass by closing Knights Landing Outfall Gates and route water from Colusa Basin into Yolo Bypass. This happened in July 2016 and also is scheduled in July and/or September in 2017 and 2018
- Spawning habitat augmentation. DWR evaluated the availability of suitable spawning areas in Suisun Marsh and Cache Slough in 2016. If the natural material needed for spawning is lacking, DWR might look into adding sand and other materials
- Adjust fish salvage operations during the summer and fall. In 2016 DWR and Reclamation began to adjust summer salvage operations so that non-native salvaged fish will be collected and counted but not be returned to the Delta. Normal fish salvage operations will resume when monitoring indicates that juvenile Chinook salmon and steelhead are entering the Delta in the fall.
- Outreach to anglers. USFWS will oversee an outreach program to ensure anglers understand the benefit of catch, without release, of fish that prey on Delta smelt.

The new strategy is just finding its legs, yet state officials remain hopeful that the actions will result in increased population of Delta smelt in coming years.

Read here about the Plan on the California Natural Resources Agency website: http://resources.ca.gov/docs/Delta-Smelt-Resiliency-Strategy-FINAL070816.pdf

The endangered Delta smelt is a tiny, silvery blue fish about 2 to 3 inches long.

The Sacramento River Water Temperature Management Plan

The Sacramento River Water Temperature Management Plan, released June 29, 2016, called for reduced releases out of Shasta Reservoir to maintain cold water through summer to protect the survival of winter-run Chinook salmon. The plan looked to adjust releases from Shasta Lake into the Sacramento River to provide adequate temperatures for the salmon without cutting water deliveries to Central Valley farmers during the growing season.

"The idea of the plan was to hold back on some of the releases out of Shasta to maintain that cold water pool," Banonis said.

The plan became necessary after a devastating salmon year in drought-stricken 2014: "Despite projections and modeling efforts in 2014, Shasta Reservoir ran out of sufficiently cold water in September 2014. After this point, there was insufficient cold water available for release to the Sacramento River to manage temperatures. This lack of ability to regulate temperature was a primary factor contributing to the loss of 95 percent of last year's class of wild Sacramento River winter-run Chinook," noted a Reclamation report https://www.usbr.gov/mp/drought/docs/shasta-temp-mgmt-plan-key-components-06-18-15.pdf

Reclamation, which operates Shasta Dam and other federal reservoirs, worked with a number of federal and state agencies to refine the plan. These agencies included: NMFS, USFWS, DWR, the California Department of Fish and Wildlife (CDFW) and the State Water Board.

The plan detailed several goals:

- Maintain access to essential water supplies for California communities throughout the CVP/SWP system
- Avoid the severe winter-run Chinook mortalities of last year - develop temperature management criteria and related operations that reduce the risk of a second year-class failure by carefully expending very limited cold water pool resources over the course of the season (June though late October). The overall strategy is to manage for warmer temperatures earlier in the season in order to reduce risk of running out of cold water and catastrophic losses later in the season
- Recognize the major uncertainties associated with predicting how 2015 will transpire given the extreme conditions and uncertain weather and prepare to manage around well-informed "real time" operations based upon ever-changing current conditions. Retain integrated system operations and flexibility for end users/water districts to devise local solutions to assist in plan implementation as the season progresses
- Maintain Delta outflows, consistent with the current Temporary Urgency Change Petition (TUCP)

Extinction in the Delta

Extinction is not new in the Delta. For example, the thicktail chub was common at one time, yet the species became extinct in the 1950s. The Sacramento perch disappeared in the 1970s, although they were planted elsewhere in the state.

Why are so many species in trouble, especially in the Delta? There is a long-term decline of many species, including striped bass and zooplankton, the food resource for these fish, Moyle said.

In addition, invasive species multiply during drought, changing the food webs on which native species depend. Two of the most pervasive are the Brazilian waterweed, which crowds out aquatic plants and degrades wildlife habitat; and the Overbite clam, which consumes large amounts of plankton, a major food source for fish, such as the Delta smelt.

"Drought is the harbinger of climate change – it tells us what is going to happen," Moyle said, pointing to a graph that showed an increase of non-native fish species and a continual decline of native fish.

What can we do?

- Provide more fresh water
- Habitat restoration/improvement
- Manage Suisun Marsh as refuge
- Rethink the Delta

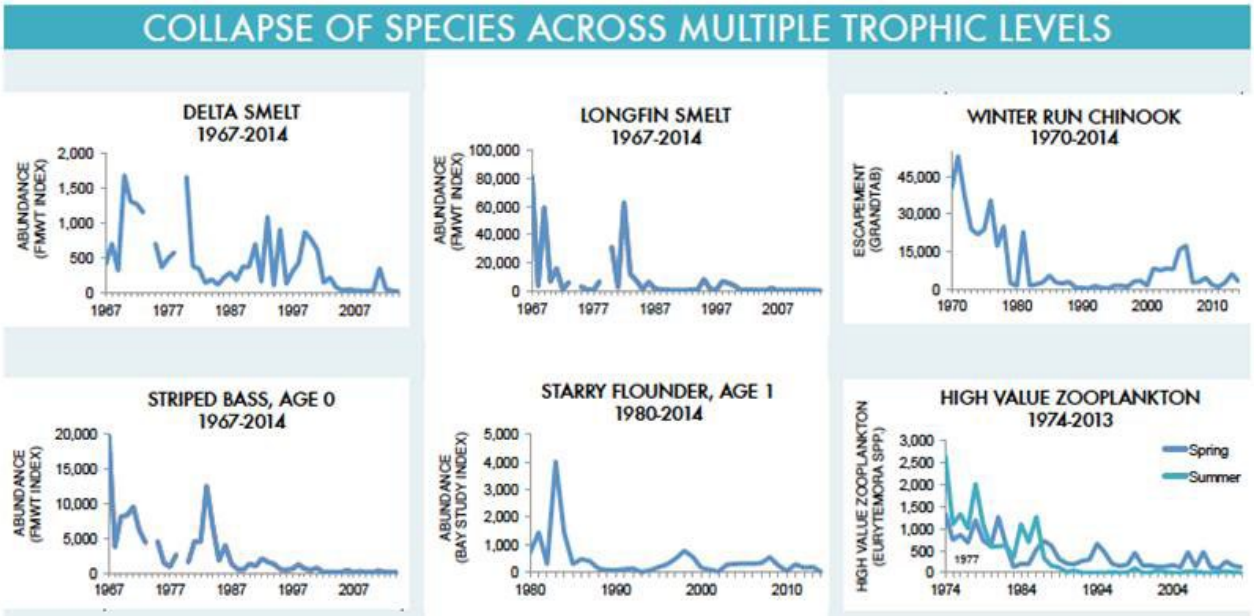


Figure 10: Abundance trends of several populations that serve as key indicators for the health of the San Francisco Bay estuary and its watershed. Data sets and length of data time series differ across species.

Restoration Efforts

"Overall we need to rethink the Delta and how we are managing it," Moyle said. He pointed to the importance of habitat restoration: "Tidal march restoration is a big deal. It is important but not a panacea for native fish recovery."

"There's a lot going on in terms of restoration," Moyle said. He emphasized the importance of floodplains and how integration into the Delta may really benefit fish. He used the Cosumnes River on the upper fringes of the Delta and the Yolo Bypass as examples.

"Salmon and splittail really benefit here," he said. "If you are a baby salmon, it's the place to be. You want to stay in that floodplain for as long as you can. You grow faster; there's lots of food. Then you move off the floodplain and out to sea at a bigger size."

Splittail have probably had the most success in the floodplains to date. A silver-gray fish that can reach about 15 inches long, the splittail prefers slow-moving water in stagnant channels. Its favorite food is insects, small clams and crustaceans and the opossum shrimp. The shrimp is essentially gone from the Delta, because it lives primarily on plankton, the number of which has dropped drastically, in large part due to invasive clams that devour plankton. In addition, the splittail has lost much of its spawning habitat. These fish depend on floodplains, especially in the North Delta, to lay their eggs from January through March.

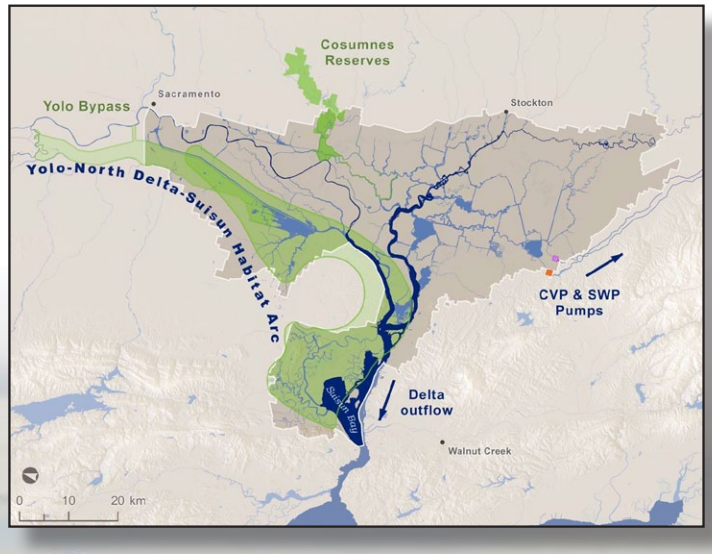
The juveniles grow, and when the floodplain starts to drain: "They know how to get out and get carried downstream. Where most of them like to end up is Suisun Marsh," Moyle said.

The Suisun Marsh is the largest contiguous brackish water wetland in western North America, providing food and habitat for thousands of migratory birds and fish. The combination of tidal wetlands, diked seasonal wetlands, sloughs and upland grassland comprises more than 10 percent of the remaining wetlands in California.

The marsh has emerged as a prime location for restoration work, because it has ample food for diverse species. As a result, there have been no major declines in fish over time compared to other areas.

"Suisun Marsh is a good place to be a fish. Tidal gates allow regulation of the salinity of the marsh. It's good for managing fish," Moyle said.

Although splittail declined during the last significant drought in the late 1980s and early 1990s, they have made a comeback in the Delta: "The reason for this is floodplain restoration. It really is a positive example.



Suisun Marsh provides excellent habitat for fish

What we are seeing is the number of splittail in the marsh has increased or the fish are doing well in recent years," he said.

He added the Delta needs rethinking for the betterment of fish: "It's hard to manage everything simultaneously at once in the Delta. From a native fish point of view, one of the best things you can do is focus your management on what we call the North Delta habitat arc. Yolo bypass down the Sacramento River past Twitchell and Sherman islands move into Suisun Marsh. If you treat that as one interconnected system, you got a place that you can manage for native fish," he said. "That's the big idea I want to get across."

Sacramento splittail are hearty minnows that can live up to 5-7 years.

CASE STUDY – The Importance of Floodplains

Floodplains are prime breeding grounds for splittail. Even in drought, there will be heavy rain that will create a flood event and spillover into floodplains. That water can make a tremendous difference to the fish, which spawn from February to April.

"In a floodplain even a few days or weeks can be to the benefit to these fish," Moyle said. "During that timing window, chances are the splittail will get in there and spawn and produce young. All they need is a week or so."

For example, 2014 was a very dry year, but a good year for splittail populations. That's because the floods of the Cosumnes River occurred just at the right time with two small pulses. The first pulse allowed the adults to enter the floodplain to spawn. The second flood provided the water to get the juveniles out. The result was millions of splittail.

"This is a good thing to know about the subtleties of native fish," he said.

Restoration along the Cosumnes River has included breaching levees to increase the number of days of flooding. The first breach was in 1997, Moyle said, "and the newest breach a couple years ago. Now it floods at 400 cubic feet per second of flow. That's a good thing. This is a simple restoration, and it's enormously beneficial to splittail."

Flooding of Cosumnes River floodplains provides crucial breeding grounds for splittail.

He suggested a "big idea" during the briefing. "Integrating functional floodplains into the Delta is good for splittail and salmon. Suisun Marsh is a good place to be a fish. The tidal gates allow regulation of the salinity of the marsh. It's good for managing fish."

WATER QUALITY

Water quality issues in the Delta have become worse during the drought, including impacts such as heightened levels of salinity and algae and bacterial blooms.

Algal Blooms

Cyanobacteria, simple life forms closely related to bacteria, are naturally occurring in water. Yet these growths can rapidly build up or "bloom" on the surface of reservoirs and waterways. The bloom - green, blue green or white - looks like a floating layer of scum and may have an unpleasant odor.

Peggy Lehman, Senior Environmental Scientist Supervisor, CDFW

"Cyanobacteria blooms have been increasing in the Delta during recent years and are very prevalent during the drought, and this year and last year have led to closures of waterways for recreational use," said Peggy Lehman, senior environmental scientist supervisor for CDFW who has conducted field research and data analysis on water quality in the Delta for 30 years.

The drought has increased the blooms due to warmer water and lower stream flows. Higher summertime temperatures have added to the problem.

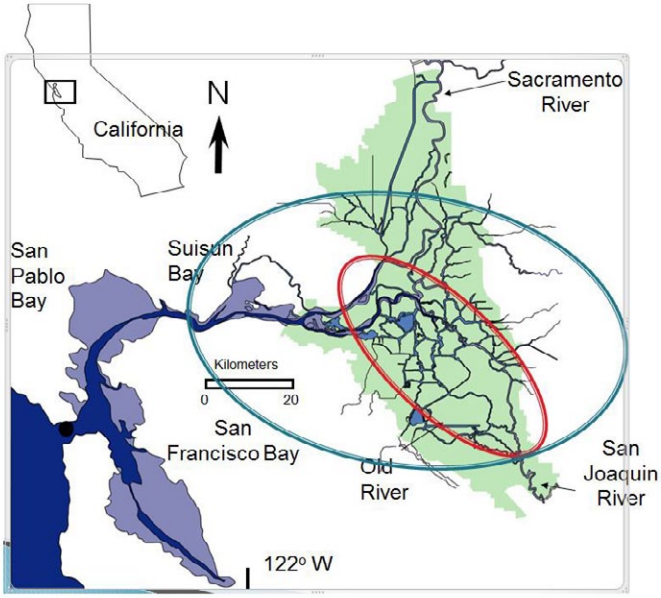
"Most of the problems in the Delta are microcystis or blue-green algae," she said. "If you are in the water and see something that looks like a green corn flake, that's microcystis."

In the Delta, blooms have been spotted along the San Joaquin River between Vernalis and Antioch, on the Sacramento River near Brannan Island State Recreation Area and in Discovery Bay in the South Delta.

Microcystis was first spotted in the Delta in 1999, and can commonly cause rashes upon contact. It also has been linked to liver cancer in humans and wildlife. Dogs are vulnerable if they lick their fur after swimming in the water. The bacteria also disrupts the food chain and can harm endangered fish such as salmon and Delta smelt.

Lehman said the greatest biological impact is to fish-food phytoplankton and zooplankton, and the blooms can affect fish health and even survival. The blooms also can impact humans, as far as aesthetics, recreation and, in severe instances, drinking water and public health.

How dangerous is toxic algae?
If toxic algae touches your skin, or you accidentally inhale or swallow water containing the toxin during recreation, you could get a rash or an allergic reaction, or develop gastrointestinal problems. The long-term effects of these exposures are not well known, but

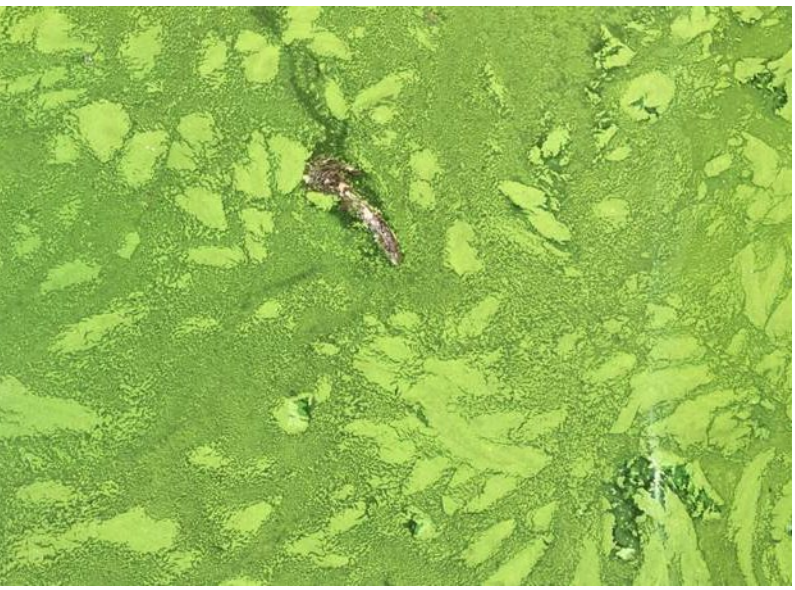


Toxic algal blooms have increased in the Delta during the drought.

children and pets are at greatest risk. Dogs can be exposed to particularly high levels of toxins by licking blue-green algae off their fur after a swim.

What should you do if you see a bloom?

- Stay out of areas where the water has foam, scum, or mats of algae. Keep children and pets out of such areas at all times. If you or your pets swim or wade in water with algae, rinse off with fresh water as soon as possible



Microcystis looks like green corn flakes in the water.

- If no algal scums or mats are visible, you should still carefully watch young children and warn them not to swallow the water
- Do not drink or cook with this water. Even if you boil or filter it, the toxins can persist
- Do not let dogs swim in or drink from areas where you see foam, scum, or mats
- Get medical treatment right away if you think that you or your pet might have been poisoned by blue-green algae toxins
- If you accidentally swallow water from an algae bloom and experience one or more of the following symptoms: stomach cramps, vomiting, diarrhea, and fever, you should contact your physician or seek medical treatment.

What about fishing and other activities? Eating fish caught during a heavy bloom can pose a health risk. Always remove the guts and liver, and rinse fillets in tap water before eating the fish. Other activities near the water such as camping, picnicking, biking and hiking are safe.

Salinity

Salinity and the Delta always have been intertwined because of daily and seasonal tides pushing in from San Francisco Bay and the flow of fresh water entering the Delta from rivers moving out toward the Bay. The intrusion and retreat of salt in the Delta is a constant pattern.

Salinity is monitored and regulated to protect water users and to prevent saltwater intrusion that can make the water unusable for fish and wildlife.

Since the CVP and SWP were constructed 50-plus years ago, salinity in the water has become a heightened issue, and carefully orchestrated reservoir releases are required to maintain the balance between salty and freshwater conditions. Drought has exacerbated the challenge.

Enough fresh water must flow into the Delta throughout dry months to repel salt water that pushes inland on ocean-driven tides from San Francisco Bay. If there is not enough water in upstream reservoirs to release to rivers to repel the saltwater, it can contaminate the channels from which water supplies are drawn, not just for the SWP and CVP but also for Delta farmers and water districts in nearby Contra Costa, Alameda and San Joaquin counties.

Salinity also has a great impact on fish and wildlife that are adapted to conditions that arise from greater flow of freshwater into and through the Delta. When that water doesn't flow through, the estuary habitat begins to not function like an estuary anymore, harming species.

In comparison to the rest of the Delta, the western Delta (roughly the area west of Isleton) suffers periodically from higher salt content, presenting a negative effect on drinking water supplies for residents of eastern Contra Costa County. The Los Vaqueros Reservoir has improved the county's drinking water quality by providing the ability to store Delta water diverted when Delta salinities are low, primarily during winter and spring, and storing it for later use.

"It was a real dry series of years; 2013, 2014 and 2015 were critically dry years. One of the things we knew was that drastic measures would have to be taken to

An emergency barrier across the West False River helped keep saltier water at bay and away from project pumps at the southern end of the Delta.

control salinity," said Jacob McQuirk, supervising engineer of water resources at DWR's Bay-Delta Office.

"Storage was low in the reservoirs that we release water out of, and that allows the Sacramento River outflow to push the Bay salts out. In 2014 we realized

we wouldn't have enough flow to push those salts out. As the Bay salt pushes in, it impacts agriculture and the environment, such as Delta smelt habitat. We knew we were going to have to take some sort of action."

The situation became so dire in 2014 that the Delta Cross Channel Gates were opened to maintain salinity standards in the southern and central Delta.

In addition, as during the 1976-1977 drought, when the state constructed barriers to slow salinity intrusion, DWR began to consider this alternate again in the north Delta along Sutter Slough and Steamboat Slough and southwest along the West False River.

"We were hoping for the best and preparing for the worst," McQuirk said, "We were looking at closing channels to try to change the plumbing in the Delta. We knew we didn't have enough water and new we couldn't meet the standards, especially D-1641, set by State Water Board."

In 2014, Gov. Jerry Brown issued an executive order exempting the California Environmental Quality Act (CEQA), a statewide policy for environmental protection, as well as the process through the Central Valley Flood Protection Board. Expedited planning and engineering put the barrier process into action. However, the barrier proposals faced opposition

Jacob McQuirk, Supervising Engineer of Water Resources, DWR

During construction, 150,000 tons of rock were used to build the barrier. A massive crane was used to complete the work.

and extensive public comments. Ultimately, in April of 2014, plans for barriers in the North Delta were dropped.

In May 2015, during the fourth year of drought, salinity once again was advancing up the Sacramento River. DWR began to focus on the construction of a temporary barrier at West False River for five months. Spanning about 750-feet wide between Jersey and Bradford islands, the barrier blocked salt water that tidal action attempts to push eastward from San Francisco Bay into Franks Tract.

To build the barrier, DWR used 150,000 tons of rocks to construct a trapezoidal barrier measuring about 120 feet wide at its base and 12-feet wide at its top

above the waterline. The rocks were dropped from barges with hinged bottoms or lifted from barges and dropped by crane into the river's channel.

Typically when saltwater threatens to encroach deeper into the Delta, water project operators repel it either by slowing the pumping of water from the Delta or increasing the amount of water flowing into the Delta from upstream reservoirs. Those options were ruled out in 2015, because of the severity of the drought. Delta pumping by the both state and federal water projects was kept to a minimum, and when fresh water was delivered to the Delta, it took three to five days for releases from Lake Oroville or Shasta Lake to reach the Delta.

The barrier removal process began on Sept. 8, 2015, and was completed on Nov. 15, 2015. DWR reported lasting benefits included permanent levee improvements (buttress rock and levee sheet-piles, 10 new monitoring stations and a rock stockpile in Rio Vista.

The West False River barrier also was not without controversy. During a February 2015 meeting in Clarksburg, many concerns were raised by Delta residents. Among those were economic impacts on the local area and the impacts that altered flow might undercut already fragile levees.

Read a meeting report from Save the California Delta Alliance: https://nodeltagates.com/2015/04/15/false-river-dam-to-be-installed.

Updating the State's Water Quality Plan

Phase 1 Bay Delta Plan update (released in Sept 2016) http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta

Les Grober, deputy director of the Division of Water Rights with the State Water Board, talked about the ongoing work by the State Water Board, which oversees water quality protection in California, to complete a review and update of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (2006 Bay-Delta Plan). The plan details water quality objectives in the Delta, including those to protect agriculture, municipal-industrial users and fish.

The last plan update was in 1995, and since then new science has evolved while the health and number of fish have declined due to water quality issues, he said.

Phase 1 of the update focuses on two changes: increasing San Joaquin River flows to protect fish and an adjustment to flows into the South Delta to decrease salinity for agriculture.

The new objectives, especially the increased flows for fish, have been controversial. The proposal calls for 30 to 50 percent of the unimpaired natural runoff from the Stanislaus, Merced and Tuolumne rivers to be sent down the Lower San Joaquin River and into the Delta.
SEE P.32

In addition to the Phase I objectives, in September 2016 the working draft of the scientific report on the Phase II update of the 2006 Bay-Delta Plan began to be circulated for review. That update will establish flow requirements for the Sacramento River and its tributaries, the east-side Delta tributaries, Delta inflow and outflow requirements.

Les Grober, Deputy Director, Division of Water Rights, State Water Board

"The Scientific Basis Report covers the science that informs the update of the rest of the Water Quality Control Plan. What is the science to inform these very controversial and difficult updates of the Water Quality Control Plan?" Grober said.

AGRICULTURE

Of the Delta's 738,000 acres, most of the land is agricultural (more than 500,000 acres). More than 7,000 water users – mostly farmers – obtain water from Delta tributaries or directly from the Delta itself. The Delta produces more than $500 million agricultural products annually.

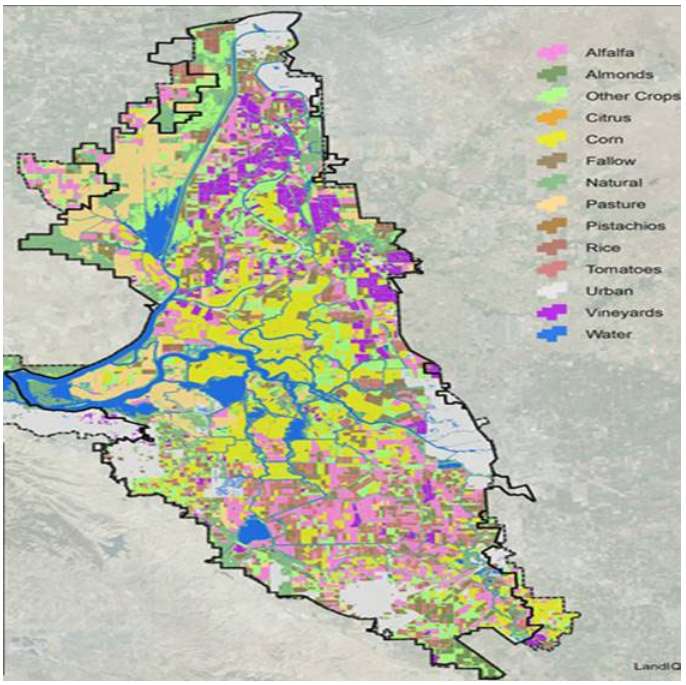
Michelle Leinfelder-Miles, who is the Delta crops resource management advisor at the University of California Cooperative Extension in San Joaquin County, pointed to salinity problems as being a major impact of drought.

Salt is added to the soil when "parent material" weathers to form salts or through amendments. Salts also are carried in irrigation water (most Delta farmlands are irrigated with surface water and not groundwater).

"Salt problems occur on approximately one-third of all agricultural irrigated lands," she said.

Delta farms face added challenges because many soils have low permeability and are difficult to leach. Surface water used for irrigation may be degraded by the time it reaches the Delta from its main source. "The Delta is at the end of the pipeline so that irrigation water may be degraded. That water has been used and reused then put back into the system. When it finally gets to the Delta, growers are using the same water that already has been used several times."

Shallow, saline groundwater also is a source of salinity. That becomes an added problem in the Delta because so many tracts and islands are below sea level.



Farmers in the Delta grow a diversity of crops.

Leinfelder-Miles outlined the challenges:

- Soil salinity conditions are made worse when water is limited
- Salinity is a problem in the Delta because soils have low permeability, surface irrigation water may be degraded, saline groundwater is shallow, and elevation is below sea level
- Crops experience stress under conditions of salinity, and research data illustrate that salts are building up in the soil to levels that have the potential to reduce crop yields
- The Delta's unique growing conditions and best management practices put constraints on growers' ability to leach salts

Top Crops:

Corn for grain and forage (98,000 acres)	Wine grape (32,800)	Almond (8,300)
Alfalfa (72,900)	Processing tomato (28,500)	Rice (6,900)
Wheat (43,100)	Safflower (11,800)	Oat (5,700)
	Asparagus (8,500)	

The number of acres planted in wine grapes has increased to 85,000.
Chardonnay is the most widely planted variety with 19,806 reported acres
Zinfandel is a 2nd at 19,494 acres. (2012 statistics)

Michelle Leinfelder-Miles, Delta Crops Resource Management Advisor, UC Cooperative Extension, San Joaquin County

- Salinity will continue to impact Delta agriculture, especially under conditions of limited water supplies or higher surface water salinity

Limited water availability also has had its impacts on Delta agriculture during the drought.

Chris Scheuring, managing counsel for the California Farm Bureau Federation, detailed the Farm Bureau's role and also described his personal experience. Scheuring's family grows walnuts and almonds in western Yolo County, in the Cache Creek watershed. He said during 2014, they were unable to get any surface water deliveries from the local water district, and in 2015, their allotment was restricted to just a number of days.

"So we did what other California farmers did, if they could; we went to groundwater. We turned on the pumps in order to survive and bring in a crop," he said.

Scheuring noted the drought was taking a noticeable toll, however. "We just completed a walnut harvest. The quality is down. One reason for that is groundwater is not a great substitute for us; our groundwater has a lot of salt and boron in it. We think there is long-term damage to our trees as a result of that. The issues are very real for me, just as they are for all California farmers."

Chris Scheuring, Managing Counsel, California Farm Bureau Federation

Farmers Take Voluntary Action to Save Water - Diversion Reduction Program

In April 2015, Gov. Brown stood in a meadow at 6,800 feet in the Sierra Nevada that should have been buried in deep snow. Instead, the governor's feet were on dry ground. It was the first time in 75 years that no snow was found during an April snow measurement.

About 180 miles downstream, growers with riparian rights in the Central and South Delta were growing concerned that lack of snow in the mountains would mean a curtailment of water deliveries later in the summer. They came up with a plan to reduce stress on the water system, in general, and, specifically, to avoid future curtailments on their supply. The growers proposed a voluntary program to reduce their surface water diversions by 25 percent from June through September. In return, the State Water Board agreed to refrain from enforcing deeper curtailments, if the governor ordered them during the summer season.

In total there were 217 plans covering two-thirds of the Central and South Delta (and a portion of Contra Costa County), or 180,000 irrigated acres. In the end, the program exceeded its target, reducing surface water diversions by 32 percent.

"It was amazing to me the various ways which farmers could very creatively reduce their diversions," Delta Watermaster George said. While initial expectations were that growers would fallow fields, "we got a great deal more creativity. People changed crops. They changed the way they were growing their crops. They took advantage of new irrigation systems – not just investment in, let's say, drip irrigation, but actual changes in the way they wet their fields."

Strategies included rotating crops to those that use less water, reducing irrigation frequency, employing more efficient equipment and irrigation techniques and reconfiguring fields. For example, one of the most creative things was going from 30-inch furrows to 60-inch furrows, watering corn from either side rather than from both sides.

George noted the program achieved results without waiving water rights, going to court or triggering regulation. "What it unleashed was incentivized farmers to do the best they could."

Looking into the future, however, Scheuring noted the state is facing a dire challenge, given the restraints of the existing water system and the projected effects of climate change and prolonged drought.

"As an exponent of agriculture, we feel we are the low-hanging fruit, because we think the urbans are going to do OK. We think that urban California is going to continue to brush its teeth, run the dishwasher, to pick up the dry cleaning and go to work and cash their paychecks," he said. "The environmental seems to be doing pretty well. Dr. Moyle would disagree. But for us, we can't fix the fisheries. We would if we could. What seems to be happening is an ever-increasing overlay into the existing pattern of water uses."

CASE STUDY – McCormack Sheep and Grain

Delta rancher and farmer Al Medvitz said during the drought he has been constantly adapting his practices to keep up with the impacts.

Medvitz and his wife, Jeanne McCormack, run McCormack Sheep and Grain, a 3,700-acre ranch in the Montezuma Hills along the Sacramento River on the outskirts of Rio Vista. Her grandfather began sustainable farming in 1896. Today they grow dry land wheat and barley, as well as about 100 acres of alfalfa that is irrigated directly from the river with a pump and, most recently, a 50-acre vineyard overlooking the river. And they raise grass-fed sheep and Boer goats - 4,000 animals, including 1,200 ewes.

Medvitz said diversity is important to build sustainability and security for the future: "We rotate between cultivated land where we grow grain during the winter, and then after it is harvested, it lies fallow for two years and it's grazed by animals - and then cultivated again."

Because the grains rely entirely on rainfall, drought can wreak havoc on operations. However, he said, "the rains came just at the right time during the past few years, so the grains were OK."

Drier conditions during the past few years encouraged non-native plants to spring up: "The biggest problem we've had is invasive species that were coming in under the new climate and making it much more difficult for us to control. Some of those species had characteristics that were damaging to our animals. Things like foxtails, brome-type grasses – parts of the plants would burrow into the animal skins."

During his talk, Medvitz focused on his alfalfa and grapes "because that's more consistent with what goes on in the rest of the Delta."

DWR maintains a series of stations throughout the Delta to record water quality issues. Salinity is measured in terms of electroconductivity to determine the saltiness of the water. For example, grapes are tolerant to about 1,000 microsiemens – "this is the number where we need to stop irrigating."

"This is a tidal region. High tide brings the salinity with it. When it goes out, the salinity reduces. So we monitor this. On our ranch, we monitor the water when it when comes out of the pumps. When it reaches 1,000, we can turn off the pump, wait [for the salinity to reduce] and then turn it back on, and

Photo by Stephen Joseph, stephenjosephphoto.com

I can irrigate. I can still irrigate, I just expend my time. It's an inconvenience and it's costly. I spend more management time, or I pay people to start monitoring it," he explained.

Facing restricted surface water for irrigation, "We did what all the farmers in the state were doing; we went to the other source of water, which is groundwater," Medvitz said. "We have on our ranch a 500 gallon-per-minute well that we use for irrigating some alfalfa. I had to spend close to one quarter of a million dollars to adapt that well, building a conveyance facility to get to my pump so I could keep my grapes in production."

In 2016, he didn't conduct salinity monitoring because of the reliance on groundwater. Yet, that, too, brought on added expense to track levels of salinity and boron in the supply.

The groundwater alternative gave his operations options: "Now I have alternatives. How we are going to go into the future is another matter. If we want to expand our production to increase the value of our agriculture, that then becomes really problematic."

"When we think about the welfare of California agriculture, we not only have to look at what the product value is, we have to look at what the increasing costs are to the farmer, and also, then, what the pressures are to take that land out of production," he explained.

Medvitz also noted the importance of farmers to the environment: "We are the largest environmental managers in the state. That's what we do. We manage the environment to produce subsidence for the population. The population pays us to manage that environment," he said. "When you take land out of production, you lose the environmental benefits."

Al Medvitz shows the boundaries of his and his wife's 3,700-acre ranch during his talk about the challenges he's faced during drought.

POLICY

One of the things that has been realized during the prolonged drought is the need to improve data. George detailed several ways the State Water Board has been working to improve the information set they use to make decisions.

Consumptive Water Use

With passage of 2015's Senate Bill 88, which requires growers to measure surface water diversions for agricultural use, efforts increased to measure crop consumptive water use and develop a more accurate reflection of agricultural water use. Consumptive water use is the water that evaporates, is used for crops or is consumed by people or livestock and doesn't return to the immediate water environment.

An interim report, released in September 2016, addresses consumptive water use in the Delta. https://watershed.ucdavis.edu/project/delta-et

Watermaster Michael George said: "We are trying to refine our understanding of consumptive use in the Delta in real time." How much evaporation is there from bare soil? How much water is consumed by crops? How much water is returned are key questions. Then there's a fourth question that is unknown in the Delta – what's seeping in? How much seepage is occurring from channels surrounding the Delta islands?

Part of better understanding is calibrating seven different analysis methods for accuracy.

"We're trying to calibrate them against each other so someone can figure out which is the best method for their uses," George said, "…. giving all seven methods the same data from the Delta so that all can operate on a consistent, real-time database so we can see what the differences are."

"Once we have this rich data set, we will be able to take that data and go back to look historically at what's happened, forecast much better and correlate with real-time evaporation and consumptive use. So this is a big deal; it's an important study," he stressed.

George addressed the importance of 'rules of thumb' until there is more certainty so that impacts in the Delta are reduced and management of the water system is clear and effective.

"We are focused on some technical issues, some policy issues and some legal issues," he said. "I want to see it done in that sequence because I think we'll get more credible agreement on technical issues that will allow us to inform some policy issues before the lawyers sue."

Watermaster Michael George detailed the work the State Water Resources Control Board is doing to improve the information and policies it depends on to make water-related decisions.

Water Availability Analysis

One thing motivating the farmers' voluntary Diversion Reduction Program (SEE P.28) was uncertainty about who would stop receiving water if the drought conditions mandated curtailments. The State Water Board was coming up with a refined process to determine water availability – "this was a way to alert people to the potential for their water rights to be cut off and give them some notice," George said.

Yet, it wasn't easy on several levels. First, there is a confounding factor in the Delta because appropriative and riparian water rights have a different set of rules in times of shortage.

"It's pretty clear in the appropriative system how you deal with reductions in use; you cut off the junior in order to get the senior the water. We could say, for instance. that we anticipated there would be water unavailability at, let's say, 1910. If your priority was prior to 1910 you'd have water; if it was after 1910, you wouldn't have water," George explained. "It's a practical system that makes sense, yet it's often harsh in terms of how it is implemented in shortage."

But with the riparian system, it's a shared shortage. The significant conflict between the two systems makes it difficult to administer shortage within the Delta.

"It is inadequate to meet the Delta's needs - that is something on which everyone can agree," George said "But what we will never agree on, I think, is what we should put in its place. My view is we must work really hard to administer the priority system intelligently, predictably, transparently, and honestly so we can keep a system that can work for allocating all the water we get when we need it or when we get it and know how to cut back when we don't get it."

Delta Enforcement

Challenges around reduced Delta diversions and getting water across the Delta during the drought brought the topic of enforcement into light. During 2014, the State Water Board was doing a monthly analysis of what water conditions would be like at given times. However, the monthly "time-steps" were different than what was happening for actual daily irrigation. In addition, lacking data, forecasts considered an entire watershed rather than a specific point of diversion.

So when the State Water Board took action based on these analyses, "the question became ... whether what we were telling people was a 'courtesy notice' or an 'order to stop diverting' or simply an empty threat," George said.

Two citations were issued, to Byron Bethany Irrigation District in Byron and the West Side Irrigation District in Tracy, claiming they diverted water when the water supply analysis had determined there wasn't water available.

The citations were dismissed by the State Water Board. Yet litigation is ongoing about whether the State Water Board has the authority to tell someone that water is not available in time of shortage.

"We failed the test of demonstrating unlawful diversion. We must do better next time. How do we identify how to manage in shortage?" George said.

2006 Bay-Delta Plan - Flows

State and federal law require the review of water quality control plans to ensure that they reflect current conditions. The current update of the 2006 Bay-Delta Plan, which features two phases, is scheduled for completion in 2018 by the State Water Board. This will be the fourth update of the plan since the plan's adoption in 1978.

Phase 1 (initiated in 2009; scheduled adoption, Summer 2017) proposes:

- Flow objectives for the protection of fish and wildlife in the San Joaquin River that migrate through the Delta
- Salinity objectives for the protection of agriculture in the southern Delta
- An implementation program for the objectives and monitoring and special studies requirements

Phase 2 (initiated in 2012; proposed adoption, Spring 2018) will propose:

- Objectives for Delta outflows, Sacramento River inflows, export constraints, Delta Cross Channel Gate closure requirements and Suisun Marsh protection
- Potential new objectives for reverse flows on Old and Middle rivers and floodplain habitat
- Potential changes to the monitoring and special studies program and the program of implementation

In 2015 the National Marine Fisheries Service noted winter-run Chinook salmon was one of eight species under its jurisdiction most in danger of imminent extinction. With such a dire prediction, there became a sense of urgency for government and non-government agencies to take stepped-up measures to save the fish.

"Why focus on flow? Flow is one of the critical factors that affects so many other things, principally habitat and temperature. Those are two things that are in short supply or have critical stresses," Grober said. "So more flow is equal to more habitat, lower water temperatures and more success in protecting various life stages. There's been a lot of science done in the past several years showing how important flow is for those two things but also other things, such as migration pathways."

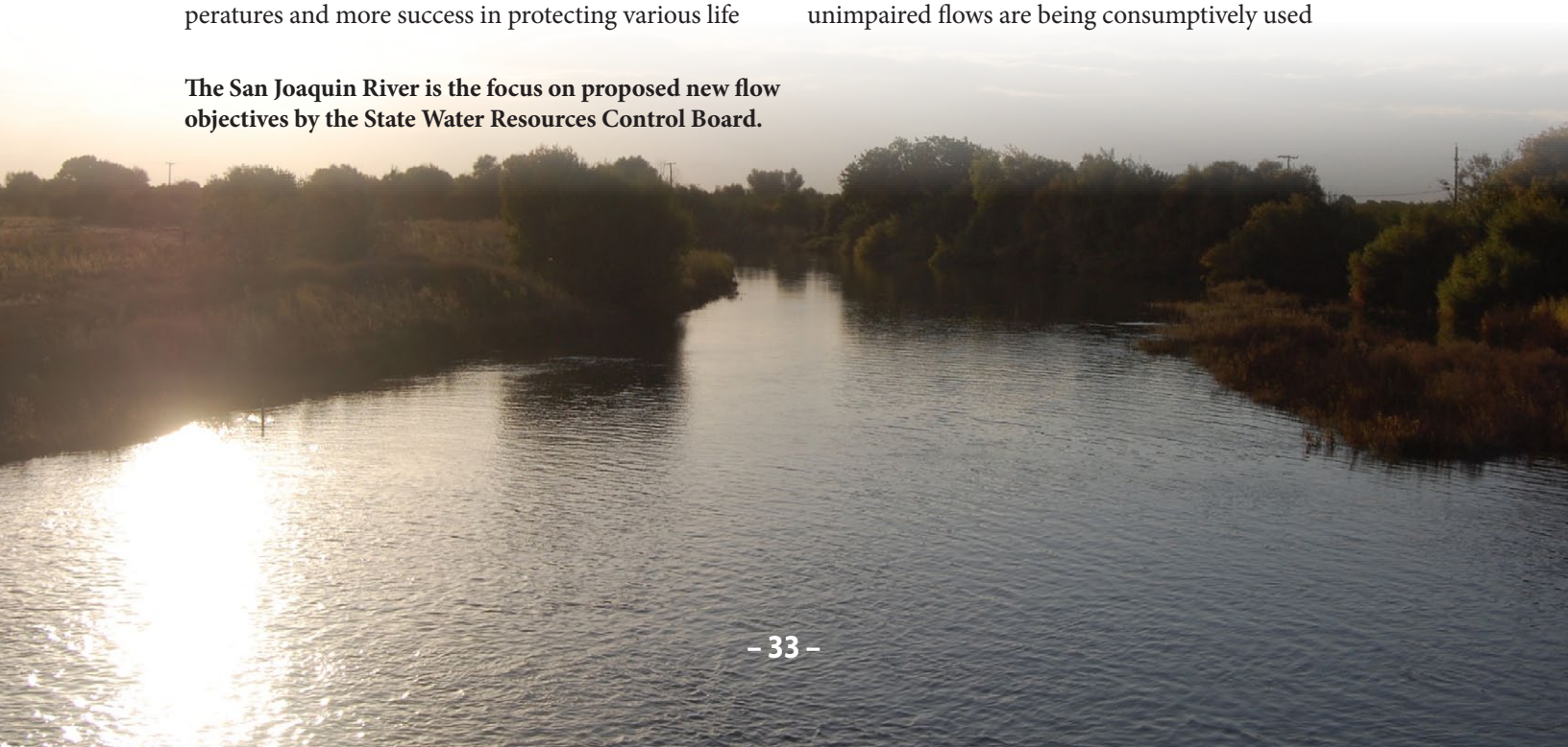
Current flow objectives for the San Joaquin River focus on just one location, at the point where the river flows into the Delta. In general, flows have come in only from only one tributary, the Stanislaus River. The updated proposal includes flow objectives in the salmon-bearing tributaries of the San Joaquin, Merced, Tuolumne and Stanislaus rivers.

"If you weren't to consider other uses of water, the science has shown you would need 60 percent of unimpaired flow in the San Joaquin River to protect fish and wildlife," Grober said. Unimpaired flow is the total quantity of water that would come out of a basin if it weren't stored behind reservoirs or consumptively used.

"Science shows you need 60 percent unimpaired flow, but that doesn't take into account the balancing. It doesn't take into account agriculture uses, municipal uses, hydropower uses," Grober said. "So the State Water Board flow proposal is for an adaptive range of 30-50 percent of unimpaired flow with a starting point of 40 percent. That takes into account those competing uses of water."

Currently, on the Merced and Tuolumne rivers, upward of 80- and 90 percent of the total quantity unimpaired flows are being consumptively used

The San Joaquin River is the focus on proposed new flow objectives by the State Water Resources Control Board.



for agricultural and other purposes, leaving just 10 percent, and sometimes less than 10 percent, in these tributaries, he added.

The proposal has been quite controversial. In public workshops, critics have said the flow objectives would result in a 14 percent reduction in surface water to the region, would increase groundwater pumping by 105,000 acre-feet a year, increase unmet agricultural water demand by at least 69,000 acre-feet a year and decrease the region's economic output by $64 million.

The report notes the flow proposal at a 40 percent level would result in about 290,000 acre-feet a year redirected from agricultural uses and municipal uses to instream flow.

Also, critics of the plan say there is concern from river rights holders that a change in flow patterns could unravel carefully crafted agreements made through the decades and, in some cases, after a trip to court.

Scheuring also addressed the complexities of a new flow standard: "Huge numbers have to be achieved to put that water back in the rivers at the expense of diverters who have human uses and needs and probably 100,000 acres of farmland at a minimum. How do you implement those numbers consistent with water rights with human use patterns without major impacts, particularly to my industry, agriculture? How do you do that without voluntary agreements? I haven't figured that out yet."

During his discussion about the updated report Grober stressed, "The major point to make about all of this is that this is something very hard. It requires balancing. Anyone who tracks and understands water In California and in the Delta knows especially during certain periods, water is in short supply. So how do you balance reasonable protection for all of the uses and take into consideration all of the beneficial uses of the water?"

2006 Bay-Delta Plan - Salinity

The second part of Phase I addresses a change in salinity objectives to protect agriculture in the southern Delta.

Salinity in water is measured in terms of electrical conductivity. The more salt there is in water, the easier it is for and electric current to flow. This conductivity is measured in siemens.

Grober noted today in the southern Delta, "We've been having difficulty meeting what is now the variable 0.7 decisiemens per meter for April through August and 1.0 decisiemens per meter for the rest of the year."

The new objectives propose an adjustment to enact a year-round mark of 1.0 decisiemens per meter.

"The science and studies have shown that crops, cropping patterns and production of crops (the 1.0 measure) would provide reasonable protection for all crops in the southern Delta," he said.

Grober noted the San Joaquin River flow objectives and southern Delta salinity objectives are interconnected: "The two together are a package – a net result. This would result in an augmentation of flows into the Southern Delta for that February-through-June period of about 290,000 acre-feet per year on average (varying depending on water-year type)."

One final aspect of the updated 2006 Bay-Delta Plan is an implementation program.

"This is recognizing it's not just locked into one fixed percent of unimpaired flow. This is intended to provide a water budget that can be adaptively managed to be smart about the quantity of water."

For example, a pulse flow into an April-May period could mean the state might direct higher amounts of unimpaired flow to achieve the biological functions that are needed by salmon.

"This is going to be a hotly debated topic and we're looking for comments from public workshops. The plan then is to make a revised draft to respond to comments and get it back before the board for consideration by July," he said.

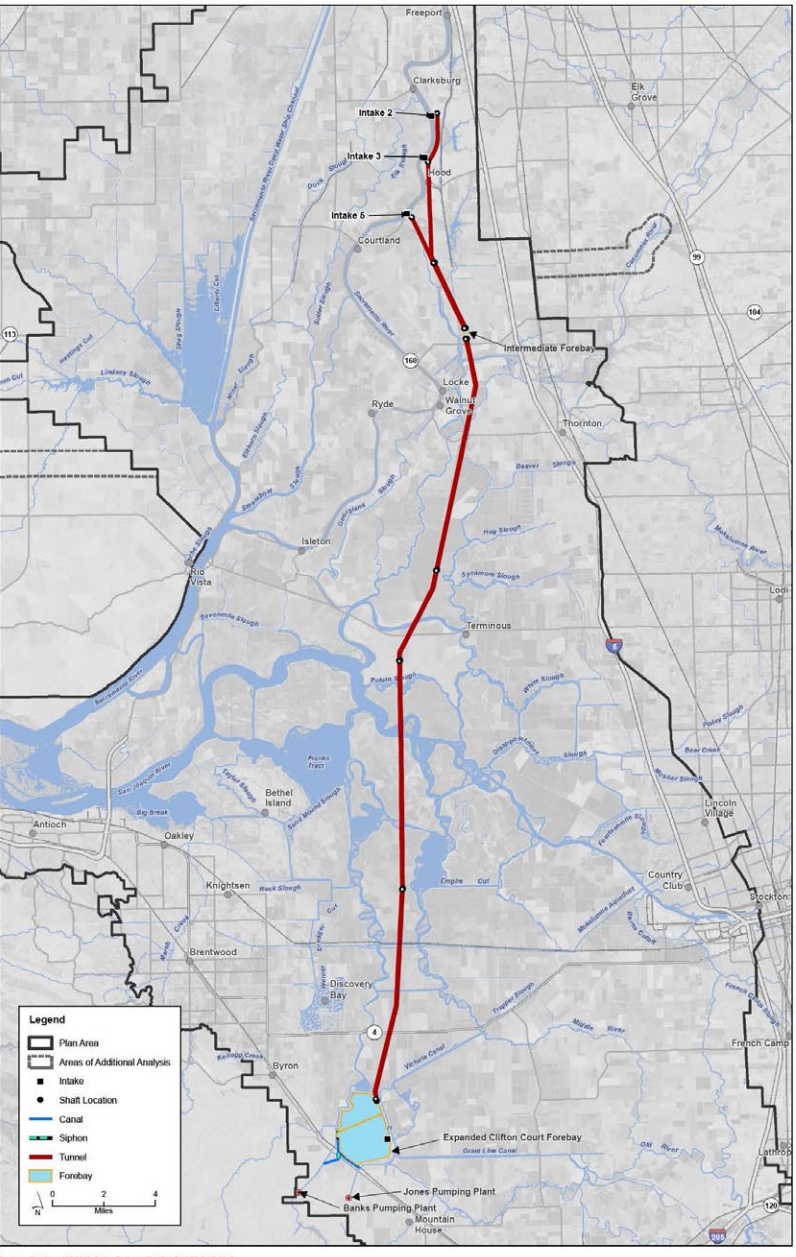
WaterFix

The California WaterFix, formerly known as the Bay Delta Conservation Plan, calls for three new intakes in the northern Delta and two 35-mile-long tunnels to transport water to the existing pumping plants in the south Delta. New intakes and tunnels also would help guard water supplies against saltwater intrusion as sea levels rise and in the event of an earthquake or storm powerful enough to destroy levees in the low-lying Delta. The plan has generated quite a bit of controversy and is opposed by in-Delta residents.

Water project operations in the south Delta have been heavily restricted to protect several endangered or threatened species of native fish, such as the Delta smelt. The WaterFix aims to reduce that conflict so that water supplies are stabilized and reliable deliveries can be made for the 25 million Californians and farms that depend on the water.

Securing a reliable source of water for the state's farmers is a top priority for the Farm Bureau, which has not taken a position on the proposed WaterFix and twin tunnels.

"We certainly are interested, as the state as a whole is, in improved conveyance to points south of the Delta that were accustomed to some point of water delivery in the past," Scheuring said. "At the same time, we are fiercely protective of our in-Delta membership and the agriculture in the Delta, as well. We would like to find a win-win solution."



This map, from 2015, shows the proposed pipeline/tunnel alignment.

SUMMARY

Keynote speaker Lund began his presentation on drought and the Delta by quoting Heraclitus, a pre-Socratic Greek philosopher living around 500 B.C.: "You cannot step into the same river twice, for other waters are continually flowing on."

The same thing is true for droughts, he said: "Every year of a drought is going to be different, as we manage it and as we experience it. You have to view these droughts in a larger arc of human occupancy of this part of the world."

The first lesson is to look at droughts as a test of our water systems, Lund pointed out.

"Droughts are one of the main ways we test water systems," he said, adding with every hardship in any given year, the water system is serving a different society – groups of users with specific needs and challenges.

For example, studying California's water systems during previous droughts in 2007, 1988-1992, 1976-77 and the 1930s, the state's economic structure, needs and priorities were different.

"There were substantially different things we were looking for in the performance and support of our water systems," Lund said.

Scheuring also noted that, compared to earlier droughts, more environmental commitments have been enacted, such as ESA and the Clean Water Act during the last 30 years. In 2012, the Central Valley Project Improvement Act enabled a "rebirth" of the California Fish and Game Code Section 5937, which states that the 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.

"There now is a long list of environmental restrictions on a system that actually wasn't designed for it in the first place," Scheuring said.

He added perspective future challenges: "California continues to urbanize. We are 39 million people now going to 50 million in short order. As a shorthand expression, that is about three or four Californians for every one Californian that existed at the time the current system was built out."

Scheuring also pointed to the added challenge of changing hydrology: "We know the system - the hydrology - has become flashier; we are going to have more rain, less snow; diminished snowpack; possibly a more flood-prone hydrology with longer cycles of drought. Existing reservoirs are probably going to have to be re-operated as some of this goes on at the expense of storage."

Against the backdrop of change and challenges, Lund stressed the positive: "The droughts, in effect, provide us with opportunities to focus on that water system, how it is performing and what kind of changes we want to make."

"I tell my students that in water resources planning and management, you spend most of your career waiting for a flood, a drought or a lawsuit," he said. "And that's when you have the political attention to actually get things done. Drought has really helped to galvanize some big changes."

During the most recent drought, for instance, there has been more political movement in groundwater policy unseen for 100-plus years. In 2014, the Legislature passed the Sustainable Groundwater Management Act, a set of new groundwater management laws that enable local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities. Before that, California was one of the last states to enact any form of groundwater law to monitor or regulate pumping.

Lund also noted the drought has brought forth large ecosystem problems that haven't been focused upon before.

Also, "We've noticed we have some accounting problems – and as any system under stress, now it becomes more important to do the numbers and make sure we have a good accounting of the water use, support water rights and other water management," he said.

The New Normal

What can we do in terms of managing the state's water supply in the grips of a "new normal?" George noted the importance of having a plan in order that covers all aspects of water management.

"We are focused on some technical issues, some policy issues and some legal issues," he said. "I want to see it done in that sequence because I think we'll get more credible agreement on technical issues that will allow us to inform some policy issues before the lawyers sue."

One of the things that comes out of the drought is the need to improve data and "We've also got to recognize that inevitably we are going to retain a level of uncertainty, a margin of error," Lund added.

Lund stressed the role of establishing "rules of thumb" for operations during uncertainty so impacts in the Delta are reduced and management of the water system is clear and effective.

Despite the dour conditions, Lund pointed to some positive takeaways from the current drought. Most important, he said, is learning from the situation.

1. Water systems and the societies they serve are always changing
2. Droughts bring attention to needs for change
3. This drought is helping improve groundwater
4. Ecosystem and accounting problems
5. Every generation needs at least a threatening drought, and a threatening flood
6. Learn from test! Don't panic
7. Pay attention

As a close to his talk, Lund recalled a Dutch engineer, addressing the proclivity for floods in the Netherlands: every generation needs a threatening flood, the engineer noted. What happens if you have a generation of a profession that doesn't see anything challenging? They get comfortable. They start to think that filling out that paperwork is actually important relative to the purpose of their profession.

"His point was, even in the world capital for water management and flood management, if you don't have threatening events, you lose track of what's really important," Lund said. "And I think that's also true for California for floods and drought. We need droughts and floods to come along so that we continue to adapt our water system to the changing society and the objectives that we have."

"So we can look at these droughts as a test. As a professor I'll tell you, the reason we have tests is not to torture people, but encourage people to learn. If you panic about a test - about a drought - you don't get as much good out of it as if you study and pay attention. Get as much good out of it as you can."