MEMORANDUM

TO: SLDMWA Water Resources Committee Members and Alternates

FROM: Scott Petersen, Water Policy Director

DATE: February 5, 2024

RE: Update on Water Policy/Resources Activities

Background

This memorandum is provided to briefly summarize the current status of various agency processes regarding water policy activities, including but not limited to the (1) Reinitiation of Consultation on Long-Term Operations of the Central Valley Project and State Water Project, including environmental compliance; (2) State Water Resources Control Board action; (3) San Joaquin River Restoration Program; (4) Delta conveyance; (5) Reclamation action; (6) Delta Stewardship Council action; (7) San Joaquin Valley Water Blueprint and San Joaquin Valley Water Collaborative Action Plan.

Policy Items

Reinitiation of Consultation on Long-Term Operations of the Central Valley Project and State Water Project

In August 2016, the Bureau of Reclamation and California Department of Water Resources (DWR) requested reinitiation of consultation with NOAA Fisheries, also known as National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) due to multiple years of drought, low populations of listed species, and new information developed as a result of ongoing collaborative science efforts over the last 10 years.

On Jan. 31, 2019, Reclamation transmitted its Biological Assessment to the Services. The purpose of this action is to continue the coordinated long-term operation of the CVP and SWP to optimize water supply delivery and power generation consistent with applicable laws, contractual obligations, and agreements; and to increase operational flexibility by focusing on nonoperational measures to avoid significant adverse effects to species.

The biological opinions carefully evaluated the impact of the proposed CVP and SWP water operations on imperiled species such as salmon, steelhead and Delta smelt. FWS and NMFS documented impacts and worked closely with Reclamation to modify its proposed operations to minimize and offset those impacts, with the goals of providing water supply for project users and protecting the environment.

Both FWS and NMFS concluded that Reclamation's proposed operations will not jeopardize threatened or endangered species or adversely modify their critical habitat. These conclusions were reached for several reasons – most notably because of significant investments by many partners in science, habitat restoration, conservation facilities including hatcheries, as well as protective measures built into Reclamation's and DWR's proposed operations.

On Oct. 21, 2019, FWS and NMFS released their biological opinions on Reclamation's and DWR's new proposed coordinated operations of the CVP and SWP.

On Dec. 19, 2019, Reclamation released the final Environmental Impact Statement analyzing potential effects associated with long-term water operations for the CVP and SWP.

On Feb. 18, 2020, Reclamation approved a Record of Decision that completes its environmental review for the long-term water operations for the CVP and SWP, which incorporates new science to optimize water deliveries and power production while protecting endangered species and their critical habitats.

On January 20, 2021, President Biden signed an Executive Order: "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis", with a fact sheet[1] attached that included a non-exclusive list of agency actions that heads of the relevant agencies will review in accordance with the Executive Order. Importantly, the NOAA Fisheries and U.S. Fish and Wildlife Service Biological Opinions on the Long-Term Operation of the Central Valley Project and State Water Project were both included in the list of agency actions for review.

On September 30, 2021, Reclamation Regional Director Ernest Conant sent a letter to U.S. FWS Regional Director Paul Souza and NMFS Regional Administrator Barry Thom requesting reinitiation of consultation on the Long-Term Operation of the CVP and SWP. Pursuant to 50 CFR § 402.16, Reclamation indicated that reinitiation is warranted based on anticipated modifications to the Proposed Action that may cause effects to listed species or designated critical habitats not analyzed in the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) Biological Opinions, dated October 21, 2019. To address the review of agency actions required by Executive Order 13990 and to voluntarily reconcile CVP operating criteria with operational requirements of the SWP under the California Endangered Species Act, Reclamation and DWR indicated that they anticipate a modified Proposed Action and associated biological effects analysis that would result in new Biological Opinions for the CVP and SWP.

Following this action, on October 20, 2021, the SLDMWA sent a letter to Reclamation Regional Director Ernest Conant requesting participation in the reinitiation of consultation pursuant to Section 4004 of the WIIN Act and in the NEPA process as either a Cooperating Agency or Participating Agency.

On February 26, 2022, the Department of the Interior released a Notice of Intent To Prepare an Environmental Impact Statement (EIS) and Hold Public Scoping Meetings on the 2021 Endangered Species Act Reinitiation of Section 7 Consultation on the Long-Term Operation of the Central Valley Project and State Water Project[2]. In response to this, on March 30, 2022, the SLDMWA submitted a comment letter highlighting actions for Reclamation to consider during preparation of the EIS.

[1] https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/20/fact-sheet-list-of-agency-actions-for-review/

[2] https://www.govinfo.gov/content/pkg/FR-2022-02-28/pdf/2022-04160.pdf

During May 2022, Reclamation issued draft copies of the Knowledge Base Papers for the following management topics and requested supplementary material review and comments, to which the Authority submitted comment letters in June:

1. Spring-run Juvenile Production Estimate- Spring-run Survival Knowledge Base Document, May 2022
2. Steelhead Juvenile Production Estimate-Steelhead Survival Knowledge Base Document, April 2022
3. Old and Middle River Reverse Flow Management – Smelt, Chinook Salmon, and Steelhead Migration and Survival Knowledge Base Document, May 2022
4. Central Valley Tributary Habitat Restoration Effects on Salmonid Growth and Survival Knowledge Based Paper, March 2022
5. Delta Spring Outflow Management Smelt Growth and Survival Knowledge Base Document, May 2022
6. Pulse Flow Effects on Salmonid Survival Knowledge Base Document, May 2022
7. Summer and Fall Habitat Management Actions – Smelt Growth and Survival Knowledge Base Document, May 2022
8. Shasta Cold Water Pool Management – End of September Storage Knowledge Base Document, May 2022

Subsequent to the Knowledge Base Paper review, a Scoping Meeting was held, to which Water Authority staff provided comments, resulting in the release of a Scoping Report[3] by Reclamation in June 2022.

On October 14, 2022, Reclamation released an Initial Alternatives Report (IAR).

On May 16, 2023, Reclamation provided an administrative draft copy of the Proposed Action, titled “State and Federal Cooperating Agency Draft LTO Alternative” to agencies that have executed an MOU with Reclamation on engagement. Authority staff is reviewing the document and provided feedback to Reclamation, in coordination with member agencies and other CVP contractors.

On June 30, 2023, Reclamation released a draft Qualitative Biological Assessment for review by agencies that have executed an MOU with Reclamation on engagement, though Reclamation is not accepting formal comments. Note that this release does not initiate formal ESA consultation and is being provided to assist the fishery agencies in setting up their documents and resources for the formal consultation, which we expect to begin in late September/early October.

On July 21, 2023, Reclamation released an Administrative Draft Terrestrial Biological Assessment for review by agencies that have an MOU with Reclamation on engagement, though Reclamation is not accepting formal comments. Note that this release does not initiate formal ESA consultation and is being provided to assist the fishery agencies in setting up their documents and resources for the formal consultation, which we expect to begin in late September/early October.

On September 15, Reclamation released a Draft Environmental Impact Statement for 30-day NEPA Cooperating Agency review. The SLDMWA coordinated review of the document with member agencies

[3] https://www.usbr.gov/mp/bdo/docs/lto-scoping-report-2022.pdf

and technical consultants and submitted both high-level and technical comments on the document[4] on October 16.

On October 10, Reclamation transmitted an Aquatic species Quantitative Biological Assessment, and on October 18, Reclamation transmitted a Terrestrial Species Quantitative Biological Assessment to the Services and to consulting agencies pursuant to the WIIN Act.

Staff anticipates a second Administrative Draft EIS to be released in February for Cooperating Agency review.

Current Milestones

- Spring 2023 – Public Draft EIS
  - The public draft EIS will be the avenue for comments to Reclamation
  - Cooperating agencies will receive an administrative draft of the EIS
- Fall 2024 – Record of Decision

State Water Resources Control Board (State Water Board) Activity

Bay Delta Water Quality Control Plan Update

Background

The State Water Board is currently considering updates to its 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary ("Bay Delta Plan") in two phases (Plan amendments). The first Plan amendment is focused on San Joaquin River flows and southern Delta salinity ("Phase I" or "San Joaquin River Flows and Southern Delta Salinity Plan Amendment"). The second Plan amendment is focused on the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne rivers), Delta outflows, and interior Delta flows ("Phase II" or "Sacramento/Delta Plan Amendment").

During the December 12, 2018 Water Board Meeting, the Department of Water Resources ("DWR") and Department of Fish and Wildlife presented proposed "Voluntary Settlement Agreements" ("VSAs") on behalf of Reclamation, DWR, and the public water agencies they serve to resolve conflicts over proposed amendments to the Bay-Delta Plan update.[5] The State Water Board did not adopt the proposed VSAs in lieu of the proposed Phase 1 amendments, but as explained below, directed staff to consider the proposals as part of a future Delta-wide proposal.

Phase 1 Status: The State Water Board adopted a resolution[6] to adopt amendments to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary and adopt the Final Substitute Environmental Document during its December 12, 2018 public meeting.

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[4] Request from Authority staff.

[5] Available at https://water.ca.gov/-/media/DWR-Website/Web-Pages/Blogs/Voluntary-Settlement-Agreement-Meeting-Materials-Dec-12-2018-DWR-CDFW-CNRA.pdf.

[6]Available at https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2018/rs2018_0059.pdf.

Most recently, on July 18, 2022, the State Water Resources Control Board issued a Notice of Preparation (NOP)[7] and California Environmental Quality Act (CEQA) Scoping Meeting for the Proposed Regulation to Implement Lower San Joaquin River Flows (LSJR) and Southern Delta Salinity Objectives in the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta Plan).

The purpose of the NOP is: (1) to advise responsible and trustee agencies, Tribes, and interested organizations and persons, that the State Water Board or Board will be the lead agency and will prepare a draft EIR for a proposed regulation implementing the LSJR flow and southern Delta salinity components of the 2018 Bay-Delta Plan, and (2) to seek input on significant environmental issues, reasonable alternatives, and mitigation measures that should be addressed in the EIR. For responsible and trustee agencies, the State Water Board requests the views of your agency as to the scope and content of the environmental information related to your agency's area of statutory responsibility that must be include in the draft EIR.

In response to the release of the NOP, the Water Authority and member agencies provided scoping comments[8].

Phase 2 Status: In the State Water Board's resolution adopting the Phase 1 amendments, the Water Board directed staff to assist the Natural Resources Agency in completing a Delta watershed-wide agreement, including potential flow and non-flow measures for the Tuolumne River, and associated analyses no later than March 1, 2019. Staff were directed to incorporate the Delta watershed-wide agreement as an alternative for a future, comprehensive Bay-Delta Plan update that addresses the reasonable protection of beneficial uses across the Delta watershed, with the goal that comprehensive amendments may be presented to the State Water Board for consideration as early as possible after December 1, 2019.

On March 1, 2019, the California Department of Water Resources and the Department of Fish and Wildlife submitted documents[9] to the State Water Board that reflect progress since December to flesh-out the previously submitted framework to improve conditions for fish through targeted river flows and a suite of habitat-enhancing projects including floodplain inundation and physical improvement of spawning and rearing areas.

Since the March 1 submittal, work has taken place to develop the package into a form that is able to be analyzed by State Water Board staff for legal and technical adequacy. On June 30, 2019, a status update with additional details was submitted to the Board for review. Additionally, on February 4, 2020, the State team released a framework for the Voluntary Agreements to reach "adequacy", as defined by the State team.

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[7] Available at https://www.waterboards.ca.gov/public_notices/notices/20220715-implementation-nop-and-scoping-dwr-baydelta.pdf

[8] Request from Authority staff

[9] Available at http://resources.ca.gov/docs/voluntary-agreements/2019/Complete_March_1_VA_Submission_to_SWRCB.pdf

Further work and analysis is needed to determine whether the agreements can meet environmental objectives required by law and identified in the State Water Board's update to the Bay-Delta Water Quality Control Plan.

On September 28, The State Water Resources Control Board released a draft Staff Report in support of possible updates to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) that are focused on the Sacramento River watershed, Delta, and Delta eastside tributaries (Sacramento/Delta).

The draft Staff Report includes scientific information and environmental and economic evaluations to support possible Sacramento/Delta updates to the Bay-Delta Plan. The report assesses a range of alternatives for updating the Sacramento/Delta portions of the Bay-Delta Plan, including: an alternative based on a 2018 Framework document identifying a 55% of unimpaired flow level (within an adaptive range from 45-65%) from Sacramento/Delta tributaries and associated Delta outflows; and a proposed voluntary agreements alternative that includes voluntary water contributions and physical habitat restoration on major tributaries to the Delta and in the Delta. In addition, based on input from California Native American tribes, the draft Staff Report identifies the proposed addition of tribal and subsistence fishing beneficial uses to the Bay-Delta Plan.

The draft Staff Report is available for review on the Board's website. The Authority coordinated and submitted comments with member agencies[10].

Schedule

LSJR Flow/SD Salinity Implementation Next Steps Assuming Regulation Path (Phase 1)

- Winter/Spring 2024
  - Final draft Staff Report for Tuolumne River VA
  - Board workshop and consideration of Tuolumne River VA
  - Final draft EIR and regulation implementing Lower SJR flows and South Delta Salinity
  - Board consideration of regulation implementing Lower SJR flows and South Delta Salinity

Sac/Delta Update: Key Milestones

- Fall 2024: Response to comments and development of proposed final changes to the Bay-Delta Plan
- Winter 2024: Board consideration of adoption

Voluntary Agreements

On March 29, 2022, members of the Newsom Administration joined federal and local water leaders in announcing the signing of a memorandum of understanding[11] that advances integrated efforts to improve ecosystem and fisheries health within the Sacramento-San Joaquin Bay-Delta. State and federal agencies

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[10] See Appendix A.

[11] Available at https://resources.ca.gov/-/media/CNRA-Website/Files/NewsRoom/Voluntary-Agreement-Package-March-29-2022.pdf

also announced an agreement[12] specifically with the Sacramento River Settlement Contractors on an approach for 2022 water operations on the Sacramento River.

Both announcements represent a potential revival of progress toward what has been known as "Voluntary Agreements," an approach the Authority believes is superior to a regulatory approach to update the Bay-Delta Water Quality Control Plan.

The broader MOU outlines terms for an eight-year program that would provide substantial new flows for the environment to help recover salmon and other native fish. The terms also support the creation of new and restored habitat for fish and wildlife, and provide significant funding for environmental improvements and water purchases, according to a joint news release from the California Natural Resources Agency and the California Environmental Protection Agency (CalEPA). Local water agency managers signing the MOU have committed to bringing the terms of the MOU to their boards of directors for their endorsement and to work to settle litigation over engaged species protections in the Delta.

On June 16, the SLDMWA, Friant Water Authority and Tehama Colusa Canal Authority signed onto the VA MOU. Additionally, since that time, in September and November, four more agencies – Contra Costa Water District, San Francisco Public Utilities Commission (SFPUC), Turlock Irrigation District (TID) and Modesto Irrigation District (MID) – have signed onto the VA MOU.

Work continues to develop the working documents associated with execution and implementation of the VA's and workgroups for participating agencies have been formed, with the formation of a VA Science Workgroup to develop the framework of the VA's proposed Science program, as well as the recent formation of Scheduling and Funding workgroups to ensure that the program remains coordinated.

U.S. Bureau of Reclamation

Reclamation Manual

Documents out for Comment

Draft Policy

- There are currently no Draft Policies out for review.

Draft Directives and Standards

- CMP 08-01 Capital Investment and Repair Needs (comments due 02/23/24)
- EMG 02-01 Emergency Action Planning for Water Impoundment Structures (comments due 02/19/24)
- EMG 03-01 Critical Information Requirements Reporting and Duty Officer Program (comments due 02/02/24)
- PEC 05-03 Funding and Extended Repayment of Extraordinary Maintenance Costs (comments due 12/21/23, *comment period extended*)[13]

[12] Available at https://calepa.ca.gov/2022/03/29/informational-statement-state-federal-agencies-and-sacramento-river-settlement-contractors-agree-on-approach-for-2022-water-operations-on-the-sacramento-river/

[13] SLDMWA submitted comments, request from staff.

- Nov 30, 2023 PEC 05-03 Public Outreach Session Slides

Draft Facilities Instructions, Standards, and Techniques (FIST)

- There are currently no Instructions, Standards, and Techniques our for review.

Draft Reclamation Safety and Health Standards (RSHS)

- There are currently no Safety and Health Standards out for review.

Draft Reclamation Design Standards

- There are currently no Design Standards out for review.

San Joaquin Valley Water Blueprint

The Water Blueprint for the San Joaquin Valley (Blueprint) is a non-profit group of stakeholders, working to better understand our shared goals for water solutions that support environmental stewardship with the needs of communities and industries throughout the San Joaquin Valley.

Blueprint's strategic priorities for 2022-2025: Advocacy, Groundwater Quality and Disadvantaged Communities, Land Use Changes & Environmental Planning, Outreach & Communications, SGMA Implementation, Water Supply Goals, Governance, Operations & Finance.

Mission Statement: *"Unifying the San Joaquin Valley's voice to advance an accessible, reliable solution for a balanced water future for all.*

Committees

Executive/Budget/Personnel

The new Board Treasurer and Finance Committee are reviewing contributions and providing recommendations for 2024 contributions and support services. Hallmark has provided a revised scope for 2024 that is to be reviewed by the committee.

- Urban Water Agency Partnerships: Several meetings took place at ACWA and a request for a letter agreement with Urban Water Agencies and the Blueprint has been requested for monetary participation and pursuit of water storage and conveyance opportunities.
- February 21-23, 2024, Urban Water Institute's Spring Water Conference in Palm Springs, California: Leading water experts will deliver presentations on today's most pressing water management issues, representing a broad range of expertise and perspectives. The Blueprint has been asked to be a panelist during the conference.
- SB 366 (Caballero) The California Water Plan: long term water supply targets – The co-sponsors of SB 366, California Municipal Utilities Association, California State Association of Counties and California Council for Environmental and Economic Balance, and the coalition of organizations. Blueprint is reviewing support and contribution.

Technical Committee

Two specific priorities/efforts to help bridge the water deficit in the San Joaquin Valley, the Patterson ID conveyance project, and Delta Operations have been selected. The committee is evaluating total recharge opportunities and potential environmental enhancement and utilization.

Advocacy/Communications

Blueprint will be scheduling a meeting in the first of the year in Sacramento to brief legislative staff, policy makers, legislators, and Advisor Villaraigosa to highlight alignment with the Governor's water resiliency plan and priorities for a potential Water Bond, highlighting policy decisions that need to be made on reducing impacts to the central valley. The second phase of the Farmer to Farmer Delta/SJV summit is scheduled for January 29th and 30th here in the Central Valley.

Activities

Farmer to Farmer Summit – Second Session

The second phase of the Farmer to Farmer Delta/SJV summit was held on January 29th and 30th and took place here in the Central Valley. The Summitt was two nights, the first night in Bakersfield with a presentation and tour of the South Valley and the second night at Santa Nella with a presentation of the Westside and the San Luis unit. The group has agreed to focus on two priorities in the coming year: (1) the installation of a non-physical fish passage barrier at the Delta Cross Channel gates, and (2) South Delta Channel maintenance, including dredging.

Unified Water Plan for the San Joaquin Valley

The Blueprint and California Water Institute, Fresno State are developing a Unified Water Plan for the San Joaquin Valley, consistent with the Bureau of Reclamation grant. Both Stantec and The Hallmark Group are helping develop the plan. The final water plan will include measures to address San Joaquin Valley needs and potential portfolios to address needs and objectives, this report will ultimately be transmitted to Congress by Reclamation in 2025.

Correspondence

The Blueprint sent two letters[14] last month on the Bay-Delta Plan Update by the SWRCB.

San Joaquin Valley Water Collaborative Action Program (SJVW CAP)

Background

The CAP Plenary Group met on February 28 and approved the formation of work groups to advance the revised Term Sheet[15], adopted on November 22, 2022. Phase II, Work Groups are beginning to meet and discuss priorities and drafting for their respective areas: Safe Drinking Water; Sustainable Water Supplies; Ecosystem Health; Land Use, Demand Reduction and Land Repurposing; Implementation.

The Plenary Group met[16] on January 23, to finalize certain 2023 actions and to set priorities for 2024.

Final Actions for 2023

The group reviewed the actions intended to be completed by the end of 2023.

[14] Included in Appendix A.

[15] Request from Authority staff

[16] Notes included in Appendix A.

1. The letters to the Governor regarding the climate/natural resource bond and groundwater recharge are complete and will be sent to the Governor. [17]
2. The caucuses have approved the SB 522 letter to county elected officials and will be circulated to the Plenary Group requesting approval for CAP members who would like their names listed.
3. The caucuses have approved the on-farm habitat position statement and restoration principles, which will be used to guide future recommendations.
4. An issue regarding the Williamson Act recommendations in the letter to the Governor regarding process improvements to utility-scale solar needs additional discussion between the author and local government caucus members before it is finalized. However, it is supported by the other four caucuses.
5. Recommendations for protecting domestic shallow wells will be carried over into the new year.

The next meeting of the CAP Plenary Group will be held on February 27, from 3:30 – 5:00 on Teams.

[17] SLDMWA signed onto the climate bond recommendations letter. Request from staff.

APPENDIX A

January 19, 2024

State Water Resources Control Board
Division of Water Rights
Attn: Bay-Delta & Hearings Branch
P.O. Box 100
Sacramento, CA 95812-2000

Email: SacDeltaComments@waterboards.ca.gov

Re: Comment Letter – Sacramento/Delta Draft Staff Report

Dear Chair Esquivel and State Water Board Members:

I. Introduction

The San Luis & Delta-Mendota Water Authority ("Water Authority") and its member agencies Westlands Water District ("Westlands"), Banta-Carbona Irrigation District ("BCID"), Byron Bethany Irrigation District ("BBID"), San Benito County Water District ("District"), San Luis Water District, and Del Puerto Water District (together, "the Water Authority and Member Agencies")[1] appreciate the opportunity to comment in response to the draft Staff Report/Substitute Environmental Document ("Draft Staff Report") in support of possible updates to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary ("Bay-Delta Plan Update"). Through this ongoing planning process the State Water Resources Control Board ("State Water Board") will be making policy decisions on matters of vital importance to the future of California, including its protected native fish and wildlife species, tens of millions of people, and millions of acres of prime farmland.

In the Draft Staff Report, the State Water Board describes proposed amendments to the Bay-Delta Plan that include a 55% numeric unimpaired flow objective[2] (the "proposed Plan amendments"). The Water Authority and Member Agencies have significant concerns about the efficacy of those measures for the protection of native fish and wildlife, and the potentially

[1] See Attachment 1 for a description of the Water Authority and Member Agencies.

[2] The proposed Plan amendments include five "objectives and implementation measures" that are described in detail on pages 7.1-1 and 7.2-1 – 7.2-2.

devastating impact of those measures on California's water supply and associated socioeconomic health. The financial and public health impacts of the proposed Plan amendments cannot be overstated – if adopted, they would have significant impacts to local government revenues and would increase the need for public support for those impacted by the reductions in water supply, particularly in already economically underdeveloped regions of California like the San Joaquin Valley, further straining an already volatile state budget structure. The Draft Staff Report also describes alternatives to the proposed Plan amendments, including the mandatory measures embodied in "Voluntary Agreements." For the reasons discussed herein, the Voluntary Agreements approach ("VA alternative") is the superior choice for California, and these commenting agencies urge the State Water Board to adopt it. The proposed Plan amendments, in contrast, would cause severe disruption of California's water supplies with more limited prospects for efficiently achieving desired benefits for native fish and wildlife. In addition to failing to strike the appropriate balance among beneficial uses of water, adoption of the proposed Plan amendments in their current form would be contrary to requirements of the California Environmental Quality Act ("CEQA"), the Porter-Cologne Act, and Article X, section 2 of the California Constitution.

Attached hereto are detailed comments on the proposed Plan amendments and Draft Staff Report, which are incorporated here by this reference. In this cover letter, the Water Authority and Member Agencies highlight the advantages associated with State Water Board adoption of the VA alternative, as well as a few critical defects with the proposed Plan amendments and the Draft Staff Report.

II. The Voluntary Agreements Alternative Offers the Best Approach to Reasonable Protection of Beneficial Uses

Chapter 9 of the Draft Staff Report describes what have been termed the "Voluntary Agreements" or "VAs."[3] The VAs are a set of measures proposed by a group of state and federal agencies, local water agencies, private companies, and a non-profit mutual benefit corporation as an alternative to the proposed Plan amendments. As described in the Draft Staff Report these measures include "a combination of proposed flow and non-flow habitat restoration measures on a portion of the Sacramento/Delta tributaries over 8 years (with the intent to extend the term), including varying amounts of increased flows, depending on water year type, and non-flow habitat restoration actions targeted at improving spawning and rearing capacity for juvenile salmonids, estuarine species, and other native fish and wildlife." (Draft Staff Report at p. 9-1.) Additional details regarding the VAs are included in Chapter 9 and Appendix G, including the final draft Scientific Basis Report in support of the VAs that is being submitted for independent peer review. Additional draft components of the VAs are expected to be presented to the State Water Board in early 2024. The VAs offer a superior pathway for achieving protection of fish and wildlife that is consistent with the State Water Board's legal obligations when adopting water quality objectives and that will provide for reasonable protection of all beneficial uses, while maintaining consistency

[3] The VAs are also referred to as "Agreements to Support Healthy Rivers and Landscapes."

with other statewide policy objectives, including the human right to water, the coequal goals of the Delta Reform Act, and the Water Resilience Portfolio and Water Supply Strategy..

First, unlike the proposed Plan amendments, the VA alternative would not include numeric unimpaired flow objectives. Rather, the VA alternative would include a new narrative objective to achieve the viability of native fish populations. It would include both flow and non-flow measures as implementation measures for the new narrative water quality objective and the existing Narrative Salmon Protection Objective in the Bay-Delta Plan. The agreements would provide the participating parties' share of flow and other contributions, during implementation of the VAs, to contribute to achieving the existing Narrative Salmon Protection Objective by 2050. Notwithstanding the term "voluntary," the measures included will be implementable and enforceable. (Draft Saff Report at p. 9-16 ("the Bay-Delta Plan program of implementation would be amended to require that either the proposed VA flow and non-flow habitat restoration actions are achieved in any region covered by a VA"); *id*., at p. 5-2 ("[t]he proposed VAs identify a regulatory implementation pathway that would exist in parallel with the VA implementation pathway").)

This difference from the proposed Plan amendments – i.e., a narrative objective rather than a numeric unimpaired flow objective – has significant implications for the scope of analysis required in the Draft Staff Report. A narrative objective, unlike a numeric objective, does not represent a commitment of a specific volume of water to a specific use at the time an objective is adopted. A narrative objective leaves room for further analysis and adaptation during implementation, to make use of the science-based adaptive management included as part of the VAs. In contrast, adoption of a numeric unimpaired flow objective requires that much more analysis and information be ready at the time of adoption because it represents a commitment of a specific volume of water to one use at the expense of other beneficial uses. As is discussed below, the Draft Staff Report impermissibly seeks to defer analysis and information needed at the time of adoption of a numeric unimpaired flow objective.

Second, the VA alternative offers a much quicker path to achieving benefits for fish and wildlife. For example, projects to restore habitat have been identified and are ready to implement. The VAs include early implementation of dozens of projects. The state agencies participating in the VAs have committed hundreds of millions of dollars to purchasing additional water for environmental purposes. The VAs offer flows with function, with attention to how more flow interacts with an improved landscape to support biological function.

Third, the VA alternative includes measures the State Water Board could not mandate through exercise of its regulatory authority alone. The agencies participating in the VAs are bringing their authorities and financial resources to bear to improve both habitat and scientific monitoring and study. As an example, the water agencies are imposing fees on their users to fund VA measures. While the State Water Board has extensive authority over flow, all stakeholders acknowledge that fish are negatively affected by factors other than flow and that recovery will require measures more than flow. The VA alternative provides a direct means to address some of those other factors with non-flow measures. The proposed Plan amendments and other unimpaired flow alternatives, in contrast, do not include non-flow measures.

Fourth, and especially important, the VA alternative offers more benefits with fewer adverse impacts. While the VA alternative will result in water supply impacts for water users, they are much less significant than the substantial impacts of the proposed Plan amendments. According to the Draft Staff Report, the proposed Plan amendments would reduce south of Delta water exports by an average of 912,000 acre-feet. (Draft Staff Report at p. 6-57.) Other regions will suffer substantial loss of water supply as well. For the reasons described below, the potential adverse impacts of the proposed Plan amendments are even more significant than the Draft Staff Report acknowledges.

For these reasons, the Water Authority and Member Agencies urge the State Water Board to adopt the VA alternative rather than the proposed Plan amendments.

III. The Proposed Unimpaired Flow Approach Would Effect a Dramatic Shift in California Water Policy, the Consequences of Which Have Not Been Adequately Addressed in the Draft Staff Report

The most salient aspect of the State Water Board's proposed Plan amendments is a requirement that a percentage of "unimpaired flow" be left instream. Delta inflow from the Sacramento River, its tributaries, and Delta Eastside tributaries would be required to be "55 percent [of] unimpaired flow, with an adaptive range from 45 percent to 65 percent unimpaired flow." (Draft Staff Report at p. 1-2.) Unimpaired flow is "the flow that would occur without water diversions with existing channel configurations." (*Ibid*.) The essential premise for requiring that a percentage of unimpaired flow be left instream is that "[i]n general, naturally variable flow conditions provide the conditions needed to support the biological and ecosystem processes imperative to protect fish and wildlife beneficial uses. Conversely, altered flow regimes have been shown to be a major source of degradation to aquatic ecosystems worldwide (Petts 2009)." (*Id*. at p. 3-2.)

The stated purpose of the Bay-Delta Plan Update is to establish water quality objectives that provide "for the reasonable protection of [native] fish and wildlife." (Draft Staff Report at p. 7.1-5.) Reasonable protection of fish and wildlife and the environment is a valid and necessary component of water quality planning. However, improving such protection cannot be the only goal of the Bay-Delta Plan Update. Any amendments to the Bay-Delta Plan must be consistent with reasonable protection for *all* beneficial uses, and must account for efficient use of the state's water resources in pursuit of reasonable protection.

This proposed approach of requiring that water be left instream to create a more variable flow regime represents a radical shift in California water policy. California's climate provides most of the available water supply in the winter and spring, but little or none in the summer or early fall. There is a mismatch in timing between the availability of supply and need. California's citizens, the Legislature, and state agencies including the State Water Board, long ago recognized this reality. Article X, section 2 of the California Constitution, among other laws, was adopted to support and enable storage of water to support California's development. Congress too has recognized this need in authorizing and funding federal water projects, including the Central Valley Project ("CVP"). Over the last 100 years, billions of dollars have been invested in building, maintaining and operating California's water supply storage infrastructure to alter the timing of flow of water so it can be put to use at the times and places needed. That infrastructure has enabled California's growth, and some 40 million people, diverse industries, and millions of acres of highly productive farmland and managed habitat now depend on the ability to alter the natural flow regime. The proposed Plan amendments would precipitously and materially diminish and impair the ability of California's water infrastructure to meet the needs of its citizens and environment, contradict the assumptions on which massive investments have been made, and harm the beneficial uses that have come to depend on California's water supply infrastructure, at tremendous cost to the State.

Another complication for the proposed Plan amendments, which aim to protect native fish and wildlife with a numeric unimpaired flow objective, is that many factors in addition to the flow regime have changed. One is the presence of major dams on many of California's rivers, dams that are essential to meeting California's water supply needs. The proposed percentage-of-unimpaired-flow approach would also pose significant challenges for operation of California's reservoirs. The timing and volume of flows can be unpredictable. How reservoir operators will be able to adapt operations to new numeric criteria based on unimpaired flow is uncertain and untested[4]. How operators will maintain cold water in storage to provide suitable habitat conditions below dams is uncertain as well. This uncertainty would further undermine the ability of California's water supply infrastructure to meet California's needs. The Draft Staff Report offers no answers to these important questions, and instead proposes that the State Water Board adopt the proposed Plan amendments before seeking answers.

Among other things, before adopting the proposed Plan amendments, the State Water Board must fully understand and consider the consequences for all beneficial uses of declaring that a majority of the water in the Sacramento River, its tributaries, and the eastside Delta tributaries (the Consumnes and Mokelumne Rivers) is unavailable for other uses. As the first sentence of the Draft Staff Report explains, the State Water Board's mission "is to preserve, enhance, and restore the quality of California's water resources and drinking water for the protection of the environment, public health, and all beneficial uses, and to ensure proper water resource allocation and efficient use for the benefit of present and future generations." (Draft Staff Report at p. 1-1.) A fundamental policy underlying the Porter-Cologne Act, which governs water quality planning, is to regulate factors affecting water quality "to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." (Wat. Code, § 13000.)

[4] The Draft Staff Report states that there is currently not any method to "determine required streamflows under the proposed Plan amendments." (Draft Staff Report at p. 5-56.) Historically, estimates of unimpaired flow have been very difficult to quantify and were only intended to provide a rough comparison to historical observed flows. Computing unimpaired flows in real time (e.g., on a daily basis) is unproven for the purpose of regulatory compliance. Difficulties in quantifying unimpaired flows include: limited number of gaging locations, uncertainty regarding snowmelt runoff dynamics, uncertainty about total number of small and medium diversions and return flows in the system, and uncertainty about stream-groundwater interaction. (*Ibid*.) The Draft Staff Report does not suggest that it will be feasible to resolve these uncertainties in the timeframe required for implementation.

Water quality control plans must conform to this policy. (*Id.* at § 13240.) The policy in Water Code section 13000 is reinforced by California's Constitution, which commands that "the water resources of the State be put to beneficial use to the fullest extent of which they are capable" and "with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare." (Cal. Const., art. X, § 2.) CEQA likewise requires the State Water Board to fully understand the environmental consequences of its proposed action, and alternatives and mitigation that may avoid or reduce those impacts, before taking action. Whatever disagreements fair-minded people may have over the correct policy choices, such as what represents reasonable protection for all beneficial uses, California law requires the choices to be made to be well-informed.

The radical change to California water policy proposed via the proposed Plan amendments would have sweeping and damaging consequences for many beneficial uses. Because of those sweeping consequences, the full implications and operation of the proposed Plan amendments must be carefully analyzed and described in order for the State Water Board to make an informed decision consistent with its responsibilities. As described below, the Draft Staff Report's analysis of the proposed Plan amendments is not up to this task and falls significantly short in many respects. Among other things, it defers much of the information and analysis essential to an informed decision on whether to adopt the proposed numeric unimpaired flow objective until *after* its adoption. It is, in essence, a proposal to first declare a majority of the flow unavailable for diversion, and then to figure out later during implementation (or require others to figure out later) the consequences and feasibility of the objective. This approach is fraught with uncertainty and is likely to lead to unanticipated negative impacts to many beneficial users of water.

The approach based on the Voluntary Agreements is a better approach.

IV. Conclusion

The Water Authority and Member Agencies welcome an opportunity to work with the State Water Board to address the comments raised in this letter and the attached detailed comment letter ("Detailed Comment Letter"). The State Water Board's attention to these comments will result in an improved Bay-Delta Plan, a plan that is consistent with the best available science, addresses the multiple sources of impacts to water quality in the Sacramento River watershed, Delta eastside tributaries, interior Delta, and Delta, and ultimately strikes a balance between competing demands for the water involved.

Sincerely,

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Lon Martin, General Manager
San Luis Water District

Anthea Hansen, General Manager
Del Puerto Water District

cc: Members of the State Water Resources Control Board

Attachment 1: Description of Water Authority and Member Agencies
Attachment 2: Detailed Comments on Draft Amendments to the Bay-Delta Plan and Draft Staff Report
Exhibit 1: Buchanan, *et al*. (2021) study
Exhibit 2: Kimmerer and Gross (2022) study

Attachment 1
(Description of Water Authority and Member Agencies)

The Water Authority is a public agency with its principal office located in Los Banos, California. It was formed in 1992 as a joint powers authority and has twenty-seven member agencies. Twenty-five of the Water Authority's member agencies contract with the United States for the delivery of water from the federal "CVP". Most of the Water Authority's member agencies depend upon the CVP as the principal source of water they provide to users within their service areas. That water supply serves approximately 1.2 million acres of agricultural lands within areas of San Joaquin, Stanislaus, Merced, Fresno, Kings, San Benito, and Santa Clara Counties, a portion of the water supply for nearly 2 million people, including in urban areas within Santa Clara County referred to as the "Silicon Valley," and millions of waterfowl that depend upon nearly 200,000 acres of managed wetlands and other critical habitat within the largest contiguous wetland in the western United States. The operations of the CVP are therefore of vital interest and importance to the Water Authority, its member agencies, and the people, farms, businesses, communities, and wildlife refuges they serve. As a result of their functions and responsibilities, the Water Authority and its member agencies have special expertise regarding many of the environmental issues related to the Bay-Delta Plan Update.

Westlands is a California water district formed pursuant to California Water Code sections 34000 *et seq*. Westlands' principal office is in Fresno, California. Westlands' service area is in western Fresno and Kings counties and encompasses approximately 614,000 acres that include some of the most highly productive agricultural lands in the world. Growers in Westlands produce more than 60 high-quality food and fiber crops, including almonds, pistachios, tomatoes, cotton, grapes, melons, wheat, lettuce, and onions. Farms in Westlands produce an average of more than $2 billion worth of food and fiber annually, generating more than twice that in farm-related economic activity, and contribute significantly to nine of the State of California's top fifteen exported agricultural commodities. Westlands provides water primarily for irrigation, but also provides water for some municipal and industrial uses, including for use by disadvantaged communities, and to Naval Air Station Lemoore. To provide water in its service area, Westlands has contracted with the United States Bureau of Reclamation ("Reclamation") to receive water from the CVP. Westlands has contractual entitlements to approximately 1,195,000 acre-feet of CVP water per year. The contractual rights to CVP water that is delivered to areas within Westlands are held by Westlands, as well as two distribution districts formed by Westlands. Due to regulatory restrictions, hydrologic conditions, and Reclamation's operation of the CVP, south-of-Delta CVP agricultural water service and repayment contractors like Westlands in the past 25 years have rarely received a 100 percent allocation of their contractual entitlement to CVP water. Over the last 15 years Westlands' allocations have averaged approximately 36% of full entitlement.

Banta-Carbona Irrigation District ("BCID") provides agricultural irrigation water supplies to farmers growing over a dozen different crops on approximately 17,500 acres in San Joaquin County. Over 60% of the acreage in BCID is devoted to permanent crops. BCID holds pre-1914 and post-1914 appropriative water rights to divert water from the San Joaquin River, downstream of Vernalis in the South Delta. Landowners in BCID generally do not have groundwater wells and rely exclusively on the surface water available from BCID to irrigate their crops.

The Byron Bethany Irrigation District ("BBID") is a multi-county irrigation district created in 1919 to serve irrigation and municipal water to parts of Alameda, Contra Costa, and San Joaquin Counties across fifty-five square miles (36,000 acres). BBID serves nearly 300 agricultural customers and approximately 40,000 residents in the rapidly growing communities of Mountain House and Tracy Hills located near the base of the Altamont.

The San Benito County Water District ("District") is a California Special District formed in 1953 by the San Benito County Water Conservation and Flood Control Act. The District has broad powers for the conservation and management of water (flood, surface, drainage, and groundwater). The district boundary is coterminous with that of San Benito County, with an area of 1,400 square miles and a population of over 63,500 people. The District is the Groundwater Sustainability Agency (GSA) for the county and is responsible to sustainably manage groundwater for the groundwater basin. The District manages local and imported surface water through the San Benito River System and the San Felipe Distribution System. The San Benito River system, through the operation of two reservoirs (Hernandez and Paicines) is used to help recharge the aquifer to support agricultural operations in northern San Benito County. The San Felipe System delivers imported CVP water to irrigation, municipal and industrial customers. The District has a contract with the United States Bureau of Reclamation to receive 43,800 acre-feet of CVP water annually, of which 8,250 acre-feet is for municipal and industrial purposes.

San Luis Water District provides agricultural and domestic water services along the westside of the San Joaquin Valley serving over 300 small farms and 2,000 rural residents. The CVP water supply is the only reliable water supply for these farms and rural communities, groundwater in the western foothills is non-existent. The surface water supply from the CVP is vital, and its continued degradation will have a lasting detrimental impact to the viability of San Joaquin Valley residents.

The Del Puerto Water District is a California special district formed under the provisions of Division 13 of the Water Code of the State of California. The approximately 45,000 acres of irrigable District lands are located along the west side of Stanislaus, San Joaquin and Merced Counties. The District is under contract with the Bureau of Reclamation for its water supply, which provides for the delivery of up to 140,210 acre-feet of water annually, and is the District's primary source of supply. District lands have produced more than 30 different commercial crops over the years. Among the principal crops currently grown are almonds, tomatoes, apricots, walnuts, oats, wheat, barley, grains, broccoli, sweet corn, melons, peaches, citrus, garlic, cherries, wine grapes and olives.

Attachment 2
(Detailed Comments on Draft Amendments to the Bay-Delta Plan and Draft Staff Report)

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Attachment 2
(Detailed Comments on Draft Amendments to the Bay-Delta Plan and Draft Staff Report)

I. The VA Alternative Must Be Selected, Whereas the Proposed Plan Amendments Cannot Lawfully Be Adopted

A. To Comply with CEQA, the State Water Board Must Select the VA Alternative

1. CEQA

The California Environmental Quality Act ("CEQA") (Pub. Resources Code, § 21000 et seq.) requires the State Water Board to adopt the VA alternative because it is the only alternative that achieves the purpose of the proposed Sacramento/Delta update to the Bay-Delta Plan ("Project")[5], is feasible, and will avoid significant adverse environmental impacts associated with the proposed Plan amendments.[6] In contrast, the proposed Plan amendments fail to meet the purpose of the Project, are not feasible, and the Draft Staff Report's analysis of the proposed Plan Amendments fails to comply with CEQA's substantive provisions.

The State Water Board's certified regulatory program is exempt from certain provisions of CEQA under Public Resources Code section 21080.5(c), but this is not a blanket CEQA exemption. (*Pesticide Action Network North America v. Department of Pesticide Regulation* (2017) 16 Cal.App.5th 224, 239, 241-242 ("*Pesticide Action Network*").) An agency operating under a certified regulatory program remains subject to most of CEQA's provisions, including CEQA's broad policy goals and substantive standards. (*Ibid.*; *POET, LLC v. California Air Resources Board* (2013) 218 Cal.App.4th 681, 710 ("*POET*").) Because CEQA's broad policy goals apply, the State Water Board's Draft Staff Report must include the same types of essential environmental information as an environmental impact report ("EIR"). (*Pesticide Action Network, supra*, 16 Cal.App.5th at p. 247.)

Essential information includes an accurate and complete project description, analysis of the project's reasonably foreseeable direct and indirect environmental consequences, mitigation measures and alternatives to avoid or substantially lessen significant environmental impacts, and evaluation of cumulative impacts. (*Ibid.*) In short, the Draft Staff Report must provide agencies and the public with the functional equivalent of the information required in an EIR. (Pub. Resources Code, §§ 21002, 21080.5; CEQA Guidelines, §§ 15250, 15251(g).) The Draft Staff Report's analysis regarding the proposed Plan amendments runs afoul of CEQA's substantive

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[5] The "Project" is more particularly described as proposed "updates to the Bay-Delta Plan focused on the reasonable protection of fish and wildlife in the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne Rivers), and Delta (referred to as the *Sacramento/Delta watershed*). This effort is referred to as the *Sacramento/Delta update to the Bay-Delta Plan*." (Draft Staff Report at p. 1-2.)

[6] The "proposed Plan Amendments" have the same meaning as defined as in the Draft Staff Report and, among other things, would require 55 percent unimpaired flow, with an adaptive range of 45 to 65 percent and would include a new cold water habitat objective for the Sacramento/Delta tributaries. (Draft Staff Report at pp. 1-2 – 1-3, 5-1, 5-9, 5-22.)

provisions, and the proposed Plan amendments cannot be adopted due to this failure to satisfy all applicable CEQA requirements. (*John R. Lawson Rock & Oil, Inc. v. California Air Resources Board* (2018) 20 Cal.App.5th 77, 100.)

Additionally, a fundamental purpose of CEQA is to "prevent significant avoidable damage to the environment by *requiring* changes in projects through the use of alternatives or mitigation measures when the government agency finds the changes to be feasible." (CEQA Guidelines, § 15002(a)(3) (emphasis added); Pub. Resources Code, § 21080.5(d)(2)(A) [same regarding certified regulatory programs]; *POET, supra*, 218 Cal.App.4th at p. 735.) The proposed Plan amendments would result in significant damage to the environment that cannot be mitigated. By rejecting the proposed Plan amendments and instead selecting the VA alternative, which better satisfies the Project purpose, the State Water Board will avoid these significant environmental impacts.

2. The VA Alternative Meets the Project Objectives and Is the Only Alternative Reasonably Calculated to Achieve the Salmon Doubling Objective

The signatories to the "Memorandum of Understanding Advancing a Term Sheet for the Voluntary Agreements to Update and Implement the Bay-Delta Water Quality Control Plan, and Other Related Actions" ("MOU") ("VA Parties") "submitted the VAs as a proposed alternative for updating the Bay-Delta Plan to achieve reasonable protection of fish and wildlife beneficial uses in the tributaries covered by the VAs (VA tributaries)." (Draft Staff Report at p. 1-3.) Fundamentally, the VA alternative is designed "to contribute to achieving the existing Narrative Salmon Protection Objective by 2050," also referred to as the "Salmon Doubling Objective." The Salmon Doubling Objective is "the doubled (average) natural production from the population size" of chinook salmon "calculated for 1967 to 1991. Natural production is defined as the portion of production that is not produced in hatcheries." (Draft Staff Report, Appendix G2 at p. 5-4 [the "Draft Supplement Report"[7]]; Draft Staff Report at p. 9-7.)[8]

The VAs will coordinate flow and non-flow actions, over an initial eight-year term, to provide the participating parties' share to achieve the Salmon Doubling Objective by 2050. (Draft Staff Report at p. 9-7; *id.* at p. 9-190 ["[T]he VAs propose flow assets and habitat restoration measures in the Sacramento/Delta for an 8-year period that are intended to provide for reasonable protection of fish and wildlife beneficial uses in the Sacramento/Delta"].) The VA Parties intend

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[7] Consistent with the Draft Staff Report, Appendix G2 of the Draft Staff Report, the "Final Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan" is defined as the "Draft Supplement Report." (Draft Staff Report, Appendix G2 at p. ES-1.)

[8] "The existing Narrative Salmon Protection Objective (also referred to as the salmon doubling objective) states: 'Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of chinook salmon from the average production of 1967- 1991, consistent with the provisions of State and federal law.'" (Draft Staff Report at p. 9-7.)

to extend the initial eight-year term. (Draft Staff Report at p. 1-3.) If the VAs are substantially achieving the Bay/Delta Plan objectives, the VA Parties propose that the VAs "would continue without any substantial modification in terms or, if the VAs are expected to achieve the stated objectives with some modifications, the VAs could continue implementation with substantive modifications in terms." (Draft Staff Report at p. 9-6.) The VA alternative's success in achieving the Project objectives would be determined based upon the best available, objective data from the VA Science Program and recommendations from the VA Governance Committee and the Delta Independent Science Board. (*Ibid*.; see also *id*. at pp. 9-190 ["The proposed VAs include a monitoring and evaluation program to inform adaptive management of flows and future changes to the Plan" to ensure Project goals are met.], 9-198 [Over $120 million devoted to the VA alternative's science and adaptive management programs].) In sum, the VA alternative contains a robust science program, guided by principles of adaptive management, which will enable the VA alternative to achieve Project goals over the initial term and beyond.

The VA alternative also will achieve reasonable protection of native species through its "proposed Narrative Viability Objective," (the "New Narrative Objective") which states:

> *Maintain water quality conditions, including flow conditions in and from tributaries and into the Delta, together with other measures in the watershed, sufficient to support and maintain the natural production of viable native fish populations. Conditions and measures that reasonably contribute toward maintaining viable native fish populations include, but may not be limited to, (1) flows that support native fish species, including the relative magnitude, duration, timing, temperature, and spatial extent of flows, and (2) conditions within water bodies that enhance spawning, rearing, growth, and migration in order to contribute to improved viability. Indicators of viability include population abundance, spatial extent, distribution, structure, genetic and life history diversity, and productivity. Flows provided to meet this objective shall be managed in a manner to avoid causing significant adverse impacts to fish and wildlife beneficial uses at other times of the year*.

(Draft Staff Report at p. 9-7.)

Qualitatively, this proposed objective provides reasonable protection through (1) specific "flows that support native fish species"; (2) "conditions within water bodies that enhance spawning, rearing, growth, and migration in order to contribute to improved viability. Indicators of viability include population abundance, spatial extent, distribution, structure, genetic and life history diversity, and productivity"; and (3) the need to manage flows to "avoid causing significant adverse impacts to fish and wildlife beneficial uses at other times of the year," such as adverse temperature impacts associated with reservoir operations. (Draft Staff Report at p. 9-7; see also *id*. at p. 9-190 ["Overall, the proposed VAs are intended to provide improved tributary and in-Delta habitat conditions, improved migratory conditions, and increased floodplain inundation, which would promote habitat conditions that favor native fishes over nonnative fishes"].)

Quantitatively, the VAs will provide reasonable protection of native fish species through the "specific flow and non-flow habitat restoration actions in the tributaries, flood bypasses, and Delta outlined in the VAs." (Draft Staff Report at p. 9-190.) The VA alternative defines the "flow and non-flow habitat restoration measures," designed to provide improved habitat conditions as "VA assets." (Draft Staff Report at p. 9-6.) Table 9.3.1 of the Draft Staff Report lists the proposed VA assets as modeled in the Draft Staff Report, which illustrates the additive flows the VAs would contribute[9] and the number of acres of habitat restoration for spawning, instream rearing, and floodplain habitat. (Draft Staff Report at pp. 9-4 & 9-5; see also *id*. at p. 9-8 [Table 9.3-2. Summary of VA Tributary Habitat Restoration Commitments by Habitat Type and Watershed].) As extensively documented in the Draft Supplement Report, the VA alternative's flow and non-flow assets target recovery and are carefully designed to achieve reasonable protection of native fish species.

The VA alternative also has the advantage of transparency: The VA flow assets and non-flow activities are clearly disclosed to the public and will be evaluated using the best available science. These core features of accountability and rigorous, continuous study will ensure that VA flow and non-flow assets continue to provide reasonable protection and maximize beneficial uses of the Sacramento-Delta's scarce water resources, thereby promoting recovery of native fish species while minimizing environmental impacts to the greatest degree feasible. As such, the VA alternative is the environmentally superior alternative under CEQA. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(a) The Draft Staff Report's Description of the Proposed Plan Amendments Violates CEQA Because the Description Is Incomplete

In contrast to the VA alternative, the Draft Staff Report's discussion of the proposed Plan amendments fails to disclose integral components unique to the proposed Plan amendments. Under CEQA, a regulatory plan designed to improve environmental conditions must include objective performance criteria by which to measure success.[10] (*POET, supra*, 218 Cal.App.4th at pp. 739-740.) The Draft Staff Report's analysis of the proposed Plan amendments violates CEQA because it omits essential information necessary to evaluate whether implementation of the proposed Plan amendments can achieve fish and wildlife benefits. These omitted components, which are only essential to the proposed Plan amendments and are *not* part of the VA Alternative, include: (1) an adequate description of proposed temperature control and reservoir management provisions and performance standards and (2) flow shifting / shaping criteria and performance standards. These protocols and principles governing flow patterns are key considerations in deciding whether and how to implement the proposed Plan amendments, not mere design or engineering details or flexible operational components that are suited for ad hoc formulation.

The proposed Plan amendments' omitted essential project components are all premised on adaptive implementation. Under CEQA, however, an adaptive plan designed to change in response to future events or studies must identify the type of actions that may be taken and *criteria* for their implementation. (*Preserve Wild Santee v. City of Santee* (2012) 210 Cal.App.4th 260, 281 [post-

[9] The VA flows assets would be "additive to the 2019 BiOps condition." (Draft Staff Report at p. 9-13.)

[10] Unlike the proposed Plan amendments, the VA Science Program contains objective performance criteria/standards to both measure and ensure the VA alternative's success in providing reasonable protection to native fish species. (Detailed Comment Letter at pp. 36-37.)

approval formulation of active habitat management plan invalid because EIR did not describe expected management actions or include management standards].) To properly frame the proposed Plan amendments' omitted project components for adaptive implementation, the State Water Board must develop a detailed management plan and associated experimental design for monitoring their ability to achieve the stated objectives for the Bay-Delta Plan Updates. (See *POET, supra*, 218 Cal.App.4th at p. 740 [agency implementing a certified regulatory program must specify "what tests will be performed and what measurements will be taken" to demonstrate progress toward achieving stated objectives].) Such actions cannot be deferred, as the State Water Board has impermissibly done for the proposed Plan amendments.

(i) Temperature Control/Reservoir Management Criteria

The Draft Staff Report's description of the proposed Plan amendments' Cold Water Habitat Objective violates CEQA because it omits a fundamental component – temperature control / reservoir management criteria necessary to evaluate and determine the objective's success. The Draft Staff Report proposes to allow implementation of the Cold Water Habitat Objective without *any* specific temperature control and reservoir management provisions or performance standards.

"The narrative cold water habitat objective is proposed to apply throughout the watershed, including upstream tributaries and distributaries, on all the Sacramento/Delta tributaries that support or contribute to the protection of native cold water fish species." (Draft Staff Report at p. 5-23.) The stated purpose of the Cold Water Habitat Objective is "to ensure that there are no redirected impacts on cold water habitat from the new inflow and Delta outflow objectives and to address other existing and potential future temperature management concerns on the tributaries for salmonids and other native species." (Draft Staff Report at pp. 7.1-8, 5-22.)

The proposed Plan amendments' description calls for "[c]old water habitat provisions that would require reservoirs to be operated in a manner that provides needed cold water habitat for salmonids or other measures to provide cold water habitat." (*Id.* at p. 7.1-1.) The proposed measures include "management of cold water storage and releases or alternate protective measures (including measures to install and operate temperature control devices, measures to provide for passage above dams, *and other measures*[11])." (*Id.* at 7.1-8.) The project description cautions, however, that the appropriateness of temperature requirements depends "on the species of salmonid, the life stage, and other factors" that affect "the specific circumstances of each tributary." (*Id.* at 7.1-8.) The Draft Staff Report therefore recognizes that for temperature requirements to work, they must be carefully tailored in response to highly specific biological and physical factors. This high degree of specificity underscores the essential nature of detailed temperature control and reservoir management criteria — which the Draft Staff Report failed to provide. For each tributary subject to the Cold Water Habitat Objective, the State Water Board must develop criteria based on the species of salmonid, the life stage, and all other material factors relevant to the proposed temperature requirements.

[11] "[A]nd other measures" highlights the Cold Water Habitat Objective's ambiguity and lack of specificity. The objective's project description fails to adequately disclose the full range of temperature control and reservoir management operations the State Water Board may decide to take.

The Draft Staff Report provides that "[a]s described further in the program of implementation, the owners and operators of rim reservoirs would be responsible for undertaking actions to comply with the [Cold Water Habitat Objective] through voluntary or default processes." (*Id*. at p. 5-22.) The Draft Staff Report also fails to describe any management criteria or performance standards that would guide implementation activities under the Cold Water Habitat Objective. Instead, the description envisions an ad hoc implementation process.

In the first step in the implementation process, "all rim reservoir owners/operators on the Sacramento/Delta tributaries, in coordination with the State Water Board and fisheries agencies, would be required to conduct an assessment of the effectiveness of cold water habitat protection measures on their tributaries and needed improvements to those measures for the purpose of complying with the cold water habitat objective. Based on that assessment, reservoir owners/operators would be required to develop a long-term strategy for implementing feasible measures to improve the protection of cold water habitat, in coordination with State Water Board and fisheries agency staff and other appropriate entities as necessary." (*Id*. at p. 5-23.) The problem with this process, however, is that without objective performance standards, it is impossible to effectively and meaningfully evaluate the effectiveness of proposed cold water habitat protection measures. If those performance standards are not disclosed as part of the Plan amendments' description, then agencies and members of the public are deprived of essential information necessary to evaluating the Cold Water Habitat Objective and its environmental impacts.

The annual strategies intended to implement the Cold Water Habitat Objective "would be required to evaluate measures that can be taken to improve temperature management in both the short term and long term and to identify the feasibility and suitability of those measures." (*Id*. at p. 5-24.) "Temperature control measures that should be evaluated include installation and improvements in TCDs [temperature control devices], cold water bypasses, passage, riparian reforestation, operational changes" and other relevant improvements identified by staff. (*Ibid*.) But once again, the Draft Staff Report fails to provide any performance standards necessary to evaluate these temperature control management measures. Additionally, the Draft Staff Report's references to undefined "operational changes" and additional improvements identified by staff are ambiguous and must be expanded upon to adequately inform the public pursuant to CEQA. If the proposed Plan amendments are the proposed alternative, then the State Water Board must revise the Draft Staff Report to include performance criteria to evaluate each of the temperature control management measures identified above.

Finally, the lack of performance criteria infects the proposed Plan amendments' description regarding annual operations plans under the Cold Water Habitat Objective. The proposed Plan amendments' description states, "Required elements of the annual operations plans would include provisions for reservoir carryover storage levels; minimum and maximum flow releases and ramping rates to provide appropriate temperature protection, preserve cold water supplies, and avoid stranding and dewatering concerns; reservoir TCD operations; adaptive management; and other relevant provisions, as well as the technical basis for those provisions." (*Id*. at p. 5-24.) But once again, these components of the proposed Plan amendments are ambiguous in terms of how they are defined, how they would be implemented and evaluated, and what their environmental impacts would be. Here, the Draft Staff Report's failure to disclose this essential information about the proposed Plan amendments stems in crucial part from the lack of performance standards /

criteria regarding (1) carryover storage levels; (2) reservoir refill requirements and operations[12]; (3) minimum and maximum flow releases and ramping rates; (4) temperature control operations; (5) adaptive management criteria and their respective abilities to achieve (a) "appropriate temperature protection;" (b) preserve cold water supplies; and (c) avoid stranding and dewatering concerns. If the proposed Plan amendments are the proposed alternative, then the State Water Board must revise the Draft Staff Report to include specific performance criteria to evaluate each of these annual operations elements and their goals.

The Draft Staff Report assumes that the proposed Plan amendments' Cold Water Habitat Objective will result in long-term environmental benefits without identifying any protocols or principles to govern possible temperature control and reservoir management activities, or any standards or criteria by which to measure whether and to what degree any environmental benefits occur on the various tributaries.

(ii) Flow Shifting/Shaping Criteria

The Draft Staff Report discloses that in implementing the proposed Plan amendments, the State Water Board would utilize "the flexibility provided in the flow objectives," including the "shaping and shifting of flows." (Draft Staff Report at p. 7.6.2-104; see also *id.* at p. 3-101 ["Adaptive management provisions, including any necessary sculpting of that flow, would provide specific functional flows to improve fish and wildlife protection"]; *id.*, Appendix B at p. 1-11 ["Sculpting and shaping of flows is provided in recognition that rainfall and snowmelt patterns have changed and will continue to change, as has the physical environment, and that consideration of and adaptation to these changes are needed to protect native fish and wildlife"].) The 2017 Scientific Basis Report, Appendix B of the Draft Staff Report, further provides that "[w]ith increasing climate change, it is expected that further sculpting and shaping of flows would be needed. New and existing tools could be used for shaping the flows based on the availability of information for a watershed (e.g., specific instream flow studies, presence of reservoirs)." (*Id.*, Appendix B, at p. 1-16.) Consistent with the 2017 Scientific Basis Report, the Draft Staff Report provides:

> [A]s discussed further in Chapters 1, Executive Summary, and 5, Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta, regulatory requirements based on unimpaired flows acknowledge that *native species now inhabit an altered landscape and that adaptive management is needed to allow for sculpting and shaping of those flows to address the realities of that modified landscape.* Adaptive management of unimpaired flows can also address changes to the landscape over time due to climate change, habitat restoration, and other factors.

(*Id.* at p. 2-4 (emphasis added).)

Accordingly, the Draft Staff Report portrays flow shaping, shifting, and sculpting as a key component of the proposed Plan amendments designed in response to the Sacramento/Delta's

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[12] If the State Water Board does not develop reservoir refill criteria as part of its temperature control and reservoir management components of the proposed Plan amendments, then it must separately develop and disclose reservoir refill criteria.

highly altered landscape and the effects of climate change. The Draft Staff Report fails to disclose the proposed Plan amendments' proposed flow shifting/shaping provisions, however, and omits any shaping/shifting criteria in its description.

As demonstrated, under CEQA, an adaptive plan designed to change in response to future events or studies must identify the type of actions that may be taken and criteria for their implementation. (*Preserve Wild Santee v. City of Santee* (2012) 210 Cal.App.4th 260, 281; *POET, supra*, 218 Cal.App.4th at p. 740.) If the proposed Plan amendments are the State Water Board's proposed alternative, then the State Water Board must revise the Draft Staff Report to disclose the type of actions it would take to shift and shape flows in an attempt to provide reasonable protection to fish species, and identify objective performance criteria for their implementation and evaluation. In contrast, the VA Alternative *already* has objective performance criteria/standards to both measure and ensure the VA alternative's success in providing reasonable protection to native fish species. (Detailed Comment Letter at pp. 36-37.) As with the other reasons discussed throughout this letter, this makes the VA Alternative superior to the proposed Plan amendments and further shows how the VA Alternative is CEQA compliant.

3. The Proposed Plan Amendments Fail to Meet the Project Purpose

(a) Non-Flow Measures Are Essential

The Sacramento/Delta is a highly altered ecosystem. (Draft Staff Report at p. 2-4.) "For over 150 years, humans have altered the Sacramento River and its tributaries to reclaim wetlands, and provide irrigation during the dry months," among other uses. (*Ibid*.) While the "Delta is about 738,000 acres," all but 48,000 of those acres are now "agricultural or urban, reflecting an almost complete loss of wetland habitats since California became a state." (*Id*. at p. 1-8.) "Dams and other physical modifications . . . block access to habitats and alter temperatures and other conditions important to aquatic species." (*Id*. at pp. 2-1 – 2.2.)

The Draft Staff Report recognizes the adverse effects of physical habitat loss and modification on native fish species. For example, the Sacramento perch and thicktail chub have been extirpated "primarily due to a loss of suitable habitat." (Draft Staff Report at p. 1-9.) The Draft Staff Report further acknowledges that habitat restoration is likely to play a crucial role in shifting the abundance and distributions of native species throughout the Bay-Delta estuary. (*Ibid*.) In such a highly altered ecosystem that does not resemble historic conditions, flow alone is insufficient to provide reasonable protection to fish species. Indeed, the Draft Staff Report even admits so: "[P]opulations of native aquatic species in the Bay-Delta watershed have shown significant signs of decline due to a combination of factors, including hydrologic modifications, *non-flow physical habitat degradation*, water quality impairments, and climate change. Scientific information indicates that restorations of flows and the functions that flow provides *in an integrated fashion with physical habitat improvements* is needed to address the declines." (*Ibid*. (emphasis added).) Flow-based requirements alone are insufficient to provide reasonable protection of native fish species. An approach that mandates integrated flow and non-flow measures – like the VA alternative – must be adopted.

(b) The Proposed Plan Amendments Cannot Be Adopted Because They Fail to Incorporate Integral Scientific Findings Regarding Necessary Non-Flow Actions

The State Water Board's proposed Plan amendments are predominately a flow-based approach. (E.g., Draft Staff Report at p. 5-3 ["The proposed objectives include new inflow and cold water habitat objectives[13] for the Sacramento/Delta tributaries, new and modified Delta outflow objectives, modified Suisun Marsh objectives, and new and modified interior Delta flow objectives."].) All of the "modular" alternatives also are entirely flow-based, with the exception of the "Head of Old River Barrier Alternative," which would involve installing a physical barrier to prevent entrainment. (*Id*. at pp. 7.2-9 – 7.2-13.)

The Draft Staff Report claims the proposed Plan amendments are "based on the science discussed" in the Draft Staff Report and the Scientific Basis Report. But as extensively documented in Chapters 3, 4, and 5 of the Draft Staff Report, "[t]he State Water Board recognizes that ecosystem recovery in the Delta depends on more than just adequate flows." (Draft Staff Report at p. 4-1; *id*. at pp. 3-1, 3-134, 5-7, 5-41.) The Draft Staff Report accepts that "[m]any stressors other than flow can affect ecosystem processes." (Draft Staff Report at p. 3-1.) It further acknowledges that the "Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta, fish and wildlife protection *cannot be achieved solely through flow*— habitat restoration and stressor reduction also are needed. The dynamic nature of flow interacts with the physical environment to produce aquatic habitats suitable for native fish and wildlife. The function and ability of ecosystems to support these species can be reduced by stressors. *One cannot substitute one for another; flow improvements, stressor reduction, and habitat restoration are all essential for protecting fish and wildlife resources*. Suitable flows are a critical element of protection and restoration and are the subject of this chapter." (Draft Staff Report at p. 3-1 (emphasis added).) "*Recovery of native species would require both habitat restoration and increased flow in Central Valley tributaries and the Delta. Successful recovery of native species is not possible without parallel investment in both efforts*." (*Id*. at p. 3-134 (emphasis added).) The Draft Staff Report's analysis regarding the essential nature of habitat restoration and other non-flow measures raises three crucial points.

First, the purpose of the proposed Bay-Delta Plan Update "cannot be achieved solely through flow." (Draft Staff Report at p. 3-1; *id*. at p. 4-1 ["The State Water Board recognizes that ecosystem recovery in the Delta depends on more than just adequate flows. Many scientific studies have identified the involvement of other aquatic ecosystem stressors, such as reduced habitat, pollutants, nonnative invasive and predatory species, and abiotic factors, as contributing factors in

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[13] The purpose of the cold water habitat objective is to require "carryover storage in rim reservoirs . . . needed for cold water habitat." (Draft Staff Report at p. 7.2-8; *id*. at p. 1-3.) It therefore regulates reservoir operators' release of flows for beneficial uses and is inextricably tied to flows. (E.g., Draft Staff Report at p. 7.12.1-66 ["To meet the instream flow and cold water habitat (storage) requirements, diversions would need to be reduced from both storage and streams, allowing retention of more water in storage for cold water habitat protection, which could reduce flows on some tributaries at times. In particular, summer and early-fall flows would be reduced to some extent for CVP/SWP tributaries such as the Sacramento, Feather, and American Rivers, where, under baseline conditions, substantial storage releases to downstream diversions create artificially high summer and early fall flows."].)

species declines"].) Habitat restoration and stressor reduction, in combination with flow, are also needed. (*Id*. at pp. 3-1, 5-3 "Protection of the Bay-Delta ecosystem and its native aquatic species requires an integrated approach" that links flows with "habitat restoration and other complementary ecosystem measures"].) A flow-only approach is demonstrated to be insufficient and is virtually certain to fail.

Second, neither the proposed Plan amendments nor the other unimpaired flow alternatives *require* habitat restoration and stressor reduction to the necessary degree. Habitat includes all the physical, chemical, and biological attributes that affect or sustain the organisms within an ecosystem. There is no dispute that flow is "a major determinant of physical habitat" in aquatic ecosystems like the Sacramento/Delta. (Draft Staff Report at p. 3-2.) In a highly altered ecosystem like the Sacramento/Delta, however, more than flow alone is required to maintain and establish suitable habitat for native fish species. (E.g., *Id*. at p.4-1 ["The benefits of flows are enhanced when implemented in concert with habitat restoration, control of waste discharges, control of invasive species, fisheries management, and other efforts. A multifaceted approach is needed to address Delta concerns and reconcile an altered ecosystem"].) While the proposed Plan amendments aspire to an integrated multi-dimensional approach, they only mandate flows.

Chapters 4 (Other Aquatic Ecosystem Stressors), 5 (Proposed Changes to the Bay-Delta Plan), and 7.21 (Impacts analysis of Habitat Restoration and Other Ecosystem Projects) document the non-flow actions that must be taken in combination with increased flows to protect native fish species. But the State Water Board submits that these non-flow actions are "beyond what the State Water Board can require," and that "[m]any of those actions are within the purview of other agencies and entities." (Draft Staff Report at pp. 4-1 - 4.2.) The State Water Board only *recommends* other entities take such actions and offers to "help to facilitate those efforts in a coordinated fashion." (*Ibid*; see also Draft Staff Report at pp. 5-41, 5-9 [The proposed Plan amendments only provide "recommendations to other agencies and parties" to undertake habitat restoration and other complementary ecosystem measures]; see *id*. 7.21-1 ["The proposed program of implementation identifies actions that other entities *should* take to address other ecosystem stressors and provides a framework to incorporate both flow and complementary ecosystem projects such as physical habitat restoration into voluntary implementation plans." (emphasis added)].)

The legal and practical differences between mere recommendations and binding requirements cannot be understated, yet the Draft Staff Report glosses over this crucial distinction when it comes to the proposed Plan amendments. (E.g., Draft Staff Report at p. 5-3 [Non-flow measures under the proposed Plan amendments "*may be implemented*," a manifestly inadequate assurance (emphasis added)].) The proposed Plan amendments are plagued by a material enforcement gap, which results in no guarantees that *necessary* non-flow measures actually will be implemented. Contrary to the Draft Staff Report's assertion, the proposed Plan amendments do not succeed in "linking and integrating tributary inflow, cold water habitat, Delta outflow, and interior Delta flow measures with physical habitat restoration and other complementary ecosystem measures." (*Id*. at p. 5-3.) Neither the proposed Plan amendments nor its variations (i.e., the "Low Flow Alternative" and the "High Flow Alternative") can realize the State Water Board's fundamental goal of reasonable protection of native fish species.

Third, "[s]uccessful recovery of native species is not possible without parallel investment in both" flow and non-flow efforts. (Draft Staff Report at p. 3-134.) The VA alternative represents an unprecedented "parallel investment" in essential flow and non-flow measures. Indeed, "Appendix 3 of the VA Term Sheet identifies that the total cost for implementing the proposed VAs is $2,589 million" (i.e., $2.589 *billion*). (Draft Staff Report at p. 9-198.) This sum is only for the VA Agreements' first eight-year term and represents a fraction of the total funding that would be available to achieve the VA's New Narrative Objective by 2050. The categories of these costs include habitat construction, voluntary fallowing, water purchases, and water development costs, and a science and adaptive management program. (*Ibid.*) This is a watershed-scale approach and the best opportunity for substantial investment that will provide reasonable protection for native fish species. The primary funding sources are all well-funded public entities, such as the State of California, the United States, and public water agencies, which creates stability and reliability. (*Ibid.*) The VA alternative therefore best satisfies the scientific recommendations the State Water Board seeks to follow and best satisfies its fundamental goals.

The Draft Staff Report acknowledges that reasonable protection of native fish species in the Sacramento/Delta requires "both habitat restoration and increased flow. Successful recovery of native species is not possible without parallel investment in both efforts." (Draft Staff Report at p. 3-134; *id.* at p. 3-1 ["One cannot substitute one for another; flow improvements, stressor reduction, and habitat restoration are all essential for protecting fish and wildlife resources"].) The Draft Staff Report even declares that the "Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta, fish and wildlife protection *cannot be achieved solely through flow*—habitat restoration and stressor reduction also are needed." (*Id.* at p. 3-1 (emphasis added).)

Despite the Draft Staff Report's clear calls for non-flow measures, the narrative submits that these non-flow actions are "beyond what the State Water Board can require," and that "[m]any of those actions are within the purview of other agencies and entities." (Draft Staff Report at pp. 4-1 - 4.2.) In the Draft Staff Report, the limits of the State Water Board's authority are greatly exaggerated and the Board's obligations to pursue *coordinated* control of all factors affecting water quality are largely ignored in order to favor a flow-only regulatory approach. In contrast, the VA alternative provides the essential non-flow measures the proposed Plan amendments lack. As demonstrated above, the VA alternative would provide reasonable protection to native fish species through integrated flow improvements, stressor reduction, and habitat restoration.[14] The VA

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[14] The VA alternative is a comprehensive and integrated approach to achieving reasonable protection of native fish species by targeting recovery and eliminating obstacles to implementation of non-flow measures, which the California Natural Resources Agency describes as follows:

> The approach -- sometimes referred to as the "Voluntary Agreements" because parties came together to propose it, is a comprehensive, multi-year solution that brings together dozens of water agencies with the state and federal governments to pool resources and take concrete actions to provide targeted river flows and expand habitat in the Sacramento and San Joaquin Rivers and Bay Delta. These environmental improvements are guided by scientific monitoring and collaborative decision making.
>
> This new approach will also allow water managers to adapt operations based on real-time conditions and enable broad coordination across watersheds to manage flows for maximal

alternative bridges the enforcement gap left by the proposed Plan amendments by *requiring* a combination of flow and non-flow measures based on the best available science.

The VA alternative is feasible because the State Water Board has the authority to enter into binding, enforceable agreements with the VA Parties that will achieve the State Water Board's fundamental purpose, provide greater benefits to native fish species, and avoid or substantially reduce the proposed Plan amendments' impacts. The State Water Board must therefore select the environmentally superior VA alternative. (CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

4. Although Underestimated in the Draft Staff Report, the Proposed Plan Amendments' Adverse Environmental Impacts Greatly Exceed Those Associated with the VA Alternative

A fundamental purpose of CEQA is to "prevent significant avoidable damage to the environment by *requiring* changes in projects through the use of alternatives or mitigation measures when the government agency finds the changes to be feasible." (CEQA Guidelines, § 15002(a)(3); Draft Staff Report at pp. 1-13. 7.1-3 (emphasis added).) The Draft Staff Report provides that the VA regulatory pathway is largely consistent with the proposed Plan amendments in terms of core project features:

> The VAs propose flow assets and habitat restoration measures in the Sacramento/Delta for an 8-year term. The proposed VAs identify that there will be a regulatory implementation pathway that would exist in parallel with the VA implementation pathway. The staff-proposed regulatory pathway under the VA alternative would apply to non-VA parties and could apply to VA parties in the event the VAs are discontinued. The proposed [VA] regulatory pathway is largely consistent with the proposed Plan amendments, except that instead of being amended into the water quality objectives, the inflow, inflow-based Delta outflow, and cold water habitat provisions of the proposed Plan amendments would be included in the program of implementation and could become applicable in the future if the VAs are not continued.

(Draft Staff Report at p. 7.1-2.)

> benefits. This more flexible, adaptive management is critical as climate change increases uncertainty and drives extreme conditions.
>
> The agreements, if approved by the State Water Board as an implementation pathway for an updated Bay-Delta Plan, could help state agencies meet requirements to protect beneficial uses in the Sacramento and San Joaquin watersheds. Through this approach, California would dedicate a large quantity of water to the environment and restore 45,000 acres of aquatic habitat for fish and other animals. The agreements provide a promising pathway to protect and restore our environment, enable California's economy to thrive, and provide a foundation for a more resilient future.

(https://resources.ca.gov/Initiatives/Voluntary-Agreements-Page.)

Additionally, as documented in the Draft Supplement Report, the VA alternative's integrated flow and non-flow measures are reasonably expected to increase native fish species' population abundance consistent with achieving the Salmon Doubling Objective by 2050. (Draft Staff Report, Appendix G2 at p. 7-1.) Indeed, the VAs provide *greater* fish benefits than the proposed Plan amendments' one-dimensional, flow-based approach, and the severe, unmitigable impacts associated with the proposed Plan amendments require the State Water Board to select and implement the feasible, environmentally superior VA alternative. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

An unimpaired flow-only approach will lead to significant damage to the environment; to biological resources; surface water resources; groundwater resources; conversion of prime agricultural farmland; cumulative impacts; and impacts attributed to proposed mitigation measures, among other impacts. These significant environmental impacts are avoidable by adopting the proposed VA alternative, which integrates flow and non-flow measures and thereby adequately coordinates control of all factors necessary to provide reasonable protection to fish and wildlife beneficial uses. Based upon the evidence contained in the Draft Staff Report, the best available science, and reasonably foreseeable water supply and other environmental impacts, CEQA requires the State Water Board to select the feasible and environmentally superior VA alternative.

(a) Implementing the Proposed Plan Amendments' Flow-Only Approach Would Have Significant Adverse Impacts on Aquatic and Terrestrial Biological Resources

(i) The Draft Staff Report's Analysis of the Proposed Plan Amendments Violates CEQA by Failing to Analyze and Disclose Their Significant Adverse Impacts on Aquatic Biological Resources

CEQA requires a lead agency to first provide a detailed statement setting forth all of the proposed project's significant effects on the environment *before* analyzing mitigation measures proposed to avoid or substantially lessen those significant effects. (CEQA Guidelines, §§ 21061, 21100(b)(1) & (3), 21002.1(a) ["The purpose of an environmental impact report is to identify the significant effects on the environment of a project, to identify alternatives to the project, and to indicate the manner in which those significant effects can be mitigated or avoided."]; *Friends of Sierra Madre v. City of Sierra Madre* (2001) 25 Cal.4th 163, 183.) The Draft Staff Report's analysis of the proposed Plan amendments violates CEQA because their temperature control and reservoir management provisions are mitigation measures rather than design features. (Draft Staff Report at p. 7.1-8.) Incorporating proposed mitigation measures as elements of the proposed action, as the State Water Board has done here with the proposed Plan Amendments, precludes meaningful evaluation of the proposed activity's impacts and violates CEQA. (*Lotus v. Department of Transportation* (2014) 223 Cal.App.4th 645, 656-58 ("*Lotus*").) The Draft Staff Report violates CEQA by analyzing environmental impacts attributed to the proposed Plan amendments *while applying* its Temperature Control and Reservoir Management Mitigation Measure.

The Draft Staff Report expressly provides that the proposed Plan amendments' Cold Water Habitat Objective is both a Project Component and a mitigation measure. (Draft Staff Report at pp. 5-9 [project component], 7.6.2-103 [mitigation measure].) Indeed, the first component of Mitigation Measure MM-AQUA-a,d to "[m]itigate impacts on aquatic special-status species and wildlife movement or wildlife nurseries" instructs the State Water Board to "Implement Cold Water Habitat Objective." (*Id.* at p. 7.6.2-103; *id.* at p. 7.6.2-95 ["Implementation of Mitigation Measures MM-AQUA-a,d: 1 through 3 will avoid or reduce temperature impacts from the proposed Plan amendments. Specifically, implementation of the proposed cold water habitat objective would reduce or avoid temperature impacts on special-status species in the Sacramento/Delta."].)

It is immaterial, however, whether the Draft Staff Report labels mitigation of the proposed Plan amendments' impacts through the Cold Water Habitat Objective as a "mitigation measure" and/or a "project component." "In the case of the adoption of a plan, policy, regulation, or other public project, mitigation measures can be incorporated into the plan, policy, regulation, or project design." (CEQA Guidelines, § 15126.4 (a)(2).) But such incorporation does not change CEQA's substantive requirements that govern an agency's description and analysis of actions intended to avoid or substantially lessen the adverse impacts of its plans.[15] Even if mitigation measures are incorporated into a plan or project's design, the criteria, performance standards and effectiveness of such actions cannot be merely assumed, and the environmental impacts of implementing mitigating actions must be disclosed. (*Lotus, supra*, 223 Cal.App.4th at pp. 651-652 [incorporating mitigation measures into a plan or project does not provide a "shortcut" to CEQA compliance]; CEQA Guidelines, 15126.4(a).) Whether the Cold Water Habitat Objective is a project component or a mitigation measure, the State Water Board must disclose the significance of impacts attributed to this feature and show that the mitigation measures are feasible, effective, and enforceable. (CEQA Guidelines, § 15126.4(a)(2); see also CEQA Guidelines, § 15126.4(a)(1)(D) [requirement to analyze significant environmental impacts caused by mitigation measures].) To comply with the informational purposes and disclosure requirements of CEQA, this analysis regarding mitigation measures must occur after the full extent of the proposed Plan amendments' impacts are described in detail.

Mitigation Measure MM-AQUA-a,d (1)(i) requires long-term strategy and operations plans that include, among other things, provisions for carryover storage levels and flow releases from rim reservoirs to "avoid or reduce temperature impacts" to native fish species. (*Id.* at p. 7.6.2-103.) The stated purpose of the Cold Water Habitat Objective is "to ensure that there are no redirected impacts on cold water habitat from the new inflow and Delta outflow objectives and to address other existing and potential future temperature management concerns on the tributaries for salmonids and other native species." (See, e.g., Draft Staff Report at p. 5-22.) In sum, the objective is plainly intended to mitigate the adverse temperature impacts associated with satisfying the

[15] If mitigation measures are incorporated into a project to mitigate its significant effects, a "public agency shall adopt a reporting or monitoring program for the changes made to the project . . . to mitigate or avoid significant effects on the environment" and ensure compliance during implementation. (Sierra Club v. County of San Diego (2014) 231 Cal.App.4th 1152, 1165, quoting Pub. Resources Code, § 21081.6(a)(1); see also Federation of Hillside & Canyon Associations v. City of Los Angeles (2000) 83 Cal.App.4th 1252, 1261 n.4 ["to incorporate mitigation measures into a project means to amend the project so that the mitigation measures necessarily will be implemented"].)

proposed Plan amendments' higher flow requirements and its implementation is MM-AQUA-a,d (1)(i). (*Id*. at pp. 7.6.2-95, 7.6.2-103.)

Yet, the Draft Staff Report fails to evaluate the effects of the various unimpaired flow scenarios on aquatic biological resources without the Temperature Control and Reservoir Management Mitigation Measure. Instead, the Draft Staff Report's aquatic biological resources impact analysis for the proposed Plan amendments included "end-of-September carryover storage targets" in the SacWAM flow scenarios. (Draft Staff Report at pp. 7.6.2-57 – 7.6.2-88.) Consequently, the State Water Board applied Mitigation Measure MM-AQUA-a,d (1)(i) during its evaluation of whether the proposed Plan amendments will result in significant environmental impacts. In so doing, the State Water Board violated the CEQA principle that a project's environmental impacts first must be described before the lead agency can apply mitigation measures. (*Lotus, supra*, 223 Cal.App.4th at pp. 656-58.)

As the Court of Appeal held in *Lotus*, blurring the lines between an agency's determination of environmental impacts and mitigation "precludes both identification of potential environmental consequences arising from the project and also thoughtful analysis of the sufficiency of measures to mitigate those consequences." (*Lotus, supra*, 223 Cal.App.4th at p. 658.) In the present matter, it also prejudices the VA alternative, as the Draft Staff Report's discussion of its impacts on end-of-September carryover storage were *not* mitigated. On the one hand, the State Water Board masked the proposed Plan amendments' adverse temperature impacts upon special-status species in the Sacramento/Delta – *the species the Project is designed to protect*. On the other hand, the Draft Staff Report fully disclosed the VA alternative's impacts *without* mitigation, which created an uneven playing field and misleading discussion of potential impacts, in violation of CEQA.

(ii) The Draft Staff Report's Analysis of the Proposed Plan Amendments Fails to Adequately Apprise the Public and the Decision Makers of Their Significant Adverse Impacts on Special-Status Fish Species, Including the Fully Protected Desert Pupfish

The Draft Staff Report acknowledges the proposed Plan amendments would reduce the Sacramento/Delta water supply for irrigation use, and that "[t]hese conditions could adversely affect special-status fish species" such as the desert pupfish. (Draft Staff Report at p. 7.6.2-96.) The Draft Staff Report notes that the desert pupfish is listed as endangered under both the federal Endangered Species Act and California Endangered Species Act, that it is fully protected, and that its habitat includes the Coachella Valley agricultural drains and the Salton Sea. (*Id*. at pp. 7.6.2-6; 7.6.2-96.)

The Draft Staff Report indicates that "in addition to pupfish, there may be other aquatic species that rely on Sacramento/Delta water supplies that could be affected by reductions in this supply," but asserts it was "speculative and unknown" what actions individual water districts will take in response to reduced supply. (*Ibid*.) No analysis of the proposed Plan amendments is provided as to the potential nature or magnitude of likely impacts to desert pupfish. The Draft Staff Report indicates that potential impacts of the proposed Plan amendments may be avoided by implementation of MM-AQUA-a,d:3, 4, but these measures are unenforceable, and Mitigation

Measure MM-AQUA-a,d:3 in particular depends on voluntary habitat protection and restoration actions – actions that are *required* under the VA alternative. (*Id.* at p. 7.6.2-96.)

(iii) Unlike the VA Alternative, the Proposed Plan Amendments' Significant Adverse Impacts on Terrestrial Biological Resources Would be Exacerbated by the Lack of Binding Habitat Restoration Activities

Under the proposed Plan amendments, "[o]verall, the effects on giant garter snakes resulting from changes in Sacramento/Delta water supplies would range from less than significant (if maximum replacement groundwater pumping is used) to potentially significant (if no replacement groundwater pumping is used to supply rice lands and wetlands at wildlife refuges affected by changes in surface water supply)." (Draft Staff Report at p. 7.6.1-64.) The Draft Staff Report engaged in substantially the same analysis regarding the proposed Plan amendments' impacts to the Swainson's hawk, greater sandhill crane, and the tri-colored blackbird populations. (*Id.* at pp. 7.6.1-65, 7.6.1-66, 7.6.1-68.)[16] The maximum replacement groundwater scenario is not supported by the facts. (*Infra* at p. 25-26.) The proposed Plan amendments and their variations[17] will reduce Sacramento/Delta surface water supplies under all unimpaired flow scenarios. In contrast, the VA alternative will prevent significant damage to groundwater resources in terms of both quantity and quality, which are interconnected. The VA alternative also increases flow in a manner that benefits special status species, with fewer detrimental effects. (Draft Staff Report at p. 9-100.)[18]

Though the Draft Staff Report notes that "[r]estoration of wetland habitat would benefit the giant garter snake and could offset habitat loss associated with decreased Sacramento/Delta water supplies to wildlife refuges and decreased rice production," it fails to acknowledge that, under the proposed Plan amendments, habitat restoration is a primarily voluntary measure. (Draft Staff Report at pp. 7.6.1-64, 7.6.1-88 [Mitigation Measure MM-TER-a: 3, Voluntary Implementation Plans, which include habitat restoration].) The VA alternative explicitly provides for defined and enforceable habitat restoration measures. (*Id.*, Appendix G2 at pp. 1-9; *id.* at ES-5; *id.* at pp. 9-77.)

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[16] As to each of these species, the VA alternative consistently outperforms the proposed Plan amendments. (Draft Staff Report at pp. 7.6.1-65-68, 9-102-104.) As to the California Black Rail, it appears that the Draft Staff Report has no actual analysis as to the impact of the Project on its habitat, other than to conclude that the Project's impact is "potentially significant." (*Id.* at pp. 7.6.1-69; 9-104.) Here again, the VA alternative avoids much of this uncertainty.

[17] The "Low Flow" and "High Flow" Alternatives are identical to the proposed Plan amendments, but would require between 35-45 percent and 65-75 percent unimpaired flow, respectively. (Draft Staff Report at pp. 7.2-6 - 7.2-7.)

[18] Under the proposed Plan amendments with no replacement groundwater pumping, the reduction in giant gartersnake habitat in the Sacramento/Delta and San Joaquin Valley region was 6% in an average year, compared to baseline conditions. (Draft Staff Report at p. 7.6.1-63.) Under the VA alternative the reduction is only 1.2%. (*Id.* at p. 9-102.)

Furthermore, under the proposed Plan amendments, Mitigation Measure MM-TER-a: 4(i) recommends the "conversion of rice fields to other uses near areas likely to support giant gartersnake populations." (Draft Staff Report at p. 7.6.1-88.) This conversion from "rice fields to other uses" would be voluntary, however. (*Ibid.*) State Water Board therefore cannot accurately predict (1) the amount of land voluntarily converted from rice fields to protect giant gartersnake (cf. fallowing rice fields), if any; and (2) the precise locations of such voluntary habitat restoration measures. Without this crucial information, the efficacy of MM-TER-a: 4(i) would be highly uncertain if voluntarily implemented. The VA alternative reduces much of this uncertainty through its firm habitat restoration commitments and is the environmentally superior alternative under CEQA. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(b) The Proposed Plan Amendments' Water Supply Impact Analysis is Inadequate, and Implementing a Flow-Only Approach Would Have Devastating Surface Water Supply Impacts

The proposed Plan amendments, developed prior to the VA proposal in 2022, included options for voluntary implementation pathways to incorporate essential non-flow measures like habitat restoration. (Draft Staff Report at pp. 7.1-6, 7.1-2 [The Draft Staff Report "was nearing completion" when the State Water Board received the VA MOU in 2022], 7.1-21 [regarding voluntary "complementary ecosystem projects"].) Indeed, the Draft Staff Report concludes that those "voluntary implementation pathways . . . can provide for better outcomes *with lower water supply costs*" than flow objectives could provide alone. (*Id*. at p. 7.1-6 (emphasis added).) The Draft Staff Report further explains that such lower water supply costs would occur when flows are in the lower adaptive range due to "successful voluntary implementation plans that demonstrate they can achieve the narrative objective using a combination of flow and other measures," as achieved by the VA alternative. (*Id*. at p. 7.1-7.) Accordingly, these water supply "costs" are attributed to the physical levels of inflows required under the proposed Plan amendments to support fish and wildlife beneficial uses. While these "costs" have an economic dimension, they are physical in nature due to their water supply effects and related physical impacts (e.g., on agricultural resources). These findings, as evidenced by the Draft Supplement Report, demonstrate that better fish and wildlife protection can reasonably be achieved using the VA alternative's holistic approach, which combines flow and non-flow measures, than can be achieved through the proposed Plan amendments' flow-only approach – while greatly reducing interrelated surface water, groundwater, greenhouse gas emissions (from reduced groundwater pumping), and agricultural resources impacts. (Draft Staff Report at p. 9-83 [As the VA alternative would cause less significant water supply impacts, "the magnitude of changes from other water management actions that would occur as a result of changes in water supply would be less under the proposed VAs than the proposed Plan amendments"]; *id*. at pp. 7.12.2-29, 7.12.2-40 [groundwater use and impacts tend to be higher when surface water is generally less available]; *id*. at pp. 7.4-1, 7.4.4 [proposed Plan amendments' agricultural impacts result from changes in hydrology or changes in water supply]; *id*. at pp. 7.8-16 [energy required for groundwater pumping increases as the depth of groundwater decreases], 6-80 [proposed Plan amendments will result in lower groundwater levels due to diminished groundwater recharge following reduced surface water supplies];7.10-14 [increased groundwater pumping from diesel pumps in response to the proposed Plan amendments would increase GHG emissions].)

(i) The Draft Staff Report's Analysis of the Proposed Plan Amendments' Surface Water Supply Impacts Fails to Satisfy CEQA's Informational Requirements by Failing to Consider Any Adaptive Scenarios

The fundamental purpose of an EIR is to "provide public agencies and the public in general with detailed information about the effect which a proposed project is likely to have on the environment." (CEQA Guidelines, § 21061.) The proposed Plan amendments propose a 55 percent unimpaired flow "starting point," with an adaptive range "between 45 percent and 65 percent unimpaired flow." (Draft Staff Report at pp. 7.1-1, 7.1-7.) The purpose of the adaptive range is to "provide flexibility to address the unique circumstances of different tributaries," based on the Project's monitoring and evaluation program. (*Id.* at pp. 7.1-6 - 7.1-7.) The Draft Staff Report fails to disclose how adaptive implementation would occur. The Draft Staff Report states that the State Water Board opposes "rigid regimes," like "a fixed flow schedule." (*Id.* at p. 7.2-16.) Thus, as in the Phase 1 Plan Amendments, the proposed Plan amendments, if implemented, will allow for and likely would result in detailed monthly adaptive adjustments. But, the Draft Staff Report fails to consider impacts associated with adjustments within the 45 percent to 65 percent flow range *during a single water year*. Instead, the Draft Staff Report merely presents annual scenarios that assume – contrary to the State Water Board's own preferences – rigid regimes of fixed unimpaired flow levels.

Indeed, the Draft Staff Report admits the State Water Board selected a 55 percent starting point because it "is the flow level at which more significant improvements to fish and wildlife beneficial uses are expected and cold water supplies can still be maintained." (*Id.* at p. 7-1-7.) This rationale evidences the proposed Plan amendments' intent to maximize flows provided to fish while still maintaining cold water storage. An alternative method for evaluating how to maximize unimpaired flow while maintaining cold water storage would be to create a matrix of monthly scenarios tailored to particular hydrologic conditions. The Draft Staff Report thus fails to provide the public with adequate information regarding the proposed Plan amendments' likely impacts because it presents only static pictures of annual flow levels during various water years. A more complete analysis is necessary to reflect the complexity of the proposed Plan amendments' likely implementation scenarios and resulting environmental impacts.

(ii) Failing to Disclose that it Is Not Feasible to Achieve Carryover Storage Targets as Modeled Under the Proposed Plan Amendments Violates CEQA's Informational Purposes

CEQA provides that "an agency must use its best efforts to find out and disclose all that it reasonably can" when forecasting environmental impacts and the feasibility of alternatives. (CEQA Guidelines, § 15144; see also *id.* at § 15151 ["[T]he sufficiency of an EIR is to be reviewed in light of what is reasonably feasible"].) "'Feasible' means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors." (*Id.* at § 21061.1.) Accordingly, if the proposed Plan amendments are the proposed alternative, then the State Water Board must disclose all that it reasonably can regarding the infeasibility of its carryover storage targets. As the Draft Staff Report itself observes:

> Chapter 6, Changes in Hydrology and Water Supply, evaluates changes in end-of-September carryover storage for the 35 to 75 scenarios in 10-percent increments compared with baseline conditions for rim reservoirs, upstream reservoirs, and total storage in each tributary. These analyses generally indicate that carryover storage can be maintained (with less than a 10-percent change) in the tributaries under the 35, 45, and 55 scenarios, except for Stony and Putah Creeks (Black Butte Reservoir and Lake Berryessa, respectively) and the Calaveras and Mokelumne Rivers (Comanche and Pardee Reservoirs, respectively) (see Tables 6.3-8 and 6.3-9 in Chapter 6, Changes in Hydrology and Water Supply). These tributaries are highly impaired, creating challenges for carryover storage and temperature control. In the 65 scenario, carryover storage becomes more challenging for these tributaries as well as for the Yuba River. In the 75 scenario, it is not possible to maintain carryover storage as modeled. Although modeling assumptions could be modified to further reduce diversions in an attempt to better achieve carryover storage levels, it would not be possible to significantly improve carryover storage levels without dramatic water supply reductions.

(Draft Staff Report at p. 3-134.)[19]

The Draft Staff Report's analysis of the proposed Plan amendments thus concedes that the modeling results presented in Tables 6.3-8 and 6.3-9 are not possible to achieve in practice in various cases. (Draft Staff Report at p. 6-41.) But these tables do not disclose these discrepancies between the Draft Staff Report's theoretical modeling results and the State Water Board's real-life predictions. Indeed, the purpose of modeling is to represent reasonably likely conditions so that the lead agency can make informed decisions. Therefore, if the State Water Board adopts the proposed Plan amendments without informing the public of the discrepancies regarding the modeled carryover storage results and expected conditions in Tables 6.3-8 and 6.3-9, it would improperly lead the public to believe the information presented in those tables is accurate, when in reality the carryover storage modeling results presented in Table 6.3-9 are likely overstated on the tributaries listed above. To serve its purpose as an informational document, the Draft Staff Report must clearly reflect its conclusion that "it is not possible to maintain carryover storage as modeled" for the proposed Plan amendments and that it becomes "more challenging" to maintain certain modeled values in practice.

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[19] The carryover storage targets were "general assumptions" made by the State Water Board. (Draft Staff Report at pp. 3-132–3-133.) New protections to mitigate cold water habitat impacts of the proposed Plan amendments will be identified in later proceedings. (*Ibid*.) The Draft Staff Report fails to adequately define the proposed Plan amendments' cold water habitat protections, and further fails to provide sufficient information to understand the water supply tradeoffs between the proposed Plan amendments' unimpaired flow requirement, cold water habitat provisions, and existing beneficial uses. (*Id.* at p. 7.6.2-94 [satisfying the unimpaired flow requirement and cold water habitat provision could require "dramatic water supply reductions"].) Accordingly, the Draft Staff Report's analysis of the proposed Plan amendments does not provide enough information to meaningfully consider how these tradeoffs will be managed. (*Cleveland National Forest, supra*, 17 Cal.App.5th at p. 426.)

(iii) The VA Alternative Will Prevent Significant Adverse Impacts Related to Surface Water Resources

The VA alternative is "estimated to result in an average annual reduction of Sacramento/Delta surface water supply of approximately 123 [thousand acre-feet ("TAF")] per year for the entire study area," which includes the Sacramento/Delta watershed, the San Joaquin Valley, the San Francisco Bay Area, Central Coast, and Southern California. (Draft Staff Report at p. 9-59 (emphasis added).) 123 TAF equates to approximately one percent (1%) loss of total annual Sacramento/Delta water supply under baseline conditions. (*Id*. at p. 9-60 [Table 9.5-45].) Under the VA alternative, surface water supplies would decrease by 81 TAF in Critical years; 306 TAF in Dry years; 132 TAF in Below Normal years; and 184 in Above Normal years. (*Ibid*.) During Wet years, surface water supplies will increase under the VA alternative by 22 TAF relative to baseline conditions. (*Ibid*.) An average annual reduction of Sacramento/Delta surface water supplies of 123 TAF therefore reflects impacts experienced in Below Normal water years. (*Ibid*.)

In contrast, under the proposed Plan amendments, on average, Sacramento/Delta water supply is reduced by "over 1,682 TAF/yr[20] (14 percent of Sacramento/Delta supply)." (Draft Staff Report at p. 6-57.) Therefore, compared to the VA alternative, the proposed Plan amendments would result in an additional 1,559 TAF of water supply impacts. The proposed Plan amendments would result in 13.67 times *more* impacts than the VA alternative. The VA alternative would result in only 7.3 percent (7.3%) of the water supply impacts attributed to the proposed Plan amendments, meaning that 92.7 percent (92.7%) of the proposed Plan amendments' water supply impacts can be avoided by selecting the VA alternative. Across all sectors and regions, the VA alternative will avoid significant water supply impacts associated with the proposed Plan amendments, while better satisfying the Project objectives. CEQA therefore requires the State Water Board to adopt the feasible and environmentally superior VA alternative. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

The VA alternative would result in a total average annual water supply loss of 123 TAF across the entire study area. Under the proposed Plan amendments, Sacramento/Delta water supply available to agriculture in the San Joaquin Valley alone would, on average, decrease by 353 TAF. (Draft Staff Report at pp. 6-54 – 6-55 [Table 6.4-1, reduction in supply from 2,422 TAF to 2,069 TAF for agricultural uses in San Joaquin Valley].) Water supply impacts related to San Joaquin Valley agriculture under the proposed Plan amendments(353 TAF) greatly exceed *all* water supply impacts under the VA alternative (123 TAF).

The proposed Plan amendments would burden the San Joaquin Valley agricultural sector with over 20 percent of total (1,682 TAF) water supply reduction, with an average annual reduction of 353 TAF compared to baseline supply. (Draft Staff Report at pp. 6-54 – 6-55 [Table 6.4-1, reduction in supply from 2,422 TAF to 2,069 TAF for agricultural uses in San Joaquin Valley].) Reduced supply of 353 TAF would constitute a 14.5 percent loss in surface water supply of Sacramento/Delta water for agricultural uses in the San Joaquin Valley. (*Ibid*.)

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[20] As illustrated in Table 6.4-2, an average annual reduction of 1,682 TAF is close to the average reduction during below normal (-1,937 TAF) and above normal (-1,278) years. (Draft Staff Report at p. 6-57.)

Under baseline conditions, "Sacramento/Delta [State Water Project ("SWP")] and CVP deliveries to the San Joaquin Valley region have high variability based on available supply." (*Id.* at p. 6-72.) Reductions in supplies exported by the CVP and SWP, predominately to the San Joaquin and Southern California Study Areas, "are estimated to account for roughly 50 to 60 percent of overall Sacramento/Delta supply reductions, with larger proportional reductions in the higher flow scenarios." (*Ibid.*) Accordingly, given the volatility of annual Sacramento/Delta water supply, Sacramento/Delta reductions frequently will be greater than "average," especially as "below normal," "dry," and "critical" water years are expected to occur more frequently due to climate change. (*Id.* at pp. 6-56 – 6-57.) During these three water year types, total annual average reductions from the Sacramento/Delta are estimated to be 1,927 TAF (below normal), 2,630 TAF (dry)[21], and 2,232 (critical) under the 55 percent unimpaired flow scenario – all significantly greater impacts than the "average" 1,682 TAF. (*Id.* at p. 6-57 [Table 6.4-2].) Under a 55 percent unimpaired flow regime, Sacramento/Delta supply to agriculture in the San Joaquin Valley region would be reduced by 476 TAF and 658 TAF during "below normal" and "dry" years, respectively. (*Id.* at p. 6-75.) Likewise, impacts of 476 TAF and 658 TAF greatly exceed the "average" impact to San Joaquin Valley agriculture of 353 TAF.

In contrast, while achieving *better* fish benefits, the VA alternative would result in "changes in Sacramento/Delta supplies to the San Joaquin Valley region" ranging from an average annual increase of up to 46 TAF/yr to an average annual decrease of up to 68 TAF/yr. (*Id.* at pp. 9-65 – 9-66 [Table 9.5-50].) The range of these water supply changes depends on the source(s) of the VA alternative's "unspecified water purchases." (*Id.* at p. 9-65.) To account for uncertainties regarding the sources of these VA water purchases, the Draft Staff Report analyzes two potential water supply scenarios, the "VA" scenario and the "VA High Export Cuts" scenario. (*Id.* at p. 9-65.) The "VA" scenario assumes all unspecified VA water purchases would be from willing sellers in the Sacramento/Delta watershed. (*Ibid.* Under the VA High Export Cuts scenario, all unspecified water purchases would be provided "through reductions in Delta exports to agricultural users in the San Joaquin Valley." (*Ibid.*) As the unspecified water purchases are more likely to be "provided through a combination of inflow sources within the Sacramento/Delta watershed and reductions in exports," water supply impacts will likely fall within the "VA" and "VA High Export Cuts" scenarios. (*Ibid.*) Regarding potential *increases* in Sacramento/Delta supplies under the VA alternative, the Draft Staff Report provides such increases would not be a direct result of the VAs "but the possible result of changes in BiOp and ITP related constraints." (*Ibid.*) Overall, under all possible scenarios, surface water supply impacts under the VA alternative will be far less than those resulting from the proposed Plan amendments.

The proposed Plan amendments' severe water supply impacts would have deleterious effects on water transfers and threaten their viability. As illustrated by Table 6.6-1, from 2007 to 2016, annual water transfers to/within the San Joaquin Valley averaged 498 TAF. (Draft Staff Report at pp. 6-85 - 6-86.) Most of these transfers (332.1 TAF/yr) occurred *within* the San Joaquin Valley. (*Id.* at p. 6-86.) The Sacramento/Delta is the only significant source of water transfers to the San Joaquin Valley. (*Id.* at p. 6-85 ["[E]ntities located within the Sacramento River watershed

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[21] For context as to the significance of this impact, baseline Sacramento/Delta water use to supply *all* water uses in the San Joaquin Valley region during dry years is also 2,630 TAF. (Draft Staff Report at p. 6-74 [Table 6.4-20].)

region have temporarily transferred approximately 157 TAF on average to the San Joaquin Valley over the 10-year period."].) Under the proposed Plan amendments' 55 percent unimpaired flow scenario, however, reductions in Sacramento/Delta water supply to agriculture in the Sacramento River watershed "frequently exceed 500 TAF/yr." (*Id*. at pp. 6-58, 6-60 [average reduction of 511 TAF in annual Sacramento/Delta supply to agriculture].) During dry and critical years, Sacramento/Delta water supply to agriculture in the Sacramento River watershed would decrease by 778 TAF and 1,208 TAF, respectively. (*Id*. at p. 6-60.) Consequently, under the proposed Plan amendments, water transfers from the Sacramento River watershed to the San Joaquin Valley would no longer be viable—especially during dry and critical years when transfers are most needed.

In addition to avoiding the proposed Plan amendments' significant impacts to agricultural uses, the VA alternative avoids impacts to municipal and wildlife refuge beneficial uses. Under the VA alternative, supply reductions would "be largely or entirely from agricultural supplies, reservoir reoperations, or based on groundwater substitution." (*Id*. at p. 9-66.) As such, the VA alternative would not result in any significant changes in Sacramento/Delta supplies for municipal or wildlife refuge uses in the San Joaquin Valley. (*Ibid*.) In contrast, under the proposed Plan amendments, average Sacramento/Delta supply to municipal uses in the San Joaquin Valley would, on average, decrease by 22 TAF (over 22 percent of baseline supply), while average annual supply to wildlife refuges in the region would decrease by 4 TAF at 55 percent unimpaired flow. (*Id*. at p. 6-76 – 6-77.) Thus, in addition to preventing significant impacts to agricultural resources in the San Joaquin Valley, the VA alternative will also prevent significant impacts related to water supplies for municipal and wildlife refuge purposes.

(c) Groundwater Supply

In its analysis of the proposed Plan amendments' groundwater supply impacts, the Draft Staff Report provides that such impacts could be reduced by employing coordinated flow and non-flow measures:

> The proposed Bay-Delta Plan program of implementation encourages and allows for voluntary implementation plans. Those voluntary implementation plans would be required to include measures to coordinate implementation of the proposed Plan amendments with groundwater management activities, including with implementation of [the Sustainable Groundwater Management Act ("SGMA")]. Voluntary implementation plans also may allow flow requirements lower in the range if complementary measures (ecosystem projects) are implemented that provide for equivalent protection of fish and wildlife beneficial uses. Such projects could reduce the potential impacts associated with decreased consumptive water uses, including impacts on groundwater.

(Draft Staff Report at p. 7.12.2-48.)

But the Draft Staff Report concluded these other measures "are largely within the jurisdiction and control of other agencies," and therefore did not integrate non-flow measures into the proposed Plan amendments. (*Ibid*.) The VA alternative, in contrast, provides crucial tools to implement other non-flow actions and mitigation measures that will provide at least equivalent protection of fish and wildlife beneficial uses. Because the State Water Board has the authority to enter into binding, enforceable agreements with the VA Parties that will achieve the State Water Board's fundamental purpose, provide greater benefits to native fish species, and avoid or substantially reduce impacts to groundwater resources, the State Water Board must select the VA alternative. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(i) The VA Alternative Will Avoid Significant Impacts to Groundwater Resources

Compared to the proposed Plan amendments, the VA alternative will avoid significant impacts to groundwater resources in terms of both quantity and quality. The Draft Staff Report provides: "Historically, in areas with adequate groundwater, the local response to decreased surface water availability has been to use more groundwater." (Draft Staff Report at p. 6-80.) More precisely, areas with *accessible* groundwater historically increased groundwater pumping in response to reduced surface water supply. As California's long history of groundwater overdraft culminating in SGMA shows, however, groundwater supplies are frequently accessible but inadequate to prevent a range of undesirable results, such as land subsidence, reduced groundwater quality, reduced groundwater availability to shallow (often domestic) wells, chronic lowering of water tables, and increased greenhouse gas ("GHG") emissions and pumping costs associated with operating deeper wells.

The proposed Plan amendments' unimpaired flow approach will reduce Sacramento/Delta surface water supplies under all scenarios within the 45 to 65 percent adaptive range. As a result, the proposed Plan amendments would result in reasonably foreseeable indirect environmental impacts related to increased groundwater pumping, which must be analyzed under CEQA. (CEQA Guidelines, § 15064(d); Draft Staff Report at p. 6-80 ["The proposed Plan amendments have the potential to affect groundwater levels due to potential changes in groundwater pumping and changes in managed and incidental recharge."].) The degree of the proposed Plan amendments' groundwater impacts therefore is primarily determined by the level of increased groundwater pumping following reduced Sacramento/Delta surface water supplies.

"Changes in Sacramento/Delta water supply from baseline would be smaller in magnitude under the proposed VAs than the changes that would occur under the proposed Plan amendments." (Draft Staff Report at p. 9-83.) Therefore, in an attempt to compensate for reduced Sacramento/Delta surface water supplies, groundwater replacement pumping and impacts would be significantly higher under the proposed Plan amendments. Regardless of whether full replacement pumping occurs, there will be a greater tendency to maximize allowable groundwater pumping when faced with a 1,682 TAF reduction (proposed Plan amendments) versus a 123 TAF reduction (VA alternative). (*Id*. at pp. 6-57, 9-59.)

Given the current state of overdraft in several Study Areas, groundwater pumping above baseline would cause significant environmental impacts. For example, regarding groundwater quality impacts in the San Joaquin Valley, the Draft Staff Report provides: "Because of the high level of impairment and overdraft conditions in this region, potentially significant impacts on groundwater quality could result from even a limited amount of substitute groundwater pumping[.]" (Draft Staff Report at p. 7.12.2-60.) Thus, the more groundwater pumping, the greater the impacts on groundwater quality – likely even at small levels of increased pumping.

Additionally, under the proposed Plan amendments' "higher flow requirements, there would be less applied water for irrigation of agricultural lands," which would cause reductions in incidental groundwater recharge in areas reliant on Sacramento/Delta surface water supplies. (*Id.* at p. 6-81.) Simply put, groundwater recharge declines as unimpaired flow increases. As a result, under the proposed Plan amendments, groundwater recharge would decrease compared to baseline conditions in critically overdrafted groundwater basins within the San Joaquin Valley region, further exacerbating significant adverse groundwater impacts.

(ii) The Draft Staff Report Underestimates Impacts to Groundwater Resources Attributed to the Proposed Plan Amendments

The Draft Staff Report purports to describe the proposed Plan amendments' impacts on groundwater resources in relation to two "bookends" of reduced Sacramento/Delta surface water supplies – "maximum replacement groundwater pumping" and "no replacement groundwater pumping" scenarios. (Draft Staff Report at p. 7.12.2-40.) Under the "maximum replacement" scenario, water users could use groundwater to offset all Sacramento/Delta supply reductions. (*Ibid.*) Under the "no replacement" scenario, described as the "potential lower limit of groundwater pumping," "groundwater would not be available to replace reductions in surface water availability beyond current use under the baseline condition." (*Ibid.*) After introducing these scenarios, the Draft Staff Report, without any supporting evidence, concludes: "the analysis captures the breadth of likely responses, which would be somewhere in between – meaning that water users likely would increase groundwater pumping to replace some amount of the reduced surface water supplies, but not at volumes sufficient to replace all of the reduced surface water supplies." (*Ibid.*)

Here, the analysis is severely flawed. The "no replacement scenario" erroneously and without any evidentiary support assumes that, under the proposed Plan amendments, all baseline pumping (*i.e.*, pumping levels from 2005 to 2015) can continue. This assumption is undermined by the Draft Staff Report's discussion of chronic groundwater overdraft in the Study Area, such as the San Joaquin Valley. The Draft Staff Report's analysis of the proposed Plan amendments ignores that increased pumping during the 2005-2015 baseline period prompted the Legislature to enact SGMA, which requires water uses to "halt" overdraft. (Draft Staff Report at pp. 7.12.2-9, 6-81.) The Draft Staff Report's analysis of the proposed Plan amendments provides no factual or evidentiary basis that baseline groundwater pumping in critically overdrafted areas can be sustained, much less *increase* above baseline conditions, in light of SGMA. Indeed, the discussion regarding the proposed Plan amendments' impacts to groundwater resources ignores SGMA. (Draft Staff Report at p. 7.12.2-42 ["SWAP model results indicate that agricultural users in the valley floor of the Sacramento River watershed and Delta eastside tributaries regions could replace much or all of the reduced Sacramento/Delta surface water supply with groundwater, *excluding consideration of SGMA that may place limits on groundwater pumping in some locations* (Tables 7.12.2-9 and 7.12.2-10)" (emphasis added)].)

The Draft Staff Report goes on to concede, however, that "[t]he maximum replacement groundwater pumping limits used in the SWAP analysis would likely overstate the actual amount of substitute groundwater pumping that would occur as a result of the proposed Plan amendments. . . . In localized areas with existing groundwater quantity (e.g., overdraft, low well yields) or quality issues, including in the high- and medium-priority basins identified by the SGMA 2019 Basin Prioritization, substitute groundwater pumping would be less likely to increase substantially above the baseline condition." (Draft Staff Report at p. 7.12.2-43.) The Draft Staff Report's analysis of the proposed Plan amendments' groundwater impacts further provides:

> In the San Joaquin Valley and other regions, many groundwater basins are *critically overdrafted* (California Statewide Groundwater Elevation Monitoring [CASGEM] and subsequent Sustainable Groundwater Management Act [SGMA] 2019 Basin Prioritization determinations [see Section 7.12.2, Groundwater]) ***and as such are not likely to serve as an additional source of supply in place of reduced Sacramento/Delta supplies***. . . . SGMA requires local public agencies, in alluvial groundwater basins designated as high and medium priority and subject to the Act, to *halt overdraft* and balance levels of pumping and recharge.

(Draft Staff Report at p. 6-81 (emphasis added).)

Under the proposed Plan amendments, groundwater pumping is *not likely* to replace reduced Sacramento/Delta surface water supplies or persist at pre-SGMA levels in most critically overdrafted basins. The "no replacement" scenario, which is more accurately a "status quo pumping scenario," is clearly not the "potential lower limit of groundwater pumping" and may even exceed the upper limits of allowable pumping in the Study Area's numerous critically overdrafted basins. As a result, the State Water Board cannot adopt the proposed Plan amendments due to the Draft Staff Report's contradictory accounts of SGMA and its flawed groundwater impacts analysis.

(d) Conversion of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance

Fallowing and potential permanent loss of agricultural resources add to the significant adverse impacts of the proposed Plan amendments, including cumulative impacts that will occur over time. (CEQA Guidelines, App. G, §§ II(a), (e); III(a)-(c); VII(b) [fallowing of agricultural lands and potential permanent loss of agricultural resources would have obvious attendant environmental impacts such as soil erosion and loss of topsoil, as well as additional dust and particulate emissions].)

The Draft Staff Report superficially acknowledges these impacts, indicating that the proposed Plan amendments would both: (1) convert prime farmland, unique farmland, or farmland of statewide importance, and (2) involve other changes in the existing environment that could result in conversion of farmland to non-agricultural use. (Draft Staff Report at p. 7.4-2.) These impacts are potentially significant impacts. (*Ibid*.; Draft Staff Report at p. 7.4-36.) The analysis fails to provide any meaningful evaluation as to the anticipated magnitude of these significant impacts, which in itself violates CEQA.[22] Moreover, the failure to evaluate the magnitude of these impacts makes it impossible to determine if the identified mitigation measures would be effective.

(i) The Proposed Plan Amendments Would Result in Significant Fallowing of Farmland and Related Environmental Impacts in the San Joaquin Valley

The Draft Staff Report's analysis of the Plan Amendments' impacts related to agricultural resources "focuses on the potential conversion of irrigated farmland to nonagricultural uses as a result of changes in hydrology and changes in water supply." (*Id.* at p. 7.4-34.) Indeed, "[c]hange in water supply is the primary impact mechanism" that causes conversion of agricultural lands and fallowing. (*Ibid.*)[23] As demonstrated above, under the proposed Plan amendments, on average, Sacramento/Delta water supply would be reduced by over 1,682 TAF/yr, with an average annual reduction of 353 TAF to the San Joaquin Valley agricultural sector alone – over 20 percent of the total water supply impacts attributed to the proposed Plan amendments. (*Id.* at pp. 6-54 – 6-55, 6-57, 7.4-55.) In contrast, the VA Alternative would result in an average annual reduction of Sacramento/Delta surface water supply of approximately 123 TAF across the entire study area, a fraction of the proposed Plan amendments to the San Joaquin Valley alone. (*Id.* at p. 9-59.) Implementation of the proposed Plan amendments would also cause significant reductions in Sacramento/Delta water supply to agriculture in the Sacramento River watershed, which, in turn, would reduce water transfers from the Sacramento River watershed to the San Joaquin Valley. (Detailed Comment Letter at p. 22.)

For the reasons stated above, the Draft Staff Report's analysis of the proposed Plan amendments' agricultural resource impacts using "no replacement" and "maximum" groundwater replacement scenarios is flawed and fails to accurately disclose the proposed Plan amendments' impacts on irrigated crop acreage. As demonstrated, the "no replacement" scenario is not the low end of "a continuum" because it erroneously assumes status quo pumping can be maintained in the overdrafted San Joaquin Valley region. (Draft Staff Report at p. 7.4-61.) Indeed, the Draft Staff Report's analysis of the proposed Plan amendments' agricultural resource impacts concedes that "reduced irrigated acres in western San Joaquin Valley are likely to be closer to those modeled for no replacement groundwater pumping. Conversion would likely be toward the higher end of the modeled range." (*Id.* at p. 7.4-63.) The Draft Staff Report disclosed that the maximum groundwater

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[22] Under CEQA, the Draft Staff Report is required to describe the nature and magnitude of impacts it finds significant when it is reasonably feasible to do so. (Sierra Club v. County of Fresno (2018) 6 Cal.5th 502, 519; City of Long Beach v City of Los Angeles (2018) 19 Cal.App.5th 465, 486.)

[23] "Fallowing involves growing no crop on a piece of land for a season or more." (Draft Staff Report at p. 7.4-13.) "Conversion is the permanent change in land use from agriculture to another use," and "may be the result of extended idling." (*Ibid.*) Land idling, a form of conversion, is "a long-term change in land use" that "results when conditions become unfavorable for productive farming," such as lack of adequate water supply due to drought or water supply availability changes. (*Ibid.*) If agricultural land is unirrigated for more than four (4) consecutive years, it no longer qualifies as prime farmland, farmland of statewide importance, or unique farmland under the California Department of Conservation's Farmland Mapping and Monitoring Program ("FMMP"). (*Ibid.*; *id.* at p. 7.4-3.)

replacement scenario is not feasible in the Westside subbasin, which underlies Westlands Water District, due to overdraft and poor groundwater quality:

> Agriculture in parts of the western portion of the San Joaquin Valley region, notably the Westlands Water District area, is potentially more sensitive to reductions in Sacramento/Delta surface water supplies because of its relatively poor groundwater quality in the shallow aquifer and the high cost of developing supplies from the deep aquifer. Additionally, most of the groundwater subbasins underlying this area are in overdraft.

(*Id*. at p. 7.4-62; see *id*. at p. 7.4-63 [maximum replacement groundwater is not feasible within Westlands Water District because the underlying Westside subbasin "is ranked as high priority and identified as critically overdrafted. . . . *These conditions could indicate that current levels of groundwater pumping are not sustainable*." (emphasis added)].)

Given similar conditions of overdraft throughout the San Joaquin Valley region, the State Water Board cannot reasonably assume that current levels of groundwater pumping can be maintained. (*Id*. at pp. 7.4-25, 7.4-28, 7.4-61 [overdraft throughout the San Joaquin Valley region], 7.4-30 ["Several groundwater basins in the Friant Division service area are critically overdrafted and are ranked as high priority by SGMA"].) Accordingly, if implemented, the proposed Plan amendments' impacts to agricultural resources in the San Joaquin Valley would likely be similar to or greater than the "no replacement" scenario in most cases. As confirmation, the Draft Staff Report's analysis of the proposed Plan amendments' impacts on irrigated crop acreage does not even present tabular data regarding impacts under the "maximum replacement" scenario. (*Cf. id.* at p. 7.4-60 [Table 7.4-22 regarding impacts to irrigated crop acreage in the San Joaquin Valley region under the no replacement groundwater scenario].)

Under the "no replacement scenario," implementation of the proposed Plan amendments' 55 percent unimpaired flow requirement would reduce the irrigated crop acreage in the San Joaquin Valley by 107,000 acres relative to baseline in an average water year. (Draft Staff Report at p. 7.4-58 [Table 7.4-21].) The proposed Plan amendments' perennial reductions in available water supply would invariably cause land idling, other forms of conversion, and the permanent loss of the important farmland types identified above. Fallowing would result in lost jobs and appreciable declines in regional economic activity, with impacts disproportionately large in the Valley's lowest-income communities. (See David Sunding & David Roland-Holst, UC Berkeley, Blueprint Economic Impact Analysis: Phase One Results (2020) at pp. 1-17.) In contrast, the VA alternative will achieve greater fish benefits while causing far fewer water supply-related environmental impacts, and the State Water Board must avoid the proposed Plan amendments' significant impacts on agricultural resources by selecting the VA alternative.

(ii) The Draft Staff Report Fails to Adequately Analyze and Mitigate Agricultural Impacts of the Proposed Plan Amendments

While the Draft Staff Report makes some estimates as to the amount of agricultural land that may be converted as a result of implementing the proposed Plan amendments, its overarching conclusion is that the impact is unknowable:

> Given the uncertainty and individual decisions involved, any attempt to precisely predict conversion within the stated flow scenarios would require inappropriate speculation… A series of intermediate decisions lie between imposition of the proposed Plan amendments unimpaired flow requirements and the conversion of farmland to nonagricultural uses. [Lists series of intermediate decisions.] The State Water Board does not control any of these decisions and does not have authority to place conditions on local agencies to implement measures that would reduce or avoid the potentially significant impacts in this analysis.

(Draft Staff Report at pp. 7.4-54, 7.4-74, 7.4-89.)

If groundwater is not used as an offset, under the proposed Plan amendments in the Sacramento/Delta, the Draft Staff Report concludes that a 3.9 percent decline in irrigated crop acres would occur, and a decrease in alfalfa, pasture, and rice would have the most significant declines. (Draft Staff Report at pp. 7.4-45-46.) Even with substitution of crops with lower applied water requirements, "it is likely that fallowing would occur." (*Id*. at pp. 7.4-46.) The Draft Staff Report estimates that in the 55% unimpaired flow scenario, this would result in up to 88,900 irrigated crop acres fallowed in an average year, and 144,000 in a dry year. (*Id*. at 7.4-45, 7.4-48.) The analysis stops there and does not assess how much permanent conversion of prime farmland may be expected or what the reasonably foreseeable environmental impacts associated with such conversion (e.g., air quality, greenhouse gas emissions, geology and soils, loss of habitat, etc.) are anticipated to be. In addition, the Draft Staff Report fails to adequately evaluate cumulative impacts on agricultural resources due to the proposed Plan amendments' impacts in combination with anticipated water supply reductions under the Phase 1 Plan Amendments.

Similarly, SGMA implementation is acknowledged in the Staff Report as a cumulative impact (see Staff Report, p. 7.23-16), but the analysis does not quantify the impact of reduced water supply attributable to the cumulative impacts of the proposed Plan amendments plus SGMA implementation, even for basins with approved Groundwater Sustainability Plans ("GSPs") that have adopted demand management measures. These impacts are capable of being analyzed and are not speculative for basins with approved GSPs that include demand management measures. Therefore, the State Water Board cannot adopt the proposed Plan amendments due to this failure to adequately account for and quantify the cumulative impacts of SGMA implementation (*i.e.*, in decreasing the availability of groundwater) for basins with approved GSPs that include demand management measures.

The Draft Staff Report also fails to adequately analyze agricultural impacts to the western San Joaquin Valley because the modeling data aggregates water supply impacts on a regional level, as opposed to analyzing the specific impacts to agricultural uses in areas with junior water rights that are more vulnerable to water supply reductions. The Draft Staff Report evaluation of agricultural impacts in Section 7.4 aggregates available supplies throughout the entire San Joaquin Region to support the conclusion that a proposed Plan amendment. would only result in a 2% reduction in total water supply. (Draft Staff Report at pp. 5-9 – 5-10; 7.4-55 – 7.4-56.) This approach masks the significance of water supply impacts to junior water rights holders, such as CVP agricultural water service contractors, who experience greater cuts to water supplies in times of shortage and have less reliable access to replacement supplies. The Draft Staff Report acknowledges that the western San Joaquin Valley is "more sensitive to reductions in

Sacramento/Delta surface water supplies," but "does not account for the possibility that groundwater pumping at the historical rates under the maximum replacement groundwater pumping assumption could yield only poor-quality water with limited ability to replace Sacramento/Delta surface supplies." (*Id*. at pp. 7.4-63 – 7.4-64.) As a result, the Draft Staff Report fails to adequately analyze agricultural impacts to the western San Joaquin Valley because it underestimates the total water supply impacts through aggregation of available supplies and unrealistically assumes that replacement water supplies will be available in certain areas.

(iii) Despite Underestimating its Benefits, the Draft Staff Report Shows that the VA Alternative is Environmentally Superior

The Draft Staff Report's analysis of agricultural resources impermissibly obscures one of the primary benefits of the VA alternative – that the decisions regarding which land is fallowed or converted will not be made in chaotic response to ever-changing economic and water supply conditions (as in the proposed Plan amendments), but, rather, in many cases will be made in advance. The VA alternative provides that (1) landowners will dedicate certain agricultural land to habitat restoration; and (2) other land will be converted in a conscious, logical and predetermined manner that allows for planning and deliberation that is simply unavailable under an unimpaired flow regime.

The VA alternative also bridges the enforcement gap left by the proposed Plan amendments by requiring a combination of flow and non-flow measures based on the best available science. (Draft Staff Report at p. 9-198.) The VA alternative provides crucial tools to implement other non-flow actions and mitigation measures that will provide at least equivalent protection of fish and wildlife beneficial uses. By selecting the VA alternative, which in many ways better satisfies the Project's purpose, the State Water Board can avoid and substantially reduce many of the proposed Plan amendments' significant adverse environmental impacts. Because the State Water Board has the authority to enter into binding, enforceable agreements with the VA Parties that will achieve the State Water Board's fundamental purpose, provide greater benefits to native fish species, and will avoid or substantially reduce impacts to agricultural resources, the State Water Board must select the VA alternative. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(e) The Draft Staff Report Fails to Adequately Analyze and Mitigate the Significant Cumulative Impacts of the Phase 1 and Phase 2 Plan Amendments

The State Water Board decided to consider updates to the Bay-Delta Plan in two steps, each one proposing Plan amendments in a different watershed, sometimes referred to as Phases 1 and 2 of the Bay-Delta Plan Update. While these related proceedings may be construed to have "independent utility" for purposes of environmental review, approaching these proceedings as independent actions does not excuse the State Water Board from good faith evaluation and full disclosure of the Plan amendments' impacts. (CEQA Guidelines, §§ 15130(a)1), 15355.) The Draft Staff Report's analysis of the proposed Plan amendments concludes that "the impacts of implementing the LSJR/southern Delta update are potentially cumulatively considerable to the Sacramento/Delta Plan amendments in the resource areas of agricultural and forest resources, air quality, biological resources, cultural resources, energy and GHG emissions, hydrology and water quality, recreation, and utilities and service systems." (Draft Staff Report at p. 7.23-14.) The Draft Staff Report offers only a cursory qualitative analysis of the proposed Plan amendments' significant cumulative impacts that fails to comply with CEQA's substantive provisions. (CEQA Guidelines, § 15130.)

Section 7.23.1.2 of the Draft Staff Report contains a "Cumulative Project List" regarding the significant cumulative impacts associated with the proposed Plan amendments. (Draft Staff Report at p. 7.23.8.) The Draft Staff Report includes the Phase 1 Plan amendments in this list. (*Id.* at pp. 7.23-13 -7.23-14.) But the information contained in this list and the Draft Staff Report's cumulative impact analysis as a whole[24] fail to: (1) provide a reasonable analysis of the cumulative impacts of Phases 1 and 2; (2) disclose an adequate summary of the expected environmental effects that would result from implementation of Phases 1 and 2; and (3) define the geographic scope of the area(s) affected by cumulative impacts. (CEQA Guidelines, § 15130(b)(3)-(5).)

The cumulative environmental impacts of the proposed Plan amendments are predictable, readily susceptible to analysis and quantification, and are certain to be severe. For example, the Phase 1 Final SED and the Phase 2 Draft Staff Report both quantify water supply impacts associated with the respective Plan Amendments. (Draft Staff Report at Ch. 6; *id.* at pp. 7.23-13 – 7.23-14 [The Substitute Environmental Document in support of the LSJR/Southern Delta Plan amendments indicates that the lower San Joaquin River flow objectives could reduce water supply annually between 149 TAF and 465 TAF on average at 30 percent unimpaired flow and 50 percent unimpaired flow, respectively. This corresponds to a 7-percent to 23-percent reduction in water supply (SWRCB 2018)].) The State Water Board therefore must quantify cumulative water supply impacts attributed to Phase 1 and the proposed Plan amendments. But instead of utilizing the quantitative data – derived through the same modeling techniques – to disclose the proposed Plan amendments' cumulative impacts, the Draft Staff Report contains a general blanket statement that potentially significant cumulative impacts associated with the proposed Plan amendments would likely impact "agricultural and forest resources, air quality, biological resources, cultural resources, energy and GHG emissions, hydrology and water quality, recreation, and utilities and service systems." (*Id.* at p. 7.23-14.)

An adequate analysis of cumulative impacts is particularly important when another related action can be expected to significantly worsen the project's adverse environmental impacts. (*Friends of the Eel River v. Sonoma County Water Agency* (2003) 108 Cal.App.4th 859, 868-69.) The types of adverse environmental impacts resulting from implementation of the proposed Plan amendments would be similar to the types of impacts associated with the Phase 1 Plan amendments. Yet here, the State Water Board declined to observe CEQA's mandate to find out and disclose all it reasonably can regarding the extent and severity of these cumulative impacts, and to identify ways to avoid or substantially lessen them. (CEQA Guidelines, §§ 15144, 15151;

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[24] The remainder of the Draft Staff Report's cumulative impact analysis regarding Phase 1 and 2 fails to analyze any of the significant adverse cumulative impacts of the proposed Plan amendments and concludes "Implementation of the LSJR/southern Delta Plan amendments would result in flows at Vernalis that contribute to Delta outflow, resulting in a cumulative beneficial effect on native anadromous, estuarine, and resident fish species and winter spring increases in low-salinity habitat." (Draft Staff Report at pp. 7.23-29 – 7.23-30.)

Vineyard Area Citizens for Responsible Growth v. City of Rancho Cordova (2007) 40 Cal.4th 412, 428.) The Draft Staff Report's analysis of the proposed Plan amendments violates CEQA because its superficial qualitative treatment of significant environmental impacts fails to comply with these standards. If the proposed Plan amendments are the State Water Board's proposed alternative, then it must thoroughly evaluate and disclose the cumulative impacts of Phases 1 and Phase 2 as described above.

Additionally, having failed to disclose the cumulative impacts associated with the proposed Plan amendments, agencies and members of the public are unable to evaluate whether the Draft Staff Report's proposed mitigation measures are feasible, effective, and enforceable, or determine whether the Draft Staff Report's various analyses of the proposed Plan amendments' impacts are supported by substantial evidence. For example, proper evaluation of cumulative water supply impacts resulting from the proposed Plan amendments may further undermine the Draft Staff Report's assumptions concerning the ability of other beneficial users of water to diversify their water portfolios. The undisclosed cumulative groundwater supply impacts of Phases 1 and 2 also may further undermine the Draft Staff Report's assumption that increased groundwater pumping could serve as a short-term form of mitigation of the proposed Plan amendments' significant impacts.

(f) The Draft Staff Report Fails to Disclose Impacts of the Proposed Plan Amendments' Temperature Control and Reservoir Management Mitigation Measure

"If a mitigation measure would cause one or more significant effects in addition to those that would be caused by the project as proposed, the effects of the mitigation measure shall be discussed but in less detail than the significant effects of the project as proposed." (CEQA Guidelines, § 15126.4(a)(1)(D).) As further demonstrated below, Mitigation Measure MM-AQUA-a,d (1) sets forth a "Temperature Control and Reservoir Management" mitigation measure. (Draft Staff Report at p. 7.6.2-103.) Mitigation Measure MM-AQUA-a,d (1)(i) would instruct the State Water Board to "Implement Cold Water Habitat Objective" to mitigate temperature impacts to aquatic special-status species. (*Ibid.*) Among other provisions, Mitigation Measure MM-AQUA-a,d (1)(i) would require carryover storage targets and provisions that establish minimum and maximum flow releases. (*Id.* at pp. 7.6.2-103 – 7.6.2-104.) But the Draft Staff Report's impact analysis of the proposed Plan amendments does not engage in a separate analysis regarding the significant effects that would be caused by implementation of Mitigation Measure MM-AQUA-a,d 1(i) as required by CEQA.

Instead, the Draft Staff Report aggregates the impacts caused by compliance with the various unimpaired flow scenarios *and* the impacts caused by the carryover storage targets that would be developed pursuant to Mitigation Measure MM-AQUA-a,d 1(i). (Draft Staff Report at p. 6-6 ["The general approach to using SacWAM to assess the effects of Plan amendments is to simulate new flow requirements as a percentage of unimpaired flow (UF) throughout the model domain and adjust carryover (end-of-September) storage targets to maintain cold water pools for downstream fisheries."].) In addition to combining impact analysis and mitigation as discussed above, the Draft Staff Report's impact analysis of the proposed Plan amendments fails to differentiate between the specific impacts attributed to the various unimpaired flow scenarios and those attributed to Mitigation Measure MM-AQUA-a,d (1)(i) and implementation of the carryover storage targets. Failing to disclose this crucial information prejudices the environmental review process because it prevents full disclosure of the nature of the proposed Plan amendments' impacts and therefore prejudices the evaluation of alternatives.

The Draft Staff Report provides that implementation of the proposed Plan amendments' carryover storage targets (i.e., Mitigation Measure MM-AQUA-a,d 1(i)) would cause significant reductions to Sacramento/Delta water supplies. The Draft Staff Report acknowledges that "[a] large part of the demand during the irrigation season is met through delivery of water stored in reservoirs." (Draft Staff Report at p. 6-7.) It further provides "[s]urface water availability also tends to be lowest during the irrigation season," which increases the need to release water stored in reservoirs for beneficial uses. (*Id.* at p. 6-22.) The end-of-April represents "the end of the wet season going into the irrigation season," whereas end-of-September represents the end of both the dry season and the irrigation season. (*Id.* at p. 6-37.) The end-of-September carryover storage target, which follows the end-of-April target, therefore exclusively affects the availability of Sacramento/Delta water stored in reservoirs during the irrigation season. As the carryover storage targets – alongside other reservoir management mitigation measures[25] – would fundamentally alter water supply availability from key sources during peak demand, the proposed Plan amendments invariably would result in significant environmental impacts.

The Draft Staff Report's analysis of changes in surface water supply attributed to the proposed Plan amendments fails to separately quantify the impacts caused by the unimpaired flow requirements, as opposed to those caused by implementation of the Cold Water Habitat Objective. The Draft Staff Report claims to provide estimates of the annual reductions in Sacramento/Delta supplies that would be caused by the various levels of unimpaired flow during various water year types. (Draft Staff Report at p. 6-56 [Table 6.4-2, "Overall, as expected, Sacramento/Delta water supply decreases with increasing flow requirements. Reductions are the least in wet years and generally the greatest in critical, dry, and below normal years."].) This is only *partially* true, as the proposed Plan amendments' water supply impacts presented in the Draft Staff Report are based on both the unimpaired flow requirements and carryover storage. (*Ibid.* ["In the higher flow scenarios, the system is operated more conservatively at times *to maintain storage for cold water pool, which results in larger reductions* in below normal and dry years than in critical years."]; *id.* at p. 5-16 ["Because 55 percent of unimpaired flow is the flow level at which more significant improvements to fish and wildlife beneficial uses are expected *and cold water supplies can still be maintained*, the proposed starting point for the flow level is 55 percent."] (emphasis added).) But the quantities of water required to satisfy the carryover storage targets under the proposed Plan amendments' various flow scenarios are not provided. By the same token, the Draft Staff Report also leaves agencies and members of the public in the dark regarding the water supply costs purely associated with meeting the unimpaired flow requirements of the proposed Plan amendments – before mitigation through temperature control and reservoir management.

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[25] The proposed Plan amendments' temperature control and reservoir management mitigation measure would require annual operations plans with provisions for carryover storage, minimum and maximum flow releases, and ramping rates.

(g) The Draft Staff Report Fails to Analyze Impacts of the Proposed Plan Amendments on Public Water Agencies, Including Their Ability to Provide Consistent, Reliable, and Affordable Water Service to Their Customers

The Draft Staff Report's analysis of the proposed Plan amendments fails to adequately analyze and discuss the multiple significant impacts to Public Water Agencies ("PWAs"), in violation of CEQA. CEQA requires analysis and discussion of significant impacts related to "relevant specifics of the area, the resources involved, physical changes,… the human use of the land (including commercial and residential development), health and safety problems caused by the physical changes, and other aspects of the resource base such as water, historical resources, scenic quality, and public services." (CEQA Guidelines § 15126.2(a); *id.* at Appendix G "XV. Public Services"; see also *id.* at § 15144 [an environmental document must "disclose all that it reasonably can."].) The proposed Plan amendments are unworkable and will cause significant negative impacts on PWAs, their customers, and the environment.

First, the proposed Plan amendments threaten the ability of PWAs to ensure a reliable water supply and to provide consistent, reliable and affordable water service to customers, which include disadvantaged communities and other customers that provide essential public services. Westlands, for example, serves water to the Lemoore Naval Air Station and the communities of Huron, Avenal and Coalinga. The proposed Plan amendments threaten to impact the ability to provide consistent, reliable and affordable water service to these end users and raise concerns ranging from threats to national security to impacts on incarcerated populations in Coalinga and Avenal. The Draft Staff Report should specifically acknowledge and evaluate these impacts.

Furthermore, and as discussed throughout this comment letter, the proposed Plan amendments will have numerous significant impacts including:

- Precluding PWAs from meeting beneficial uses essential to California's economy including for agriculture, industrial uses, and to serve California's massive unmet demand for housing;

- Impacting hydropower operations and threatening the stability of California's grid; and

- Threatening to undermine existing restoration successes by PWAs (e.g., restoring floodplain habitat, fisheries, and promoting watershed health).

The State Water Board cannot adopt the proposed Plan amendments due to these failures to disclose and fully evaluate the proposed Plan amendments' significant impacts to PWAs, their customers, and the environment.

5. The Draft Staff Report's Analysis of the Proposed Plan Amendments Is Inadequate and Misleading Because It Relies on Inadequate or Invalid Mitigation Measures

To comply with CEQA's substantive provisions, the Draft Staff Report "shall describe feasible measures which could minimize significant adverse impacts." (CEQA Guidelines, § 15126.4(a)(1). The Draft Staff Report must "identify mitigation measures for each significant environmental effect identified." (*Id*. at § 15126.4(a)(1)(A).) "Mitigation measures must be *fully enforceable* through permit conditions, agreements, or other legally binding instruments. In the case of the adoption of a plan, policy, regulation, or other public project, mitigation measures can be incorporated into the plan, policy, regulation, or project design." (*Id*. at § 15126.4(a)(2) (emphasis added).) Subject to a narrow exception, "[f]ormulation of mitigation measures *shall not be deferred* until some future time." (*Id*. at § 15126.4(a)(1)(B) (emphasis added); *POET, supra*, 218 Cal.App.4th at p. 735; *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645, 670-71 [EIR's deferral to a "future management plan (or plans)" to mitigate special-status species impacts violated CEQA].) As set forth in CEQA Guidelines section 15126.4(a)(1)(B), the "specific details of a mitigation measure" may only be deferred "when it is impractical or infeasible to include those during the project's environmental review" *and* the agency: "(1) commits itself to the mitigation, (2) adopts specific performance standards the mitigation will achieve, and (3) identifies the type(s) of potential action(s) that can feasibly achieve that performance standard and that will considered, analyzed, and potentially incorporated in the mitigation measure."

The Draft Staff Report's analysis of the proposed Plan amendments improperly defers key mitigation measures and relies on non-binding, unenforceable measures to mitigate the proposed Plan amendments' impacts. This deferred mitigation violates CEQA for two reasons. First, it is both feasible and practicable for the State Water Board to develop the specific details of the proposed Plan amendments' mitigation measures *during* the environmental review process. (CEQA Guidelines, § 15126.4(a)(1)(B).) Second, even if it were "impracticable and infeasible" to develop certain measures to mitigate the impacts of the proposed Plan amendments, the Draft Staff Report failed to identify and adopt specific performance criteria or standards the mitigation will achieve, and to identify the types of potential actions that can and will be used to feasibly achieve them. (CEQA Guidelines, § 15126.4(a)(1)(B).)

(a) The Draft Staff Report's Analysis of the Proposed Plan Amendments Improperly Relies on SGMA Implementation as a Mitigation Measure

The Draft Staff Report's analysis of the proposed Plan amendments improperly included SGMA implementation as Mitigation Measure MM-GW-b (1), which purports to mitigate groundwater impacts. (See, e.g., Draft Staff Report, at p. 1-37.) Mitigation Measure MM-GW-b (1)-(6) is, in turn, incorporated into several other mitigation measures, including Mitigation Measure MM-AG-a,e (5), regarding impacts to agriculture resources; and Mitigation Measure MM-AQUA-a,d (2), regarding impacts to aquatic biological resources. (*Id*. at pp. 1-47, 1-51.) SGMA implementation is not a proper mitigation measure for several reasons.

First, with respect to Mitigation Measure MM-AG-a,e, it is inappropriate to include SGMA implementation as a measure to mitigate impacts on agricultural resources because with implementation of SGMA, groundwater is increasingly a less reliable substitute supply for reduced surface water deliveries. In fact, groundwater sustainability agencies and other public water agencies that rely on groundwater are now searching for flood flow recharge opportunities and alternative sources of supply to mitigate against SGMA cutbacks and to achieve subbasin balance and sustainability. More broadly, the Draft Staff Report acknowledges SGMA implementation as a cumulative impact (Draft Staff Report, at. p. 7.23-16) If, as the Draft Staff Report acknowledges, SGMA contributes to cumulative impacts on agricultural resources, then it cannot also be a measure to mitigate significant impacts on agricultural resources. Second, SGMA, enacted in 2014, predates the proposed update to the Bay-Delta Plan and is therefore an existing legal requirement. (*Id*. at p. 7.12.2-9.) Third, as demonstrated above, the Draft Staff Report recognizes implementation of SGMA will require local agencies to "halt overdraft and balance levels of pumping and recharge to avoid undesirable results." (*Id*. at p. 7.12.2-9.) Consequently, SGMA implementation likely will reduce (and will not increase) groundwater supply in overdrafted basins, and the Draft Staff Report's assumptions regarding groundwater as a viable substitute supply are unreasonable for these regions.

(b) Adaptive Implementation/Flexible Mitigation of the Proposed Plan Amendments Requires Performance Standards and Criteria

To comply with CEQA, adaptive management and/or flexible mitigation requires performance standards. (CEQA Guidelines, § 15126.4, subdivision (a)(1)(B).) An adaptive plan designed to change in response to future events or studies must identify the type of actions that may be taken and criteria for their implementation. (*Preserve Wild Santee v. City of Santee* (2012) 210 Cal.App.4th 260, 281 [post-approval formulation of active habitat management plan invalid because EIR did not describe expected management actions or include management standards]; *POET, supra*, 218 Cal.App.4th at 739-740 [under CEQA a regulatory plan designed to improve environmental conditions must include objective performance criteria by which to measure success].) Accordingly, to properly frame the proposed Plan amendments for adaptive management/implementation, the State Water Board must select an alternative with a detailed management plan that identifies the types of adaptive actions that may be taken and their criteria for implementation, alongside an associated experimental design for monitoring the performance of its adaptive strategies in meeting the Project objectives. As discussed in further detail below, the VA alternative meets these rigorous CEQA requirements, whereas the proposed Plan amendments fall short and are not an appropriate vehicle for adaptive management.

The proposed Plan amendments' mitigation measures heavily rely on adaptive management and flexible mitigation without *any* accompanying performance standards. The Draft Staff Report recognizes performance standards governing adaptive management are necessary. For example, the seventh Project objective (goal) is to: "Provide for the development and implementation of a monitoring and evaluation program to inform adaptive management of flows and future changes to the Plan." (Draft Staff Report at p. 7.1-6.) But instead of developing necessary performance standards and monitoring programs in the Draft Staff Report as required by CEQA, the Draft Staff Report proposes to outsource "adaptive management provisions" to the forthcoming program of implementation. (E.g., *id*. at pp. 5-30, 5-39.) Thus, to comply with CEQA, the performance standards accompanying the adaptive management mitigation measures / project components must be disclosed and evaluated in the Draft Staff Report. Otherwise, members of the public and agencies cannot evaluate both the feasibility of these adaptive components of the proposed Plan amendments as mitigation measures and their environmental impacts. The State Water Board cannot use a program of implementation to evade its duties under CEQA.

The proposed Plan amendments are premised on three key adaptive components: (1) an adaptive flow range from 45 to 65 unimpaired flow to support salmonids and other native fish species; (2) flow shifting and flow shaping provisions; and (3) temperature control and reservoir management mitigation measures. Mitigation Measure MM-AQUA-a,d (1)(i) illustrates the proposed Plan amendments' reliance on these adaptive components. It provides that the "[t]emperature effects" upon aquatic special-status species attributed to the proposed Plan amendments "can be reduced due to the flexibility provided in the flow objectives (range of flow levels, shaping and shifting of flows[26], groups of tributaries working together) and other proposed provisions of the program of implementation." (Draft Staff Report at p. 7.6.2-104.) The Draft Staff Report's analysis of the proposed Plan amendments violates CEQA because it does not identify (1) any specific performance standards to ensure the adaptive mitigation measures will provide reasonable protection to native fish species; (2) the types of potential actions that can feasibly achieve the performance standards; or (3) a monitoring program designed to evaluate performance. (CEQA Guidelines, § 15126.4(a)(B); *Preserve Wild Santee v. City of Santee, supra,* 210 Cal.App.4th 281.)

The proposed Plan amendments cannot be lawfully adopted without management plans and monitoring criteria for the adaptive flow range in addition to flow shifting and shaping criteria. The Draft Staff Report does not identify the specific scenarios that would justify upward or downward adjustments of the unimpaired flow requirement. The Draft Staff Report also does not disclose the type of actions it would take to shift and shape flows in an attempt to provide reasonable protection to fish species. The State Water Board is required to analyze the environmental impacts associated with the adaptive management scenarios likely to occur under the proposed Plan amendments.

The VA alternative, on the other hand, contains an adaptive management framework that complies with CEQA. The VA alternative contains a robust Governance Program and a Science Program, which provide detailed performance standards and identify the actions that will be taken under the VAs to meet the Project objectives. (Draft Staff Report, Appendix G1, Appendix B [Draft Governance Program], Appendix C [Draft Science Plan].) "Adaptive management in the VA Science Program describes an approach to testing priority hypotheses related to the effects of the suite of VA measures and applying the resulting information to improve future management and regulatory decisions." (*Id.* at Appendix G1, VA Draft Science Plan at p. 2.) The VA Draft Science Plan articulates "specific hypotheses about the expected changes in key metrics relative to relevant pre-action baselines or reference sites. Observed or modeled changes relative to these metrics . . . will be the primary means through which the VA Science Committee assesses progress relative to the core objectives of the VA Program and informs decisions both within and at the end

[26] Despite being included as an essential component of/mitigation measure for the proposed Plan amendments, the Draft Staff Report does not provide any specific information regarding flow shaping and flow shifting provisions.

of the term of the VA about whether and how to modify implementation." (*Id.* at p. 3.) The VA Science Plan's hypotheses are organized into three tiers: the "Local Tier," the "Full Tributary and Delta Tier," and the "Population Level Tier." (*Id.* at pp. 4-5.) The Local Tier hypotheses concern the effects of non-flow habitat improvement actions and "organized by the specific type of habitat project undertaken" and are evaluated on an annual or sub-annual scale. (*Id.* at p. 5.) The Local Tier hypotheses provide metrics for numerous non-flow actions, such as chinook spawning habitat enhancement on tributaries; chinook salmon in-channel rearing habitat; tributary floodplain restoration; fish passage improvements; and tidal wetland restoration, among other actions. (*Id.* at § 2.2.) Each of these hypotheses is detailed, discloses the applicable metrics, baseline, covariates (other relevant variables), which creates specific performance standards.

The Full Tributary and Delta Tier hypotheses "are developed to test predictions of how flow actions in the tributaries and the Delta will benefit native species," with flow-specific hypotheses evaluated annually while "trends in the productivity of tributaries for juvenile salmon must be evaluated over several years." (*Id.* at p. 5.) Like the Local Tier hypotheses, these hypotheses disclose the applicable metrics, baseline, and covariates that create specific performance standards. (*Id.* at § 2.3.) Finally, the Population Level Tier hypotheses "prompt evaluation of general population trends at both the tributary and system-wide (Sacramento and San Joaquin Valleys, and full Central Valley) spatial scales." (*Id.* at p. 5.) "Because these hypotheses and metrics involve the full life span of native species, trends in these metrics will be reviewed on a temporal scale of 3 or more years." (*Ibid.*) Overall, these three tiers of metrics for determining success of the VA actions and informing adaptive management will ensure the VA alternative maximizes fish benefits and create objective performance standards.

The VA Science Program also contains detailed monitoring network provisions, would impose reporting requirements, and would establish a VA Science Committee to evaluate performance (i.e., a monitoring program). Therefore, the VA Science Program contains both specific performance standards and an experimental design for monitoring the VAs' success in achieving the Project objectives in accordance with CEQA's requirements. In conclusion, even in their draft form, the VA materials contained in Appendix G1 of the Draft Staff Report are sufficient to establish a valid adaptive management program under CEQA. The VA materials, unlike the proposed Plan amendments, fully define essential project components under the VA alternative, contain rigorous performance standards, and clearly disclose the actions the VA Parties intend to take and how those actions will be monitored and assessed. When the VA Parties release the final appendices to the VA alternative, the VA alternative will provide an unprecedented adaptive management program as part of an environmentally superior alternative that meets CEQA's requirements and achieves the fundamental Project purpose.

(c) Temperature Control and Reservoir Management

To mitigate the proposed Plan amendments' impacts on aquatic special-status species (e.g., native salmonids), the Draft Staff Report contains Mitigation Measure "MM-AQUA-a,d." (Draft Staff Report at p. 7.6.2-103.) Mitigation Measure MM-AQUA-a,d consists of ten (10) separate measures. Mitigation Measure MM-AQUA-a,d 1(i), entitled "Temperature Control and Reservoir Management," proposes to "Implement Cold Water Habitat Objective." (*Ibid.*) But the Draft Staff Report's analysis of the proposed Plan amendments defers development of the "Temperature

Control and Reservoir Management" mitigation measure's specific details in violation of CEQA. (*Ibid*.; *id*. at p. 7.6.2-95.)

> Mitigation Measure MM-AQUA-a,d 1(i), provides:
>
> Long-term strategy and annual operation plans for rim reservoirs are required *to be designed* and implemented to avoid or reduce temperature impacts. The long-term strategy and operation plans *will also consider* and include measures to avoid or reduce any potential impacts on the following resources: aesthetic, terrestrial biological species, cultural, energy, recreation, and water quality (including applicable provisions of State Water Board's Statewide Mercury Control Program for Reservoirs).
>
> *** Long-Term Temperature Management Strategies: The strategies *would be required to evaluate measures* that can be taken to improve temperature management in both the short term and long term and to identify the feasibility and suitability of those measures. The strategies also *would be required to include processes* for implementing feasible temperature control measures in a timely and effective manner. Temperature control measures that should be evaluated include installation and improvements in TCDs, cold water bypasses, passage, riparian reforestation, operational changes, and other relevant improvements identified by the State Water Board and fisheries agency staff. The *strategies would be required to include provisions for developing the annual plans*, including time schedules that provide for planning and coordination with the State Water Board and fisheries agencies and other appropriate stakeholders, decision-making processes for temperature operations, modeling and monitoring to support development and implementation of the annual plans, adaptive management, and other measures.
>
> Operation Plans: Annual operations *plans would be required to be developed each year* in coordination with the State Water Board and fisheries agencies identifying how temperature protection and related operations for the protection of salmonids and other native species will be achieved each year, *including provisions for reservoir carryover storage levels; minimum and maximum flow releases* and ramping rates to provide appropriate temperature protection, preserve cold water supplies, and avoid stranding and dewatering concerns; reservoir TCD operations; adaptive management; and other relevant provisions, as well as the technical basis for those provisions. The annual plans would be subject to approval and potential modification by the Executive Director.

(*Id*. at pp. 7.6.2-103 – 7.6.2-104 (emphasis added).)

Mitigation Measure MM-AQUA-a,d 1(i) therefore depends on long-term strategy and annual operations plans that are "required to be designed." (*Id*. at p. 7.6.2-103.) In other words, the Draft Staff Report *defers* the development of these plans. This deferral violates CEQA because the State Water Board failed to (a) adopt specific criteria or performance standards the mitigation will achieve; and (b) identify the type(s) of potential action(s) that can and will feasibly achieve those criteria or performance standards. (CEQA Guidelines, § 15126.4(a)(1)(B).)

Mitigation Measure MM-AQUA-a,d 1(i) does not contain *any* specific performance standards designed to avoid or reduce temperature impacts. Rather, it merely sketches a list of provisions or issues for which to create performance standards. For example, the "[l]ong-term strategy and annual operations plans" *will* "include measures to avoid or reduce any potential impacts on the following resources: aesthetic, terrestrial biological species, cultural, energy, recreation, and water quality." (*Id*. at p. 7.6.2-103.) But the mitigation measure does not contain specific performance standards regarding how these impact concerns will be measured or evaluated.

Additionally, the long-term temperature management strategies "would be required to include processes for implementing feasible temperature control measures in a timely and effective manner. Temperature control measures that should be evaluated include installation and improvements in TCDs [temperature control devices], cold water bypasses, passage, riparian reforestation, operational changes, *and other* relevant improvements identified by the State Water Board and fisheries agency staff." (*Ibid*.) But once again, the Draft Staff Report's analysis of the proposed Plan amendments lacks any criteria or performance standards necessary to evaluate the effectiveness of such measures to mitigate the proposed Plan amendments' impacts. Indeed, particular performance standards regarding (a) TCDs; (b) cold water bypasses; (c) fish passage projects; (d) riparian reforestation; and (d) operational changes would be necessary to ensure the unique benefits associated with each of these distinct activities could adequately be measured and compared objectively. Indeed, without such specific performance criteria, meaningful "modeling and monitoring" could not occur to inform the development of annual plans. (*Id*. at p. 7.6.2-103.)

Mitigation Measure MM-AQUA-a,d 1(i) measure also lacks specific performance standards to guide development and implementation of the proposed Plan amendments' contemplated annual operations plans. (*Id*. at pp. 7.6.2-103 – 7.6.2-104.) The purpose of such annual plans as part of the proposed Plan amendments is to identify "how temperature protection and related operations for the protection of salmonids and other native species will be achieved each year." (*Id*. at p. 7.6.2-103.) But no performance standards designed to guide these determinations are provided. Rather, the mitigation measure only provides a list of concepts that *require* performance standards, namely: (a) reservoir carryover storage levels; (b) minimum and maximum flow releases and ramping rates; (c) performance standards regarding stranding and dewatering concerns; (d) reservoir temperature control device operations; and (e) adaptive management. These provisions are ambiguous and uncertain. For example, it is uncertain when the "minimum and maximum flow releases and ramping rates" would apply. It is also uncertain whether the annual operations plans would include reservoir refill requirements/provisions. The proposed Plan amendments cannot be the State Water Board's proposed alternative without the development of specific performance criteria and standards and adequate definition and description of the Long-Term Temperature Management Strategies and Operations Plan components relied upon in Mitigation Measure MM-AQUA-a,d (1)(i).

6. The VA Alternative Provides Greater Fish Benefits and Is the Environmentally Superior Alternative

A direct link exists between the quality of habitat and the abundance of native fish species. (E.g., Draft Staff Report, Appendix, G2 at pp. 6-1 - 6-2 [numerous studies have found increases in spawners and adult salmon populations following habitat improvement efforts]; *id*. at p. 6-6 [improved rearing habitat leads "to an increased capacity to produce more juveniles].) Recent studies demonstrate that "Sacramento River winter-run Chinook salmon rely on a more diverse suite of rearing habitats than previously thought, thereby motivating the need to restore instream rearing habitat in the Sacramento River and its contributing tributaries." (Draft Staff Report, Appendix G2 at p. 6-1.) Additionally, "56 percent of the variability" in the juvenile salmon catch at Chipps Island[27] is explained by factors other than flow, likely including biological factors such as the amount of suitable habitat and food supply. (*Id.* at p. 6-25.) By integrating flow and non-flow physical restoration actions, the VA alternative provides a holistic and more effective approach to habitat improvements than the State Water Board's proposed Plan amendments.

The goal of the VA alternative's habitat restoration activities is "to restore spawning and rearing habitats sufficient to support approximately 25 percent of the offspring of the salmon doubling goal populations for each tributary." (Draft Staff Report, Appendix G2 at p. 1-9; *id*. at ES-5; Draft Staff Report at p. 9-77.) Table 5-1 of the Draft Supplement Report illustrates the amount of rearing and spawning habitat on the Sacramento River (Spring Run and Fall Run), Feather River, Yuba River, American River, and the Mokelumne River (the "VA Tributaries") required to support 100 percent of the Salmon Doubling Objective.

Table 5-1. Summary of the Doubled Escapement of Fall Run (all tributaries) and Spring Run (Sacramento River), Number of Juveniles, and Rearing and Spawning Habitat Needed to Support the Doubled Escapement

Watershed	Doubled Escapement	Juveniles Produced	Rearing Area (acres)	Spawning Area (acres)
Sacramento River: Fall Run	154,000	146,300,000	1,808	177
Sacramento River: Spring Run	22,000	20,900,000	258	25
Feather River	98,000	93,100,000	1,150	112
Yuba River	26,000	24,700,000	305	30
American River	82,000	77,900,000	962	94
Mokelumne River	6,600	6,270,000	77	8

(Draft Staff Report, Appendix G2, at p. 5-4.)

The VA alternative is expected to meet or exceed its spawning and rearing habitat restoration goals on almost all of the VA Tributaries. (E.g., Draft Staff Report, Appendix G2 at p. 6-3 [Figure 6-1 illustrating increases in spawning habitat under the VA alternative]; *id*. at p. 6-15 [Figure 6-10 illustrating increases in rearing habitat under the VA alternative].) "The results of the habitat analysis indicate that VA non-flow assets produce more suitable habitat for fall-run Chinook salmon and spring-run Sacramento River Chinook salmon during spawning and rearing as compared to the reference condition scenario." (*Id*. at p. 6-1.) "Expanding habitat availability, both spatially and temporally, for juvenile salmon is expected to improve abundance, productivity,

[27] All juvenile salmonids outmigrating from the Sacramento (and San Joaquin) River must pass Chipps Island, which marks the confluence between the Sacramento-San Joaquin watershed and San Francisco Bay. Chipps Island therefore is the key measuring point for determining outmigration (i.e., escapement) rates and abundance.

diversity, and spatial structure of Central Valley salmon populations, and it may also lead to incidental benefits for other native fish species (State Water Board and California Environmental Protection Agency 2018)." (*Ibid*.) The results also show that the VA alternative is environmentally superior to the proposed Plan amendments in terms of benefiting native fish species quantitatively and qualitatively. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(a) Quantitative Benefits to Native Fish Species: Spawning Habitat

(i) VA Alternative

"The proposed habitat restoration commitments identified in the VA Term Sheet include spawning habitat for the Sacramento River (113.5 acres), Feather River (15 acres), American River (25 acres), and Putah Creek (1.4 acres). (Draft Staff Report, Appendix G2, p. 6-4.) "Across all water year types, the VAs offer more spawning habitat (October through December) than the reference condition in the American, Feather, and Sacramento Rivers. Across Critical to Wet water year types, the VAs offer 49 to 122 percent more spawning habitat (0–5 total acres) in the American River; 27 to 31 percent more spawning habitat in the Feather River (10–14 acres); 144 to 205 percent more spawning habitat in the Sacramento River for fall run (71–113 acres); and 158 to 233 percent more spawning habitat in the Sacramento River for spring run (41–108 acres)." (*Ibid*.) Table 6-1 of the Draft Supplement Report illustrates these increases in suitable spawning habitat in terms of median percent change between the reference condition and the VA alternative across various water year types.

Table 6-1. Median Percent Change between the Reference Condition and VA Scenarios for Suitable Spawning Habitat by Water Year Type and Watershed

Watershed	Critical	Dry	Below Normal	Above Normal	Wet
American River	59% (2)	60% (3)	49% (0)	59% (2)	122% (5)
Feather River	27% (10)	29% (13)	30% (13)	31% (14)	30% (13)
Mokelumne River	0% (0)	0% (0)	0% (0)	0% (0)	NA
Sacramento River: FR	151% (71)	160% (110)	144% (113)	167% (103)	205% (104)
Sacramento River: SR	158% (41)	184% (76)	176% (90)	206% (96)	233% (108)
Yuba River	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)

Note: The numbers in parentheses are median increases in suitable spawning habitat acreage. Results are presented for fall run in all tributaries and for spring run in the Sacramento River. Mokelumne River results are based on the Mokelumne River water year type definitions, which do not contain a "wet" category.
FR = fall run; NA = not applicable; SR = spring run

(Draft Staff Report, Appendix G2 at p. 6-4.)

Commentators or the State Water Board may emphasize that, with the exception of the American River, both reference condition and VA habitat "exceed the VA target of 25 percent of the doubling goal for spawning habitat in all water year types." (Draft Staff Report, Appendix G2 at p. 6-2.) In the Sacramento (for spring run) and Yuba Rivers, habitat under the reference condition exceeds 100 percent of the habitat required to achieve the Salmon Doubling Goal. (*Ibid*.; *id*. at pp. 6-3.) While spawning habitat *currently* may be adequate, however, the VA habitat projects remain necessary to achieve long-term objectives for several reasons.

First, the Draft Staff Report calls for habitat restoration activities to provide reasonable fish protection, and spawning habitat is among the most critical to ensure species abundance. Because dams "disrupt the natural transport of sediment (e.g., spawning gravel) and other materials (e.g., large woody material that maintain spawning and rearing grounds," routine gravel augmentation projects are necessary to maintain spawning habitats. (Draft Staff Report at pp. 3-35 – 3-36; *id*. at p. 5-41 [recommended physical habitat restoration actions]; *id*. at p. 4-3 [in 2019, the federal budget for the Central Valley Project Improvement Act ("CVPIA") Restoration Fund for "projects such as American River spawning and rearing habitat" and "Clear Creek spawning gravels and channel restoration" was $62 million].)

Second, the VA alternative's habitat improvements must be viewed holistically. As illustrated in the Draft Early Implementation Project List, most VA projects address multiple habitat conditions. (Draft Staff Report, Appendix G1 at Appendix D [starting at p. 238].) Many projects enhance instream rearing; maintain spawning habitat; create new spawning habitat; create floodplain habitat; and take other coordinated actions such as adding large wood clusters or removing predation hotspots to provide refuge from predators. (*Ibid*.) Therefore, while spawning and rearing habitat improvements are quantified separately in the scientific analyses, these benefits are realized through integrated projects at the implementation level.

Third, there are distinct advantages to exceeding the VA alternative's goal of providing 25 percent of the habitat required to support the Salmon Doubling Goal. Increasing the spatial distribution of spawning habitat will increase life history diversity because rearing begins at spawning grounds. (Draft Staff Report at pp. 3-25, 3-27, 3-29 [After emerging from spawning gravel, various species of juveniles may hold in the river for a few months to over a year]; *id*. at p. 3-3 [Improved temporal and spatial variability would increase genetic and life-cycle diversity].) Increased habitat with greater spatial distribution – alongside VA activities such as adding large wooden clusters and removing predation hotspots – will reduce the effects of stressors like predation and water quality impairments. (Draft Staff Report at p. 3-41 [Large wooden clusters provide spatial complexity and refuge from predators].) With the development of additional spawning habitat, there will be more opportunities for spawning, and consequently an increase in the number of juveniles. (Draft Staff Report, Appendix G2 at p. 6-1.) Additionally, VA restoration activities will be coordinated with VA flow assets to ensure that the spawning habitat created by the VAs will be viable in all water year types.

Fourth, the VA habitat improvements on the Sacramento River benefit both fall-run and spring-run Chinook salmon. Sufficient spawning habitat exists under the reference condition for spring-run Chinook salmon on the Sacramento River. (*Id*. at p. 6-4.) Reference condition habitat for fall-run on the Sacramento River is well below 100 percent of the habitat required to meet the Doubling Goal, however. (*Ibid*.) Additionally, in terms of total acreage, the Sacramento River provides the greatest amount of potential spawning habitat out of all the tributaries. This high potential for spawning habitat makes habitat restoration on the Sacramento River a priority activity.

In short, the VA alternative will lead to robust quantitative improvements in spawning habitat relative to the reference scenario. For the most part, these improvements surpass the amount of spawning habitat to support 25 percent of the Salmon Doubling Objective in all water year types.

(ii) Proposed Plan Amendments

In contrast to the substantial quantitative improvements that would result from implementation of the VA alternative, estimated increases in spawning habitat under the proposed Plan amendments' Unimpaired Flow Scenarios are zero (0) in most cases, as illustrated in Table 3.14-8 of the Draft Staff Report. (Draft Staff Report at pp. 3-127 – 3-128.)

Table 3.14-8. Change in Median (across All Years Modeled) Spawning Habitat from Baseline for Each Flow Scenario

Watershed	35	45	55	65	75
American River	0% (0)	8% (0)	0% (0)	4% (0)	84% (3)
Antelope Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Battle Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Bear River	1% (0)	1% (0)	1% (0)	1% (0)	2% (0)
Big Chico Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Butte Creek - FR	0% (0)	0% (0)	0% (0)	1% (0)	54% (0)
Butte Creek - SR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Calaveras River	6% (0)	10% (0)	16% (1)	22% (1)	28% (1)
Clear Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Cosumnes River	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Cottonwood Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Cow Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Deer Creek - FR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Deer Creek - SR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Elder Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Feather River	-1% (-1)	-5% (-2)	-9% (-4)	-8% (-3)	-15% (-6)
Mill Creek - FR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Mill Creek - SR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Mokelumne River	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Paynes Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Sacramento River - FR	0% (0)	0% (0)	0% (0)	4% (1)	4% (3)
Sacramento River - SR	0% (0)	0% (0)	-1% (-1)	-9% (-4)	-9% (-4)
Stony Creek	0% (0)	1% (0)	1% (0)	1% (0)	1% (0)
Sutter Bypass	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Thomes Creek	0% (0)	0% (0)	0% (0)	0% (0)	-2% (-2)
Yuba River	0% (0)	8% (0)	0% (0)	4% (0)	84% (3)

Results are presented as percent change with the difference in acres in parentheses, both rounded to the nearest whole number. Unless noted otherwise, results are for fall-run.
FR = fall-run
SR = spring-run

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State Water Resources Control Board Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations

(Draft Staff Report at pp. 3-127 – 3-128.)

At the proposed Plan amendments' starting point of 55 percent unimpaired flow, implementation of the Plan amendments would not lead to *any* increases in spawning habitat on nearly every tributary including (1) the American River; (2) the Sacramento River (Fall Run); and (3) on the Yuba River. (*Ibid.*) Indeed, with this flow level alone, existing spawning habitat would *decrease* on the Sacramento River (Spring Run) and on the Feather River, two critical reaches of the Sacramento-Delta home to a substantial number of native salmonid populations and with capacity to support greater populations through habitat restoration activities. (*Ibid*; *id*. at Appendix

B, pp. 3-25 [spring-run], 3-27 [following the construction of Shasta and Keswick Dams, late-fall-run salmon depend upon upper mainstem of Sacramento River for habitat], 3-30 [regarding fall-run Chinook, "historic levels of genetic and phenotypic diversity of Central Valley stocks have likely been substantially reduced by the cumulative effects of habitat loss and degradation," which reduces resilience and increases susceptibility to population collapse], 3-30 ["Existing native steelhead populations now occur in the Sacramento, Yuba, Feather, Bear, and American Rivers"]; State of California, Department of Fish and Wildlife (2006), Annual Report Chinook Salmon Spawner Stocks in California's Central Valley, 2004 at p. 41 [Sacramento River Mainstem supported a total of 60,691 chinook salmon, consisting of 43,604 fall-, 8,824 late-fall-, 7,869 winter- and 394 spring-run fish]; National Marine Fisheries Service ("NMFS") (2014) Recovery Plan for Central Valley Chinook Salmon and Steelhead (2014) at pp. 31 [current distribution of Central Valley spring-run Chinook salmon], 41 [a "major reason why spring-run Chinook salmon are in need of ESA [Endangered Species Act] protection is because the remaining spawning and rearing habitat for this species is severely degraded"].) The VA alternative, in contrast, will result in substantial spawning habitat increases that overall meet or exceed fish protection goals. In terms of quantitative spawning benefits, which are expected to improve abundance, productivity, diversity, and spatial structure of Central Valley salmonids, the VA alternative is environmentally superior to the proposed Plan amendments. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(b) Quantitative Benefits to Native Fish Species: Instream and Floodplain Rearing Habitat

Native Sacramento-Delta species, such as salmonids, require integrated networks of high-quality in-channel and floodplain habitat to ensure their long-term abundance. Increases in suitable instream rearing habitat through habitat improvement efforts leads to an increased capacity to produce more juveniles. (Draft Staff Report, Appendix G2 at p. 6-6.) Floodplain habitat is crucial to the survival of juvenile Chinook salmon because it "creates access to foraging habitat and provides refuge from high velocities during high-flow events;" enhances life history diversity in salmonids; improves fish growth due to high prey abundance, lower water velocities, and higher temperatures compared to the adjacent river channel; and because "[a]ccess to floodplain habitat also provides increased space required for growth, development, and survival." (Draft Staff Report, Appendix G2 at p. 6-9.) Floodplain inundation and "[d]ynamic connectivity between rivers and their floodplains" are critical components of floodplain habitat that provide fish access. (*Ibid.*)

The Draft Staff Report's quantitative analyses show the proposed Plan amendments fail to create any meaningful benefits to rearing habitat. On the other hand, the quantitative benefits attributed to the VA alternative will contribute to the New Narrative Objective and the Salmon Doubling Objective. Therefore, the VA alternative is the only alternative that satisfies the State Water Board's fundamental purpose of achieving reasonable fish protection and must be selected.

(i) VA Alternative

(A) In-Channel

The VA alternative's instream rearing habitat goal is to meet the "25-percent-of-doubling-goal threshold." (Draft Staff Report, Appendix G2 at p. 6-6.) "The proposed habitat restoration commitments identified in the VA Term Sheet include in-channel habitat for the Sacramento River (137.5 acres), Feather River (5.25 acres), Yuba River (50 acres), American River (75 acres), and Mokelumne River (1 acre)." (Draft Staff Report, Appendix G2 at p. 6-6.) These increases are insufficient to meet the 25 percent of the Doubling Goal target on the American, Feather, and Sacramento (Fall Run) Rivers. (*Ibid*.) When VA floodplain and instream rearing habitat are viewed holistically, however, which is required given their interconnected nature, the VAs substantially achieve or exceed the 25 percent habitat goal across all VA Tributaries. (*Id*. at p. 6-15.)

"The VAs offer 45 to 128 percent more in-channel rearing habitat (21–51 acres) in the American River; 1 percent less to 4 percent more in the Feather River (-2–4 acres); 3 to 0 percent less in the Mokelumne River (-3–0 acres); 15–83 percent more in the Sacramento River for fall run (14–50 acres); 13 to 69 percent more in the Sacramento River for spring run (23–64 acres); and 3 to 11 percent more in the Yuba River (7–25 acres) (Table 6-2, Figure 6-4). These analyses show reductions in in-channel rearing habitat in some wetter year types in the Sacramento, American, Mokelumne, and Yuba Rivers, which may seem counterintuitive. In wetter years, however, velocities and depths become less suitable in the channels, particularly when the flows are confined by levees. These results highlight the importance of restoring floodplain and off-channel habitat to provide lower-velocity refugia during high flow years," which the VA alternative provides. (Draft Staff Report, Appendix G2 at p. 6-7; see also *id*. at p. 6-9 [Table 6-2].)

(B) Floodplain

Access to adequate floodplain habitat "improves juvenile fish survival by improving food availability in addition to providing refuges from predators during the critical spawning, rearing, and migration period of several Central Valley fish species, especially Sacramento splittail and salmonids." (Draft Staff Report, Appendix B at p. 3-5.)[28]

"Restoring floodplain habitat and connectivity to the main river channels . . . [is] a key objective of current ecosystem restoration and recovery efforts for Chinook salmon and other native fishes in the Central Valley." (Draft Staff Report at p. 3-41.) Floodplain habitat has ecological importance to Chinook salmon and steelhead during multiple life stages as it provides a suite of benefits for fish." (Draft Staff Report, Appendix G2 at p. 6-17.) Compared to instream habitat, floodplains typically provide increased food resources, which leads to faster growth rates and increased resilience. (*Ibid*.; *id*. at p. 6-9 ["Juveniles in shallow, low-velocity habitats supported by floodplain inundation have been found to grow more rapidly than juveniles in deeper, faster habitat" due to improved access to food resources and refuge from high velocities during flow events]; Draft Staff Report at p. 3-107 [Faster growth and higher survival rates associated with floodplain rearing]; *id*. at p. 3-5 [Inundation of suitable floodplain habitat "improves juvenile fish survival by improving food availability, in addition to providing refuges from predators during the critical spawning, rearing, and migration period of several native Central Valley fish species –

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[28] This demonstrates that the Splittail, one of the 4 estuarine indicator species, will benefit from more than just flow, and further shows that the benefits to fish abundance associated with VA alternative flows are underestimated in the Draft Staff Report.

especially Sacramento splittail and salmonids."]; *id*., Appendix G2 at p. 5-20 ["fish are expected to tolerate higher temperatures in floodplain habitats due to greater food availability"].)

"The proposed floodplain and flood basin actions identified in the VA Term Sheet include floodplain habitat and/or fish food production for the Sutter Bypass, Butte Sink, and Colusa basin (20,000 acres of fish food and 20,000 acres of flood habitat); Feather River (1,655 acres); Yuba River (100 acres); and Mokelumne River (25 acres)," which will be accompanied by inundation and connectivity for fish access. (Draft Staff Report, Appendix G2 at p. 6-9.)

The Draft Supplement Report evaluates floodplain benefits in terms of the frequency of meaningful floodplain events ("MFE"). (Draft Staff Report, Appendix G2 at p. 6-10.) "An MFE is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years." (*Ibid*.) The goal of the VA alternative is to provide MFE occurrences to support 25 percent of the Salmon Doubling Goal for the Sacramento River and each of the subject tributaries. (*Ibid*.)

As illustrated in Figures 6-5, 6-6, and 6-7 of the Draft Supplement Report, the "VAs will likely offer a greater proportion of MFE occurrence" for the Feather, Mokelumne, and Yuba rivers compared to the reference condition. (Draft Staff Report, Appendix G2 at pp. 6-10 -6-12.) These floodplain improvements are material. For example, on the Feather River, the VA scenario meets 50 percent Salmon Doubling Goal in 49 percent of years, whereas this result would only occur in about 5 percent of years under the reference condition. (*Id*. at pp. 6-9 – 6-10.) "On the Yuba River, the reference condition MFEs meet 25 percent of the doubling goal in 11 percent of the years, while the VAs meet 25 percent of the doubling goal in 72 percent of the years." (*Id*. at pp. 6-9 – 6-12.)

Regarding the Sutter Bypass, the VAs will generate twenty thousand (20,000) acres of floodplain habitat within the three flood basins (Sutter Bypass, Butte Sink, and Colusa basin) via the Tisdale Weir and other modifications. (Draft Staff Report, Appendix G2 at p. 6-12.) "This change in hydrologic operations of the Tisdale Weir does not create new physical habitat; rather, it improves the inundation frequency and duration of reference condition and VA proposed floodplain habitat in the Sutter Bypass." (*Ibid*.) If this increased inundation is "accompanied by additional topographic modifications, land management changes, and habitat enhancements in these flood basins," the Draft Supplement Report concludes this "additional floodplain habitat would exceed the rearing doubling goal habitat need for the Sacramento River (1,961 acres) during times when the floodplain is inundated, and fish have access." (*Id*. at pp. 6-12 – 6-13.) As illustrated in Figure 6-9, the maximum acreage subject to a MFE in the Sutter Bypass is approximately 5,000 acres. (*Id*. at p. 6-14.) In contrast, under the VA scenario, MFEs will occur at 15,000 acres in almost all years and in over twenty-five percent (25%) of years at 20,000 acres. (*Ibid*.) This dramatic increase demonstrates the effectiveness of non-flow measures under the VA scenario, which cannot be matched by a flow-only approach.

(C) Combined Instream and Floodplain Habitat

Compared to the reference scenario, "[t]he VAs offer 46 to 52 percent more rearing habitat (23–51 total acres) in the American River; 5 to 72 percent more in the Feather River (6–344 acres); 1 percent less to 14 percent more in the Mokelumne River (-1 to 8523 acres); 11–42 percent more in the Sacramento River for fall run (14– 51 acres); 10 to 28 percent more in the Sacramento River for spring run (24–65 acres); and 3 to 51 percent more in the Yuba River (7–122 acres)." (Draft Staff Report, Appendix G2 at p. 6-17.) Table 6-3 of the Draft Supplement Report illustrates these increases in suitable rearing habitat in terms of median percent change between the reference condition and the VA alternative across various water year types.

Table 6-3. Median Percent Change between the Reference Condition and VA Scenarios for Suitable Rearing Habitat (Including Both Instream and Floodplain) by Water Year Type and Watershed

Watershed	Critical	Dry	Below Normal	Above Normal	Wet
American River	48% (23)	52% (38)	52% (50)	51% (50)	46% (51)
Feather River	5% (6)	47% (75)	67% (114)	72% (204)	67% (344)
Mokelumne River	0% (0)	-1% (-1)	0% (0)	14% (23)	NA
Sacramento River: FR	15% (14)	20% (24)	42% (50)	24% (51)	11% (50)
Sacramento River: SR	13% (24)	24% (38)	28% (51)	23% (65)	10% (62)
Yuba River	3% (7)	10% (30)	41% (101)	51% (122)	46% (113)

Notes: Results are presented for fall run in all tributaries and for spring run in the Sacramento River. Numbers in parentheses are median changes in suitable rearing (including instream and floodplain) habitat acreage. Mokelumne River results are based on the Mokelumne River water year type definitions, which do not contain a "wet" category.
FR = fall run; NA = not applicable; SR = spring run

(Draft Staff Report, Appendix G2 at p. 6-17.)

The combined VA rearing habitat also substantially achieves the goal of providing enough rearing habitat to support 25 percent of the Salmon Doubling Goal. (Draft Staff Report, Appendix G2 at pp. 6-14 – 6-15.) On the Yuba River, the increased habitat under the VA alternative will exceed 100 percent of the habitat required to support the Doubling Goal. (*Id*. at p. 6-15.) The improvements on the Sacramento (Fall Run) River come close to providing 100% of the Doubling Goal rearing habitat requirement. (*Ibid*.) In all but Critical dry years, the VA alternative will meet the 25 percent goal on the Feather River. (*Id*. at p. 6-14.) While not illustrated in Table 6-3, the addition of only 9,000 acres of the 20,000 acres of floodplain restoration "would surpass the 25 percent goal in the Sacramento River (fall run) during times when this floodplain is inundated and fish have access." (*Id*. at p. 6-15.) As the VA Parties will restore these 20,000 acres with the sole purpose of providing fish access during meaningful floodplain events, implementation of the VAs will exceed the 25 percent goal on the Sacramento River (Fall Run).

Overall, "[t]he quantitative analyses indicate expected increases in suitable spawning and rearing habitat for salmonids and increases in suitable habitat and population abundance indices for estuarine species. Chinook salmon fall-run and spring-run (only analyzed for the Sacramento River) spawning (Figure ES-1), instream rearing (Figure ES-2), and floodplain (Table ES-2) habitats are expected to contribute toward the narrative objectives described above." (*Ibid*. [referring to the VA alternative's proposed new Narrative Viability Objective].)

(ii) Proposed Plan Amendments

The same defects of a flow-only approach apply equally to the proposed Plan amendments' creation (or lack thereof) of instream and floodplain rearing habitat for native fish species. As illustrated in Table 3.14-9 of the Draft Staff Report, the flow resources associated with the proposed Plan amendments and its variations also fail to create meaningful improvements in rearing habitat (instream and floodplain) compared to baseline conditions. (Draft Staff Report at pp. 3-129 – 3-130.)

Table 3.14-9. Change in Median (across All Years Modeled) Rearing (Instream and Floodplain) Habitat from Baseline for Each Flow Scenario

Watershed	35	45	55	65	75
American River	1% (1)	1% (1)	3% (2)	2% (2)	4% (4)
Antelope Creek	0% (0)	0% (0)	1% (0)	1% (1)	1% (1)
Battle Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Bear River	0% (0)	-1% (-1)	-3% (-2)	-5% (-4)	-7% (-5)
Big Chico Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Butte Creek - FR	0% (0)	0% (0)	0% (0)	0% (0)	1% (0)
Butte Creek - SR	0% (0)	0% (0)	0% (0)	0% (0)	-1% (-1)
Calaveras River	12% (1)	14% (2)	16% (2)	18% (2)	19% (2)
Clear Creek	2% (0)	2% (0)	4% (0)	5% (0)	6% (0)
Cosumnes River	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Cottonwood Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Cow Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Deer Creek - FR	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Deer Creek - SR	0% (0)	0% (0)	0% (0)	-1% (-1)	-1% (-1)
Elder Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Feather River	10% (21)	22% (45)	33% (78)	44% (102)	54% (125)
Mill Creek - FR	0% (0)	0% (0)	0% (0)	1% (0)	2% (0)
Mill Creek - SR	0% (0)	0% (0)	0% (0)	0% (0)	1% (0)
Mokelumne River	8% (17)	16% (32)	25% (47)	31% (60)	38% (70)
Paynes Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Sacramento River - FR	0% (0)	0% (-1)	-1% (-2)	-1% (-3)	-1% (-2)
Sacramento River - SR	0% (-1)	-1% (-2)	-1% (-3)	-2% (-5)	-1% (-2)
Stony Creek	3% (1)	2% (1)	2% (1)	3% (1)	4% (2)
Sutter Bypass	-1% (-22)	0% (9)	1% (31)	1% (51)	-6% (-242)
Thomes Creek	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Yuba River	-1% (-2)	-2% (-6)	-4% (-10)	-4% (-12)	-5% (-12)

Results are presented as percent change with the difference in acres in parentheses, both rounded to the nearest whole number. Unless noted otherwise, results are for fall-run.
FR = fall-run
SR = spring-run

(Draft Staff Report at pp. 3-129 – 3-130.)

Unimpaired flows of 55 percent would create a 33 percent increase in median rearing habitat on the Feather River; a 25 percent increase on the Mokelumne River; and a 3 percent increase on the American River. (*Ibid.*) But net *decreases* would still occur on the Sacramento River (Fall Run and Spring Run) (-1% for Fall Run and Spring Run) and on the Yuba River (-4%). (*Id.* at p. 3-130.)

Recall that the "VAs offer 46 to 52 percent more rearing habitat (23–51 total acres) in the American River; 5 to 72 percent more in the Feather River (6–344 acres); 1 percent less to 14 percent more in the Mokelumne River (-1 to 8523 acres); 11–42 percent more in the Sacramento River for fall run (14– 51 acres); 10 to 28 percent more in the Sacramento River for spring run (24–65 acres); and 3 to 51 percent more in the Yuba River (7–122 acres)." (Draft Staff Report, Appendix G2 at p. 6-17.) Across the board, the VA alternative yields significantly better quantitative rearing habitat benefits, which will lead to greater increases in abundance.

(c) Meaningful Floodplain Events Analysis & Creation of Rearing Habitat

Despite requiring greater flows than the VA alternative, the proposed Plan amendments do not create better MFE results than the VA alternative. (Compare Draft Staff Report at pp. 3-130 – 3-132 and Draft Staff Report, Appendix G2 at pp. 6-9 – 6-12.)

On the Mokelumne River, the proposed Plan amendments achieve MFEs at 25 percent of the Doubling Goal in 98 percent of years, whereas MFE occurrence under the VA alternative is 51 percent. (*Id.* at p. 3-131; *id.*, Appendix G2 at p. 6-10.) Yet, based on the best available science, VA Flow assets are not concentrated on the Mokelumne River; no spawning habitat improvements are proposed; and a relatively small amount of instream rearing (1 acre) and floodplain (25 acres) of habitat are proposed on the Mokelumne. (Draft Staff Report, Appendix G2 at pp. ES-3, 6-3 – 6-4.) Put simply, increasing MFEs on the Mokelumne is not an efficient or an effective solution to maximize fish benefits using California's scarce water resources.

On the Feather River, the proposed Plan amendments satisfy the 25 percent goal in 76 percent of years, while the VA alternative satisfies the same goal in 66 percent of years. (Draft Staff Report at p. 3-131; *id.*, Appendix G2 at p., 6-10.) In terms of MFEs, these outcomes are comparable and fall within the same general range. In terms of quantitative fish benefits, however, the VA MFEs will result in far greater benefits. Based on the median water year modeled (i.e., "Below Normal"), the 55% Flow Alternative will result in 78 acres of floodplain and instream rearing habitat, a 33 percent increase from the baseline. (Draft Staff Report at pp. 3-129 – 3-130.) In contrast, under the VA alternative, in a "Below Normal" water year, median rearing habitat on the Feather River will increase by 114 acres, a 67 percent increase from the reference condition. (Draft Staff Report, Appendix G2 at p. 6-17.) The VA alternative's multi-dimensional approach explains the increased efficiency of VA Flow Assets and the VA alternative's greater net benefits. The proposed Plan amendments would achieve a slightly higher rate of MFEs. But the synergies between the VA Flow Assets – 60 TAF in Dry, Below Normal, and Above Normal years – and restoration of 50 acres of instream rearing habitat and 1,655 acres of floodplain habitat underscore that creating suitable habitat requires more than just flows or inundation. (*Id.* at p. 6-18 [synergy between flow and non-flow habitat].)

On the Yuba River, the proposed Plan amendments only create MFEs in 11 percent of years – the same as the baseline/reference condition.[29] (*Id*. at p. 3-131.) In contrast, under the VA alternative, MFEs occur in 72 percent of years, a huge increase from the reference condition / baseline of 11 percent. (*Id*., Appendix G2 at pp. 6-10, 6-12.) The best available science shows that investing in coordinated flow and habitat actions on the Yuba River provides a feasible pathway to maximize fish benefits. (*Id*. at pp. 2-7 – 2-9 ["[T]he disconnection and destruction of rearing habitat are considered ecosystem stressors for salmonids on the Yuba River," and are addressed by the VA alternative].) As such, the VA alternative would provide 50 TAF (50,000 AFY) of flow assets in Dry, Below Normal, and Above Normal water years, coupled with restoration of 50 acres of instream rearing and 100 acres of floodplain habitat. (*Id*., Appendix G2 at pp. ES-3, 3-3.)

The Draft Supplement Report documents the quantitative benefits of integrated VA flow and non-flow assets on the Yuba River. In a "Below Normal" water year, the VA alternative will result in a median increase in rearing habitat on the Yuba River of 101 acres, a 41 percent increase from the reference condition. (Draft Staff Report, Appendix G2 at p. 6-17.) In contrast, under the proposed Plan amendments, rearing habitat on the Yuba River would decrease by 10 acres (-10 acres) in the median year, a 4 percent reduction (-4%) from baseline conditions. (Draft Staff Report at pp. 3-129 – 3-130.)

Regarding the Sacramento River (Fall Run and Spring Run), the Draft Staff Report fails to quantify whether the VA alternative is expected to offer a greater proportion of MFE occurrence. Section 6.1.2.2 should include this analysis – especially as the Draft Staff Report provides a quantitative evaluation of MFE occurrence on the Sacramento River under the proposed Plan amendments. (Draft Staff Report at pp. 3-130 – 3-131 [Table 3.14-10].)

As provided in Table 3.14-10, MFEs on the Sacramento River (Fall Run and Spring Run) are expected to remain at baseline levels under the proposed Plan amendments. (*Ibid*.) Despite maintaining the status quo, however, total instream and floodplain rearing habitat under the proposed Plan amendments would *decrease* on the Sacramento River for both salmon runs. (Draft Staff Report at pp. 3-129 – 3-130 [Table 3.14-9].) In contrast, under the VA alternative, in a Below Normal water year, total rearing habitat on the Sacramento River would increase by a median of 42 and 28 percent for fall and spring run Chinook salmon, respectively. (*Id*. at Appendix G2 at p. 6-17.)

Overall, the Draft Staff Report's MFE analysis demonstrates the VA alternative's ability to create more fish benefits using lower but more strategic flows. A material distinction exists between *actively restoring habitat* and merely *inundating a highly altered ecosystem*. The scientific data proves that physical restoration plus inundation will yield better results in terms of fish protection than taking a one-dimensional inundation approach, as prescribed by the proposed Plan amendments. (Draft Staff Report at pp. 3-125 – 126 ["Increased flows, along with restoration of floodplain habitat, would help restore the important functions provided by floodplain

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[29] It should be noted that the "baseline" and "reference" conditions are not the same on the other tributaries but happened to be the same on the Yuba River. We understand this difference to be explained by the fact that VA alternative habitat is additive to existing conditions as of December 2018. (Draft Staff Report at p. 9-5.)

inundation. All these benefits [of increased floodplain inundation] would be enhanced ever further with physical habitat restoration actions that maximize the effectiveness of additional flow"]; *id.* at p. 4-1 ["The benefits of flows are enhanced when implemented in concert with habitat restoration, control of waste discharges, control of invasive species, fisheries management, and other efforts. A multifaceted approach is needed to address Delta concerns and reconcile an altered ecosystem"]; *id.* at pp. 3.) While the proposed Plan amendments aspire to a multi-dimensional approach, they fall far short by only mandating flows. In contrast, the VA alternative will restore 20,000 acres of floodplain habitat and maximize the effectiveness of additional flow, making it environmentally superior to the proposed Plan amendments. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

(d) The VA Alternative Will Restore 5,227 Acres of Tidal Wetlands, Which Will Increase Survival Rates and Ameliorate Predation

The VA alternative is the only alternative that will result in tidal wetlands habitat restoration, which is crucial to native fish species' survival. "The Delta is currently composed mostly of deep, open-water habitats with low productivity due to lack of light penetration." (*Id.* at p. 6-26.)[30] This low productivity limits available food sources, while deep open-water habitats limit opportunities for refuge from predators. (*Id.* at p. 6-27 [juvenile salmon growth rates are higher in floodplain habitats compared to main-channel habitats and salmonids that rear in West Coast estuaries have higher survival than those that rear in other habitats]; Draft Staff Report at p. 3-40 [lack of large woody instream debris limits spatial complexity and refuge from predators]; Draft Staff Report, Appendix B at pp. 3-4 – 3-5 [lack of "habitat connectivity in riverine and deltaic systems" results in more "hostile conditions" with less protection from predators compared to connected river, floodplain, and estuary habitats].)

In response to these adverse conditions that threaten fish survival, "[t]he VAs propose restoration of 5,227 acres of tidal wetlands within the Delta and Suisun Marsh." (Draft Staff Report, Appendix G2 at p. 6-26.) This restoration will result in interrelated benefits to native fish species of increased food, diminished predation, increased resilience, greater life history diversity, and ultimately improved survival and abundance.

The Draft Staff Report concludes restoration of such tidal wetlands likely will "increase ecosystem productivity and provide increased food supply." (*Id.* at p. 6-25.) Indeed, based on the best available science, the Draft Supplement Report concluded that these 5,227 acres of restored habitat "could result in additional algal production of 0.9 to 1.95 kilotons per year and additional vascular plant production of over 12 kilotons per year, or an increase in aquatic primary production of up to 15 percent over current levels of productivity." (Draft Staff Report, Appendix G2 at p. 6-26.) These increases in production will result in cascading benefits up the trophic levels of the food chain, with increased organic carbon and phytoplankton supporting greater populations of zooplankton and other invertebrates that fish eat, such as terrestrial arthropods, which are

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[30] While the Draft Staff Report states that agricultural diversions are partially responsible for this existing condition (see Draft Staff Report at Appendix B, p. 2-66), it fails to account for a crucial distinction among alternatives – the VA alternative will address this existing condition in furtherance of the State Water Board's fundamental purpose, but the proposed Plan amendments will not.

"particularly important for juvenile salmon rearing." (*Id.* at pp. 6-26 – 6-27 [e.g., "Carbon from vegetation forms the base of the foodweb in wetlands in the Delta" and is a crucial part "of the open-water foodweb historically"].) The VA alternative's tidal wetland habitat improvements will create "[b]enefits of increased food supply" that "directly translate to increased fish foraging efficiency, growth, and survival." (*Id.* at p. 6-27.)

In addition to promoting fish growth and survival, increased food resources associated with VA alternative's tidal estuary habitat improvements will reduce predation. For example, silversides, whose "distribution overlaps that of native species like Delta smelt, juvenile salmonids, and Sacramento splittail . . . may outcompete other small planktivorous fish for limited resources." (Draft Staff Report at p. 4-22.) With substantial increases in phytoplankton (algae) and zooplankton created by the VA habitat improvements, there will be less competition between these native species and silversides. Additionally, with increased access to abundant and high-quality food sources like zooplankton and other invertebrates, invasive species will be less reliant on preying upon native larval fish and eggs. (See *ibid.*)

Wetlands restoration will also improve water quality factors, such as temperature and contamination levels. (Draft Staff Report, Appendix G2 at p. 6-28.) "[T]emperatures in wetlands may be reduced at some times when compared to nearby channels due to cooling of water at night on the marsh plain during summertime spring tides," which provides cold water refugia during critical rearing and outmigration periods. (*Ibid.*) Regarding water quality constituents, tidal wetlands effectively filter pollutants like pesticides and have been found to "reduce mercury methylation," and "issues with low dissolved oxygen," major fish stressors. (*Ibid.*)

Compared to the proposed Plan amendments' one-dimensional approach, the VA alternative will create greater quantitative fish benefits due to its combination of flow and non-flow assets and must be selected as the environmentally superior alternative. (Pub. Resources Code, §§ 21002-21002.1, 21004; CEQA Guidelines, §§ 15002(a), (h), 15021, 15126.6(d), (e)(2).)

B. The Draft Staff Report Does Not Provide the Information and Analysis Necessary Under the Porter-Cologne Act to Support Adoption of the Proposed Plan Amendments as Water Quality Objectives

1. The Porter-Cologne Act Requires the State Water Board to Consider a Broad Range of Factors When Adopting Water Quality Objectives, and to Balance Protection of All Beneficial Uses to Decide What is Reasonable

The Porter-Cologne Act requires that the State Water Board set water quality objectives that will provide "reasonable protection" of all beneficial uses. (Wat. Code §§ 13000, 13240, 13241.) Water Code section 13240 requires the State Water Board to "formulate and adopt water quality control plans . . . [in conformity with] the policies set forth in Chapter 1 (commencing with Section 13000) of this division and any state policy for water quality control." In turn, section 13000 provides:

> The Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.

Finally, section 13241 mandates the "[f]actors to be considered by a regional board in establishing water quality objectives." (Wat. Code, § 13241.)

Sections 13000, 13240 and 13241 impose both broad powers and broad responsibilities on the State Water Board when it adopts a water quality control plan. (*United States v. State Water Resources Control Board* (1982) 182 Cal.App.3d 82, 110, 116, 117, 118, 122 (hereinafter "*Racanelli*").) In *Racanelli*, the Court of Appeal explained:

> In formulating a water quality control plan, the Board is invested with wide authority "to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." (§13000.) In fulfilling its statutory imperative, the Board is required to "establish such water quality objectives ... as in its judgment will ensure the reasonable protection of beneficial uses ..." (§ 13241), a conceptual classification far-reaching in scope. "'Beneficial uses' of the waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves." (§ 13050, subd. (f).) Thus, in carrying out its water quality planning function, the Board possesses broad powers and responsibilities in setting water quality standards.

(*Id*. at 109–110.) As explained below, the information in the Draft Staff Report supporting the proposed Plan amendments is insufficient for the State Water Board to meet the "statutory imperative" under Porter-Cologne to "consider all demands" and "ensure the reasonable protection of beneficial uses." (*Ibid*.)

2. The Draft Staff Report Does Not Provide Sufficient Description of the Unimpaired Flow Alternatives, or Analysis and Information of the Benefits and Costs Thereof, For the State Water Board to Make an Informed Decision Regarding Whether Objectives Based on Unimpaired Flow Would Provide Reasonable Protection of Beneficial Uses

The Draft Staff Report does not provide sufficient information for the State Water Board to determine that the proposed Plan amendments provide "reasonable protection" for beneficial uses, as required by the Porter-Cologne Act. Because the Draft Staff Report defers formulation of biological goals until implementation, it does not contain meaningful projections on the degree to which the proposed Plan amendments will improve conditions for fish and wildlife. Additionally, because the Draft Staff Report does not describe specific cold water habitat provisions, the State

Water Board does not have the information necessary to determine whether the proposed Plan amendments will provide reasonable protection to beneficial uses. Lastly, the timing and amount of the unimpaired flow requirement can vary widely depending on implementation, and the impacts to other beneficial uses across that range are not sufficiently described in the Draft Staff Report. Collectively, these information gaps in the Draft Staff Report demonstrate that the State Water Board does not have sufficient information to support the determination that the proposed Plan amendments provide "reasonable protection" for beneficial uses. (Wat. Code, § 13241; *Racanelli, supra*, at 109–110.)

In contrast, the portions of the Draft Staff Report that evaluate the VA alternative identify biological goals and specific flow and non-flow measures that, when coupled with requisite analysis, can support the determination that the VA alternative provides "reasonable protection" for beneficial uses.

(a) Without Identifying Biological Goals, the State Water Board Does Not Have Sufficient Information to Determine that the Proposed Plan Amendments Provide Reasonable Protection for Fish and Wildlife

Because the State Water Board deferred development of biological goals, the State Water Board does not have information to support the conclusion that the proposed Plan amendments provide "reasonable protection" for beneficial uses, as required by the Porter-Cologne Act. The Draft Staff Report states that biological goals "are quantitative metrics that are intended to be used to inform adaptive management and future changes to the Bay-Delta Plan, including assessment of both the proposed voluntary and default implementation provisions at achieving narrative objectives and reasonably protecting fish and wildlife." (Draft Staff Report at p. 5-64.) Instead of identifying biological goals, the Draft Staff Report states that the "proposed program of implementation calls for State Water Board staff, in consultation with other appropriate entities, to further develop biological goals for approval by the State Water Board." (*Ibid*.) Because the Draft Staff Report defers discussion of biological goals that would serve as a metric for whether the proposed Plan amendments will provide reasonable protection for fish and wildlife, the State Water Board does not have information to determine that the proposed Plan amendments provide "reasonable protection" for beneficial uses, as required by the Porter-Cologne Act.

The Draft Staff Report explicitly defers formulation of biological goals designed to measure the benefits that the proposed Plan amendments will provide to fish and wildlife, even though the State Water Board determined that the proposed Plan amendments are anticipated to provide greater protections for fish and wildlife than other unimpaired flow alternatives. Out of three unimpaired flow alternatives with identical narrative provisions for fish and wildlife, the State Water Board selected the proposed Plan amendments because "55 percent unimpaired flow is the flow level at which more significant improvements to fish and wildlife beneficial uses are expected and cold water supplies can still be maintained." (Draft Staff Report at p. 7.1-7.) The proposed Plan amendments include a "range" of instream flow requirements – between 45% and 65% of unimpaired flow – with the specific timing and amount of instream flows to be determined by adaptive management. (*Id*. At pp. 3-100 – 3-101.) Adaptive management, in turn, will be informed by biological goals that will be developed while the Project is being implemented to inform adaptive management measures and evaluate success. (*Id*. At p. 5-64.)

The Draft Staff Report's current proposal for identifying biological goals that will determine whether the proposed Plan amendments provide "reasonable protection" for fish and wildlife is mired in circular reasoning. The Draft Staff Report begins with the conclusion that "mimicking natural hydrographic conditions" will "protec[t] a wide variety of ecosystem processes," but defers any projection of the specific improvements to fish and wildlife that can be expected until implementation. (Draft Staff Report at p. 7.2-16.) Without information regarding the outcomes that will be achieved as instream flow requirements are increased by specific amounts, the Draft Staff Report does not provide information to support the conclusion that the proposed Plan amendments provide "more significant improvements to fish and wildlife," as compared to other alternatives. (*Id*. At p. 7.1-7.) Furthermore, there is no attempt to quantify the level of protection that the proposed Plan amendments will provide for fish and wildlife. Because the State Water Board defers development of metrics that will determine whether the proposed Plan amendments provide "reasonable protection" for fish and wildlife, it does not have the information to make findings regarding "reasonable protection" of fish and wildlife at this stage. (*Id*. At p. 5-64.)

(b) Because the State Water Board Does Not Provide Information on Specific Cold Water Habitat Protections, It Cannot Make an Informed Decision on Whether They Protect Beneficial Uses

The State Water Board does not have sufficient information to determine that the proposed Plan amendments will protect beneficial uses because it did not propose specific cold water habitat provisions, which is a critical component of the scientific conclusions regarding correlations between higher flow and improved conditions for fish and wildlife.

One major caveat in the scientific conclusions regarding unimpaired flow is that higher flow and lower X2 during the winter and spring will only result in improved outcomes if "adequate supplies are maintained for cold water flow at other times." (Draft Staff Report, Appendix B at p. 3-13.) However, the Draft Staff Report defers formulation of specific cold water habitat provisions and therefore avoids meaningful evaluation of the full range of impacts to other beneficial uses that would result from implementation of project components that are at odds.[31] (Draft Staff Report at pp. 3-132 – 3-133 ["there are tradeoffs between providing instream flows and carryover storage that are considerations in determining the required flow and cold water habitat measures, including the flow levels, carryover storage requirements, and flexibility and adaptive management provisions"].) To address this omission, the model results in the Draft Staff Report include

[31] Under existing conditions, flows stored during the winter and spring are released during the summer and fall to provide cold water habitat for salmon in low elevation reaches of Sacramento River and its tributaries because access to high-elevation spawning habitat is restricted by dams. The modeling results in the Draft Staff Report show that the proposed Plan amendments will deteriorate cold water habitat (as compared to existing conditions) even with hypothetical parameters for reservoir operations that are designed to protect cold water habitat. (Draft Staff Report at pp. 7.6.2-56 – 7.6.2-88.) The Draft Staff Report acknowledges that meeting unimpaired flow requirements will impact cold water habitat impacts without additional mitigation, such as reduced diversions or implementation of Voluntary Improvements Projects ("VIPs"). (*Id*. at p. 76.2-94; p. 3-101.) As a result, the Draft Staff Report concludes that implementation of unimpaired flow requirements will interfere with narrative cold water habitat objectives and that further mitigation measures are required.

hypothetical carryover storage targets that are designed to provide cold water habitat protection,[32] however, the model results still indicate that the proposed Plan amendments will provide *less* protection for cold water habitat than the status quo. (*Id.* At p. 7.6.2-56 – 7.6.2-88.) As a result, the Draft Staff Report concludes that "dramatic water supply reductions" will be needed to maintain carryover storage levels necessary implement the narrative cold water habitat provisions. (*Id.* At p. 3-134.)

Because the Draft Staff Report does not disclose specific cold water habitat provisions, or evaluate the "dramatic water supply reductions" that will be needed to implement them, the State Water Board does not have information necessary to determine that the proposed Plan amendments provide "reasonable protection" for beneficial uses. A fundamental component of the scientific conclusions regarding the fish and wildlife benefits from the proposed Plan amendments is the continued preservation of cold water habitat; however, the proposed Plan amendments provide less protection for cold water habitat even with "hypothetical" protections in place. (Draft Staff Report at pp. 7.6.2-56 – 7.6.2-88.) It is not clear whether the "hypothetical" cold water habitat protections are even feasible[33], let alone whether they can be improved upon, meaning that the State Water Board cannot reasonably conclude that the proposed Plan amendments will improve conditions for fish and wildlife. To address this logical gap, the Draft Staff Report concludes that "dramatic water supply reductions" will be needed but does not evaluate how those reductions will impact other beneficial uses. (*Id.* At p. 3-134.) The major information gaps described above demonstrate that the State Water Board does not have the information necessary to determine that the proposed Plan amendments will "ensure the reasonable protection of beneficial uses."

(c) The State Water Board Cannot Lawfully Adopt the Proposed Plan Amendments While Deferring Analysis That Is Necessary to Determine the Reasonable Protection of Beneficial Uses for the Implementation Phase

The State Water Board does not provide information on how the proposed Plan amendments will operate in practice because it defers formulation of specific flow and flow timing requirements to the implementation phase. (Draft Staff Report at pp. 3-100 – 3-101.)

The Draft Staff Report states that the proposed Plan amendments will lead to "more significant improvements to fish and wildlife" but will also cause more significant impacts to other beneficial uses, as compared to the Low Flow alternative. (Compare Draft Staff Report at p. 7.1-7 to Draft Staff Report, Appendix F at pp. F-18 – F-38.) Indeed, the analysis throughout the Draft Staff Report concludes that increasing instream flow causes increased environmental impacts through significant declines in water availability to other beneficial uses. (See, e.g., Draft Staff Report, Figure 7.4-16.) Despite the clear correlation between increased unimpaired flows and increased impacts to other beneficial uses, the proposed Plan amendments include a "range" of

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[32] The carryover storage targets were "general assumptions" created by SWRCB. (Draft Staff Report at pp. 3-132 – 3-133.) New protections to mitigate cold water habitat impacts will be identified in later proceedings. (*Ibid.*)

[33] This parameter could not be achieved in certain tributaries under several different unimpaired flow scenarios. (Draft Staff Report at p. 3-134.)

instream flow requirements with undefined release schedules that will be developed during implementation. Given the wide range of impacts that could occur to beneficial uses from the proposed Plan amendments, the Draft Staff Report does not include information necessary to support the conclusion that all potential permutations of flow and flow-timing provide "reasonable protection" for beneficial uses. In short, the State Water Board does not have sufficient information to determine that the wide range of instream flow scenarios authorized by the proposed Plan amendments provide reasonable protection to beneficial uses.

The approach described above precludes the State Water Board from "consider[ing] all demands" and "ensur[ing] the reasonable protection of beneficial uses." (*Racanelli*, *supra*, at 109–110.) Without information on the specific instream flow requirement and the timing of that instream flow requirement, the State Water Board necessarily lacks information to determine the degree to which other beneficial uses will be impacted by the proposed Plan amendments. The lack of analysis regarding the severity of impacts that would result from the full range of flows included in the proposed Plan amendments, or variations in timing (e.g., when the water will be released), means that the State Water Board does not have information to support the finding that other beneficial uses are protected.

(d) The State Water Board Lacks Information Necessary to Determine that the Proposed Plan Amendments Provide Reasonable Protection for Beneficial Uses Because the Draft Staff Report Understates Impacts to Beneficial Uses

As discussed in Section I.A, the Draft Staff Report understates the impacts from the proposed Plan amendments on other beneficial uses, including aquatic biological species, terrestrial species (particularly waterfowl), and agricultural water uses. For brevity, these points are incorporated here by reference.

Because the Draft Staff Report understates the impacts that will occur to the beneficial uses, such as aquatic biological species and agricultural uses, the State Water Board lacks sufficient information to conclude that the proposed Plan amendments will provide reasonable protection for those beneficial uses. Without a clear understanding of impacts to beneficial uses that is supported by competent evidence, the State Water Board cannot make an informed finding that the proposed Plan amendments provide reasonable protections for beneficial uses. As a result, because the Draft Staff Report understates impacts to beneficial uses it does not provide sufficient information to support required findings under the Porter-Cologne Act.

(e) The VA Alternative Provides the State Water Board with Sufficient Information to Determine that the Enumerated Flow and Non-Flow Measures Provide Reasonable Protection for Beneficial Uses

The specific enumerated details regarding implementation of the VA alternative provide the State Water Board with sufficient information to determine that the VA alternative will achieve reasonable protection of beneficial uses. Section 9.3 of the Draft Staff Report includes a discussion of the specific flow and non-flow assets that would be implemented to achieve the narrative goals identified in the VA alternative. Section 9.3.2 identifies narrative viability objectives for native fish and wildlife species. Lastly, the VA alternative includes a well-defined and fully funded program of scientific monitoring and evaluation to inform adaptive management of flow and future changes. Because the Draft Staff Report relies on these specific details when evaluating the fish and wildlife benefits and water supply impacts from the VA alternative, the State Water Board has sufficient information to determine that the VA alternative will achieve reasonable protection of beneficial uses.

3. The Draft Staff Report Does Not Analyze What Water Quality Conditions Could Reasonably Be Achieved by the Proposed Plan Amendments Through the Coordinated Control of All Factors Affecting Water Quality for Fish

Water Code section 13241(c) requires the State Water Board to consider "[w]ater quality conditions that could reasonably be achieved through the *coordinated control of all factors which affect water quality* in the area." (Emphasis added.)

The Draft Staff Report acknowledges that the reasonable protection of fish and wildlife will require both flow and non-flow actions but abdicates its responsibility to outline how those conditions could be achieved through the coordinated control of all factors. Chapters 3, 4, and 5 of the Draft Staff Report state that "ecosystem recovery in the Delta depends on more than just adequate flows[34]." (Draft Staff Report at p. 4-1; *id*. at pp. 3-1, 3-134, 5-7, 5-41.) Despite the Draft Staff Report's clear calls for non-flow measures, it also states that these non-flow actions are "beyond what the State Water Board can require," and that "[m]any of those actions are within the purview of other agencies and entities[35]." (*Id*. at pp. 4-1 – 4.2.)

Contrary to this assertion, the Porter-Cologne Act requires that the State Water Board evaluate how it can pursue coordinated control of all factors affecting water quality, even when those actions are within the purview of other agencies. (Wat. Code, § 13242(a); *Racanelli*, 182 Cal.App.3d at 116.) Because the Draft Staff Report does not evaluate any specific non-flow measures, the State Water Board has ignored its obligation to evaluate "coordinated control of all factors" in pursuit of a flow-only approach to the Bay-Delta Plan Update. (Draft Staff Report at p. 5-3.)

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[34] The Draft Staff Report also provides that "[m]any stressors other than flow can affect ecosystem processes." (Draft Staff Report at p. 3-1.) It further acknowledges that the "Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta, fish and wildlife protection cannot be achieved solely through flow—habitat restoration and stressor reduction also are needed. The dynamic nature of flow interacts with the physical environment to produce aquatic habitats suitable for native fish and wildlife. The function and ability of ecosystems to support these species can be reduced by stressors. One cannot substitute one for another; flow improvements, stressor reduction, and habitat restoration are all essential for protecting fish and wildlife resources." (*Ibid*.)

[35] The Draft Staff Report separately states that non-flow measures "may be implemented" under the proposed Plan amendments. (Draft Staff Report at p. 5-3.) This non-committal statement further demonstrates the Draft Staff Report did not consider how to "control" other factors that affect the reasonable protection of fish and wildlife.

Water quality objectives are the limits or levels of water quality constituents or characteristics necessary to provide reasonable protection of beneficial uses within a specific area. (Wat. Code, § 13050(h).) Those limits or levels may not be achievable through exercise of the State Water Board's authority alone. Accordingly, the proposed Plan amendments must include "recommendations for appropriate action by any entity, public or private." (Wat. Code, § 13242(a).) In turn, Water Code section 13247 requires that state offices, departments and boards comply with water quality control plans approved or adopted by the State Water Board. (Wat. Code, § 13247; *State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674, 730.)

If actions by entities not subject to section 13247 are necessary to achieve a water quality objective, identification of those actions in the program of implementation is crucial to inform implementation efforts, including for example the need for additional funding or legislative action. Those purposes of water quality planning are not served if, instead of basing an objective on what is needed for reasonable protection, the State Water Board bases an objective on only the actions it can require of itself.[36]

The State Water Board made a similar error when it adopted the water quality control plan at issue in *Racanelli*; basing an objective on what can be required using only the State Water Board's regulatory authority. In *Racanelli*, the State Water Board improperly limited water quality objectives to conditions that could be achieved through regulation of the water rights of the CVP and SWP only. (*Racanelli*, 182 Cal.App.3d at 116.) The court explained the State Water Board erred in assuming "that upstream users retained unlimited access to upstream waters," which prevented it from fulfilling the statutory directive "to consider . . . all competing demands for water in determining what is a reasonable level of water quality protection (§ 13000) . . . as well as '[w]ater quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.'" (*Id*. at 118.) In other words, "in order to fulfill adequately its water quality planning obligations, we believe the Board cannot ignore other actions which could be taken to achieve Delta water quality, such as remedial actions to curtail excess diversions and pollution by other water users." (*Id*. at 120.) As a result, the effect of the Draft Staff Report's failure to address non-flow measures in favor of a flow-only approach is similar to the State Water Board's self-imposed limitation in *Racanelli* – its approach to water quality control planning is rendered defective from the start. (*Id*. at 116.)

(a) The VA Alternative Provides Analysis Regarding the Protections that Could be Achieved Through Coordinated Control of All Factors Affecting Fish and Wildlife

The VA alternative includes flow and non-flow measures that are implemented by a group of state and federal agencies, local water agencies, private companies, and a non-profit mutual benefit corporation as an alternative to the proposed Plan amendments. These actions address a wide array of factors that affect water quality for fish and wildlife and other beneficial uses, and represent a significantly more-diverse approach than the proposed Plan amendments. As a result,

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[36] The Draft Staff Report acknowledges that non-flow actions are required for the reasonable protection of fish and wildlife but has explicitly deferred its obligation to identify those actions under the premise that these actions are "beyond what the State Water Board can require." (Draft Staff Report at pp. 4-1 - 4.2.)

the Draft Staff Report's evaluation of the benefits of the VA alternative includes analysis regarding the protections that could be achieved through coordinated control of all factors.

4. Flow Is Not a Lawful Parameter for a Water Quality Objective

The proposed Plan amendments that include water quality objectives based on flow, such as the proposed new inflow requirements defined using a percentage of instream flow, suffer from another fatal inconsistency with the Porter-Cologne Act. Flow is not a lawful parameter for a water quality objective.

As used in the Porter-Cologne Act, the term "water quality objective" means: "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." (Wat. Code, § 13050(h).) Flow is not a measure of water quality; flow is a measure of water volume. (Merriam-Webster Dict., at https://www.merriamwebster.com/dictionary/flow [defining flow as "the quantity that flows in a certain time"]; Dictionary.com at https://www.dictionary.com/browse/flow [defining flow as "the volume of fluid that flows through a passage of any given section during a unit of time"]; Donald W. Meals and Steven A. Dressing, Surface Water Flow Measurement for Water Quality Monitoring Projects, Tech Notes 3 (March 2008) Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc. at https://www.epa.gov/nps/nonpoint-source-monitoring-technotes, p. 2 [defining surface water flow as "the volume of water that passes through a channel cross section in a specific period of time"].) Water volume is not a measure of water quality. That is, a description of the *quantity* of water does not describe the *quality* of the water. To illustrate, a gallon of water may be pure or contaminated, fresh or saline, clear or turbid, hot or cold. That it is a gallon of water says nothing about the quality of the water. Like volume measured by the gallon, volume measured by a percentage of unimpaired flow is not a proper parameter for a water quality objective because it is not a water quality constituent or characteristic.

Subdivision (g) of Water Code section 13050 defines the term "quality of the water" as the "chemical, physical, biological, bacteriological, radiological, and other properties and characteristics of water which affect its use." In the 1995 Bay-Delta Plan the State Water Board relied on this definition to justify its adoption of flow-based water quality objectives, on the theory that flow is a physical property or characteristic of water. (1995 Bay-Delta Plan at 9.) That reliance is unfounded. The definition of "quality of the water" in subdivision (g) refers to the properties and characteristics of "water." (Wat. Code § 13050(g).) Examples of the "physical" properties or characteristics of "water" which affect its use include color, odor, taste, and temperature. For example, cloudy water may be unsuitable for use as drinking water due to appearance or taste. Water that is too high in temperature may be unsuitable to sustain use by some species of fish, or its warmth may encourage the growth of algae or vegetation renders the water unsuitable for recreational uses such as swimming or boating. These are examples of physical properties or characteristics of water that affect use of the water. In contrast, whether there is a large volume or a small volume of cloudy water does not alter what uses can be made of the water.

In the 1995 Bay-Delta Plan the State Water Board relied on the definition "quality of the water" in subdivision (g) to justify use of flow as a water quality objective. (1995 Bay-Delta Plan at 9.) It explained that flow is one of the physical properties or characteristics of the relevant water body, "the Bay-Delta Estuary." Indeed, flow can be a physical property or characteristic of a water *body* such as a river, stream or estuary. However, the State Water Board's view that flow can be a water quality objective, and its reliance upon subdivision (g) to support that view, depends upon impermissibly adding the words "or a water body" to the definition in subdivision (g). When construing a statute, a court's task is to "ascertain and declare what is in terms or in substance contained therein, not to insert what has been omitted, or to omit what has been inserted." (*Wilson v. Safeway Stores, Inc.* (1997) 52 Cal.App.4th 267, 271.) The definitions in subdivisions (h) and (g) of Water Code section 13050 refer only to water, not a water body. The State Water Board's interpretation depends upon doing what courts have explained it cannot.

In addition to being contrary to the statutory text, the State Water Board's use of flow as a parameter for a water quality objective undermines the process and standards set out in the Porter-Cologne Act. The State Water Board is in essence taking a regulatory short cut, one that skips the valuable, broad-based analysis required by the Porter-Cologne Act when adopting water quality objectives. Under section 13241, the State Water Board is directed to determine the water *quality* constituents or characteristics that are needed to ensure the reasonable protection of beneficial uses. That is, it must define the limits or levels of water quality characteristics such as temperature, clarity, bacteria, salinity or other measures that are consistent with reasonable protection of beneficial uses. Doing so requires a rigorous, science-based approach that informs sound decision making. Instead of defining the water quality characteristics needed for reasonable protection, the State Water Board is proposing to use flow as a proxy or substitute for the desired water quality characteristics.

Under the Porter-Cologne Act, when setting water quality objectives, the State Water Board is required to decide what level of water quality protection is reasonable, and to describe the means of achieving that level of water quality in a program of implementation. Regulation of diversions to affect flow is one means of implementing water quality objectives. By using flow as a parameter, the State Water Board has substituted a means of implementation for what section 13241 requires it to do when adopting a water quality objective—defining the water *quality* constituents or characteristics necessary to achieve reasonable protection of beneficial uses. Using flow as a parameter for water quality objectives suggests that requiring more instream flow is an end in itself. That is, whether the objectives require more flow and at what level, rather than whether such flows provide reasonable protection of beneficial uses, has become the State Water Board's apparent benchmark. That approach is contrary to and a misuse of its authority pursuant to the Porter-Cologne Act.

Even if the statutory definitions were ambiguous, and the State Water Board's interpretation that flow may be a parameter for a water quality objective were a permissible interpretation given such ambiguity, the State Water Board still could not lawfully rely on that interpretation for the proposed Plan amendments. The State Water Board has not complied with the requirements of the Administrative Procedure Act ("APA") for its interpretation. A "regulation" subject to the APA includes "every rule, regulation, order, or standard of general application" adopted by a state agency to "implement, interpret, or make specific the law enforced or administered by it." (Gov. Code, § 11342.600.) The State Water Board has not followed the requirements of the APA for its regulation interpreting the Porter-Cologne Act to allow use of flow as a parameter of water quality. Government Code section 11340.5 prohibits a state agency from relying upon any regulation not "adopted as a regulation and filed with the Secretary of State pursuant to this chapter." (*Id*. at § 11340.5(a), emphasis added.) Even if, as the State Water Board has contended regarding the 2018 amendments, its interpretation is a part of water quality planning and therefore subject to Government Code section 11353, it still must comply with the requirements in subdivision (b) of Government Code section 11353. To date, the State Water Board has not satisfied even those more limited APA requirements for its interpretive regulation.

In summary, the State Water Board must exercise its authority to adopt water quality objectives consistently with section 13241 and the definitions in subdivisions (g) and (h) of section 13050. Under the Porter-Cologne Act, when setting water quality objectives, the State Water Board must define the water *quality* constituents and characteristics necessary to ensure reasonable protection of beneficial uses. Flow is not a water *quality* constituent or characteristic within the meaning of the Porter-Cologne Act, and the State Water Board therefore cannot lawfully use flow as a parameter for a water quality objective in the proposed Plan amendments.

C. Adoption of the Proposed Plan Amendments Based on the Draft Staff Report Would Be Contrary to Article X, Section 2 of California's Constitution

As we have explained above, the Draft Staff Report provides only flawed and incomplete information and analysis with respect to the proposed Plan amendments. To adopt the numeric and flow-based objectives in the proposed Plan amendments when critical information regarding whether expected benefits and potential costs of that use would be an unreasonable use of water, and violates Article X section 2 of the California Constitution. Article X, section 2 provides:

> It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.

(Cal. Const., art. X, § 2.) Water Code section 100 imposes the same prohibition against waste and unreasonable use. Water Code section 275 directs the State Water Board to "take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water in this state."

The State Water Board's adoption of the proposed Plan amendments would be subject to Article X, section 2. (*City and County of San Francisco v. Regents of University of California* (2019) 7 Cal.5th 536, 558 ["the California Constitution is the paramount authority to which even sovereignty of the state and its agencies must yield"].) "[G]overnment actors are bound by the self-executing proscriptions of article X, section 2, and therefore can be held accountable in court or before the proper administrative agencies if they use water in a wasteful and unreasonable manner." (*Los Angeles Waterkeeper v. State Water Resources Control Board* (2023) 92 Cal.App.5th 230, 272.) "As the Supreme Court recognized soon after Article X, Section 2 was added, the rule limiting water use to that reasonably necessary 'appl[ies] to the use of all water, under whatever right the use may be enjoyed.' The rule of reasonableness is now 'the overriding principle governing the use of water in California.'" (*Light v. State Water Resources Control*

Board (2014) 226 Cal.App.4th 1463, 1479 [quoting (*Peabody v. City of Vallejo* (1935) 2 Cal.2d 351, 367–368 and *People ex rel. State Water Resources Control Bd. v. Forni* (1976) 54 Cal.App.3d 743, 750.].) "All uses of water, including public trust uses, must [] conform to the standard of reasonable use." (*National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419, 443.) How *much* benefit a use provides also matters for reasonableness. That a particular use of water provides *some* benefit does not establish that it is necessarily reasonable. Claiming that any benefit from a use is enough to satisfy Article X, section 2 "ignores rather than observes the constitutional mandate." (*Joslin v. Marin Municipal Water Dist.* (1967) 67 Cal.2d 132, 143.) Finally, what constitutes reasonable use is case-specific. "California courts have never defined ... what constitutes an unreasonable use of water, perhaps because the reasonableness of any particular use depends largely on the circumstances." (*Light*, 226 Cal.App.4th at 1479.)

Water Code section 13247 provides state agencies "shall comply" with water quality control plans. (Wat. Code, § 13247.) The State Water Board and other state agencies are required to exercise their authorities in a manner consistent with water quality objectives as adopted. (*Id.; State Water Resources Control Board Cases* (2006) 136 Cal.App.4th 674, 730.) As the current amendment process demonstrates, water quality objectives are not quickly or easily amended after adoption.

It is essential that the State Water Board understand the costs and benefits of adopting new water quality objectives at the *time of adoption*, and not defer that analysis until later. That is particularly so with the proposed numeric objective for Delta inflow. The proposed inflow objective would require "inflows from the Sacramento/Delta tributaries at 55% of unimpaired flow, within an allowed adaptive range between 45 and 65% of unimpaired flow." (Draft Staff Report at p. 5-17.) Adoption of that objective would be a decision to commit a volume of water, at minimum 45% of unimpaired flow, to instream uses each year.

As is explained above, the Draft Staff Report lacks the information and analysis necessary to determine what benefits the proposed Plan amendments are expected to provide and at what cost to other beneficial uses. By design, the State Water Board would defer analysis and decisions essential to adoption of objectives to a later phase, during implementation of the already-adopted objectives. For example, the Draft Staff Report does not identify the biological goals for the fish intended to be benefited by the flow-based amendments, instead deferring definition of those goals to implementation after adoption of the proposed Plan amendments. (Draft Staff Report at pp. 5-64 – 5-65; see also, *supra*, Section I.B.2(a).) Likewise, new reservoir operating criteria necessary to preserve cold water habitat will be required if the inflow objectives are adopted, because meeting the instream flow requirements will deplete reservoir storage. But the State Water Board would defer defining what those measures will be to implementation, making it impossible to determine the benefits and costs of the proposed water quality objectives at the time of adoption. (Draft Staff Report at p. 5-23 – 5-24.) Despite acknowledging that the full set of conditions fish need to thrive include factors other than flow, the Draft Staff Report fails to analyze what water quality conditions could be achieved through the coordinated control of *all* factors, including through use of non-flow measures.

Under Water Code section 13247, if the proposed Plan amendments are adopted, the State Water Board will be bound to require water rights holders to limit their diversions to meet the numeric inflow objective. Adoption of that objective would leave no room to sort out later, such as during implementation, questions of whether requiring that volume of flow in a particular watershed, or in the Delta, or through the Delta as outflow is a reasonable use of water. A minimum of 45% of unimpaired flow for inflow to the Delta will be mandated. The volume of water prescribed by the objective would have to be left instream regardless of the benefits for fish, and would be largely unavailable for other beneficial uses regardless of the costs to other uses. Substantial volumes of water would thus flow to the ocean to the detriment of existing beneficial uses before the State Water Board even understands what benefits will likely be realized therefrom or at what cost. That would be poor stewardship of the state's water resources.

In essence, the proposed numeric inflow objective would commit a defined quantity of water to instream use without and before an assessment of whether doing so will use the water resources of the state "to the fullest extent of which they are capable" or consistently with "the reasonable and beneficial use thereof in the interest of the people and for the public welfare." Adopting numeric flow-based objectives and deferring to later on how to make wise use of that set volume of water is a "ready, fire, aim" approach. It would be an unreasonable use of water and hence violate Article X, section 2 of the California Constitution.

II. Additional Specific Comments on the Draft Staff Report

A. Appendix A – Modeling for Unimpaired Flow Scenarios

1. Appendix A1 (Inconsistent Baselines Used for Modeling)

San Joaquin River inflow is an important modeling component that affects Delta exports. However, the modeling assumptions for San Joaquin River inflow that were used to simulate hydrological changes under the VA alternative differs from the modeling assumptions that were used to simulate hydrological changes under the proposed Plan amendments.

Concerning the San Joaquin River ("SJR") input (inflow) to the Sacramento Water Allocation Model ("SacWAM") analyses, staff has incorporated a CalSim 3 baseline data set for Vernalis that equates to an average annual flow of approximately 2,662 thousand acre-feet ("TAF") and will manifest into a certain set of hydraulic/hydrological consequences throughout the Delta and SacWAM domain, including Delta Outflow, internal Delta circulation, and Delta Exports. In contrast, the SJR input for the State Water Board's Water Supply Effects modeling of the VAs alternative ("WSE-VA") incorporates a different baseline (CalSim II based) that is used to simulate incremental changes at Vernalis due to differing San Joaquin River flow operations. The CalSim II based result at Vernalis equates to an average annual flow of approximately 3,130 TAF, which would manifest a different set of hydraulic/hydrologic consequences throughout the SacWAM domain, and/or provide a baseline in WSE-VA different than was used to evaluate the proposed Plan amendments. This discrepancy caused an inconsistent and misrepresentative baseline in one or both models and complicates effective comparisons between modeling results.

2. Appendix A1 (SacWAM Modeling of Changes to Delta Salinity)

The Draft Staff Report's method of modeling Delta salinity/flow for the proposed Plan amendments is inadequate and flawed. The Draft Staff Report states that the Vernalis flow data set does not change among baselines or alternative scenarios, and that the Delta Simulation Model II ("DSM2") and Delta flow relationships are not changed among alternatives in the context of

Vernalis flow and quality. Results for interior Delta conditions and Delta outflow would be different from that presented if full integration of changed Vernalis flows was integrated within scenario analyses.

The Draft Staff Report's post-analysis adjustment to SacWAM (without SJR actions) results, as described in Section G3a.2.5, beginning at page G3a-9, is not adequate to illustrate all of the hydrologic/hydraulic effects of changes to SJR flows. The assumed incremental changed flows at Vernalis will manifest throughout the Delta, not just at selected points of interest or compliance. The estimated incremental changes in Vernalis flow should be implemented throughout the modeling tools.

3. Appendix A1 (CVP Deliveries Among Customer Sectors and Total Delta Exports)

The Draft Staff Report's evaluation of the proposed Plan amendments' water supply impacts to the CVP is flawed. The CVP customer sector delivery statistics, which are depicted in a series of graphs in Appendix A1 (*e.g.*, section A1.12.8.54), suggest that State Water Board staff did not correctly incorporate current water delivery allocation forecasting procedures or correct temporal delivery assumptions for annually allocated water in its modeling of the proposed Plan amendments. Further, the Draft Staff Report does not include comprehensive modeling to inform the reviewer if water shortages to the south of Delta Exchange Contractors can in fact be met by exercising water rights to divert from the San Joaquin River, as suggested in the text.

B. Chapter 3 – Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations

1. Section 3.2.1, p. 3-3

The Draft Staff Report states that: "Implementation of a more natural flow regime with high spring flows has been shown to favor native over nonnative species in Putah Creek, although nonnatives still dominate in the lowermost reach (Kiernan et al. 2012)."

To the contrary, Kiernan et al. 2012 states:

> We propose that the expansion of native fishes was facilitated by creation of favorable spawning and rearing conditions (e.g., elevated springtime flows), cooler water temperatures, maintenance of lotic (flowing) conditions over the length of the creek, and displacement of alien species by naturally occurring high-discharge events. Importantly, restoration of native fishes was achieved by manipulating stream flows at biologically important times of the year and only required a small increase in the total volume of water delivered downstream (i.e., water that was not diverted for other uses) during most water years. Our results validate that natural flow regimes can be used to effectively manipulate and manage fish assemblages in regulated rivers.

This study highlights the importance for flow measures to be implemented at biologically critical times to disrupt non-natives and recognizes the need for multiple factors to be in place to manage non-native fish. The Draft Staff Report's discussion of the benefits of unimpaired flow with respect to invasive species should be revised to acknowledge that existing studies have focused on using water at biologically important times, and have hypothesized that these benefits can be achieved with only a "small increase in the total volume of water delivered downstream."

2. Section 3.14.1.1, p. 3-112

The Draft Staff Report states that: "The significant difference between these flow levels indicates that existing Bay-Delta Plan and [2019] BiOp flow requirements are not adequate to ensure Delta outflow conditions necessary for the reasonable protection of fish and wildlife beneficial uses."

To the contrary, the figures that follow (Figures 3.14-2 – 3.14-5) fail to demonstrate that the BiOp flow requirements are not adequate, as the demonstrated flow requirement level of the 2019 BiOps is not separated out from the other requirements within the baseline.

3. Chapter 3 (Current Longfin Smelt Abundance Trends)

In discussing the scientific basis for a decline in longfin smelt abundance, the Draft Staff Report presents a re-analysis of "the most recent Fall Midwater Trawl ("FMWT") indices" (pg. 3-55) including data from 1967-2016. First, data through 2016 is not the most recent since FMWT indices of abundance are available from California Department of Fish and Wildlife ("CDFW") for the period from 2017-2023, which have not been included in the SWRCB analysis. Second, the CDFW FMWT surveys longfin smelt abundance indices only during September-December and only at sampling locations in the western Delta and Suisun Bay. Data from the midwater trawl and otter trawl sampling by CDFW demonstrate that a portion of the longfin smelt population is present in San Pablo and San Francisco Bays and therefore are not included in the FMWT survey further upstream.

The Draft Staff Report, to be complete, should present an up-to-date analysis of trends in abundance based on both the midwater trawl and otter trawl sampling, recognizing that an additional portion of the longfin smelt population resides in coastal marine waters that are not sampled for longfin smelt at all. Although the Draft Staff Report presents results of the relative abundance indices for longfin smelt, it does not discuss the fact that there are no absolute estimates of longfin smelt abundance each year from the estuary. In addition, the discussion of the Delta outflow and abundance index for longfin smelt (Figure 3.5-2 pg. 3-57) is based on the same incomplete data (e.g., based on relative indices of abundance and not population estimates, does not include data for 2017-2023) as discussed above. The high variance and uncertainty in the flow-abundance index analysis presented in the Draft Staff Report produces estimates of the Delta outflow needed to produce a 50% probability of population growth ranging from 51,000 cfs between January and March, 42,800 cfs from January to June, and 35,000 cfs between January and March. (Draft Staff Report at p. 3-57.) The flow estimates that range from 35,000 to 51,000 cfs, but that produce the same predicted population response, reflect the high degree of uncertainty in the Draft Staff Report's assessment of Delta outflows.

4. Chapter 3 (Flow Abundance Correlation for Longfin Smelt)

Chapter 3 discusses flow-abundance correlations for a number of fish and invertebrates with the underlying premise that higher Delta inflow and outflow will produce greater abundance and that lower outflow will produce lower indices of species abundance. The Draft Staff Report should be revised to clearly articulate that correlation is not causation. Longfin smelt are cited as the species with the strongest correlation between outflow and abundance. However, the longfin smelt correlation between outflow and abundance has changed substantially in recent years, such that the same level of Delta outflow no longer is correlated with the earlier relationship. (See *infra* Figures 1 and 2.) The data from the CDFW Bay Study surveys, depicted below in Figures 1 and 2, provide a better representation of longfin smelt distribution and abundance when compared to the FMWT data depicted in Figure 3.5-2.

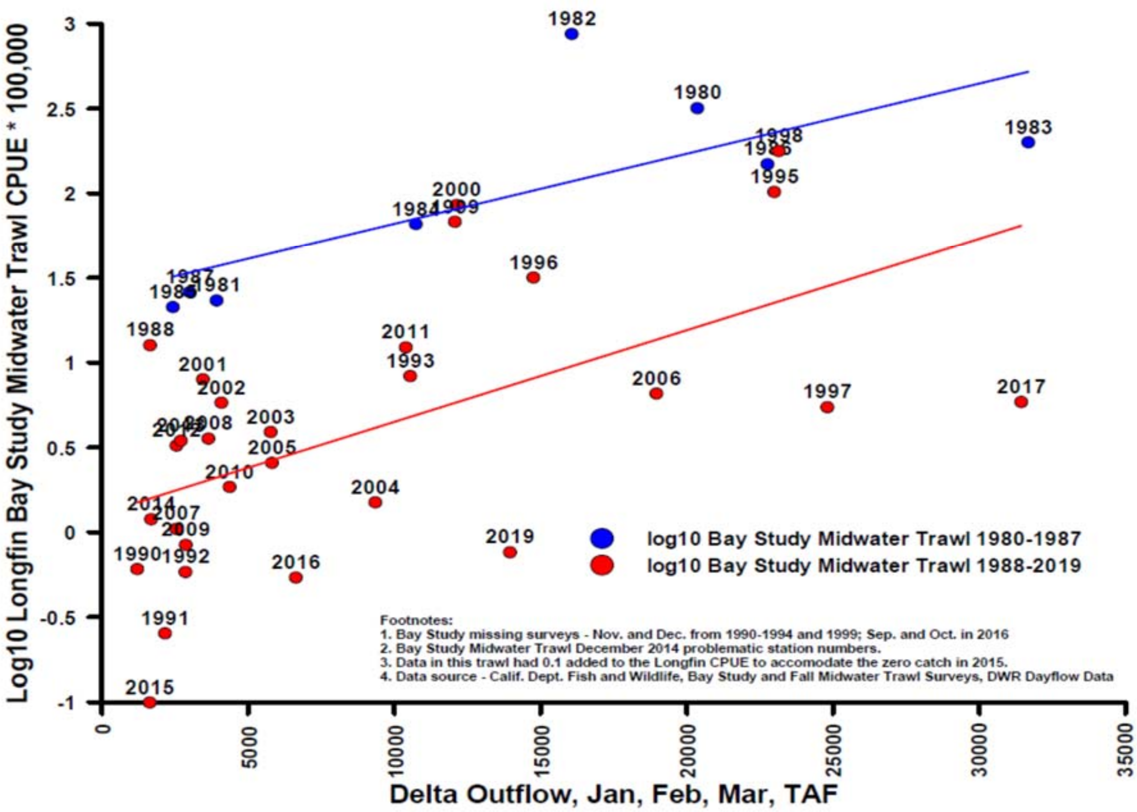

Figure 1. Relationship between Log10 Bay Study Midwater Trawl longfin smelt catch and Delta Outflow (Jan-Mar), in surveys from 1980 through 2019.

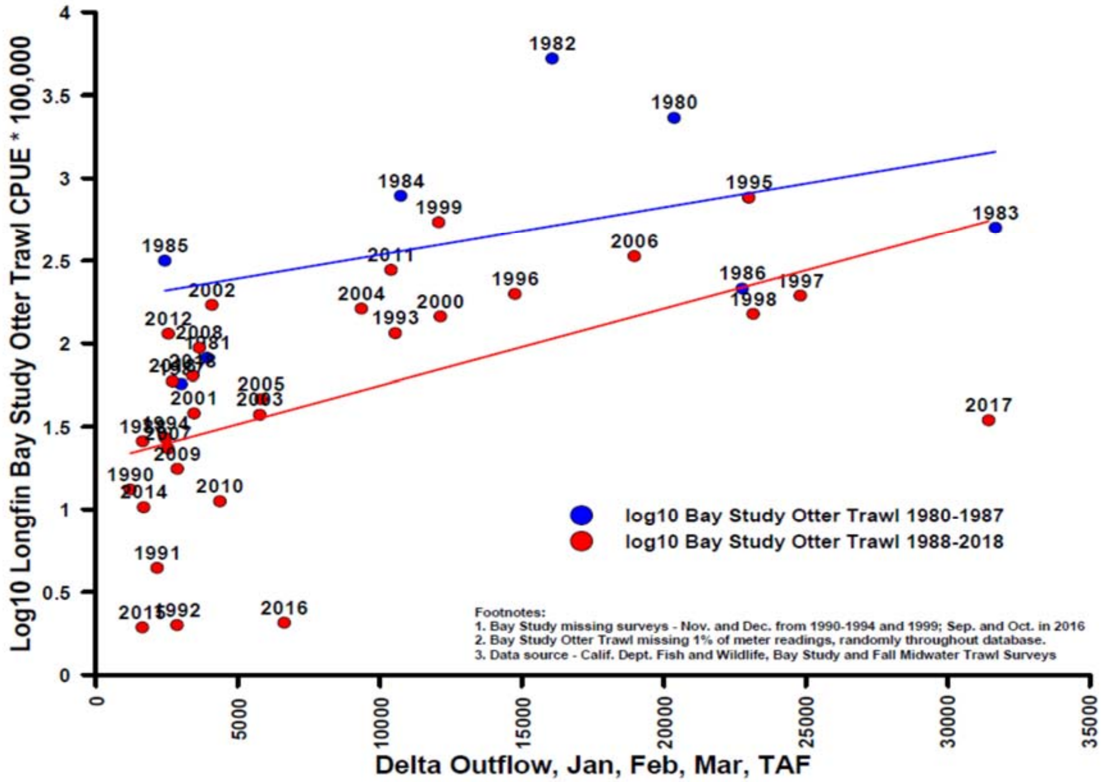

Figure 2. Relationship between Log10 Bay Study Otter Trawl (OT) longfin smelt catch and Delta Outflow (Jan-Mar), in surveys from 1980 through 2018

Further, longfin smelt abundance indices would be predicted to increase substantially in wet years with high winter-spring outflow and be low in years of drought when Delta outflow is low. However, the CDFW FMWT abundance index for recent wet and dry years, shown below, does not support that conclusion:

Year	Condition	Longfin smelt index
2011	Wet	477
2017	Wet	141
2021	Dry	323
2022	Dry	403
2023	Wet	464

The Draft Staff Report (Figure 3.5-2 on pg. 3-57) presents the FMWT indices for longfin smelt relative to average January-June Delta outflow for 1967-2016. The Draft Staff Report did not include available data for the years 2017 – 2023. The explanatory notes for Figure 3.5-2 acknowledge that several step changes have occurred (declines in FMWT indices of longfin smelt abundance and the daily average January – June outflow relationship) that have been detected through statistical analyses related to introduction of the invasive Asian overbite clam (first detected in 1987) and the Pelagic Organism Decline (2003). Including data from 2017-2023 changes the interpretation and the narrative of the relationships between longfin smelt abundance and Delta outflow. Specifically, the positive relationship between longfin smelt abundance and Delta outflow appears to have declined further in recent years. (See *supra* Figures 1 and 2.) Further, evidence of a significant change in the population dynamics is evident in the longfin smelt abundance indices during recent drought conditions of 2021 and 2022 when the FMWT abundance was the highest observed since the extremely wet year of 2011, although the mechanisms underlying the variable relationship between outflow and longfin smelt abundance is unknown. The Draft Staff report presents a logistic relationship using FMWT data from 1967-2016 (Figure 3.5-3 pg 3-58) to predict longfin population response to Delta outflow but provides no discussion or acknowledgement of the responses in 2021 and 2022 that were not predicted using the earlier relationship.

The Draft Staff Report (Figure 3.14-1 on pg. 3-110) presents the FMWT indices for longfin smelt, delta smelt and Sacramento splittail relative to average January-June Delta outflow for 2008-2014. The Draft Staff Report did not include available data for the years 2015 – 2022. Including these additional years changes the interpretation and the narrative of the relationships. Specifically, the positive relationship between longfin smelt FMWT indices and Delta outflow is no longer observable using these data. (See *infra* Figure 3.) In fact, the longfin smelt abundance indices during 2021 and 2022 were the highest observed since the extremely wet year of 2011, although the Delta outflows were generally similar to those of the drought years of 2014-2015.

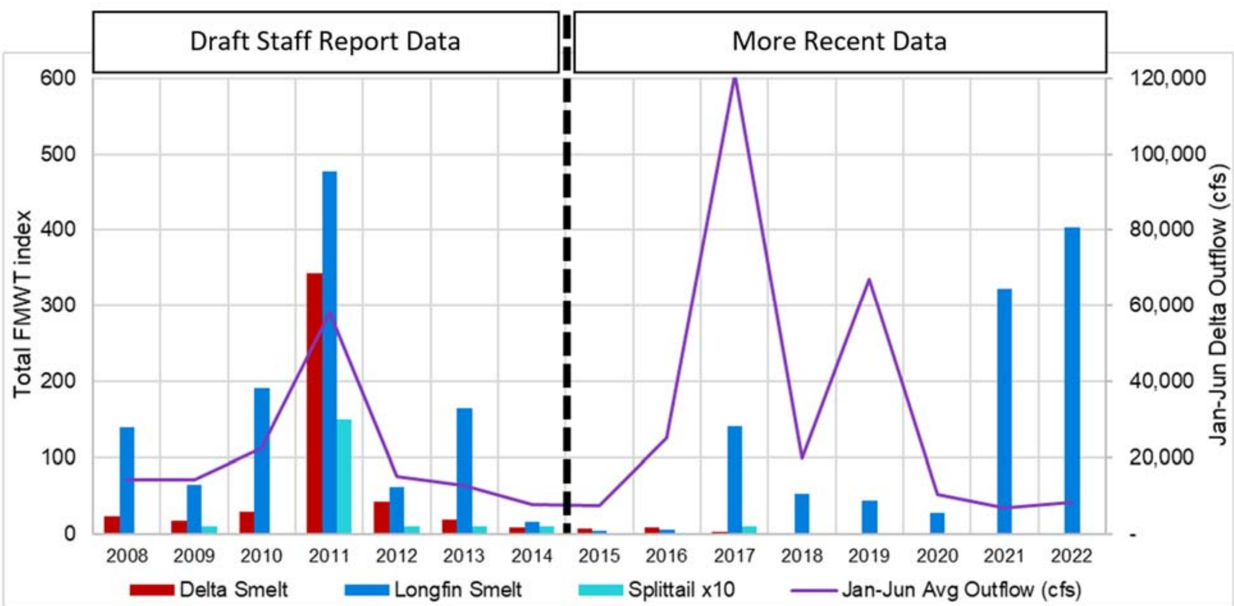

Figure 3. Updated version of Figure 3.14-1 from Pg. 3-110 of the Draft Staff Report showing FMWT indices for delta smelt, longfin smelt and Sacramento splittail with average January-June Delta outflow from 2008-2022.

Based on these recent FMWT results, there is a high degree of uncertainty in the accuracy of earlier predictions that longfin smelt abundance will increase substantially in response to high Delta outflow during the winter and early spring. The level of uncertainty in the outflow abundance relationship and the associated premise that longfin smelt abundance will increase substantially in response to increased Delta outflow is not discussed nor is it transparent in the Draft Staff Report. The level of uncertainty in flow-abundance relationships for other species presented in the Draft

Staff Report should also be presented since the underlying mechanisms affecting the population dynamics of these species are unknown.

5. Section 3.5.4.1, p. 3-56

The Draft Staff Report states that the "population abundance of longfin smelt in fall is positively correlated to Delta outflow or X2 as its proxy during the previous winter and spring", and "the strongest relationship is with outflow between January and June". (Draft Staff Report at p. 3-56.) However, Kimmerer and Gross (2022) study, attached hereto as Exhibit 2, found that "Population size was unrelated to freshwater flow in the year of hatching but positively related to the subsequent juvenile abundance index. Thus, the mechanisms underlying the strong variability in the annual abundance index of longfin smelt with freshwater flow are constrained to occur after March." (Kimmerer and Gross (2022) **Exhibit 2** at p. 1.)

This apparent contradiction in findings regarding the relationship between Delta outflow (or X2 location) during the spawning season and subsequent juvenile abundance is not discussed in the Draft Staff report. (See also, Draft Staff Report at p. 7.6.2-13.) In fact, neither Chapter 3 nor Chapter 7 acknowledge or cite the published paper by Kimmerer and Gross (2022).

The Draft Staff Report should be revised to include references to the published paper by Kimmerer and Gross (2022). It should also be revised to focus its evaluation of the effects of Delta outflow on the longfin smelt population during months outside of January-March.

6. Section 3.6

The Draft Staff Report discusses white sturgeon, noting that "[l]ong life and high fecundity make it possible for sturgeon to maintain a stable population with infrequent high-outflow years." (Draft Staff Report at p. 3-62.) In the absence of any further analysis of the frequency of high outflows needed to maintain a stable sturgeon population, the Draft Staff Report identifies a Delta outflow averaging 37,000 cfs or larger between March and July (Table 3.6-1 pg 3-68) but does not present estimates of how frequently that outflow is needed to maintain stable populations of either green or white sturgeon. In the absence of data reflecting the frequency that these outflows are needed, it would not be possible for the Draft Staff Report to assess if the proposed action provides reasonable protection of sturgeon.

7. Section 3.7 (Evaluation of the Big Notch Project)

The Draft Staff Report discusses the analyses that predict Delta outflows of 30,000 to 47,000 cfs between February and May are needed to produce strong year classes of Sacramento splittail. (Draft Staff Report at p. 3-68.) As discussed for sturgeon, the Draft Staff Report does not present results of lifecycle modeling to estimate the frequency at which these flows would be needed. The Draft Staff Report acknowledges that successful reproduction by splittail is linked to frequency and duration of floodplain inundation during the spring spawning season. The Draft Staff Report notes that the required average daily Delta outflow would not be as high as the 30,000 to 47,000 cfs (Table 3.7-1) if non-flow actions were taken to increase the frequency, duration, and magnitude of floodplain inundation in the Yolo Bypass and other floodplains. (Draft Staff Report at p. 3-70.)

The Draft Staff Report fails to discuss that the California Department of Water Resources ("DWR") has designed, permitted, and is currently completing construction of a large opening in the Freemont Weir (known as the Big Notch Project) that regulates floodplain inundation in the Yolo Bypass. Operation of the Big Notch Project to increase the frequency, duration, and magnitude of floodplain inundation in the Yolo Bypass, and the commensurate reduction in Sacramento River or Delta outflow needed for successful splittail spawning, is not presented in the Draft Staff Report or included in the hydrologic simulation modeling of the proposed Plan amendments. The hydrologic modeling presented in the Draft Staff Report does not reflect actual conditions contributing to floodplain inundation for splittail and many other resident and migratory fish, and therefore is not the best available scientific foundation for assessing effects of the proposed Plan amendments on splittail and other native fish that use floodplain habitat for spawning, egg incubation, larval rearing, juvenile rearing and growth, and as a migratory pathway for both juvenile and adult fish.

The Draft Staff Report should be amended to discuss and analyze: (a) whether the construction and operation of the Big Notch Project can increase the magnitude, frequency, and duration of seasonal floodplain inundation in the Yolo Bypass without an increase in Sacramento River flows; and (b) whether the construction and operation of the Big Notch Project would affect the daily Delta outflow recommendations presented in the Draft Staff Report.

8. Section 3.7

The Draft Staff Report (pg. 3-69 to 3-70) describes and displays the relationship between splittail abundance (FMWT catch data) against flow for years with a linear regression, showing a reduction in catch from 1976-2016. However, FMWT catch data should not be used for trends in Sacramento splittail abundance because splittail are a bottom-oriented species and the FMWT does not target bottom-oriented species (Malinich et al. 2022; Moyle et al. 2020). If Figure 3.14-1 on pg. 3-110 of the Draft Staff Report were to be updated, it would show 0 splittail catch in the FMWT data from 2018 through 2022, despite varying Delta outflow conditions.

By contrast, the UC Davis Suisun Marsh Study, which includes both otter trawl and beach seine surveys, should be used to illustrate trends in relative splittail abundance (Moyle et al. 2020; O'Rear et al. 2022) and assess recruitment goals.

The Suisun Marsh Study splittail catch data show an overall increasing trend in annual abundance since 1994, including the highest CPUE ever recorded in the Suisun Marsh Study's history (starting in 1980) in 2018 (O'Rear et al. 2022). Based on catch data going back to 1980, the Suisun Marsh Study demonstrates a recovery of CPUE to levels observed in the early 1980s and the resiliency of the splittail population during and subsequent to a multi-year drought. As stated by Moyle et al. (2020), although it should be carefully monitored given its limited distribution, splittail can be regarded as a management success over the past 10-20 years due to favorable flows, floodplain restoration, and potentially due to operation of the Salinity Control Gates on Montezuma Slough. As a result, the Draft Staff Report should be revised to include analyses of the correlation of splittail abundance based on increased flow or floodplain inundation using otter trawl surveys, as compared to FMWT data.

9. Chapter 3 (Incomplete References to Scientific Literature)

The references to scientific literature presented in Chapter 3 are incomplete. For example:

- The Draft Staff Report (p. 3-12) discusses high mortality rates of fish within Clifton Court Forebay, citing Castillo et al. 2012. The Draft Staff Report, however, fails to include any discussion of the scientific literature regarding quantification of pre-screen loss of juvenile steelhead in Clifton Court Forebay (Clark et al. (2009)) or the over 1,000 page compilation of Clifton Court Forebay predation studies compiled by US Bureau of Reclamation (https://www.usbr.gov/mp/bdo/docs/ba-appendix-g-clifton-court-forebay-predation-studies.pdf).

- The Draft Staff Report (pg. 3-48) discusses the salmonid survival studies for the San Joaquin River published by Buchanan, *et al.* in 2013 and 2018 but fails to discuss the much more comprehensive study results of the 6-year steelhead survival study published by Buchanan, *et al.* in 2021. The study published by Buchanan, *et al*. in 2021 is attached hereto as **Exhibit 1**.

- The Draft Staff Report fails to discuss the almost 500 page synthesis report prepared by DWR in 2015 titled "An Evaluation of Juvenile Salmonid Routing and Barrier Effectiveness, Predation, and Predatory Fishes at the Head of Old River, 2009–2012" (https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/State-Water-Project/Operations-And-Maintenance/Files/Bay-Delta/South-Delta-Temporary-Barriers-Project/Reports/An-Evaluation-of-Juvenile-Salmonid-Routing-and-Barrier-Effectiveness-Predation-and-Predatory-Fishes.pdf).

- The Draft Staff Report discusses the effects of Delta Cross Channel gate operation and Georgiana Slough on salmonid migration into the interior Delta and effects on survival (p. 3-44). The Draft Staff Report, however, fails to discuss or even include a citation to the extensive testing and studies done by DWR of the effects of behavioral barriers on salmonid migration into Georgiana Slough and juvenile survival (https://water.ca.gov/Programs/State-Water-Project/Operations-and-Maintenance/Georgiana-Slough-Salmonid-Migratory-Barrier-Project) and the DWR final report on pilot testing done in 2012 (https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626712.pdf).

- The Draft Staff Report's discussion of delta smelt abundance trends (pg 3-74 and 3-75) based on FMWT data from 1967 to 2016 is outdated (missing the most recent data from 2017 to 2023). The Draft Staff Report discusses the high level of uncertainty when assessing potential relationships between indices of delta smelt abundance and reproductive success (20 mm indices) and winter-spring outflow, summer outflow, and fall outflow. Baxter, *et al.* (2015) evaluated the potential relationship between spring outflow and the delta smelt 20 mm index over an 11-year period (2003-2013) and found statistical evidence suggesting a potential relationship (pg 3-76), however, they cautioned that the results should be considered preliminary until additional data, analyses, and review were completed. Results of extensive statistical analyses have recently been completed as part of developing current lifecycle models for delta smelt (Maunder and Deriso 2011, Hamilton and Murphy 2018, Rose, *et al.* 2013, and most recently Smith, *et al.* 2021) that offer insight into factors effecting delta smelt, including consideration of Delta outflow, are not discussed in detail in the Draft Staff Report. In fact, the Smith, *et al.* (2021) lifecycle model developed by the US Fish and Wildlife Service is not even cited in the Draft Staff Report. Further, the Draft Staff Report cites Feyrer, *et al.* (2007, 2011) as the scientific base for a fall outflow relationship with delta smelt preferred low-salinity habitat used in the 2008 United states Fish and Wildlife Service ("USFWS") BiOp. The Draft Staff Report does not discuss, however, that the habitat-outflow relationship presented by Feyrer, *et al.* Further, the staff report presents a relationship between the 20 mm delta smelt index of abundance and September-December average X2 location (Figure 3.8-4 pg 3-80) as part of the scientific foundation for the fall outflow recommendation based on the Baxter, *et al.* (2015) analyses that the authors cautioned as preliminary and needing further data and analysis. Despite scientific controversy and recent reinitiation of consultation with USFWS regarding delta smelt, the Draft Staff Report recommends inclusion of a summer outflow (X2< 80 km in July and August) and a fall outflow in wet and above normal water years (Table 3.8-1 pg 3-79) as one element of the proposed Plan amendments.

10. Chapter 3 (Non-Flow Actions Needed)

Natural flows are just one of many elements that impact the quality and availability of suitable habitat and the population dynamics of aquatic species. For example, many of the main Delta tributaries have been channelized by levees that significantly alter channel geometry. Under natural channel conditions, the availability of wetted channel habitat and floodplain inundation increase in response to increased instream flows that benefit fish and other aquatic species. As shown in Figures 4 and 5, below, increasing flows in channelized reaches of the Sacramento River does not translate to habitat benefits through inundation of shallow lower velocity channel margin habitat or floodplain. The predicted effectiveness of more natural flow regimes varies substantially among rivers based on geomorphology of the channels.

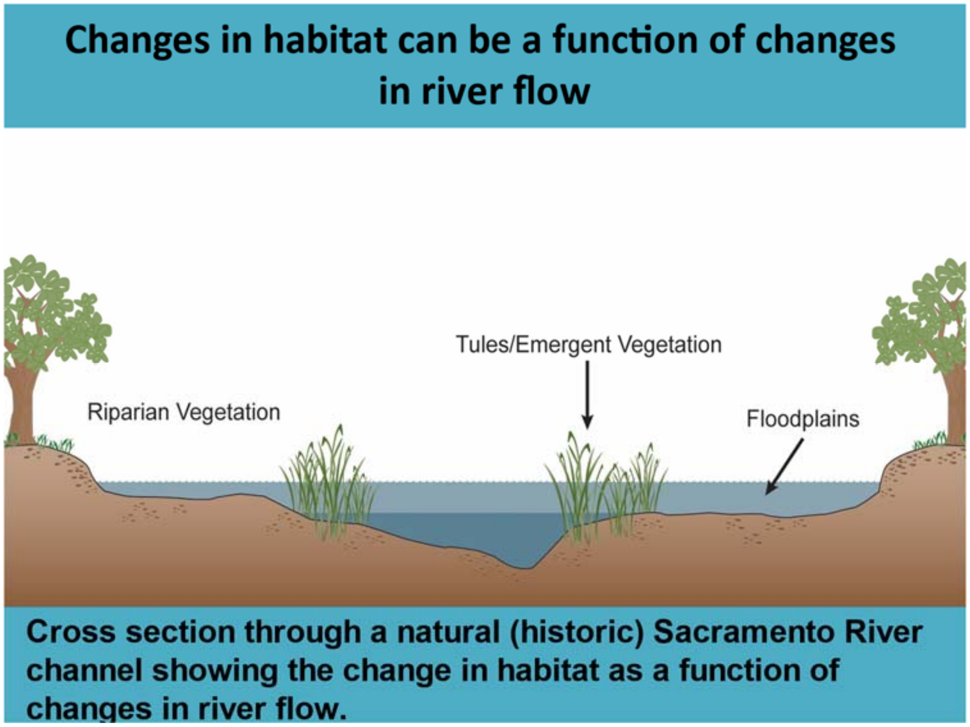

Figure 4. Cross section of a natural Sacramento River channel.

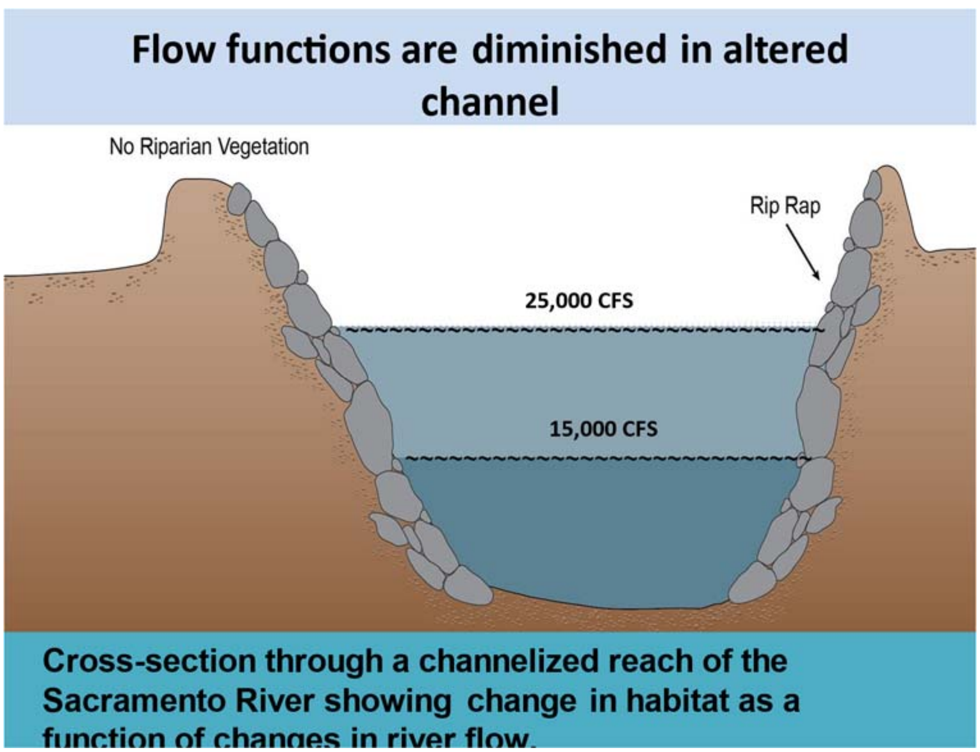

Figure 5. Cross section of a channelized reach of the Sacramento River.

C. Chapter 4 – Other Aquatic Ecosystem Stressors

1. Section 4.4.1, p. 4-22

The Draft Staff Report states: "The altered hydrology creates more competitively favorable conditions for spawning and rearing of nonnative species than for native organisms (Brown and Bauer 2009), suggesting that a return to a more natural hydrology may be one of the few ways of favoring native species at the expense of introduced ones (Bunn and Arthington 2002)."

In reviewing the citation Bunn and Arthington 2002, it does not appear to support the claim that "a return to a more natural hydrology may be one of the few ways of favoring native species at the expense of introduced ones." Instead, this source outlines the importance of flow and impacts of altered flow regimes but does not appear to comment on the effectiveness of returning an altered hydrograph back to a more natural hydrograph and if that will decrease introduced species after they have already been established. In relevant part, Bunn and Arthington 2002 provides that "[c]urrently, evidence about how rivers function in relation to flow regime and the flows that aquatic organisms need exists largely as a series of untested hypotheses. To overcome these problems, aquatic science needs to move quickly into a manipulative or experimental phase, preferably with the aims of restoration, and measuring ecosystem response."

The statements on pg. 4-22 of the Draft Staff Report should be revised because the study does not suggest "that a return to a more natural hydrology may be one of the few ways of favoring native species at the expense of introduced ones." Alternatively, the citation should be deleted.

2. Section 4.5.2, p. 4-30

The Draft Staff Report states: "Recent reviews and evaluations of these hatchery programs (California Hatchery Scientific Review Group 2012 and Hatchery Genetic Management Plans) have led to a number of proposed strategies or recommended changes in hatchery policies and management to address these impacts and assist in the conservation and recovery of listed evolutionary significant units and distinct population segments and other naturally spawning Chinook salmon populations. These recommendations include marking hatchery-produced fish to distinguish them from naturally spawned individuals, examining the role and contribution of existing hatchery production to overall population abundance, and maintaining genetic diversity and integrity of different runs."

The Draft Staff Report should be revised to recognize the work that has been done in rivers/tributaries both before the review and in response to the review. Additionally, the Draft Staff Report should describe its recommendations with more specificity. The cited review of hatchery programs did not recommend a blanket marking approach to hatchery-produced fish to distinguish them from naturally spawned individuals. Instead, it offered specific recommendations of the amount of marking that should occur: "For Chinook salmon mitigation/harvest programs, the California HSRG recommends tagging 100 percent of hatchery-released fish with CWT plus marking 25 percent of hatchery-released fish by adipose fin-clip." "For Chinook salmon conservation-oriented programs (winter run Chinook salmon produced at Livingston Stone Hatchery), the California HSRG recommends 100 percent CWT plus 100 percent adipose fin-clip marking and tagging."

D. Chapter 5 – Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta

1. Sections 5.4.2.1 and 5.4.2.2, pp. 5-13 – 5-15

With respect to certain Sacramento/Delta tributaries, the Draft Staff Report states that "some of these tributaries may dry up at times of year, affecting native fish and wildlife due to the lack of flow requirements; and other tributaries may have inadequate flow and water quality conditions to protect fisheries resources." (Draft Staff Report at p. 5-14.) In response, the proposed action would include a requirement for year-round inflows in the Sacramento/Delta tributaries. (*Ibid*.) However, the Draft Staff Report does not provide any analysis to demonstrate that it is feasible to satisfy minimum instream flow and water quality conditions year-round in all Sacramento/Delta tributaries, particularly during consecutive drought years.

2. Section 5.6.1.3, pp. 5-56 – 5-57

The Draft Staff Report highlights numerous uncertainties and information gaps associated with implementation of the numeric unimpaired flow requirement. Specifically, it has not developed any method to "determine required streamflows under the proposed Plan amendments." (Draft Staff Report p. 5-56.) Specifically, the "proposed program of implementation would include provisions for development of methods to determine unimpaired flow and required flow levels for applicable tributaries and the Delta, including methods to estimate and account for losses to groundwater and riparian vegetation, including floodplain inundation. The program of implementation also would include provisions for forecasting." (*Ibid*.) These statements demonstrate that the significant uncertainties associated with implementation of the proposed Plan amendments. In comparison, the VA alternative does not involve these major uncertainties.

Historically, estimates of unimpaired flow have been very difficult to quantify and were only intended to provide a rough comparison to historical observed flows on a seasonal timescale. In the past, estimates of unimpaired flow were calculated well after the runoff season was over.

Implementation of the proposed Plan amendments will require the unimpaired flow objective to be implemented in real time, requiring significant new investment in monitoring and gaging (with no assurance that adequate monitoring will occur). Computing these unimpaired flows in real time, on a daily basis, is unproven for the purpose of regulatory compliance. Factors that make it difficult to quantify unimpaired flows include: limited number of gaging locations, uncertainty regarding snowmelt runoff dynamics, uncertainty about total number of small and medium diversions and return flows in the system, and uncertainty about stream-groundwater interaction. The Draft Staff Report does not suggest that it will be feasible to resolve these uncertainties in the timeframe required for implementation.

In contrast to the proposed Plan amendments, the operations and actions outlined in the VA alternative are better defined and understood, are closer to the range of historic operations.

3. Section 5.6.1.4, pp. 5-63 5-64

Section 5.6.1.4 discusses developing SMART (specific, measurable, achievable, relevant, and time-bound) quantitative measurable biological goals that would be developed to evaluate performance of the proposed Plan amendments. (Draft Staff Report at pp. 5-63 – 5-64.) Because quantitative biological goals (*e.g.*, abundance, productivity, genetic and life history diversity, population spatial extent, distribution, structure, and quantity of spawning, rearing, and migration habitat, juvenile production, and juvenile outmigrant survival) have not been developed, it is not clear how any analysis was performed to determine that the proposed Plan amendments will meet the objectives of the Bay Delta Plan Update or provide a reasonable level of protection for fish and wildlife. In addition, the Draft Staff Report does not discuss how these SMART objectives will be applied to evaluating performance of the proposed Plan amendments. For example, if the population of a target fish species does not meet the quantitative biological goal, what tools will the State Water Board use to determine whether the cause was insufficient instream flow or other stressors that are outside the control of the proposed action (*e.g.*, insufficient quantity and quality of physical habitat, bioaccumulation of contaminants, poor ocean productivity and food supplies, etc.)?

4. Chapter 5 (Balancing Beneficial Uses)

The Draft Staff Report notes that the proposed Plan amendments are intended to <u>maximize</u> the benefits of flows in protecting native fish and wildlife in a reasonable manner with protection for other beneficial uses (with the exception that p. 5-19 reports a balancing goal is to provide minimum health and safety water supplies in drought years). (Draft Staff Report at p. 5-10.) Balancing competing water allocations for a variety of beneficial uses implies that the proposed Plan amendments are intended to provide a <u>reasonable</u> level of protection for sensitive fish and other aquatic species inhabiting the Bay-Delta estuary. The Draft Staff Report does not appear to balance competing beneficial uses of the available water supply but rather identifies actions that **maximize** fish benefit (Draft Staff Report at pp. 5-19, 5-20, 5-31, 7.6.2-54) and **optimize** flows for fisheries protection (*Id*. at 7.6.2-99). The Draft Staff Report does not clearly describe the balancing done to achieve a reasonable level of protection for sensitive aquatic species. The proposed Plan amendments require annual operations plans be developed for State Water Board approval that avoid or minimize any potential adverse impacts of reservoir operations on recreation, terrestrial species, aesthetics, power generation, cultural, and other environmental resources but omits adverse impacts on water supplies. (Draft Staff Report at p. 5-24.)

The Draft Staff Report should be revised to include more explicit consideration regarding other beneficial uses of water and how to optimize flows for fisheries protection while protecting other existing and future beneficial users of water, as required by the Porter-Cologne Act.

E. Chapter 6 – Changes in Hydrology and Water Supply

MBK Engineers has prepared a technical review of the Draft Staff Report and associated modeling. The MBK report provides useful information the State Water Board should consider. A copy of MBK's report will be submitted together with the comments by other water agencies, and hence the Water Authority and its Member Agencies will not submit another copy. The MBK Report confirms that the information and analysis in the Draft Staff Report does not support adoption of the proposed Plan amendments.

In summary, MBK's technical review: (1) compares the VA alternative with the proposed Plan amendments; (2) summarizes independent modeling of the VA alternative done by the Department of Water Resources using the CalSim 3.0 model; (3) describes the unavoidable impacts caused by unimpaired flow based requirements, such as are included in the proposed Plan amendments; (4) describes key information that is missing from the Draft Staff Report, including the effects of climate change that will exacerbate the consequences of unimpaired flow based requirements; and (5) provides a technical review of the SacWAM modeling.

Key findings in MBK's report include:

- The VA alternative provides more benefits with less impacts than the proposed Plan amendments.
- Separate modeling of the VA alternative, performed by DWR, wherein the regulatory requirements remain consistent with those in the DWR baseline, show significantly more Delta outflow with the VA alternative as compared to results set forth in the Draft Staff Report.
- The SacWAM modeling underestimates the water supply impact that would occur to south of Delta CVP contractors under the proposed Plan amendments because it does not accurately represent how the Bureau of Reclamation allocates shortages under its existing policies and contracts.
- The unimpaired flow approach in the proposed Plan amendments will exacerbate the adverse effects of climate change, but the analysis in the Draft Staff Report does not account for climate change.
- The Draft Staff Report lacks a plan for implementing the unimpaired flow approach in combination with the proposed cold water habitat objective.
- The lack of an implementation plan and the wide range of potential actions for the proposed Plan amendments make it extremely difficult to understand the impacts of the proposed Plan amendments on reservoir operations, river flows, water deliveries, and Delta outflow.
- The Draft Staff Report does not provide information on the impacts of the proposed Plan amendments during multi-year drought periods.
- The Draft Staff Report provides discloses the results of quantitative analysis of the effects of only one of the "modular" alternatives, despite acknowledging they may have significant impacts.
- Differences in how the unimpaired flow requirements and narrative cold water habitat objective are modeled on different river systems within the Sacramento Valley result in disproportionate impacts within the Sacramento Valley, North and South of Delta, and between the CVP and SWP.

More detail on the analysis supporting these findings is included in MBK's report.

F. Chapter 7 – Environmental Analysis

1. Section 7.1, p. 7.1-5; Section 7.2, p. 7.2-10

The Draft Staff Report states that:

> In addition, specific proposed changes to the interior Delta flow objectives include new and modified numeric objectives. For the most part, the proposed changes to the interior Delta flow objectives and implementation measures involve the addition of existing BiOp and ITP requirements into the Bay-Delta Plan, including requirements contained within the USFWS and National Marine Fisheries Service BiOps and California Fish and Wildlife ITP. While these requirements already exist, it is possible that they will change. To avoid undue complexity in an already complex regulatory regime, these measures are proposed to be built on existing requirements and implemented in an integrated fashion with the BiOps and ITP. In so doing, implementation of the objectives is proposed to rely on the existing BiOp and ITP processes, including monitoring, evaluation, coordination, and review processes, with the incorporation of the State Water Board into these processes. In the event of changes to the BiOps and ITP, as discussed further in Chapter 5, Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta, the proposed implementation measures would provide flexibility to adjust the requirements as appropriate.

(Draft Staff Report at pp. 7.1-9 – 7.1-10.) It also states that:

> However, removal of the export constraints based on San Joaquin River inflows could have a larger effect if those provisions are not maintained into the future, with greater effects at lower flow levels. Accordingly, this alternative largely evaluates removal of the new I:E provisions from the proposed Plan amendments and other flow alternatives.

(*Id*., at p. 7.2-10.)

The Draft Staff Report should not incorporate the Fall Delta Outflow Objective, I:E provisions, or other BiOp- or Incidental Take Permit ("ITP")-related provisions into the proposed Plan amendments because these requirements will change over time in response to the best available science. There is no indication that the Bay-Delta Plan can be easily or quickly changed or amended to address future changes to BiOp or ITP related provisions. Instead, future changes to BiOp or ITP related provisions will result in conflicts and confusion regarding implementation of the proposed Plan amendments. Additionally, USFWS, NMFS, and CDFW are currently faced with a number of scientific uncertainties with respect to existing provisions of the BiOps and ITP and need to maintain future flexibility as new scientific information is generated and applied through the adaptive management process. As a result, consistent with Alternative 4a, the State Water Board should not incorporate BiOp- or ITP-related provisions into the proposed Plan amendments.

2. Section 7.1, p. 7.1-8

The Draft Staff Report states that there would be two potential pathways to implementation of the cold water habitat provisions, voluntary or default implementation. Presumably, "default" implementation refers to actions directed by the State Water Board, as opposed to by the reservoir operators. If the State Water Board anticipates that "default" implementation will be required, then it should have evaluated the methods for default implementation that it is proposing. Additionally, the State Water Board does not provide justification for omitting any discussion of details regarding "default" implementation (which does not include actions by third parties) as compared to "voluntary" implementation (which does require action by third parties).

3. Section 7.2

The Draft Staff Report lists and analyzes both stand-alone and "modular" alternatives that could be layered onto one or more of the stand-alone alternatives, including the VAs alternative.

Of the stand-alone alternatives, the Water Authority and its Member Agencies support the VA alternative. The Water Authority and its Member Agencies oppose Alternative 3, the "High Flow" alternative, because it retains all the flaws of the proposed Plan amendments but worsens water supply impacts by requiring even higher inflows to the Delta. Alternative 2, the "Low Flow" alternative, would have lesser water supply impacts but still is lacking the benefits including from non-flow measures that the VA alternative would provide.

The "modular" alternatives are numbered 4a, 4b, 4c, 5a and 5b. The Draft Staff Report provides that "Alternatives 4a, 4b, and 4c could be adopted in combination with the proposed Plan amendments or other flow alternatives. Alternatives 5a and 5b could be adopted in combination with the proposed Plan amendments, other flow alternatives, or the Proposed VAs." (Draft Staff Report at p. 7.2-3.) The modular alternatives should not be added to any of the stand-alone alternatives. As an initial matter, the modular alternatives were not modeled, or at least the Draft Staff Report does not disclose the results of any modeling. Even if the modular alternatives were modeled, they could not be added to any of the alternatives without modeling the combined alternative, as there could be significant effects related to the combining of alternatives. The combined effect of any modular alternative and any of the other alternatives could have a significant impact on the environment. Moreover, adding the modular alternatives to the VAs alternative could undermine the VAs alternative such that it is no longer reflective of the parties' understanding and intent expressed in their respective MOU, and for that additional reason should not be paired with the VAs alternative.

In addition, the best available science does not support the adoption of any of the modular alternatives.[37] The San Joaquin River I:E ratio (excluded from Alternative 4a, included in

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[37] While it is possible that Alternative 4a, the "Exclusion of Interior Delta Flow and Fall Delta Outflow Related Amendments Alternative," could avoid duplication of or inconsistency with requirements imposed on CVP and SWP operations pursuant to the federal Endangered Species Act (ESA) in the BiOps, or on SWP operations only under the California Endangered Species Act (CESA) in the ITP appliable to SWP operations, Alternative 4a was not modeled, and would be of no real effect, since the CVP and SWP are already required to comply with requirements of the federal ESA and CESA, respectively.

Alternative 4c) is not currently imposed on CVP or SWP operations in the 2019 BiOp issued pursuant to the ESA, but is a requirement imposed on the SWP in the ITP issued under CESA. The Draft Staff Report notes that adopting the I:E ratio as a Plan amendment would result in a significant loss of water supply to regions south of the Delta. (Draft Staff Report at pp. 7.24-38 to 39.) According to the estimates in Table 7.24-5, omitting the I:E ratio from the proposed Plan amendments would reduce the loss of CVP water supplies by an average of 76 TAF across all year types, and by 122 TAF for the CVP and SWP combined if the I:E ratio were also eliminated from the ITP.

As discussed elsewhere in these comments, the I:E ratio is not scientifically supported as a management tool. The I:E ratio was originally adopted in the 2009 BiOp as a measure to protect juvenile steelhead emigrating from the San Joaquin River. The Buchanan, *et al*. (2021) studies have since demonstrated that the rate of exports does not affect survival of juvenile steelhead migrating from the San Joaquin River. (Buchanan, *et al*. (2021) **Exhibit 1** at pp. 1882-1883.) While the rate of San Joaquin River inflow to the Delta may be important to survival, the rate of exports is not. The I:E ratio is flawed because it combines two factors, one which is not important to survival (exports) and a second one that may be (inflow). Imposing the I:E ratio is also inconsistent with the reasonable protection and balancing required by the Porter-Cologne Act, because it would restrict exports and hence water supply without providing benefits to survival of out-migrating fish. To the extent the I:E ratio is rationalized as a way to reduce entrainment at the export pumps, there are other existing restrictions based on Old and Middle River ("OMR") flows that directly address entrainment. The I:E ratio is the wrong tool for addressing entrainment.

Alternative 4c, the "Extended Export Constraint Alternative," would expand the period the I:E ratio is in effect to five months, from February through June. The proffered scientific justification for the measure is to benefit native fish by restoring "more natural" inflow from the San Joaquin River to the Delta. (Draft Staff Report at pp. 7.2-11, 7.24-43, 7.24-45, 3-53.) This "more natural" justification is exceedingly weak. The Draft Staff Report cites no scientific studies suggesting that the resulting difference in flows within the Delta would provide any meaningful benefit to native fish. There are many reasons to believe it would not. Even assuming relatively more inflow from the San Joaquin River would be more "natural" in the sense that it would more closely resemble pre-development conditions, much besides inflow from the San Joaquin River to the Delta has changed over the last two hundred years. For example, the Delta has been channelized, resulting in massive losses of tidal wetlands and marshes. Tidal wetlands in the Delta are now 3% of the acreage they were before the Gold Rush. (Draft Staff Report at p. 4-4.) Further, non-native species now predominate within the Delta. "It has been acknowledged by the scientific community that the Bay-Delta estuary has become a novel ecosystem given all the nonnative introductions (Moyle et al. 2012)." (*Id*. at p. 4-22.) And movement of water within the Delta is largely determined by the tides, not by inflow. "Because it is a tidal environment, water in Delta channels flows both landward and seaward twice each day. The flow volumes of fresh water from the rivers entering the Delta are generally two or three orders of magnitude less than tidal flows." (*Id*. at p. 3-11.) "At channel junctions dominated by tidal influence (interior Delta channels), river inflow and diversions had relatively small effects on predicted fish routing because of the large influence of tidal action on the direction and volume of flow." (*Id*. at 3-45.) The notion that partially restoring "more natural" inflow from the San Joaquin River relative to the Sacramento River or other tributaries will benefit native fish within the Delta is simply speculation.

Against such speculative benefit for native fish the State Water Board must weigh the likely massive water supply impacts from restricting exports based on the I:E ratio for the five months from February through June. In a narrative discussion at pages 7.24-45 and 7.24-46, the Draft Staff Report acknowledges Alternative 4c would significantly reduce water supply. It states "the water supply impacts of this alternative would be very significant and may not be considered reasonable, particularly in combination with the water supply impacts from the flow alternatives." (*Id.* at p, 7.24-46.) The Draft Staff Report does not disclose the quantity of those water supply reductions. If Alternative 4c is to be given any further consideration, those water supply impacts must be quantified and disclosed, in addition to the myriad environmental impacts that would be caused by such a "very significant" loss of water supply. In sum, there is no substantial evidence presented in the Draft Staff Report that would support adoption of Alternative 4c.

Alternative 5a (Instream Flow Protection Provision Alternative) would require water diverters (in addition to DWR and Reclamation) to bypass water needed to meet existing water quality objectives during drought circumstances similar to existing standard water right Term 91; Alternative 5b (Shared Water Shortage Provision Alternative) would require all water users to reduce their use during drought conditions. There is a critical need to protect limited available water supplies in times of drought, consistent with water rights. Assuming water rights are respected, the Water Authority and its Member Agencies would welcome additional efforts by the State Water Board to prevent unlawful diversions in times of drought.

4. Section 7.4

The Draft Staff Report should be updated to more fully evaluate and disclose economic (and related environmental) impacts of the proposed Plan amendments to export reductions. The Draft Staff Report should be updated to describe and include reference to the Shires study conducted for Westlands Water District (See https://wwd.ca.gov/wp-content/uploads/2022/03/economic-impact-report-2022-update.pdf.), which demonstrates that poverty rates are tied to water allocations, as well as the Sunding study conducted for the Water Blueprint for the San Joaquin Valley, which correlated water supply reductions to reduced economic output in various geographic regions of the San Joaquin Valley (see https://waterblueprintca.com/wp-content/uploads/2021/09/Blueprint.EIA_.PhaseOne.2.28-v41.pdf). In comparison to the proposed Plan amendments, the VA alternative would cause less harm to local economies and communities.

5. Section 7.4, pp. 7.4-8 – 7.4-10, 7.4-61, 7.4-92

Reliance on groundwater pumping data from 2005-2015 is a skewed representation of baseline pumping, and it is not reasonable to assume that same level of groundwater pumping will continue. The baseline water supply data summarized on pages 7.4-8 - 7.4-10 demonstrates that the Draft Staff Report used average water supply data from years prior to SGMA implementation, including 2014 and 2015 – drought years that saw major spikes in groundwater pumping. By using a higher groundwater pumping baseline, the modeling results cannot accurately represent the likely effects to agricultural productivity associated with diminished water supplies. This is particularly true for the San Joaquin Valley, which relies heavily on groundwater for agricultural water supply during years of reduced surface water supplies. The Draft Staff Report assumes that current agricultural groundwater use in the San Joaquin Valley is 9,034,000 AFA (65% of all groundwater used for agriculture in the state), however, this assumes that pumping has remained consistent since SGMA implementation.

Furthermore, the "maximum replacement groundwater pumping scenario" and the "no replacement groundwater pumping scenario" are both unrealistic because they do not account for several factors that will reduce availability of groundwater supplies. The Draft Staff Report admits that the "maximum replacement" groundwater scenario is unrealistic; this is particularly true because it results in projections that there will be no impacts to agriculture. Even the no replacement groundwater scenario that maintains pumping at historic levels in the San Joaquin Valley is unrealistic because the Draft Staff Report admits that the entire region would experience a reduction in physical availability of groundwater through implementation of the proposed Plan amendments.

6. Section 7.4, pp. 7.4-55 – 7.4-56

The Draft Staff Report aggregates alternative available supplies throughout the entire San Joaquin Region to support the conclusion that a proposed Plan amendments would only result in a 2% reduction in total water supply. This approach masks impacts to junior water rights holders, such as CVP agricultural water service contractors, who experience greater cuts to water supplies in times of shortage and have less reliable access to replacement supplies. The Draft Staff Report's evaluation of water supply impacts from the proposed Plan amendments to agricultural users in the San Joaquin Valley should be revised to evaluate the availability of replacement water supplies on the district and sub-regional level, as opposed to the current approach which aggregates replacement water supplies on a regional level.

7. Section 7.6.1, p. 7.6.1-56

The Draft Staff Report states that: "Changes in Delta outflows that would occur as a result of the proposed Plan amendments would provide for more natural salinity conditions in Suisun Marsh, which would likely benefit special-status plant and wildlife species in Suisun Marsh. Changes would likely benefit special-status plant species including but not limited to, soft bird's-beak, Suisun thistle, Delta tule pea, Mason's lilaeopsis, Delta mudwort, and Suisun Marsh aster. These changes also would likely benefit special-status wildlife, including but not limited to, California black rail, California Ridgway's rail, saltmarsh common yellowthroat, Suisun song sparrow, salt-marsh harvest mouse, and Suisun shrew. The proposed flow requirements also would complement the planned tidal marsh restoration and management and enhancement of managed wetlands, including those actions identified under the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Reclamation, *et al.* 2013). The restoration activities in Suisun Marsh are expected to create more saline areas in the western portion of the marsh, allowing for restored areas in the eastern portion of Suisun Marsh to remain fresher."

The Draft Staff Report should be amended to provide evidence for this statement and cite relevant source material for that evidence. While the species identified above have evolved with exposure to high water levels from high fluvial flows and tidal flooding, if water levels ramp up, then these tidal marsh species would move to higher ground and refugia in vegetation to avoid predation. However, if these flows occur before habitat restoration actions can be implemented, then there could be a negative impact to the species due to a lack of cover and/or suitable marsh habitat that are associated with more saline conditions (e.g., the California Ridgway's rail). Depending on the frequency, duration, and magnitude of the increases in water surface elevations (due to increased delta outflows, climate change, or those events occurring with a high tide event) an increase in delta outflows could increase predation events on salt marsh harvest mouse. The State Water Board should not consider action to adopt the proposed Plan amendments (or any unimpaired flow regime) before a quantitative analysis is undertaken.

8. Section 7.6.1, p. 7.6.1-64

The Draft Staff Report states that: "Restoration of wetland habitat… could offset [giant garter snake] habitat loss."

The potentially significant habitat loss of giant garter snake, by up to 21% of their habitat in the Sacramento and San Joaquin basins, stresses the importance of including habitat restoration actions alongside flow actions. There is no discussion on the mitigation of lost habitat except to cite that EcoRestore restoration projects are currently planned and would help offset potential decreases. As EcoRestore is not linked with the proposed Plan amendments, it cannot be relied on to offset potential population decreases. This comment also applies to projected decreases in other species under the proposed Plan amendments, such as Swainson's hawk and greater sandhill crane.

9. Section 7.6.2, pp. 7.6.2-37 - 7.6.2-38

The Draft Staff Report includes modeling results that indicate the frequency "at which winter-spring outflows associated with positive population growth for [target species] (20,000 to 47,000 cfs) are met or exceeded under the proposed Plan amendments. (Draft Staff Report at pp. 7.6.2-37 - 7.6.2-38 [Tables 7.6.2-4 and 7.6.2-5].) However, the data shown on Tables 7.6.2-4 and 7.6.2-5 combine the results for all water year types (e.g., wet, average, and dry years).

These modeling results would be more informative if: (1) the results were based on the juvenile Chinook salmon survival model, rather than just the percentage of months exceeding a criterion to show changes in a biological metric of interest; and, (2) the results were presented by water year-type to reflect changes in predicted hydrology. The predicted magnitude of biological benefits from the proposed Plan amendments cannot be assessed based on a simple comparison of flows meeting or not meeting a selected outflow criteria.

10. Section 7.6.2, p. 7.6.2-41

The Draft Staff Report states that: "Under existing conditions, export pumping at the SWP and CVP export facilities can cause OMR reverse flow that may result in the movement of large numbers of fish, including but not limited to longfin smelt, into the interior Delta and result in their entrainment (USFWS 2008 BiOp; NMFS 2009 BiOp)."

The citation supporting this statement should be updated. Citing the 2008/2009 BiOps to describe existing conditions is not relevant, as the regulatory requirements built into existing conditions today are different than the existing conditions described pre-2008/2009 BiOps. There are significant efforts to ensure that a large number of fish are not entrained.

11. Section 7.6.2, p. 7.6.2-44

The Draft Staff Report presents SacWAM model results of average monthly I:E ratio on the San Joaquin River between October and June under different numeric unimpaired flow requirements. (Draft Staff Report at p. 7.6.2-44 [Table 7.6.2-11].) The report cites the Salmonid Scoping Team's 2017 report titled, "Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta," as the base for concluding that "higher San Joaquin River I:E ratios result in higher survival through the Delta." The Salmonid Scoping Team's 2017 report discusses the difficulty in evaluating the effect of the I:E ratio on survival because the same I:E ratio applies to both increases in San Joaquin River flow and reductions in export rates. Additionally, subsequent juvenile steelhead survival studies conducted as part of the 6-year study, which were not available to the Salmonid Scoping Team in 2017, found that juvenile steelhead survival was statistically related to increased San Joaquin River instream flows during migration, while survival in the lower tidal reaches of the Delta was statistically related to migration route selection. (Buchanan, *et al.* (2021) **Exhibit 1** at pp. 1882-1883.)

Buchanan, *et al.* (2021) evaluated the relationship between a number of environmental covariates and juvenile steelhead survival (P values less than 0.05 are considered to be statistically significant) but did not detect a statistically significant relationship between SWP export rates (P=0.22), CVP export rates (p=0.49), or combined SWP and CVP export rates (P=0.64), but did detect significant relationships between San Joaquin River inflow with the Head of Old River installed (P<0.0001) and when the barrier was not installed (P=0.01). (Buchanan, *et al.* (2021) **Exhibit 1** at p. 1879 [Table 5].) These results illustrate the complexity of interpreting a potential relationship between the I:E ratio and survival. Further, the results of the SacWAM modeling in the Draft Staff Report (Table 7.6.2-11), excerpted below, show very little difference in estimated I:E ratios during the primary juvenile salmonid migration period (February-May) as compared to baseline.

Scenario	February	March	April	May
Baseline	0.60	0.78	2.32	2.40
35	0.58	0.76	2.19	2.45
45	0.61	0.76	2.16	2.61
55	0.59	0.78	2.23	2.84
65	0.64	0.87	2.34	3.09

SacWAM estimates of average monthly I:E ratio in the lower San Joaquin River (Source: Table 7.6.2-11 pg 7.6.2-44)

The results from page 7.6.2-44 of the Draft Staff Report, excerpted above, in combination with results from Buchanan, *et al.* (2021) (which is not even cited on page 7.6.2-44), indicate that there would be no significant benefit to increased juvenile salmonid survival based on regulation of exports using the I:E ratio. The Draft Staff Report should be revised to indicate that estimated increases to the I:E ratio under the proposed Plan amendments will not result in increased juvenile salmonid survival.

12. Section 7.6.2, p. 7.6.2-62

The Draft Staff Report's discussion of the modeling data regarding temperatures impacts should be revised. The data is provided in a location-specific manner in an appendix, however, the presentation of the data in the body of the Draft Staff Report omits this information and makes it difficult to identify what locations are most at risk of impacts. As a result, the Draft Staff Report should be revised to summarize what rivers/reaches will undergo temperature impacts more clearly and discuss the resulting potential degree of impact to the species that received unfavorable temperature conditions compared to baseline.

13. Section 7.6.2, p. 7.6.2-68 – 7.6.2-71

The Draft Staff Report should be updated with analysis of over-summer survival of steelhead. Water temperature management is a key issue for juvenile steelhead rearing during the late spring, summer, and early fall in a number of streams and rivers, including the American River, and there are limitations on temperature control under existing conditions.

14. Section 7.6.2, p. 7.6.2-91

The Draft Staff Report states that: "Instead, an increase in water temperature could lead to a minor beneficial effect because, if food is not limiting, fish grow faster in warmer water due to higher metabolism, resulting in larger individuals with potentially higher survival (Ward, et al. 1989; Sommer, et al. 2001a)."

While Sommer, et al. 2001a shows that juvenile salmon in the floodplain can thrive in warmer temperatures, the statement in the staff report oversimplifies the findings of the study. Floodplains function quite differently from the adjacent river channel and the paper does not provide a scientific basis for water temperature increases on adjacent river channels. More analysis or a more current literature review is needed before making the conclusion that an increase in water temperature in this case would lead to a beneficial effect. More current literature should be shown or, if not possible, the statement of potential beneficial effects should be removed.

15. Section 7.6.2, p. 7.6.2-92

Regarding the effects of the proposed Plan amendments on juvenile green sturgeon, the Draft Staff Report assumes that "[e]ffects from changes in hydrology on juvenile green sturgeon, which are present in the Delta year-round, are expected to be similar to those described above for juvenile salmonids during winter and spring months." (Draft Staff Report at p. 7.6.2-92.) However, the Draft Staff Report does not provide any scientific support for the assumption that, with respect to potential benefits from the proposed Plan amendments, juvenile salmonids are a representative surrogate for juvenile green sturgeon. Notably, the habitat of salmonids and sturgeon are different, the foraging behavior and prey are different, the size and swimming performance are different, etc. As a result, the Draft Staff Report should be amended to include scientific support for the statement regarding anticipated benefits from the proposed Plan amendments to green sturgeon.

16. Section 7.12.1, p. 7.12.1-62

Pg. 7.12.1-62 of the Draft Staff Report states that: "[t]he effect of increases in mercury and methylmercury may carry downstream to the Delta, San Francisco Bay, exports, export reservoirs, and streams downstream of export reservoirs. The effect would be dissipated by mixing with other water sources, settling of mercury attached to sediment, dredging, accumulation in organisms, and photodegradation of methylmercury back to mercury (Central Valley Water Board 2010)." Because the Draft Staff Report only includes a single citation regarding dissipation, it should be revised to include additional support for the claim that the increased mercury and methylmercury in downstream areas would dissipate.

17. Section 7.12.1, p. 7.12.1-88

The Draft Staff Report states that the proposed Plan amendments will result in significant increases in Harmful Algal Blooms ("HABs") in Victoria Canal, which is a primary conveyance facility for the Delta export pumps, but it does not propose any mitigation. The Draft Staff Report should be amended to discuss mitigation for the potentially significant increase in HABs in Victoria Canal.

18. Section 7.12.2, p. 7.12.2-25

The following statement on pg. 7.12.2-25 of the Draft Staff Report: "…to recharge the aquifer through groundwater infiltration basins" should be revised to state: "…groundwater infiltration basins <u>and creeks</u>." Without the additional underlined language, the description of groundwater recharge programs in the Santa Clara Valley is incomplete.

19. Section 7.12.2, p. 7.12.2-59

The Draft Staff Report states that: "As described under Impact GW-b, Sacramento/Delta surface water supplies primarily are used for municipal water in the Bay Area, and potential impacts on groundwater levels in this region primarily would be related to the effects of local substitute groundwater pumping that might be implemented to replace lost surface water supplies."

Contrary to this statement, water providers such as Santa Clara Valley Water ("Valley Water") would have a compounded impact to groundwater due to reduced imported supplies in Valley Water's service area, since imported water is used for both treated water and managed recharge. As a result, the Draft Staff Report does not fully recognize the extent of the groundwater impacts that would occur to Valley Water.

20. Section 7.12.2, pp. 7.12.2-66 – 7.12.268

Many of the mitigation measures identified to address groundwater impacts are programs/regulations that are already being implemented and should be considered as a part of the baseline. The mitigation measures should be feasible, meaning "capable of being accomplished in a successful manner with a reasonable period of time, taking to account economic, environmental, social and technological factors" (Pub. Resources Code, § 21061.1.) If the existing program/regulations that are described as mitigation measures have not been successful to maintain clean and sustainable groundwater levels in the existing condition, there is no evidence that the application of these mitigation measures would be successful in a reasonable amount of time, especially if the proposed Plan amendments will reduce supplies that are currently used to recharge groundwater. Further, any amount of inelastic land subsidence should be considered a significant impact with irreversible outcomes. Impacts to groundwater supplies should be fully mitigated to avoid inelastic land subsidence.

21. Section 7.16, p. 7.16-3

The Draft Staff Report should rely on more recent population data and include San Francisco County as a county within the San Francisco Bay Area region. California Department of Finance maintains annual estimates that could be used for updated information.

22. Section 7.20, p. 7.20-13

The Draft Staff Report states that Valley Water "manages the Santa Clara groundwater subbasin." Although Valley Water does manage the Santa Clara groundwater subbasin, it also manages the Llagas subbasin; the statement should be revised.

23. Section 7.20, p. 7.20-14

The Draft Staff Report states: "The Bay Area has a history of recycled water planning and high municipal water use efficiencies. Per capita municipal water use in the Bay Area is relatively low due to high water rates, cool climate, and small lot sizes. Water use in the Bay Area during recent years ranged from 104 R-GPCD in 2013 to 85 R-GPCD in 2018, based on analysis of data from the State Water Board's Urban Water Supplier Monthly Reports Dataset (SWRCB 2018a)."

Notably, municipal water use in the Bay Area is not only low because of high water rates, cool climate, and small lot size. Robust conservation programs, water conservation education, and outreach efforts also play a crucial role and should be included in the Draft Staff Report's description above.

24. Section 7.20, p. 7.20-21

The Draft Staff Report states: "Several strategies could be implemented at the local or regional level using existing infrastructure to reduce potential impacts from reduced Sacramento/Delta surface water supplies, including groundwater storage and recovery, water transfers, water recycling, and conservation measures."

The Draft Staff Report's characterization of recycling, excerpted above, is incorrect. Increasing recycling is not possible using "existing infrastructure." New infrastructure, especially to make it suitable for treated water augmentation, which would be needed to meet treated water contract commitments with reduced water supply from exports. Furthermore, these types of new infrastructure projects take many years and resources to plan, design, permit, and construct. The additional time and finances for these sources to come online should be acknowledged in the Draft Staff Report.

25. Section 7.20, p. 7.20-22

The Draft Staff Report states: "This lower quality recycled water would not be expected to enter water treatment plants or WWTPs."

This statement from the Draft Staff Report, excerpted above, is unclear. Tertiary treated water (recycled water for recharge or irrigation) is treated at wastewater plants. The Draft Staff Report should be clarified to explain why this water would not be expected to enter water treatment plants.

26. Section 7.23, p. 7.23-5

The Draft Staff Report states: "The proposed Plan amendments provide a framework that would allow stakeholders to implement complementary ecosystem projects in addition to flow requirements and actions that other entities could take that would contribute to the overall goal of providing reasonable protection to fish and wildlife in the Sacramento/Delta."

The Draft Staff Report should be revised to include a citation to where this framework is located in the Draft Staff Report.

27. Section 7.23, p. 7.23-3

The reference to the Pacheco Reservoir Expansion Project in Section 7.23, pg. 7.23-33, Table 7.23-1 should be amended. The table states that the current proposed dam capacity is 141.6 TAF, but the current proposed dam capacity is 140 TAF.

Also, the conveyance infrastructure statement should be separated from the information about the refuges. The way it is currently written implies that the infrastructure is needed to deliver the water to the refuges, which is not the case. The new infrastructure will be required to deliver the water from the new Pacheco reservoir to Valley Water's point of use. The refuge water will be delivered via exchange and/or existing infrastructure.

G. Chapter 8 – Economic Analysis and Other Considerations

1. Section 8.4.2.3, p. 8-63

Pg. 8-63 of the Draft Staff Report states that: "Valley Water serves water to all of Santa Clara County, including agricultural lands (SCVWD 2015, p. 3-1). However, most agricultural users in the county rely on groundwater." This statement should be revised to state that Valley Water also provides surface water for agricultural users through the Pacheco Conduit.

2. Section 8.4, p. 8-69

The Draft Staff Report appears to split Santa Clara County into two different regions for purposes of evaluating impacts: San Francisco Bay Area and Central Coast. It appears that agricultural use in south Santa Clara County is included in the Central Coast Region, while Municipal and Industrial uses are included in the SF Bay Area region. To the contrary, Santa Clara

County is located in the San Francisco Bay Area and the analysis related to Santa Clara County should be organized within sections pertaining to the San Francisco Bay Area.

3. Section 8.5.1, p. 8-95

Regarding the "Lower Bound" (the minimum annual cost to municipalities to replace the service of reduced Sacramento/Delta supply), it is not reasonable to assume that "a reduction in municipal supply of up to 10 percent often would be managed through more intensive use of demand management measures." (Draft Staff Report at p. 8-95.) The Draft Staff Report's analysis assumes that "urban water conservation measures represent the first source of replacement water" and that these replacement sources come at "no economic cost to the municipal provider." (*Ibid.*) The Draft Staff Report's current analysis assumes urban agencies use these reserves first, before acquiring new supplies, however, water conservation measures – where feasible – cost money to develop. The existing analysis underestimates the financial impacts associated with water conservation measures, and the feasibility of achieving such large-scale conservation in all regions, and should be revised.

4. Section 8.8.3, p. 8-119

The projected costs of groundwater banking as a replacement water source do not reflect the increased competition and associated increase in cost that would be anticipated from a reduction of surface supplies. The economic analysis in Chapter 8 should be revised to address likely increases in projected costs of groundwater banking associated with increased competition for replacement water sources.

H. Chapter 9 – Proposed Voluntary Agreements

1. Section 9.6, p. 9-78

Figure 9.6-3 is too difficult to read. The data in C and D years is obscured by the current size of the Figure. This figure should be restructured so that the size increases to a readable level.

2. Section 9.9, p. 9-199

The Draft Staff Report identifies a "modular alternative" that could be adopted with the VAs alternative, titled "Protection of Voluntary Agreement Flows Alternative." This alternative would identify as part of the program of implementation additional measures to protect the base upon which the VA flows are intended to be added from new or expanded water diversions. "Specifically, under this modular alternative, any new point of diversion of water or expanded point of diversion of water would not be authorized to divert water during the January-through-June period unless Delta outflows were at levels determined in the State Water Board's 2017 Scientific Basis Report, or future equivalent analyses, to provide conditions expected to result in the recovery of a wide array of native fish and wildlife species." (Draft Staff Report, pp. 9-199 to 9-200.) Specific accounting measures for this modular alternative are not described in the draft Staff Report. It is unclear whether the intent is that the VA parties' accounting approach would be used (or adapted for use) with this modular alternative, if selected. Clarity should be added on this point.

EXHIBIT 1

Canadian Science Publishing

ARTICLE

Outmigration survival of a threatened steelhead population through a tidal estuary

Rebecca A. Buchanan, Elissa Buttermore, and Joshua Israel

Abstract: Juvenile steelhead (*Oncorhynchus mykiss*) are exposed to numerous threats in heterogeneous, estuarine environments, yet understanding of survival patterns and processes during this migratory stage is often limited by studies that use surrogate species or are restricted in duration and spatial specificity. Lack of detailed survival information in this critical migratory stage limits the effectiveness of management to maintain juvenile life history diversity in threatened populations. We used acoustic telemetry with multistate mark–recapture models to investigate survival patterns during a key stage of the juvenile emigration of anadromous steelhead through the Sacramento–San Joaquin River Delta of California, United States, over multiple years, including three drought years. Survival was highly variable both within and among the six years of the study; estimated total survival through the Delta ranged from 0.06 (May 2014) to 0.69 (March 2011). Survival in the upstream reaches was associated with river discharge into the Delta, while survival through the lower reaches was associated with migration route. The lack of a single factor associated with survival in all reaches counteracts preconceived ideas of survival processes. Hydrodynamic manipulation and habitat improvements are recommended to support this anadromous population in a changing climate.

Résumé : Si les truites arc-en-ciel (*Oncorhynchus mykiss*) anadromes juvéniles sont exposées à de nombreuses menaces dans les milieux estuariens hétérogènes, la compréhension des motifs et processus de survie durant cette étape migratoire est souvent limitée par des études qui utilisent des espèces substitutives ou dont la durée et la spécificité spatiale sont restreintes. L'absence d'information détaillée sur la survie à cette étape migratoire critique limite l'efficacité de la gestion visant le maintien de la diversité des cycles biologiques de juvéniles au sein de populations menacées. Nous avons utilisé la télémétrie acoustique combinée à des modèles multi-états de lâcher–recapture pour examiner les motifs de survie durant une étape clé de l'émigration de truites arc-en-ciel anadromes juvéniles par le delta des fleuves Sacramento–San Joaquin en Californie (États-Unis) sur plusieurs années, incluant trois années de sécheresse. La survie était très variable durant chacune des six années de l'étude et d'une année à l'autre, le taux de survie total estimé dans le delta allant de 0,06 (mai 2014) à 0,69 (mars 2011). La survie dans les tronçons supérieurs était associée au débit des fleuves entrant dans le delta, alors que la survie dans les tronçons inférieurs était associée à l'itinéraire de migration. Le fait qu'il n'y a pas un facteur unique associé à la survie dans tous les tronçons contredit des idées préconçues concernant les processus de survie. La manipulation hydrodynamique et l'amélioration des habitats sont recommandées pour soutenir cette population anadrome dans un contexte de climat changeant. [Traduit par la Rédaction]

Introduction

Survival during juvenile emigration is considered a limiting factor for persistence of some populations of steelhead (anadromous rainbow trout, *Oncorhynchus mykiss*; Satterthwaite et al. 2010). Extensive study has been conducted on steelhead migration survival through managed rivers, but fewer studies have addressed survival in the estuarine environment in spatiotemporal detail despite observations that juvenile salmonid survival tends to be lower in estuaries than in neighboring environments (Welch et al. 2011; Thorstad et al. 2012). Estuary survival is challenging to study because of dynamic environments and complex migration routing, resulting in costly studies that often last only one or several years (e.g., Clemens et al. 2009; Harnish et al. 2012; Brodsky et al. 2020) or produce spatially inexplicit estimates (Rechisky et al. 2013; Sandstrom et al. 2020). The resulting lack of detailed spatiotemporal information on survival patterns and processes hinders management of imperiled steelhead populations, resulting in decisions based on untested conceptual models, survival estimates from surrogate species, or small data sets that underrepresent seasonal and annual variability or reflect overly large spatial scales.

The Central Valley (CV) Distinct Population Segment (DPS) of steelhead in California, United States, is an example of an imperiled population being managed in a highly degraded estuary with inadequate data. The CV DPS includes both naturally spawned fish from the Sacramento and San Joaquin river basins and fish reared in three hatchery programs in the CV. This DPS was listed as threatened under the US Endangered Species Act (1973) in 1998 (Lindley et al. 2006), and the Southern Sierra Nevada diversity group component of the DPS is of particular concern due to a recent multiyear drought. This southern population emigrates from the San Joaquin River (SJR) basin through the Sacramento–San Joaquin Delta (Delta), a heavily modified tidal estuary that provides water for municipal and agricultural use for millions of

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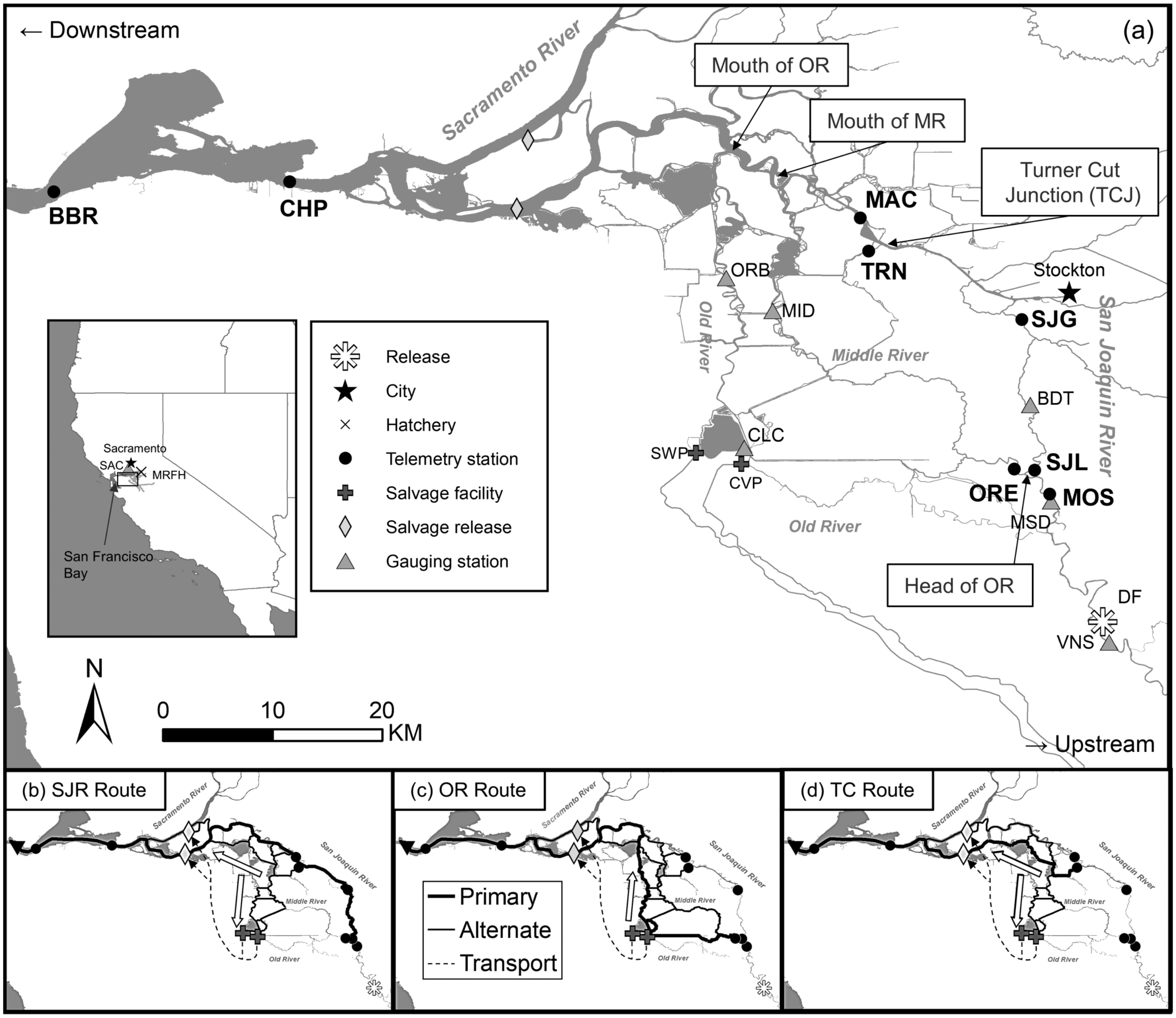
Fig. 1. The study area in the southern Sacramento–San Joaquin River Delta (*a*) and major routes through the study area: San Joaquin River (SJR) route (*b*) and Old River (OR) route (*c*) from the head of OR and Turner Cut (TC) route (*d*) from the Turner Cut Junction (TCJ). Middle River (MR) is a subcomponent of all three routes. White arrows on route maps indicate predominant direction of fish movement in route through the interior Delta. Marked locations are Mokelumne River Fish Hatchery (MRFH; inset map), Durham Ferry (DF) release site, key cities, acoustic telemetry stations, river gauging stations, salvage facilities, and salvage release sites (i.e., after trucking from salvage facilities). Inset map shows state of California, United States (light shading) and the Delta, San Francisco Bay, and Pacific Ocean (dark shading); detailed area is marked with rectangle. Water export and salvage facilities are CVP = Central Valley Project and SWP = State Water Project. Telemetry and gauging stations are defined in Table 2. Map data copyrighted OpenStreetMap contributors (Open Database License), downloaded via Overpass Turbo API (https://overpass-turbo.eu); Delta boundary data downloaded from https://gis.water.ca.gov/app/boundaries/. Map created using "rgdal" and "geosphere" packages in R (R Core Team 2020) and ArcMap 10.7.1 (Esri 2011).



Californians (Fig. 1). Before now, there had been no direct information on Delta survival for this SJR steelhead population or how survival varies with environmental conditions and resource management operations. In the absence of such information, management decisions for this population have been based largely on juvenile Chinook salmon (*Oncorhynchus tshawytscha*) survival studies (McEwan 2001) and a series of untested hypotheses that Delta survival is higher for SJR steelhead when more water enters the Delta from upstream, when less water is extracted from the Delta for human use (export), and when fish remain in the mainstem migration route (National Marine Fisheries Service 2009). It is unknown how relationships may change resulting from increased drought under climate change.

A six-year acoustic-telemetry study of juvenile steelhead began in spring 2011 designed to address uncertainties in SJR steelhead survival through the Delta and its relationship with the seasonal water management strategies used by federal and state agencies in the Delta. This paper presents the migration survival results for the six years of the study, discusses spatial patterns in survival estimates, investigates survival patterns compared to water management and environmental conditions, and explores drought effects on survival modeling. These results and the multistate

Table 1. Release year, sample size (*N*), release dates, mean (range) fork length at tagging, transmitter type (manufacturer and model), mean (range) tag burden (= tag weight/fish weight), and mean estimated tag life (SE; days) for release groups of juvenile steelhead.

Year	*N*	Release dates	Fork length (mm)	Tag type	Tag burden (%)	Tag life (days)
2011	2196	22 March – 18 June	277 (149–396)	HTI 795 LD	0.5 (0.2–2.7)	83.1 (15.5)
2012	1435	4 April – 23 May	234 (115–316)	VEMCO V6	0.9 (0.3–2.9)	77.7 (10.8)
2013	1425	6 March – 11 May	212 (115–300)	VEMCO V6	1.1 (0.4–3.3)	69.0 (10.7)
2014[a]	958	24 April – 24 May	247 (151–283)	VEMCO V5	0.5 (0.3–1.2)	75.2 (15.8)
2015	1427	4 March – 25 April	235 (97–287)	VEMCO V5	0.5 (0.3–3.8)	65.4 (7.6)
2016	1440	24 February – 30 April	248 (147–292)	VEMCO V5	0.5 (0.3–2.2)	63.9 (6.4)

[a]A release group of 476 steelhead from March 2014 was omitted because of tag programming error.

analytical methods employed are expected to be informative for steelhead performance in other estuarine systems facing challenges from development and a globally changing climate.

Materials and methods

Study area

The Sacramento–San Joaquin Delta is the dendritic component of an inverted tidal estuary where the riverine environment transitions to a brackish estuarine environment, connecting the inland waters of the CV to a series of bays ending in the Pacific Ocean (Fig. 1). Delta aquatic habitats have been heavily modified through land use changes, altered flow patterns and nutrient input from upstream dams, and large-scale removal of Delta water for human population use (Yoshiyama et al. 1998; McEwan 2001; Sommer et al. 2007; Moyle et al. 2010). The Delta is also home to an increasing number of naturalized invasive plant and animal species, including large populations of non-native piscivorous fishes such as striped bass (*Morone saxitilis*) and largemouth bass (*Micropterus salmoides*) (Cohen and Carlton 1998; Nobriga and Feyrer 2007; Conrad et al. 2016). Little information is available on avian or mammalian predators of salmonids in the Delta, but such predation is likely to occur (Grossman 2016; Nelson et al. 2020). Decreased turbidity over recent decades has been associated with increased biomass of submerged aquatic vegetation and may contribute to predation risk (Gregory and Levings 1998; Hestir et al. 2016).

The Delta is dominated by the Sacramento River (SR) entering from the north and the SJR entering from the south. The region discussed in this paper is the southern portion of the Delta extending from the area near the source (head) of Old River (OR) in the south to Chipps Island in the west (SJR Delta; Fig. 1). The OR is the SJR's primary distributary in the Delta. Chipps Island is the downstream exit of the Delta and is the presumed migration target for juvenile salmonids emigrating seaward through this region. The SJR Delta is bounded to the south by Mossdale Bridge (hereinafter referred to as "Mossdale"; located adjacent to the MSD gauging station; Fig. 1) over the SJR south of OR, to the east and north by the lower SJR, and to the west by OR, which rejoins the SJR approximately 40 river kilometres (rkm) east of Chipps Island. Middle River (MR) is a distributary of OR that runs north between the SJR and OR and joins the SJR 4 rkm upstream of the SJR-OR convergence. Two large water pumping facilities are located off OR in the southwestern corner of the Delta, the federal Central Valley Project (CVP) and the State Water Project (SWP). Several channels connect the SJR to the interior region of the Delta downstream (i.e., north) of the OR source. The first such channel is Turner Cut (TC), which connects to the SJR at the Turner Cut Junction (TCJ; Fig. 1). The mouths of MR and OR are 11 rkm and 15 rkm downstream of TCJ, respectively (Fig. 1). The SJR is notably wider and more dominated by tidal forces downstream of TCJ.

There are multiple migration routes through the SJR Delta for juvenile salmonids emigrating past Mossdale (Fig. 1). Primary route selection occurs at the head of OR, where fish may either enter OR (OR route) or remain in the SJR (SJR route). Both the SJR route and the OR route include multiple subroutes in addition to travel entirely within the SJR and OR, respectively. Fish in the SJR route may either migrate entirely within the SJR to Chipps Island, or may enter the interior Delta through TC or other connections downstream (Fig. 1*b*). Fish in the OR route may migrate through Delta waters in either OR or MR to rejoin the SJR upstream (east) of Chipps Island (Fig. 1*c*). Alternatively, fish in both the OR and SJR routes may enter the water export facilities in the southwestern corner of the Delta, where they may be salvaged (i.e., captured) at the associated fish protection facilities or lost into the diversion pumps. Salvaged fish are transported by truck and released in the SJR or SR approximately 20 km upstream of Chipps Island (Fig. 1). The salvage route is more likely to be used by fish in the OR route because OR passes the entrances to both water export facilities, but fish in the SJR route may also be salvaged if they enter the interior Delta via TC or downstream (e.g., Fig. 1*d*).

A temporary rock barrier was installed in OR near its head in most study years to prevent salmonid access to that route under the expectation that survival is lower in the OR route. Although designed to block access, the barrier included culverts that allowed some passage of both water and fish. The barrier was not installed in 2011 because river discharge was too high, or in 2013. Each year in which the barrier was installed, some study fish reached the barrier either before construction was complete or after dismantling began.

Field study methods

The telemetry study's main objective was to estimate through-Delta survival from the head of OR to Chipps Island and to determine how that survival varied within and between study years. Study fish were obtained from the Mokelumne River Fish Hatchery (MRFH), one of the three artificial propagation programs included in the CV DPS. In the spring of each year from 2011 to 2016, 958 to 2196 one-year-old juvenile steelhead from MRFH were surgically implanted with microacoustic transmitters and released in the SJR at Durham Ferry (DF), located approximately 25 rkm upstream of the head of OR and approximately 80 km from MRFH by truck (Fig. 1; Table 1). The 2011 study used the Hydroacoustic Technology, Inc. (HTI) Model 795 LD microacoustic tag (mean tag weight in air = 1.01 g). The 2012 and 2013 studies used the VEMCO V6-180 kHz tag (1.05 g), and the 2014–2016 studies used the VEMCO V5-180 kHz tag (0.67 g). The tagging team included three to four surgeons each year; all surgeons received either new-surgeon training or refresher training annually. Fish fork length at the time of tagging ranged from 97 to 396 mm and averaged 212 mm (2013) to 277 mm (2011) each year (Table 1). Tag burden (i.e., the ratio of dry tag weight in air to fish weight) ranged from 0.2% to 3.8%. In 2011, tagging was performed at the California Department of Water Resources Collection, Handling, Transport, and Release Laboratory, located at the SWP's Skinner Fish Protection Facility approximately 50 km from DF by truck. In 2012–2016, tagging was performed at MRFH. After tagging, fish were trucked to the release site in insulated tanks designed

Table 2. Geographic acronyms and site names including type and location indicated by river kilometre (rkm) measured from the Golden Gate Bridge (entrance to Pacific Ocean).

Name	Type	Description[a]	rkm
CV	Region	Central Valley of California	
MR	River	Middle River	
OR	River	Old River	
SJR	River	San Joaquin River	
SR	River	Sacramento River	
TC	Channel	Turner Cut	
TCJ	River junction	Turner Cut Junction	137
MRFH	Fish hatchery	Mokelumne River Fish Hatchery	213
DF	Release site	Durham Ferry	195
BBR	Telemetry station	Benicia Bridge	57
CHP	Telemetry station	Chipps Island	77
MAC	Telemetry station	MacDonald Island	134
MOS	Telemetry station	Mossdale	174
ORE	Telemetry station	Old River near head	164
SJG	Telemetry station	San Joaquin at Garwood Bridge	150
SJL	Telemetry station	San Joaquin at Old River head	170
TRN	Telemetry station	Turner Cut	138
CVP	Water export facility	Central Valley Project	144
SWP	Water export facility	State Water Project	146
BDT	Gauging station	SJR at Brandt Bridge (Water Data Library B955740Q)	161
CLC	Gauging station	Clifton Court Forebay (CDEC CLC)	142
MID	Gauging station	MR at Bacon Island (USGS 11312676)	126
MSD	Gauging station	Mossdale Bridge (Water Data Library B95820Q)	175
ORB	Gauging station	OR at Bacon Island (USGS 11313405)	123
SAC	Gauging station	SR at Freeport (Dayflow SAC)	169
VNS	Gauging station	SJR at Vernalis (Dayflow SJR)	198

Note: Distances to sites on the San Joaquin River are measured along the main stem of the river.
[a]Database source and site ID are identified for gauging stations.

for dissolved oxygen control and structural stability during transport. Fish were acclimatized prior to transfer into the SJR if the water temperature difference between the transport tanks and river was >5 °C. Fish were held in the river at the release site at least 24 h before release. Fish tagging and handling procedures were based on those outlined in Adams et al. (1998) and Martinelli et al. (1998) and were updated to the Standard Operating Protocol developed by the US Geological Survey's (USGS) Columbia River Research Laboratory (Liedtke et al. 2012).

For each study year, in-tank tag-life studies were performed to measure the failure rate of tags used in the study. Between 82 and 149 tags were sampled across manufacturing lots and study months each year. Tag-life studies typically began at the time of the tagged fish release or within several weeks after release. Tank water temperature was maintained using river water pumped from OR to maintain temperatures similar to the Delta environment when tagged fish were migrating.

Tagged steelhead were monitored during their migration through the Delta using fixed-site acoustic hydrophones and receivers (telemetry stations; Fig. 1; Table 2). Each telemetry station was composed of 1 to 24 hydrophones to achieve complete coverage of the river channel. Hydrophone spacing across the river channel was based on range tests; at Chipps Island, HTI hydrophone spacing was approximately 150 to 300 m, and VEMCO spacing was approximately 100 to 150 m. Telemetry station locations were determined by the possible routes of juvenile salmon passage and the requirements of the statistical multistate mark–recapture model to distinguish and estimate movement, survival, and detection processes (described below). The locations of key stations remained constant across the six years of the study. Delta entry was denoted by detection at the Mossdale station (MOS) and Delta exit by detection on the Chipps Island station (CHP). The CHP station was composed of a dual (2011–2014) or triple (2015, 2016) line of hydrophones across the river for estimation of the detection efficiency at that site. Telemetry stations were installed within 0.6–3.0 km downstream of the head of OR in both the SJR (SJL station) and OR (ORE station) for estimation of survival from the head of OR. In the SJR route, telemetry stations were also installed at Garwood Bridge (SJG) near the city of Stockton, California, at MacDonald Island (MAC), and in TC (TRN); together, detections on the MAC and TRN stations denoted arrival at TCJ. In 2014–2016, a telemetry station was installed at Benicia Bridge (BBR) downstream of Chipps Island and used to estimate the detection efficiency at CHP.

Covariates

Environmental and operational data from various gauging and monitoring stations throughout the Delta were downloaded from several online databases: California Department of Water Resources' Dayflow database (https://data.cnra.ca.gov/dataset/dayflow: river discharge, Delta inflow and outflow, export rate, salinity), the California Data Exchange Center (CDEC; https://cdec.water.ca.gov: temperature), the California Water Data Library (water.ca.gov/waterdatalibrary: temperature, river discharge), and the USGS National Water Information System (waterdata.usgs.gov/nwis: river discharge). River discharge and temperature data were reviewed for quality and obvious errors were omitted. In particular, records were removed if they were marked as missing by the database, were out of sequence with neighboring readings, or were part of a string of three or more identical readings (discharge only).

Covariates were selected to represent environmental and operational conditions in several ways to address management questions (Table 3). Environmental conditions were represented by measures of river flow (discharge), temperature, salinity, and time of day. The primary measure of river flow was the SJR discharge into the Delta (SJR inflow) measured near Vernalis, California (VNS). The Delta inflow from the SR (SR inflow), measured at Freeport, California (SAC), was also considered because flow conditions in

Table 3. Covariates evaluated in individual-based models.

Name	Type	Station	Duration (days)	Metric	Unit
SJR.hor, SJR.tcj	Delta inflow	VNS	5 (hor), 1 (tcj)	Mean	cfs[d]
SR.hor, SR.tcj	Delta inflow	SAC	5 (hor), 1 (tcj)	Mean	cfs
CVP.hor, CVP.tcj	Export rate	CVP	5 (hor), 1 (tcj)	Mean	cfs
SWP.hor, SWP.tcj	Export rate	SWP	5 (hor), 1 (tcj)	Mean	cfs
CVPSWP.hor, CVPSWP.tcj	Export rate	CVP, SWP	5 (hor), 1 (tcj)	Mean	cfs
pCVP.hor, pCVP.tcj	Export (proportion CVP)	CVP, SWP	5 (hor), 1 (tcj)	Mean	
IE.hor, IE.tcj	Inflow : export ratio	VNS, CVP, SWP	5 (hor), 1 (tcj)	Mean	
X2.hor, X2.tcj	Salinity[a]		5 (hor), 1 (tcj)	Mean	km
Tmsd.hor, Tmsd.tcj	Temperature	MSD	7[b]	Mean of daily maximum	°C
Tclc.hor, Tclc.tcj	Temperature	CLC	3	Mean of daily mean	°C
OMT.hor.net, OMT.tcj.net	Mid-Delta flow	ORB, MID	1	Mean net	cfs
OMT.hor.rms, OMT.tcj.rms	Mid-Delta flow	ORB, MID	1	RMS	cfs
BDT.hor.net, BDT.tcj.net	Flow	BDT	1	Mean net	cfs
QOUT	Delta outflow	Chipps Island[c]	1	Natural log of mean	cfs
Fork length at tagging	Fish size				mm
Barrier	Barrier				True, false
Time of Day	Time of day				Day, night, dusk

Note: Station = gauging station or pumping station. Summary period duration (in days) began at detection at the head of Old River (hor; SJL or ORE telemetry stations) or Turner Cut Junction (tcj; MAC or TRN telemetry stations) telemetry stations unless otherwise noted; a common duration was used for each tag. Mean net = average net flow; RMS = root mean square. See Fig. 1 and Table 2 for location of monitoring stations.

[a]Distance from Golden Gate Bridge to 2 ppt salinity at river bottom (2 psu isohaline).

[b]Summary period ended at detection at HOR or TCJ telemetry stations.

[c]As reported in CDWR Dayflow database (https://data.cnra.ca.gov/dataset/dayflow); measured on day of detection at CHP; if not detected at CHP, measured on day 5.6 after detection at SJL or day 5.5 after detection at ORE (= median travel time from HOR to CHP by route, rounded to nearest 0.1).

[d]1 cubic foot per second (cfs) = 28.32 $L \cdot s^{-1}$

northern and western part of the study area are influenced by SR inflow (Monsen et al. 2007; Cavallo et al. 2013). River flow measurements were used from locations within the Delta, including the SJR at Brandt Bridge (between the head of OR and Stockton, California; BDT), OR at Bacon Island (ORB), and MR at Bacon Island (MID) (Fig. 1; Table 2). The ORB and MID 15-minute river flow measures were summed to provide an overall measure of flow conditions in the interior Delta north of the water export facilities: OMT = ORB + MID. Water temperature was measured at Mossdale (MSD) and Clifton Court Forebay (CLC). Salinity was represented by the measure X2 (Dayflow), which reports the distance (km) upstream from the Golden Gate Bridge where the river bottom salinity concentration reaches 2 ppt (2 psu isohaline). Time of day was measured by whether fish were detected at the upstream boundary of the survival reach during day, night, or crepuscular periods.

Operational conditions reflected management of the water project operations, including reservoir releases upstream, barrier installation, and water export rates. Reservoir releases were represented by the Delta inflow measures, which were thus both environmental and operational variables. The status of the barrier at the head of OR was defined as "present" if the tagged fish was last detected at the SJL or ORE telemetry stations between the date of barrier closure during installation and the date of barrier opening during removal, or as "absent" otherwise. Water export rates were represented by the daily export rates reported for the CVP and SWP. The combined export rate (CVP + SWP) and the CVP proportion of the combined export rate (pCVP = CVP/(CVP+SWP)) were also considered. Finally, a regulatory metric defined as the ratio of SJR inflow to the combined export rate, or the "I:E ratio", was considered.

Environmental and operational variables were recorded either daily (Delta inflow, export rates, I:E ratio, X2) or at 15-minute intervals (river flow, temperature). To reduce effects of subhourly fluctuations in measurements and to better represent conditions when the fish were actually migrating through the system, the measured conditions were summarized over a time period defined by tag detection at either the OR head or TCJ. The median travel time from the head of OR to Chipps Island (approximately 5.6 days) was used to select a 5-day summary period for measures of Delta inflow, exports, the I:E ratio, and X2 starting at the time of detection at the head of OR. Delta inflow, exports, I:E ratio, and X2 were also summarized over a 1-day period starting at tag detection at TCJ, for modeling survival in the lower reaches of the Delta. SJR inflow and the I:E ratio were summarized as the natural log of the mean daily reading; SR inflow, X2, and export measures were summarized as the mean of the daily readings. The gauging station readings of river flow at the BDT, ORB, and MID stations were missing a considerable amount of data in some years, and the longer summarization periods had more missing data than shorter periods; thus, the BDT and OMT measures used 1-day summarization periods to maximize the amount of data available. River flow at BDT and OMT were summarized as the average (i.e., arithmetic mean) of the 15-minute event data during the summarization period; this measure accounted for changes in direction of river flow due to tidal cycles or water pumping operations and represented the average net river flow during the summary period. Reverse flows were particularly common in the mid-Delta; thus, an alternative measure of OMT river flow used the root mean square of the 15-minute event data and represented the average magnitude of flow passing the gauging station during the summary period. Water temperature at MSD was represented as the 7-day average daily maximum temperature (7DADM, the usual management metric from this site) through the time period that ended at detection at the head of OR or TCJ. Water temperature at the CLC station was summarized as the average over a 3-day period starting at the time of tag detection at the head of OR.

A daily index of Delta outflow was used to represent flow conditions at the time of tag passage of the CHP telemetry station: QOUT, using the outflow index from the Dayflow database. The metric QOUT was measured on the day of tag detection at CHP, or on the day of expected tag detection for tags not observed at CHP. The day of expected tag detection was estimated using the median observed travel time from the head of OR to CHP using data pooled across all years and categorized by migration route:

5.6 days after tag detection at SJL, and 5.5 days after tag detection at ORE.

Statistical methods

Data processing

The raw acoustic tag detection data were processed into detection events for each tag by the USGS lab in Cook, Washington (2011) or Sacramento, California (2012–2016). The processed detection data were transferred to the University of Washington, Seattle, Washington, United States, for further processing into chronological detection histories. The study fish were expected to be migrating in a seaward direction; however, the tidal nature of the Delta meant that study fish may have temporarily moved upstream on reverse flows. The detection histories used the final pass of the study fish past each receiver or river junction as the best representation of the fish fate.

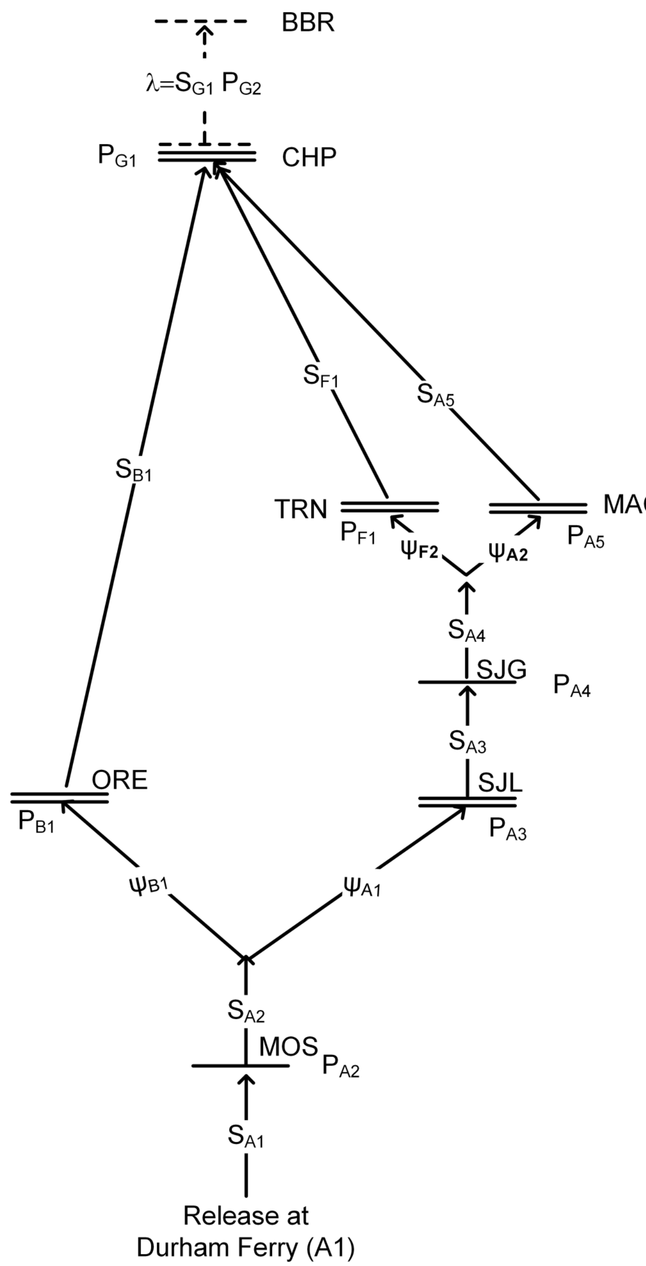
The possibility of a predatory fish eating a tagged steelhead and then moving past a receiver with the active acoustic tag still in its gut raised the potential for biased survival estimates. Suspected detections of predatory fish on steelhead tags were identified and removed from the data set using a "predator filter". The predator filter was based on assumed behavioral differences between juvenile steelhead and resident predatory fish such as juvenile and subadult bass. It focused on residence time in the vicinity of the receivers or in regions of the Delta, movements directed against river flow, and travel time between receivers. The predator filter removed between 7.3% and 13.9% of the detection events each year, including a total of 111 (5.4%) of the detection events at Chipps Island (3.5% of the tags detected there). More information on the predator filter is available in Buchanan (2018*a*, 2018*b*, 2018*c*) and US Bureau of Reclamation (USBR 2018*a*, 2018*b*, 2018*c*).

Survival estimation

Survival was estimated from the filtered detection data using a multistate mark–recapture (MSMR) model in which migration route was represented by model state (Fig. 2; Perry et al. 2010; Buchanan et al. 2013, 2018). Model parameters consisted of reach-specific survival probabilities (*S*), junction-specific route selection probabilities (*Ψ*), and site-specific conditional detection probabilities (i.e., detection efficiencies, *P*). In some reaches, survival and route selection could not be separately estimated, and the joint probability of route selection and survival was estimated instead. A multinomial likelihood function was constructed under the assumptions of common survival, route selection, transition, and detection probabilities within a release group and independent detection events. The MSMR model accounted for imperfect detection efficiencies in estimating survival and incorporated multiple migration routes to estimate route-specific or region-specific survival probabilities. Survival was estimated for various regions in the Delta, including (1) through-Delta survival (i.e., Mossdale to Chipps Island: MOS to CHP), (2) route-specific survival from the head of OR to Chipps Island (SJL–ORE to CHP), (3) survival from the head of OR to TCJ (SJL to MAC–TRN), and (4) route-specific survival from TCJ to Chipps Island (MAC–TRN to CHP). Special attention was given to the SJR route because it is typically considered preferable to the OR route. Cumulative survival along the SJR route was estimated to identify regions where the mortality rate was highest.

The precise structure of the MSMR model each year depended on the locations of the detection sites. Although additional detection sites were added in later years as study objectives expanded, the same core sites were used in all years. Figure 2 shows the model structure on the scale addressed in this paper, common to all years. The full model schematic for each individual year can be found in the annual reports (Buchanan 2018*a*, 2018*b*, 2018*c*; USBR 2018*a*, 2018*b*, 2018*c*).

Fig. 2. Schematic of multistate mark–recapture model to estimate survival of juvenile steelhead from Mossdale (MOS) through the Delta to Chipps Island (CHP). The Head of Old River (OR) is monitored by telemetry stations at SJL (San Joaquin River [SJR] route) and ORE (OR route). The Turner Cut Junction is monitored by telemetry stations at MacDonald Island (MAC) and Turner Cut (TRN). SJG is the SJR at Garwood Bridge. Site BBR (Benicia Bridge) was available only in 2014, 2015, and 2016. Horizontal lines indicated acoustic receiver lines; parallel lines indicate dual-line or triple-line receiver array. The third receiver line at CHP was available only in 2015. Model parameters are probabilities of reach survival (*S*), detection (*P*), route selection (*Ψ*), and the last reach parameter λ = SP.



For each study year, the MSMR model was fit separately to each release group and annual averages were computed of the release-specific parameter estimates weighted by release size. The MSMR model was fit to data using maximum likelihood estimation in the software program USER (Lady and Skalski 2009). On occasion, the full model had to be simplified to account for sparse data through certain routes, resulting in loss of some route-specific information but not affecting the estimate of overall through-Delta survival; for example, there were too few detections at TCJ from the March release in 2013 to estimate survival from this junction to Chipps Island, but overall survival from Mossdale to Chipps Island in the SJR route could be inferred.

Tag life was measured as the time between tag activation and final tag failure time in the in-tank tag-life studies. Observed tag survival was modeled separately for each year using the four-parameter vitality curve (Li and Anderson 2009). The estimated fish survival probabilities in the MSMR model were adjusted for tag failure using methods adapted from Townsend et al. (2006) using the observed travel time per release group from tag activation to downstream detection sites and the fitted vitality curves (Buchanan et al. 2018). Travel time and the associated probability of tag survival to Chipps Island were estimated separately by migration route for this purpose.

Survival modeling

The relationship between steelhead survival through the Delta and covariates was investigated for three spatial regions: from the head of OR to Chipps Island, from the head of OR to TCJ, and from TCJ to Chipps Island. Statistical survival models were developed using individual-based generalized linear models (GLM) with a multinomial error structure and fixed effects (McCullagh and Nelder 1989; Buchanan and Skalski 2020).

The form of the GLM depended on the spatial region being considered. Survival to Chipps Island was modeled using tags detected at the telemetry stations at the upstream end of the reach (virtual release): SJL and ORE for the head of OR, and MAC and TRN for TCJ (Fig. 2). Tag detections at the CHP and BBR telemetry stations were modeled as a multinomial random variable in a mark–recapture framework in which both the survival component and the detection component were modeled as functions of covariates. The detection model was defined first and modeled detection probabilities at CHP and BBR as a function of the measure of Delta outflow, QOUT, on the log scale using a GLM with a logit link; detailed methods on the detection probability modeling are provided in the online Supplemental Material[1]. The survival model also used a logit link to express the probability of survival to Chipps Island as a function of covariates, including an offset for the probability of tag survival.

For survival from the head of OR to TCJ, the lack of river gauging stations near TCJ complicated modeling of route selection and detection probabilities at the TCJ telemetry stations (MAC and TRN) and made a multinomial GLM impractical. Thus, a GLM with binomial errors and logit link function was used to relate detection at the TCJ telemetry stations to covariates for tags that were previously detected at SJL. Inference to survival required the assumption that all tags present at MAC and TRN were detected there (i.e., $P_{\mathrm{MAC}} = P_{\mathrm{TRN}} = 1$). The potential bias in survival inference due to imperfect detection efficiencies at MAC and TRN was assessed through a simulation process. For each simulation, a random subset of the tags that were not detected at MAC or TRN was reassigned to "detected" status; the number of tags selected for reassignment equaled the estimated number of tags that missed detection at MAC or TRN based on the mark–recapture estimates of survival and detection probabilities. The final GLMs identified in the modeling process were refit to the new data set that consisted of the observed and simulated tag detections. The mean regression parameter estimates were computed over 100 simulations and compared to the parameter estimates from the observed data set.

Both group-level and individual-level variables were used to account for variation in survival on all three spatial scales. The default baseline model used for assessment of environmental and operational covariates included fixed effects of year, migration route, and barrier, as well as time of day of detection at the upstream end of the reach and fork length at tagging. An interaction effect between route and barrier was included because the barrier both blocks most fish access to the OR route and influences the river flow entering the route. The default baseline model had the following form:

$$\mathrm{logit}(S_{yrbi}) = \beta_{0y} + \rho I_r + \tau I_b + \gamma I_r I_b + \delta_d I_d + \beta_L L_i$$

where logit(·) is the logit link function, β_{0y} is the baseline intercept for year y (SJR route, no barrier, departure during day), ρ, τ, and δ_d are intercept adjustments and I_r, I_b, and I_d are indicator functions for the non-SJR route (i.e., OR route for survival from the head of OR, or TC route from TCJ), barrier, and time of day (night or crepuscular period), respectively, γ, is the additional intercept adjustment for the combination of barrier and OR route, β_L is the slope (regression coefficient) for fork length, and L_i is fork length for fish i. Terms in the default baseline model were retained if they were significant at the 5% level from F tests. The default baseline model omitted the ρ and γ terms for survival from the Head of OR to TCJ, and omitted the γ term for survival from TCJ to Chipps Island.

Environmental and operational variables (X) were added to the baseline model using forward stepwise model selection (F tests); both main effects and interaction effects with the baseline variables were considered. Baseline variable effects were retested with variable X in the model, and Bonferroni corrections were used to account for multiple testing (Sokal and Rohlf 1995). The Akaike information criterion (AIC; Burnham and Anderson 2002) was used to select among single-variable models for different environmental and operational variables. The single-variable model with the lowest AIC was used as the basis of the next step in model construction, with the possibility of adding other X variables. Selected models were significant if the experimentwise (i.e., multiple comparison) type I error rate was <0.05 and $\Delta\mathrm{AIC} < 2$ compared to the model with the smallest AIC value.

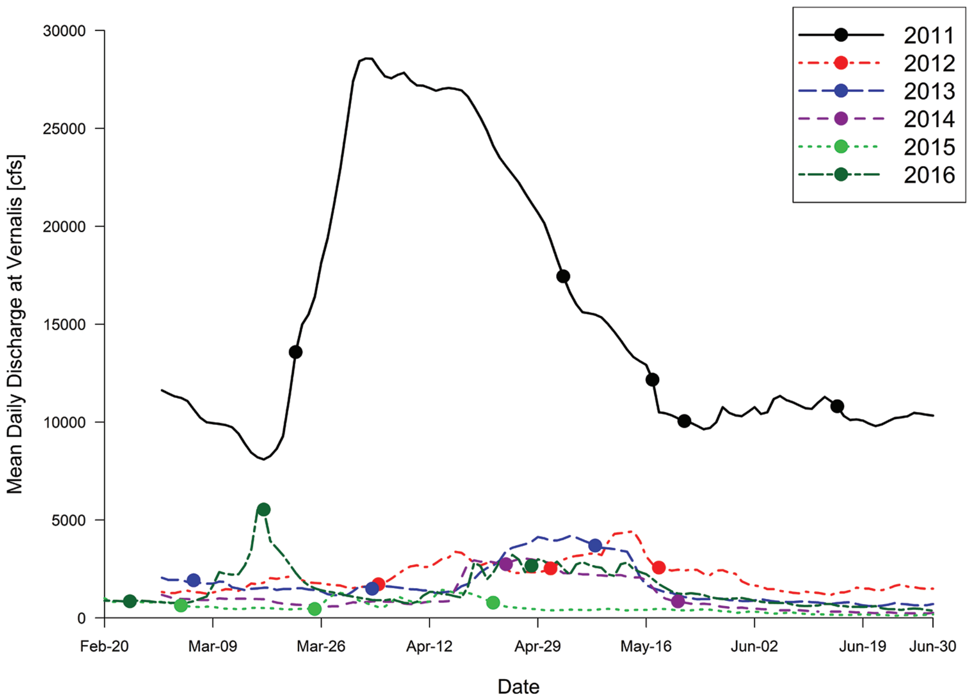
Goodness-of-fit was investigated in two ways. First, the area under the curve (AUC) was computed for the Receiver Operating Curve (Nam and D'Agostino 2002); values > 0.7 were considered acceptable (Hosmer and Lemeshow 2000). Second, the predicted joint probability of fish and tag survival and detection at the downstream site (either CHP or TCJ) was visually compared to the observed proportion of tags detected there, computed for groups of individual tags ordered by model predictions. Fifteen approximately equal-sized groups were used for both assessments.

Drought effects

The potential effect of drought on steelhead survival patterns through the Delta was investigated in several ways. Drought years were considered to be those classified as "critical" for water resource planning by the California Department of Water Resources: critical years were 2013, 2014, and 2015, while 2011 was classified as "wet" and 2012 and 2016 were both classified as "dry" (cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). Drought was hypothesized to affect survival in a number of possible ways: lower overall survival from the head of OR or TCJ to Chipps Island in either route, lower survival to TCJ, a shift upstream of the reach with the highest mortality rate per kilometre, or lower variability in survival estimates. Differences in the magnitude of survival estimates by drought status were tested using a one-way weighted ANOVA of the log-transformed survival estimates with weights equal to the inverse squared coefficient of variation. Visual inspection of cumulative survival through the SJR route was used to identify the reach of highest mortality rate per kilometre for

[1]Supplementary data are available with the article at https://doi.org/10.1139/cjfas-2020-0467.

Fig. 3. Mean daily San Joaquin River discharge (flow) at the VNS gauging station near Vernalis, California, (SJR inflow) through the study period for each year. Points indicate the observed mean daily discharge on the first day of each release group. (Note: 1 cfs = 28.32 L·s^{-1}.) [Colour online.]



each year. Another possible ramification of drought status is alteration of the survival dynamics across the system, in which different relationships between covariates and survival are observed under different degrees of drought conditions. For example, the annual variability in survival represented by year-specific intercepts in GLM models may be primarily associated with drought status. This possibility was investigated by comparing the model fits of a year-based model as defined above and a drought-based model using fixed drought effects in place of fixed year effects (*F* tests); the final model structure for each spatial region was used as the basis for testing. The comparison was performed using the two-way classification of drought vs. non-drought years (2013–2015 vs. 2011, 2012, and 2016), and also using a three-way classification of wet (2011), dry (2012, 2016), and drought (2013–2015) years.

Results

Delta conditions

The study year 2011 had considerably higher river discharge than any of the later years in the study, following a wet autumn in 2010 and high precipitation events in February and March 2011 (Fig. 3). Mean daily SJR inflow into the Delta measured at VNS averaged 15 491 cubic feet per second (cfs; 1 cfs = 28.32 L·s^{-1}) during March–June 2011, and 739 to 2721 cfs during the study months in 2012–2016. The pattern of covariate values used in the survival modeling showed no overlap in SJR inflow values between 2011 and the other study years, and noticeably lower inflow in 2015 (Fig. 4*a*). Average combined export rates (CVP+SWP) were <5000 cfs throughout most of the study periods but increased to >10 000 cfs at the end of the 2011 study. The I:E ratio tended to be higher for 2011 and lowest for 2015 and 2016. As with SJR inflow and exports, the 1-day average net mid-Delta flow (OMT) was most variable for 2011 and was mostly <0 cfs for 2012–2016 (Fig. 4). Temperature at MSD was inversely related to river flow ($r = -0.69$). The salinity measure X2 was highest in the extreme drought years of 2014 and 2015 and lowest in 2011 and 2016 (Fig. 4*f*).

Survival: Mossdale to Chipps Island

Estimates of through-Delta survival from Mossdale to Chipps Island ranged from 0.06 ($\widehat{SE}$ = 0.02) for the May 2014 release to 0.69 ($\widehat{SE}$ = 0.03) for the March 2011 release; annual estimates were lowest in 2013 (0.14, $\widehat{SE}$ = 0.01) and highest in 2011 (0.54, $\widehat{SE}$ = 0.01; Table 4). In addition to the annual differences, there was variation among release groups within each year. For example, the April 2014 release had considerably higher survival (0.43, $\widehat{SE}$ = 0.03) than the May release of the same year (0.06, $\widehat{SE}$ = 0.02) (Table 4). Travel time from Mossdale through the Delta to Chipps Island varied from 1.5 to 35.0 days; the median travel time each year ranged from 5.8 to 8.0 days. Conditional detection probability estimates were high at the CHP telemetry station throughout most of the study: 15 of the 19 estimates were ≥0.95 (Table 4).

Survival: head of Old River to Chipps Island

Travel time from the head of OR to Chipps Island ranged from 1.4 to 34.9 days; the median travel time through this region was 5.6 days, and neither the SJR route nor the OR route had a consistently shorter travel time (Fig. 5). Survival estimates from the head of OR to Chipps Island ranged from 0 (March 2013) to 0.72 ($\widehat{SE}$ = 0.04; March 2011) for the SJR route, and from 0.05 ($\widehat{SE}$ = 0.03; mid-May 2012) to 0.71 ($\widehat{SE}$ = 0.04; March 2011) for the OR route (Table 4). The estimated route selection probability for the SJR route ranged from 0.08 ($\widehat{SE}$ = 0.02; March 2013) to 0.97 ($\widehat{SE}$ = 0.01, early May 2012) (Table S1, Supplemental Material[1]). Within the SJR route between the head of OR and Chipps Island, cumulative survival declined most sharply in the region upstream of SJG for the drought years of 2013–2015, whereas the other years showed either little difference in the per-kilometre survival rate throughout the route (e.g., 2011, 2016) or else had a higher mortality rate downstream of TCJ (2012) (Fig. 6).

Survival and detection modeling on this spatial scale was based on 2515 tags detected at SJL and 2122 tags detected at ORE; 1772 of these tags were subsequently detected at either CHP or BBR. *F* tests indicated an association between Delta outflow and detection probability at Delta exit (P = 0.0107). AIC selected unique

Fig. 4. Box plots of key covariates by study year. Box represents interquartile range and thick horizontal line is median. Covariates are (*a*) 5-day average SJR inflow (log scale; cfs; 1 cfs = 28.32 L·s^{-1}), (*b*) 5-day average combined export rate (cfs), (*c*) 5-day average I:E ratio (log scale), (*d*) 1-day average net Old River – Middle River (OMT) flow (cfs), (*e*) 7DADM temperature at MSD (°C), and (*f*) 5-day average X2 value (km).

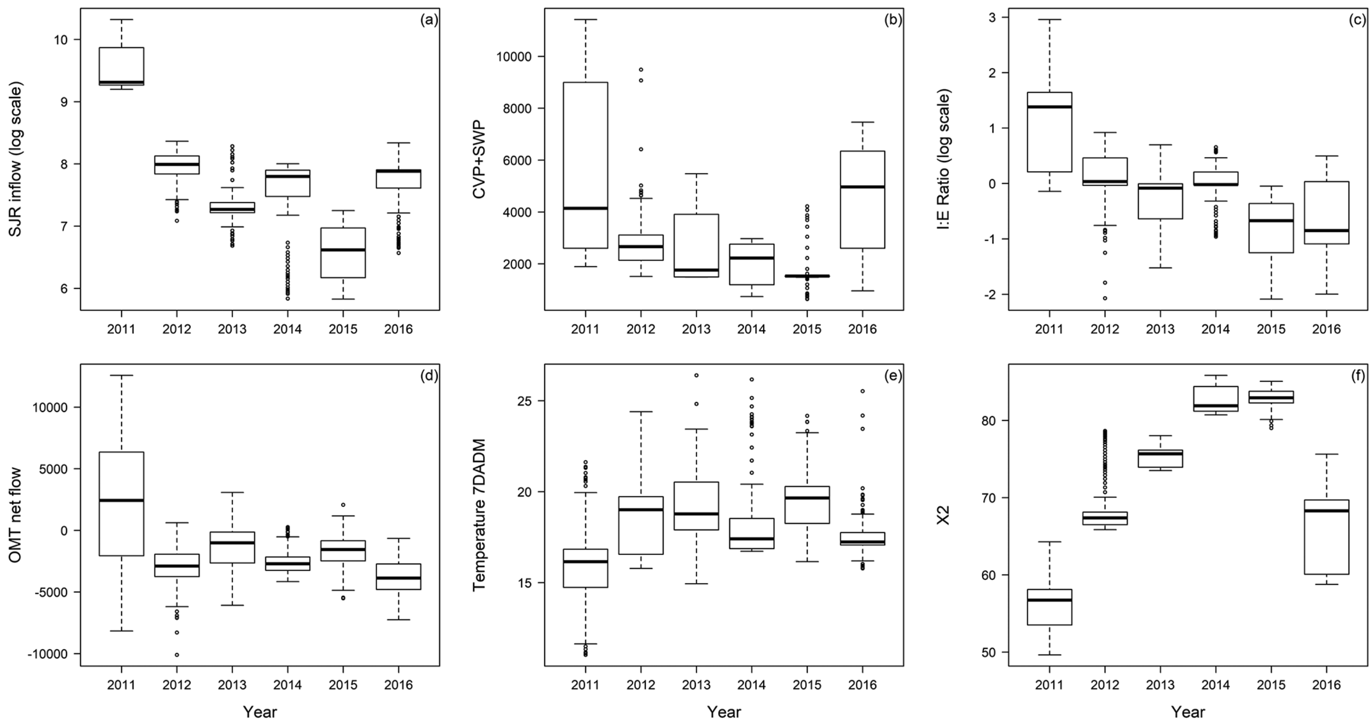


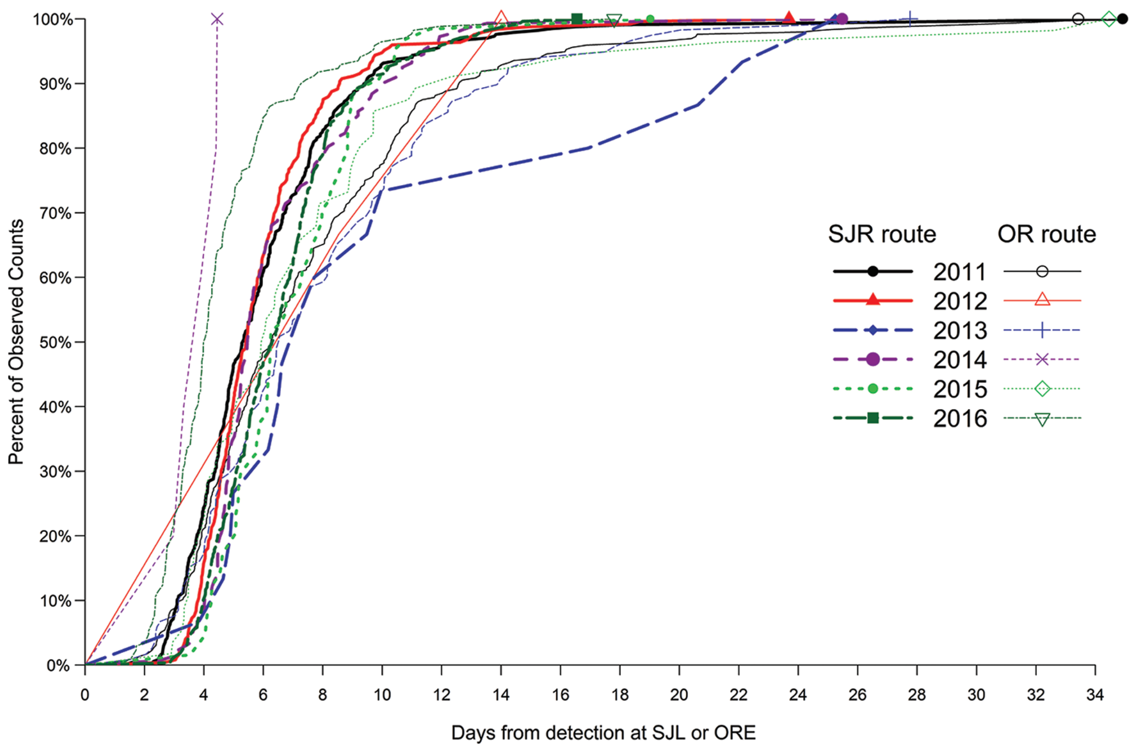
Table 4. Release dates, number (*N*) released at Durham Ferry, and estimates (standard errors in parentheses) of the probabilities of survival (*S*) and detection (*P*) for release groups of acoustic-tagged juvenile steelhead.

Year	Release dates	*N*	$\hat{S}_{MOS-CHP}$	$\hat{S}_{SJL-CHP}$	$\hat{S}_{ORE-CHP}$	$\hat{S}_{SJL-TCJ}$	$\hat{S}_{MAC-CHP}$	$\hat{S}_{TRN-CHP}$	$\hat{P}_{CHP}$	$\hat{P}_{MAC}$	$\hat{P}_{TRN}$
2011	22–26 March	479	0.69 (0.03)	0.72 (0.04)	0.71 (0.04)	0.92 (0.02)	0.82 (0.04)	0.37 (0.13)	0.97 (0.01)	1.00 (0.00)	1.00
	3–7 May	474	0.52 (0.03)	0.57 (0.04)	0.51 (0.04)	0.88 (0.03)	0.81 (0.05)	0.32 (0.08)	0.99 (0.00)	0.99 (0.00)	1.00
	17–21 May	478	0.44 (0.03)	0.51 (0.05)	0.49 (0.05)	0.83 (0.03)	0.69 (0.05)	0.35 (0.10)	1.00 (0.00)	1.00 (0.00)	1.00
	22–26 May	480	0.60 (0.03)	0.69 (0.04)	0.55 (0.05)	0.89 (0.03)	0.81 (0.05)	0.69 (0.08)	0.98 (0.01)	1.00 (0.00)	1.00
	15–18 June	285	0.38 (0.05)	0.34 (0.06)	0.46 (0.07)	0.72 (0.07)	0.50 (0.13)	0.34 (0.11)	0.99 (0.01)	0.89 (0.10)	1.00
	2011 Total	2196	0.54 (0.01)	0.58 (0.02)	0.55 (0.02)	0.86 (0.01)	0.75 (0.03)	0.42 (0.05)	0.98 (0.00)	0.98 (0.01)	1.00
2012	4–7 April	477	0.26 (0.02)	0.28 (0.02)	0.07 (0.04)	0.79 (0.04)	0.42 (0.04)	0.12 (0.05)	1.00 (0.00)	1.00 (0.00)	0.58 (0.11)
	1–6 May	478	0.35 (0.03)	0.36 (0.03)	0.10 (0.07)	0.83 (0.02)	0.52 (0.04)	0.17 (0.05)	1.00 (0.00)	0.97 (0.02)	1.00
	18–23 May	480	0.33 (0.04)	0.37 (0.04)	0.05 (0.03)	0.91 (0.02)	0.50 (0.05)	0.24 (0.06)	0.98 (0.01)	1.00 (0.00)	1.00
	2012 Total	1435	0.32 (0.02)	0.34 (0.02)	0.07 (0.03)	0.84 (0.02)	0.48 (0.03)	0.18 (0.03)	0.99 (0.00)	0.99 (0.00)	0.86 (0.04)
2013	6–9 March	476	0.15 (0.02)	0.00[a] (0.00)	0.17 (0.02)	0.00[a] (0.00)	NA	NA	1.00 (0.00)	*n* = 0	*n* = 0
	3–6 April	477	0.09 (0.02)	0.13 (0.06)	0.08 (0.02)	0.24 (0.07)	0.81 (0.18)	0.25 (0.22)	0.99 (0.01)	1.00	1.00
	8–11 May	472	0.20 (0.02)	0.21 (0.06)	0.20 (0.02)	0.37 (0.07)	0.84 (0.11)	0.00[a] (0.00)	0.99 (0.00)	1.00	1.00
	2013 Total	1425	0.14 (0.01)	0.11 (0.03)	0.15 (0.01)	0.20 (0.03)	0.82 (0.10)	0.13 (0.11)	0.99 (0.00)	1.00	1.00
2014	24–27 April	480	0.43 (0.03)	0.45 (0.03)	0.32 (0.09)	0.80 (0.02)	0.74 (0.03)	0.17 (0.04)	0.98 (0.01)	1.00	1.00
	21–24 May	478	0.06 (0.02)	0.08 (0.03)	0.09 (0.09)	0.21 (0.05)	0.43 (0.13)	NA	0.71 (0.17)	1.00	1.00
	2014 Total	958	0.24 (0.02)	0.26 (0.02)	0.21 (0.06)	0.50 (0.02)	0.59 (0.07)	0.17 (0.04)	0.85 (0.09)	1.00	1.00
2015	4–7 March	480	0.15 (0.03)	0.19 (0.07)	0.15 (0.03)	0.32 (0.08)	0.81 (0.12)	NA	1.00 (0.00)	1.00	1.00
	25–28 March	478	0.35 (0.03)	0.48 (0.05)	0.28 (0.04)	0.64 (0.05)	0.78 (0.06)	0.60 (0.22)	1.00 (0.00)	1.00	1.00
	22–25 April	469	0.20 (0.04)	0.38 (0.07)	0.08 (0.08)	0.49 (0.07)	0.94 (0.06)	0.33 (0.19)	0.89 (0.07)	1.00	1.00
	2015 Total	1427	0.23 (0.02)	0.35 (0.04)	0.17 (0.03)	0.48 (0.04)	0.84 (0.05)	0.47 (0.15)	0.97 (0.02)	1.00	1.00
2016	24–27 February	480	0.39 (0.03)	0.24 (0.09)	0.43 (0.04)	0.60 (0.10)	0.34 (0.16)	0.50 (0.20)	0.95 (0.03)	1.00	1.00
	16–19 March	480	0.42 (0.02)	0.51 (0.05)	0.40 (0.03)	0.74 (0.05)	0.82 (0.06)	0.33 (0.11)	0.93 (0.02)	1.00	1.00
	27–30 April	480	0.59 (0.02)	0.61 (0.02)	0.17 (0.06)	0.89 (0.02)	0.81 (0.02)	0.31 (0.05)	0.93 (0.02)	0.99 (0.00)	1.00
	2016 Total	1440	0.47 (0.02)	0.45 (0.03)	0.33 (0.03)	0.74 (0.04)	0.66 (0.06)	0.38 (0.08)	0.94 (0.01)	1.00 (0.00)	1.00

Note: TCJ = Turner Cut Junction, denoted by the MAC and TRN telemetry stations. See Fig. 1 for station locations. Values without standard errors were estimated at exactly 1.00; *n* = 0 indicates 0 detections.

[a]Under assumption of 100% conditional detection probability.

Fig. 5. Cumulative travel time (days) from the Head of Old River to Chipps Island, by year and route. SJR = San Joaquin River, OR = Old River. Icon marks latest observed travel time for the study year. [Colour online.]



detection models using Delta outflow for the CHP receiver lines and λ to the BBR station (ΔAIC $\geq$ 38.7).

The baseline survival model to Chipps Island retained the effects of year, barrier, and fork length at tagging ($P < 0.0001$ for year and $P \leq 0.0207$ for barrier and fork length). Migration route and the time of day at the head of OR were not associated with survival on this spatial scale ($P \geq 0.1282$) and were omitted from the model. The SJR measure of Delta inflow, temperature, the I:E ratio, and X2 were all associated with survival when effects of year, barrier, and fork length were accounted for ($P \leq 0.0016$; testwise $\alpha = 0.0042$; Table 5). The mean mid-Delta flow, SR inflow, and CVP proportion of exports were also associated with survival at the testwise 0.05 level ($P \leq 0.0196$). The top covariate selected by AIC was SJR inflow (SJR.hor, $P < 0.0001$, ΔAIC $\geq$ 31.87; Table 5). When SJR inflow was included in the model, no other covariates had statistically significant added effects ($P \geq 0.0653$ vs. testwise $\alpha = 0.0091$). The SJR inflow model achieved acceptable fit based on the AUC of the Receiver Operating Characteristic curve (AUC = 0.72). However, all models had AUC $\geq$ 0.70 (i.e., considered acceptable) including the baseline model (Table 5), demonstrating little added explanatory value of any of the covariates once year, barrier status, and fork length were included. For comparison, a model that included SJR inflow but omitted year, barrier, and fork length had AUC = 0.66, indicating the relatively large effects of year, barrier, and fork length on the model predictions. The fitted SJR inflow model for this reach was

$$\text{logit}(S_{ybi}) = \hat{\beta}_{0y} + 0.582(\widehat{\text{SE}} = 0.238)I_b + 0.012(\widehat{\text{SE}} = 0.004)L_i + 1.000(\widehat{\text{SE}} = 0.191)\ln(\text{SJR.hor}_i)$$

where $\hat{\beta}_{0y}$ ranged from –12.485 ($\widehat{\text{SE}}$ = 2.224) for 2011 to –10.617 ($\widehat{\text{SE}}$ = 1.647) for 2015. Survival from the head of OR to Chipps Island was predicted to be higher for higher levels of SJR inflow as represented by the 5-day mean daily average (Fig. 7), when the barrier was installed at the head of OR, and for larger individuals. Different years were predicted to have different magnitudes of survival for the same Delta inflow levels, consistent with the release-level survival estimates. For example, survival was modeled to be lower in 2014 compared to 2016 for the same levels of SJR inflow when the barrier was in place (Fig. 7). However, 2016 predictions without the barrier were comparable to 2014 predictions with the barrier for the same inflow levels, indicating that the barrier can help to offset non-inflow factors that may lower overall survival. While estimated survival was generally higher in 2011 than in either 2014 or 2016 (Table 4; Fig. 6), the regression model indicates that only part of that increase in survival was associated with the high Delta inflow values observed in 2011; the highest predicted survival in 2016 (approximately 0.61) was greater than the majority of the survival predictions for 2011 (0.41–0.68) (Fig. 7).

Survival: head of Old River to the Turner Cut Junction

Of the 2515 tags detected in the SJR route at the head of OR (SJL telemetry station), 1914 were also detected at the TCJ telemetry stations (MAC or TRN). Travel time from SJL to the TCJ stations ranged from 0.4 to 25.5 days (median = 2.4 days), and survival estimates in this reach ranged from 0 (March 2013) to 0.92 ($\widehat{\text{SE}}$ = 0.02, March 2011) (Table 4). Cumulative survival curves showed that survival in this reach declined most sharply between the head of OR and Garwood Bridge (SJG) in four of the six years (2013–2016) (Fig. 6).

The estimated probability of tag survival to TCJ was $\geq$0.998 for all study years, so no adjustment for tag failure was included in the survival and detection regression model. The estimated probability of detection at the TCJ telemetry stations (MAC and TRN) was $\geq$0.98 for 33 of 36 estimates (Table 4). The lowest estimate of detection probability was 0.58 ($\widehat{\text{SE}}$ = 0.11), for the TRN telemetry station for the April 2012 release group (Table 4).

Regression modeling of the joint probability of survival and detection found a highly significant year effect ($P < 0.0001$) and a moderately significant barrier effect after adjusting for year ($P = 0.0342$). The effect of fork length at tagging was not significant ($P = 0.1005$) but was retained in the baseline model for comparison

Fig. 6. Cumulative survival from Mossdale (MOS) to Chipps Island (CHP) along the San Joaquin River (SJR) route. HOR = Head of Old River (OR), SJG = San Joaquin at Garwood Bridge, and TCJ = Turner Cut Junction. Release-specific estimates are lightly shaded and annual estimates (weighted averages of release-specific estimates) are bolded. Intervals are 95% confidence intervals for annual estimates. Spacing on the horizontal axis is scaled to migration distance. [Colour online.]

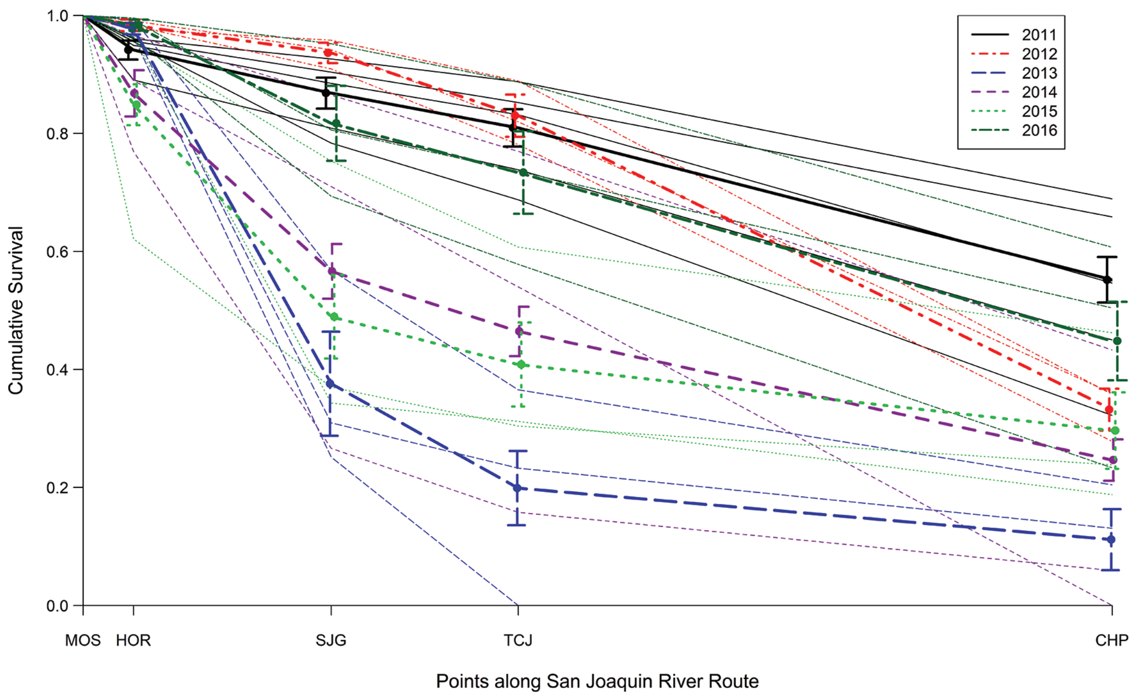


Table 5. Single-variate regression results for survival from the head of Old River (SJL or ORE) to Chipps Island (CHP), tested against the baseline model that adjusted for fixed year effects (2011–2016), barrier effects, and fork length at tagging.

Covariate	Name	Type	Sign	*P*	ΔAIC	AUC
SJR.hor	SJR inflow	Delta inflow	+	<0.0001	0	0.72
Tmsd.hor	Temperature at MSD	Temperature	–	<0.0001	31.87	0.72
Tclc.hor	Temperature at CLC	Temperature	Mixed	0.0001	38.12	0.72
IE.hor	I:E Ratio	I:E Ratio	+	0.0008	68.18	0.71
X2.hor	X2	Salinity	–	0.0016	73.21	0.71
OMT.hor.net	Mean net OMT flow	Mid-Delta flow	+	0.0054	78.70	0.71
SR.hor	SR inflow	Delta inflow	+	0.0121	84.20	0.71
pCVP.hor	CVP proportion of exports	Exports	+	0.0196	89.35	0.71
SWP.hor	SWP exports	Exports	–	0.2228	104.37	0.70
[Baseline]					108.76	0.70
CVP.hor	CVP exports	Exports	+	0.4868	109.42	0.70
CVPSWP.hor	CVP–SWP exports	Exports	–	0.6375	109.55	0.70
OMT.hor.rms	RMS of OMT flow	Mid-Delta flow	+	0.9085	124.93	0.70

Note: *P* values result from *F* tests and should be compared to a testwise α = 0.0042 for an experimentwise α = 0.05. See Table 3 for definitions of covariates. Sign refers to the estimated regression coefficient. AUC = area under the curve for the Receiver Operating Characteristic curve.

with other spatial scales. The effect of time of day at SJL was not significant (P = 0.7276) and was omitted from the model. The baseline model included effects of year, barrier, and fork length.

Single-covariate regression models found significant interactions between barrier and the CVP and combined CVP-SWP export rates (testwise α = 0.0045; $P \leq 0.0012$); there was a positive association between exports and survival when the barrier was in place ($P \leq 0.0007$) and no association when the barrier was absent ($P \geq 0.2221$). The effects of other covariates were not associated with the barrier ($P \geq 0.0738$). After adjusting for year, barrier, and fork length effects, SJR inflow accounted for the largest source of variability in the joint probability of survival and detection at the TCJ telemetry stations ($P < 0.0001$, ΔAIC ≥ 61.64; Table 6). SJR flow at BDT, the I:E ratio, 7DADM temperature at MSD, and the CVP export rate also accounted for a statistically significant amount of variability ($P \leq 0.0010$ vs. testwise α = 0.0045). Additionally, the combined CVP-SWP export rate, the X2 measure of salinity, and the CVP proportion of combined exports all had significant effects at the testwise 0.05 level ($P \leq 0.0232$). When SJR inflow was accounted for, no other covariates had significant added effects ($P \geq 0.1161$). The effect of SJR inflow was not associated with the barrier presence (P = 0.7524), and the main effect of the barrier was no longer significant when inflow was included in the model (P = 0.1146). When the model was fitted without the two release groups that had low (<0.95) probability of detection at the MAC or TRN telemetry stations, the same model structure for the SJR inflow model was selected. Alternative models that used the I:E ratio or the CVP export rate in place of SJR inflow also required MSD temperature (I:E and CVP models) and barrier status (CVP model). Among the SJR inflow, I:E ratio, and CVP models, the SJR inflow model was most supported by the data (ΔAIC ≥ 26.2) and had AUC = 0.74 compared to the

Fig. 7. Predicted probability and 95% confidence band of surviving from the head of Old River (SJL or ORE stations) to Chipps Island (CHP station) as a function of the 5-day average daily Delta inflow from the San Joaquin River (SJR) measured at Vernalis, for model: $\text{logit}(S_{ybi}) = \hat{\beta}_{0y} + 0.582(\widehat{\text{SE}} = 0.238)I_b + 0.012(\widehat{\text{SE}} = 0.004)L_i + 1.000(\widehat{\text{SE}} = 0.191)\ln(\text{SJR.hor}_i)$. Results are shown using 2011, 2014, and 2016 intercepts: $\hat{\beta}_{0,2011} = -12.485$ ($\widehat{\text{SE}} = 2.224$), $\hat{\beta}_{0,2014} = -11.612$ ($\widehat{\text{SE}} = 1.806$), and $\hat{\beta}_{0,2016} = -10.988$ ($\widehat{\text{SE}} = 1.840$). Model predictions were fit for the average fork length at tagging, 245 mm.

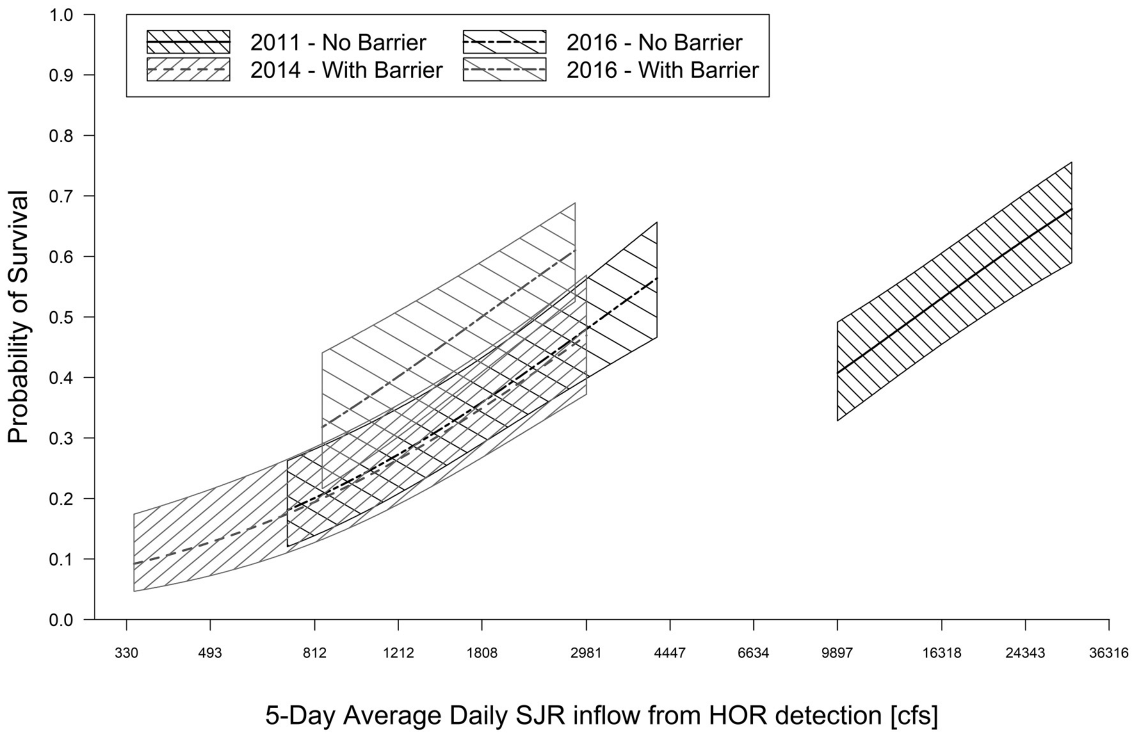


Table 6. Single-variate regression results for the joint probability of survival from the head of Old River (SJL) to the Turner Cut Junction (TCJ; MAC or TRN) and detection at TCJ, tested against the baseline model that adjusted for fixed year effects (2011–2016), barrier effects, and fork length at tagging.

Covariate	Name	Type	Sign	P	ΔAIC	AUC	Barrier × X
SJR.hor	SJR inflow	Delta inflow	+	<0.0001	0.00	0.74	No
BDT.hor.net	Mean Net BDT flow	Flow	+	<0.0001	61.64	0.73	No
IE.hor	I:E Ratio	I:E Ratio	+	<0.0001	80.54	0.73	No
Tmsd.hor	Temperature at MSD	Temperature	–	<0.0001	85.45	0.71	No
CVP.hor	CVP exports	Exports	Mixed	0.0010	115.78	0.69	Yes
CVPSWP.hor	CVP-SWP exports	Exports	Mixed	0.0051	131.07	0.69	Yes
X2.hor	X2	Salinity	–	0.0162	133.56	0.71	No
pCVP.hor	CVP proportion of exports	Exports	+	0.0232	134.23	0.71	No
OMT.hor.net	Mean net OMT flow	Mid-Delta flow	+	0.0932	142.08	0.69	No
SWP.hor	SWP exports	Exports	–	0.1966	147.17	0.70	No
OMT.hor.rms	RMS of OMT flow	Mid-Delta flow	–	0.3791	151.78	0.68	No
[Baseline]					153.58	0.70	

Note: P values result from F tests and should be compared to a testwise α = 0.0045 for an experimentwise α = 0.05. See Table 3 for definitions of covariates. Sign refers to the estimated regression coefficient. AUC = area under the curve for the Receiver Operating Characteristic curve. Barrier × X indicates whether the model included an interaction effect between the covariate and barrier status.

baseline AUC of 0.70. The simulated bias calculations found a mean relative bias in regression parameters of 4% for the SJR inflow model due to imperfect detection, compared to 113% for the I:E model and 67% for the exports model. Thus, the inflow model was preferred over alternative models.

The fitted SJR inflow model was

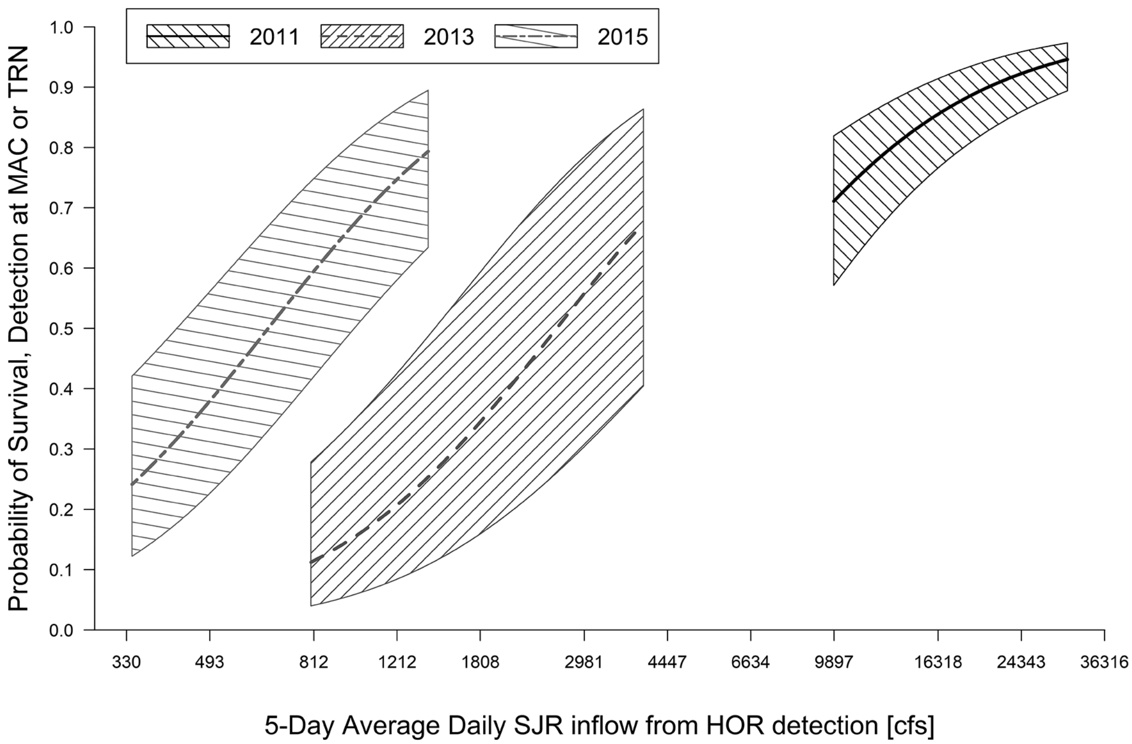
$$\text{logit}(\text{SP}_{yi}) = \hat{\beta}_{0y} + 0.016(\widehat{\text{SE}} = 0.006)L_i + 1.751(\widehat{\text{SE}} = 0.290)\ln(\text{SJR.hor}_i)$$

where $\hat{\beta}_{0y}$ ranged from –19.2816 ($\widehat{\text{SE}}$ = 3.3882) for 2011 to –15.4221 ($\widehat{\text{SE}}$ = 2.5744) for 2015. An increase in SJR inflow from 800 to 1400 cfs was associated with a modeled increase in SP from 0.11 ($\widehat{\text{SE}}$ = 0.06) to 0.25 (0.10) in 2013, and from 0.59 (0.09) to 0.79 (0.07) in 2015 (Fig. 8).

Survival: Turner Cut Junction to Chipps Island

Of the 1914 tags detected at the TCJ telemetry stations (MAC or TRN), 1104 were subsequently detected at either CHP or BBR. Travel time from TCJ to Chipps Island ranged from 0.9 to 30.5 days (median = 3.0 days). Route-specific survival estimates in this region ranged from 0 (May 2013) to 0.94 ($\widehat{\text{SE}}$ = 0.06, April 2015), and tended to be higher in the SJR route (0.34–0.94) than in the TC route (0–0.69) (Table 4). Survival estimates were unavailable for some release

Fig. 8. Predicted probability and 95% confidence band of surviving from the head of Old River (SJL station) to the Turner Cut Junction (TCJ) and detection at MAC or TRN stations as a function of the 5-day average daily Delta inflow from the San Joaquin River measured at Vernalis, for model: $\text{logit}(\text{SP}_{yi}) = \hat{\beta}_{0y} + 0.016(\widehat{\text{SE}} = 0.006)L_i + 1.751(\widehat{\text{SE}} = 0.290)\ln(\text{SJR.hor}_i)$. Results are shown using 2011, 2013, and 2015 intercepts: $\hat{\beta}_{0,2011} = -19.282\ (\widehat{\text{SE}} = 3.388)$, $\hat{\beta}_{0,2013} = -17.849\ (\widehat{\text{SE}} = 2.749)$, and $\hat{\beta}_{0,2015} = -15.422\ (\widehat{\text{SE}} = 2.574)$. Model predictions were computed for the average fork length at tagging for fish in this analysis, 248 mm.



groups because of low survival to TCJ (i.e., March 2013, May 2014, early March 2015; Table 4). Route selection probability estimates for the TC route ranged from 0.09 ($\widehat{\text{SE}} \leq 0.04$; March 2011, late March 2015) to 0.50 ($\widehat{\text{SE}}$ = 0.09, June 2011) (Table S1, Supplemental Material[1]).

Survival and detection modeling used the same detection probability model structure as from the head of OR to Chipps Island. The effect of migration route (SJR vs. TC) was highly significant in accounting for variation in survival to Delta exit ($P < 0.0001$); year was also significant (P = 0.0192). Barrier at the head of OR and time of day at TCJ were not significant ($P \geq 0.4194$) and were omitted from the survival model. Fork length at time of tagging was significant at the 10% level (P = 0.0945); although not strongly significant, fork length was retained in the model for comparability with other spatial scales. When year, route, and fork length were all accounted for, no other covariate was associated with survival to Chipps Island ($P \geq 0.2283$). The baseline model that adjusted for year, route, and fork length had an AUC value of 0.75, indicating good model fit without any other covariates; the added effects of covariates increased the AUC by no more than 0.01. The model estimated that remaining in the SJR increased the probability of survival from TCJ to Chipps Island by 0.29 ($\widehat{\text{SE}}$ = 0.04) to 0.44 ($\widehat{\text{SE}} \leq$ 0.07), depending on the year and fish length (e.g., Fig. 9).

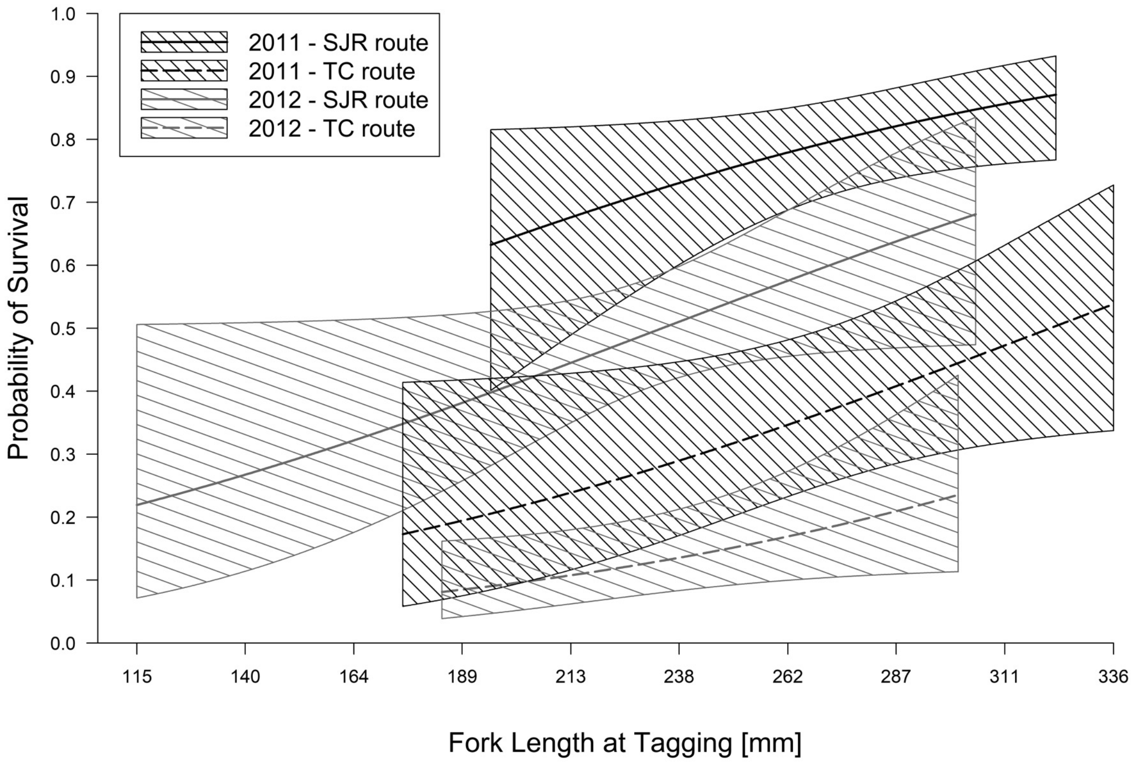
Drought effects

Comparisons of survival estimates with drought status found a significant association between drought and survival from the head of OR to Chipps Island in the OR route ($P < 0.0001$) but not in the SJR route (P = 0.1458). Average survival across release groups in the OR route was 0.17 ($\widehat{\text{SE}}$ = 0.01) during the drought years (2013–2015) and 0.36 (0.02) during the non-drought years (2011, 2012, and 2016). The drought effect in the OR route persisted when the barrier was not in place (P = 0.0005) and when 2011 was excluded from analysis (P = 0.0034). In the SJR route, there was a difference in survival from the head of OR to TCJ based on drought status (P = 0.0276); average survival was 0.44 (0.03) during the drought years and 0.82 (0.01) during the non-drought years. There was no significant difference in survival from TCJ to Chipps Island between drought and non-drought years in either route ($P \geq 0.3309$). Visual inspection of cumulative survival curves found higher per-km mortality rates upstream of TCJ in the drought years compared to non-drought years (Fig. 6). GLM models that replaced year-specific intercepts with drought-specific intercepts (two-way classification) or water-year-specific intercepts (three-way classification) fit considerably more poorly than the year-effects model on all three spatial scales ($P \leq 0.0106$).

Discussion

The broad challenges faced by steelhead emigrating through the SR–SJR Delta are representative of those faced by salmonids in estuaries of other river systems. The combination of habitat loss, reduced river flows, increased resource use, warming temperatures, and non-native aquatic community structure is intensified in the SJR Delta by its southern latitude in the steelhead range and by human development of the region. Other populations are soon likely to face comparable challenges as a result of climate change, growing population density, and expanded modification of estuary habitat (Magnusson and Hilborn 2003; Moyle et al. 2008). Studies of both Pacific salmonids and Atlantic salmon (*Salmo salar*) demonstrate that survival of juvenile salmonids tends to be lower and more variable in estuaries than in either river or marine habitats (Welch et al. 2011; Thorstad et al. 2012). Thus, understanding estuarine survival is of paramount importance to population persistence. This study was the first to yield a

Fig. 9. Predicted probability and 95% confidence band of surviving from Turner Cut Junction (TCJ) to Chipps Island as a function of fork length at tagging and route selection, for model: $\text{logit}(S_{yri}) = \hat{\beta}_{0y} - 1.895(\widehat{\text{SE}} = 0.125)I_r + 0.011(\widehat{\text{SE}} = 0.003)L_i$. Results are shown using 2011 and 2012 intercepts: $\hat{\beta}_{0,2011} = -1.542\ (\widehat{\text{SE}} = 1.620)$ and $\hat{\beta}_{0,2012} = -2.499\ (\widehat{\text{SE}} = 1.374)$.



multi-year time series of spatially detailed steelhead estuarine survival estimates and has demonstrated that survival varies considerably spatially, between years, and seasonally through this inland estuary. This level of variability would not have been apparent from a study shorter in duration. Despite the effort required to estimate estuarine survival, multi-year time series are necessary to represent the variability in conditions and survival experienced by steelhead populations in these environments.

This study presents the first direct estimates of survival of CV steelhead as they emigrate from the SJR through the SR–SJR Delta. The few previous CV steelhead survival studies focused on steelhead emigrating from the SR, representing the northern components of the CV Evolutionarily Significant Unit, and presented results from only single study years or for only broad spatial areas (Singer et al. 2013; Brodsky et al. 2020; Sandstrom et al. 2020). Historically, management approaches for SJR steelhead have been geared toward Chinook salmon rather than steelhead patterns of migration and habitat use, and steelhead survival has been inferred from adult escapement and CWT data from salmon (McEwan 2001). These acoustic-telemetry estimates show that steelhead survival through the Delta varies considerably both between and within years: release-level survival estimates from Mossdale to Chipps Island varied from 0.06 to 0.69 (Table 4). These survival levels are more variable and often considerably higher than those observed for fall-run Chinook Salmon migrating through the same regions at similar times, which were consistently ≤0.05 for 2011–2014 (Buchanan et al. 2015, 2018). However, these steelhead survival estimates were comparable to or lower than those reported for SR steelhead and late fall-run Chinook salmon migrating through the Delta from the north only a few months earlier in mid- to late-winter (Singer et al. 2013; Perry et al. 2013; Michel et al. 2015; Sandstrom et al. 2020). The temporal and spatial variation in survival across the CV demonstrates the continuing need for acoustic telemetry studies using relevant populations of juvenile salmonids to understand potential ecological processes and management strategies linked to survival, rather than inferring these measures from past studies or different basins.

Although monitoring the performance of imperiled populations is preferred for their management, studying such populations is often difficult. Regulations and small population sizes may prevent collection of individuals from protected species and individuals suitable for tagging may represent only larger size classes or late juvenile life stages. In this study, we used yearling hatchery fish from MRFH to represent steelhead emigrating from the SJR basin. Although MRFH steelhead are included in the threatened CV DPS and this hatchery is in the SJR basin, the SJR steelhead that emigrate past our release site are naturally produced rather than hatchery fish. Differences have been found in survival patterns between wild and hatchery salmonids in the Columbia River basin and may exist between the hatchery and wild components of the CV DPS as well (Buchanan et al. 2010; Murphy et al. 2011). Nevertheless, we believe that hatchery steelhead provide better inference than hatchery Chinook Salmon, which have otherwise been the basis for management of SJR steelhead. Other considerations include tag size, which may limit the individuals available for study, and tag effects on survival performance. This study used multiple strategies to limit or eliminate tag effects, and we recommend the same for future studies. Additionally, increased monitoring of juvenile steelhead exiting upstream tributaries would facilitate characterization of the proportion of run-of-river emigrants represented by the tagged fish.

Management strategies designed to support steelhead survival in the Delta have included keeping fish out of the OR route, releasing water from upstream reservoirs to increase river inflow to the Delta, and limiting water pumping rates at the export facilities in the spring when the fish are migrating. The I:E ratio has been used as a regulatory metric to moderate water export rates and Delta inflow. The results in this study provide a look at how consistent actual steelhead survival patterns are with these management strategies and demonstrate agreement with some expected patterns but not others. Estimated survival was higher when the barrier was in place at the head of OR and when Delta inflow and the I:E ratio were higher, as expected. However, survival was not notably higher in the SJR route compared to the OR route or for lower export rates, contrary to expectations. Furthermore, different survival processes were apparent in adjacent habitats, indicating that actions to support survival should also be spatially defined.

The lack of a consistent route-specific survival difference between the SJR and OR routes was surprising, considering that both water export facilities are located in the OR route. Although the point estimates of survival were higher for the SJR route compared to the OR route for 16 of 19 release groups (Table 4), the differences were sometimes very small and were not statistically significant when adjusted for year, barrier status, and fork length (P = 0.1282). The barrier affects route selection at the head of OR by blocking most access to the OR route, so it is possible that the perceived barrier effect was at least partially a route effect: if the SJR route is superior and the barrier directs fish into that route, then the barrier effect would be positive. If this were true, then a route effect should be observed whether or not the barrier was present. However, the within-year difference between annual route-specific survival estimates was close to 0 (−0.04 to 0.03) for years without the barrier and ranged up to 0.27 for years when the barrier was installed. Additionally, the barrier effect was significant even when route was accounted for (P = 0.0207), and AIC was lower for a barrier model over a route model (ΔAIC = 15.3). These results suggest that perceived survival differences between the routes were primarily due to the presence of the temporary rock barrier. The fact that survival was not associated with route further suggests that it was the barrier's influence on hydrodynamic conditions in the SJR that contributed to higher survival by diverting SJR inflow away from OR and into the lower SJR. Likewise, the survival modeling for the SJR route upstream of the TCJ suggests that survival benefits in this reach can be attained either by increasing Delta inflow or by installing the barrier. The mechanical nature of the barrier's action, i.e., diversion of both fish and water, lends support to the hypothesis that the perceived survival differences associated with the barrier are due to the barrier's physical presence rather than to other, unacknowledged variables (e.g., season). Discontinuation of barrier use in future years may have a negative effect on steelhead survival in the Delta unless additional management strategies are implemented to direct both fish and flow into the SJR, such as modifying hydrodynamics or channel morphology in the head of OR region.

This work represented the OR route effect as a difference in total survival probability to Chipps Island in the OR route compared to the SJR route. This is reasonable for identifying factors associated with overall fish fate in this region (successfully leave the Delta vs. mortality in the Delta). An alternative assessment of route effects would explore the relative differences in survival rate per kilometre rather than total survival probability, i.e., $\sigma = S^{1/d}$ for route length d. Because different routes have different lengths, a route effect on the survival rate scale may not be apparent on the total survival scale. A similar consideration applies to daily survival rate. A difficulty in modeling survival rate rather than total survival probability is identifying a well-defined migration route distance: both the OR and SJR routes from the head of OR include multiple subroutes of varying lengths. In the OR route, the migration pathway from the head of OR to Chipps Island is approximately 45 km via the salvage subroutes (omitting distance trucked) but is 88 km via OR itself (bold line in Fig. 1*c*). In the SJR route, the total migration pathway is approximately 88 km via the mainstem SJR compared to up to 100 km via the salvage facilities, depending on routing choices at TCJ and throughout the interior Delta (Fig. 1*b*). We performed a preliminary survival rate analysis using an OR route length weighted toward the salvage subroutes (km = 55) and a SJR route length representing non-salvage subroutes (km = 88). Using these route lengths to define survival rate per kilometre, we found a significant negative effect of the OR route on the survival rate ($P < 0.0001$), suggesting more intense mortality forces in the OR route. This is consistent with expectations that the OR route is more treacherous but is highly sensitive to the migration route lengths assumed in analysis and appears to have been largely offset by the actual pathway lengths experienced by the study fish in the OR and SJR routes when considering total survival probability to Delta exit. Future work will investigate the migration route distances more fully and the potential effect of routing choices on survival in and through the Delta.

The relationship between SJR inflow and survival was particularly strong and, together with year, barrier status, and fork length, accounted for all the variation in survival that was associated with other environmental and operational covariates. The positive relationship between SJR inflow and survival translated to a positive relationship between the I:E ratio and survival as well. Several mechanisms may contribute to the positive relationship observed between inflow and survival. One possibility is that higher flows result in faster water velocities and shorter travel times, so that fish are at risk of mortality in the study area for a shorter period of time (Anderson et al. 2005). Travel time was negatively associated with SJR inflow in the tidal transitional reach from the head of OR to the TCJ (P = 0.0001), where there was also a positive relationship between SJR inflow and survival, consistent with this hypothesis. However, travel time was also negatively associated with SJR inflow in the tidal reach between TCJ and Chipps Island (P = 0.0363), where survival was unrelated to inflow. This heterogeneous spatial pattern is consistent with findings in Perry et al. (2018) for the northern Delta. Alternatively, higher flows are associated with lower temperatures, higher levels of dissolved oxygen, and lower levels of contaminants (Sinokrot and Gulliver 2000; Monsen et al. 2007; Grossman 2016), all of which may influence survival. It is likely that more than one mechanism accounts for the inflow-survival relationship observed.

Despite the strong findings for Delta inflow, there were limitations to the dependence of survival on inflow. The first year of the study, 2011, was a high flow year and had daily inflow values that were 1.5 to 91 times the inflow observed in the other five years of the study (Fig. 3). Nevertheless, some release groups from 2011 had survival estimates that were comparable to or lower than those seen in drier years (Table 4). The high flow in 2011 prevented installation of the barrier at the head of OR; it appears that the barrier may help mitigate for effects of low flows in drier years (Fig. 7). Additionally, the inflow-survival relationship was notably absent in the region between the TCJ and Chipps Island. The region downstream (i.e., north and west) of the TCJ is strongly tidally dominated, and it is reasonable that environmental conditions there are largely insensitive to SJR inflow from >50 rkm upstream. Additional management strategies beyond reservoir releases and the head of OR barrier will be needed to improve survival in this region.

Current management strategies assume that survival is lower when Delta exports are higher, in particular because of the increased risk of migration delay at the facilities or entrainment at the pumps. There is also thought to be a large population of predators in and within close proximity to the facilities (Grossman 2016; Moyle et al. 2017). Nevertheless, this study found no association between export rate and survival from the head of OR to Chipps Island ($P \geq 0.2228$; Table 5). There was weak support for an association between survival and the CVP proportion of combined exports (pCVP; P = 0.0196), which measures the allocation of exports across the two large export facilities; even this evidence was inconclusive, however, given the large number of covariates considered. On the other hand, we observed a positive association between export rate and survival in the SJR main stem upstream of the TCJ when the barrier was in place. This was surprising because fish in this reach are not near the export facilities and hydrodynamics models have found little effect of exports on flow and velocity patterns in this region (Cavallo et al. 2013). However, export rate and Delta inflow tend to be positively correlated (partial correlation coefficient = 0.56, $P < 0.0001$, after adjusting for year with the barrier in place) and survival was more strongly associated with SJR inflow than with exports in this reach, so the association between exports and survival in the SJR main stem may result from an inflow effect rather than causal export effects. Overall, we recommend that the export rate results be viewed in the context of existing policy, which uses the I:E ratio regulatory metric to dictate restricted export levels during the spring outmigration and thus low variability in export levels during the tagging study. For example, during the study period each year, mean daily combined (CVP+SWP) export levels were ≤6100 cfs, compared to values up to 12 862 cfs during the full 2011–2016 water years (October to September). The relatively low variability in export levels in this study makes it difficult to detect potential survival effects; it is conceivable that different survival patterns might be exhibited under unrestricted (i.e., higher) exports, especially in the OR route which passes the entrances to the pumping facilities. For these reasons, the assessment of exports reported here should not be interpreted as a complete assessment of the policy that defines allowable export operations in the spring but rather an assessment of the variability in exports actually observed in the springs of 2011–2016.

The survival patterns observed in relation to the barrier and to some extent exports help explain the surprisingly high through-Delta survival observed in the extreme drought year of 2015 (Table 5). Of the six years in the study, 2015 had the lowest inflow, highest temperatures, and highest X2 (salinity) levels (Fig. 3). Despite the harsh conditions, the overall estimated probability of survival from Mossdale to Chipps Island in 2015 (0.23) was considerably higher than for 2013 (0.14), which was also a drought year but had higher inflow, slightly lower temperatures, and lower X2. However, export levels were lower and less variable in the 2015 study (mean 1765 cfs) than in the 2013 study (mean = 2464 cfs; Fig. 4), and the barrier was installed for the majority of 2015 but not in 2013. Average fork length at tagging was also higher in 2015 (235 mm) than in 2013 (212 mm). Survival in the SJR route was considerably higher in 2015 than in 2013, and it was also higher than in the OR route in 2015, consistent with a positive barrier effect. Comparison of these years demonstrates the potentially mitigating effects of fish size, the head of OR barrier, and lower exports in very low flow years. Although these factors are insufficient to fully compensate for lack of water entering the Delta, they may help prevent very low survival that could lead to further declines in anadromous *O. mykiss* abundance.

Despite the lack of route-specific survival differences from the head of OR to Chipps Island, there was a strong survival difference between the mainstem (SJR) route and the interior Delta (TC) route from the TCJ ($P < 0.0001$). Remaining in the SJR route at TCJ was estimated to increase the survival probability to Chipps Island by up to 0.44 (Fig. 9). This finding is similar to observations that late-fall-run Chinook salmon and steelhead migrating from the SR had lower survival in interior Delta routes than in mainstem river routes (Perry et al. 2010; Singer et al. 2013). The interior Delta connects the mainstem river to the water export facilities located in the SW Delta, and one hypothesis is that entering the interior Delta at the TCJ lowers survival by increasing the risk of entrainment at the facilities; entrained fish that are salvaged may appear at Chipps Island as successful Delta migrants, but those that are not salvaged are lost to the pumps, water conveyance canals, or predation and appear as mortalities in the statistical models. Indeed, of the 489 steelhead detected entering TC, 135 (28%) were subsequently detected at the water export facility entrances, compared to 5% of the 1451 fish using the SJR mainstem route from the TCJ. However, the route with the highest proportion of fish entering the facilities was the OR route: 67% of the fish in that route, compared to only 8% of the fish that chose the SJR route at the head of OR. If increased entrainment was the source of the reduced survival in the TC route, then we would also expect to see markedly lower survival in the OR route compared to the SJR route from the head of OR. This was not observed. Another possibility is that the habitat in the interior Delta results in higher mortality risk compared to the mainstem river. The TC route leads fish to the central portion of the interior Delta, which is also the region encountered by SR salmon that enter the interior Delta. This region includes several submerged islands that have low water velocities, low turbidity, dense mats of non-native vegetation such as Brazilian waterweed (*Egeria densa*), and populations of non-native, warm-water predatory fish such as largemouth bass (Nobriga and Feyrer 2007; Conrad et al. 2016). Although the late-fall-run Chinook salmon from the SR studies migrate through the region in winter when predation rates are expected to be lower compared to this study's spring steelhead migration, the lake-type habitat common in the central region of the interior Delta may pose similar challenges to both populations of migrating salmonids. Preventing fish from entering the interior Delta at TC is challenging because the hydrodynamics in the junction do not allow for a barrier to be installed, and fish may enter the interior Delta through multiple routes from further downstream. Instead, management strategies to improve habitat in the interior Delta for native fish and make it less desirable for non-native predators may have the potential to increase survival in this region for salmonids migrating from both the SJR basin and the SR basin.

Precipitation patterns in California are projected to be more volatile under climate change, with more frequent and extreme droughts and also more extreme flood events (Dettinger 2011; Diffenbaugh et al. 2015; Swain et al. 2018), and one question managers face is how mitigation strategies may be affected by drought. This study showed evidence of a drought effect on steelhead survival through the Delta, in particular in the OR route and in the SJR downstream to the TCJ; survival through these regions tended to be higher in non-drought years. However, investigation efforts were hampered by the large differences in flow among the non-drought years, in particular between 2011 (wet year) and the dry years of 2012 and 2016. Although both drought status and water year status varied by year, neither criterion fully accounted for the year effects in the survival models. This result hinders efforts to predict survival as a function of drought status without better understanding of the factors that drive year effects.

Drought may affect survival patterns in the Delta in several ways, including lowering inflows and increasing temperatures. One mechanism by which drought may affect survival is to move the location of the zone where the habitat transitions from unidirectional flow to bidirectional tidal flows. This transition zone and its dependence on Delta inflow may be critical to the relationship between inflow and survival (Perry et al. 2018). A shift of that transition zone farther upstream during drought would introduce migrating salmonids to reverse flows and altered water quality factors earlier in their migration. In the SJR, the transition reach lies between the head of OR and the TCJ most years, depending on inflow conditions and barrier status at the head of OR (Cavallo et al. 2013; National Oceanic and Atmospheric Administration Fisheries Salmon Scoping Team 2017). Because the barrier keeps more river flow in the SJR, it is expected to keep the location of the transition farther downstream even in drought years, and thus may be an important mitigating factor for low inflow during drought. These possibilities are supported by cumulative survival curves from this study, which show that for all three drought years and only one non-drought year, the SJR reach that had the highest mortality rate downstream of the head of OR was in the upstream portion of the stretch from OR to the TCJ, specifically from OR to Garwood Bridge (SJG; Fig. 6). The mortality rate to Garwood Bridge was noticeably higher in the drought years than in the wet and dry years and was the highest in 2013, the only drought year without a barrier installed at the head of OR (Fig. 6). Efforts to mitigate effects of drought should include improving habitat for migrating salmonids in this reach as well as either installing the barrier at the head of OR or redesigning channel morphology at that river junction to keep more flow in the SJR. These actions may be especially important to support steelhead populations as climate change affects the frequency of drought and lower seasonal flows.

This study is a step forward in understanding the temporal and spatial variability in survival of CV steelhead populations as they emigrate through the San Joaquin Delta and the factors that affect survival. Although the specific results are unique to this population, a similar degree of spatial and temporal variability may be expected in other estuarine systems. Likewise, the investigative and analytical approaches used in this paper may be employed in other systems to monitor steelhead performance through the crucial estuarine juvenile life stage and inform management strategies to support the anadromous life history. The results here have implications for management designed to support emigrant survival in the Delta, including timing reservoir releases from the multiple SJR tributaries to coincide with the juvenile migration, directing more flow down the SJR rather than OR, and restoring habitat south of TC and in the central interior Delta. There is more work to be done in studying this threatened population, and future tagging studies will provide data for testing the models developed here. Questions for future investigation include the factors driving route selection at various junctions in the Delta, juvenile steelhead residence time and the propensity of Delta rearing, reach-specific flow–survival relationships, survival differences between hatchery and run-of-river steelhead and between steelhead and Chinook salmon, the role of non-native predators and non-native vegetation on survival patterns in different regions of the Delta, and the sensitivity of adult returns to estuarine and early marine survival. Another important management need is estimating steelhead survival further downstream through the bays. Understanding these and other issues will be necessary to support the anadromous component of the CV's *O. mykiss* population and maintain the life history diversity necessary for this population to persist in a changing climate.

Competing interests statement

The authors declare there are no competing interests.

Contributors' statement

RB contributed research ideas, developed the analytical methods, performed the analysis, and was lead author. JI and EB both contributed research ideas, interpretation of results, and assisted in writing.

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Data availability statement

The data used in this analysis are available upon request from the lead author.

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References

Adams, N.S., Rondorf, D.W., Evans, S.D., and Kelly, J.E. 1998. Effects of surgically and gastrically implanted radio transmitters on growth and feeding behavior of juvenile Chinook Salmon. Trans. Am. Fish. Soc. **127**(1): 128–136. doi:10.1577/1548-8659(1998)127<0128:EOSAGI>2.0.CO;2.

Anderson, J.J., Gurarie, E., and Zabel, R.W. 2005. Mean free-path length theory of predator–prey interactions: application to juvenile salmon migration. Ecol. Modell. **186**(2): 196–211. doi:10.1016/j.ecolmodel.2005.01.014.

Brodsky, A., Zeug, S.C., Nelson, J., Hannon, J., Anders, P.J., and Cavallo, B.J. 2020. Does broodstock source affect post-release survival of steelhead? Implications of replacing a non-native hatchery stock for recovery. Environ. Biol. Fishes, **103**: 437–453. doi:10.1007/s10641-020-00951-2.

Buchanan, R.A. 2018*a*. 2014 six-year acoustic telemetry and steelhead study: statistical methods and results. Technical report to the US Bureau of Reclamation. Available from http://www.cbr.washington.edu/papers.

Buchanan, R.A. 2018*b*. 2015 six-year acoustic telemetry and steelhead study: statistical methods and results. Technical report to the US Bureau of Reclamation. Available from http://www.cbr.washington.edu/papers.

Buchanan, R.A. 2018*c*. 2016 six-year acoustic telemetry and steelhead study: statistical methods and results. Technical report to the US Bureau of Reclamation. Available from http://www.cbr.washington.edu/papers.

Buchanan, R.A., and Skalski, J.R. 2020. Relating survival of fall-run Chinook salmon through the San Joaquin Delta to river flow. Environ. Biol. Fishes, **103**: 389–410. doi:10.1007/s10641-019-00918-y.

Buchanan, R.A., Skalski, J.R., and Giorgi, A.E. 2010. Evaluating surrogacy of hatchery releases for the performance of wild yearling Chinook Salmon from the Snake River Basin. N. Am. J. Fish. Manage. **30**: 1258–1269. doi:10.1577/M09-175.1.

Buchanan, R.A., Skalski, J.R., Brandes, P.L., and Fuller, A. 2013. Route use and survival of juvenile Chinook Salmon through the San Joaquin River Delta. N. Am. J. Fish. Manage. **33**(1): 216–229. doi:10.1080/02755947.2012.728178.

Buchanan, R.A., Brandes, P.L., Marshall, M., Foott, J.S., Ingram, J., LaPlante, D., and Israel, J., 2015. 2012 South Delta Chinook Salmon Survival Study. *Edited by* P. Brandes. US Fish and Wildlife Service. Available from https://www.fws.gov/lodi/salmonid_survival_studies/juvenile_salmonid_survival_reports.htm [accessed 4 June 2020].

Buchanan, R.A., Brandes, P.L., and Skalski, J.R. 2018. Survival of juvenile fall-run Chinook salmon through the San Joaquin River Delta, California, 2010–2015. N. Am. J. Fish. Manage. **38**(3): 663–679. doi:10.1002/nafm.10063.

Burnham, K.P., and Anderson, D.R. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd ed. Springer, New York.

Cavallo, B., Gaskill, P., and Melgo, J. 2013. Investigating the influence of tides, inflow, and exports on sub-daily flow in the Sacramento–San Joaquin delta. Report prepared by Cramer Fish Sciences. Available from https://www.researchgate.net/profile/Bradley_Cavallo/publication/329075645.

Clemens, B.J., Clements, S.P., Karnowski, M.D., Jepsen, D.B., Gitelman, A.I., and Schreck, C.B. 2009. Effects of transportation and other factors on survival estimates of juvenile salmonids in the unimpounded lower Columbia River. Trans. Am. Fish. Soc. **138**(1): 169–188. doi:10.1577/T07-090.1.

Cohen, A.N., and Carlton, J.T. 1998. Accelerating invasion rate in a highly invaded estuary. Science, **279**(5350): 555–558. doi:10.1126/science.279.5350.555. PMID:9438847.

Conrad, J.L., Bibian, A.J., Weinersmith, K.L., De Carion, D., Young, M.J., Crain, P., et al. 2016. Novel species interaction in a highly modified estuary: association of largemouth bass with Brazilian waterweed *Egeria densa*. Trans. Am. Fish. Soc. **145**: 249–263. doi:10.1080/00028487.2015.1114521.

Dettinger, M. 2011. Climate change, atmospheric rivers, and floods in California—a multimodel analysis of storm frequency and magnitude changes. J. Am. Water Resour. Assoc. **47**(3): 514–523. doi:10.1111/j.1752-1688.2011.00546.x.

Diffenbaugh, N.S., Swain, D.L., and Touma, D. 2015. Anthropogenic warming has increased drought risk in California. Proc. Natl. Acad. Sci. U.S.A. **112**(13): 3931–3936. doi:10.1073/pnas.1422385112. PMID:25733875.

Esri. 2011. ArcGIS Desktop: Release 10. Environmental Systems Research Institute, Redlands, Calif.

Gregory, R.S., and Levings, C.D. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Trans. Am. Fish. Soc. **127**: 275–285. doi:10.1577/1548-8659(1998)127<0275:TRPOMJ>2.0.CO;2.

Grossman, G.D. 2016. Predation on fishes in the Sacramento–San Joaquin delta: Current knowledge and future directions. SFEWS. **14**(2): Art. 8. doi:10.15447/sfews.2016v14iss2art8.

Harnish, R.A., Johnson, G.E., McMichael, G.A., Hughes, M.S., and Ebberts, B.D. 2012. Effect of migration pathway on travel time and survival of acoustic-tagged juvenile salmonids in the Columbia River estuary. Trans. Am. Fish. Soc. **141**(2): 507–519. doi:10.1080/00028487.2012.670576.

Hestir, E.L., Schoellhamer, D.H., Greenberg, J., Morgan-King, T., and Ustin, S.L. 2016. The effect of submerged aquatic vegetation expansion on a declining turbidity trend in the Sacramento–San Joaquin river delta. Estuaries Coasts, **39**: 1100–1112. doi:10.1007/s12237-015-0055-z.

Hosmer, D.W., and Lemeshow, S. 2000. Applied logistic regression. 2nd ed. Wiley, New York.

Lady, J.M., and Skalski, J.R. 2009. USER 4: user-specified estimation routine. Columbia Basin Research, School of Aquatic and Fishery Sciences, University of Washington, Seattle. Available from http://www.cbr.washington.edu/analysis/apps/user.

Li, T., and Anderson, J.J. 2009. The vitality model: a way to understand population survival and demographic heterogeneity. Theor. Popul. Biol. **76**(2): 118–131. doi:10.1016/j.tpb.2009.05.004. PMID:19500610.

Liedtke, T.L., Beeman, J.W., and Gee, L.P., 2012. A standard operating procedure for the surgical implantation of transmitters in juvenile salmonids. US Geological Survey, Open-File Report 2012-1267, Reston, Virginia. Available from https://pubs.usgs.gov/of/2012/1267/pdf/ofr20121267.pdf.

Lindley, S.T., Schick, R.S., Agrawal, A., Goslin, M., Pearson, T.E., Mora, E., et al. 2006. Historical population structure of Central Valley steelhead and its alteration by dams. SFEWS. **4**(1): Art. 3. doi:10.15447/sfews.2006v4iss1art3.

Magnusson, A., and Hilborn, R. 2003. Estuarine influence on survival rates of coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) released from hatcheries on the US Pacific coast. Estuaries, **26**: 1094–1103. doi:10.1007/BF02803366.

Martinelli, T.L., Hansel, H.C., and Shively, R.S. 1998. Growth and physiological responses to surgical and gastric radio transmitter implantation techniques in subyearling chinook salmon (*Oncorhynchus tshawytscha*). Hydrobiologia, **371**: 79–87. doi:10.1023/A:1017019006039.

McCullagh, P., and Nelder, J. 1989. Generalized linear models, 2nd ed. Chapman and Hall, London.

McEwan, D.R. 2001. Central Valley Steelhead. *In* Contributions to the biology of Central Valley salmonids. Vol. 1. *Edited by* R.L. Brown. Fish Bulletin 179. pp. 1–44. Available from https://escholarship.org/uc/item/6sd4z5b2 [accessed 1 June 2020].

Michel, C.J., Ammann, A.J., Lindley, S.T., Sandstrom, P.T., Chapman, E.D., Thomas, M.J., et al. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. Can. J. Fish. Aquat. Sci. **72**(11): 1749–1759. doi:10.1139/cjfas-2014-0528.

Monsen, N.E., Cloern, J.E., and Burau, J.R. 2007. Effects of flow diversions on water quality and habitat quality: examples from California's highly manipulated Sacramento–San Joaquin Delta. SFEWS, **5**(3). Art. 2. doi:10.15447/sfews.2007v5iss5art2.

Moyle, P.B., Israel, J.A., and Purdy, S.E. 2008. Salmon, steelhead, and trout in California: status of an emblematic fauna. Report for California Trout, 2008. Available from https://watershed.ucdavis.edu/library [accessed 1 June 2020].

Moyle, P.B., Bennett, W.A., Fleenor, W.E., and Lund, J.R. 2010. Habitat variability and complexity in the upper San Francisco Estuary. SFEWS. **8**(3). doi:10.15447/sfews.2010v8iss3art1.

Moyle, P.B., Lusardi, R.A., Samuel, P.J., and Katz, J.V.E. 2017. State of the salmonids: status of California's emblematic fishes 2017. Center for Watershed Sciences, University of California, Davis and California Trout, San Francisco, California. Available from https://caltrout.org/wp-content/uploads/2017/08/SOS-II_Final.pdf [accessed 9 December 2020].

Murphy, D.D., Weiland, P.S., and Cummins, K.W. 2011. A critical assessment of the use of surrogate species in conservation planning in the Sacramento–San Joaquin Delta, California. Conserv. Biol. **25**: 873–878. doi:10.1111/j.1523-1739.2011.01711.x. PMID:21790783.

Nam, B.-H., and D'Agostino, R.B. 2002. Discrimination index, the area under the ROC curve. *In* Goodness-of-fit tests and model validity. *Edited by* C. Huber-Carol, N. Balakrishnan, M.S. Nikulin, and M. Mesbah. Birkhauser Verlag, Boston.

National Marine Fisheries Service. 2009. Endangered Species Act Section 7 Consultation: Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Project. National Marine Fisheries Service, Southwest Region, Long Beach, California. Available from https://www.fisheries.noaa.gov/resource/document/biological-opinion-and-conference-opinion-long-term-operations-central-valley [accessed 15 October 2020].

National Oceanic and Atmospheric Administration Fisheries Salmon Scoping Team. 2017. Effects of water project operations on juvenile salmonid migration and survival in the south delta. Appendix B: Effects of water project operations on delta hydrodynamics. Technical report prepared for Collaborative Adaptive Management Team. Available from https://www.fisheries.noaa.gov/resource/document/effects-water-project-operations-juvenile-salmonid-migration-and-survival-south.

Nelson, T.R., Michel, C.J., Gary, M.P., Lehman, B.M., Demetras, N.J., Hammen, J.J., and Horn, M.J. 2020. Effects of artificial lighting at night on predator density and salmonid predation. Trans. Am. Fish. Soc. **150**: 147–159. doi:10.1002/tafs.10286.

Nobriga, M.L., and Feyrer, F. 2007. Shallow-water piscivore-prey dynamics in California's Sacramento–San Joaquin delta. SFEWS. **5**(2): Article 4. doi:10.15447/sfews.2007v5iss2art4.

Perry, R.W., Skalski, J.R., Brandes, P.L., Sandstrom, P.T., Klimley, A.P., Ammann, A., and MacFarlane, B. 2010. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento–San Joaquin River Delta. N. Am. J. Fish. Manage. **30**(1): 142–156. doi:10.1577/M08-200.1.

Perry, R.W., Brandes, P.L., Burau, J.R., Klimley, A.P., MacFarlane, B., Michel, C., and Skalski, J.R. 2013. Sensitivity of survival to migration routes used by juvenile Chinook Salmon to negotiate the Sacramento–San Joaquin River Delta. Environ. Biol. Fish. **96**: 381–392. doi:10.1007/s10641-012-9984-6.

Perry, R.W., Pope, A.C., Romine, J.G., Brandes, P.L., Burau, J.R., Blake, A.R., et al. 2018. Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. Can. J. Fish. Aquat. Sci. **75**(11): 1886–1901. doi:10.1139/cjfas-2017-0310.

R Core Team. 2020. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from https://www.R-project.org/.

Rechisky, E.L., Welch, D.W., Porter, A.D., Jacobs-Scott, M.C., and Winchell, P.M. 2013. Influence of multiple dam passage on survival of juvenile Chinook Salmon in the Columbia River estuary and coastal ocean. Proc. Natl. Acad. Sci. U.S.A. **110**(17): 6883–6888. doi:10.1073/pnas.1219910110. PMID:23576733.

Sandstrom, P.T., Ammann, A.J., Michel, C., Singer, G., Chapman, E.D., MacFarlane, R.B., et al. 2020. Low river survival of juvenile steelhead in the Sacramento River watershed. Environ. Biol. Fish. **103**: 531–541. doi:10.1007/s10641-020-00954-z.

Satterthwaite, W.H., Beakes, M.P., Collins, E.M., Swank, D.R., Merz, J.E., Titus, R.G., et al. 2010. State-dependent life history models in a changing (and regulated) environment: steelhead in the California Central Valley. Evol. Appl. **3**(3): 221–243. doi:10.1111/j.1752-4571.2009.00103.x. PMID:25567921.

Singer, G.P., Hearn, A.R., Chapman, E.D., Peterson, M.L., LaCivita, P.E., Brostoff, W.N., et al. 2013. Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). Environ. Biol. Fishes, **96**: 363–379. doi:10.1007/s10641-012-0037-y.

Sinokrot, B.A., and Gulliver, J.S. 2000. In-stream flow impact on river water temperatures. J. Hydraul. Res. **38**(5): 339–349. doi:10.1080/00221680009498315.

Sokal, R.R., and Rohlf, F.J. 1995. Biometry. 3rd ed. Freeman, New York.

Sommer, T., Armor, C., Baxter, R., Breuer, R., Brown, L., Chotkowski, M., et al. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries, **32**(6): 270–277. doi:10.1577/1548-8446(2007)32[270:TCOPFI]2.0.CO;2.

Swain, D.L., Langenbrunner, B., Neelin, J.D., and Hall, A. 2018. Increasing precipitation volatility in twenty-first century California. Nat. Clim. Change, **8**: 427–433. doi:10.1038/s41558-018-0140-y.

Thorstad, E.B., Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A.H., and Finstad, B. 2012. A critical life stage of the Atlantic salmon *Salmo salar*: behaviour and survival during the smolt and initial post-smolt migration. J. Fish Biol. **81**(2): 500–542. doi:10.1111/j.1095-8649.2012.03370.x. PMID:22803722.

Townsend, R.L., Skalski, J.R., Dillingham, P., and Steig, T.W. 2006. Correcting bias in survival estimation resulting from tag failure in acoustic and radiotelemetry studies. J. Agric. Biol. Environ. Stat. **11**: 183–196. doi:10.1198/108571106X111323.

USBR. 2018*a*. NMFS Biological Opinion RPA IV.2.2: 2011 six-year acoustic telemetry steelhead study. Contributions by Buchanan, R.A., Israel, J.A., Brandes. P., and Buttermore, E. US Bureau of Reclamation Bay–Delta Office, Mid-Pacific Region, Sacramento, California, United States. Final Report 14 May 2018.

USBR. 2018*b*. NMFS Biological Opinion RPA IV.2.2 2012. six-year acoustic telemetry steelhead study. Contributions by Buchanan, R.A., Brandes, P., Israel, J.A., and Buttermore, E. US Bureau of Reclamation Bay–Delta Office, Mid-Pacific Region, Sacramento, California, United States. Final Report 16 May 2018.

USBR. 2018*c*. NMFS Biological Opinion RPA IV.2.2: 2013 Six-Year Acoustic Telemetry Steelhead Study. Contributions by Buchanan, R.A., Brandes, P., Israel, J.A., and Buttermore, E. US Bureau of Reclamation Bay–Delta Office, Mid-Pacific Region, Sacramento, California, United States Final Report. June 2018.

Welch, D.W., Melnychuk, M.C., Payne, J.C., Rechisky, E.L., Porter, A.D., Jackson, G.D., et al. 2011. In situ measurement of coastal ocean movements and survival of juvenile Pacific salmon. Proc. Natl. Acad. Sci. U.S.A. **108**(21): 8708–8713. doi:10.1073/pnas.1014044108. PMID:21558442.

Yoshiyama, R.M., Fisher, F.W., and Moyle, P.B. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. N. Am. J. Fish. Manage. **18**(3): 487–521. doi:10.1577/1548-8675(1998)018<0487:HAADOC>2.0.CO;2.

EXHIBIT 2

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Population Abundance and Diversion Losses in a Threatened Estuarine Pelagic Fish

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Abstract
Variation in freshwater flow into estuaries can profoundly alter abundance of estuarine organisms through a variety of mechanisms. In the San Francisco Estuary, California, an annual abundance index of juvenile longfin smelt *Spirinchus thaleichthys* has varied by ~ 100-fold over the range of flow, and over the last five decades the index has declined by over 100-fold. The unknown mechanisms for variation with flow may include removal of larvae by freshwater diversions during low-flow periods. Using data from larval trawl surveys during January–March 2009–2020, we estimated larval population size, its response to freshwater flow, and losses of larvae to freshwater diversions. Population size was estimated by a Bayesian hierarchical model linking a process model, with salinity and water clarity as covariates, to an observation model representing catch by a negative binomial distribution. Population size averaged across surveys within years—an index of the number of larvae produced—decreased over the study period from ~ 10^9 to 10^8 larvae. Population size was unrelated to freshwater flow in the year of hatching but positively related to the subsequent juvenile abundance index. Thus, the mechanisms underlying the strong variability in the annual abundance index of longfin smelt with freshwater flow are constrained to occur after March. Estimated proportional losses to water diversions accumulated over the period of vulnerability averaged 1.5% of the population, too low to measurably influence population dynamics.

Keywords Longfin smelt · *Spirinchus thaleichthys* · Freshwater flow · San Francisco Estuary · Population estimates · Water diversions · Bayesian inference

Introduction

The effects of human activities on populations of pelagic organisms in estuaries can be difficult to assess. First, these populations are subject to myriad influences, not all under human control. Second, pelagic organisms are largely unseen and their distribution and abundance can be inferred only through sampling, which involves a known but unresolved set of difficulties including uncertain capture efficiency and its size dependence, incomplete coverage of the species' range, overdispersion, and small sample sizes. Third, the influences on populations may occur at time scales shorter than sampling intervals or at unobserved locations or life stages. And fourth, the dynamics of fish or macroinvertebrate populations are often assessed through indices assumed to be correlated with population size, whereas the actual number of organisms in the population can be more useful for understanding the environmental cost of human activities and the risk of extirpation.

Controversies arise when human activities induce damage which must be balanced against the value of these activities, or mitigated at a cost that may exceed the value of those activities. In estuaries, numerous such controversies revolve around eutrophication, contamination, over-fishing, protection of at-risk species, and uses of fresh water (Nichols et al. 1986; Montagna et al. 2002; Paerl et al. 2006; Breitburg et al. 2018). Resolution can be clouded by the uncertainties in the magnitude of the harm to the species of concern, which is most clearly defined relative to population size (Rothschild et al. 1994).

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In the San Francisco Estuary (SFE), the most intense controversies surround the use of freshwater in the watershed. California's climate is Mediterranean, with most of the precipitation occurring in winter-spring, high interannual variability, and a pronounced latitudinal gradient with greater precipitation in the northern part of the state. About 29 million people and a US $50 billion agriculture industry rely on the watershed for all or part of their water supply. At the same time, the highly urbanized and modified estuary (Nichols et al. 1986; Whipple et al. 2012) is home to numerous species in decline, resulting in government actions for protection that have come into conflict with the needs of water users (Williams 1989; Hanak et al. 2008; Lund et al. 2008).

The temporal and spatial patterns of precipitation in this watershed would constrain its intensive use for agriculture, industry, and a large urban population were it not for the transfer of water from times and places of abundance to those of shortage. Extensive water infrastructure, built throughout the watershed over the last seven decades, achieves this transfer. The centerpiece of this system is a set of immense pumps that divert up to ~ 36 million m^3 day^{-1} of freshwater from the tidal freshwater reach of the California Delta formed by the confluence of the Sacramento and San Joaquin Rivers (Fig. 1). During the wet season (roughly November–May), these pumps are operated to capture water to be used or stored south of the Delta, while during the dry season (roughly June–October) water stored in reservoirs to the north of the Delta is released into the rivers and some of it is pumped out in the Delta for use to the south. These diversions remove 29% (median; range 5–54% from 1980 to 2020) of the annual river flow into the Delta (CNRA 2021).

River flow into the Delta is termed "inflow," while "outflow" equals inflow less diversion (or export) flow and net consumption within the Delta. These and other net flows are reported as daily estimates by the Dayflow accounting program (CNRA 2021).

The diversion of young fish from the estuary has a long history of contention. The water-diversion facilities are equipped with louvers that divert fish out of the flow in order to return them to the estuary, but the louvers are ineffective for fish smaller than ~ 20 mm, whose losses to diversions are unobserved (Brown et al. 1996). Early concerns over the role of diversion losses in a decline in abundance of striped bass *Morone saxatilis* (Stevens et al. 1985) were not supported by subsequent analyses showing density dependence of juveniles and increasing mortality of adults (Kimmerer et al. 2000, 2001). More recently the focus of concerns over diversion effects has been on the endangered delta smelt *Hypomesus transpacificus*. As an endemic species in brackish to fresh regions of the estuary with a 1-year life cycle and a declining population, this fish appears uniquely vulnerable to losses to diversions during both adult and larval life stages (Moyle et al. 1992; Kimmerer 2008; Korman et al. 2021), and as a result efforts to protect delta smelt, including limitations on water diversions, have engendered intense controversy (Moyle et al. 2018).

The longfin smelt *Spirinchus thaleichthys* is another small pelagic fish in the estuary that may be vulnerable to losses in water diversions. The annual abundance index of juvenile longfin smelt has declined by ~ 100-fold over the last

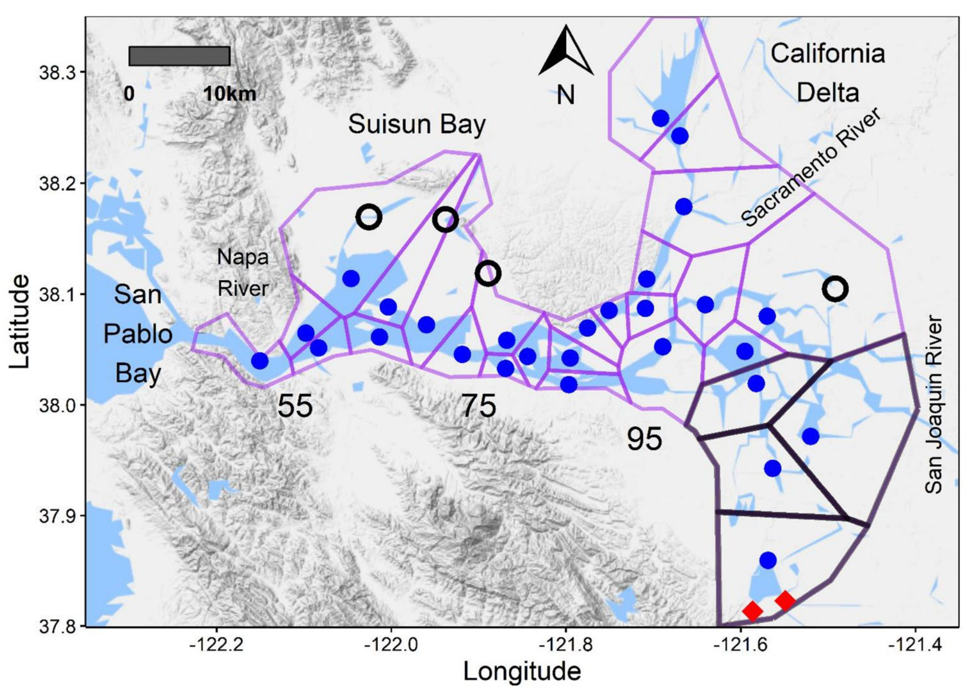


Fig. 1 Map of the upper San Francisco Estuary showing all sampling stations from the Smelt Larva Survey that were used in the analysis. All circles are stations used to estimate the response of abundance to covariates. Filled circles are stations used also to estimate population size, each of which represents an area enclosed in polygons; lines in black enclose the four stations used to characterize population density in the south Delta and thereby loss rates to diversions. Diamond shapes indicate intake sites for water-diversion facilities in the south Delta. Numbers indicate approximate locations of the salinity 2 isohaline for X2 at 55, 75, and 95 km

five decades (Nobriga and Rosenfield 2016, and see below), and the population is listed as threatened by the State of California and as eligible for listing under US endangered species regulations (Federal Register 77 FR 19755, 85 FR 73164). However, its distribution may make it less vulnerable than delta smelt to diversions. Much of the life cycle occurs in brackish to saline waters far removed from the diversion points (Rosenfield and Baxter 2007), and a substantial spawning population has been found in South San Francisco Bay (Hobbs et al. 2010) over 200 km by water from the diversion point. Although the species can spawn in freshwater (Chigbu 2000; Moyle 2002), in the SFE longfin smelt hatch mostly in brackish water and the larvae move seaward as they develop (Lewis et al. 2020, Gross et al. in review).

Superimposed on the ~100-fold decline in the annual abundance index is a strong interannual covariation with winter–spring freshwater flow into the estuary, also of ~100-fold magnitude (Stevens and Miller 1983). Several candidate mechanisms for this variation have been suggested (Jassby et al. 1995; Kimmerer 2002), one of which is high proportional losses to diversions during years of low freshwater flow. These losses have been somewhat mitigated following the 2009 Incidental Take Permit (CDFW 2009) which set limits on the southward flows of water in the southern Delta during the January–March hatching period of longfin smelt; these limits were met by reducing diversion flow (Fig. S1).

Using data on distributions of catches from six surveys of fish abundance, we determined which life stages were most vulnerable to diversion losses based on their occurrence near the diversion points and in low-salinity water. We then estimated the population size of longfin smelt larvae during winter 2009–2020 in the upper San Francisco Estuary using data from a larval survey aimed at this species. This study attempted to answer two questions: (1) Does the population size of larval longfin smelt vary with freshwater flow into the estuary? and (2) What is the likely contribution of diversion losses of larvae to the long-term decline in the fall abundance index and to its relationship to freshwater flow? Using the same data set for 2013 and 2017, a related study applied particle-tracking methods with a Bayesian analysis to back-calculate hatching locations from observed locations of larvae (Gross et al. in review). That analysis also estimated cumulative losses of larvae to diversions for those years.

Methods

Study Site and Species

The San Francisco Estuary (SFE) links the rivers of California's Central Valley to the Pacific Ocean via the California Delta and a series of shallow bays with deeper channels: Suisun Bay, San Pablo Bay, and San Francisco Bay (Fig. 1). The Delta is largely fresh except for intrusion of salt from the west during dry periods. The salinity gradient shifts by ~50 km in response to seasonal and interannual variation in freshwater flows (Jassby et al. 1995; Monismith et al. 2002). During January–March of the study years, freshwater outflow (from the Delta into Suisun Bay) had a median of 534×10^6 m^3 day^{-1} and a range of $(12–658) \times 10^6$ m^3 day^{-1}, while diversion flows had a median of 13×10^6 m^3 day^{-1} and a range of $(4–29) \times 10^6$ m^3 day^{-1} (CNRA 2021). The highest diversion flow rates of this period occurred in 2017 to capture some of the high winter flows in that very wet year.

Longfin smelt is native to lakes and estuaries from the SFE to Alaska (Moyle 2002). In the SFE, longfin smelt spawn mostly at age 2 years, laying adhesive eggs that hatch in Suisun Bay, San Pablo Bay, the western Delta, and south San Francisco Bay during January–March (Moyle 2002; Hobbs et al. 2010; Gross et al. in review). Longfin smelt larvae were abundant in Suisun Marsh during high-flow periods in February and March (Meng and Matern 2001). Although spawning habitat has been described as freshwater, otolith microchemistry of adults and distributions of larvae suggested that they hatch at an average salinity of 2 (Hobbs et al. 2010; Lewis et al. 2020).

Early larvae in the SFE are surface-oriented and most abundant around a salinity of 2, moving seaward with the net flow, but as they reach approximately 10–12 mm they spread throughout the water column, and begin to migrate vertically on a diel pattern and possibly also a tidal pattern (Bennett et al. 2002; Dege and Brown 2004). Larval longfin smelt that hatch in the northern estuary disperse at least as far as San Pablo Bay (Grimaldo et al. 2021). Both tidal vertical migration and distribution into the lower part of the water column may help to retain the larvae and possibly move them landward to the low-salinity zone (salinity 0.5–5), as suggested by results of particle-tracking modeling (Kimmerer et al. 2014).

Setting the Context

The background for this study is the long-term declines in a key abundance index of longfin smelt and in its short-term interannual variation with freshwater flow (Jassby et al. 1995; Kimmerer et al. 2009; Nobriga and Rosenfield 2016). The index is derived from catches in the midwater trawl survey conducted annually from September to December in 1967 through 2020 except 1974 and 1979 (Moyle et al. 1992; https://www.dfg.ca.gov/delta/data/fmwt/indices.asp, accessed 29 June 2021; Table S1). We updated the trend analysis using "X2," the estimated distance up the estuary to where daily-averaged near-bottom salinity is 2 (Jassby et al. 1995). X2 is a measure of the physical response of the estuary to freshwater flow and the extent of the estuarine salinity field (Monismith et al. 2002). We analyzed the abundance index using a generalized linear model (function *glm*, R Core Team 2020) with a log link function and variance proportional to the mean squared, with mean X2 from January to June as a linear predictor and a second-order polynomial in year (function *poly* in R) to allow for deviation of the year trend from linear. X2 for the hatching period (January–March) was also used to analyze the immediate effect of the position of the salinity field on the distribution of the larvae (below).

Additional background was provided by comparing the distributions of longfin smelt in salinity space and in proximity to the diversion intakes using data collected by all six fish-monitoring programs that cover a large part of the upper estuary (Table S1; Stompe et al. 2020; Tempel et al. 2021; Bashevkin et al. 2022). The intent of this comparison was to determine which of the monitoring programs showed the greatest proportion of fish in fresh water and near the diversion intakes. The diversion operators must meet salinity standards for ecosystem protection and to prevent pumping saline water. Therefore, the proportion of total catch in each program that is taken in fresh water and, in particular, near the diversion intakes should indicate which program shows the highest potential for proportional losses of fish to diversions. To assess this, we determined the catch of longfin smelt per trawl using all data from each monitoring program near the intakes and in three salinity bins, <0.5 (essentially fresh), 0.5–5, and >5.

Overview of Abundance Modeling

The population size of larvae was estimated from catch data collected by the Smelt Larva Survey (SLS) designed to collect larval longfin smelt (Mitchell et al. 2019; Tempel et al. 2021). "Population size" here means the estimated total number of larvae in the region sampled by the SLS during a given survey. "Population density" refers to the estimated number of larvae m^{-3} at each sampling station during each survey. "Adjusted population size" is population size adjusted to account for larvae outside of the spatial extent of the survey, as explained below. An annual mean population size index and proportional diversion losses were calculated as arithmetic means from the surveys in each year; some conceptual difficulties with this practice are discussed below.

The SLS began collecting data on abundance of larval fishes in 2009. Five or six surveys (i.e., single sampling events) were taken at 2-week intervals during January–March. Each survey was taken over 4 days at nominally 32 stations. At each station, a single 10-min oblique tow was taken with a 500-µm or 505-µm mesh net with a mouth area of 0.37 m^2, attached to a frame equipped with skis to limit damage if the net hit bottom. The net was deployed while underway and lowered to a target depth by adjusting the amount of towing cable let out to attain an angle of the wire to the vertical of 71°; the target depth compared favorably with measurements using depth sensors (T. Tempel, California Department of Water Resources, pers. comm. 30 August 2021). The estimated sampling depth averaged ~ 2 m greater than the water depth measured by a depth sounder on the vessel, and was greater in 95% of the tows, indicating that the net was usually reaching the bottom and sampling the full water column.

Each sample was preserved in 4% formaldehyde. A flowmeter was used to estimate volume sampled. Data on salinity, temperature, and Secchi depth were also collected at each station, and turbidity was measured beginning in 2010. Larval fish were subsequently identified to species and either all (2009 and 2010) or up to 50 (2011–2020) longfin smelt larvae were measured to the nearest millimeter notochord length.

Population size estimates for each survey were made with a Bayesian hierarchical model (Gelman et al. 2004) in which a process model related the unobserved true population density to salinity and water clarity, and an observational model linked the population density estimated by the process model to the field observations. Then, the proportional losses of longfin smelt larvae to diversions in the Delta were estimated with a method conceptually similar to that used in a study of delta smelt (Kimmerer 2008), in which the flux of larvae to the diversion facilities was estimated as the product of estimated local population density and diversion flow rate.

The year 2017 had the second-highest flow among water years (October 2016–September 2017), and the highest mean flow in January–March, for any year since 1955. Because the estuarine salinity field moves in response to variation in freshwater flow (Jassby et al. 1995; MacWilliams et al. 2015) and larval longfin smelt are generally found at salinity ~ 2 (Dege and Brown 2004; Kimmerer et al. 2013), most of the larvae in 2017 were seaward of the region sampled by the SLS (Lewis et al. 2020; Grimaldo et al. 2021). Although we included these data in most analyses, the results for 2017 were so anomalous that they were excluded from our analyses of interannual trends and the consequences of losses to diversions.

Key assumptions in this analysis were as follows: (1) Sampling locations were representative of the distribution of the population; (2) larvae (mostly 5–10 mm length) are unable to avoid the sampling gear, or any avoidance was similar in the southern Delta to that in the broader region; (3) the distribution of larvae is unimodal in salinity space, with some effect of water clarity; and (4) a negative binomial error distribution is suitable for these data. The degree to which sampling was representative cannot be determined independently. The weakly swimming larvae (Bennett et al. 2002) were almost certainly collected quantitatively, since the net mesh was selected to capture larvae at all sizes, and the 5–10-mm larvae are unlikely to avoid the net. The distributions of most estuarine plankton and fish are unimodal in salinity space (Kimmerer et al. 2013). The negative binomial distribution is commonly used to represent the statistical distribution of planktonic organisms (Taft 1960); it is identical to a Poisson distribution in which the parameter λ increases with the predicted mean.

Data Preparation

The distribution of larvae was analyzed using salinity and Secchi depth as covariates. Like most estuarine organisms, larval longfin smelt are most abundant over a range of salinity and less abundant at higher or lower salinities. Since salinity due to ocean salts decreases with distance up the main channel of the estuary, salinity can be used as a measure of distance along the channel in the reference frame of the fish. Also, like many fishes in the estuary (Latour 2016), larval longfin smelt are more abundant in turbid water than clear. Secchi depth measurements have been taken in every year of the SLS with only one missing value. Turbidity measurements began in 2010 (though with 22 missing values since 2010). Because Secchi depth is more closely aligned than turbidity with the sight distance of a visually oriented organism, and the data were more complete, we used Secchi depth (cm) as a covariate representing water clarity.

Data were available for 2009–2020. Out of 70 surveys conducted during that time, one had samples from only half of the stations and one was missing data from three of the four stations in the southern Delta. Stations in the lower Napa River (Fig. 1) were excluded because they were sampled during only half of the years. Three stations in the San Joaquin River (stations 906, 910, and 912) were excluded because salinity is often elevated by agricultural return flow, i.e., not due to ocean salts, and including these stations distorting the relationships of catch to salinity.

This left a total of 68 surveys (5 each in 4 years, 6 in the remaining years) comprising 2165 samples from 32 stations. Eleven samples were missing, with two stations unsampled twice and seven stations unsampled once, while all other stations were sampled during every survey. Catches ranged from 0 to 1678 fish, with a median of 3 and a mean of 37. Salinity data were missing for three samples and Secchi depth for one sample, and these values were filled in from nearby stations by linear interpolation. All 32 stations were used in the Bayesian analysis to determine the relationships between environment and catch per trawl, but missing catch data were excluded from this analysis.

A subset of 28 stations was selected as representative for estimating population size from catch per trawl predicted by the Bayesian analysis. Stations excluded from this part of the analysis (Fig. 1) were three in Suisun Marsh, whose habitat volume is negligible, and one in a small slough in the eastern Delta far removed from the larger channels, which therefore did not seem representative. This resulted in a complete set of 1904 samples in the 68 surveys of 28 stations.

Volume sampled from the flowmeter measurements had a median and mean of 187 m^3 and a range of 6–345 m^3, with 10th and 90th percentiles of 153 and 220 m^3 respectively. Eighteen samples had volume estimates < 100 m^3 and these values were unrelated to tow duration or catch and therefore appear spuriously low. Since most of the volume estimates were within a narrow range, whereas the catch data were wildly variable and highly skewed, we used the median volume sampled of 187 m^3 to convert catch to catch per unit volume.

Length data were used to develop length-frequency plots and to estimate the age ranges of larvae vulnerable to the net. Longfin smelt hatch at 5.3– 6.8 mm length (Wang 2007), with a mean based on field sampling of 6.2 mm (Gross et al. in review). We calculated the frequency by length from 5 to 30 mm at 1-mm length intervals. This was converted to age using a growth rate of ~ 0.19 mm day^{-1}, determined on cultured larvae of known age and on wild-caught fish using age determined from otoliths (Gross et al. in review). All larvae with interpolated sizes of 6.2 mm or smaller were assigned age 0; then, 7 mm fish were assigned age 4.2 d, 8 mm fish 9.5 d, and so on.

Process Model

We conducted a preliminary analysis of the SLS data set to determine a reasonable representation of covariates. Since both the salinity distribution and abundance varied among years and among surveys within years, we used survey number (1 to 68) as a blocking variable. Other covariates included Secchi depth (linear) and salinity (unimodal), both from measurements taken with each fish sample. Salinity was log-transformed to spread out the scale where longfin larvae are most abundant and to make the scale closer to linear in geographic distance. The response variable for this preliminary analysis only was the log of (catch per trawl + 1).

We explored various methods for representing a unimodal distribution in salinity space, including generalized additive models (*gam* in R, R Core Team 2020), locally weighted smoothing (*loess* in R), and polynomials of order 2 to 5. Although criteria for model selection such as AIC (Akaike 1974) are helpful generally, we had two specific criteria related to our purpose. The first was that the fit should not underestimate abundance at the freshwater end of the larval distribution, and the second was that it should not overestimate abundance near the peak. Most of the above models failed one or both criteria, particularly the first. We selected a quadratic fit as the most parsimonious representation of the abundance pattern, although it did not fit as well overall as *gam* in this exploratory analysis.

A symmetrical quadratic fit to a log-transformed response variable is a Gaussian curve in raw data units.

The final process model selected was

$$\ln\left(\mu_{i,k}\right) = a_i + b_i S_{i,k} + c_i S_{i,k}^2 + d_i D_{i,k} \tag{1}$$

where i is the survey, k is the station, $\mu_{i,k}$ is the estimated mean catch per trawl at station k for survey i, a through d are the parameters to be estimated for each survey, S is the log of salinity (Practical Salinity Scale), and D is the Secchi depth (cm).

Observation Model

The distribution of catch per trawl about the mean catch per trawl predicted by Eq. 1 was modeled with a negative binomial distribution

$$p_{i,k} = \frac{1}{1 + \alpha\ \mu_{i,k}} \tag{2}$$

$$C_{i,k} \sim dnegbin\left(p_{i,k}, 1/\alpha\right) \tag{3}$$

where $p_{i,k}$ is the probability parameter for the negative binomial function *dnegbin*, α is the overdispersion parameter which was the same for all samples and surveys, and $C_{i,k}$ is the observed catch of longfin smelt for survey i at station k. Overdispersion increases with $\alpha > 0$, while with $\alpha \approx 0$ the negative binomial distribution becomes a Poisson distribution (alternative formulations of the negative binomial use λ or $\theta = 1/\alpha$ to represent overdispersion). Preliminary analyses with values of α that varied by survey gave similar means of population size index to those using a single value of α, but with greater uncertainty.

A similar result was obtained using a 4th-order process model and an observation model using a Poisson distribution with parameter λ that was lognormally distributed to allow for overdispersion (Royle and Dorazio 2008). Predictions of the annual estimates of losses to diversions were similar between the two models in most years (Fig. S2), but diagnostic statistics for this model showed evidence of instability and this model is not discussed further.

The observation model might have been improved by using zero inflation to account for an excess of zeros in the catch data (shown below) compared to the model predictions (Wenger and Freeman 2008). However, zero-inflated models are suitable only when the zero inflation arises through a different process from the one that generates the negative binomial component of the model (Royle and Dorazio 2008), which is not the case for these data.

Post hoc Calculations

Station locations were mapped using *ggmap*. Each station was assigned a region whose volume was used to extrapolate estimates of local density to population size. Polygons around each station were calculated using a tessellation function (*deldir* in R) that assigns every geographic point to the nearest station. Some of the polygons are unbounded, so they were constrained using *tile.list* with points defining lines bordering the estuary that were selected on a Google Earth map of the sampling domain (Fig. 1). This resulted in some anomalies where boundaries crossed land, connecting water bodies that would logically be in different polygons (Fig. 1), but the volumes so assigned were negligible and this was ignored for simplicity. The volume of water in each polygon was calculated from a spatial grid used in a recent version of the UnTRIM hydrodynamic model (Gross et al. 2019).

Post hoc calculations of population size and daily diversion loss rate, both by survey and by year, were taken directly from the iterations of the Bayesian model. Population size (number of fish) from each survey was calculated as

$$A_i = \sum_{k=1}^{28} \frac{C_{i,k} V_k}{v} \tag{4}$$

where A_i is the population size for survey i, V_k is the volume of water in the polygon around station k, and v is the median (also mean) volume sampled of 187 m^3 used for all samples. Then, the mean daily proportional loss of larvae to diversions was calculated under Assumption 1, i.e., that the density of larvae in the diverted water was the mean of that in the four stations near the diversion facilities,

$$L_i = \frac{Q_i}{n A_i v} \sum_{j=1}^{n} C_{i,j} \tag{5}$$

where L_i is the daily proportional loss during survey i, Q_i is the diversion (export) flow rate on that day (m^3 day^{-1}), and n is the number of stations (4) and j the index for each station in the south Delta (Fig. 1). The annual population size index and the mean of the daily proportional loss rates were calculated as the means of the respective values from the surveys in each year. To assess the cumulative effect of these losses on the larval population, we accumulated losses over the mean and 90th percentile of age of the population calculated from length distributions (see the "Discussion" section).

The sampling program did not cover the full salinity range of the larvae, and in many surveys no samples were taken at salinity above ~ 10. In surveys that covered salinities up to 15, the decline in abundance at high salinity became obvious (examples below). Therefore, in those surveys lacking data at high salinity, the population size (A_i in Eq. 4) was underestimated and the impact of diversion was overestimated. To provide a rough estimate of these biases, we estimated the proportion of the population missed by the sampling program. The key assumption was that the distribution of habitat volume by salinity range does not vary much with X2 values above ~ 55 km (Figs. 3 and 5 in Kimmerer et al. 2013). We used the parameters in Eq. 1 calculated for each of 14 surveys with maximum salinity > 15 (which occurred in 7 years spanning 2009–2020). Predicted catch was calculated for these surveys in 21 bins of salinity (0 to 1, 1 to 2, etc.), with Secchi depth set to its median of 51 cm. From these, we calculated the cumulative proportion of the catch in each salinity bin and averaged those proportions over the 14 surveys. The maximum observed salinity in each of the 68 surveys was then used with the cumulative mean proportions by salinity to estimate the proportion of the population that was missed in the survey. This proportion was then used to estimate the fraction by which the estimated population size should be increased and the fractional loss to diversions decreased. Because these calculations were crude and post hoc, we first present results below focusing on the observed data and then discuss the proportional losses both as calculated and after this adjustment.

Model Fitting

The model was run in JAGS v. 4.3.0 (Plummer 2017) from R (R Core Team 2020) using the function *jags* in package jagsUI. Prior distributions (priors) for *a*, *b*, *c*, and *d* (Eq. 1) were normal with means of 0 and standard deviations of 10, and therefore uninformative except that *b* was constrained to be positive and *c* and *d* were constrained to be negative. This reflects our intent that the salinity functions should be concave downward since the larvae are most abundant at intermediate salinity and uncommon in fresh or highly saline water, and that larvae should be rarer in clear water than turbid. The single value of α was given a uniform prior U (0.01, 10). Examination of extreme values of the output showed that effects of these priors on the posterior distributions of the parameters were negligible.

Run parameters included three Markov chains with a burn-in of 1000 iterations to minimize the effect of (randomly selected) initial values, tenfold thinning, and 5000 iterations (samples from the posterior distribution) after thinning. The algorithm was verified by running it with simulated data and comparing the computed mean and distribution of the simulated data with values from the Bayesian model.

Standard post hoc diagnostic tests were conducted. The Gelman-Rubin statistic *rhat* (Gelman et al. 2004) for annual population size index had a maximum value of 1.015 and that for annual proportional loss to diversion had a maximum value of 1.001, both indicating convergence. Autocorrelation plots (not shown) indicated that the number of iterations was sufficient. An additional check ensured that parameter estimates were similar between the first and last 10% of the series of iterations after burn-in. Finally, we repeated the run with the standard deviations of the priors for parameters in Eq. 1 set to 30 instead of 10, and increased run time to a burn-in of 2000 iterations and 10,000 iterations retained after thinning. This run produced similar values to the original run, and values for the annual mean population size index and mean annual proportional loss were within 3% of those in the original run, but diagnostic statistics indicated poorer convergence for some of the surveys.

A comparison of predicted and observed catch per trawl was made graphically and by summary statistics (see the "Results" section). To provide an order-of-magnitude check of the calculations through the entire analysis, the mean catch per trawl from all surveys was used with the total habitat volume to calculate an expected mean population size across all surveys, which was 68% of the overall mean from the Bayesian analysis.

Results

The autumn abundance index for juvenile longfin smelt continued downward with shorter-term variation largely related to spring X2 (Fig. 2A). The model explained 81% of the deviance in the index, and partial residuals show that the two components had approximately the same influence on the index (Fig. 2B, C). Partial residuals for both year and X2 had ranges near log(100), meaning that the index varied by 100-fold over its 54-year span and over the 43-km range of X2. The slight downward curvature in the partial residual for year suggests an accelerating decline.

Boxplots of catches from six monitoring programs compare the likely vulnerability of early larvae to diversions with that of other life stages (Fig. 3, Table S1). Mean catch per trawl was highest in the 0.5–5 salinity range for all sampling programs. Among sampling programs, mean catch near the diversion points was highest for early larvae (Fig. 3A), near zero for late larvae (Fig. 3B), and zero for juveniles and adults (Fig. 3C-E). Mean and median catches at salinity < 0.5, excluding stations near the diversion points, were higher for early larvae than for any other life stage, and only early larvae had a median and an upper quartile > 0 in this salinity range.

Environmental conditions during each study year show substantial variation in Delta outflow and corresponding shifts in X2 during the larval period (Table 1). Salinity ranges covered by the SLS always included fresh water but had maxima that varied with X2. Results of the Bayesian analysis (also summarized in Table 1) are discussed below.

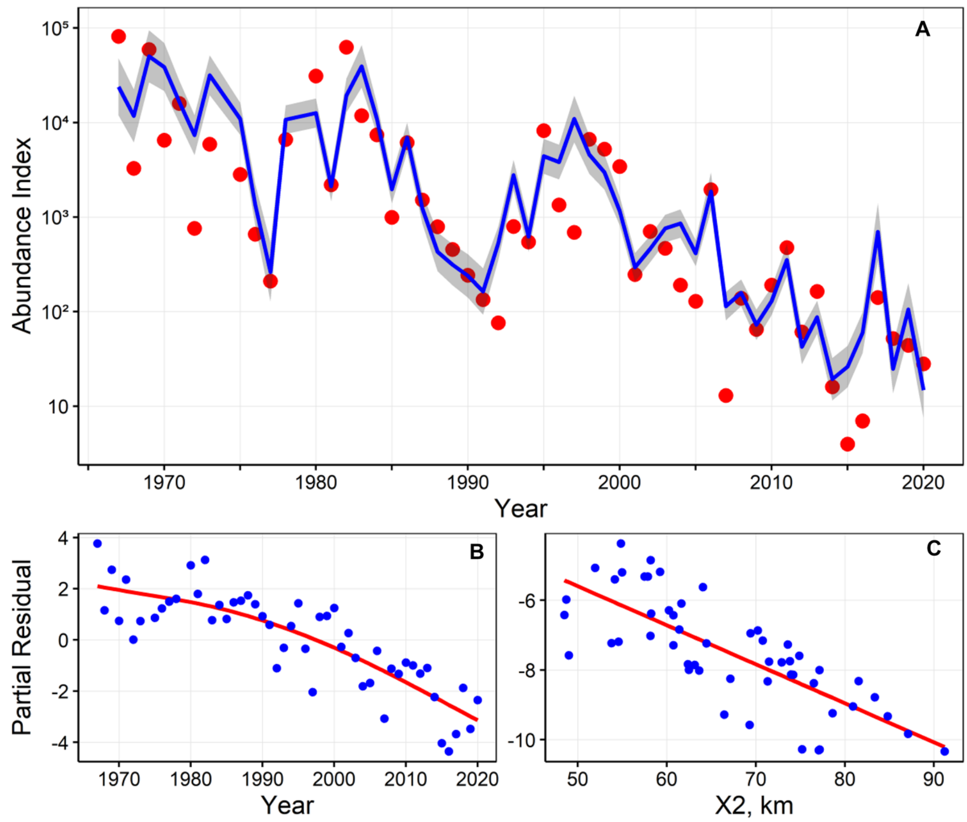


Fig. 2 Relationship of annual fall abundance index of juvenile longfin smelt to year and X2 averaged over the preceding January–June. **A** Abundance index (points) with line fitted to the index with a generalized linear model in X2 and a quadratic function for year; the shaded region shows 95% the confidence interval. **B** and **C** Partial residuals (natural-log scale) from the fit in **A** for year and X2 respectively. The model (function *glm* in R) was glm (index ~ X2 + *poly*(year, 2), family = quasi (link = log, variance = mean^2)). The fit was index = 15.4 – (0.13 ± 0.02) X2 – (11.7 ± 1.7)P1 – (2.5 ± 1.7) P2, parameters with 95% confidence intervals, 48 degrees of freedom, where P1 and P2 are the terms of an orthogonal transformation for a quadratic function of year (function *poly*). This model explained 81% of the deviance in the abundance index

The larvae collected by the Smelt Larva Survey were small, with a mode at 7 mm and medians of 7–8 mm. The < 0.5 salinity range had a greater proportion of 6 mm fish than the other two salinity ranges (Fig. 4). About 99% of all fish measured were between 5 and 13 mm and 95% were between 5 and 10 mm. Using the assumed growth rate of 0.19 mm day^{-1}, about 26% of the fish were age 0 days, the mean age was 6.8 days, and the 50th, 75th, and 90th percentiles of age were 3, 7, and 13 days respectively.

The variance:mean ratio of a Poisson distribution is 1, and overdispersion causes that ratio to increase above 1 in a negative binomial distribution at a rate that itself increases with the mean and also with the α parameter. The Bayesian analysis gave a mean for the single value of α of 1.43 (95% credible interval ± 0.11, median 1.43). At the median predicted catch per trawl of 8 fish, the median variance:mean ratio was 7, while at the mean predicted catch per trawl of 50 fish the median variance:mean ratio was 24.

Predicted and observed catch per trawl for all data had a correlation coefficient of 0.6, but scatter was wide and related to predicted mean, as expected for an overdispersed distribution (Fig. S3A, B). About 32% of the observed catches were zero, while 16% of the predicted catches were 0 when rounded to the nearest whole number, and 81% of the samples were on the principal diagonal of the presence/absence matrix (Table S2). Residuals from the analysis, determined separately for three salinity ranges, had interquartile ranges that included zero and a wide scatter of outliers, as expected from the overdispersion of the catches (Fig. S3C).

Example plots of observed and predicted catch per trawl show how patterns varied depending on the range of salinity covered by the surveys (Fig. S4). The underlying response to salinity was quadratic and therefore smooth, so the jagged appearance of the lines is due to variation in Secchi depth. The model predictions agree broadly with the observed catches, with the highest values generally occurring at salinity between 0.5 and 5 (Fig. S4B, C, E, F). However, many surveys did not cover the high-salinity end of the range of larval longfin smelt (e.g., Fig. S4A, D). Below we discuss consequences of the resulting underestimate of population size, particularly for samples taken during high-flow periods such as in 2017.

As a check on whether the modeled population estimate was reasonable, we calculated the population size for each survey by simply multiplying the observed catch m^{-3} by the volume assigned to each station and summing the result across stations. The mean of the annual means calculated from data from surveys without missing data (60 out of 68 surveys) was 0.41×10^9 compared with 0.49×10^9 from the model, and all of the individual annual means so calculated were within the 95% credible intervals of the model-generated results.

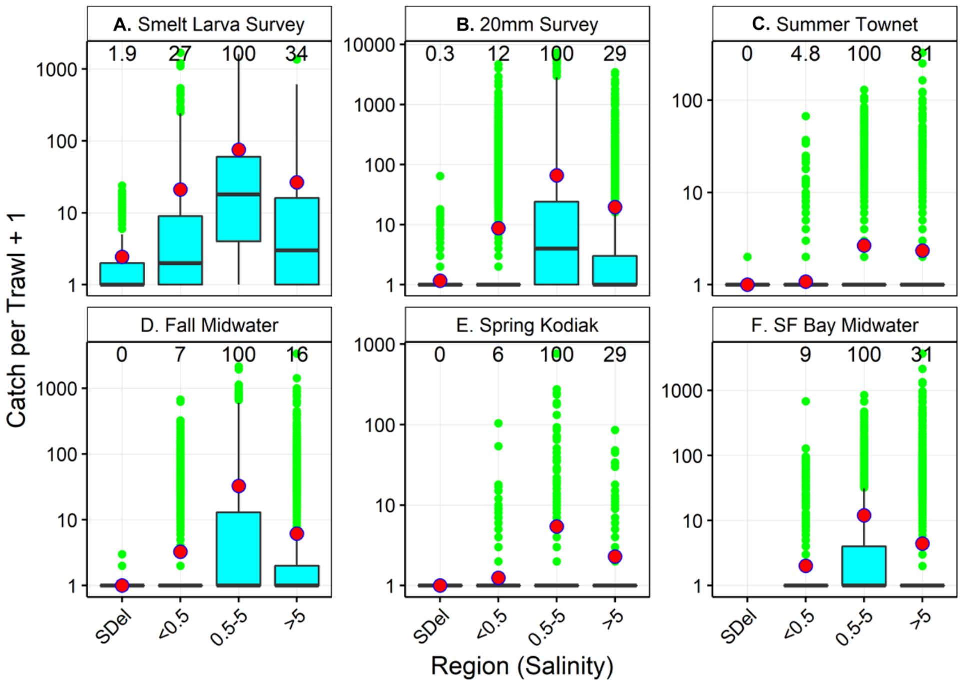


Fig. 3 Boxplots showing catch per trawl of longfin smelt for each of six sampling programs in the upper estuary (panels **A**–**F**; see Table S1). The four boxes in each panel show differences among four regions: the south Delta near the diversion intakes ("SDel"), and three regions defined by salinity ranges but excluding the south Delta. Boxes show quartiles, whiskers extend to the furthest point within 1.5 times the interquartile range from the boxes, and points are outliers. Circles give means, and numbers at the top of each panel give the percent of each mean to the highest mean in the panel, rounded to one decimal place if < 0.5. The south Delta was not sampled by the San Francisco Bay Study (**F**). Data are from all years when the program operated; confining the data to the years when the Smelt Larva Survey was operating, 2009–2020, gave essentially the same result

Table 1 Environmental conditions, annual population size index (billions with 95% credible interval), and daily mean losses to diversions (%), averaged across surveys. Flow and X2 are means for January–March from CNRA (2021), and the range of maximum salinity is based on the maxima from each of the 5 or 6 surveys in that year. Population values are from the Bayesian analysis. The estimated percentage of the population not sampled is based on extrapolating to salinity of 15 for those surveys in which the maximum salinity was < 15. Adjusted values of the population size index have been increased over the respective raw data by dividing by the fraction of habitat sampled, and adjusted daily percentage losses are based on the adjusted population size index. The daily percent loss is also given based on raw population size index and adjusted by the fraction of the habitat not sampled. Cumulative percent adjusted losses are given for two values of the assumed duration of exposure (see text) and also for the diversion patterns that existed during 1980–2008 before limitations on diversions were imposed

Year	Outflow, $m^3 s^{-1}$	X2, km	Range of max. salinity	Percent not sampled	Population size index		Daily percent loss		Cumulative percent adjusted loss		1980 to 2008
					Raw	Adjusted	Raw	Adjusted	6.8 d	13 d	13 d
2009	570	77	7.2–17.8	18	0.55 ± 0.20	0.67	0.19	0.17	1.2	2.2	3.3
2010	861	71	1.8–13.7	73	0.99 ± 0.42	3.68	0.13	0.09	0.6	1.2	1.6
2011	1839	62	0.5–12.2	37	0.76 ± 0.34	1.21	0.21	0.12	0.8	1.5	1.7
2012	521	77	4.1–16.2	29	1.11 ± 0.42	1.56	0.16	0.13	0.9	1.7	2.6
2013	579	70	2–11.6	46	1.79 ± 0.92	3.31	0.09	0.04	0.3	0.5	0.8
2014	340	81	14.6–20.7	4	0.27 ± 0.08	0.28	0.10	0.09	0.6	1.2	2.2
2015	412	77	4.5–18.5	14	0.06 ± 0.02	0.07	0.05	0.05	0.3	0.6	1.0
2016	1155	69	0.8–20.1	43	0.04 ± 0.01	0.07	0.29	0.23	1.6	2.9	3.7
2017	5332	49	0.2–9.4	~ 100	0.002 ± 0.001	0.03	0.38	0.05	0.3	0.6	0.3
2018	664	74	5.6–12.4	20	0.12 ± 0.04	0.15	0.14	0.11	0.7	1.4	2.0
2019	2356	61	0.2–16.9	83	0.05 ± 0.05	0.32	0.27	0.09	0.6	1.2	1.2
2020	479	75	9.2–15.9	7	0.14 ± 0.04	0.15	0.27	0.23	1.6	2.9	4.6

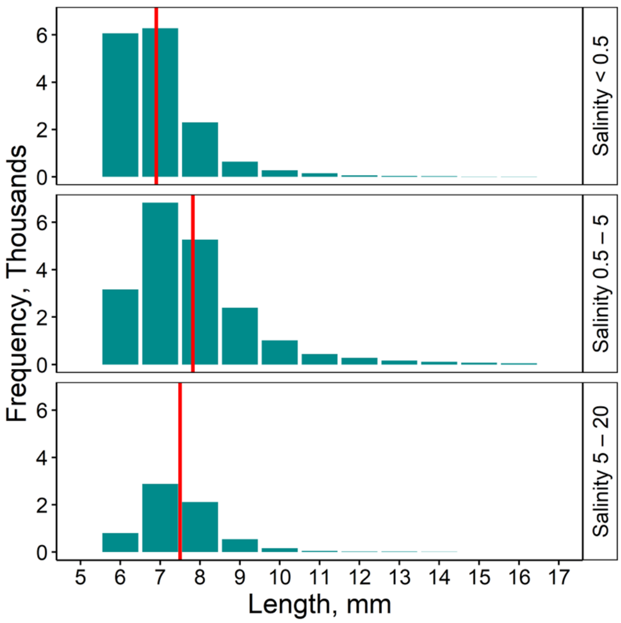


Fig. 4 Size frequency distributions of longfin smelt captured by the Smelt Larva Survey, 2009–2012 (43,730 fish), by three salinity ranges. Vertical lines are median lengths for each salinity range

The annual population size index of larvae showed a large decline from 2013 to 2015 with an intermediate value in 2014 and an anomalously low value in 2017 (Fig. 5). The population size index in the earlier period was ~ 10^9 fish, while that in the latter period excluding 2017 was ~ 10^8 fish. Variability was high among surveys within years, as the first and last surveys caught fewer fish than the other surveys (in a few cases, the sixth survey was dropped when the fifth produced few longfin smelt).

Adjusting the population size estimates for each survey for the incomplete coverage of the salinity range gave increases that scaled with the position of the salinity field and therefore the maximum salinity during each survey, and had variable effects on the annual population size index (Table 1). As expected, these adjustments were most extreme in wet years such as 2017 and 2019.

The annual population size index of larvae, whether adjusted as above or not, was positively related to the subsequent fall index of juvenile abundance (Fig. 6, 2017 not included). The adjusted indices gave a somewhat better fit than the raw indices (AIC of 30 and 34 respectively). The larval population size index was unrelated to flow conditions as indexed by the mean X2 value for January to March of each year (Fig. 7). The slope of the population size index vs. X2 was within 1 standard error of 0 in linear models with and without adjustment for incomplete coverage of the salinity range and with and without the outlier year 2017. Adding a linear effect for year, or a step function for year occurring after 2013 (Fig. 5), did not improve the fit.

Losses of larval longfin smelt to diversions were highly variable with large error bars around some of the survey-specific values (Fig. 8), especially for 2017. Annual mean values of the daily losses had an overall mean of 0.19% day^{-1} and a range of 0.05–0.23% (Table 1). However, adjusting values for the proportion of the habitat not sampled reduced some of the values, so that the adjusted mean was 0.12% day^{-1}. After this

Fig. 5 Population size estimates by survey and indices by year. Symbols give population size estimates by survey with 95% credible intervals. Boxes give medians (cross-bar) and quartiles (edges of boxes) of annual population size indices by year. Colors and shapes distinguish adjacent years but have no other meaning. Asterisks indicate that results for 2017 were unreliable because the surveys covered so little of the habitat of larval longfin smelt

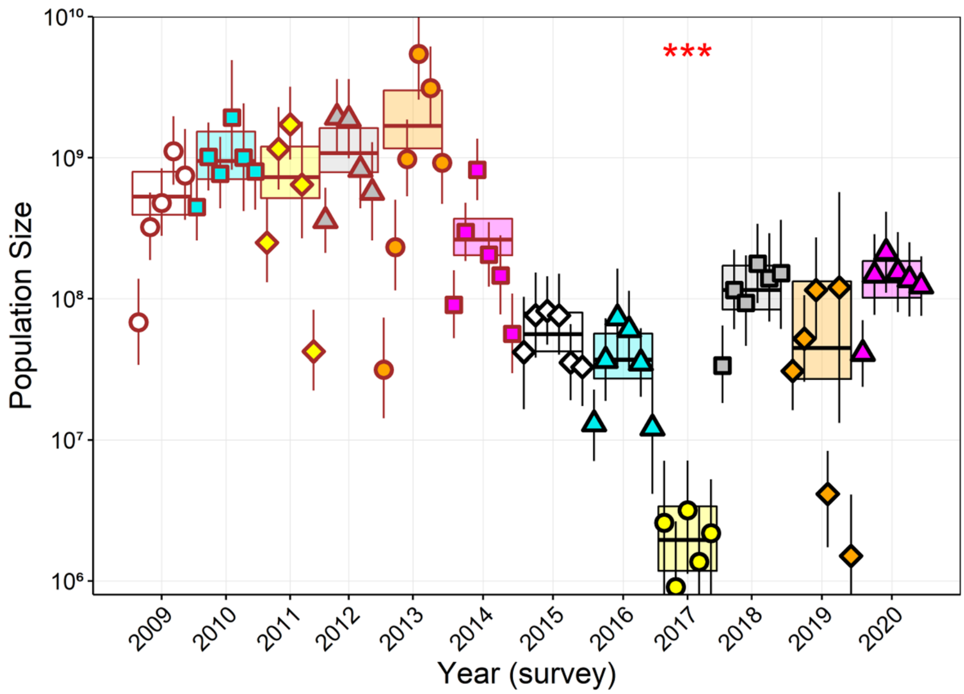
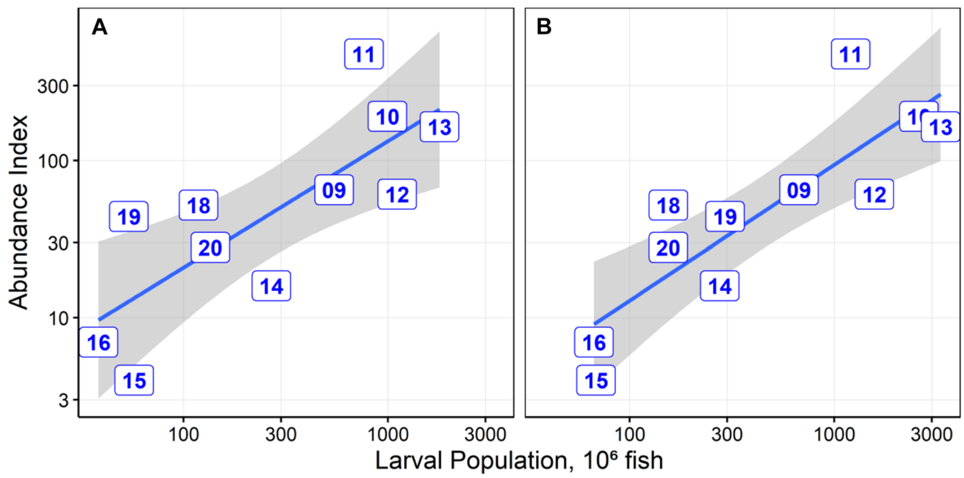


Fig. 6 Population size indices of larval longfin smelt vs. subsequent value of the Fall Midwater Trawl Index by year with 2017 excluded. **A** Raw population size index; $y = -0.66 + 0.80 \pm 0.50x$ (95% CI), $R^2 = 0.56$ for log–log regression. **B** Population size index adjusted for incomplete sampling; $y = -1.42 + 0.86 \pm 0.40x$ (95% CI), $R^2 = 0.69$ for log–log regression. Numbers indicate years. Data for 2017 were as follows: abundance index 141, larval population in **A**, 2×10^6; **B**, $26 \times 10.^6$



adjustment, the percent daily loss by survey was above 0.2% day^{-1} only when X2 > ~70 km, when the maximum salinity values on each survey were often > 15 resulting in maximum precision in the population size estimate (Table 1, Fig. 9).

Discussion

This paper contributes to the growing body of literature on the effects of freshwater flow and flow diversions on populations of estuarine organisms (Livingston et al. 1997; Montagna et al. 2002; Kimmel and Roman 2004). These effects are of scientific interest for understanding the factors driving estuarine populations, and of management interest for developing ways to minimize harmful human impacts. Our results show that the strong relationship of the fall index of abundance to flow (as X2) continues to hold, although the temporal decline includes a worrisome acceleration (Fig. 2). This decline in the fall index is mirrored in the abundance of longfin smelt during the early larval stage (January–March) which declined over the duration of this study, between 2009 and 2020. However, larval abundance is unrelated to freshwater outflow during January–March, and losses of larvae to diversions appear far too low to contribute measurably to the population response to flow, as discussed below.

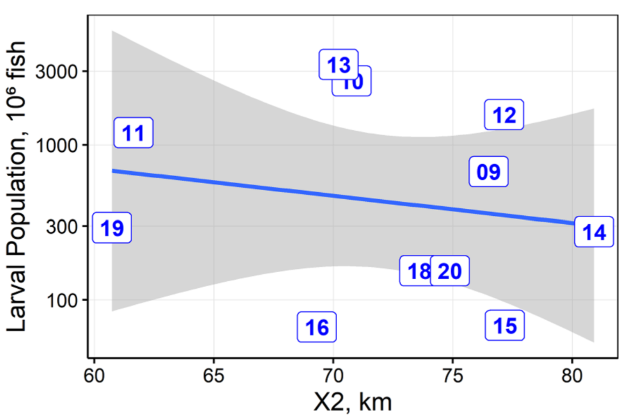


Fig. 7 Population size index of larval longfin smelt vs. mean X2 for January–March with 2017 omitted; $y = 9 - 0.04 \pm 0.16\ x$ (95% CI), $R^2 = 0.03$ for log-linear regression. Numbers indicate years as in Fig. 6. The data point for 2017 is at X2 = 48.5 km, population = $25 \times 10.^6$

Evaluation

The selection of a negative binomial observation model was somewhat arbitrary, although this model has a long history of use in analyzing distributions of organisms (Taft 1960; Jahn and Smith 1987; Drexler and Ainsworth 2013). This use is consistent with the schooling behavior of many estuarine fish populations even as larvae, which causes catches to be overdispersed. For example, the catches in the Smelt Larva Survey had a mean of 37 fish and a maximum of 1678 with 34% of the values being zero; a Poisson distribution with the same mean would have 1st and 99th percentiles of 24 and 52, respectively. Several alternatives to the negative binomial were rejected as either inappropriate for overdispersed data (Poisson) or difficult to fit (zero-inflated models as discussed above). An alternative model using a Poisson model with a lognormally distributed prior for the single parameter λ and a process model that was fourth-order polynomial in salinity gave results that were similar to those of the model described in Eqs. 1–3 (Fig. S2), but convergence was poor in some cases.

Of the 2165 samples in the survey data, 1472 had at least one longfin smelt (Table S2) and 1810 had a predicted catch per trawl of at least 1 after rounding to whole numbers. Graphical and tabular analyses revealed that predictions of positive catch when actual catch was zero were more frequent in later years than in early years. This may be an artifact of fitting a

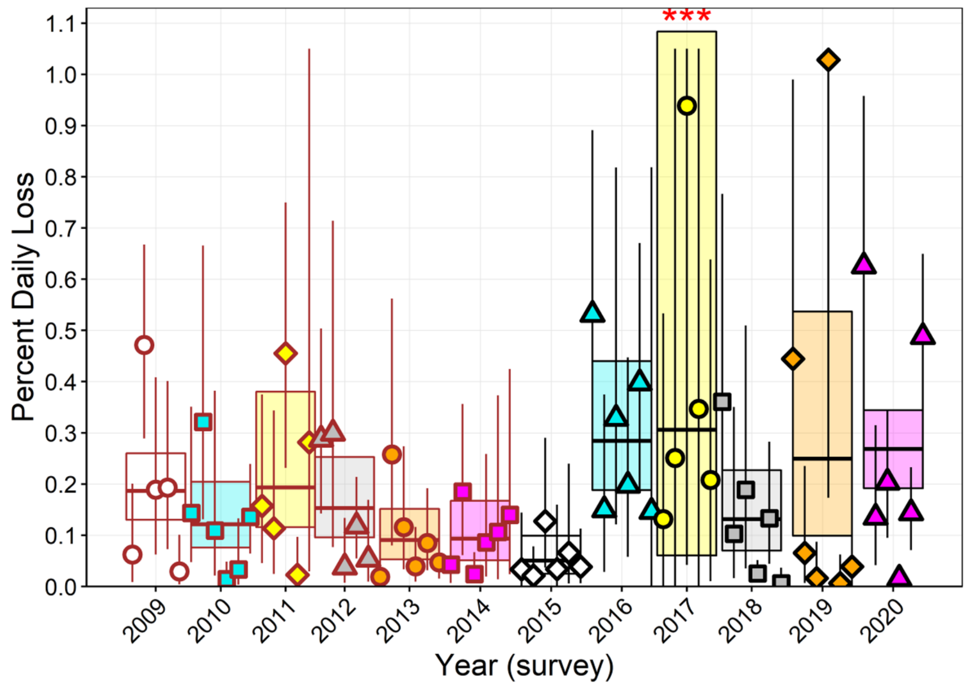


Fig. 8 As in Fig. 5 for daily loss of fish to diversions as a percent of the estimated population size, not adjusted for incomplete sampling. Asterisks indicate that results for 2017 were unreliable because the surveys covered so little of the habitat of larval longfin smelt

model with a single value of the overdispersion parameter α to data spanning a tenfold decline. Since the other diagnostics of the fit were satisfactory and varying α degraded the fit, we used the results with constant α. There was no evidence that catch per trawl at low salinity was underpredicted on average (Fig. S3C), which would result in an underestimate of the proportion of the population lost to diversions.

Like other pelagic estuarine organisms, longfin smelt larvae are most abundant across a range of salinity, and are not strongly linked to geographic position (Grimaldo et al. 2017, 2021). However, many surveys did not fully cover the salinity range where larvae are likely to occur. The maximum salinity in any one survey ranged from 0.2 to 21, but the seaward limit of the population was reasonably well

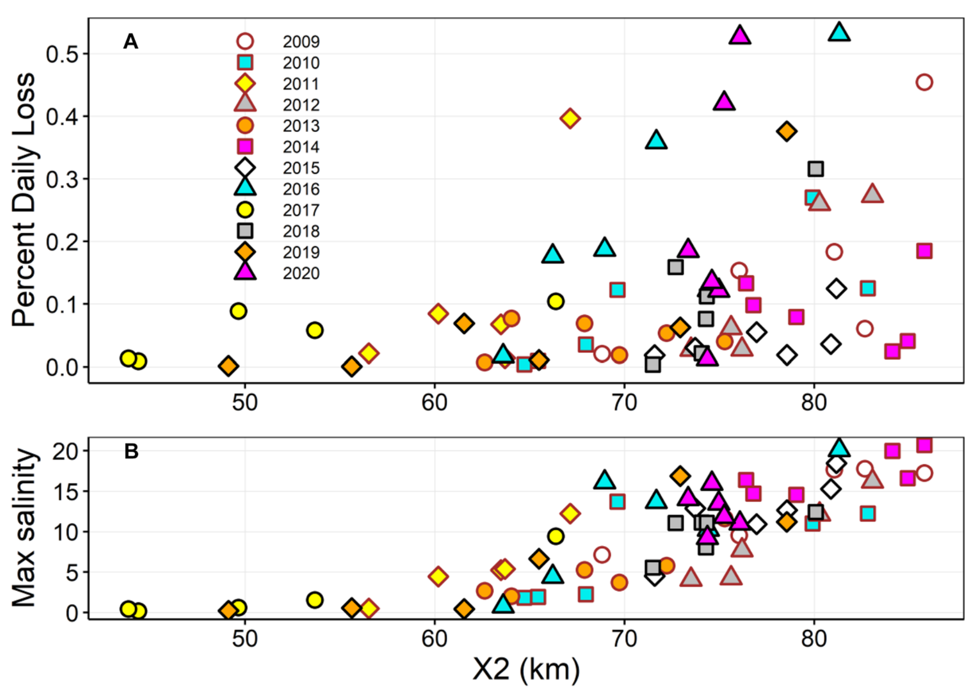


Fig. 9 **A** Adjusted percent daily loss by survey of the larval longfin smelt population to diversions, and **B** maximum salinity by survey, as a function of X2. Percent daily loss in **A** has been adjusted to account for incomplete sampling as indicated by the maximum salinity in **B**. Symbol shapes and colors as in Fig. 8

defined only when the salinity ranged at least up to 15 (e.g., contrast Fig. S4A and D with C and F). The adjustment for incomplete sampling was inversely related to the maximum salinity during each survey, and for some of the surveys in the very wet 2017 the estimates of population size were highly uncertain (Fig. S4D). The basis for the adjustment was that the abundance at salinity higher than sampled could be extrapolated from the fit of the model to the available data (e.g., Fig. S4), assuming that the volume of habitat in each salinity range did not depend strongly on where that salinity range was. This assumption was supported by a finding that the volume of oligohaline habitat did not change much as X2 moved between 90 and 55 km (Figs. 3 and 5 in Kimmerer et al. 2013), which encompassed all of the X2 values during these surveys except on four dates in 2017 and one in 2019.

In some circumstances, different processes may govern presence or abundance of a species and probability of detection (e.g., McGowan et al. 2013). For example, turbidity might affect the probability of observation of a pelagic fish more than it does the underlying distribution of fish. However, it is more likely that turbidity is a fundamental habitat attribute that determines where the fish are (Utne-Palm 2002; DeRobertis et al. 2000 Aksnes et al. 2004), whatever the underlying mechanism. In the SFE, the frequency of occurrence of delta smelt in net samples and in samples taken at the entrance to the diversion facilities were similarly affected by turbidity suggesting that, instead of being harder to catch in clear water than turbid, the fish were simply absent from clear water (Grimaldo et al. 2009). This observation led resource managers to limit diversion rates during times of high turbidity to reduce mortality to this endangered species, which is more vulnerable than longfin smelt to diversion losses because of its distribution in lower-salinity water (Kimmerer 2008, 2011; Kimmerer et al. 2013).

Abundance–Flow Relationships

A variety of mechanisms have been shown or proposed to underlie relationships between freshwater flow and the abundance or distribution of estuarine species (e.g., Drinkwater and Frank 1994). These can generally be divided into mechanisms involving correlations of loading with flow (e.g., nutrients in the "agricultural model," Nixon et al. 1986; Day et al. 1994; Vörösmarty et al. 2003), and those involving the physical response of estuarine habitats to changes in flow. Physical responses to changing flow may include floodplain inundation (Sommer et al. 2001, 2020), decreased residence time (Livingston et al. 1997), compression of the longitudinal salinity field (Monismith et al. 2002) or its extension into the coastal ocean (Hickey and Banas 2003), and increased stratification with attendant intensification of two-layer net circulation. In some estuaries, entrainment of organisms into large water intakes can be a source of concern over mortality, and this entrainment may be inversely related to ambient freshwater flow. How these play out depends on the dynamic ranges of flow and tides and the details of bathymetry and extent of the estuary (Monismith et al. 2002).

Longfin smelt has the strongest known relationship to freshwater flow of any pelagic fish or invertebrate in the SFE (Jassby et al. 1995; Fig. 2; Kimmerer 2002; Fig. 6). Most of the mechanisms suggested to explain this relationship have emphasized physical dynamics rather than the agricultural model (Kimmerer 2002; Kimmerer et al. 2013). Losses to diversions are likely to be a minor contributor to the flow relationship of longfin smelt, as discussed below.

Pelagic estuarine organisms are generally capable of behaviors that are flexible or adaptable enough to accommodate the effects of tidal fluctuations, changing freshwater flow, and spatial variation in water depth. For example, zooplankton and fish can maintain position in estuaries through a variety of behaviors that respond to the flow field (Greer Walker et al. 1978; Forward et al. 1999; Kimmerer et al. 2014), and young salmon lacking previous experience of tides quickly learn which way is flood and ebb when they enter estuaries (Lacroix and McCurdy 1996). Longfin smelt may undergo tidal migration and maintain a position near the bottom to avoid being swept to sea (Bennett et al. 2002), but the period in the life cycle where this happens is uncertain. This timing may be critical for ensuring a good year class, especially during high-flow years.

The length distributions of larval longfin smelt (Fig. 4) show a sharp decline at larger sizes. This decline could be due to avoidance of the net by larger larvae, mortality, or departure of the larvae from the region sampled by the larval nets. Net avoidance is unlikely for these larvae. Probability of capture for delta smelt larvae collected using the same net was high for larvae < 20 mm, though confidence intervals were large (Mitchell et al. 2019). The SLS net captures numerous Pacific herring larvae with a median length of 11 mm (data not shown). We calculated an apparent mortality rate from the rate of decline in size for each year using growth rate of 0.19 mm day^{-1} (Gross et al. in review) and found a median of 15% day^{-1}. This seems too high to be the actual mortality rate, as it would result in only 0.04% of larvae reaching 16 mm; a more refined analysis of data from 2013 that combined particle-tracking and Bayesian models calculated a mortality rate of 2.4% day^{-1} (Gross et al. in review). This contrast implies that the larvae were progressively less available to the SLS sampling gear as they grew.

The larger larvae could have been unavailable to the nets by being out of the sampled area, either in depth, laterally, or along the channels. The available information on sample depth indicates that the entire water column was fished for many if not most samples. Longfin smelt larvae appear to be largely surface-oriented up to about 10–12 mm length

(Bennett et al. 2002), so it is unlikely that larger larvae were abundant at the sampling stations but missed. Catch per volume in 2016 and 2017 was similar between shoals and channels, ruling out lateral avoidance of the sampled area (Grimaldo et al. 2017). In a particle-tracking study, most of the passive particles released in inferred hatching regions drifted far seaward of the sampled region in the time it would take for larvae to reach approximately 10–12 mm (Gross et al. in review). Longfin smelt larger than approximately 10–12 mm length begin to disperse vertically and possibly to migrate tidally (Bennett et al. 2002), which can result in retention (Kimmerer et al. 2014). We speculate that the lack of the larger larvae in the SLS samples was a result of seaward drift of early larvae followed by an ontogenetic shift from passive behavior to bottom-oriented or tidally migrating behavior.

Each individual survey is a sample of a limited temporal and size range in a growing population. With a sampling interval of ~ 2 weeks, about 92% of the larvae that were in the population on one sampling day would be gone by the next, through mortality and seaward movement out of the range of the survey. This means that each survey sampled a largely different population of larvae hatched over a different period (Gross et al. in review). This is why we refer to the annual mean as a population size index rather than an estimate. A more informative measure of the annual population may be the number of larvae that passed through the size of vulnerability to the nets during the entire season, which is an estimate of annual production of larvae at that size range. Dividing the mean adjusted population size index by the mean age of the larvae (6.8 days) and multiplying by the duration of the sampling program (median 70 days) give ~ 19×10^9 larvae over the first 5 years of the survey and ~ 1.5×10^9 over the last 7 years. Gross et al. (in review) obtained a population estimate of 12.6×10^9 total fish hatched during 2013. Using the unadjusted value for consistency with Gross et al. (in review), our population index for 2013 only was $(18 \pm 9) \times 10^9$ fish passing through age 6.8 days. After correcting for 6.8 days' mortality using estimates from Gross et al. (in review), we estimate that $(21 \pm 11) \times 10^9$ fish hatched in 2013, not very divergent from their value of 12.6×10^9 given the difference in approaches (though using the same data).

Stevens et al. (1983) first identified the positive relationship between the fall abundance index of longfin smelt and freshwater flow in the SFE. The authors speculated that this relationship was due to dispersal of larvae by high flows resulting in an expanded habitat and range and therefore reduced density-dependent mortality. Jassby et al. (1995) formalized flow-abundance relationships for several species including longfin smelt, using X2 in spring as an index of freshwater flow. Kimmerer (2002) and Kimmerer et al. (2009) updated these relationships and showed how the abundance index of longfin smelt had declined markedly in relation to the original relationship, though the index was still strongly related to X2. Thomson et al. (2010) developed a statistical model of the long-term pattern of the abundance index; in addition to the strong relationship with X2, two declines were detected that were not explained by flow or other covariates, one around 1989 and the other around 2004. The first decline was likely related to decreased availability of their zooplankton food following the introduction of the "overbite" clam *Potamocorbula amurensis* (Kimmerer 2002; Feyrer et al. 2003; Mac Nally et al. 2010). The cause of the second decline remains unknown.

Regulations governing freshwater outflow in the SFE have a long history, but regulations specifically for protecting populations of estuarine fish were first established in 2000. These regulations apply from January through June, based on the relationships of several fish and shrimp species to X2 and their life histories (Jassby et al. 1995). The underlying assumption behind the selection of that time period was to protect longfin smelt during the entire period from hatching to the early juvenile stage. Since X2 is strongly autocorrelated across months, the time period when the relationship of the autumn index to X2 comes into effect cannot be determined through statistical analysis, but must instead be inferred from other surveys and other sources of information. Our results show that larval abundance is unrelated to X2, though it is correlated with the autumn index. Therefore, the mechanism for the strong relationship of the index to X2 must arise after early larval development, i.e., after March, rather than during spawning, hatching, or early larval development and movement.

How much do diversion losses contribute to the flow relationship of longfin smelt abundance index? The values determined above are estimated daily proportional losses to the population collected by the SLS net, but larvae in the Delta may be exposed to risk of loss to diversion over more than a day. Since the denominator of this calculation (Eq. 5) is the population size estimated from the SLS, a suitable time frame for accumulating losses is the duration of vulnerability of the larvae to the nets. We used alternatively the mean (6.8 days) and 90th percentile of age of the larvae (13 days); the latter is conservative in overestimating the time of vulnerability and therefore the annual loss rate. The estimated mean annual loss rate accumulated over 6.8 days was 0.8%, and that at 13 days was 1.5% (Table 1). These values can be compared to the range of interannual variability in the autumn abundance index of ~ 100-fold (Fig. 2B). Clearly in this context, the effect of diversion losses is small, and its contribution to the longfin smelt's flow-abundance relationship is negligible. As discussed above, proportional losses to diversions are likely lower for other life stages than for early larvae, so losses of these stages to diversions are likely even a smaller contributor to interannual variability or the X2 relationship than that for larvae.

Regulations limiting diversion flows were established in ~ 2009, so the entire period of this study took place under more benign conditions than previously existed. The difference in diversion flows between these periods was greatest when inflow was lowest, and the sign of the difference reversed above inflow of about 2400 $m^3 s^{-1}$ (Fig. S1). When inflow (and therefore outflow) is low, the larvae are further landward and therefore more vulnerable to entrainment in the diverted water; therefore, the measures limiting diversion flows were effective in reducing these losses by about half under worst-case conditions. Regardless of the legal requirements to minimize harm to listed populations of fish, even this higher level of loss would have been insufficient to materially affect the population's response to flow.

Previous studies have examined consequences of losses of estuarine populations to diversions in the SFE, arriving at contrasting conclusions that depend mainly on the vulnerability of the particular species. Diversion flows remove about 2% day^{-1} of passively transported plankton from the freshwater reaches of the Delta, which is equivalent to about 18% day^{-1} of phytoplankton production, but this had no statistically detectable effect on biomass trends (Jassby et al. 2002). Much of the work on fish has focused on salmon, mainly on the vulnerability of Chinook salmon *Onchorhynchus tschawytsha* to poor habitat and diversion losses during migration and residence of juveniles in tidal freshwaters of the Delta (e.g., Buchanan et al. 2013; Zeug and Cavallo 2013; Perry et al. 2018). However, the actual losses to diversions and their consequences have not been determined with sufficient rigor to be reliable (Jahn and Kier 2020). Abundance of Sacramento splittail *Pogonichthys macrolepidotus* varies strongly with interannual fluctuations in freshwater flow, but the population is maintained by high production of young during years when floodplains are inundated by uncontrollably high flows, and diversion losses cannot contribute much to this variability (Sommer et al. 1997). High loss rates of the larvae of striped bass (Stevens et al. 1985) were found to be offset by strong density dependence between the larval and juvenile stages (Kimmerer et al. 2000). By contrast, estimated losses of delta smelt during winter–spring were large in some years and likely contributed to their decline in abundance (Kimmerer 2008, 2011; Miller 2011; Korman et al. 2021). Our finding that the proportional losses of longfin smelt are negligible adds to the understanding of this controversial source of mortality, but will probably do little to still the controversy.

Management Implications

Management of the San Francisco Estuary is balkanized between communities that focus on San Francisco Bay (e.g., https://bcdc.ca.gov/) and those that focus on the upper estuary, especially the California Delta (Lacan and Resh 2017). Recent grant solicitations have even spelled out a requirement for focus of research within the bounds of the Delta and its tributaries. This is both a partial cause and a result of the management and political focus on the impacts of diversions from the southern Delta.

Longfin smelt, no respecters of geographic boundaries, show why management focus on the Delta is misguided. The SLS program, though designed to sample for longfin smelt larvae, fails to cover their range of abundance in moderate to high-flow years (Fig. S4, Table 1; Grimaldo et al 2021). Only one of the four programs designed to sample juvenile fish in the estuary covers the entire in-estuary range of the fish, and no program samples them during residence in the coastal ocean. Moreover, little monitoring for longfin smelt occurs in shallow habitats where they can be abundant (Grimaldo et al. 2017, 2021; Lewis et al. 2020). Their zooplankton prey are intensively monitored in the Delta and Suisun Bay (5297 and 2291 samples respectively during 2009–2020), less so in San Pablo Bay (1140 samples) and not at all in Central or South San Francisco Bays. None of these programs samples at night, when vertical distributions of most organisms change. It is difficult to provide actionable advice to managers based on such a distorted sampling regime. This shortfall is finally being acknowledged (Anonymous 2020), but it will take some years before expanded monitoring can begin to fill in the missing pieces.

Finally, both this paper and Gross et al. (in review), which used the same data but very different methods, showed the cumulative proportional losses of longfin smelt to diversions to be small in comparison to the 100-fold dynamic range of the population index. This finding indicates that attempts to reverse the decline of this species through manipulation of diversion flows are unlikely to bear fruit.

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References

Akaike, H. 1974. A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 19: 716–723.

Aksnes, D.L., J. Nejstgaard, E. Saedberg, and T. Sornes. 2004. Optical control of fish and zooplankton populations. *Limnology and Oceanography* 49: 233–238.

Anonymous. 2020. Longfin smelt science plan. Sacramento, CA.

Bashevkin, S.M., J.W. Gaeta, T.X. Nguyen, L. Mitchell, and S. Khanna. 2022. Fish abundance in the San Francisco Estuary (1959-2021), an integration of 9 monitoring surveys. ver 1. *Environmental Data Initiative*. https://doi.org/10.6073/pasta/0cdf7e5e954be1798ab9bf4f23816e83. Accessed 5 Apr 2022.

Bennett, W.A., W.J. Kimmerer, and J.R. Burau. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low-salinity zone. *Limnology and Oceanography* 47: 1496–1507.

Breitburg, D., L.A. Levin, A. Oschlies, M. Gregoire, F.P. Chavez, D.J. Conley, V. Garcon, D. Gilbert, D. Gutierrez, K. Isensee, G.S. Jacinto, K.E. Limburg, I. Montes, S.W.A. Naqvi, G.C. Pitcher, N.N. Rabalais, M.R. Roman, K.A. Rose, B.A. Seibel, M. Telszewski, M. Yasuhara, and J. Zhang. 2018. Declining oxygen in the global ocean and coastal waters. *Science* 359.

Brown, R., S. Greene, P. Coulston, and S. Barrow. 1996. An evaluation of the effectiveness of fish salvage operations at the intake to the California Aqueduct, 1979–1993. In *San Francisco Bay: The ecosystem*, ed. J.T. Hollibaugh, 497–518. San Francisco: AAAS.

Buchanan, R.A., J.R. Skalski, P.L. Brandes, and A. Fuller. 2013. Route use and survival of juvenile Chinook salmon through the San Joaquin River Delta. *North American Journal of Fisheries Management* 33: 216–229.

California Department of Fish and Wildlife (CDFW). 2009. Longfin smelt incidental take permit no. 2081-2009-001-03. https://www.dfg.ca.gov/delta/data/longfinsmelt/documents/ITP-Longfin-1a.pdf. Accessed 6 April 2022.

California Natural Resources Agency (CNRA). 2021. Dayflow. https://data.cnra.ca.gov/dataset/dayflow. Accessed 12 April 2022.

Chigbu, P. 2000. Population biology of longfin smelt and aspects of the ecology of other major planktivorous fishes in Lake Washington. *Journal of Freshwater Ecology* 15: 543–557.

Day, J.W., Jr., C.J. Madden, R.R. Twilley, R.F. Shaw, B.A. McKee, M.J. Dagg, D.L. Childers, R.C. Raynie, and L.J. Rouse. 1994. The influence of Atchafalaya River discharge on Fourleague Bay, Louisiana (USA). In *Changes in fluxes in estuaries: implications from science to management*, ed. K.R. Dyer and R.J. Orth, 151–160. Fredensborg, Denmark: Olsen & Olsen.

Dege, M., and L.R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. In *Early life history of fishes in the San Francisco Estuary and Watershed*, ed. F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, 49–65. Bethesda MD: American Fisheries Society.

DeRobertis, A., J.S. Jaffe, and M.D. Ohman. 2000. Size-dependent visual predation risk and the timing of vertical migration in zooplankton. *Limnology and Oceanography* 45: 1838–1844.

Drexler, M., and C.H. Ainsworth. 2013. Generalized additive models used to predict species abundance in the Gulf of Mexico: An ecosystem modeling tool. *PLoS ONE* 8: 1–7.

Drinkwater, K.F., and K.T. Frank. 1994. Effects of river regulation and diversion on marine fish and invertebrates. *Aquatic Conservation: Marine and Freshwater Ecosystems* 4: 135–151.

Feyrer, F., B. Herbold, S.A. Matern, and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco Estuary. *Environmental Biology of Fishes* 67: 277–288.

Forward, R.B., Jr., K.A. Reinsel, D.S. Peters, R.A. Tankersley, J.H. Churchill, L.B. Crowder, W.F. Hettler, S.M. Warlen, and M.D. Green. 1999. Transport of fish larvae through a tidal inlet. *Fisheries Oceanography* 8: 153–172.

Gelman, A., J.B. Carlin, H.S. Stern, and D.B. Rubin. 2004. *Bayesian data analysis*. Boca Raton, FL: CRC Press.

Greer Walker, M., F.R. Harden Jones, and G.P. Arnold. 1978. The movements of plaice *Pleuronectes platessa* L. tracked in the open sea. *Journal Du Conseil International Pour L'exploration De La Mer* 38: 58–86.

Grimaldo, L., J. Burns, R.E. Miller, A. Kalmbach, A. Smith, J. Hassrick, and C. Brennan. 2021. Forage fish larvae distribution and habitat use during contrasting years of low and high freshwater flow in the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 18. https://doi.org/10.15447/sfews.2020v18iss3art5.

Grimaldo, L., F. Feyrer, J. Burns, and D. Maniscalco. 2017. Sampling uncharted waters: Examining rearing habitat of larval longfin smelt (*Spirinchus thaleichthys*) in the upper San Francisco Estuary. *Estuaries and Coasts* 40: 1771–1784.

Grimaldo, L.F., T. Sommer, N.V. Ark, G. Jones, E. Holland, P.B. Moyle, B. Herbold, and P. Smith. 2009. Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: Can fish losses be managed? *North American Journal of Fisheries Management* 29: 1253–1270.

Gross, E., S. Andrews, B. Bergamaschi, B. Downing, R. Holleman, S. Burdick, and J. Durand. 2019. The use of stable isotope-based water age to evaluate a hydrodynamic model. *Water* 11: 2207.

Gross, E., W. Kimmerer, J. Korman, L. Lewis, S. Burdick, L. Grimaldo. In review. Hatching distribution, abundance, and losses to diversions of longfin smelt inferred using hydrodynamic and particle-tracking models. *Marine Ecology Progress Series*.

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. Thompson. 2008. *Managing California's water: From conflict to reconciliation*. San Francisco: Public Policy Institute of California.

Hickey, B.M., and N.S. Banas. 2003. Oceanography of the US Pacific Northwest Coastal Ocean and estuaries with application to coastal ecology. *Estuaries* 26: 1010–1031.

Hobbs, J.A., L.S. Lewis, N. Ikemiyagi, T. Sommer, and R.D. Baxter. 2010. The use of otolith strontium isotopes (Sr-87/Sr-86) to identify nursery habitat for a threatened estuarine fish. *Environmental Biology of Fishes* 89: 557–569.

Jahn, A., and W. Kier. 2020. Reconsidering the estimation of salmon mortality caused by the State and Federal water export facilities in the Sacramento-San Joaquin Delta, San Francisco Estuary. *San Francisco Estuary and Watershed Science* 18. https://doi.org/10.15447/sfews.2020v18iss3art3.

Jahn, A.E., and P.E. Smith. 1987. Effects of sample size and contagion on estimating fish egg abundance. *California Cooperative Oceanic Fisheries Investigations Reports* 28: 171–177.

Jassby, A.D., J.E. Cloern, and B.E. Cole. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal estuary. *Limnology and Oceanography* 47: 698–712.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R. Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications* 5: 272–289.

Kimmel, D.G., and M.R. Roman. 2004. Long-term trends in mesozooplankton abundance in Chesapeake Bay, USA: Influence of freshwater input. *Marine Ecology Progress Series* 267: 71–83.

Kimmerer, W.J. 2002. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? *Marine Ecology Progress Series* 243: 39–55.

Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 6. https://doi.org/10.15447/sfews.2008v6iss2art2.

Kimmerer, W.J. 2011. Modeling delta smelt losses at the south Delta export facilities. *San Francisco Estuary and Watershed Science* 9. https://doi.org/10.15447/sfews.2011v9iss1art3.

Kimmerer, W.J., J.H. Cowan Jr., L.W. Miller, and K.A. Rose. 2000. Analysis of an estuarine striped bass population: Influence of density-dependent mortality between metamorphosis and recruitment. *Canadian Journal of Fisheries and Aquatic Sciences* 57: 478–486.

Kimmerer, W.J., J.H. Cowan, L.W. Miller, and K.A. Rose. 2001. Analysis of an estuarine striped bass population: Effects of environmental conditions during early life. *Estuaries* 24: 556–574.

Kimmerer, W.J., E.S. Gross, and M. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? *Estuaries and Coasts* 32: 375–389.

Kimmerer, W.J., E.S. Gross, and M.L. MacWilliams. 2014. Tidal migration and retention of estuarine zooplankton investigated using a particle-tracking model. *Limnology and Oceanography* 59: 901–906.

Kimmerer, W.J., M.L. MacWilliams, and E.S. Gross. 2013. Variation of fish habitat and extent of the low-salinity zone with freshwater flow in the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 11. https://doi.org/10.15447/sfews.2013v11iss4art1.

Korman, J., E.S. Gross, and L.F. Grimaldo. 2021. Statistical evaluation of behavior and population dynamics models predicting movement and proportional entrainment loss of adult delta smelt in the Sacramento-San Joaquin River Delta. *San Francisco Estuary and Watershed Science* 19. https://doi.org/10.15447/sfews.2021v19iss1art1.

Lacan, I., and V.H. Resh. 2017. A case study in integrated management: Sacramento - San Joaquin Rivers and Delta of California, USA. *Ecohydrology & Hydrobiology* 16: 215–228.

Lacroix, G.L., and P. McCurdy. 1996. Migratory behaviour of post-smolt Atlantic salmon during initial stages of seaward migration. *Journal of Fish Biology* 49: 1086–1101.

Latour, R.J. 2016. Explaining patterns of pelagic fish abundance in the Sacramento-San Joaquin Delta. *Estuaries and Coasts* 39: 233–247.

Lewis, L.S., M. Willmes, A. Barros, P.K. Crain, and J.A. Hobbs. 2020. Newly discovered spawning and recruitment of threatened longfin smelt in restored and under-explored tidal wetlands. *Ecology* 101: ecy.2868 https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecy.2868.

Livingston, R.J., X.F. Niu, F.G. Lewis, and G.C. Woodsum. 1997. Freshwater input to a gulf estuary: Long-term control of trophic organization. *Ecological Applications* 7: 277–299.

Lund, J., E. Hanak, W. Fleenor, W. Bennett, R. Howitt, J. Mount, and P. Moyle. 2008. *Comparing futures for the Sacramento-San Joaquin Delta*. San Francisco: Public Policy Institute of California.

Mac Nally, R., J. Thomson, W. Kimmerer, F. Feyrer, K. Newman, A. Sih, W. Bennett, L. Brown, E. Fleishman, S. Culberson, and G. Castillo. 2010. An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modelling (MAR). *Ecological Applications* 20: 1417–1430.

MacWilliams, M.L., A.J. Bever, E.S. Gross, G.S. Ketefian, and W.J. Kimmerer. 2015. Three-dimensional modeling of hydrodynamics and salinity in the San Francisco Estuary: an evaluation of model accuracy, X2, and the low-salinity zone. *San Francisco Estuary and Watershed Science* 13. https://doi.org/10.15447/sfews.2015v13iss1art2.

McGowan, J., E. Hines, M. Elliott, J. Howar, A. Dransfield, N. Nur, and J. Jahncke. 2013. Using seabird habitat modeling to inform marine spatial planning in central California's National Marine Sanctuaries. *PLoS ONE* 8: 1–15.

Meng, L., and S.A. Matern. 2001. Native and introduced larval fishes of Suisun Marsh, California: The effects of freshwater flow. *Transactions of the American Fisheries Society* 130: 750–765.

Miller, W.J. 2011. Revisiting assumptions that underlie estimates of proportional entrainment of delta smelt by state and federal water diversions from the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 9. https://doi.org/10.15447/sfews.2011v9iss1art2.

Mitchell, L., K. Newman, and R. Baxter. 2019. Estimating the size selectivity of fishing trawls for a short-lived fish species. *San Francisco Estuary and Watershed Science* 17. https://doi.org/10.15447/sfews.2019v17iss1art5.

Monismith, S.G., W.J. Kimmerer, J.R. Burau, and M.T. Stacey. 2002. Structure and flow-induced variability of the subtidal salinity field in northern San Francisco Bay. *Journal of Physical Oceanography* 32: 3003–3019.

Montagna, P.A., M. Alber, P.H. Doering, and M.S. Connor. 2002. Freshwater inflow: Science, policy, management. *Estuaries* 25: 1243–1245.

Moyle, P.B. 2002. *Inland fishes of California*. Berkeley: University of California Press.

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of the delta smelt in the Sacramento-San Joaquin Estuary, California. *Transactions of the American Fisheries Society* 121: 67–77.

Moyle, P.B., J.A. Hobbs, and J.R. Durand. 2018. Delta smelt and water politics in California. *Fisheries* 43: 42–50.

Nichols, F., J. Cloern, S. Luoma, and D. Peterson. 1986. The modification of an estuary. *Science* 231: 567–573.

Nixon, S.W., C.A. Oviatt, J. Frithsen, and B. Sullivan. 1986. Nutrients and the productivity of estuarine and coastal marine systems. *Journal of the Limnological Society of South Africa* 12: 43–71.

Nobriga, M.L., and J.A. Rosenfield. 2016. Population dynamics of an estuarine forage fish: Disaggregating forces driving long-term decline of longfin smelt in California's San Francisco Estuary. *Transactions of the American Fisheries Society* 145: 44–58.

Paerl, H.W., L.M. Valdes, B.L. Peierls, J.E. Adolf, and L.W. Harding. 2006. Anthropogenic and climatic influences on the eutrophication of large estuarine ecosystems. *Limnology and Oceanography* 51: 448–462.

Perry, R.W., A.C. Pope, J.G. Romine, P.L. Brandes, J.R. Burau, A.R. Blake, A.J. Ammann, and C.J. Michel. 2018. Flow-mediated effects on travel time, routing, and survival of juvenile Chinook salmon in a spatially complex, tidally forced river delta. *Canadian Journal of Fisheries and Aquatic Sciences*: 75: 1886–1901.

Plummer, M. 2017. JAGS Version 4.3.0 user manual.

R Core Team. 2020. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Rosenfield, J.A., and R.D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. *Transactions of the American Fisheries Society* 136: 1577–1592.

Rothschild, B.J., J.S. Ault, P. Goulletquer, and M. Héral. 1994. Decline of the Chesapeake Bay oyster population: A century of habitat destruction and overfishing. *Marine Ecology Progress Series* 11: 29–39.

Royle, J.A., and R.M. Dorazio. 2008. *Hierarchical modeling and inference in ecology: The analysis of data from populations, metapopulations and communities*. London: Elsevier.

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. *Transactions of the American Fisheries Society* 126: 961–976.

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. *Fisheries* 26: 6–16.

Sommer, T., B. Schreier, J.L. Conrad, L. Takata, B. Serup, R. Titus, C. Jeffres, E. Holmes, and J. Katz. 2020. Farm to fish: lessons from a multi-year study on agricultural floodplain habitat. *San*

Francisco Estuary and Watershed Science 18. https://doi.org/10.15447/sfews.2020v18iss3art4.

Stevens, D.E., D.W. Kohlhorst, L.W. Miller, and D.W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. *Transactions of the American Fisheries Society* 114: 12–30.

Stevens, D.E., and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. *North American Journal of Fisheries Management* 3: 425–437.

Stompe, D.K., P.B. Moyle, A. Kruger, and J.R. Durand. 2020. Comparing and integrating fish surveys in the San Francisco Estuary: why diverse long-term monitoring programs are important. *San Francisco Estuary and Watershed Science* 18. https://doi.org/10.15447/sfews.2020v18iss2art4.

Taft, B.A. 1960. A statistical study of the estimation of abundance of sardine (*Sardinops caerulea*) eggs. *Limnol and Oceanogr* 5: 245–264.

Tempel, T.L., T.D. Malinich, J. Burns, A. Barros, C.E. Burdi, and J.A. Hobbs. 2021. The value of long-term monitoring of the San Francisco Estuary for Delta Smelt and Longfin Smelt. *California Fish and Game* 107: 148–171.

Thomson, J., W. Kimmerer, L. Brown, K. Newman, R. Mac Nally, W. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change-point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. *Ecological Applications* 20: 1431–1448.

Utne-Palm, A.C. 2002. Visual feeding of fish in a turbid environment: Physical and behavioural aspects. *Marine and Freshwater Behaviour and Physiology* 35: 111–128.

Vörösmarty, C.J., M. Meybeck, B. Fekete, K. Sharma, P. Green, and J.P.M. Syvitski. 2003. Anthropogenic sediment retention: Major global impact from registered river impoundments. *Global and Planetary Change* 39: 169–190.

Wang, J.C.S. 2007. Spawning, early life stages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. In Tracy fish facility studies. Denver: U.S. Department of the Interior Bureau of Reclamation, Mid-Pacific Region

Wenger, S.J., and M.C. Freeman. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. *Ecology* 89: 2953–2959.

Whipple, A.A., R.M. Grossinger, D. Rankin, B. Stanford, and R.A. Askevold. 2012. Sacramento-San Joaquin Delta historical ecology investigation: exploring pattern and process. In Publication #672. Richmond, CA: San Francisco Estuary Institute.

Williams, P.B. 1989. Managing freshwater inflow to the San Francisco Bay Estuary. *Regulated Rivers - Research and Management* 4: 285–298.

Zeug, S.C., and B.J. Cavallo. 2013. Influence of estuary conditions on the recovery rate of coded-wire-tagged Chinook salmon (*Oncorhynchus tshawytscha*) in an ocean fishery. *Ecology of Freshwater Fish* 22: 157–168.

Water Blueprint
for the San Joaquin Valley

January 19, 2024

State Water Resources Control Board
Division of Water Rights
Attn: Bay-Delta & Hearings Branch
P.O. Box 100
Sacramento, CA 95812-2000

Submitted via email to: SacDeltaComments@waterboards.ca.gov

RE: Comment Letter – Sacramento/Delta Draft Staff Report

Dear Chair Esquivel and State Water Board Members:

The Water Blueprint for the San Joaquin Valley ("Blueprint") appreciates the opportunity to provide comments on the draft Staff Report/Substitute Environmental Document in Support of Potential Updates to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary for the Sacramento River and Its Tributaries, Delta Eastside Tributaries, and Delta ("Draft Staff Report"). Like every region of California, the quality of life and prosperity in the San Joaquin Valley is highly dependent on adequate, affordable water supplies. But unlike other regions of the State, the economy of the San Joaquin Valley is highly dependent on irrigated agriculture, and declining water supplies have resulted in a significant decline in the socioeconomic health of the 4 million Californians who call the Valley their home. Reductions in water supplies are the result of many factors, including climate change, the reallocation of water from irrigation uses to environmental uses, and regulations imposed on projects that supply water to the San Joaquin Valley. The Blueprint is a coalition of San Joaquin Valley community leaders, businesses, water agencies, local governments, and agricultural representatives working together to advance common sense water solutions and to improve socioeconomic health for the Valley's residents.

Of particular concern to the Blueprint are potential impacts in the San Joaquin Valley related to reduced surface water supplies and associated reductions in irrigated agriculture resulting from implementation of the proposed unimpaired flow objectives ("UIF alternative" or "proposed Plan amendments") evaluated in the Draft Staff Report. Although the Draft Staff Report contains significant information on hydrology, water supply, and agricultural resources, it presents that information in a disjointed manner and is based on inaccurate or inconsistent assumptions. Of additional concern, adoption of the UIF alternative is inconsistent with other statewide policy objectives advanced by the Newsom Administration, including the human right to water, advancement of the coequal goals, and implementation of the Water Resilience Portfolio and Water Supply Strategy.

Analysis of Existing and Resulting Water Supplies

The Draft Staff Report's analysis of existing surface water supplies compared to surface water supplies under alternatives identified in the document highlight the significant undesirable impacts resulting from adopting the UIF alternative. Chapter 2 of the Draft Staff Report, entitled "Hydrology and Water Supply," is intended to describe existing conditions. (Draft Staff Report, pgs. 2-1, 2-124.) Surface water supplies for the San Joaquin Valley are highly dependent on operations of the Central Valley Project ("CVP") and the State Water Project ("SWP"), a fact acknowledged by the Draft Staff Report (Draft Staff Report, pg. 137), which are limited by application of the Endangered Species Act to the operations of the CVP and SWP. This too is acknowledged by the Draft Staff Report. (Draft Staff Report, pg. 2-101.)

However, for areas served by the CVP and SWP, the surface water supplies analysis presented in Chapter 2 appears to be based on project operations under biological opinions issued in 2008 and 2009. For this reason, much of the information presented in Chapter 2 does not accurately describe "existing" water supplies because the more recent 2019 biological opinions modified restrictions imposed on operations of the CVP and SWP, in some circumstances increasing the delivery capability of the projects.

Some changes in CVP and SWP operations resulting from the 2019 biological opinions are described in that portion of Chapter 6 of the Draft Staff Report, entitled "Changes in Hydrology and Water Supply," which describes SacWAM modeling "baseline assumptions." (Draft Staff Report, pgs.6-4 – 6-6.) However, the Draft Staff Report fails to evaluate how these changes affected existing surface water supplies, described in Chapter 2, in areas served by the CVP and SWP. Moreover, at least one baseline assumption is erroneous because it assumes "the 2020 Incidental Take Permit I:E export limit was assumed to apply to SWP and CVP." (Draft Staff Report, pg. 6-6, Table 6.2-1, note c.)[1]

[1] The 2020 Incidental Take Permit was issued by the California Department of Fish and Wildlife for long-term operations of the SWP pursuant to Fish and Game Code section 2081, subdivisions (b) and (c). By its terms, the 2020 Incidental Take Permit applies only to operations of the SWP, and it should be noted that the I:E export limit was imposed, in part, for the protection of longfin smelt (Incidental Take Permit No. 2081-2019-066-00, pg. 104), a species that is presently not listed under the federal Endangered Species Act. In addition, the Draft Staff Report does not explain why the SacWAM baseline analysis applies one of the Incidental Take Permit limits to operations of the CVP, but not others.

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Applying the 2020 Incidental Take Permit inflow-to-export ("I:E") export limit to operations of the CVP underestimates the water supply reductions in areas of the San Joaquin Valley that would result from implementation of unimpaired flow alternatives evaluated in the Draft Staff Report. The magnitude of this underestimation is significant; in some below normal and above normal years, it could be as much as 300,000 acre-feet. For south-of-Delta CVP agricultural contractors, this represents a potential 10-15% reduction in their contract allocation. These reductions in surface water supplies are not reflected in Chapter 6. Conversely, for areas served by the SWP, applying the 2020 Incidental Take Permit I:E export limit to operations of the CVP overestimates the water supply reductions that would result from implementation of unimpaired flow alternatives evaluated in the Draft Staff Report. For these reasons, the reductions in Sacramento/Delta water supplies resulting from implementation of the proposed unimpaired flow objectives in south-of-Delta areas served by both the CVP and the SWP are inaccurate and likely significantly underrepresent the potential socioeconomic impacts.

Impacts on Agricultural Resources and Potential Measures to Offset Water Supply Reductions

Chapter 7.4 of the Draft Staff Report, entitled "Agriculture and Forest Resources," describes the potential impacts for agriculture resources that may result from implementation of the proposed unimpaired flow alternatives, and it describes the conversion of prime farmland, unique farmland, or farmland of statewide importance as a "potentially significant impact." (Draft Staff Report, pg. 7.4-2.) The Draft Staff Report correctly states "[i]f reduced water availability decreases agriculture's profitability by increasing the price of water, reducing the land's productivity, or both, the economic incentive to convert to urban use could grow." (Draft Staff Report, pg. 7.4-13.)[2]

The underestimation of water supply reductions in south-of-Delta areas served by the CVP described above will undoubtedly exacerbate the "potentially significant impact[s]" identified in the Draft Staff Report. Moreover, the Draft Staff Report fails to appropriately characterize the disparate impact of reductions in Sacramento/Delta surface water supply to differing regions of the San Joaquin Valley; it states:

> While the reductions in Sacramento/Delta surface water supply represent a substantial amount of water, when compared with the

[2] Inadequate water supplies not only increase the price of water and reduce the land's productivity. Recent experience demonstrates that inadequate water supplies results in farmland not being cultivated at all. A comparison of fallowed acres in 2011, when surface water supplies were abundant, and 2015, when surface water supplies were significantly reduced, is illustrative. According to the NASA Ames Research Center, inadequate water supplies resulted in the fallowing of 522,000 acres in the Central Valley, compared to 2011. According to NASA, "[i]n 2015, the largest increases in idle acreage were observed along the west side of the San Joaquin Valley in Fresno, Kings and Kern counties." (Federal Agencies Release Data Showing California Central Valley Idle Farmland Doubling During Drought | Landsat Science (nasa.gov).)

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> total San Joaquin Valley region average annual supply of over 18.4 MAF as estimated by historical water deliveries data, the reductions are proportionally smaller. The reductions in total supply amount to 1 percent and 2 percent in the 45 and 55 scenarios, respectively (see Table 6.4-1).

(Draft Staff Report, pg. 7.4-55.) This statement ignores that the impacts of reduced Sacramento/Delta surface water supply do not affect the entire San Joaquin Valley. Rather, these impacts are experienced in specific regions of the San Joaquin Valley, areas served by the CVP and the SWP. At least one of these regions - the area served by the Delta-Mendota Canal in the northern San Joaquin Valley - is particularly susceptible to urbanization because of its proximity to the San Francisco Bay area.

Chapter 7.4 of the Draft Staff Report also describes measures that purportedly could be undertaken to mitigate some of the impacts on farmlands resulting from implementing the proposed UIF alternative. Among these is "Diversify Water Portfolios," which includes sustainable conjunctive use of groundwater and surface water, water recycling, water conservation and efficiency upgrades, and water transfers. (Draft Staff Report, pg. 7.4-97.) However, for large areas of the San Joaquin Valley, it is unlikely the actions described could offset reductions in surface water that will result from implementation of the unimpaired flow alternatives.

Sustainable conjunctive use of groundwater and surface water requires that farmers rely on surface water during wet periods and on groundwater during drought. However, because of existing constraints on operations of the CVP and the SWP, even in average and above average years, surface water supplies are inadequate to meet demands for irrigation water. As an example, the Northern Sierra Precipitation: 8-Station Index for the 2015-16 water year was 57.9, which is well above average. Yet the allocation for south-of-Delta CVP agricultural contractors in 2016 was 5%, and the allocation for south-of-Delta SWP contractors was 60%. The Northern Sierra Precipitation: 8-Station Index for the 2018-19 water year was 70.7, which at that time was the third wettest year on record. Yet, in 2019 the allocation for both south-of-Delta CVP agricultural contractors and SWP contractors was 75%. Sound principles of conjunctive use demand that in water years like 2016 and 2019, farmers in the San Joaquin Valley rely on surface water and that surplus water be used to replenish groundwater aquifers. However, existing regulations of the CVP and SWP and limited water storage infrastructure already frustrate the implementation of "sustainable conjunctive use," and each of the unimpaired flow alternatives evaluated by the Draft Staff Report will only further diminish the water delivery capability of the projects in every water year type. (Draft Staff Report, pg. 6-74, Table 6.4-20.) In areas of the San Joaquin Valley that rely on Sacramento/Delta water supplies, sustainable conjunctive use is not a feasible measure to mitigate impacts on water supply resulting from implementation of any of the unimpaired flow alternative analyzed by the Draft Staff Report.

Similarly, the Draft Staff Report identifies water transfers as a water management action that may be utilized to offset reductions in surface water and mitigate farmland conversions that could result from implementation of the unimpaired flow alternatives. However, such mitigation is only feasible if the following can be identified: (1) from where will the water to be transferred come and (2) how

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will it be conveyed to areas in the San Joaquin Valley seeking to offset reductions in surface water?

Water transfers presently are a critical tool used by water agencies in the San Joaquin Valley to offset surface water supply reductions under the existing regulatory baseline, particularly in areas that rely on Sacramento/Delta water, (Draft Staff Report, pg. 6-103), and the primary source of water for these transfers is water made available from agencies in the Sacramento Valley and American River watershed through groundwater substitution, regional water project reoperations, or conservation of surface supplies. A major impediment to the effectiveness of potential mitigation measure is conveyance of this water through the Delta because: (1) the "transfer window" extends only from July 1 through November 30, (2) capacity at the CVP and SWP Delta pumping plants is often limited, and (3) biological opinions for coordinated long-term operations of the CVP and SWP limit exports from the Sacramento River watershed to 360,000 acre-feet in below normal, above normal, and wet years, the water year types when water in the Sacramento River watershed is normally available for transfer. Implementation of any of the unimpaired flow alternatives identified in the Draft Staff Report will: (1) reduce water availability in the Sacramento River watershed, (Draft Staff Report, pg. 6-57, Table 6.4-2); and (2) impose additional limitations on the operations of CVP and SWP pumping plants in the southern Delta. The Draft Staff Report provides no explanation of how water transfers could play any meaningful role in offsetting future water supply reductions resulting from implementation of any unimpaired flow alternative. Its analysis is limited to the following statement:

> It is difficult to predict with certainty how reduced Sacramento/Delta surface water supplies will affect water transfers. With new instream flow and cold water habitat requirements, overall supplies of water from the Sacramento/Delta will decline. This may result in less water available for transfer. At the same time, it could incentivize transfers as the value of transfer water increases, leading to transfers from lower value temporary crops to higher value municipal uses and permanent crops.

(Draft Staff Report, pgs. 6-89 – 6-90.)

Contrary to this statement, it is not difficult to predict with certainty how reduced Sacramento/Delta surface water supplies will affect water transfers to areas in the San Joaquin Valley presently benefiting from transfers. New instream flow and cold water habitat requirements that result in Sacramento/Delta surface water supply reductions in the Sacramento River watershed of the magnitude reflected in Table 6.4-2, (Draft Staff Report, pg. 6-57), will result in a significant decrease in water transfers to south-of-Delta areas served by Sacramento/Delta surface water.

Water conservation is another water management action identified by the Draft Staff Report that may be utilized to offset surface water supply reductions in in the San Joaquin Valley resulting from the proposed Plan amendments. (Draft Staff Report, pgs. 7.4-75, 7.4-98.) The potential effectiveness of this measure is also doubtful. Water agencies and the farmers they serve in the San Joaquin Valley have already invested significantly in water conservation to offset water supply

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shortages experienced over the last two decades. For instance, Westlands Water District, an agency that is mentioned often in the Draft Staff Report, reports that the farmers it serves have achieved a water use efficiency of 96%. (Personal communication from Katarina Campbell, P.E., Supervisor of Resources, Westlands Water District.) Other agencies in the CVP area served by the Delta-Mendota Canal, the CVP's San Luis Unit, and agencies in the SWP service area have implemented similar programs, and it is uncertain to what degree additional conservation in these areas could mitigate farmland conversion impacts resulting from implementation of any of the UIF alternatives.

Moreover, there are other areas of the San Joaquin Valley where implementation of stringent conservation measures of the type implemented with the CVP and SWP service areas would significantly reduce groundwater recharge. The Draft Staff Report does state "[w]ith higher flow requirements, there would be less applied water for irrigation of agricultural lands, which would in turn cause reductions in incidental groundwater recharge from transmission losses and deep percolation in both the Sacramento/Delta and areas that receive water from the Sacramento/Delta," (Draft Staff Report, pg. 6-81), but this generalized statement does not account for additional reductions in "incidental" groundwater recharge resulting from implementation of mitigation measures proposed by the Draft Staff Report.

Impacts of SGMA Implementation

The Draft Staff Report does contain significant information on existing groundwater conditions in various study areas, including the San Joaquin Valley, but it improperly analyzes potential impacts of implementing the proposed unimpaired flow objectives on groundwater conditions. Importantly, the Draft Staff Report is confusing because it suggests that increased reliance on groundwater pumping may offset surface water supply reductions, but it then goes on to note that the implementation of the Sustainable Groundwater Management Act ("SGMA") may restrict the use of groundwater to offset these reductions. (Draft Staff Report, pgs.6-80 – 6-81.) Herein lies one of the biggest challenges in the analysis contained within the Draft Staff Report; it fails to sufficiently evaluate the effects of simultaneously implementing the proposed unimpaired flow objectives and implementing SGMA.

Standing alone, SGMA implementation will have significant socioeconomic and environmental impacts in the San Joaquin Valley. Restrictions on the extraction of groundwater will increase land fallowing, reduce crop production, and result in job losses and other economic disruption. Paired with the proposed unimpaired flow objectives described in the Draft Staff Report, these impacts will undoubtably be exacerbated. This is evidenced through the results of a February 15, 2020, study prepared by David Sunding, Ph.D., and David Roland-Holst, Ph.D., from the University of California, Berkley, entitled "Blueprint Economic Impact Analysis: Phase One Results." That report, which is readily available online at https://waterblueprintca.com, analyzed the economic impacts of two types of water supply restrictions on the San Joaquin Valley: (i) limitations on groundwater pumping implemented as part of SGMA, and (ii) future reductions in surface water supplies available to farmers in the San Joaquin Valley resulting from several regulatory processes initiated by the State of California and the federal government, including amending the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

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through the adoption of the UIF alternative. The analysis concluded that together, these restrictions on water supply in the San Joaquin Valley would result in up to one million acres having to be fallowed, which amounts to fallowing of approximately one-fifth of all acres currently under cultivation, and farm revenue losses of $7.2 billion per year. Total job losses would be roughly 42,000 annually and would be concentrated in Fresno, Tulare, and Kern Counties. Kern County would be especially impacted, with nearly 17,000 farm jobs lost annually.

Impacts on poverty rates are also likely to be significant. A March 16, 2022, report entitled "The Economic Impact of the Westlands Water District on the Local and Regional Economy: 2022 Update," prepared by Michael A. Shires, Ph.D., associate dean for strategy and special projects and an associate professor of public policy at the Pepperdine School of Public Policy, states:

> Perhaps even more importantly, the overall trend of these poverty levels moves concurrently with the reductions in water deliveries from the CVP to the Westlands Water District. While certainly not proof of causality, the visual correlation is quite high over the last decade, including significant declines in poverty rates in 2016 and 2017 when surface water was abundant in Westlands. The key insight here, however, is that even with the real declines in poverty rates over the past several years, poverty persists more strongly in Fresno and Kings Counties and fluctuations in the agricultural water supply are likely important contributors to some of these changes.

(The Economic Impact of the Westlands Water District on the Local and Regional Economy: 2022 Update, pgs. 17-18.)

These economic impacts are particularly relevant in the context of amending the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary because as the Draft Staff Report correctly observes: "Under the Porter-Cologne Water Quality Control Act (Porter-Cologne Act), the State Water Board is required to consider several factors, including economic considerations, when establishing water quality objectives for the reasonable protection of beneficial uses (Wat. Code, § 13241)."[3] (Draft Staff Report, pg. 8-1.) Although Chapter 7.23 of

[3] Indeed, Water Code section 13241 enumerates numerous factors that must be considered when establishing water quality objectives to ensure the reasonable protection of beneficial uses of water, including past, present, and probable future beneficial uses of that water. (Wat. Code, § 13241(a).) In addition, Water Code section 13000 provides: "[t]he Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." (Wat. Code, § 13000(a).) Given the existing demands being placed on the water that would be affected by the imposition of an unimpaired flow objective and detrimental economic and social impacts resulting from its imposition, there is a substantial question as to whether any unimpaired flow objectives evaluated in the Draft Staff

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the Draft Staff Report does contain a Cumulative Impact Analysis, its assertion that impacts of implementing SGMA are “speculative” (Draft Staff Report, pg. 7.23-16) mischaracterizes the analytical work that has been done to date to analyze these compounded impacts.

Air Quality and Valley Fever

Another element of the Draft Staff Report analysis that the Blueprint finds particularly troubling involves air quality, which is contained in Chapter 7.5. The Draft Staff Report correctly concludes that implementation of the proposed unimpaired flow objectives could have potentially significant impacts with respect to some aspects of air quality. (Draft Staff Report, pgs.7.5-1 – 7.5-2.) However, with respect to “[e]xpose sensitive receptors to substantial pollutant concentrations,” the Draft Staff Report concludes the impacts will be less than significant. (Draft Staff Report, pg. 7.5-2.) This mischaracterizes the public health impacts of implementation of the UIF alternative.

As noted in the Draft Staff Report, because of the Coast and Sierra Nevada mountain ranges, temperature inversions occur frequently in in the San Joaquin Valley, trapping air pollutants near the surface and not allowing them to disperse upward. (Draft Staff Report, pg. 7.5-2.) The Draft Staff Report also states:

> Naturally occurring asbestos and Valley fever are endemic to areas within the study area (i.e., mountain counties and the Central Valley, respectively). The potential for exposure to Valley fever exists in agricultural areas, such as the southern portions of the San Joaquin Valley, where reported Valley fever cases have historically exceeded 10 per 100,000 people (CDPH 2016). Fallowed land could result in exposed soils and windblown fugitive dust, which could increase the likelihood of exposure to naturally occurring asbestos and Valley fever. However, some fallowed fields would retain crop stubble cover, ultimately experience regrowth, or both. The root material and regrowth would stabilize soils to some extent and reduce their potential for increased windblown erosion. Additionally, fallowing lands may result in a reduction in windblown dust because these lands would not be in active agricultural production, which includes substantial soil disturbance from tillage, crop harvesting, and other activities (see Section 7.9, Geology and Soils). Therefore, any potential for an increase in exposure to substantial pollutant concentrations would be minimal. Furthermore, the potential for sensitive receptors to be in proximity to fallowed land would be minimal. This impact would be less than significant.

Report could be accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.

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(Draft Staff Report, pg. 7.5-13.)

The conclusion of this analysis, that the impact of increased incidence of Valley Fever would be less than significant, is at odds with the experience of people who live and work in the San Joaquin Valley. They observe that water supply reductions do increase land fallowing, which results in increased fugitive dust. They also observe that farmers often till their fields in preparation for planting, only to leave them fallow when the farmers learn their final water supply will not support that cultivation or that farmers will plow under a growing crop because they do not have sufficient water to finish the irrigation of their crop. And because of the persistent inversion layer described on page 7.5-2 of the Draft Staff Report, windblown dust spreads throughout the San Joaquin Valley. They have not observed that fallowing fields results in a reduction of windblown dust.

The anecdotal observations of people who live and work in the San Joaquin Valley are consistent with a recent analysis conducted by Elizabeth Ann Weaver at Virginia Polytechnic Institute and State University. In her doctoral thesis, Ms. Weaver found climate and land cover variables explain up to 76% of valley fever variability in Kern County. (Investigating the Valley Fever – Environment Relationship in the Western U.S, 2019, Virginia Polytechnic Institute and State University.) In the San Joaquin Valley, among the factors that most influence ground cover is the availability of water for irrigation. Similarly, a recent study, entitled "Valley Fever: Environmental Risk Factors and Exposure Pathways Deduced from Field Measurements in California," reported in Int J Environ Res Public Health, August 2020, which included an analysis of Valley Fever cases at Naval Air Station Lemoore in Kings County, concluded preventing a further increase in Valley Fever incidence in California requires improved dust mitigation management. Among the most effective dust mitigation management techniques in the San Joaquin Valley is growing crops, which requires adequate water for irrigation.

From the perspective of people who live and work in the San Joaquin Valley, any increase in the incidence of Valley Fever would be significant and contrary to public health goals advanced by the Newsom Administration.

Conclusion

It is clear from the Draft Staff Report that amending the Water Quality Control Plan by imposing an unimpaired flow objective would have detrimental impacts on the water supply, environment, and economy of the 4 million Californians who live and work in the San Joaquin Valley. A smarter, more feasible, approach that is more expedient to implement would be to amend the Water Quality Control Plan by adopting a new narrative objective to achieve the viability of native fish populations and implementing the actions described in the Voluntary Agreements, now referred to as the Agreements to Support Healthy Rivers and Landscapes. This alternative would provide additional outflow compared to the existing baseline. However, of greater importance, this alternative includes measures to address other factors that limit abundance of native fish species. Finally, its impacts on the water supply, environment, and economy of the 4 million Californians who live and work in the San Joaquin Valley would not be nearly as severe as those resulting from an unimpaired flow alternative.

Thank you for your consideration of these comments.

Very truly yours,

Austin Ewell
Voluntary Executive Director

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January 19, 2024

Honorable Joaquin Esquivel, Chair
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814

Dear Chair Esquivel:

The undersigned organizations are writing to express our support for, and to encourage you to take definitive action to approve, the **Agreements to support Healthy Rivers and Landscapes as** the alternative for updating the Bay-Delta Water Quality Control Plan.

On March 29, 2022, the Governor convened federal, state, and local water leaders to announce broad agreement on measures to provide additional water flows, new habitat and other non-flow ecosystem benefits, a robust, collaborative and transparent science and governance structure, and long-term, stable funding to help improve conditions in the San Francisco Bay/Sacramento-San Joaquin River Delta watershed. This agreement, referred to as the Healthy Rivers and Landscapes proposals, are the culmination of more than five years of collaboration among the California Natural Resources Agency, the California Environmental Protection Agency, public water agencies throughout California, and other stakeholders to develop a modern approach to protecting all beneficial uses of water in the Bay-Delta watershed.

This collaborative and scientifically-grounded approach to resolving conflicts in the Bay-Delta is critical for water users south of the Delta. The region has already made, and is planning to make, investments in our diverse and connected water supply that has and will continue to reduce reliance on the Bay-Delta while ensuring e safe, affordable drinking water for more than 20 million Californians. Southern California has long been a leader in proactively finding flexible and efficient solutions to address the strains that climate change is placing on our water delivery system. We've established robust water use efficiency programs while simultaneously making significant investments in local and regional projects that increase our regional self-sufficiency.

While we continue to increase our local supplies, the State Water Project remains an essential source for the state and our region, serving as the foundation for our daily water needs as more local and regional projects are explored and implemented. The Agreements to Support Healthy Rivers and Landscapes are essential components for creating the reliability, certainty, and availability of water supplies from the state's backbone infrastructure system to protect south of Delta water resilience.

Water suppliers acknowledge that water flows are important components of habitat protection – and the Healthy Rivers and Landscapes proposal dedicates between 500,000 acre-feet and 800,000 acre-feet of additional water to the environment in many water years – but we need a new approach where every drop of water dedicated to the environment serves a biological function. The updated Delta water quality standards should protect all beneficial uses. The unimpaired flow (flow-centric) approach that is also on the table for consideration in updating the Bay-Delta Plan, may not improve conditions for fish and wildlife and will not protect all beneficial uses, including water supplies for millions of Southern Californians, irrigation for agriculture, and hydroelectric power generation that is essential to California's resilient energy grid.

The Healthy Rivers and Landscapes proposal is consistent with California's co-equal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem and would satisfy and fulfill many of the substantial needs to advancing a comprehensive and integrated approach to updating the Bay-Delta Water Quality Control Plan, including:

- √ Substantial dedication of water flows to the environment
- √ Significantly reduced environmental effects throughout California
- √ A comprehensive portfolio of actions designed to reactivate floodplains for robust populations of fish and wildlife
- √ A commitment to over $2.5 billion in funding to support the proposals
- √ Actions throughout the state designed to restore ecosystem function
- √ Recognition of the important contribution that hydroelectric generation during the summer provides for California's grid stability and reliability

√ Inclusive governance that will address changing climate conditions and support research to improve management actions

√ Commitment to collaborative, adaptatively managed and structured science programs

√ Processes for resolving litigation and regulatory issues that have stifled implementing innovative water resources stewardship and management practices

While there have been some notable successes, the various efforts to manage the Bay-Delta over the recent decades have not worked as planned overall, as both important species and water supply reliability have declined in the Bay-Delta and throughout the state. To change course and offer a different approach and trajectory, it is important to advance these innovative agreements for healthy rivers and landscapes, which will improve environmental conditions quickly and holistically, and will provide certainty to communities, farms, and businesses.

We encourage the State Water Board's adoption of the Healthy Rivers and Landscapes proposals as the best alternative for meeting the objectives for the Delta Plan update and to fulfill the State Water Board's obligation to reasonably balance the multitude of factors and considerations when updating the Delta Plan.

Sincerely,

Charles Wilson, Executive Director
Southern California Water Coalition

Jon Switalski, Executive Director
Rebuild SoCal Partnership

Heather Dyer, Chief Executive Officer
San Bernardino Valley Municipal Water District

Matthew Stone, General Manager
Santa Clarita Valley Water Agency

Tracy Hernandez, Founding CEO
Los Angeles County BizFed

Adnan Anabtawi, General Manager
Mojave Water Agency

J. M. Barrett, General Manager
Coachella Valley Water District

Adel Hagekhalil, General Manager
Metropolitan Water District of Southern CA

Gail Delihant, Senior Director, CA Government Affairs
Western Growers

Darin Kasamoto, General Manager
San Gabriel Valley Municipal Water District

Jeffrey Ball, President/Chief Executive Officer
Orange County Business Council

Martin Ludlow, President
Groundswell for Water Justice

Benjamin Lopez, Director of Public Policy and Advocacy
Inland Empire Economic Partnership

Richard Lambrose, Executive Director
Secure Water Alliance

Austin Ewell, Voluntary Executive Director
Water Blueprint for the San Joaquin Valley

Joe Mouawad, P.E., General Manager
Eastern Municipal Water District

Luis Portillo, President & CEO
San Gabriel Valley Economic Partnership

Stephanie Klopfenstein, President
Assn. of California Cities – Orange County

Mike Roos, President
Southern California Leadership Council

cc: Members, State Water Resources Control Board

SAN JOAQUIN VALLEY WATER COLLABORATIVE ACTION PROGRAM
Plenary Group Meeting
Notes

January 23, 2024 | 3:00 pm - 5:00 pm

Participation

On January 23, 2024, the Plenary Group meeting had 36 members participate in the discussion, and all five caucuses were represented.

Agenda Item #2 Additions to the Agenda

The agenda was changed to provide an introduction of a new CAP member Robert Jeff, Vice Chair of the Tachi Yokut Tribe .

Mike Lynes (Audubon) provided an overview of AB 828 which would amend the Sustainable Groundwater Management Act to address safe drinking and wetland issues. Mike will schedule meeting to discuss the legislation with interested CAP members.

Agenda Item #3 Proposed CAP 2024 Focus

Groundwater Recharge:

The first proposed CAP 2024 focus presented was groundwater recharge. The group discussed the benefits of groundwater recharge, as well as the possible negative impacts it may have. Sustainable Conservation is studying the data gained from the recharge and water quality testing in 2023, and they are using that data to better understand the best areas to do recharge, and the necessary next steps for better monitoring. CAP's 2024 focus on groundwater recharge will be developing interim best practices for recharge based on what was learned in 2023.

Additionally, there will be a follow-up with the Governor's office to have further conversations about their plans. CAP will be vital in sharing important information and best practices that would ensure recharge benefits.

Safe Drinking Water

The second proposed CAP focus discussed was a comprehensive valley-wide plan to address safe drinking water needs. This focus would involve using State Water Board assessments to identify the valley-wide need and magnitude of actions needed, integration of state programs, improvements to the consolidation process, protection of shallow domestic wells, and support for reducing the well drilling backlog.

There was concern about the task of determining the magnitude of actions needed, as some interpreted that as not following the priority that was adopted by CAP last year, which was making sure everyone in the valley has access to safe drinking water. It was clarified that this was not the intention, and CAP would stay consistent with that priority. The original intention was determining the different needs across the valley have and the specific solutions that will need to be applied to each community.

GSA Probationary Process

The third proposed CAP 2024 focus was finding ways the Groundwater Sustainability Agency probationary process can be improved, and making sure this process is working the way it was intended. Aaron and Justine volunteered to discuss a scope that will see if there's common ground around recommendations to be considered by the CAP members that could be provided to the State Board and GSAs for the probationary process.

Wet Year Surplus

The fourth proposed CAP 2024 focus was the wet water year surplus. A subgroup of the Water Supply Work group has been going through technical information to look at the estimates of wet water surplus that was developed by FloodMAR and PPIC. The subgroup will be providing a summary of what the analysis concludes and what the availability of water is and needs to be addressed are.

Multibenefit Land Repurposing

The fifth proposed CAP 2024 focus was multibenefit land repurposing, which would include developing an approach for programmatic conservation agreements, identifying strategies for habitat corridors, and finalizing the utility-scale solar recommendations. The goal of these actions would be minimizing the impacts of unmanaged lands, and maximizing the public benefits that can be achieved.

Funding

The final CAP 2024 focus is funding. There were suggestions at the December in-person meeting about advocating for additional funding for various components, which included local government, San Joaquin River Restoration program, Multibenefit land repurposing program, restoration and improvements to conveyance infrastructure, job training, and following-up with the Governor's office on bond recommendations.

Agenda Item #4 Briefing on Voluntary Agreements

Jennifer Pierre gave a presentation about voluntary agreements. This presentation included background information about what the voluntary agreements are, and what the State Board staff analysis says about different alternatives as it relates to groundwater recharge.



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Healthy Rivers California

Adapting to our climate reality by strengthening California's landscapes, communities and farms

The Voluntary Agreement Process - Presentation to the San Joaquin Valley CAP
January 2024

Presentation Overview

- What is the purpose of the Voluntary Agreements?
- What is included in the Voluntary Agreements?
  - Flows with Function (Rivers, Delta, and Floodplains)
  - Science and Governance
  - Funding Commitments
- How are the Voluntary Agreements different than other approaches?
- How are the Voluntary Agreements related to the San Joaquin Valley?

Setting: Sacramento-San Joaquin Delta Estuary

State Water Board Update to the Water Quality Control Plan

The State Water Board is required to periodically update the Bay-Delta Water Quality Control Plan (WQCP)

- Last update was 2006
- Required to balance beneficial uses

State Water Board staff have proposed 3 phases for updates

- Phase 1: San Joaquin River (complete Dec 2018)
- Phase 2: Sacramento River & Delta
- Phase 3: Assignment of responsibilities for Phases 1 & 2

State Water Board staff have proposed an 'unimpaired flow approach'

- Flow only; no habitat or adaptive management
- Estimated 2M acre-feet of water cost to cities and farms
- Adjudication of the entire basin; could take 10-20 years to resolve

Voluntary Agreements Process

2018	▪ State presented Voluntary Agreement to State Water Board
2019	▪ State submitted Voluntary Agreement proposal to State Water Board
2020	▪ State presented Framework of Voluntary Agreement
2022	▪ Governor convened agencies and water suppliers to sign MOU advancing VAs
2023	▪ VA parties develop Governance Plan, Science Plan, Strategic Plan, Implementing Agreements ▪ Release of Science Basis Report (Feb) and Staff Report (Sept)

State, Federal & Local Agencies

CALIFORNIA NATURAL RESOURCES AGENCY

State, Federal Agencies Announce Agreement with Local Water Suppliers to Improve the Health of Rivers and Landscapes

Published Date: 29 Mar 2022

MOU a Key Step in Years-Long Effort to Help Recover Salmon While Protecting Water Reliability

SACRAMENTO – State, federal and local water leaders announced broad agreement today on measures to provide additional water flows and new habitat to help improve conditions in the Sacramento-San Joaquin River Delta watershed.

The memorandum of understanding (MOU) signed today outlines terms for a transformational eight-year program that would provide substantial new flows for the environment to help recover salmon and other native fish, create new and restored habitat for fish and wildlife, and provide significant funding for environmental improvements and water purchases. It also outlines a governance and habitat monitoring framework with clear metrics and goals to allow state, federal and local partners to analyze progress, manage adaptively and decide whether the program should be continued, modified or ended after eight years.

Red Bluff to San Diego--Who has Signed the MOU?

- US Bureau of Reclamation
- CA Natural Resources Agency
- CA Environmental Protection Agency
- CA Department of Water Resources
- CA Department of Fish and Wildlife
- Garden Highway Mutual Water Company
- River Garden Farms
- Sutter Mutual Water Company
- Friant Water Authority
- Glenn Colusa Irrigation District
- RD 108
- Yuba Water Agency
- Western Canal Water District
- Regional Water Authority
- East Bay Municipal Utility District
- Turlock Irrigation District
- Modesto Irrigation District
- San Francisco Public Utilities Commission
- Solano County Water Agency
- State Water Contractors
- Contra Costa Water District
- Kern County Water Agency
- Metropolitan Water District
- Westlands Water District
- Tehama-Colusa Canal Authority
- San Luis-Delta Mendota Water Authority

Voluntary Agreement Goals and Objectives

The VAs will state actions, together with other measures in the Bay-Delta Plan, necessary to implement two water quality objectives in the plan related to protection of native fishes:

(1) the existing narrative objective that provides for water quality conditions, together with other measures in the watershed, to achieve doubling of the reference salmon population (1967-1991) (Narrative Salmon Objective); and

2) a new narrative objective to achieve the viability of native fish populations (Narrative Viability Objective).

What Does the Total Program Look Like?

8 years concurrent with the new ITP and BiOps

Water agencies contribute water and funding for water, habitat, and science

State and federal funding contributions for water, habitat and science

All-hands governance program

Frequent reporting to inform adaptive management and potential extension of the agreement

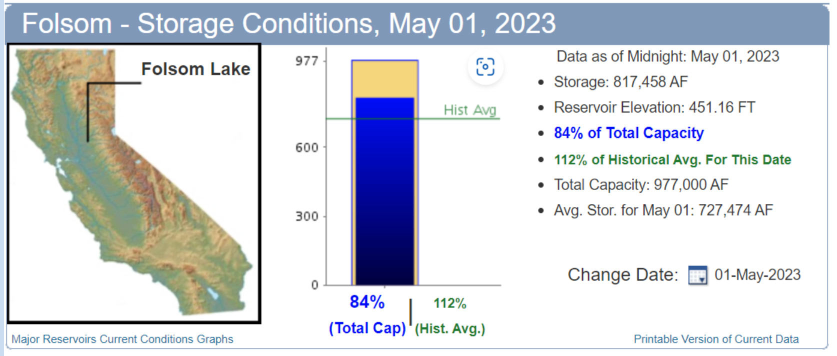
What is in the Voluntary Agreements?

- Upstream environmental flows integrated with physical habitat
- Floodplain re-activation
- Delta flows and restoration
- Science and Governance
- Funding

Upstream/Sacramento River environmental flows integrated with physical habitat

- Over 250,000 acre-feet of dedicated flows in certain years
- 85 habitat enhancement projects with expedited permitting
  - Salmon rearing and spawning habitat
  - Ecosystem function
- Flows with function!
- Application of science and monitoring to inform designs and future adjustments

Delta flows and restoration



Delta outflow

- In May 2023, Folsom Reservoir had ~800 thousand acre-feet (AF) of water
- 1 acre-foot supplies enough water for about 3 Californian homes for a year
- The Voluntary Agreements would increase Delta flows by 750,000 to 825,000 AF in above normal, below normal and dry year types
- Additional water in critical and wet years

Delta restoration

Focus on tidal wetlands in the north Delta arc- high certainty for benefits

How Much Water Will Be Added to The Delta?

	Flows (thousand acre-feet) by water year type				
Location	Critical	Dry	Below Normal	Above Normal	Wet
Sacramento	2	102	100	100	0
American	30	40	10	10	0
Yuba	0	60	60	60	0
Feather	0	60	60	60	0
Putah	7	6	6	6	0
Friant	0	50	50	50	0
Mokelumne	0	5	5	7	0
Delta	0	125	125	175	0
PWA Fixed Price Purchases	3	63.5	84.5	99.5	27
PWA Market Price Purchases	0	50	60	83	0
Permanent State Water purchases	65	108	9	52	123
Proposed San Joaquin, including Tuolumne	48	156	181	122	0
Total	**155**	**825.5**	**750.5**	**824.5**	**150**

Science, Decision-Making and Governance

Initial Strategic Plan, Monitoring Plans approved by State Water Board

- Agreed upon implementation and efficacy metrics

Governance group includes all VA parties (plus willing NGOs and Tribes?)

- Decides habitat projects and advises on flow operations

Annual reporting to the State Water Board

- Documents actions taken and what was learned

Climate Adaptation

- Ability to make adjustments to timing of flows and habitat projects to respond to real-time conditions and science outcomes

Evaluation and Potential Extension of the Program, Years 8-15

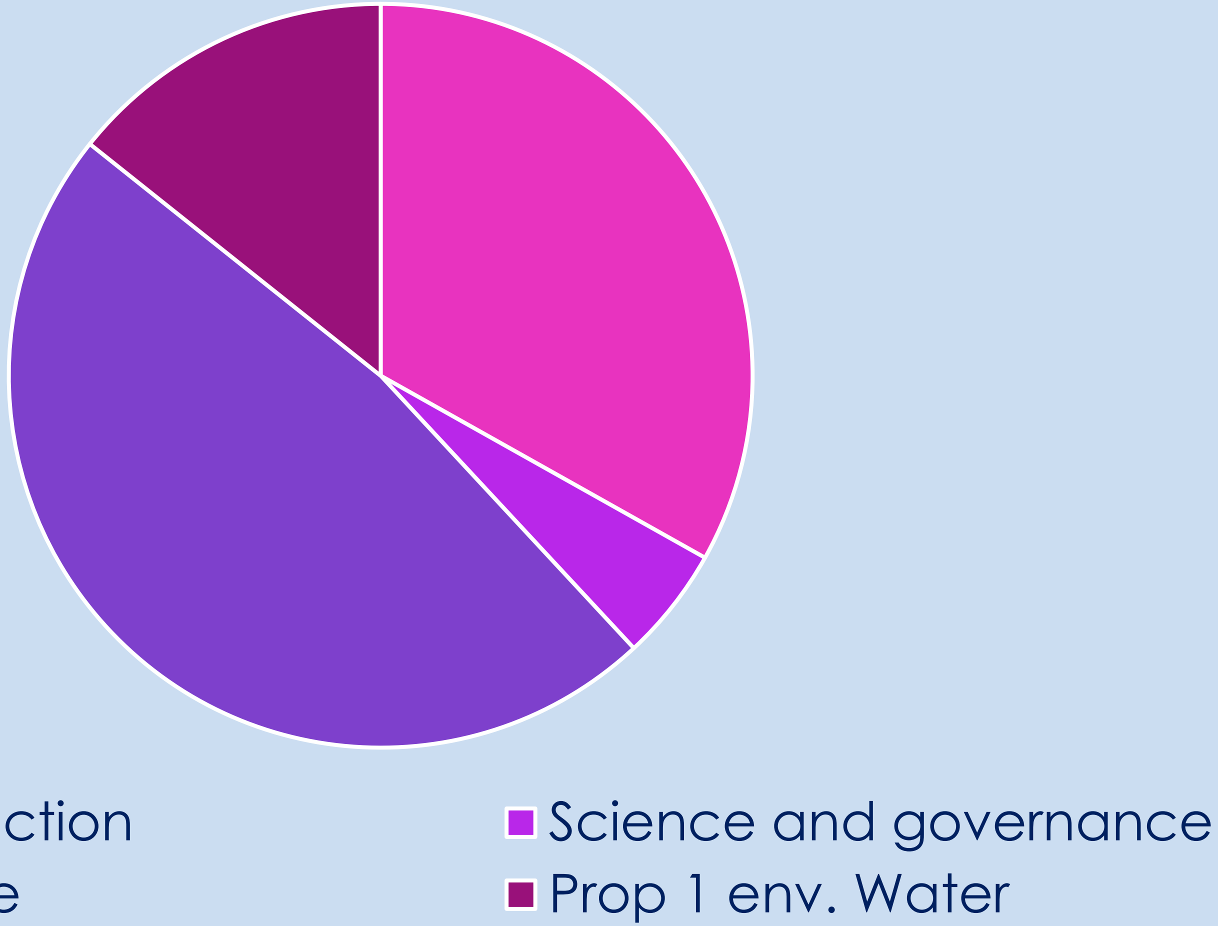
- At Year 6, State Water Board will begin evaluations of the VAs:
  - Green light: Everything is going well and continuation of the program will meet the objectives
  - Yellow light: Some modifications are necessary to meet the objectives
  - Red light: The VAs are not meeting and are not likely to meet the objectives; a new pathway is required
- Ideally, VAs are extended to 15 years

How will the Voluntary Agreement be funded?

$2.9 Billion Program

• State commitments through bonds and General Funds:	**$1.4B (49%)**
• Federal share:	**$740M (25%)**
• Other:	**$168M (6%)**
• Public Water Agencies:	**$588M (20%)**
TOTAL:	**$2.9B**

What will the funding be used for?



Concerns raised by opposing parties

1. Not enough water, habitat or funding

Science Basis Report completed by State Water Board (February 2023) is currently under an Independent Science Review by UC Berkeley and provides the scientific rationale for the proposed actions

2. Process is not inclusive of environmental groups and tribal communities

Several NGOs were fully involved in the development of the proposal through 2020

- Governance structure
- New biological objectives
- Types of habitat projects

State hosting tribal workshops in January 2024

How does the Water Quality Control Plan Update relate to the San Joaquin Valley?

Part of the solution set for CAP/San Joaquin Valley is the use of excess surface water supplies to:

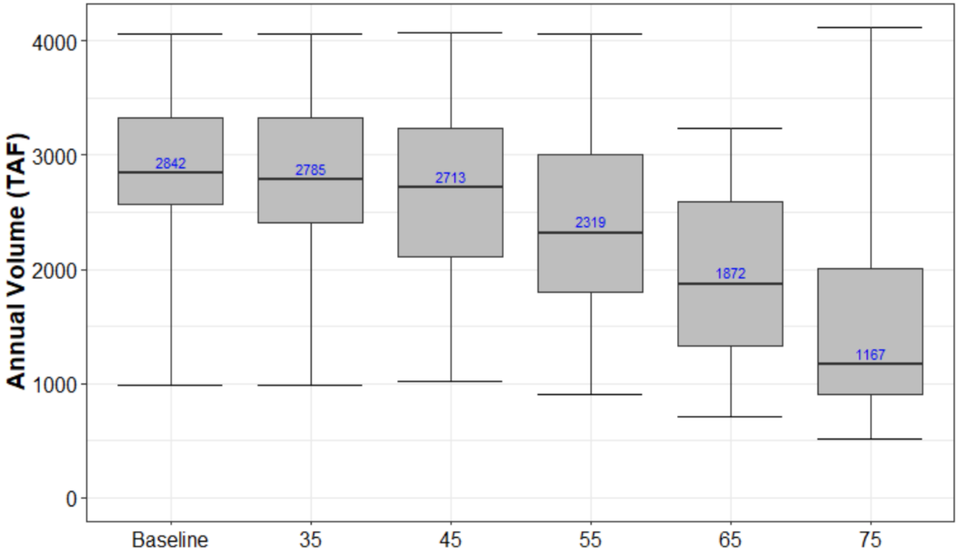
- Address losses due to SGMA implementation
- Restore habitats
- Address safe drinking water
- Improve groundwater recharge and storage

Impacts of SWB 55% Unimpaired Flow on Delta deliveries to the San Joaquin Valley Agriculture

"The annual Sacramento/Delta supply to the San Joaquin Valley region is <u>reduced…on average from 96 TAF in wet years to 707 TAF in dry years</u>."

– Page 6-72 of SWB Draft Staff Report

State Water Resources Control Board — Changes in Hydrology and Water Supply



TAF = thousand acre-feet

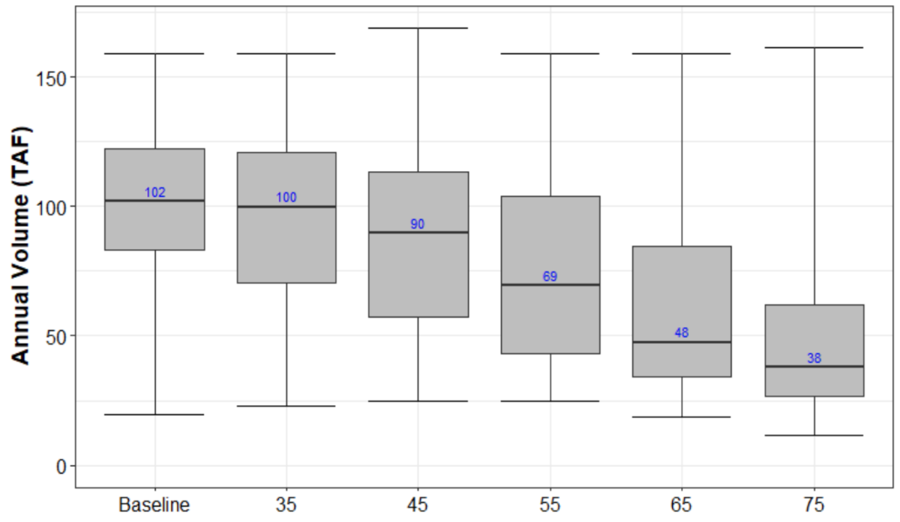
Figure 6.4-10. Annual Sacramento/Delta Supply to the San Joaquin Valley Region

Table 6.4-20. Annual Sacramento/Delta Supply to the San Joaquin Valley Region Water Year Type Average: Change from Baseline (thousand acre-feet)

Water Year Type	Baseline	35	45	55	65	75
Critical	1,713	-5	-142	-383	-682	-945
Dry	2,630	-116	-326	-707	-1,125	-1,653
Below normal	2,810	-44	-180	-510	-972	-1,585
Above normal	2,940	3	-74	-277	-918	-1,422
Wet	3,507	-11	-22	-96	-691	-1,051
All	2,819	-38	-146	-379	-868	-1,315

Impacts of SWB 55% Unimpaired Flow on Delta deliveries to the San Joaquin Valley Urban Areas

- Average of over 22% reduction in deliveries to San Joaquin Valley urban users



TAF = thousand acre-feet

Figure 6.4-12. Sacramento/Delta Supply to Urban Use in the San Joaquin Valley Region

Table 6.4-22. Sacramento/Delta Supply to Urban Use in the San Joaquin Valley Region Water Year Type Average Change from Baseline (thousand acre-feet)

Water Year Type	Baseline	35	45	55	65	75
Critical	46	-1	-6	-11	-19	-27
Dry	89	-11	-25	-39	-50	-61
Below normal	101	-6	-18	-34	-49	-61
Above normal	107	0	-8	-25	-48	-57
Wet	130	0	-1	-7	-17	-44
All	99	-4	-11	-22	-35	-50

Reduction in groundwater recharge and levels from unimpaired flows

"With higher flow requirements, there would be less applied water for irrigation of agricultural lands, which would in turn cause reductions in incidental groundwater recharge…Overall, these changes would result in a net reduction in groundwater recharge in the areas that receive Sacramento/Delta water. With no change to groundwater pumping (i.e., no replacement groundwater pumping) and a net reduction in groundwater recharge, groundwater levels could decrease compared to the baseline condition, as the instream flow requirement increases."

-Page 6-81 of Draft Staff Report

Increased groundwater use under Unimpaired Flow Alternatives

- An average of 624 thousand acre-feet of additional groundwater pumping to make up for lost surface water deliveries for the 55% flow scenario

Table 7.12.2-14. SWAP Model Results for Increased Groundwater Use Compared with Baseline Condition, Maximum Replacement Groundwater Pumping—San Joaquin Valley (thousand acre-feet)

	Flow Scenarios				
Water Year Condition	35	45	55	65	75
Average water year	84	235	624	911	1,096
Dry water year	97	201	400	477	526

Source: SWAP model results.

Increased groundwater pumping in response to reduced Sacramento/Delta supplies in the San Joaquin Valley region could lower groundwater levels. Table 7.12.2-6 lists the existing medium- and

Comparison of alternatives based on Draft Staff Report analysis

Expected Change Compared to Draft Staff Report Baseline			
		UIF Alternatives	VA Alternative
Biological Indicators	Cold Water Storage	Negative	Neutral
	Upstream Water Temperatures	Negative	Neutral
	Upstream Fishery Habitat	Neutral	Positive
	Terrestrial Habitat	Negative	Positive
	Delta Habitat	Positive	Positive
	Delta Species Abundance	Positive	Positive
Water Supply	Ag	Negative	Neutral
	M&I	Negative	Neutral
	Refuges	Negative	Neutral
	Groundwater	Negative	Neutral
Other	Agriculture	Negative	Neutral
	Hydropower	Negative	Neutral
	Economic Impacts	Negative	Neutral

Negative

Neutral

Positive

Comparison of Water Supply Reductions

	55% Unimpaired Flows			Healthy Rivers
Water Year Type	**Impacts to San Joaquin Valley Ag**	**Impacts to San Joaquin Valley Urban**	**Total Impacts to San Joaquin Valley**	**Impacts to CVP/SWP (SJV and SoCal)**
Critical	383	11	**394**	**3**
Dry	707	39	**748**	**179**
Below Normal	510	34	**544**	**200**
Above Normal	277	25	**302**	**265**
Wet	96	7	**103**	**27**

Reductions in Water Delivery to the Valley from the CVP and SWP:

- Reduces water available for recharge
- Increases costs per acre-foot of CVP and SWP water
- Requires investments in alternative supplies that increase cost of water
- Impacts Disadvantaged Communities throughout California
  - ¾ of all DACs are located within the SWP service area

2024 and Beyond

- CEQA comment period closed January 19
- Awaiting comments on the Science Basis Report from UC Berkeley Independent Science Review
- Accounting procedures, legal agreements, and additional details on funding and science plan under development
- State Water Board will release a Draft Program of Implementation for public comment
- State Water Board staff will respond to CEQA comments and prepare Final Staff Report
- State Water Board will consider approval of an Updated Water Quality Control Plan

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Discussion/Questions?