

# Fish Food on Floodplain Farm Fields

## Re-integrating Floodplain Food Resources into the River Ecosystem

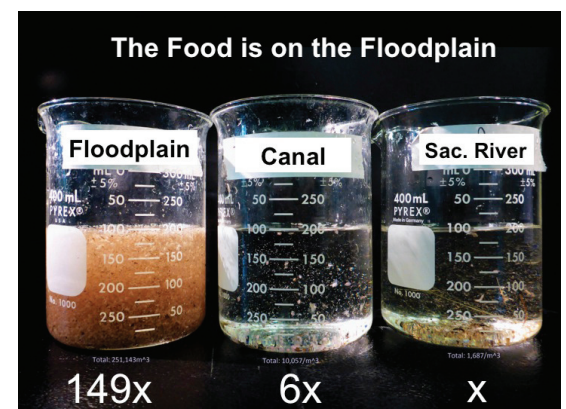
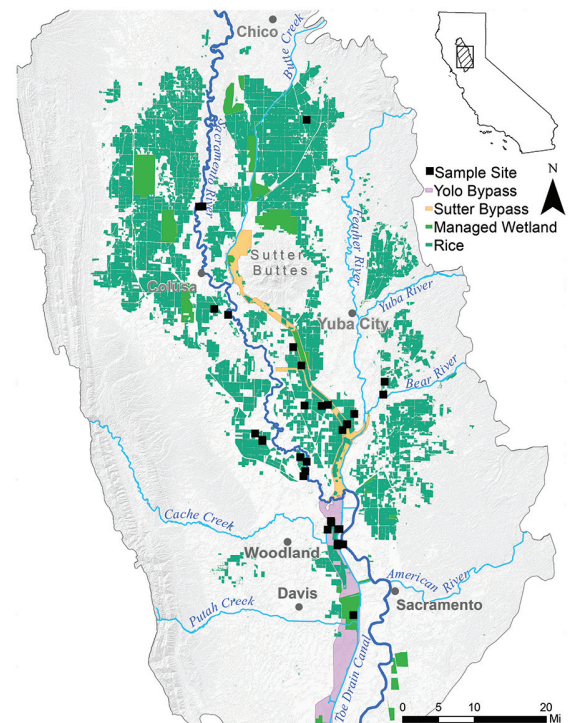
In the Central Valley, more than two thousand miles of state and federal levees, along with local flood protection projects, have cut off approximately 95% of historical floodplain wetlands from their river channels. In the 2017 pilot year, the Fish Food on Floodplain Farm Fields Project surveyed existing wetland habitat types over a broad swath of the Sacramento Valley, both inside and outside of the levees. By comparing and contrasting hydrologic conditions and aquatic food web dynamics across the spectrum of existing wetland habitat types (i.e., river channel, managed wetlands, farm fields and bypasses), the project will 1) improve understanding of aquatic food web productivity in the Sacramento Valley and 2) assess the potential for these diverse aquatic habitats, including the hundreds of thousands of acres of floodplain farmland and managed wetlands, to contribute food resources to the river ecosystem, bolster in-river and Delta food webs, and help support recovery of endangered fish populations.

## Cultivating Ecological Solutions on Agricultural Lands

Floodplains are the “solar panels” that power aquatic food webs and create abundant populations of fish and wildlife in large river valleys. An explosion of life in winter-flooded floodplain wetlands generates a huge biomass of bugs and zooplankton—the foundation of the aquatic food web. Floodplains make bugs, and bugs make healthy fish. Without hydrologically reconnecting floodplain food factories to river channels, recovery of historical numbers of fish and wildlife will be impossible. But science has shown that it’s possible to mimic natural floodplain productivity by inundating floodplain farm fields in winter when they are not in use by farmers. This project will pioneer on-farm water management practices to re-integrate the flow of floodplain food resources and nutrients back to the river and Delta. Reconnecting floodplain food factories to the river and Delta will help recover historical fish and wildlife populations of California’s Central Valley.

## Win-Win

Even during times of drought, California can get far more **pop per drop** from water used by putting it to work to create multiple benefits for both fish and people on its way downstream. The innovative water management pioneered in our projects demonstrated that California can have its fish and its farms, and they can work together in harmony.



# Reintegrating the Floodplain

## “Floodplain Fatties”

More than a hundred years ago, before the Central Valley was leveed and drained, food made on inundated floodplains supported large fish and wildlife populations in the Central Valley and downstream in the Delta. Today, rivers are cut off from their floodplain food factories by levees and thus salmon and smelt populations are starving. The goal of

### ***Flooding Agricultural Tracts For Improved Salmon Habitat***

(dubbed Operation FATFISH) is

to better understand aquatic

food web productivity on managed agricultural floodplains. The Sacramento Valley has more than 500,000 acres of managed agricultural floodplains on the dry side of the levees. Working with growers and water suppliers, we will develop new farm practices that reintegrate floodplain production into farm and water management. Floodplain fish food will once again

connect to the river and contribute to the recovery and resiliency of the river ecosystem, as well as the fish and wildlife populations that the aquatic food web supports.

Just like the rest of us, fish need to eat. For California’s water system to work effectively, threatened fish populations in the river must have access to the abundant food resources created when winter flood waters spread out and slow down across floodplains. By understanding food web dynamics across multiple wetland habitats on both sides of

the levees, Operation FATFISH will establish guidelines for functional integration of agricultural floodplains into the operations and management of California’s water system. Remaking and re-operating California’s floodplains will help restore salmon and smelt populations, sustain farms, recharge aquifers, improve flood safety, and help deliver water supply security to 25 million Californians.



## A Cooperative Partnership

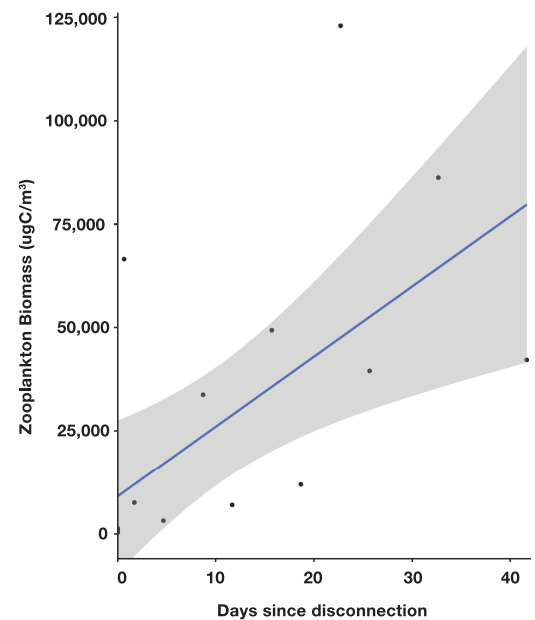
The Fish Food on Floodplain Farm Fields Project represents a private-public partnership with landowners, water districts, government agencies, NGOs, and university researchers all dedicated to finding solutions that work for water supply, agriculture, and the environment. Participants and funders include:



**Knaggs Ranch**

**Davis Ranches**

**Next Generation Foods**



*Bug density in floodplain habitats increases with residence time of water. Longer inundation = more fish food.*

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# How fish and farms can both survive in California

By Roger Cornwell and Jacob Katz | October 25, 2017 | Updated: October 25, 2017 6:21pm



Photo: Eric Paul Zamora, McClatchy-Tribune News Service

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A fisheries biologist releases a bucket of juvenile chinook salmon into the San Joaquin River.

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Fish or farm lawsuits are common in California and typically end with legal decisions that create more bureaucracy but don't make a significant difference for struggling native fish populations. And no matter who wins in court, giving water to one interest never feels like a solution.

So when water resources dwindled during the drought, many braced for a new wave of courtroom battles. Instead, farmers and fish advocates chose to pursue solutions that benefit both fish and farms. This shows us that a better future for both people and the environment is possible even in the era of climate change and ever-increasing pressures on limited water supplies.

Farmers, conservationists and government agencies have created the **Sacramento Valley Salmon Restoration Program** aimed at increasing chinook salmon populations by improving habitat conditions in the Sacramento River and its tributaries.

Farmers and California cities both benefit when fish populations rebound because regulations are reduced, allowing water to flow more securely and consistently.

For example, River Garden Farms created 25 fish habitat shelters made of almond trunks and walnut tree root wads. These were bolted to 12,000-pound limestone boulders and dropped into the Sacramento River near Redding. The roots and branches are designed to help juvenile winter-run chinook to survive by serving as a shield against swift river flows and predators. These habitat improvements paid for and implemented by a farm hundreds of miles to the south will allow the salmon more time to mature and grow before making the 300-mile journey to the Pacific Ocean.

River Garden Farms' project couldn't have come at a more important time. According to a recent study by the UC Davis Center for Watershed Sciences and California Trout, the winter-run chinook salmon is teetering on the edge of extinction. In the mid-1970s, winter-run chinook salmon totaled 25,000. The latest population count: 1,504.

But there is hope a recovery is just beyond the river bank. A survey in August conducted by wildlife biologist Dave Vogel reveals a large school of juvenile salmon have taken to the tree roots. In just three months since the tree roots were placed in the river, salmon are finding a refuge and the populations appear to be improving.

Through collaborative projects such as this one, we have a shot at reversing these dire downward population trends. But such an outcome is not just for farm communities, or the commercial fishing industry, which operates heavily around the San Francisco Bay coastline, relies heavily on healthy fish populations for survival and expects to have its worst year ever. Projects like the salmon shelters in other key rivers throughout California can help ease the financial burden these fishing families are facing.

We must now put the money, time and energy that we have spent fighting in court and invest in win-win projects that will put fish on a trajectory toward recovery.

By reallocating our effort and money beyond the courtroom and into real-world, science-driven collaborative solutions, we can support cities, farms and fish and wildlife, all of whom depend on California's water for survival.

*Roger Cornwell is general manager of **River Garden Farms** in Knights Landing. Jacob Katz is a senior scientist with nonprofit conservation organization California Trout.*

# Floodplains Adjacent to the Sacramento River Should Be Nature's Pantry

Rivers need to be reconnected with floodplains to provide essential nutrients for fish and needed habitat for birds, which will require targeted flows, says Dale Hall of Ducks Unlimited.

WRITTEN BY Dale Hall

PUBLISHED ON Oct. 24, 2017

READ TIME Approx. 3 minutes



Fremont Weir in Knights Landing, Calif., is overtopping on January 13, 2017. Fremont Weir Wildlife Area is 1,461 acres at the north end of the Yolo Bypass floodway along the Sacramento River in Sutter County and Yolo County. Florence Low / California Department of Water Resources

**ACROSS THE WORLD** and throughout history, people have settled next to rivers to take advantage of their water for transportation, fish and wildlife productivity, and the naturally fertile soils of adjacent floodplains.

Floodplains should be thought of as nature's pantry; they are among the most productive ecosystems in nature and provide the supply of nutrients and food resources necessary to keep rivers, and the many species dependent on them, healthy.

Changing with the seasons, floodplains serve as "cooking pots" for the complex food chains that rivers support. They hold concentrations of life that are found at no other time in the hydrologic cycle and act as a food supply for rivers, which need floodplain inputs to sustain the resident fish



and wildlife populations until the cycle can be repeated the following year. However, rivers must have access to floodplains during the right times of year to receive these annual injections of beneficial nutrients.

In California's Central Valley, the Sacramento River originally evolved with, and benefited from, annual flooding. But that natural cycle no longer functions due to the manmade levees and water-control structures that keep the river's rising water from naturally entering the floodplain. Today, it takes the combination of flooded agricultural lands and managed wetlands to provide the food resources necessary to support the millions of waterfowl, shorebirds and other waterbirds that call California home for a significant portion of their life cycle. I was personally involved with this complex management system during my time with the United States Fish and Wildlife Service, and have seen how important these floodplain inputs are for wildlife.

Now that natural flooding no longer occurs and millions of acres of natural wetlands have been lost because of development and other impacts, seasonally flooded rice fields have become a critical resource for waterfowl and other wildlife species. The 300,000 acres of winter-flooded rice in the Sacramento Valley during a "normal" winter are needed to provide the food resources necessary to help support nearly 7 million waterfowl (60 percent of all waterfowl in the Pacific Flyway) and 300,000 shorebirds.

The [Nigiri Project](#), which is a partnership of farmers and researchers, including California Trout, has shown that flooded rice fields benefit fish populations. In the winter, the project floods farmland used for crops during the summer, and creates a kind of "surrogate" floodplain for juvenile salmon. Results from the project have shown an increase in growth and health of salmon inside seasonally flooded rice fields, which dramatically demonstrates the need for more connectivity between the river and adjacent floodplains.

California's Central Valley contains approximately 206,000 acres of managed wetlands, covering just 5 percent of the historic 4 million acres of wetlands that once existed in the region. These remaining managed wetlands need water, for both summer irrigation and winter flooding, to provide their maximum benefits to birds and other wildlife.

The provision of this water and the habitat values it provides is reliant upon the ability of Sacramento Valley water districts and companies to divert and deliver surface water resources year-round in accordance with their contracts and water rights.

Rice fields and wetlands provide the basis for nutrients and the ensuing explosion of life that still occurs, but these fields are largely disconnected from rivers and can't currently provide nursery habitat for salmon and smelt. This impacts the food available for salmon and smelt, with the most concerning outcome being possible starvation. And it's not just fish that are at risk.

During normal years in which wetlands are managed properly and typical rice acreage is winter-flooded, there is enough food to maintain waterfowl populations throughout the winter months. However, during times of drought, models predict that food resources may run short in the middle of winter right when bird numbers are at their peak and food demand is highest. This will likely result in substantial losses of birds that rely upon this Pacific Flyway habitat.

[Ducks Unlimited](#) and our partners are convinced this problem can be reversed and, if we desire to have healthy populations of salmon, smelt, waterfowl and the remainder of Sacramento River

ecosystem constituents, it must be reversed. It is vitally important that we allow the food produced in the floodplain, along with the healthy growth of fish, to provide much-needed biological relief and support the sustainability of our rivers.

This can only occur by having water available for the floodplain and by encouraging water users and managers involved with the Central Valley's water to provide functional and targeted flows that are directly tailored for specific purposes and benefits to "nature's pantry." Continuing to develop voluntary agreements, consistent with a functional flow approach, will ensure that this important work in the Sacramento Valley will benefit fish and wildlife.

*The views expressed in this article belong to the author and do not necessarily reflect the editorial policy of Water Deeply.*

***About the Author***

[Dale Hall](#)

CEO, DUCKS UNLIMITED

Dale Hall has been the CEO of Ducks Unlimited for the past seven years. Prior to joining D.U., Hall was the director of the U.S. Fish and Wildlife Service from 2005 to 2009.

<https://www.newsdeeply.com/water/community/2017/10/24/floodplains-adjacent-to-the-sacramento-river-should-be-natures-pantry>

## Here's how rice farmers prevent flooding and help wildlife

BY SEAN DOHERTY AND BRYCE LUNDBERG

*Special to The Bee*

OCTOBER 10, 2017 12:00 PM

Last winter's heavy rains were a welcome relief for Central Valley farmers after years of drought. But the high water that came with them also made it clear that we must upgrade the flood control system designed to protect people, farms and cities from catastrophic flooding.

Watching hurricanes Harvey, Irma and Maria from afar, Californians may not realize that our own Central Valley is at high risk of this type of flooding, especially as extreme weather events are becoming more common.

Fortunately, the Central Valley Flood Protection Board recently updated its plan to improve protection for farmers and city dwellers alike. It will also help revive flagging salmon runs and support other struggling native species.

As farmers, we are often on the front lines of California's water challenges. We understand the benefits of wildlife-friendly agriculture. Rice farmers, especially, have taken the lead in finding ways to use limited water supplies to sustain farms while simultaneously benefiting birds, fish and other wildlife.

Flooding rice fields after harvest during the winter creates seasonal wetlands that are essential for the survival of the millions of birds that travel the Pacific flyway annually. With only 5 percent of the Central Valley's traditional floodplains remaining, flooded rice fields are a lifeline for these birds and also benefit struggling native fish populations such as salmon and smelt.

This multibenefit approach to flood and water management is at the core of the new Central Valley Flood Protection Plan, which calls for building projects designed to allow rivers and floodplains to function more naturally. These projects come with additional public benefits, such as improving water quality, increasing groundwater recharge and providing outdoor recreation opportunities.

One of the best ways to both prevent flood damage and improve fish and wildlife populations is to find strategic places to expand floodways. Allowing flood waters to spread out and slow down lowers crests and reduces strain on the levees that line Central Valley rivers. And when rivers can safely handle higher flows, dam managers can keep reservoir levels higher during heavy rains, potentially increasing water supplies during the summer.

In addition to increased public safety, this approach seems much more promising for fish and wildlife than the current flow strategies. Instead of pitting the needs of wildlife against those of farmers, it focuses on ways to address both.



With the right approach, changing the way we manage floods could improve the survival of native fish without harming farms. If we help fish populations rebound by improving the health of our rivers, water allocations for farms and cities may also become more predictable.

The updated Central Valley Flood Protection Plan takes this right approach. Now it's time for policymakers to ensure sufficient funding is available to turn the plan into action.

*Sean Doherty is a third-generation rice farmer in Dunnigan and can be contacted at [sean@dohertyfarms.com](mailto:sean@dohertyfarms.com). Bryce Lundberg is vice president of agriculture at Lundberg Family Farms in Butte County and can be contacted at [bryce@lundberg.com](mailto:bryce@lundberg.com).*



CARY KRAMER.NET

## Conserving Habitat for Fins and Feathers

DU's conservation work provides a host of benefits for salmon and other popular sport fish

—By Mark Petrie, Ph.D., and Jacob Katz, Ph.D.

Many of us entered the outdoor world by watching a bobber, not holding a gun. We were fishermen before we were hunters. Although we may have graduated to more elaborate and expensive tackle, most of us continue to fish outside of the duck season. It may surprise some folks that our pursuit of both fish and waterfowl depends on the same foundation of healthy and abundant wetlands. The connection between wetlands and waterfowl is a familiar one, but the link between fish and wetlands is sometimes less obvious. A salmon hooked 10 miles off the Oregon coast appears to have no such connection, yet that fish depended on wetlands to the same extent as any mallard hatched on the prairies.

One way to illustrate the connection between fish and wetlands is to highlight some of the fish species that are popular quarry among DU members. Of course it only makes sense to start with the most popular game fish of all, the black bass (largemouth and smallmouth bass). Adult largemouth bass lurk on the shallow margins of wetlands at the edges of lakes, and in floodplain wetlands associated with slow-moving rivers. Those same freshwater wetlands provide important nursery areas for juvenile bass as well. Bass may not eat wetland plants, but they certainly dine on red swamp crawfish, which eat the detritus of wetland plants. Many bass fishermen also pursue crappie, and these fish frequently spawn in forested scrub-shrub wetlands, flooded timber or brush, or in stands of shallow emergent

vegetation, where they build their nests. Since 1990, DU and its conservation partners have reforested over 1 million acres of bottomland hardwood forest throughout the Mississippi Alluvial Valley. Those same forested wetlands also provide spawning habitat for alligator gar, the largest freshwater fish in the Mississippi River system and its apex predator.

If you enjoy pursuing prehistoric predator fish and you live in the Northeast or upper Midwest, DU's work is important to you too. Take the northern pike, that indiscriminate glutton whose willingness to chase most hardware makes it a popular target in the high-latitude parts of the country. Pike spawn in the shallows of freshwater wetlands soon after ice-out, and DU is helping to provide pike access to these habitats even as we work on behalf of waterfowl. Although early wetland restoration efforts did not always meet the needs of spawning fish, those needs are now routinely included in our wetland designs. For example, DU is helping to restore and enhance spawning habitat for pike and their bigger cousin, the muskellunge, in several marshes along the St. Lawrence River in New York by installing fish ladders, creating



Recent research indicates that flooded rice fields in California can provide productive habitat for young chinook salmon.

PHOTOS: DR. JACOB KATZ





channels for fish passage, and excavating spawning pools in the marsh interiors. Similar efforts to improve fish passage and create spawning habitat are now under way in the marshes that border Wisconsin's Green Bay.

If you fish salt water, wetlands can be just as important to your quarry as they are for many freshwater species. Spotted or speckled trout are probably the most popular game fish on the Gulf Coast, followed closely by flounder and redfish. Each of these species relies heavily on seagrass meadows and salt marshes for nursery habitats, and DU has restored or enhanced nearly 400,000 acres of estuarine habitat along the Gulf Coast, including many areas important to fish as well as shrimp and crabs, which serve as their prey.

In the Pacific Northwest, coho salmon spend most of their adult life at sea; however, they rely heavily on wetlands before they ever reach the ocean. As young coho make their way to the coast, they seek out floodplain wetlands that provide an abundance of invertebrate foods, and young salmon in these habitats enjoy greater growth and survival compared to those that remain in stream channels. Juvenile chinook, or king salmon, may spend several months feeding in tidal marshes before heading out to sea, and DU has benefited both species of salmon by restoring floodplain and coastal wetlands throughout Washington and Oregon.

Following the widespread loss of natural wetlands across the United States, many waterfowl, including the majority of North America's northern pintails, now rely heavily on flooded rice fields for wintering habitat. In California's Central Valley, where the last century has seen 95 percent of wetlands converted to agriculture and other forms of development, DU has been partnering with farmers to improve the conservation benefits of agricultural lands for birds and wildlife, primarily by flooding rice fields after harvest. Ducks dabble in these winter-flooded fields in the heart of the Pacific Flyway for waste grain, weed seeds, and aquatic invertebrates. Geese also eat rice grain, as well as the roots of rice stalks and young green shoots sprouting in the fields. In fact, research has shown that flooded rice fields provide habitat for more than 150 species of birds, 28 species of mammals, and 24 species of reptiles.

Now science is showing that these same fields are also critically important for chinook salmon. Five years of experiments



MICHAEL PETERS

**In the West, mallards and other waterfowl share many riverine wetland habitats with salmon and trout.**

conducted by DU's conservation partner, California Trout (CalTrout), in collaboration with top researchers from the University of California–Davis and state and federal agencies, have shown that these shallowly inundated floodplain croplands produce phenomenal concentrations of bugs, which provide food for baby salmon and other native species. In addition, young salmon reared in these flooded agricultural habitats are 10 times larger on average than young river salmon, making them much more likely to survive at sea and return as large game fish.

Nigiri sushi is a slice of fish atop a compact wedge of rice. The Nigiri Project is a collaborative effort between farmers, conservationists, and government agencies to rebuild salmon populations by introducing juvenile fish into winter-flooded rice fields that will remain in summer production. While these fertile farmlands will never again be pristine wetlands, they can be managed to replicate natural wetland flooding patterns during winter—when crops aren't grown—and to produce food and habitat for birds, fish, and wildlife.

The science is clear: floodplain agricultural lands provide vital food resources for salmon. By comparison, adjacent leveed stream channels are relative food deserts. Now DU and its partners, including CalTrout and the California Rice Commission, are putting this science into action and pioneering new techniques that reintegrate wetland productivity into the way farm landscapes and river systems are managed to support robust populations of both fish and waterfowl. These real-world science-based conservation solutions will help secure the future of both hunting and fishing and are a win-win-win for farmers, fish, and waterfowl. ↻

*Dr. Mark Petrie is director of conservation planning in DU's Western Region. Dr. Jacob Katz is senior scientist with California Trout.*

**BOUNTIFUL HARVEST** According to the U.S. Fish and Wildlife Service, wetlands provide an essential link in the life cycle of 75 percent of the fish and shellfish commercially harvested in the United States, and up to 90 percent of the recreational fish catch.



# BUTTE CREEK SALMON RECOVERY

## A Lesson in Functional Flows

The Butte Creek Fish Passage Improvement projects are located along the middle reach of Butte Creek, a tributary of the Sacramento River in California's Central Valley. The various projects together comprise one of the nation's most significant fisheries restoration efforts, with 90 miles of Butte Creek restored for the benefit of spring-run salmon. These projects also divert water for the benefit of farms, birds and other species along the Pacific Flyway.

### BUTTE CREEK FISH PASSAGE IMPROVEMENT PROJECTS:

**Water management** in the upper reach of Butte Creek provides well-timed functional flows for spawning and holding habitat.

Rancho Esquon Diversion and Fish Ladder

Gorrill Ranch Diversion and Fish Ladder

Western Canal Gary N. Brown Butte Creek Siphon

Remove four dams from Butte Creek, restoring about 25 miles of unimpeded flow

Parrot-Phelan Diversion and Fish Ladder

Durham Mutual Water Company Diversion and Fish Ladder

Lake Oroville

Feather River

Sacramento River

#### Sutter Bypass

The passage improvements, combined with fish food production and safe rearing habitat for juvenile fish in the lower reach of the creek flowing through the wetlands created by the Sutter Bypass, have provided functional flows and an excellent environment for spring-run salmon and other species to thrive.

Sutter Buttes

East-West Diversion Weir

Sutter Bypass

Weir 1

#### Partnerships

Cooperation among the agricultural, urban and environmental communities—with funding partnerships—were essential to the success of the projects. The key stakeholders and participants included:

- Local water suppliers and farmers (see map), owner and funding partner;
- California Urban Water Agencies, funding partner;
- U.S. Department of Interior (USFWS and USBR), funding partner;
- California Department of Fish and Game



Western Canal  
Water District

**GORRILL RANCH**  
— DURHAM, CA —  
Est. 1918



**NCWA**  
Northern California Water Association





Photo: Ken "Creekman" Davis

## SUCCESS ON BUTTE CREEK

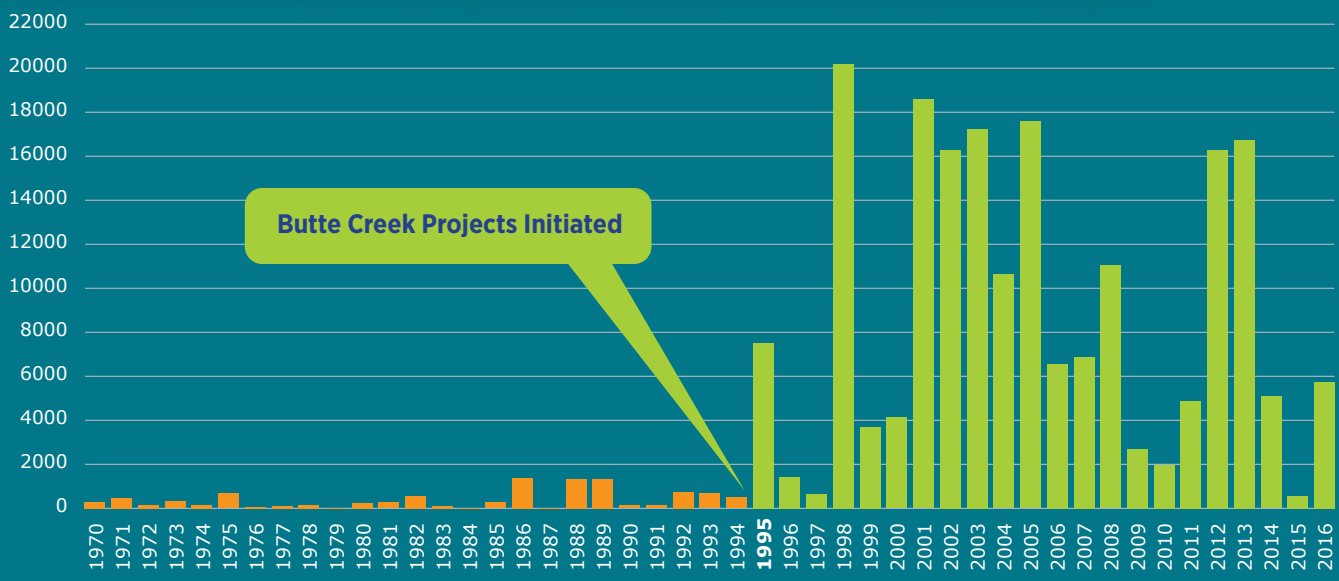
Butte Creek is one of only four Sacramento River tributaries with remaining populations of the endangered spring-run Chinook salmon. Resource agencies and conservation groups value Butte Creek as a keystone in preserving and recovering spring-run salmon, which in some years had dwindled to less than a 100 returning adults from 1970 to the early 1990s. Today, as a result of the Butte Creek Fish Passage Improvement projects, in tandem with a valuable food supply and safe rearing habitat in the Sutter Bypass wetlands, more than 10,000 spring-run salmon return on average to Butte Creek. These projects all provide multiple beneficial uses, serving water for fish, farms, birds and various other species.

Pictured above: Central Valley Spring-Run Chinook Salmon  
 Illustration by Paul Waters, courtesy of Cal Trout  
 (*Oncorhynchus tshawytscha*)



Secretary of Interior Bruce Babbitt tearing down McPherrin Dam in 1998.

## BUTTE CREEK SPRING-RUN CHINOOK SALMON POPULATION ESTIMATES



Source: CDFW

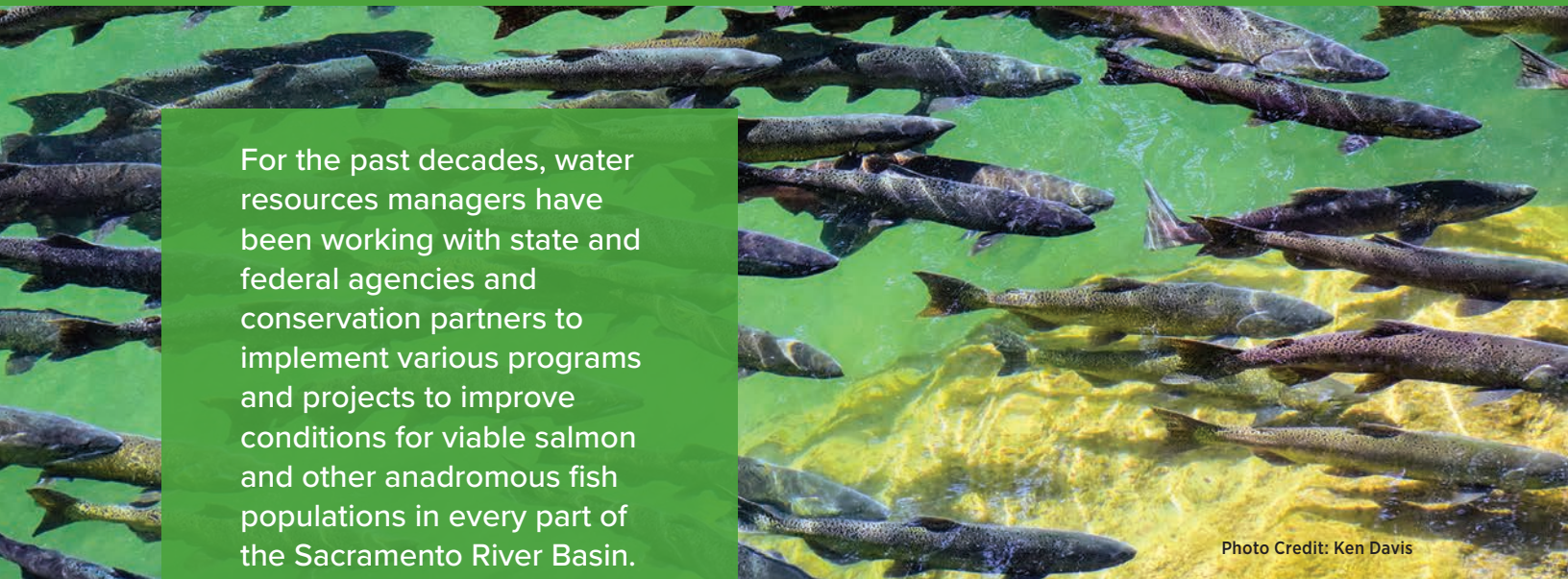


Western Canal  
 Water District

**GORRILL RANCH**  
 ——— DURHAM, CA ———  
 Est. 1918



**NCWA**  
 Northern California Water Association



For the past decades, water resources managers have been working with state and federal agencies and conservation partners to implement various programs and projects to improve conditions for viable salmon and other anadromous fish populations in every part of the Sacramento River Basin.

Photo Credit: Ken Davis

Since the State Water Board's Water Quality Control Plan update and Decision 1641 in 2000, there has been a serious and concerted effort to implement numerous flow arrangements, habitat enhancements, fish passage improvements, fish-food production projects, and studies to advance the science that informs management decisions. These programs and projects collectively address every salmon life-stage and they will be adaptively managed into the future based on lessons learned and better understanding the science.

The recent twenty-year celebration on [Butte Creek Salmon Recovery](#) showed how salmon can recover when conditions improved for every freshwater part of the spring-run salmon life-cycle ([Appendix C](#)). It is the comprehensive approach described in this document that will be critical to similar success in other parts of the Sacramento River Basin.

Updated December 8, 2017

### Flow Agreements

New instream flow agreements or requirements have been put in place on every major watercourse in the Sacramento River Basin. These requirements, which have all been designed to benefit salmon, are found in State Water Board decisions, biological opinions, streamflow agreements, and other processes.

**This includes:**

- The agreements/requirements shown on [Remanaging the Flow](#), with a more detailed summary, in [Appendix A](#).
- Various short-term flow arrangements in Appendix B that have been specifically designed to benefit salmon.
- An additional 1.3 million acre-feet (maf) of water has also been redirected annually to dedicated Delta outflow during this time (see [Retrospective](#)).

### Habitat Enhancement

Numerous habitat improvement projects have been implemented in every part of the Sacramento River Basin to aid adult salmon holding and spawning, juvenile salmon rearing, and protection from predators. This includes spawning gravels, rearing areas and floodplain restoration ([Appendix D](#)).



## Fish Passage and Migratory Corridors

Various projects have been completed to improve fish passage. This includes fish screens to prevent fish from entering diversions, structures to keep salmon from straying into the Colusa Basin Drain, siphons to keep creeks flowing unimpeded and improving migratory corridors. A complete list is shown in [Appendix D](#).

### Sacramento River Basin



Source: Department of Water Resources

## Fish Food Production

With the Delta and the major rivers in the Sacramento River Basin currently acting as a food desert, there have been three types of projects to improve fish food production as part of an effort to mimic the natural floodplain:

- bringing fish into rice fields where there is food (i.e., Nigiri Project);
- managing rice fields in the late fall and winter to produce fish food that is then released back into the river system (Fish-Food Pilot Program);
- rerouting flows through the Yolo Bypass to provide additional food production (i.e., Delta Smelt Resiliency Strategy).

These efforts are described in [Appendix E](#).

## Science Development

During this time, there also has been a targeted effort to invest in scientific studies, projects and programs that will help to advance our understanding on the actions necessary to improve conditions for salmon in the Sacramento River Basin. This has been a collaborative effort, involving partnerships with state and federal agencies, water management entities and conservation organizations to fund and conduct the scientific work. The scientific efforts have aided in the development of the various flow agreements, habitat enhancement, fish passage, and fish food production that have been implemented in the Sacramento River Basin and new work will further assist and refine these efforts ([Appendix F](#)).

For more information on ongoing programs and actions, see the [Sacramento Valley Salmon Recovery Program](#). Parties in the Sacramento River Basin are working closely with the California Natural Resources Agency and its [Sacramento Valley Salmon Resiliency Strategy](#), which should serve as a further catalyst for efforts to help improve conditions for salmon in the Sacramento River Basin; as well as the newly formed Central Valley Salmon Habitat Partnership.

**We would welcome any ideas or support for further actions to improve conditions for viable salmon populations in the Sacramento River Basin.**