

Appendix J

STATE WATER PROJECT

DRAFT ADAPTIVE MANAGEMENT PLAN



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MARCH 5, 2020

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DRAFT ADAPTIVE MANAGEMENT PLAN

J.1 INTRODUCTION

Adaptive management is a science-based approach to evaluate management actions and address uncertainties associated with those actions to achieve specified objectives and to inform subsequent decision making. When correctly designed and executed, adaptive management provides a means to evaluate management actions and their underlying scientific basis using formal science programs to assess their efficacy in achieving conservation objectives by comparing the outcomes to predicted responses, and providing the scientific basis for continuing, modifying, or abandoning the action or implementing an alternative action.

The Delta Reform Act of 2009 identifies adaptive management as the desired approach to achieve continuous improvement in management planning in the Sacramento-San Joaquin Delta system. Consistent with the Delta Reform Act, the Department of Water Resources (DWR), the Department of Fish and Wildlife (DFW), and the State Water Contractors (SWC) (collectively, “the Implementing Entities”) intend to utilize adaptive management to inform operation of the State Water Project (SWP) and related activities described herein, consistent with the requirements of the California Endangered Species Act (CESA).

While the adaptive management program (AMP) described in this document pertains only to specified operations of the SWP and activities undertaken by DWR concomitant to those operations, and will be used to support the California Fish and Game Code Section 2081 permit issued for operation of the SWP, upon unanimous agreement among the Implementing Entities it may be: (i) expanded in the future to include other operations and activities; or (ii) implemented in a coordinated manner with other adaptive management programs covering such operations and activities. These will include coordination with ongoing implementation of the 2019 Biological Opinions for the Central Valley Project (CVP)¹ and SWP, and may include implementation of Voluntary Agreements or other activities undertaken under the oversight of the State Water Resources Control Board.

The Implementing Entities anticipate that it may be necessary to undertake additional monitoring and research that builds on existing efforts in order to carry out this adaptive management program. The Implementing Entities intend to use the Collaborative Science and Adaptive Management program (CSAMP), Inter-agency Ecological Program (IEP) Science Management Team (SMT) and Project Work Teams (PWT) and the Delta Science Program (DSP), as appropriate to develop study designs and subsequent evaluations and synthesis of monitoring data and research results. Furthermore, four-year independent science reviews will be used to evaluate the results of management actions subject to this AMP.

¹ Through integration with the processes described in Appendix C Real-Time Water Operations Charter of the Final Biological Assessment for Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and the State Water Project, October 2019.

The Implementing Entities will establish an Adaptive Management Team (AMT) to carry out this adaptive management program. Members of the AMT will include one designated representative² and one designated alternate each from DWR, DFW, and a SWP contractor. In addition, the AMT will use input from DSP in order to organize and guide the activities. The AMT's role in implementing this adaptive management program is described in the sections below.

The Implementing Entities intend to draw upon inter-agency technical teams as described above, as well as selected experts as needed, to develop plans to implement and track required monitoring and research identified in Appendix JA, as well as to evaluate the program and or program components. Where appropriate, the Implementing Entities will engage with the U.S. Bureau of Reclamation (Reclamation) and the federal fish agencies to pursue and implement certain actions through collaborative planning with the goal of continuing to identify and undertake actions that benefit listed species (see Section 4.12.3 of the Final Biological Assessment for Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and the State Water Project, October 2019).

Working through the collaborative process outlined in this document, the Implementing Entities commit to reach consensus within the AMT to the maximum extent possible, while still retaining individual agency discretion to make decisions (as appropriate). To that end, the Implementing Entities seek to use the flexibility provided by an adaptive management approach in a way that balances gaining knowledge to improve future management decisions with taking actions in the face of uncertainty and achieving the best outcomes possible for CESA-listed species.

J.2 INTENT AND OBJECTIVES

Through the AMP described in this document, the Implementing Entities are committed to the ongoing adaptive management of permitted operations of the SWP and related activities. In its role as operator of the SWP, DWR seeks to avoid, minimize, and fully mitigate adverse effects of SWP operations on CESA listed species, while improving operational flexibility and increasing water supply reliability of existing South Delta diversion facilities. More specifically, the intent of this AMP is to:

1. Provide a common definition of adaptive management and explain how it links to the incidental take permit for long-term operations of the SWP (SWP Incidental Take Permit [ITP]).
2. Describe how adaptive management for ongoing operations of the SWP, as it operates in coordination with the CVP, will be implemented to assist DWR in complying with applicable California law, including CESA.
3. Identify the key uncertainties about how combined SWP and CVP water operations and other management actions to benefit CESA-listed species can be implemented to meet regulatory standards applicable to CESA.

² "Designated Representative" means in the case of DWR and CDFW the official representative designated by the director to act on her or his behalf, and in the case of the SWP contractors the official representative designated by the SWC board of directors to act on their behalf.

4. Develop and implement a science program necessary to address uncertainties and support implementation of adaptive management, working in coordination with CSAMP, IEP, other adaptive management programs, and the DSP as appropriate.
5. Identify the SWP operations and activities that will be subject to adaptive management.
6. Describe the decision-making and governance structure that will be used to implement the AMP including adaptive management changes.
7. Describe the structure for communication among the Implementing Entities and with the broader stakeholder community regarding implementation of the AMP.
8. Describe funding for the AMP.
9. Describe the relationship between the AMP and real-time operations.

The objectives of the Implementing Entities are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements; (ii) address scientific uncertainties related to the effects of water project operations on listed species in relation to proposed actions; (iii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species; and (iv) provide a mechanism for incorporating adaptive management into the SWP ITP issued for long-term operation of the SWP.

J.2.1 SCOPE OF AMP

Each existing operation and activity and each adaptive management change must be accompanied by: (1) a set of criteria that the implementing entities can use to determine whether the action is having the anticipated impacts; and (2) monitoring that will provide the data necessary in order to determine whether the performance measures are being met. It may be necessary to undertake additional monitoring and research that builds on existing efforts in order to carry out this adaptive management program. The AMP would draw upon the CSAMP and the DSP, where appropriate, to assist with these monitoring and research efforts as well as program evaluation.

The AMP extends to specified operations of the SWP and activities undertaken by DWR concomitant to those operations. They include, but are not limited to the following:

- A. Operation of Harvey O. Banks Pumping Plant
- B. Daily and annual loss thresholds restricting OMR;
- C. Delta Smelt Summer-Fall Habitat Actions, including food enhancement actions;
- D. Cultured Delta Smelt studies;
- E. Spring outflow actions;
- F. Additional summer-fall actions;
- G. Role of habitat restoration in improving conditions for listed fish species;
- H. Efficacy of Delta Smelt supplementation;

- I. Installation of the South Delta temporary barriers, including installation of other seasonal barriers, as determined necessary by the AMT;
- J. Installation of the Georgiana Slough non-physical barrier to minimize entrainment of out-migrating Sacramento River salmonids into the central and South Delta;
- K. Evaluation of non-physical barriers to route emigrating Sacramento River into Sutter and Steamboat Sloughs to improve through Delta survival to Chipps Island;
- L. Clifton Court Forebay predator management;
- M. Development of a Juvenile Production Estimate (JPE) Science Plan (by September 1, 2020);
- N. Development of a JPE index for Spring-run Chinook Salmon (within 5 years of ITP issuance);
- O. Development of predictive tools for management of entrainment;
- P. Longfin Smelt Science Program monitoring and Lifecycle Modeling; and
- Q. Monitoring associated with all of the foregoing.

Many of these topics are described in more detail in Appendix JA.

Adaptive management is used to evaluate the efficacy of the above-identified operations, actions and related activities, by addressing areas of known uncertainty, improving scientific understanding by filling data gaps, and weighing whether new information should be incorporated into the ITP through an amendment. To do so, the AMT will oversee efforts to monitor and evaluate existing operations and related activities. In addition, the AMT through the CSAMP will utilize structured decision-making to assess the relative benefits or impacts of those operations and activities for listed species. The AMT will also identify proposed adaptive management changes to those operations and activities. Any proposed changes to project operations or related activities through adaptive management should provide equivalent or increased conservation benefits to the listed species.

As noted above, a key part of the AMP will be the development of performance metrics to guide the program. It is expected that there would be both short-term (e.g., habitat attributes) and long-term (e.g., abundance) metrics. Performance metrics would be based on a suite of measures that will include monitoring (long-term surveys; new measurements), experimental methods (e.g., fish enclosures), and modeling (e.g., 3-D modeling, life cycle modeling).

J.2.1.1 FOUR-YEAR REVIEWS

In January of 2024 and January of 2028, the AMT in coordination with Reclamation, will convene an independent panel to review OMR management and measures to improve survival through the South Delta, Spring flow maintenance for longfin smelt, and the Delta Smelt Summer-Fall Habitat Action including food enhancement actions. Establishment of independent review panels composed of subject matter experts is a key component of this adaptive management approach to operation of the SWP. DFW will and, NMFS, USFWS, and DSP may provide technical assistance and input regarding the panel and its panel charge. The panel would evaluate the efficacy of these and other project actions and make recommendations. The independent panels would review actions for consistency with

applicable guidance and will provide information and recommendations to DWR and DFW. DWR, in consultation with Reclamation, will provide the results of the independent review to NMFS and USFWS. DWR will coordinate with Reclamation to document a response to the independent review and DWR may develop and propose changes to management actions through the AMT using the ITP amendment process.

J.3 GOVERNANCE AND DECISION-MAKING

The AMT will include one designated management level representative and one designated alternate each from DWR, DFW, and the SWC. The AMT will coordinate with Reclamation, DSP, FWS, and NMFS, as appropriate on matters of common interest. The AMT may draw upon additional staff from any of the Implementing Entities or consultants engaged by one or more of the Implementing Entities to provide technical assistance or other support. The Implementing Entities, through the AMT, are responsible for support, coordination, and implementation of the AMP, and shall:

- A. Be responsible for supporting components of those monitoring and research needs identified in the IEP annual work plan, Implementation Plan for Science Plan to Assess the Effects of Ambient Environmental Conditions and Flow-Related Management Actions on Delta Smelt (Reed March 2019) and by Collaborative Science Workgroups that the AMT determines are necessary to carry out the AMP as required in the ITP. Existing IEP PWT's, CSAMP scoping teams and subcommittee's and groups called for under the Real-Time Water Operations Charter of the Biological Assessment will be used to the maximum extent practicable.
- B. Serve as a venue for identifying monitoring and research needs not addressed in other science forums, and route requests for those science needs to the appropriate entity with the capacity to complete them, or with approval of the Implementing Entities, the AMT may initiate work to address priority science needs.
- C. Develop proposals for adaptive management actions or development of discrete proposals, based on consensus among AMT members. Proposals for adaptive management actions should include a description of the action, the anticipated consequences of its implementation, and whether the action can be implemented consistent with the existing SWP ITP or will require a permit amendment. Adaptive management actions will be implemented on a pilot, annual, or long-term basis.
- D. Track monitoring and research that the AMT determines are necessary to carry out the AMP.
- E. Task technical teams associated with the AMT to regularly synthesize the best available scientific information regarding the covered species and their habitats and the effects of SWP operations and activities on those species and habitats based on established criteria.
- F. Recommend changes to operations and activities subject to this adaptive management program as well as monitoring protocols where appropriate based upon the results of science and monitoring requirements in the ITP.
- G. Refer proposed adaptive management changes to project operations or activities covered under the ITP and changes in monitoring or study protocols, as appropriate, to the Delta

Science Program for review by an independent science panel individually or as part of the four-year reviews described above.

H. Assure transparency in the implementation of the AMP.

I. Comply with Reporting Annual Work Plan and Budget, and Annual Progress Report requirements set forth in Sections J.4 and J.5.

Under the AMP, the results of monitoring and research will inform proposed adaptive management changes. The Implementing Entities commit to working collaboratively to reach consensus on recommended adaptive management changes to the maximum extent feasible and to elevate any disputes over decisions to appropriate levels of officials for each Entity. Each Implementing Entity retains discretion to make decisions, as appropriate within its authority, after considering the available information and taking into account the input of the other Implementing Entities through the AMT.

- DWR retains the authority to operate the project provided it does not deviate from the Project Description, violate any permit condition, or jeopardize the continued existence of the listed species.
- CDFW retains the authority to suspend or revoke the permit in the event DWR violates any permit condition.

If any adaptive management action changes the project description including water operations or other management activities, permit requirements, DWR will first seek to amend the SWP ITP³.

J.4 ANNUAL WORK PLAN AND BUDGET

On an annual basis, the AMT will prepare an Annual Work Plan and Budget for the upcoming year that are in addition to required monitoring listed in the ITP or that is part of the IEP annual work plan. If the Work Plan describes activities that spans multiple years, the Budget will cover the entire period. The Work Plan will describe the proposed activities of the AMP. The Budget will set out projected expenditures and identify the sources of funding for those expenditures.

The AMT will develop and approve the Annual Work Plan and Budget. As part of this process, the Implementing Entities will participate in developing the draft plan. The final Annual Work Plan and Budget will be completed no later than one month prior to the beginning of the activities described therein. Upon approval the Work Plan will be posted on Permittees website.

The Implementing Entities will ensure the draft plan accurately sets forth and makes adequate provision for the implementation of the SWP ITP terms under which the SWP operates.

At a minimum, the Annual Work Plan and Budget will contain the following information.

A description of the planned actions under the AMP.

A. A description of the planned monitoring actions and the entities that will implement those actions.

³ DWR will first seek to amend the SWP ITP and any needed authorizations by other state, federal, and local agencies.

- B. A description of the anticipated research to be undertaken and the entities that will conduct the studies.
- C. A budget reflecting the costs of implementing the planned actions.
- D. A description of the sources of funds that will be used to support the budget.

J.5 ANNUAL PROGRESS REPORT

At the end of each implementation year, the AMT will prepare an Annual Progress Report. The report will provide an overview of the AMT activities carried out during the previous implementation year and provide information sufficient to demonstrate that the proposed action is being implemented consistent with the provisions of the Work Plan and the SWP ITP.

The AMT shall solicit input on the draft of the Annual Progress Report from its members prior to its review and approval. The AMT shall finalize and approve the Annual Progress Report within six months of the close of the reporting year. Moreover, these actions will also rely on web-based reporting, allowing some of the results of adaptive management actions to be examined on a real-time basis. For example, DWR recently used Bay-Delta Live as a platform to display real-time information on water quality and fish for the SMSCG and North Delta Food Web Actions. Note, however, complete reporting of all metrics for a given action will likely require a full-year or more. This is because certain metrics are time consuming to develop (e.g., zooplankton, larval fish), and more sophisticated modeling (e.g., life cycle, 3-D modeling) requires substantial time. Nonetheless, the AMT will make every effort to make data available in a timely fashion to facilitate annual planning of adaptive management actions and support structured decision making.

The annual progress report will include, among other things, the following types of information.

1. An assessment of the implementation and efficacy of operations covered by this AMP during the prior year.
2. A summary of the habitat actions that have been initiated, are in progress, or have been completed in the prior year, including information regarding the type, extent, and location of protected and restored habitat for covered species.
3. Identification of actions that have not been implemented on schedule and an explanation for the deviation from schedule. For actions that are behind schedule, a suggested schedule or process for completing them will also be included.
4. Documentation of monitoring and research actions during the prior year.
5. Adaptive management changes made during the prior year, including the scientific rationale for the action.
6. Work done in coordination with CSAMP, the DSP, and/or other entities in the prior year.
7. An accounting of the funding expended in the prior year.

The annual report will be prepared in coordination with Reclamation to document joint implement activities, monitor performance, and report on compliance with the commitments in the Proposed Project as described in the Biological Assessment and associated 2019 BOs and the CESA ITP.

J.5.1 FUNDING

The Implementing Entities agree to secure funding sufficient to implement this AMP.

It is expected that the Adaptive Management Plan will require substantial additional IEP resources to support the required evaluations. The specific level of support remains to be determined and will likely vary substantially depending on the adaptive management actions conducted each year. Based on recent experience with pilot North Delta Food Web and Suisun Marsh Salinity Control Gate flow actions, it is anticipated that the required annual cost for monitoring and adaptive management support would be approximately \$2 million/year. However, the final budget could change substantially based on input from the AMT, CSAMP, and independent reviews.

J.6 RELATIONSHIP OF ADAPTIVE MANAGEMENT TO REAL-TIME OPERATIONS

The adaptive management and decision-making processes described here do not apply to real-time operations; where individual real-time operations decisions must be made on a daily, weekly or monthly time scale. However, changes to operational criteria in the SWP ITP may be changed over time through the adaptive management process based on new information. Such a change will require an amendment of the SWP ITP.

APPENDIX JA. ADAPTIVE MANAGEMENT TOPIC AREAS AND SCIENCE ELEMENTS

The following summarizes some of the major study areas and monitoring to be pursued as part of the Adaptive Management work. These include actions that are the focus of the current ITP, as well as projects that will be coordinated with the federal biological opinions. Note that this list is not meant to be exhaustive; rather, the intent is to provide more detail about some of the key components. For each project it is expected that the adaptive management team will work to develop individual work plans complete with predictions, metrics, and other relevant information.

JA.1 FLOW ACTIONS ACROSS WET AND DRY YEARS

DWR and CDFW intend to better understand how the management of water and habitat across various hydrologic conditions affect abiotic and biotic habitat quality and covered species abundance. Testing real-time SWP exports is one important component of this concept, allowing increased exports when impacts to fish potentially can be avoided or minimized. An important aspect of this concept is improving conditions during drier periods, and how the SWP can contribute to that through the shifting of exports to wetter conditions. To test the potential abiotic and biotic benefits, DWR proposes to maintain its current spring outflow contribution across all water year types, but allow, in consultation with CDFW, for flexibility in operations during some wet conditions per the real-time operations described in 3.3.1 OMR Management of its Incidental Take Permit Application, and to provide additional water for outflow in drier subsequent spring, summer, and fall periods.

JA.2 SUMMER-FALL FLOW ACTIONS

There is a recognized lack of understanding of factors influencing Delta smelt survival in the summer and fall. To study habitat effects on Delta Smelt survival, DWR has proposed summer-fall actions as described below. This water would also be for the purposes of testing and evaluating components identified in the Delta Smelt Resiliency Strategy by studying outflow effects on Delta smelt habitat.

Operation of the Suisun Marsh Salinity Control Gates (SMSCG) for up to 60 days (non-consecutive) in AN, BN, and to achieve a salinity of 4 ppt at Belden's Landing.

Provide an adaptively-managed 100 TAF block of Delta outflow in June through October in Wet and Above Normal years, as managed through the AMP with the approval of CDFW and in coordination with the Delta Coordination Team (DWR, CDFW, Reclamation, FWS, NMFS).

Initially, this water will be used in August of wet and above normal years to maintain a monthly average X2 of 80 km to the extent possible to test hypotheses and narrow uncertainty. However, subject to the AMP, CDFW may define an alternative purpose of this volume of water within the June through October period of the identified year types.

Alternatively, this 100 TAF block for Wet and Above Normal years may instead be used as additional outflow in the spring, summer, or fall of the following year to enhance habitat conditions for longfin

and Delta smelt, except if the following year is Critical. An expected potential use would be operation of the SMSCG June through September in Dry water years.

If the 100 TAF block is deferred for use in the following year, it will be subject to spill and will not be available if spilled. The water block from Wet or Above-Normal year can be deferred only to the following year.

JA.3 ADAPTIVE MANAGEMENT IN COORDINATION WITH FEDERAL BIOLOGICAL OPINIONS

Through the Delta Coordination Group, Reclamation and DWR shall develop a multi-year science and monitoring plan consistent with selected structured decision-making models within 9 months of signing the National Environmental Policy Act Record of Decision (ROD). The Delta Coordination Group may use the IEP or CSAMP (or similar entity) to review project design and the science and monitoring plan. Within six months of signing the ROD, the Delta Coordination Group shall meet to select a structured decision-making model; and complete model runs testing various approaches to satisfying the environmental and biological goals, utilizing the available toolbox of approaches. The Delta Coordination Group shall provide the initial results of its modeling exercise in a memorandum to Reclamation, DWR, CDFW, and the Fish and Wildlife Service. The process for Delta Smelt Summer-Fall Habitat Action development and approval is incorporated by reference from the BA.

The Delta Smelt Summer-Fall Habitat Action will be incorporated into the “Four Year Reviews” under the “Governance” section of this AMP, and all reasonable and practical recommendations shall be incorporated into the Delta Smelt Summer-Fall Habitat Action. The structured decision-making model and the multi-year science and monitoring plan will be part of this Peer Review.

JA.3.1 SACRAMENTO DEEPWATER SHIP CHANNEL FOOD STUDY

Reclamation proposes to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. The ship channel has the potential to flush food production into the north Delta for delta smelt when paired with an ongoing food study. This is the topic of an in-progress study of phyto- and zooplankton production in the ship channel. Follow-up activities will include the use of structured decision making do evaluate the costs and benefits of this concept relative to other management strategies.

JA.3.2 NORTH DELTA FOOD SUBSIDIES/COLUSA BASIN DRAIN STUDY

DWR, Reclamation, and water users propose to increase food entering the north Delta by moving water from the Colusa Basin into the Yolo Bypass and north Delta in July and/or September. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote fish food production.

JA.3.3 SUISUN MARSH AND ROARING RIVER DISTRIBUTION SYSTEM FOOD SUBSIDIES STUDY

Water users propose to add fish food to Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, Roaring River Distribution System food production, and reoperation of the Suisun Marsh Salinity Control Gates. As noted in the Delta Smelt Resiliency Strategy, this management action may attract Delta Smelt into the high-quality Suisun Marsh habitat in greater numbers, reducing use of the less food-rich Suisun Bay habitat (California Natural Resources Agency 2016). Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area. In addition, managed wetland flood and drain operations can promote food export from the managed wetlands to adjacent tidal sloughs and bays. Reclamation and DWR will monitor dissolved oxygen at Roaring River Distribution System drain location(s) to ensure compliance with Water Quality Objectives established in the San Francisco Bay Basin Plan when Delta Smelt food actions are being taken.

JA.3.4 SPRING-RUN CHINOOK SALMON MANAGEMENT

Development of Spring-run Chinook Salmon JPE from BO RPM 10, within 5 years Reclamation and DWR shall assess a potential Performance Objective for young-of-year CV spring-run Chinook (See detail below)

- Develop an initial report for consideration of the four-year panel review (2024).
- Prepare summary report of findings by September 2025.
- Consider and revise incidental take estimate, based on new information.

JA.3.5 SCIENCE AND MONITORING

- Support science actions such as marking and tagging/survival studies for Battle Creek Reintroduction, spring pulse flow actions and for studying alternative release strategies for Coleman National Fish Hatchery fall-run.
- Support science, model development and monitoring; experimental design (with validation monitoring) for spring pulse flows.
- Reclamation and DWR should update and recalibrate models to use recent data to strengthen their ongoing application base for the purpose of minimizing the effect of take. Models that would benefit from recalibration include.
 - Loss-density method or other methods recommended by CSAMP
 - Delta Passage Model
 - IOS model
 - SWFSC Central Valley Winter-Run Chinook Life Cycle Model
- In order to reduce uncertainties regarding the mechanisms and extent of take in the form of juvenile salmonid behavioral modifications to hydrodynamic changes in the South Delta that are associated with water operations, Reclamation and DWR should:

- Implement the recommendations of the CAMT 2017 workplan for salmonids (Salmonid Scoping Team 2017a; Salmonid Scoping Team 2017b). As part of this workplan, Reclamation and DWR should fund continued development of enhanced particle tracking modeling that is sensitive to realistic changes in South Delta operations, analyze existing data, and conduct experiments to assist in model development.
- Develop an adaptive management approach to test key alternative hypotheses (e.g., exports are important in addition to inflow in some circumstances in influencing juvenile salmon behavior, etc.). This experimental approach should build on lessons learned from VAMP, the six-year steelhead study, and the CSAMP/CAMT gap analysis report and recent Delta salmonid research workshop (that occurred on May 22, 2018). The study design would likely need to test both more restrictive and less restrictive approaches given low survivals in the South Delta.
- This experimental operational approach could be paired with habitat restoration and or predator management actions/studies in the Delta and on the main stem San Joaquin River.

JA.4 LONGFIN SMELT SCIENCE PROGRAM

CDFW, DWR and the State Water Contractors (SWC) entered into an agreement in 2014 to implement a multiyear Longfin Smelt Science Program. The Longfin Science Program was described in a Study Plan that identified the Napa River, Coyote Creek, and other areas that required further study of environmental factors affecting the species distribution and reproduction. In addition, the Study Plan focused studies on sampling efficiency, including time of day, water transparency, and tidal conditions. The Study Plan was intended to address eight research questions, six of which were examined over the course of an initial 5-year period of field study and data analysis. The Longfin Smelt Science Program would be continued. An updated Study Plan will be developed jointly with DWR, CDFW and the SWC and would address issues that include external issues influencing population abundance, distribution, habitat use, and catchability, including vertical migration behavior and water transparency and other factors that support growth and survival. A primary goal of this effort is to improve management of Longfin Smelt, and to identify potential management actions that could improve its status.

Components of the Science Plan include:

- Longfin smelt life cycle model. DWR, CDFW and SWC will work collaboratively using the best available science to develop a mathematical life cycle model for Longfin Smelt, verified with field data collection, as a quantitative tool to characterize the effects of abiotic and biotic factors on Longfin Smelt populations.
- Factors that influence abundance growth, survival, habitat use, and distribution
- Revisions to existing IEP monitoring programs to expand the spatial distribution of LFS sampling
- Completing the LFS life cycle in captivity at the FCCL
- Characterize LFS spawning substrate and spawning microhabitat requirements
- Studies to improve the understanding of adult migration behavior.

JA.5 CONDUCT FURTHER STUDIES TO PREPARE FOR DELTA SMELT REINTRODUCTION FROM STOCK RAISED AT THE UC DAVIS FISH CONSERVATION AND CULTURAL LABORATORY

DWR is proposing to continue supporting the operation and research being conducted by the University of California, Davis (UC Davis), Fish Conservation and Culture Laboratory (FCCL). The two main goals of the FCCL are to maintain a refuge Delta Smelt population in captivity that is as genetically close as possible to the wild population and provide a safeguard against extinction. The culture technique has been improved continuously over the years and the survival rate of cultured Delta Smelt at the FCCL is high (UC Davis 2019).

The FCCL is undertaking multiple research projects that will continue to add to the understanding of Delta Smelt and other species. The laboratory works collaboratively with other researchers from different agencies and institutions, assisting them with research projects and providing them with experimental fish populations of all life stages. The FCCL currently is expanding and renovating existing facilities, increasing the capacity for culture and research. Ongoing and future studies include the following:

- The FCCL currently is conducting studies to characterize and better understand Delta Smelt spawning behavior. Because spawning behavior has never been observed in the wild and has not been formally described yet, it is unclear how and where Delta Smelt naturally spawn. In ongoing experiments, the laboratory is conducting studies that characterize Delta Smelt spawning behavior under natural conditions and examining spawning substrate preferences. The findings from these studies will be critical to continued recovery and conservation efforts.
- The FCCL is investigating the optimum conditions for hatching Delta Smelt eggs in the wild. The current laboratory practice has been optimized to hatch good-quality eggs within 10 days of spawning, although it is important to consider the conditions in which the eggs are spawned in the wild. The laboratory is studying the effects of salinity and flow rate on the survival and condition of Delta Smelt eggs. This information will inform the proposed egg frame trials as well as the conservation of suitable breeding grounds.
- The FCCL is testing the possibilities of using an egg frame, created by the Lake Suwa Fishing Collective in Hokkaido, Japan for future restoration of Delta Smelt in the Delta. The frame was designed for hatching Wakasagi (*Hypomesus nipponensis*) into a body of water with constant flow. The water flow condition around the eggs in the frame will be studied using computational flow Incidental Take Permit Application for Long-Term Operation of the California State Water Project 3-51 Project Description dynamics, and the results will be used to suggest a suitable environment for applying the egg frame in the Delta.
- The FCCL is taking steps toward promoting survival of individual families by conducting trials using small culture containers that can rear single families at a time. This method could reduce competition between families and increase the survival of each individual family. The FCCL is carrying out trials to assess this factor by individually incubating an equal number of eggs from one,

four, or eight family groups; parentage analysis will assess the survival of each family in these groups.

- The FCCL was able to increase survival rates to a level sufficient for the successful culturing of Delta Smelt from the egg through adult stage; the first complete life cycle in captivity was established in 2000–2001. Currently, the FCCL focuses on improving existing rearing techniques, with the goals of increasing the system’s efficacy and rearing success. Some of the laboratory’s current areas of emphasis are as follows:
 - Tank size and system parameters: As fish develop from newly hatched larvae to adults, they are transferred multiple times between fish-rearing systems to fulfill the needs of each life stage. Black interior tanks are used for all fish, as clear and acrylic tanks have been found to stress fish. Light is administered to the tanks, with varying intensities corresponding to what has been deemed optimal for each life stage. Each recirculating system provides ultraviolet (UV) sterilization, both particle and biological filtration, and heat pumps for temperature control. Currently, the FCCL is testing stocking densities and feeding rates for each tank and also is developing smaller culturing systems for research purposes.
 - Turbidity effect: Early-larval and late-larval stages require different turbidity environments to promote feeding. Although it is not completely understood why larval stages require turbidity, it is thought that the suspended particles provide a visual contrast that enables larval stages to better find their prey. Turbidity is introduced via the addition of concentrated algae. As fish mature into the adult stage, algal addition gradually is decreased to gently transition the fish into clearer water environments.
 - Weaning strategies: As the smelt develop, they are transitioned from a live prey diet to a dry feed diet. The FCCL currently is researching this topic to determine the best time for weaning.
 - Salinity: In their natural environment, Delta Smelt inhabit estuary areas of relatively low salinity. The precise environmental salinity values vary seasonally, in accordance with each year’s freshwater availability. In collaboration with researchers at UC Davis, the FCCL is conducting experiments that analyze the physiological effects of salinity on Delta Smelt.

JA.6 CONTINUE STUDIES TO ESTABLISH A DELTA FISH SPECIES CONSERVATION HATCHERY

The Delta Smelt (*Hypomesus transpacificus*) is currently in severe decline within its native range in the Sacramento-San Joaquin Delta. Delta Smelt have declined to such low numbers that it is difficult to detect them in traditional surveys, and it is possible that the species cannot sustain itself without additional recovery actions. In an effort to conserve the species, a refuge population has been maintained at the UC Davis FCCL in Byron, CA since 2006 (a smaller population exists as a backup to the FCCL at Livingston Stone Hatchery in Shasta Lake, CA). The refuge population provides fish for research purposes, but more importantly, is a reservoir of Delta Smelt genetic diversity that has been specifically managed for potential wild population supplementation or reintroduction.

Currently, FCCL fish have not been released into the Delta, except as part of a predation study in a South Delta fish facility (Castillo et al. 2012). Yet under the present circumstances, there is a need to at

least have an emergency plan to guide possible release of refuge fish into the wild. Logic suggests that the easiest and most effective course of action at present may be to supplement the wild population before it goes extinct. Unfortunately, little is known about the most effective way to release Delta Smelt into the Delta for the purpose of recovering the species. In recognition of this issue, since 2017 DWR has facilitated studies with the overarching goal of determining the best methods to manage Delta Smelt releases from the refuge population to benefit the wild with maximum survival, retention of genetic diversity, and minimal risk to the wild population. A first step was the organization of a public workshop that identified some of the major scientific uncertainties and to guide future studies (Lessard et al. 2018). This workshop has led to DWR's collaborative work with UC Davis, USFWS, CDFW, and Reclamation to conduct initial investigations.

The current work plan includes work on genetics, pathology, behavior, a Hatchery and Genetic Management Plan, and test use of hatchery fish in experimental enclosures placed in the wild. Ultimately, the goal of this work is to develop an adaptive population supplementation plan that will assemble current knowledge about Delta Smelt, describe successful supplementation/reintroduction approaches for other fish species, identify research priorities, recommend monitoring approaches for evaluating supplementation strategies, and detail facility upgrade requirements for the refuge population.

DWR is proposing to continue collaborative laboratory and field work to develop a strategy for successful reintroduction of Delta Smelt to their natural environment in the wild and prevention of extinction. Some of this work on cultured fish could also be useful in the design and evaluation of different management approaches such as flow actions and tidal wetlands restoration projects. The work will be led by the Culture and Supplementation of Smelt (CASS) Steering Committee (SC), composed of CDFW, USFWS, Reclamation, DWR, and UC Davis. For 2020 it is anticipated that the primary research activities will be deployment of custom smelt cages in multiple habitats (channel, tidal wetlands) and geographic areas (Suisun, Sacramento River, North Delta), genetic analysis of the wild and hatchery population, pathology, and behavioral studies. The specific details of the work will be subject to input and review by the agency hatchery advisory group. However, it is anticipated that caged smelt could be an important tool to help evaluate different management actions as part of the Adaptive Management Plan.

JA.7 SCIENCE TO IMPROVE UNDERSTANDING OF DELTA SMELT HABITAT IN THE SUMMER AND FALL

There is currently a gap in our understanding of the spatial and temporal distribution of abiotic and biotic factors influencing DS habitat and survival during the summer-fall time period. To study habitat effects on DS survival, the AMT in coordination with Reclamation and CSAMP will support the development and completion of studies during implementation of the Summer-Fall Action Plan, including deployment of the Additional 100 TAF block of water when it is available as described in the Delta Outflow Operations Plan. The benefits associated with the Additional 100 TAF block of water will be evaluated in conjunction with new monitoring in Grizzly Bay to better quantify changes in salinity

associated with SMSCG operations. This new science can also facilitate testing and evaluating components of the Delta Smelt Resiliency Strategy by studying outflow effects on DS habitat.

JA.8 MONITORING ELEMENTS

JA.8.1 CONTINUATION OF EXISTING MONITORING

Existing monitoring programs through the Interagency Ecological Program (IEP⁴) and FWS (Enhanced Delta Smelt Monitoring⁵ [EDSM] program) includes monitoring to track the status of listed species of fish, and also monitoring to ascertain performance of minimization measures associated with operations of the South Delta export facilities and their fish salvage programs. The major components of this program and DWR's commitments are summarized below in Table JA-1.

Existing monitoring programs and proposed modifications to existing IEP programs will facilitate tracking status of listed species of fish and evaluating effectiveness of minimization measures. Incidental take associated with the IEP monitoring programs is authorized via ESA Section 10(a)(1)(A) Research and Enhancement Permits and state FGC Section 2081(a) permits. Monitoring to track performance of the South Delta export facilities and their fish salvage programs is authorized through the existing biological opinions (NMFS 2009 [Section 13.4]; USFWS 2008). Use of scientific collection permits constitutes a conservative approach to take authorization associated with monitoring activities because such permits need periodic renewal, at which time methodology can be updated to ensure that incidental take is minimized consistent with available knowledge and techniques. Thus, it is expected that continuation of existing monitoring would receive take authorization either through issuance of scientific collection permits, or through an alternative consultation pathway.

JA.8.2 PROPOSED MODIFICATIONS TO IEP SAMPLING PROGRAMS

Through IEP's science management plan review process (IEP 2014), DWR will undertake a review of existing IEP larval monitoring programs to propose an expansion of CDFW SLS and 20 mm programs given new information showing that longfin smelt have a more robust distribution, both temporally (i.e., spawning window) and spatially (i.e., habitat and regions) than what is monitored by these programs (MacWilliams et al. 2016; Grimaldo et al. 2017a; Lewis et al. 2019; Grimaldo et al. 2017b, submitted manuscript). This review will be completed within one year of ITP issuance. As part of the mitigation program, the construction of RVERS is included, which should improve IEP's sampling program. This facility has been permitted through a separate state and federal environmental review process.

JA.8.3 MONITORING OF HABITAT RESTORATION SITES

DWR and CDFW will use the Tidal Wetland Monitoring Framework (2017), prepared as part of the Fish Restoration Program, to develop monitoring plans to assess environmental characteristics of restored

⁴ This program is described and data are archived at <http://www.water.ca.gov/iep/activities/monitoring.cfm>.

⁵ This program is described and data are archived at https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm

habitat (e.g., salinity and zooplankton abundance) and evaluate the benefit to listed fish, lower trophic consumers, water quality, and effects on listed botanical and wildlife species. Aquatic monitoring will focus on regional and site-specific habitat characteristics associated with listed fish species. Monitoring plans will be developed as part of each restoration action that will include both pre- and post-project monitoring requirements. These plans will be independently reviewed and evaluated by technical teams or a science panel. Monitoring will rely as much as possible on data from existing regional monitoring efforts under the IEP. In addition, site-specific monitoring data will be collected within each project site prior to restoration action. Expansion of long-term Delta-wide monitoring efforts will assist with the fulfillment of monitoring requirements.

Table JA-1: IEP Core Long-Term Monitoring Elements

<u>Title</u>	<u>Principal Investigator</u>
<u>Fall Midwater Trawl (FMWT)</u>	<u>CDFW</u>
<u>Summer Towntnet Survey (STN)</u>	<u>CDFW</u>
<u>Est and Marine Fish Survey (Bay Study)</u>	<u>CDFW</u>
<u>Bay Shrimp and Crab Surveys (Bay Study)</u>	<u>CDFW</u>
<u>Delta Flows Network</u>	<u>USGS</u>
<u>20mm Delta Smelt Survey (20mm)</u>	<u>CDFW</u>
<u>Juvenile Salmon Monitoring (DJFMP)</u>	<u>USFWS</u>
<u>Coleman Late Fall Run Tagging</u>	<u>USFWS</u>
<u>Mosssdale Spring Trawl (Mosssdale)</u>	<u>CDFW</u>
<u>Environmental Monitoring Program</u>	<u>DWR</u>
<u>Central Valley Juvenile Salmon and Steelhead Monitoring (Knights Landing)</u>	<u>CFDW</u>
<u>Upper Estuary Zooplankton Sampling</u>	<u>CDFW</u>
<u>Spring Kodiak Trawl (SKT)</u>	<u>CDFW</u>
<u>UCD Suisun Marsh Fish Monitoring</u>	<u>UCD</u>
<u>Smelt Larval Sampling (SLS)</u>	<u>CDFW</u>
<u>Operation of Thermograph Stations</u>	<u>USGS</u>
<u>Juvenile Salmon Emigration Real Time Monitoring (DJFMP)</u>	<u>USFWS</u>
<u>Tidal Wetland Monitoring</u>	<u>CDFW</u>
<u>Yolo Bypass Fish Monitoring Program (YBFMP)</u>	<u>DWR</u>
<u>Resident Fishes Survey (DJFMP)</u>	<u>USFWS</u>

Note: List based on key monitoring programs in the draft 2020 work plan. The current PI and budgets for each are shown, but will change in the future based on personnel, project scope, periodic reviews, and inflation.

JA.8.4 ADDITIONAL DELTA SMELT AND LONGFIN SMELT MONITORING

Additional sampling is needed to better understand entrainment of smelts in relationship to their overall population.

- Enhanced larval monitoring inside and immediately outside CCF
- Additional SLS surveys in December in the central and south Delta to detect initiation of LFS spawning

JA.8.5 ADDITIONAL WINTER- AND SPRING-RUN CHINOOK MONITORING AND SCIENCE:

- Enhanced upstream monitoring of spring-run Chinook redd distribution, redd dewatering and juvenile stranding during the water transfer window.
- After five years of monitoring and development of a spring-run JPE transition into the development of a spring-run life cycle model.
- Trap capture efficiency studies to guide JPE calculations should use current methods of visibly marking trap captured and hatchery sourced fish including late fall-run and fall-run, but should also include developing trap efficiency models using the paired acoustic-CWT releases from Livingston Stone NFH, Feather River Fish Hatchery, and Coleman NFH.

Ideas currently under consideration:

- Provide experimental spring- and winter-run Chinook fish with a specific additional marker to differentiate them from other hatchery fish thus not requiring euthanasia to read CWTs and enabling them to return to contribute to recovery after salvage.

New pathology monitoring: Monitoring to provide information on the source and magnitude of CHNSR loss prior to Delta entry including in-season studies in the Sacramento and Feather rivers and Delta. Disease has been well documented to be present in the Central Valley and to reduce production via reduction in adult spawners and/or egg and juvenile mortality.

JA.8.6 NEW AND EXISTING MONITORING REQUIRED TO DEVELOP A SPRING-RUN JPE:

A Spring-run JPE Team will be convened within 30 days of the effective date of the ITP composed of experts from CDFW, DWR, NMFS, USFWS, and Reclamation. If agreed upon by participating agencies, other experts in fish biology, hydrology, or operations of the SWP and CVP may also participate to assist with their discussion and analyses. Permittee shall prepare a draft Spring-run JPE Monitoring Plan in collaboration with the Spring-run JPE Team that describes monitoring required to inform the development of the CHNSR JPE prior to September 1, 2020. The plan shall include, but not be limited to:

- Feather River and Lower Yuba River Adult Passage Monitoring and Escapement Surveys: Monitoring needed to develop adult spawner abundance estimates from which to derive production estimates. Monitoring includes passage surveys via a video monitoring station at Daguerre Point Dam on the lower Yuba River and in the low flow channel in the lower Feather River. Carcass surveys, redd distribution surveys, and dewatering surveys on both the Feather River and lower Yuba Rivers would be used to complement video monitoring as needed. Life history strategy decisions during rearing and emigration (yearling versus young-of-year) make juvenile production estimates difficult. It is important to document the adult escapement to supplement juvenile data.
- Deer, Mill, and Butte Creek Adult Passage Monitoring and Escapement Surveys: Monitoring needed to develop adult spawner abundance estimates from which to derive production estimates. Monitoring includes passage surveys via video monitoring stations on each creek., Carcass surveys, redd distribution, and dewatering surveys would complement video monitoring as needed. Life history strategy decisions during rearing and emigration (yearling versus young-of-

year) make juvenile production estimates difficult. It is important to document the adult escapement to supplement juvenile data.

- Feather River Rotary Screw Trap Monitoring at RM 61 and 45.8: Monitoring to provide estimates of the number of CHNSR emigrating through the upper limits of the Feather River via two existing rotary screw traps located at RM 45.8 (High Flow Channel RST) and RM 61 (Low Flow Channel RST).
- Feather River Rotary Screw Trap Monitoring at or Below the Yuba River Mouth: New monitoring to provide estimates of the number of CHNSR entering the Delta from the Feather River Basin. Data obtained would be used to integrate all Feather River Basin-origin fish into the CHNSR JPE. The data obtained can also be used as a point of comparison for reach-specific loss estimates from upstream sites when used in conjunction with acoustic telemetry data.
- Lower Yuba River Rotary Screw Trap Monitoring: Monitoring to provide estimates of the number of CHNSR emigrating through the lower Yuba River via two existing rotary screw traps located near Hallwood Boulevard. These data can also provide an upstream measurement to assess reach-specific loss estimates in coordination with acoustic telemetry data.
- Deer, Mill, and Butte Creek Rotary Screw Trap Monitoring: Monitoring needed to develop in-season juvenile production estimates and provide data on the egg-to-fry survival and emigration timing of yearling and young-of-year CHNSR. These data can also provide an upstream measurement to assess reach-specific loss estimates in coordination with acoustic telemetry data.
- Tisdale Weir and Knights Landing Rotary Screw Trap Monitoring: Monitoring is needed to provide estimates of the number of CHNSR entering the Delta from the Sacramento River Basin. The data obtained can be used as a point of comparison for reach-specific loss estimates from upstream sites. Weir overtopping and Sutter Bypass activation can influence the detectability of Chinook salmon at the Knights Landing monitoring station. Water entering the Tisdale Bypass provides an alternative route in which juvenile salmon are routed around the Knights Landing monitoring station. Monitoring upstream of Tisdale Weir will provide an additional measure of abundance prior to weir influence.
- Rotary Screw Trap Acoustic Tagging Monitoring: Monitoring using acoustic tagged fish to provide estimates of loss and timing of yearling CHNSR emigrants in the fall and emigrating young-of-year CHNSR in the spring.
- Genetic Identification of CHNSR to Support Ongoing and New Monitoring: When genetic testing to identify CHNSR is available conduct genetic sampling and analysis associated with new and ongoing monitoring programs to improve identification of CHNSR-sized fish observed.
- A list of the entities that shall receive funding from Permittee to implement required monitoring programs.

DWR shall work collaboratively with the Spring-run JPE Team members to incorporate edits and comments on the draft monitoring plan while preparing the final monitoring plan. After the final monitoring plan is approved in writing by CDFW, Permittee shall fund and implement required monitoring beginning the calendar year after the effective date of this ITP, according to the timelines specified in the monitoring plan. At a minimum, Permittee shall convene the Spring-run JPE Team quarterly every year following initiation of the final monitoring plan to:

- Review data obtained from new and ongoing monitoring programs
- Review methods used to implement monitoring and recommend adjustments as they deem appropriate
- Formulate an approach to calculating a CHNSR JPE, including the following elements:
 - Total in-river escapement,
 - Adult female estimate,
 - Adult female estimate minus pre-spawn mortality,
 - Average fecundity,
 - Total viable eggs,
 - Estimated egg-to-fry survival based on Juvenile Production Index (JPI) at RBDD/total viable eggs (this is back calculated from passage estimate at RBDD),
 - Fry equivalents of juvenile production,
 - Fry-to-smolt survival estimates,
 - Number of smolts, and
 - Upper river to Delta survival.
- Request additional monitoring if it is deemed necessary to complete a CHNSR JPE within five years of the effective date of this ITP
- Recommend approaches to using the CHNSR JPE and monitoring results as operational criteria to minimize take of CHNSR as a result of Project operations, including operations at the south Delta export facilities

All raw data acquired as a part of the monitoring program shall be available to members of the Spring-run JPE Team within ten days of a request.

Within four years of the effective date of the ITP, and in collaboration with the Spring-run JPE Team, Permittee shall prepare a draft plan to collect the data needed to calculate a CHNSR JPE. Permittee shall submit the draft plan to the Spring-Run JPE Team for review and work collaboratively with team members to incorporate their comments into the final draft. After the final draft Spring-run JPE Plan is approved by CDFW, Permittee shall convene the Spring-run JPE Team annually after the final plan is approved by CDFW to provide an annual JPE estimate for CDFW, Reclamation, USFWS, and NMFS.

JA.9 REFERENCES

California Natural Resources Agency (CNRA). 2016. *Delta Smelt Resiliency Strategy* – July 2016.

Castillo, G., J. Morinaka, J. Lindberg, R. Fujimura, B. Baskerville-Bridges, J. Hobbs, G. Tigan, L. Ellison. 2012. *Pre-screen Loss and Fish Facility Efficiency for Delta Smelt at the South Delta's State Water Project*, California. *San Francisco Estuary and Watershed Science*, 10(4).

Grimaldo, L., F. Feyrer, J. Burns, and D. Maniscalco. 2017a. Sampling Uncharted Waters: Examining Rearing Habitat of Larval Longfin Smelt (*Spirinchus thaleichthys*) in the Upper San Francisco Estuary. *Estuaries and Coasts* 40(6):1771-1784.

- Grimaldo, L. F., W. E. Smith, and M. L. Nobriga. 2017b. *After the Storm: Re-examining Factors that Affect Delta Smelt (Hypomesus transpacificus) Entrainment in the Sacramento and San Joaquin Delta*. Unpublished manuscript.
- Interagency Ecological Program. 2014.
- Lewis, L. S., M. Willmes, A. Barros, P. K. Crain, and J. A. Hobbs. 2019. Newly Discovered Spawning and Recruitment of Threatened Longfin Smelt in Restored and Under-Explored Tidal Wetlands. *Ecology*. Available: <https://doi.org/10.1002/ecy.2868>.
- MacWilliams, M., A. J. Bever, and E. Foresman. 2016. 3-D Simulations of the San Francisco Estuary with Subgrid Bathymetry to Explore Long-Term Trends in Salinity Distribution and Fish Abundance. *San Francisco Estuary and Watershed Science* 14(2).
- National Marine Fisheries Service. 2009. *Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan*. NOAA (National Oceanic and Atmospheric Administration), National Marine Fisheries Service, Southwest Fisheries Service Center, Long Beach, California.
- Salmonid Scoping Team. 2017a (January). *Effects of Water Project Operations on Migration and Survival in the South Delta. Volume 1: Findings and Recommendations*. Prepared for the Collaborative Adaptive Management Team.
- Salmonid Scoping Team. 2017b (January). *Effects of Water Project Operations on Migration and Survival in the South Delta. Volume 2: Responses to Management Questions*. Prepared for the Collaborative Adaptive Management Team.
- U. C. Davis. 2019. University of California, Agriculture and Natural Resources. California Fish Website. <http://calfish.ucdavis.edu/species/>
- U.S. Fish and Wildlife Service. 2008. *Biological Opinion on the Coordinated Operations of the Central Valley Project and State Water Project in California*.

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