BUREAU OF RECLAMATION

National Academies of Sciences, Engineering, and Medicine's First Biennial Review of the Long-Term Operation of the Central Valley Project and State Water Project

Cover Photo: Shasta Dam releasing storage after storm, February 2022. (Reclamation)

U.S. Department of the Interior **June 2026**

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

National Academies of Sciences, Engineering, and Medicine's First Biennial Review of the Long-Term Operation of the Central Valley Project and State Water Project

Central Valley Project, California

California – Great Basin Region

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Acronyms

CVP	Central Valley Project
DWR	California Department of Water Resources
ESA	Federal Endangered Species Act
NASEM	National Academies of Sciences, Engineering, and Medicine
OMR	Old and Middle River
Panel	National Academy of Science's ad hoc Committee
Reclamation	U.S. Department of the Interior, Bureau of Reclamation

1. Introduction

This Peer Review Report documents the National Academies of Sciences, Engineering, and Medicine (NASEM) biennial review of the Long-term Operations of the Central Valley Project (CVP) and State Water Project and our responses to recommendations from the NAS's ad hoc Committee (Panel). This process lasted 15 months between January 2024 – April 2025. It included eight meetings and culminated in the Review (NASEM 2025). Five of these meetings included sessions open to the public, and the Committee heard from local, state, and federal experts about project operations and three topic areas. The three actions chosen for the study included the Shasta Coldwater Pool Management Action, the Old and Middle River (OMR) Flow Management Action, and the Summer-Fall Habitat Action for Delta Smelt and are perceived as consequential for species survival and controversial for their effects on water deliveries to contractors.

The Panel reviewed numerous documents including published and gray literature, recent National Environmental Policy Act of 1969 and Federal Endangered Species Act (ESA) consultation documents, and received many presentations from agencies and interested parties. This Peer Review followed the Peer Review Plan (Peer-Review-Plan-NAS-LTO-CVP-IndepReview.pdf).

U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR) appreciates the extensive comments and recommendations developed by the committee (NASEM 2025). The Panel included 18 members including Peter Goodwin (*Chair*), Jerad Bales, Stephen Brandt, Erin Bray, Phaedra Budy, Harindra Fernando, Rene Henery, Jay Lund, Josué Medellín-Azuara, Michelle Miro, Mohammed Ombadi, David Owen, Denise Reed, Albert Ruhi, Steven Sadro, David Senn, Jery Stedinger, Patrick Sullivan. The Study Staff included Laura Ehlers, Constance Karras, Sabina Vadnais, and Maya Frey.

2. Committee Statement of Task

At the request of the Reclamation, an *ad hoc* committee of the National Academies of Sciences, Engineering, and Medicine will conduct a biennial review of the monitoring, modeling, and other relevant scientific activities and initiatives that support the long-term operations of the CVP. Along with the State Water Project, the CVP consists of coordinated federal-state water operations that annually move millions of acre-feet of water via dams, canals, tunnels, pumps, power plants and transmission lines from Northern California to a wide variety of water users throughout the state, including municipalities, agriculture, industries and wildlife refuges. Operation of the CVP affects species protected under the ESA such as the southern distinct population segment of North American green sturgeon, California Central Valley steelhead, Central Valley spring-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Delta smelt.

In the first cycle of the study, the committee will:

1. Assess the state of science for the following topics as they relate to long-term operations of the CVP.
    a. OMR flow management
        i. Salmonid route selection and survival

ii. Delta smelt entrainment and recruitment

b. Shasta cold-water pool management

c. Summer–fall Delta smelt habitat

2. Provide recommendations on how modeling and monitoring strategies and decision-support tools can be changed, improved, or replaced to more accurately assess the impacts of the CVP operations described above.

3. Disposition of Panel Findings and Recommendations

Reclamation's Bay-Delta Office and Central Valley Office staff and DWR's Division of Integrated Science and Engineering staff reviewed every recommendation provided by the Delta Science Program panel and identified a response for each of the comments (Table 1). As part of the Long-term Operation Adaptive Management Program, Reclamation will share these responses as activities in response to actions are contemplated and move forward. Some of these actions have seen advancements since they were presented to the Committee. In other cases, anticipated activities fit into specific Adaptive Management Actions such as Entrainment Management, Delta Smelt Summer and Fall Habitat, Shasta Spring Pulse Flow Studies, Shasta Coldwater Pool Management, and Spring Delta Outflow. Discussion and improvement through the longer duration of the adaptive management program will ensure coordinated improvements to these tools used in the planning process.

Table 1. Committee Recommendations and Reclamation Responses

NASEM Recommendation	Reclamation Response
Recommendation 2-1: Reclamation should enhance the monitoring of temperature and mixing in rivers relevant to the coldwater pool management action. Temperature sensors for rivers are inexpensive to install and maintain and could provide important information to enhance the predictive accuracy of the WTMP. Reclamation should use the WTMP to determine which tributaries—particularly in the reach downstream of Keswick Dam—and locations for which additional temperature data will reduce uncertainty in simulations and increase accuracy of modeled boundary conditions. Evidence shows that the Sacramento River quickly mixes across the channel width eliminating any significant lateral variations; the main exception is the temperature gage at Shasta Dam, which should be relocated (or a secondary gage installed) downstream to a point of full lateral mixing.	Reclamation is aligning with DWR to have consistent reservoir sensors for future modeling. This includes the installation of HyDAS-compliant meteorological station part of the DWR Site Monitoring Network and California Data Acquisition System Stations.
Recommendation 2-2: Reclamation should install four to six Lake Diagnostic Systems (micro-meteorology stations mounted over a fiber-optic distributed temperature sensing system) throughout Shasta Reservoir for two years to better understand how high frequency physical dynamics within the reservoir (such as seiching and internal mixing) affect the thermocline depth and to generate more accurate estimates of the coldwater pool volume. Over this two-year period, the adequacy of a single Lake Diagnostic System linked with CE-QUAL-W2 could be evaluated for its ability to simulate and predict the formation of stratification, the internal mixing processes affecting the coldwater pool, and the influence of different TCD operational rules. This enhanced monitoring will support the WTMP and help to explain and predict why the coldwater pool can vary significantly for water years with approximately the same total annual runoff.	Previous efforts with an LDS in Shasta Reservoir demonstrated challenges and opportunities for improvement. As part of the WTMP used for coldwater pool management real time operations and planning efforts, this recommendation's intensity of temperature monitoring was not recommended. This recommendation could be pursued as a special study, if deemed necessary.

NASEM Recommendation	Reclamation Response
Recommendation 2-3: High levels of "unattributed mortality" of winter-run Chinook salmon eggs must be better understood, through research that defines specific pathways for reducing said mortality, in order to develop management actions that can increase confidence in the use of egg-to-fry survival as the principal focus for coldwater pool management. The focus on temperature dependent mortality, interactive effects of multiple-stressors, and the fine tuning of releases from the Shasta coldwater pool may increase survival, but even in years when temperature dependent mortality is minimal, high mortality can still occur. Additional management actions supportive of winter-run survival can only be identified based on understanding the influence of factors such as temperature, flow, habitat, substrate, pathogens, predation, and food quality and availability across all life stages. Ongoing studies investigating the temperature, dissolved oxygen, and flow through redds could evaluate the potential benefits of larger scale actions such as channel and floodplain restoration, gravel augmentation, and pulse flows in sustaining pool-riffle sequences and other geomorphic features conducive to spawning.	Currently, Reclamation has supported collaborative fact-finding, through the SRSP, resulted in development of an influence diagram to evaluate evidence for different stressors' relative mortality on early life stages in the Sacramento River (Kearns and West 2023). This serves as a collaborative springboard for understanding unattributed mortality in the studies described below. Reclamation has funded research to better understand how flow, water temperature, and dissolved oxygen contribute to mortality in winter-run Chinook eggs. This research includes a cooperative project between USGS, USFWS, and Reclamation in the upper Sacramento River. Findings from the pilot (WY24) and first year (WY25) have been shared through the SRSP. This research will include study planning to estimate mortality at the fry and parr life stages of winter-run Chinook salmon upstream of Red Bluff Diversion Dam. Lastly, Reclamation has received proposals to reduce uncertainty surrounding early life stages of winter-run Chinook salmon through its CVP Fishery Information Needs NOFO process. Reclamation anticipates releasing these funds in FY 2026.

NASEM Recommendation	Reclamation Response
Recommendation 2-4: As tribes, DWR, and other groups continue feasibility studies, Reclamation should develop an actionable plan to facilitate and support the reintroduction of winter-run Chinook salmon to historic spawning and rearing habitat above Shasta Reservoir and in Battle Creek. The challenges and operational constraints posed on coldwater pool management by warming air temperatures, reduced snowpack, and increased drought frequency and duration place winter-run Chinook salmon at increasing risk. The only way to mitigate that risk, especially the risk of a catastrophic population crash associated with a more than three-year drought, is to safeguard some portion of the population in existing coldwater habitats.	Reclamation partners with agencies that are facilitating and supporting the reintroduction of winter-run Chinook salmon above Shasta Reservoir and in Battle Creek. During 2025, Reclamation participated in the Technical Advisory Group supporting CDFW's development of a Feasibility Study of Salmon Passage at Shasta and Keswick Dams (Anchor QEA et al. 2026). Reclamation provided comments on uncertainties, potential impacts, and opportunities to incorporate indigenous traditional ecological knowledge to facilitate reintroduction of winter-run Chinook salmon above Shasta Reservoir. Reclamation led a Value Planning Study considering cultural resources in the project area and prepared alternatives for avoidance with the Winnemum Wintu tribe in January 2026. Reclamation participates in the Battle Creek Restoration Program and BCWRRP. Reclamation has provided technical and financial support to ensure plans by federal lead agencies are actionable and achieve reintroduction in Battle Creek. Reclamation undertook a structured decision making study, using the PrOACT process, to incorporate input from interested parties in potential reintroduction of winter-run Chinook salmon to historic spawning and rearing habitats above Shasta Reservoir and in Battle Creek. Interest holders, tribes, and agencies provided input on more than Reclamation released a technical report summarizing the rapid prototyping study, which evaluated 14 portfolios of actions addressing Reclamation's problem statement regarding actions to address Shasta Coldwater Pool management limitations for winter-run Chinook salmon.

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Recommendation 2-5: Life-cycle models should be applied to develop a long-term strategy for winter-run Chinook salmon conservation and recovery, in the context of CVP and SWP operations. Although temperature-dependent mortality has received the most focus as a factor in winter-run Chinook salmon mortality, the relative importance of other factors throughout the system remains unclear, especially in the context of interannual variability in climate and resulting variation in streamflow and water temperature. Chinook salmon life-cycle models (e.g., CVPIA SIT, WRLCM, R2R DSM) could be used to systematically investigate how combinations of stressors interact to influence both egg-to-fry survival and juvenile growth and survival in a spatially explicit context. Model comparisons could be done to quantify system-wide trade-offs in management decisions, including impacts to other Chinook run timings and native aquatic species, and to identify which combinations offer the best gains in survival for a given water year type.	Reclamation partners with organizations that are recovering winter-run Chinook salmon. Reclamation has used multiple lifecycle models to evaluate CVP and SWP operations effects on winter-run Chinook salmon including OBAN, IOS, and the SIT models. The SIT, led by USFWS, Reclamation, and USGS, has been meeting for more than 10 years to consider tradeoffs in management actions on Chinook runs, sturgeon and steelhead. A second NTRS was released in spring 2026. The SIT models are anticipated to be further developed over the next 5 years period to evaluate CVP temperature and flow operations in the Sacramento River to support development of a third NTRS. Reclamation, with cooperation by the Delta Science Program through the Delta Research Awards, funded the Reorienting to Recovery Project between 2021-2025. This project took the existing SIT Chinook salmon life cycle models, revised and enhanced them, and evaluated tradeoffs among a set of portfolios focused on conservation and recovery. The result was a system-wide evaluation of Chinook runs to identify management actions of greatest benefit to these species. In the recent winter-run Chinook salmon rapid protoyping study, the SIT lifecycle model is being applied to evaluate hatchery, Sacramento River actions, facility improvements, Battle Creek actions, and above Shasta Dam actions under the constraints of CVP Sacramento River operations (e.g., flood control, coldwater pool management, water deliveries, hydropower generation).

NASEM Recommendation	Reclamation Response
Recommendation 2-6: Shasta Reservoir operations, and the models and inputs used to inform them, should more fully consider the effects of climate impact drivers on coldwater pool management. In future years with anomalously warm temperatures, diminished snowpack, and more intense droughts, total winter-run survival is likely to drop meaningfully if current operations continue, particularly as these climate conditions worsen over time. Importantly, biophysical model predictions based on historical relationships with climate variables may become unreliable, because those relationships may no longer reflect underlying physical mechanisms. In addition, the historical pattern of wet, dry, and normal years is expected to shift, making it necessary to adopt a more refined framework for coldwater pool management. Additional modeling could create an expanded set of operational rules targeted at extreme years (or even just those that are hotter and drier than considered by current management).	Coldwater pool temperature management planning tools utilize real-time observations of coldwater pool, a conservative 25% forecasted hydrology and 3-month meteorology. These observations are updated, as available to ensure they represent the most likely conditions to be encountered during the temperature management season. Reclamation developed several climate change scenarios for the 2021 LTO. These scenarios were used for climate change sensitivity analysis utilizing both CalSim 3 and HEC5Q models. The results from this analysis are presented in Appendix F.2-1 through F.2-8

NASEM Recommendation	Reclamation Response
Recommendation 3-1: The underlying scientific bases of the thresholds and corresponding export reductions used in OMR flow management should be made available so that their use can be appropriately reviewed. Although it did not thoroughly analyze each threshold value, the Committee noted examples of thresholds that are not scientifically defendable. More thorough use of validated hydrodynamic models and particle tracking models could help defend or refine these values.	Reclamation has not received any information from agencies or interest holders other than the literature, historical salvage observations, and modeling presented to document the underlying basis of thresholds and export reductions to analyze the threshold values. DWR is working with USFWS to develop a Longfin Smelt lifecycle model, akin to what was done with Delta Smelt, to better inform holistic management of the species, including the role entrainment effects play in population dynamics. This model will continue to be refined and invested in as new mechanistic understandings of the species' ecology are published. New lines of evidence (synthesis and modeling of stressors and life cycle modeling) are being completed to quantify the population-level effects of export reductions. This new information will support evaluation of the more holistic strategy for OMR modeling and monitoring proposed by the Committee and these will undergo a DSP peer review in 2026. A recent article by Reclamation coauthors (Jensen et al. 2025) provided a synthesis of the relationships between water operations and winter-run survival and addresses some of the more holistic strategy for OMR modeling proposed by the Committee.
Recommendation 3-2: Improvements are needed for the JPE. Survival estimates are based on fixed survival rates and methods for assessing catches in traps that have inherent assumptions (e.g., catchability, handling mortality) that should be explicitly stated. The JPE could be further improved by using more sophisticated estimation procedures, regularly updating the fixed parameter estimates, and understanding estimation uncertainty through the use of the methods of O'Farrell et al. (2018) and others.	In fall of 2025, Reclamation requested a Delta Science Program peer review of the annual winter-run Chinook salmon loss exceedances in 2024 and 2025. Specific recommendations were made regarding improvements to the JPE. Additionally, Reclamation replaced previous threshold that did not include a JPE, by developing a spring-run and steelhead JPE in the Action 5 Proposed Action, which has been implemented since December 2025. These methods can be updated based on new information. Reclamation and the agencies continue to work collaboratively to improve JPE methods.

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Recommendation 3-3: To move OMR flow management beyond the use of salvage as a proxy for impacts on fish in the Delta, the monitoring and modeling in support of the action should evolve to address four questions: (1) What is the zone (or sphere) of influence of operations? (2) For any given fish population, what proportion of that population is under that influence? (3) What is the impact to fishes in these regions? (4) What are the consequences of these impacts at the full population level? Several recommendations fall out of adherence to this strategy. a. Fish spatial distribution and abundance throughout the Delta should be better assessed, which is not possible with the currently employed fish monitoring networks based on netting. The use of a combination of the latest technologies (e.g., underwater acoustics using both fixed and moving sensors, nocturnal aimed/instrumented midwater trawling) at higher temporal and spatial resolution would lead to better detection of fish at time and space scales more appropriate to OMR operations. b. Expanded modeling efforts should build upon the Reclamation's zone of influence analysis to study changes in key factors such as temperature, SAV, salinity, and other water quality conditions across regions under a variety of Delta flow conditions, spanning dry to wet years, and under a range of pumping rates, expressed in terms of dimensionless flow ratios (see Box 3-4) including those that can account for local effects. c. Ultimately, higher resolution, expanded domain, and multi-parameter integrated modeling is required for full assessment of the Delta-wide impacts of exports on hydrodynamics, water quality, and fish. This will necessitate simulating fish response to governing variables through an integrated succession of suitable models. New approaches to link 3-D hydrodynamic models to fish vital rates have been used in other large ecosystems (Delta Independent Science Board 2015) to better assess the spatial complexities of interactions and define the most sensitive drivers and should be considered here.	Recent modeling has included reanalysis and synthesis of existing literature and observed dataset to understand the zone of influence, the proportion of the population under its influence and sources of Delta mortality affect on populations. These are being considered in a summer 2026 DSP peer review to consider how this new information can address these four questions. Monitoring will be redesigned to inform these questions and new methods to consider proportional loss of longfin smelt and delta smelt are being presented in the weekly assessment and will also be reviewed in the DSP peer review. Further work to link 3-D hydrodynamic models with fish vital rates and behavior are being supported by Reclamation. One example is Reclamation funding work on south Delta hydrodynamic and juvenile salmonid vital rates, in cooperation with the DSP through the 2019 Delta Research Awards program. More recently, UC Davis postdoctoral support has focused on understanding hydrodynamics and habitat attributes effect on juvenile salmon survival. This work is promising. DWR is also working with consultants to improve particle behaviors that emulate larval Longfin Smelt, and incorporate that behavior into a PTM tool that better informs OMR management.

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Recommendation 3-4: Improvements in Delta channels, forebays, infrastructure, and operations might help to reduce Delta-wide native fish losses and should be studied for their potential to reduce the ecological impacts of pumping. Hydrodynamic models could help Reclamation and DWR explore opportunities to both dampen tidal dispersion and reduce the pumps' zone of influence via more effective Delta channels, forebays, fish screens, and tidal gates. Reclamation could assess the effects of building a separate forebay for the CVP; DWR could assess ways to improve SWP forebay management; or the agencies could explore a joint forebay such as a flooded island.	Reclamation is unclear what is meant by ecological impacts of pumping. Reclamation is unclear if the recommendation is meant to focus on site-specific loss or Delta-wide native fish loss. There was no evidence presented by the NASEM that Delta wide native fish loss is related to CVP infrastructure or operations. Recent lines of evidence regarding Delta-wide mortality sources of fishes (e.g., temperature, predator hot spots, other stressors) have identified most of these are not proximal to forebays, infrastructure, or affected by operations. Reclamation has an annual program to improve CVP fish collection facility infrastructure to maintain salvage and reduce loss of native fish within its facility. For more information see Tracy Fish Facility Improvement Program (TFFIP) | California-Great Basin | Bureau of Reclamation
Recommendation 3-5: The OMR Flow Management Action should evolve to better anticipate changing climate impact drivers. One means of doing this is to develop indicators that signal when climate conditions have shifted enough to necessitate a change in management (e.g., if water temperatures increase by a set number of degrees, the model that simulates daily fish migration is deemed no longer valid). Long-term planning based on the OMRI may need to better represent plausible changes in the components of the water balance such as evapotranspiration, or at a minimum conduct climate sensitivity testing of OMRI components.	While Reclamation and DWR have identified a temperature threshold for when fish are no longer present, which leads to offramping OMR actions, the potential to identify a temperature threshold affecting fish movement is promising and should be further investigated. Recent investigations of water temperature in the Delta have detected marginal changes in water temperature due to changing climate, suggesting primary drivers remain seasonal temperature drivers (e.g., air, solar). Old and Middle River flow management action includes Health and Safety pumping and Storm-flex provisions to address the increasingly variable Delta inflow and allows Old and Middle River management to react to environmental and fishery monitoring in real time. In water year 2026, Reclamation was able to divert an additional 44 TAF stormflex while maintaining Old and Middle River flow management conditions that protected ESA listed species.

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Recommendation 4-1: Development of a process-based Delta Smelt model in a spatial foodweb context could greatly accelerate better implementation of the SFHA and increase understanding of the effectiveness of various SFHA components. Ideally, this process-based model for Delta smelt and its prey would be linked to existing models on estuarine hydrodynamics and water quality, which would enable evaluation of how the SFHA ultimately affects Delta smelt reproduction, growth, mortality and seasonal movement. To achieve this level of prediction and analysis, monitoring may need to include the measurement of rates (e.g., zooplankton production) and not just static variables (e.g., standing crop) and should also examine zooplankton responses to action-mediated changes in water residence time. The Committee acknowledges that acquiring this modeling capacity will require targeted data collection and experimentation and possibly multi-year development horizons and investment across agencies.	Reclamation's monitoring objectives for the lower trophic foodweb should provide the spatial and temporal foodweb context for a process-based Delta smelt model. Such a model was used in a recent structured decision making process that was documented in Healy, B.D., Phillis, C.C., Mahardja, B., Koizumi, C., Pien, C., Parker, N., Conrad, J.L., Ekstrom, J., Leimbach, J., Silberblatt, R., Fischer, T., and Ehlo, C., 2025, Rapid structured decision making for *Hypomesus transpacificus* (delta smelt) summer–fall freshwater outflow management: U.S. Geological Survey Open-File Report 2025–1055, 36 p., https://doi.org/10.3133/ofr20251055. Subsequent to Healy et al. 2025, a processed-based Delta smelt modeling using best monitoring information was recently used by DWR in a related CESA ITP decision and value of information process. The effort resulted in a research plan that includes refining predictive capacity of zooplankton models to include other environmental parameters (i.e., water quality, hydrodynamics, prey) that is intended to improve food availability estimates in the Delta smelt models for more accurate estimates. Past summer-fall monitoring data and a processed-based Delta smelt model were used in a recent synthesis report completed by the Delta Coordination Group- Science and Monitoring Work Group, including a detailed analysis of how flow actions influence zooplankton populations (DCG-SMWG 2026). Summer-Fall Habitat Actions for Delta Smelt-Report on Effectiveness of Actions Taken Between 2011 and 2024. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Endangered-Species-Protection/SFHA-Synthesis-Report-Final-Version.pdf Further effort to understand the spatial foodweb that can support process-based life cycle models for fish in the Delta will be examined in second cycle of the NASEM committee on the LTO of the CVP and SWP.

Recommendation 4-2: Exploring new scientific research areas (through special studies) would enhance understanding of factors limiting Delta smelt and support the implementation of the SFHA. These research areas include genetic analyses (e.g., eDNA, DNA of predator guts), which could offer insight into the role of predators in determining the effectiveness of the SFHA. Using cultured Delta smelt, laboratory and field studies could be completed to analyze the species of zooplankton consumed by smelt (short term diet), and stable isotopes could be used to understand long-term diet and trophic position. This information in combination with other critical information (e.g., bioenergetics) could be used to update food-web models in order to better predict and understand the effects of the SFHA on other lower trophic levels, on other imperiled fishes (e.g., longfin smelt and salmonids), and on non-native competitors and predators. Finally, mark-recapture technology, and the tags specifically, are advancing rapidly and may offer opportunities for much stronger monitoring and the ability to tag smaller fishes such as Delta smelt.	The Directed Outflow Project was undertaken between 2018 and 2023 to study environmental, habitat, foodweb, and biological factors that could be influencing the success of Delta smelt over the summer and fall. It resulted in a number of technical reports and articles (e.g., Reclamation has supported USFWS and UC Davis to develop a supplementation program for Delta smelt. This program uses a science based approach to enhancing our understanding of factors limiting successful reintroduction of Delta smelt into the Delta. Given the very limited Delta smelt observed in the summer, there are constraints on new Delta smelt research that can inform implementation of the summer and fall habitat action. DWR began an enclosure program in 2019 deploying hatchery Delta smelt in cages, including regions of the SFHA in 2019, 2023, and 2024. Zooplankton consumed by caged smelt and short-term diets were evaluated, included in technical reports, and recently used in refining models where feasible. However, enclosure factors were determined to confound Delta smelt responses in cages and therefore studies have not been conducted since 2024. DWR is currently managing wetlands in Suisun Marsh to subsidize zooplankton in summer-fall of 2026-2028, stable isotope analyses will be used to determine if wetland derived zooplankton are being integrated into the pelagic foodweb, including Delta smelt, if any are captured in Suisun Marsh during the study. DWR completed an eDNA pilot study during the 2025 SFHA but the method was determined to be ineffective in the Suisun region and Lower Sacramento River to supplement long-term monitoring surveys. Several smelt were captured by EDSM, but no smelt eDNA was detected. DWR, in collaboration with USGS, and the supplementation program conducted a predation study (predator community gillnet survey and gastric lavage) focused on understanding the role predation plays on limiting success of adult releases. Additional predation studies may be investigated to improve accuracy of current models.

NASEM Recommendation	Reclamation Response
	USFWS and UCD are currently testing acoustic array technology and tagging of Delta smelt to inform the supplementation program, though this will have limited utility for the juvenile lifestage present during the SFHA. VIE tags are currently done on adults, but are limited on juveniles present during SFHA. CA DWR and UCD are investigating isotopic marking of otoliths as a tagging tool that could be used with early life stages. All of these recent studies, along with the regular monitoring of zooplankton during the previous SFHAs were integrated into a bioenergetic analysis of benefits of previous actions for Delta Smelt in the SFHA Synthesis Report (Delta Coordination Group Sediment Management Work Group 2026), and were included in the processed-based model (which included bioenergetics) for structured decision making in 2025 and 2026.
Recommendation 4-3: An annual decision process for the SFHA founded on a series of environmental triggers that encompass more than water year type should be considered. Lessons learned from previous implementation of the SFHA, including the 2017 Fall X2 action, have shown that the response of Delta smelt may be determined by environmental conditions that are unrelated to water year type, including water temperature and antecedent conditions. The success of Fall X2 in a wet or above normal year may be dependent on the conditions in the previous year. A set of triggers (for example, related to temperature and food resources) for the SMSCG could be established based on expectations developed early in the year, identifying under what conditions the action would proceed and how. Closer to the time of the action, monitoring data based on the triggers could be used to adjust SFHA implementation.	Given the very limited Delta smelt observed in the summer, there are constraints on new Delta smelt research that can inform implementation of the summer and fall habitat action. Reclamation has removed the Fall X2 component from the SFHA from the LTO. Alternative SMSCG operation scenarios (e.g., continuous or discontinuous operations) based on real-time information are being considered for the 2026 SFHA, such as spring recession, summer temperatures, and Delta smelt population status, in addition to water year type.

NASEM Recommendation	Reclamation Response
Recommendation 4-4: The SFHA should be developed and adapted using a more coherent and transparent longer-term science program, where a broader range of experts explore, develop, and preliminarily evaluate integrated actions, and agency managers and scientists adapt these more comprehensively considered actions for regulatory and operational implementation. A successful combination of SFHA components is unlikely to be developed by the current method of internal agency professional judgement and partial consensus alone.	The Directed Outflow Project was undertaken between 2018 and 2023 to study environmental, habitat, foodweb, and biological factors that could be influencing the success of Delta smelt over the summer and fall. This work was done in collaboration with academic and agency scientists and emphasized in the Collaborative Science and Adaptive Management Program. Between 2020-2024, the SFHA was developed through the Delta Coordination Group, which included agencies and interest holders in the description, evaluation, and monitoring plans for these actions. The Delta Coordination Group recently completed a robust synthesis report "Summer-Fall Habitat Actions for Delta Smelt-Report on Effectiveness of Actions Taken Between 2011 and 2024." https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Endangered-Species-Protection/SFHA-Synthesis-Report-Final-Version.pdf The focus of a more coherent and transparent long term science program for Delta smelt has focused on supplementation and understanding the factors limiting success of this action, and includes agencies, academia, and interest holders.
Recommendation 5-1: A formal feasibility study should be undertaken to assess the potential for a Science Hub for the Bay-Delta and its watershed. This hub must be fit-for-purpose and grounded in the needs and culture of the science community. It should be designed to develop solutions to problems that are difficult to address within existing agency or academic silos, without interfering with agency mandates or diminishing internal capacity. It should enhance institutional expertise by creating a collaborative environment where new approaches can be developed and tested, where monitoring can be better coordinated, and where cross-agency training can be implemented. It would also facilitate better coordination across the science that supports CVP and SWP activities.	Reclamation has participated in and supported the Delta Science Program's effort to coordinate science through the DPIIC. Such an interagency implementation committee whose priorities are documenting science expenses and increasing structured decision making make this an appropriate forum for this recommendation. Bay-Delta science, monitoring, and modeling projects funded by Reclamation include requirements to use the DSP's Delta Science Tracker. Reclamation has been increasing its use of structured decision making with interest holders through the Central Valley and Bay-Delta.

NASEM Recommendation	Reclamation Response
Recommendation 5-2: Finer scale models are needed for water and ecosystem management in the Delta and its watershed. In particular CalSim (which is now widely used to evaluate ecosystem impacts) would benefit from a finer time step (perhaps one week) coupled with explicit or empirical disaggregation to still finer ecologically relevant time steps. With such capability, CalSim (or some other model) could then provide systematic hydrologic information for the more fully coupled hydrodynamic and population models needed for ecosystem management. Innovative ecosystem-wide approaches and quantitative life-cycle models could help to identify management actions that can contribute to species recovery. Monitoring should be tailored and managed to provide data at the spatial and temporal scales needed by the models.	Reclamation continues to rely on peer-reviewed and accessible models and tools for water and ecosystem management. The integrated decision support tools linking physical models (e.g., CALSIM, DSM2) to biological outcomes (e.g., winter-run, fall-run, sturgeon Delta smelt) have gone through multiple versions about every five years in the SIT. Continued development to leverage finer scale physical models of flows, temperature, and habitat is ongoing through participatory workgroups (e.g., Science Integration Team, LTO structured decision making teams). SDM evaluations undertaken in 2025 and 2026 included integrating hydrodynamic models and quantitative life cycle models to better choose management outcomes (Healy et al. 2025).
Recommendation 5-3: DWR and Reclamation should coordinate more closely and develop shared standards and protocols for modeling climate change impacts on the CVP and SWP. Consistent protocols are essential for minimizing uncertainty in projected climate change impacts, particularly those arising from two sources: future greenhouse gas emission scenarios and model-related uncertainties (e.g., climate sensitivity). Protocols will help to explain differences between projections and avoid confusion among policy makers and the public around different representations of climate change. Moreover, DWR and Reclamation should regularly update their modeling protocols to ensure alignment with current best practices in climate impact assessment. Finally, given the increasing evidence of more frequent compound events (multiple extreme events occurring simultaneously) and cascading events (extremes occurring in sequence, there is a pressing need for more detailed modeling studies to assess how such events may affect the Projects.	Reclamation collaborates with DWR to model climate change impacts on the CVP and SWP. This collaboration uses a Tick-tock strategy where each agency builds on the previous analysis completed by the cooperating agency.

Key:
CDFW = California Department of Fish and Wildlife
CESA ITP = California Endangered Species Act Incidental Take Permit
CVP = Central Valley Project
CVPIA SIT = Central Valley Project Improvement Act Science Integration Team
Delta = Sacramento-San Joaquin River Delta
DPIIC = Delta Plan Interagency Implementation Committee
DSP = Delta Science Program
DWR = California Department of Water Resources

eDNA = environmental DNA
FY = Fiscal Year
IOS = Interactive Object-Oriented Simulation
LDS = Lake Diagnostic Systems
NASEM = National Academies of Sciences, Engineering, and Medicine
NTRS = Near Term Restoration Strategy
OMR = Old and Middle River
PrOACT = Problem, Objectives, Alternatives, Consequences, Trade-offs
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SFHA = Summer-Fall Habitat Action
SRSP = Sacramento River Science Partnership
TCD = temperature control device
USGS = U.S. Geological Survey
WTMP = Water Temperature Modeling Platform
ESA = Federal Endangered Species Act
HyDAS = Hydrology Data Acquisition System
JPE = Juvenile Production Estimates
LTO = Long-term Operation
NOFO = Notice of Funding Opportunities
OBAN = Oncorhynchus Basian Analysis Model
OMRI = Old and Middle River Index
DSM = Decision Support Model
SAV = submerged aquatic vegetation
SMSCG = Suisun Marsh Salinity Control Gates
SWP = State Water Project TAF = thousand-acre-feet
USFWS = U.S. Fish and Wildlife Service
WRLCM = Winter-Run Life Cycle Model
WY = Water Year

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