# SPECIES in the SPOTLIGHT

## Priority Actions 2021–2025

NOAA FISHERIES

Sacramento River Winter-run Chinook Salmon

(*Oncorhyncus tshawytscha*)

Cover: Winter-run Chinook salmon juveniles in Battle Creek. Photo: California Department of Fish and Wildlife.

Historical winter-run Chinook salmon habitat in the McCloud River. Photo: Brian Ellrott, NOAA Fisheries.

# The *Species in the Spotlight* Initiative

In 2015, the National Marine Fisheries Service (NOAA Fisheries) launched the *Species in the Spotlight* initiative to provide immediate, targeted efforts to halt declines and stabilize populations, focus resources within and outside of NOAA on the most at-risk species, guide agency actions where we have discretion to make investments, increase public awareness and support for these species, and expand partnerships. We have renewed the initiative for 2021–2025.

The criteria for *Species in the Spotlight* are that they are endangered, their populations are declining, and they are considered a recovery priority #1C (84 FR 18243, 4/30/2019). A recovery priority #1C species is one whose extinction is almost certain in the immediate future because of rapid population decline or habitat destruction, and because of conflicts with construction, development, or economic activity.

As of January 2021, the following nine species are our *Species in the Spotlight.*

- Atlantic salmon Gulf of Maine distinct population segment (DPS)
- Central California Coast coho salmon evolutionarily significant unit (ESU)
- Cook Inlet beluga whale DPS
- Hawaiian monk seal
- North Atlantic right whale (added in 2019)
- Pacific leatherback sea turtle
- Sacramento River winter-run Chinook salmon ESU
- Southern Resident killer whale DPS
- White abalone

For some of these species, their numbers are so low that they need to be bred in captivity; others are facing human threats that must be addressed to prevent their extinction. In most cases, we understand the limiting factors and threats to these species, and we know that the necessary management actions have a high probability of success. In some cases, we are prioritizing research to better understand the threats so we can fine-tune our actions for the maximum effect. We know we can't do this alone. A major part of the *Species in the Spotlight* initiative is to expand partnerships and motivate individuals to work with us to get these species on the road to recovery.

## Priority Action Plans

The 5-year action plan is part of a strategy to marshal resources for species listed under the Endangered Species Act of 1973 (ESA) for which immediate, targeted efforts are vital for stabilizing their populations and preventing their extinction.

In its first 5 years, the *Species in the Spotlight* initiative has been successful at raising awareness, increasing partnerships, and prioritizing funding—providing or leveraging more than $113 million toward projects that will help stabilize these highly at-risk species.

We renewed the *Species in the Spotlight* initiative for 2021–2025, and have updated the priority action plans that outline what we need to do to prevent their extinction.

The 2021-2025 5-year action plans build upon existing action, recovery, or conservation plans and detail the focused efforts needed over the next 5 years to reduce threats and stabilize population declines. We will continue to engage our partners in the public and private sectors in actions they can take to support this important effort. We will report on our progress through the Biennial Recovering Threatened and Endangered Species Report to Congress, and on our *Species in the Spotlight* web pages.

This strategy will continue to guide agency actions where we have the discretion to make critical investments to safeguard these most endangered species. The strategy will not divert resources away from the important and continued efforts to support all ESA-listed species under our authority. Many of our species have long-standing conservation programs supported by multiple partners. We remain committed to those programs.

This action plan builds on the success of the past 5 years and highlights the actions that can be taken by us, other federal and state resource agencies, environmental organizations, Native American tribes, and other partners to work toward turning the trend around for this species from a declining trajectory and toward recovery. We appreciate all of our current partners and collaborators, as the steps we need to take to stabilize these species would not be possible without them.

## NOAA Fisheries Contact

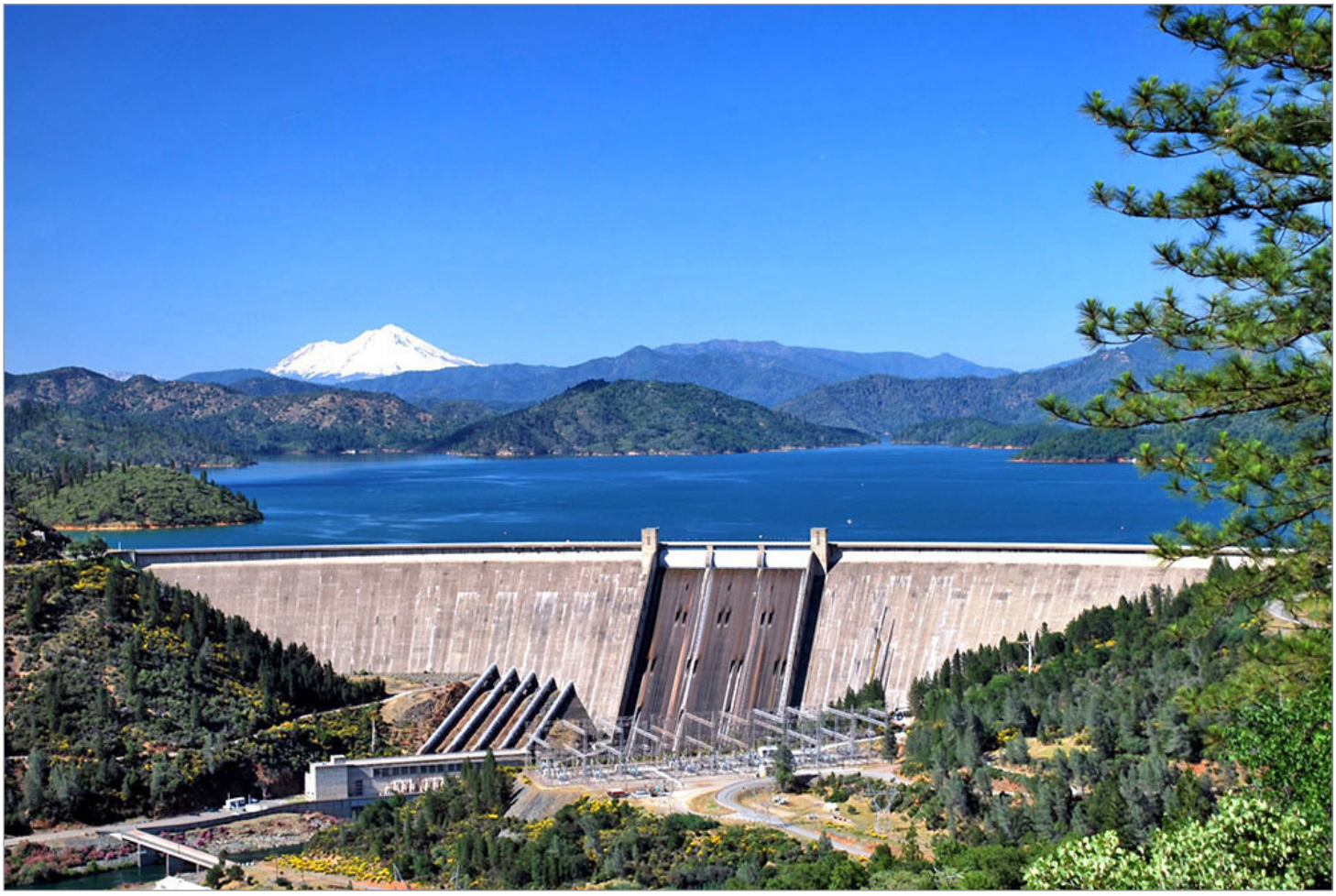
If you are interested in working with us, or if you have questions about any of the priority actions contained in this plan, please contact: Brian Ellrott, Central Valley Chinook Salmon and Steelhead Recovery Coordinator, West Coast Region, Sacramento, CA, (562) 676-2170, brian.ellrott@noaa.gov.

## Sacramento River Winter-run Chinook Salmon Status

The Sacramento River winter-run Chinook salmon ESU is one of the most at-risk endangered species because it is composed of just one small population that is a mere fraction of its historical size.

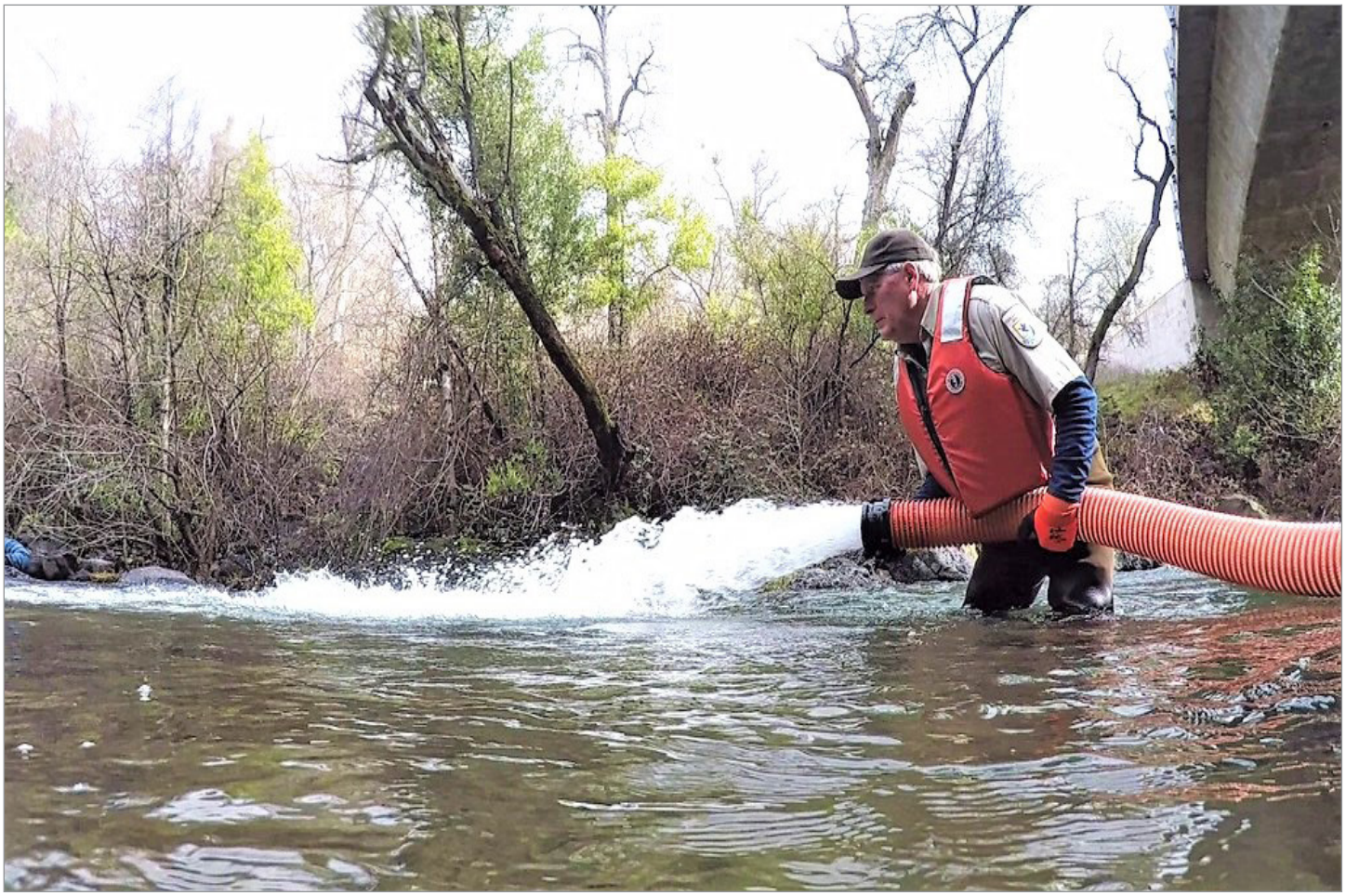
The earliest abundance data for this population is from the late 1960s, when the population size was estimated at up to 117,000 adults. Most recently, from 2010 to 2019, the combined abundance of natural- and hatchery-origin spawning winter-run Chinook salmon adults ranged from a low of 827 in 2011 to a high of 8,128 in 2019, with an average of 3,092. The 2012-2016 drought had a biologically significant effect on the abundance of natural-origin spawners; only 153 adults returned in 2017, the lowest level of natural-origin spawners on record, and 461 returned in 2018.

The winter-run Chinook salmon population crashed in the 1970s, and the ESU was subsequently listed as endangered under the ESA in 1989. The species has persisted in large part due to managed cold-water releases into the Sacramento River from Shasta Reservoir and artificial propagation from Livingston Stone National Fish Hatchery's winter-run Chinook salmon conservation program. Shasta Dam, constructed in 1945, blocks winter-run Chinook salmon from returning each year to their historical spawning grounds in the southern Cascade Mountains in the headwaters of the Sacramento, McCloud, and Pit rivers. Thus, they are dependent on sufficient cold water originating from those headwaters to be released from Shasta Reservoir from spring to fall, the time of year when they are present below the reservoir. It has long been recognized that a prolonged drought could have devastating impacts, possibly leading to the species' extinction.



Shasta Dam, constructed in 1945, blocked off three winter-run Chinook salmon populations from their spawning habitat in the headwaters of the Sacramento, McCloud, and Pit rivers. Photo: U.S. Bureau of Reclamation.

# Sacramento River Winter-run Chinook Salmon Key Recovery Efforts/Challenges



Winter-run Chinook salmon release into Battle Creek. Photo: U.S. Fish and Wildlife Service.

***Since 2018, 567,412 winter-run Chinook salmon juveniles have been released into Battle Creek to help establish a new population.***

***In 2020, over 1,000 adults from these releases returned and were the first winter-run to successfully spawn in Battle Creek in over 100 years. Also, substantial progress has been made on the Battle Creek Restoration Project, including improved fish passage at hydropower facilities through modifications and dam removal.***

Since the launch of the Species in the Spotlight Initiative, there has been substantial progress on winter-run Chinook salmon recovery, including advancement of five major actions identified in the 2016-2020 action plan (Table 1).

**Table 1. Progress of Sacramento River Winter-run Chinook Salmon Recovery Efforts.**

| Action from 2016–2020 Plan | Progress |
|---|---|
| 1. **Improve management of Shasta Reservoir cold-water storage** | Application of NOAA's Southwest Fisheries Science Center's (SWFSC) physical and biological models along with a U.S. Bureau of Reclamation (Reclamation) pilot temperature project to target colder water temperatures closer to where the winter-run spawned resulted in above average egg-to-fry survival. |
| 2. **Restore Battle Creek and reintroduce winter-run Chinook salmon** | Since 2018, 567, 412 winter-run Chinook salmon juveniles have been released into Battle Creek to help establish a new population. In 2020, over 1,000 adults from these releases returned and were the first winter-run to successfully spawn in Battle Creek in over 100 years. Also, substantial progress has been made on the Battle Creek Restoration Project, including improved fish passage at hydropower facilities through modifications and dam removal. |
| 3. **Reintroduce winter-run Chinook salmon into McCloud River** | In 2018, Reclamation awarded the California Department of Water Resources (CDWR) $2.7 million as the first installment of a 5-year contract totaling approximately $9 million for the design, construction, installation, and operation of two juvenile fish collection devices in the lower McCloud River and the McCloud arm of Shasta Reservoir. Under this contract, CDWR has made progress designing and constructing components of the juvenile collection system, including guidance nets, debris booms, and a thermal curtain. |
| 4. **Improve Yolo Bypass fish habitat and passage** | Two key milestones for improving Yolo Bypass fish habitat and passage were reached in 2017 and 2018. The Wallace Weir Fish Rescue Project was completed in 2017 and is operational. The project was championed by Sacramento Valley farmers (Reclamation District 108) in partnership with the Northern California Water Association's Sacramento River Salmon Recovery Program and state and federal support. In 2019, CDWR and Reclamation completed the Fremont Weir adult fish ladder, providing a vital fish passage route for adult winter-run Chinook salmon migrating up the Yolo Bypass to return to the Sacramento River where they can reach their spawning habitat. Overall, fish passage was improved at three weirs and three agricultural crossings. |
| 5. **Manage winter and early spring Sacramento-San Joaquin River Delta conditions to improve juvenile survival** | Acoustically tagged winter-run Chinook salmon juveniles were tracked annually in winter and spring. The tagged salmon provided real-time fish distribution information to help managers determine the survival of the juveniles from their release location in Redding through Chipps Island in the western Delta.<br><br>The SWFSC completed a winter-run life cycle model that evaluates how climate change and different water project operations and management actions (harvest, habitat restoration) influence the long-term viability of winter-run Chinook salmon. |

Additional work is needed for each of the five major actions in the 2016-2020 plan. That additional work is the focus for the 2021-2025 action plan, along with a new action for collaborative science and fostering partnerships.

# Key Actions Needed 2021–2025

## Improve Management of Shasta Reservoir Cold Water Storage

**Description and Background:** This action will continue efforts to ensure cold water is available in the Sacramento River to support the egg and fry life stages. Since the 2015-2020 action plan was released, Reclamation has modified its approach to efficiently use Shasta Reservoir's limited supply of cold water by targeting the spatial extent of protective water temperatures to the within-season distribution of winter-run Chinook salmon redds. However, despite the changes to operations and improved understanding of temperature-related effects to survival, difficulties remain in accurately forecasting operations that most efficiently use Shasta Reservoir cold water. To improve its forecasting precision, Reclamation has continued to evaluate and refine its physical models, including an effort started in 2017 to develop a revised framework for seasonal Shasta and Trinity Division planning and operations modeling. In addition, the SWFSC and

the Sacramento River Settlement Contractors are partnering with Reclamation to improve models for cold water pool management. This work is consistent with NOAA's Water Initiative, which seeks to: (1) build strategic partnerships for water information services; (2) strengthen water decision support tools and networks; (3) revolutionize water modeling, forecasting, and precipitation prediction; (4) accelerate water information research and development; and (5) enhance and sustain water-related observations.

The SWFSC has embarked on an effort starting in 2020 to identify early-life-stage-specific survival objectives for winter-run Chinook salmon that would be sufficient to support a viable population.

In addition to the refinements made to the summertime management of water temperatures, improved management of spring water temperatures and better understanding of how temperatures affect the timing of winter-run Chinook salmon spawning in the Upper Sacramento River could reduce the reliance on the available cold water in Shasta during the latter months of the temperature management season. In its 2019 proposed operation, Reclamation included a coordinated effort with NOAA Fisheries to establish experiments to understand the role that April/May water temperatures have on winter-run Chinook salmon spawning as a potential conservation measure. These efforts will also be supported by a recently established science collaborative, the Sacramento River Science Partnership (SRSP), which was developed as a means to disclose and discuss emerging science in a way that builds trust and capacity between the resource agencies and stakeholders. In 2020 the SRSP provided an evaluation of the winter-run Chinook salmon 2019 broodyear that examined a single cohort of the species across multiple life-stages, from spawning through juvenile migration, to assess the factors and freshwater environmental conditions that contributed to outmigration success from that cohort.

To ensure Shasta Reservoir's cold water pool is used most efficiently for the protection of winter-run Chinook salmon survival, the 2021-2025 action plan continues to focus on water temperature modeling improvements, and adds new elements including the development of early life stage survival objectives and tracking juvenile production from freshwater as part of the SRSP annual cohort evaluation.

**Expected Benefits to the Species:** Improved management of Shasta Reservoir's cold water will help maximize winter-run Chinook salmon survival, especially during drought conditions.

**Source:** This effort will contribute to Recovery Plan Action SAR-1.4, page 151 (NOAA Fisheries 2014) as well as implementation of Reclamation's and CDWR's proposed action for the long-term operations of the Central Valley Project and State Water Project.

**Partners:** Reclamation, NOAA Fisheries West Coast Region, SWFSC, CDFW, USFWS, SWRCB, Northern California Water Association, Sacramento River Settlement Contractors, Sacramento River Science Partnership.

**Current Status, Partners, and Resources**

| Activity | Current Status | Expected | Lead Partners(s) | Estimated Funding Needed |
|---|---|---|---|---|
| Physical modeling improvements | Ongoing | Ongoing | SWFSC and Bureau of Reclamation | $150,000 / year needed |
| Installing Keswick Reservoir thermal profiler | Not initiated, needs funding and coordination from Reclamation | 1 year from start | SWFSC and Bureau of Reclamation | $100,000 |
| Biological model development | Ongoing | 2 years from start | SWFSC, University of Amsterdam, University of Idaho | $200,000 / year |
| Identify early life stage specific survival rate objectives | Ongoing | 2024 | SWFSC | Funded by Reclamation |
| Annual Cohort Evaluation | Implemented in 2020, continued funding needed | Ongoing | NOAA Fisheries West Coast Region, SRSP | $35,000 per year |

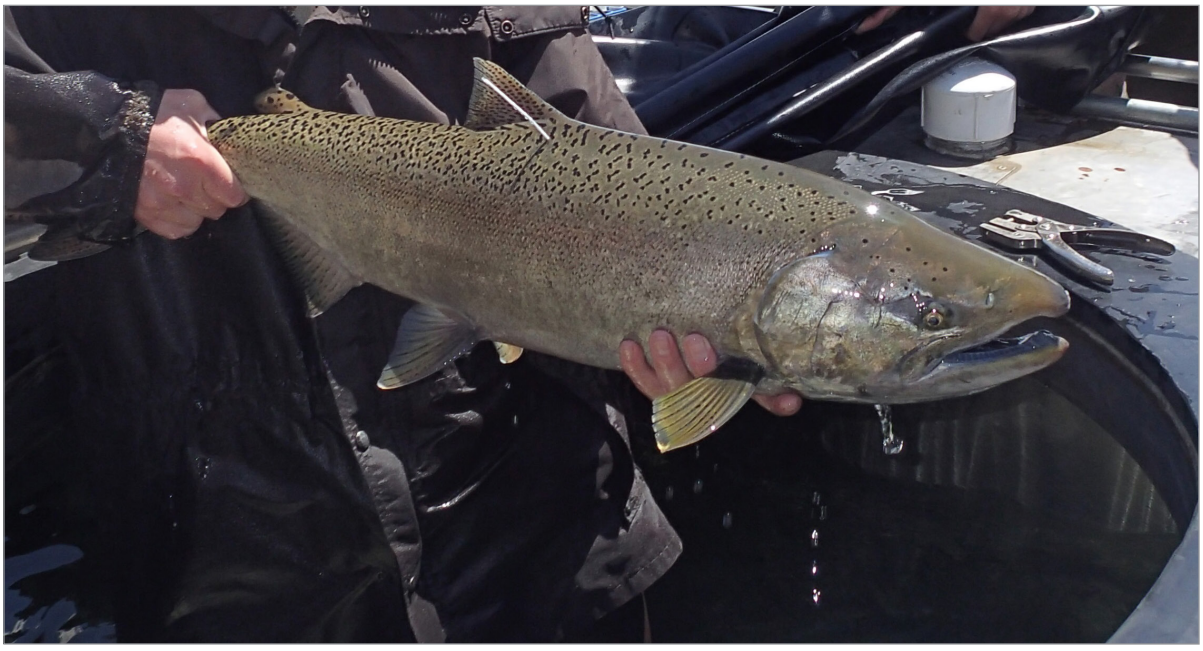
## Restore and Reintroduce Winter-run Chinook Salmon into Battle Creek

**Description and Background:** The Battle Creek Salmon and Steelhead Restoration Project (BCRP) located near the town of Manton, California, in Shasta and Tehama counties will restore and provide access to approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional 6 miles in its tributaries. Battle Creek is being restored by the modification of hydroelectric project facilities and operations, including instream flow releases. The BCRP will restore suitable winter-run Chinook salmon habitat and set the stage for reintroduction.

Since 2018, 567,412 juvenile winter-run Chinook salmon were reintroduced to Battle Creek to jumpstart the reintroduction effort. These fish have matured and started to return as adults in summer 2019. 2020 marked the second year of winter-run Chinook salmon returns to Battle Creek, with over 1,000 adults estimated to have returned. Additionally, 2020 was the first year that adults were allowed to migrate upstream and spawn naturally within North Fork Battle Creek, resulting in the first successful juvenile winter-run Chinook salmon production event in Battle Creek in over 100 years. Juvenile releases into Battle Creek have occurred annually since 2018 and are expected to continue. The jumpstart effort is intended to transition into implementation of the Reintroduction Plan with Reclamation support.

Additionally, Reclamation proposed, as part of the implementation of the long-term operations of the Central Valley Project and State Water Project, to develop and fund a Battle Creek Acceleration Plan. The Acceleration Plan will address and complement ongoing efforts of the BCRP and the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. This Acceleration Plan and the associated funding are particularly important given the recent uncertainty associated with the hydroelectric facilities within Battle Creek as a result of PG&E's decision not to renew their FERC license. The Acceleration Plan will also involve coordination with USFWS to identify Livingston Stone National Fish Hatchery infrastructure improvements necessary to support the Battle Creek Winter-run Chinook Salmon Reintroduction Plan.

**Expected Benefits to the Species:** The restoration of a drought-resistant, spring-fed system like Battle Creek is especially important to species such as winter-run and spring-run Chinook salmon and steelhead, which are dependent on cold water stream habitats. Winter-run Chinook salmon are particularly dependent upon habitats like Battle Creek that have stream reaches kept cold year-round by natural springs. Historically, winter-run Chinook salmon populations inhabited Battle Creek, the upper Sacramento River, the McCloud River, and the Pit River, bolstering the



Winter-run Chinook salmon at Livingston Stone National Fish Hatchery. Photo: Naseem Alston, NOAA Fisheries.

species' viability with population redundancy, but currently the single remaining population spawns in the mainstem of the Sacramento River downstream from Shasta Dam (Yoshiyama et al. 1998). In wetter years, this reach of the river is typically kept cold enough for winter-run Chinook salmon by releases from Shasta Reservoir. However, periods of extended severe drought, like the one California recently faced from 2012-2016, can exhaust the reservoir's cold water reserve, leaving winter-run Chinook salmon susceptible to reproductive failure. Restoring habitat and reestablishing a population in Battle Creek will increase the species' abundance, spatial structure, and diversity, and ultimately contribute to its chances of long-term survival and recovery.

**Source:** This effort will contribute to Recovery Plan action BAC-1.1 (Restoration), BAC-1.2 (Reintroduction), page 199 (NOAA Fisheries 2014) as well as Section 4.10.1.5.2 of the Bureau of Reclamation's Proposed Action for the Long-term Operations of the Central Valley Project and State Water Project, and Section 3.1.8 and 13.5 of the Central Valley Project and State Water Project (CVP/SWP) 2019 Biological Opinion (NOAA Fisheries 2019).

**Partners**: NOAA Fisheries West Coast Region, USFWS, CDFW, Reclamation, PG&E, CDWR, Battle Creek Watershed Conservancy, and Greater Battle Creek Watershed Working Group.

**Current Status and Resources:** A California State Proposition 50 grant in the amount of $14,390,000 was executed in June 2019 between CDFW and USFWS to support implementation of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. The grant will be matched with $3,747,836 in funding from the USFWS. The funding will cover the following activities, including grant administration and management:

| Activity | Expected Completion Date |
|---|---|
| North Fork Battle Creek Barrier Modification and Fish Passage Improvement Project | 2023 |
| Securing Long-term Rearing Facility in North Fork Battle Creek for the Battle Creek Winter-run Reintroduction Program | 2024-2025 |
| Short-term Rearing Facility in North Fork Battle Creek | 2021 |
| Coleman National Fish Hatchery Trap and Sorting Facility Environmental Planning | 2023 |

Some of the activities identified above are already underway. In August 2020, USFWS awarded the North Fork Battle Creek Barrier Modification and Fish Passage Improvement Project Phase 1 Agreement to Cal Trout. Additionally, in September 2020 a Cooperative Agreement between Mt. Lassen Trout Farms and USFWS was signed for the Short-term Rearing Facility in North Fork Battle Creek. This agreement is an important step toward implementation of the Battle Creek Winter-run Chinook salmon Reintroduction Plan because it allows for the transfer of salmon eggs from the Livingston Stone National Fish Hatchery on the Sacramento River to Mt. Lassen Trout Farm's Jeffcoat Springs Facility in the North Fork Battle Creek watershed to be reared until their release, instead of transferring the eggs to Coleman National Fish Hatchery. During 2018 and 2019, winter-run Chinook salmon were transferred to Coleman National Fish Hatchery prior to their release into Battle Creek. The water supply for Coleman National Fish Hatchery is a mixture of water from the North Fork and the South Fork of Battle Creek. The South Fork is not ideal for winter-run Chinook salmon due to lower flows and higher water temperatures, so the intent is to encourage winter-run Chinook salmon to return to the North Fork and keep them out of the South Fork. Releasing juvenile winter-run Chinook salmon from the Jeffcoat Springs Facility will help them imprint on the North Fork of Battle Creek so they return there as adults to spawn.

Reclamation has committed to providing up to $14.5 million over 10 years to support ongoing efforts to accelerate implementation of the Battle Creek Winter-run Chinook salmon Reintroduction Plan and the Battle Creek Salmon and Steelhead Restoration Project. This funding will go toward fish passage construction and reintroduction implementation activities. This includes 10 years of annual plan monitoring and implementation costing up to $1.4 million annually. As the Reintroduction Plan continues, additional funding will likely be needed to cover the annual costs.

# Reintroduce Winter-run into Historical Habitats Above Shasta Dam

**Description and Background:** The 2012-2016 drought and ongoing challenges with water temperature management downstream of Shasta Dam have accentuated the urgent need to reintroduce winter-run Chinook salmon populations into their historical habitats, which are not dependent on Shasta Reservoir storage and are buffered from drought due to the influence of cold water springs. The survival and recovery of winter-run Chinook salmon cannot be achieved without establishing additional populations.

**Expected Benefits to the Species:** Reintroducing winter-run Chinook salmon into historical habitats above Shasta Dam, such as the McCloud River, would increase the species abundance, spatial structure, and diversity, and ultimately contribute to its chances of long-term survival and recovery. Ensuring there are greater numbers of winter-run Chinook salmon widely distributed across a variety of habitats will reduce the species' risk of extinction. Reintroducing winter-run Chinook salmon to higher elevation, spring-fed habitat upstream of Shasta Dam would reduce the ESU's vulnerability to droughts, climate change, and other catastrophic events. Re-establishing winter-run Chinook salmon in their historical habitat would promote the ecological and evolutionary processes responsible for the local adaptation and diversity that allowed the species to persist for thousands of years (Anderson et al. 2014).

Preparing for a Winter-run Chinook salmon release. Photo: U.S. Fish and Wildlife Service.

***Reintroducing winter-run Chinook salmon into historical habitats above Shasta Dam, such as the McCloud River, would increase the species abundance, spatial structure, and diversity, and ultimately contribute to its chances of long-term survival and recovery.***

**Source:** This effort will contribute to Recovery Plan action SAR-1.1 (page 150, NOAA Fisheries 2014) and the California Natural Resources Agency's Sacramento River Salmon Resiliency Strategy.

**Location:** Historically available habitats above Shasta Dam.

**Partners:** NOAA Fisheries, CDWR, Reclamation, CDFW, USFWS, and United States Forest Service.

**Current Status:** NOAA Fisheries West Coast Region is working with CDWR to submit a proposal to the California Department of Fish and Wildlife under Proposition 1. Funding will be used for the first-round testing of a juvenile salmonid collection facility in the McCloud Arm of Shasta Reservoir.

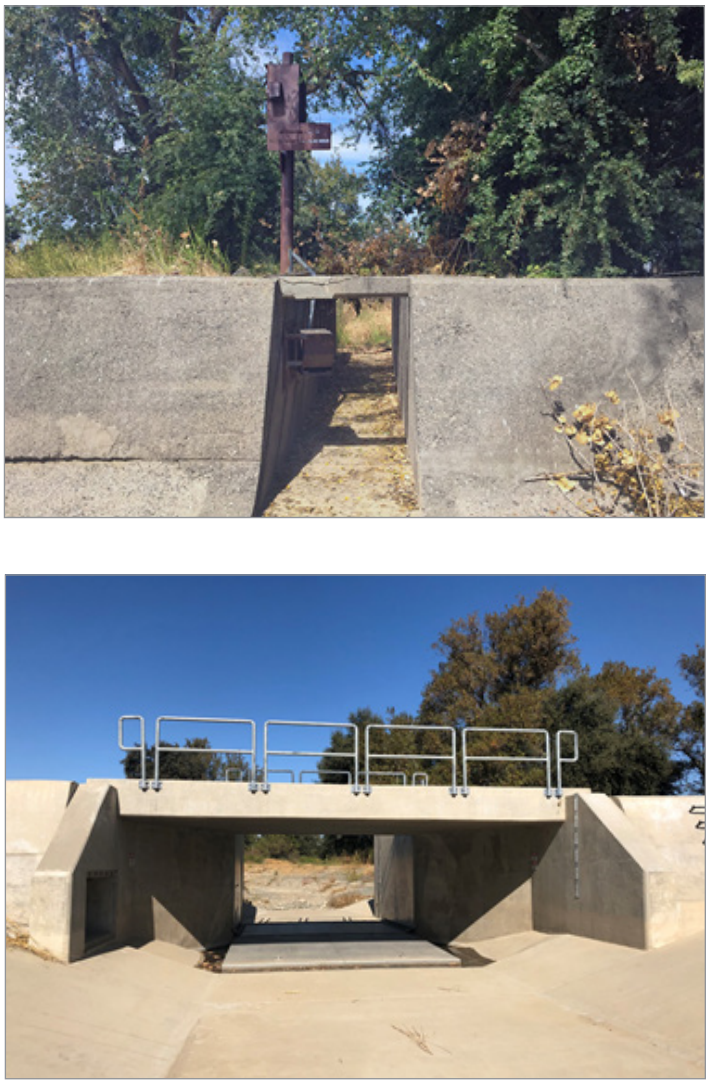
**Resources:** There is currently very little funding available for reintroduction efforts above Shasta Dam. CDWR has used available funding from a Reclamation contract to move the juvenile salmonid collection system forward. The cost of implementing a comprehensive pilot plan is estimated to be $15 million. Costs for the long-term program are dependent on the results of the pilot study and are not available at this time. Funding for implementation of the pilot plan has not yet been identified.

## Improve Yolo Bypass Fish Habitat and Passage

**Description and Background:** Significant modifications have been made to the historic floodplain of California's Central Valley for water supply and flood damage reduction purposes, resulting in losses of rearing habitat, migration corridors, and food web production for juvenile winter-run Chinook salmon. The Yolo Bypass, a 59,000-acre leveed floodplain engineered to convey floodwaters of the greater Sacramento Valley, still retains many biologically valuable characteristics of the historic floodplain habitat that are favorable to salmon. However, the value of this habitat is compromised in drier years, when there is little or no water on floodplains and poor connectivity between the Yolo Bypass and the Sacramento River. In addition, adult winter-run Chinook salmon stray into the Yolo Bypass during their upstream migration. Existing flood control and agricultural structures within the Yolo Bypass are inadequate to allow passage back into the Sacramento River at most flow levels. This leads to significant migratory delays, illegal harvesting, and reduced access to spawning grounds.

***Six projects from the 2016-2020 action plan have been completed by Reclamation and CDWR, including improvements to three weirs and three road crossings within Yolo Bypass to increase fish passage for adults.***

Six projects from the 2016-2020 action plan have been completed by Reclamation and CDWR, including improvements to three weirs and three road crossings within Yolo Bypass to increase fish passage for adults. These projects will continue to be monitored during flood management operations, using adaptive management to meet goals.



Fremont Weir fish ladder in 1965 (top) and 2018 (bottom). The new fish ladder provides much improved passage for adult winter-run Chinook salmon to return to the Sacramento River from the Yolo Bypass. Photos: U.S. Bureau of Reclamation.

The focus for the 2021-2025 action plan related to the Yolo Bypass is the Yolo Bypass Salmonid Habitat Restoration Project, commonly referred to as the Big Notch Project. Actions for the Big Notch Project include modifications to Fremont Weir to allow better fish passage for adult salmon and provide increased frequency, magnitude, duration, and access to seasonal floodplain habitat in the bypass for juvenile salmon. The Big Notch Project also includes improving one road crossing within the bypass to improve connectivity and fish passage.

**Expected Benefits to the Species:** Restoration of floodplain rearing habitat for juvenile Sacramento River winter-run Chinook salmon in the Yolo Bypass will provide floodplain connectivity, physical and biological habitat rearing conditions to promote food web productivity, and protection from predators that will in turn support juvenile winter-run Chinook salmon development, growth, and survival. Improvement of flood control and agricultural structures in the Yolo Bypass will reduce adult migratory delays, stranding, illegal harvesting, and losses to the population.

**Source:** This effort will contribute to Recovery Plan actions SAR-1.12 and SAR-1.13 (pages 158 and 159, NOAA Fisheries 2014) as well as the Bureau of Reclamation's Proposed Action for the Long-term Operations of the Central Valley Project and State Water Project.

**Partners:** Reclamation, CDWR, NOAA Fisheries West Coast Region and SWFSC, CDFW, USFWS, Metropolitan Water District, State and Federal Contractors Water Agency, Yolo Basin Foundation, Yolo County, Sacramento Area Flood Control Agency Sacramento and San Joaquin Drainage District, CDWR, Port of Sacramento and private landowners.

Winter-run Chinook juvenile. Photo: U.S. Fish and Wildlife Service.

**Current Status:** Lead agencies and partners are undergoing engineering and design planning and completing the permitting process for the Big Notch Project, and project completion is scheduled for 2022.

**Resources:** CDWR and Reclamation have allocated $160 million for Big Notch Project planning, design, construction, real estate easement acquisition, and implementation.

## Manage Winter and Early Spring Delta Conditions to Improve Juvenile Survival

**Description and Background:** This action is composed of three related activities intended to understand, manage, and reduce the exposure of juvenile winter-run Chinook salmon to negative flows and increased predation in the central and south Delta. The first activity is the installation of barriers at Georgiana Slough and other key junctions to keep juvenile salmon from entering areas known to have poor survival.

The second activity is real-time salmon monitoring and water export management in the Delta. Prediction of winter-run Chinook salmon presence is based on historical distribution data and current monitoring data from rotary screw traps, beach seines, Sacramento River trawl surveys, and tracking acoustically tagged fish. Data from active collections can be used to inform timely management decisions if the data are compiled quickly and relayed to managers through communication like the weekly Salmon Management Team meeting.

The third activity is development of eDNA science for potential application in the export management decision-making process. While acoustic tagging of fish is currently the most reliable technology employed to establish presence and understanding the route-use in the Delta, this approach has substantial limitations. Tags are only implanted in a subset of larger-sized Chinook salmon that are reared in hatcheries, and may not accurately represent the presence and movement of the natural-origin population in the Delta. These issues are resolved through the use of filtrate-eDNA, which is non-destructive, can detect the presence of any Chinook salmon (not just a tagged subset) in real time, and can be deployed in the field. By deploying an eDNA system (hereafter, DNA Tracker) for detecting and tracking juvenile winter-run Chinook salmon in the Delta, we would be able to detect their presence before they arrive at water supply pumping facilities.

**Expected Benefits to the Species:** Survival of juvenile winter-run Chinook salmon is expected to increase by: (1) expanding our knowledge of how Delta conditions impact juvenile salmon; (2) minimizing the distribution of juveniles from the Sacramento River into the interior Delta; and (3) minimizing exposure of juveniles to reverse flows and predation if they do enter the interior Delta by using improved real-time spatial distribution and movement information.

**Source:** This effort will contribute to Recovery Plan actions DEL-1.18 (minimize reverse flows), DEL-1.20 (minimize access to Delta interior), and DEL-1.22 (curtail exports when winter-run are present) (NOAA Fisheries 2014).

**Partners:** SWFSC, CDWR, Reclamation, CDFW, United States Geological Survey (USGS), USFWS, University of California Santa Cruz (UCSC), University of California Davis (UCD).

**Current Status:** The fish-guidance barriers at Georgiana Slough and other key junctions are in the planning phase. Real-time monitoring to inform water export management occurs annually to minimize impacts on winter-run Chinook salmon. The application of eDNA tracking systems for detecting Chinook salmon in field conditions is in the development stage.

**Resources:** The cost of the Georgiana Slough fish barrier is estimated at $12.8 million for construction and installation, with annual operations and maintenance estimated at $510,000. The cost of a fish barrier at another key junction (e.g., Sutter or Steamboat Slough) is estimated at $7.6 million for construction and installation, with annual operations and maintenance estimated at $390,000.

***By deploying an eDNA system (hereafter, DNA Tracker) for detecting and tracking juvenile winter-run Chinook salmon in the Delta, we would be able to detect their presence before they arrive at water supply pumping facilities.***

Real-time monitoring of winter-run Chinook salmon presence in the Delta costs the Delta Juvenile Fish Monitoring Program approximately $985,000 per year. The estimated annual total cost for acoustically tagging and tracking winter-run Chinook salmon is approximately $1.24 million.

The estimated cost of developing real-time eDNA tracking systems is approximately $250,000 per year for 3 years.

Chinook salmon. Photo: Bill Chesney, California Department of Fish and Wildlife.

## Collaborative Science and Fostering Partnerships

This action promotes the development of science and partnerships to adaptively manage Central Valley salmon, habitat, and water to meet winter-run Chinook salmon recovery goals. Three key efforts are: (1) the Collaborative Science and Adaptive Management Program (CSAMP); (2) the SWFSC's winter-run Chinook salmon science program; and (3) the Sacramento River Science Partnership (SRSP). These efforts collectively form key components of adaptive management, from identifying winter-run Chinook salmon recovery priorities and key threats, to modeling impacts of water operations and infrastructure projects, to evaluating impacts of actions taken.

### 1. Collaborative Science and Adaptive Management Program

**Description and Background:** The CSAMP partnership and process is essential to achieve a better understanding of Delta conditions and impacts to ESA species there. CSAMP is a voluntary collaborative initiated in 2013 involving state and federal resource agencies, environmental interests, and public water agencies. CSAMP is focused on science and adaptive management issues related to current and future operations of the State Water Project (SWP) and Central Valley Project (CVP) as well as emerging science and information needs regarding water management and species of concern in the Delta and upriver, including actions to improve the resiliency of Delta smelt and salmonids. CSAMP strives to provide a forum for communication among the agencies, non-governmental organizations, and public water agencies; act as a catalyst to address the most contentious and urgent management-relevant science issues; and provide timely compilation and dissemination of information for decision-makers on contentious and urgent science issues.

**Source:** Recovery Plan action DEL-2.25, Coordinate efforts to identify and highlight funding needs for restoration planning, monitoring, tracking, synthesis and adaptive management in the near- and long-term.

**Partners:** Non-governmental organizations, Public Water Agency, Reclamation, NOAA Fisheries West Coast Region, SWFSC, CDFW, USFWS, CDWR, State Water Resources Control Board, Delta Stewardship Council, Regional Sanitation Board.

**Current Status:** A Delta Science Planning Assessment focused on salmonids was finalized in December 2020 and CSAMP will identify next steps for actions and alignment with other programs in early 2021. CSAMP is also elevating species recovery as a priority for 2021.

**Resources:** Total cost averages approximately $1.2 million per year. NOAA Fisheries West Coast Region contributes approximately $50,000 per year.

### 2. SWFSC Winter-run Chinook Salmon Science Program

**Description and Background:** Since the launch of the *Species in the Spotlight* initiative in 2015, the SWFSC has prioritized winter-run Chinook salmon research and made progress on a number of fronts. In addition to the progress made on Shasta Reservoir temperature modeling and acoustic tracking of winter-run Chinook salmon juveniles discussed in Table 1, the SWFSC also has advanced the winter-run life cycle model (WRLCM), helped reveal the importance of non-natal rearing habitats, and developed a new model for forecasting adult abundance in the ocean. Each of these additional progress areas are briefly discussed below.

The SWFSC WRLCM has been in development since 2009. In 2017, SWFSC began regular outreach meetings and workshops in which stakeholders gain a better understanding of the data used to inform the model, the hypotheses employed to structure the mechanisms of the model, and implications of model results. Stakeholders have also offered additional data sources for use and approaches for mechanism implementation. These outreach and workshop efforts have continued and are extremely valuable in providing stakeholder

***Recent SWFSC collaborative research revealed that the majority of surviving adult winter-run Chinook salmon reared in non-natal habitats as juveniles. Most of these non-natal habitats were not previously known to be important for winter-run Chinook salmon recovery.***

understanding and acceptance of the tool, which NOAA Fisheries considers best available science and has regularly used for evaluations of conditions that may affect critical winter-run Chinook salmon riverine life stages.

Recent SWFSC collaborative research revealed that the majority of surviving adult winter-run Chinook salmon reared in non-natal habitats as juveniles. Most of these non-natal habitats were not previously known to be important for winter-run Chinook salmon recovery.

The SWFSC also developed a new model for forecasting the ocean abundance of winter-run Chinook salmon. The ocean abundance forecast is a function of adult returns to the river in previous years and river temperatures experienced by eggs, and is used by the Pacific Fishery Management Council to design commercial and recreational fishery seasons that maintain impacts on winter-run Chinook salmon below limits specified in the Biological Opinion on those fisheries. Fishery management will now reduce impacts during droughts, whereas the older system did not provide protections until after reduced egg survival due to drought was apparent in adult population declines.

For the 2021-2025 action plan, the SWFSC will focus their winter-run Chinook salmon research in four areas:

1. **Continuing development of the WRLCM and Enhanced Particle Tracking Modeling (ePTM):** The SWFSC is making improvements to the WRLCM by releasing a substantially updated project website that will include a new interface allowing the user to explore population dynamics by broodyear and lifestage, alter the model assumptions and view the population responses, and download all of the associated data and documentation; and updating the model to include a particle tracking component that estimates smolt survival in the Delta (ePTM version 2) and a habitat restoration evaluation component that incorporates fish size (WRLCM-S).
2. **Tracking effects of a study of thiamine deficiency in Chinook salmon stocks:** Thiamine deficiency syndrome was identified as an emerging threat for the first time in California salmon in 2020, resulting in widespread early life stage mortality. The SWFSC and agency and academic partners established a rapid response to understand the causes and impacts. Half of the progeny of winter-run Chinook salmon in the hatchery that were not prophylactically treated with thiamine showed signs of thiamine deficiency while none of the thiamine-treated females were afflicted. This provides insights into the significance of thiamine deficiency in wild winter-run Chinook salmon. While scientific investigations are ongoing, additional resources are needed to understand the marine food web conditions that cause freshwater impacts to winter-run Chinook salmon survival.
3. **Quantifying winter-run Chinook salmon juvenile rearing habitat:** Identifying juvenile rearing habitats that contribute to improved growth, survival, and ultimately reproductive success is a fundamental goal in species recovery. SWFSC and colleagues have developed isotope tools in archival tissues (otoliths and eye lenses) that allow quantitative assessments of the role floodplains and non-natal habitats play in growth and the survival of salmon to adulthood. Ongoing collections of archival tissues in winter-run Chinook salmon carcasses is providing the needed time-series to quantify the importance of floodplains and particular rearing habitats for winter-run Chinook salmon recovery.
4. **Studying effects of pathogen exposure:** Because the extent to which the survival of winter-run Chinook salmon outmigrating to the Delta are affected by pathogens is currently not well understood, the SWFSC is applying advanced environmental monitoring techniques to detect and enumerate pathogens along migration routes in the Sacramento River. This work is primarily relying on sampling environmental water and fish tissues from sentinel salmon to infer the distribution and levels of pathogens present. Data from these monitoring efforts are being used to build a disease transmission model, which will simulate the health outcome for salmon exposed to *Ceratonova shasta* (a

pathogen of particular concern in the Pacific Northwest) while outmigrating to the Delta under different hydrologic and thermal regimes.

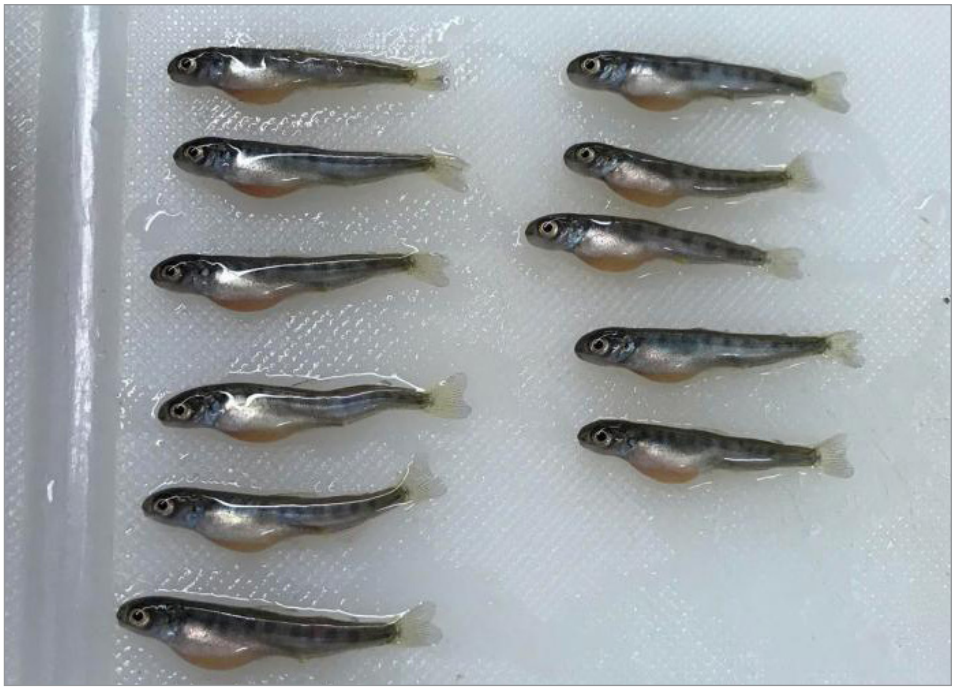
**Source**: Recovery Plan action DEL-2.25, Coordinate efforts to identify and highlight funding needs for restoration planning, monitoring, tracking, synthesis, and adaptive management in the near and long term.

### Partners

1. Continuing WRLCM and ePTM: Reclamation, UCSC, USGS.
2. Thiamine study: USFWS, CDFW, UCD, USGS, State University of New York.
3. Quantifying rearing habitat: UCD and USFWS.
4. Studying pathogen exposure: UCD, Oregon State University, Metropolitan Water District, USFWS, UCSC.

### Current Status

1. Continuing WRLCM and ePTM: current funding ends in June 2022. Some discussions have begun with Reclamation about future funding, but nothing concrete at this time.
2. Thiamine study: 1 year of funding covered 2020. Funding is needed to continue this work in 2021.
3. Quantifying rearing habitat: This research is underway and is funded through May 2021.
4. Studying pathogen exposure: funding for pathogen monitoring ends in February 2022.



Offspring of endangered female winter-run Sacramento River Chinook salmon that had been injected with vitamin B1 at the Livingston Stone National Fish Hatchery to help treat thiamine deficiency, a new threat to West Coast salmon populations. Photo: Heather Bell, University of California, Davis.

### Resources

1. Continuing WRLCM and ePTM: costs are approximately $750,000 per year, but are influenced by the number of projects to which the model is applied (running specific scenarios for major projects that require NEPA or ESA consultations typically requires additional funding).
2. Thiamine study: Efforts in 2020 were heavily leveraged with NOAA ocean surveys, collaborations with anglers and CDFW port samplers for ocean salmon samples, USFWS and CDFW for egg samples at hatcheries, UCD physiologists working to understand impacts to salmon survival, and out-of-basin experts in thiamine deficiency in salmonids. Approximately $450,000 per year is needed starting in 2021.
3. Quantifying rearing habitat: this is currently in the last year of funding and should be considered as part of long-term monitoring of winter run. Approximately $450,000 per year is needed starting in 2021.
4. Pathogen exposure study: to continue research is approximately $300,000 per year at the current effort level. Acquired funds totaled approximately $900,000 for 3 years.

### 3. Sacramento River Science Partnership

**Description and Background:** The mission of the Sacramento River Science Partnership is to establish and maintain a science enterprise for voluntary collaborative research, modeling, monitoring, and synthesis relevant to salmonid and other in-river species recovery and water management on the main stem Sacramento River to facilitate joint learning and fact-finding between and among scientists and managers. With the recent signing of a memorandum of understanding between NOAA Fisheries West Coast Region and SWFSC, CDFW, CDWR, USFWS, Reclamation, and the Sacramento River Settlement Contractors, a large suite of stakeholders are well-positioned to provide a collaborative approach to species protection and adaptive management in this critical region of the river.

**Source**: Recovery Plan action DEL-2.25, Coordinate efforts to identify and highlight funding needs for restoration planning, monitoring, tracking, synthesis, and adaptive management in the near and long term.

**Partners**: Sacramento River Settlement Contractors, Reclamation, NOAA Fisheries West Coast Region, SWFSC, CDFW, USFWS, CDWR.

**Current Status:** An SRSP Science Plan was approved in September 2020. The partnership is helping to organize a floodplain habitat science workshop set to occur in 2021.

**Resources**: Reclamation has committed about $215,000 per year for facilitation services. NOAA Fisheries West Coast Region contributes approximately $50,000 per year in staff. Additional funding of about $100,000 would support SRSP activities including evaluation and potential funding for science proposals solicited by the SRSP, as well as the planning and facilitating of science sharing workshops.

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Back cover photo: Preparing for a Winter-run Chinook salmon release into Battle Creek. Photo: U.S. Fish and Wildlife Service.

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