UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

In response reply to:
2008/09022

JUN - 4 2009

Mr. Donald Glaser
Regional Director
Mid-Pacific Region
U.S. Bureau of Reclamation
2800 Cottage Way, MP-3700
Sacramento, California 95825-1898

Dear Mr. Glaser:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) final biological opinion and conference opinion (Opinion, enclosure 1) based on NMFS review of the proposed long-term operations of the Central Valley Project and State Water Project (hereafter referred to as CVP/SWP operations) in the Central Valley, California, and its effects on listed anadromous fishes and marine mammal species, and designated and proposed critical habitats, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). This final Opinion is based on information provided in the Bureau of Reclamation's (Reclamation) October 1, 2008, transmittal letter and biological assessment (BA), discussions between NMFS and Reclamation staff, declarations filed pursuant to Pacific Coast Federation of Fishermen Association *et al. v.* Gutierrez *et al.* 1:06-cv-245-OWW-GSA (E.D. Cal. 2008), comments received from Reclamation, peer review reports from CALFED and the Center for Independent Experts, and an extensive literature review completed by NMFS staff. A complete administrative record of this consultation is on file at the NMFS Sacramento Area Office.

Based on the best available scientific and commercial information, NMFS' final Opinion concludes that the CVP/SWP operations are likely to jeopardize the continued existence of Federally listed:

- Endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*),
- Threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*),
- Threatened Central Valley steelhead (*O. mykiss*),
- Threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and
- Southern Resident killer whales (*Orcinus orca*).

NMFS also concludes that the proposed action is likely to destroy or adversely modify the designated critical habitats of:

- Sacramento River winter-run Chinook salmon,

- Central Valley spring-run Chinook salmon, and
- Central Valley steelhead, and
- proposed critical habitat for the Southern DPS of North American green sturgeon.

The final Opinion concludes that the CVP/SWP operations are not likely to jeopardize the continued existence of Central California Coast steelhead (O. *mykiss*).

The conference opinion concerning proposed critical habitat for Southern DPS of North American green sturgeon does not take the place of a biological opinion under section 7(a)(2) of the ESA unless and until the conference opinion is adopted as a biological opinion when the proposed critical habitat designation for the Southern DPS of North American green sturgeon becomes final. Adoption may occur if no significant new information is developed, and no significant changes to the project are made that would alter the contents, analyses, or conclusions of this Opinion.

Take of threatened green sturgeon is currently not prohibited by Section 9 of the ESA. When the rule proposed on May 21, 2009 (74 FR 23822) under section 4(d) of the ESA becomes effective as a final rule, all take of threatened green sturgeon not in conformance with that rule will be prohibited under the ESA. Upon the effectiveness of the final green sturgeon take rule, compliance with this Incidental Take Statement provides exemption for take under section 7(o).

The ESA provides that if NMFS has reached a jeopardy or adverse modification conclusion, it must identify a reasonable and prudent alternative (RPA) to the proposed action that is expected to avoid the likelihood of jeopardy to the species and adverse modification of designated and proposed critical habitat, if such an alternative action can be offered. NMFS includes with this Opinion a RPA that we believe meets all four regulatory requirements, as set forth in 50 CFR 402.02. This has been a very challenging consultation for our agencies due to its complexity, long-term nature, and importance to the people of California and the resources we are required to manage. NMFS and Reclamation have had extensive discussions on the preparation of the BA, the draft Opinion, and the draft RPA, and while NMFS understands that Reclamation may have reservations with portions of the Opinion, NMFS understands that it is a package that Reclamation can accept. Because this is a jeopardy Opinion, Reclamation is required (402.15(b)) to notify NMFS "...of its final decision on the action." NMFS, therefore, requests that Reclamation provide NMFS with timely notification as to your agency's final decision.

Also enclosed are Essential Fish Habitat (EFH) Conservation Recommendations for Pacific Coast Salmon species, as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended (16 U.S.C. 1801 *et seq.*; enclosure 2). NMFS EFH analysis concludes that the CVP/SWP operations will adversely affect EFH for Pacific Coast Salmon species in the action area. The RPA that was developed for the ESA-listed salmon was designed to avoid jeopardy and adverse modification for those species but it also has substantial benefits to Pacific salmon EFH, and commercially valuable Central Valley fall-run Chinook salmon. Pursuant to the MSFCMA, Conservation Recommendations are also provided to further reduce adverse effects on EFH.

I want to express my sincere appreciation to you and to your staff for their professionalism and commitment to find a solution that comports with our various Federal mandates. You have my commitment that NMFS will continue to be close partner with Reclamation, CA Department of Water Resources, CA Fish and Game, and US Fish and Wildlife Service as we embark on implementation. I also look forward to continuing our participation with Reclamation, partner agencies and stakeholders in the Bay Delta Conservation Planning effort, a very important action to boost habitat improvements in the Delta and counterbalance some of the aging infrastructure limitations. If you have any questions regarding this consultation, please contact Mr. Garwin Yip, of my staff, at (916) 930-3611 or via e-mail at garwin.yip@noaa.gov.

Sincerely,

Rodney R. McInnis

Rodney R. McInnis
Regional Administrator

Enclosures:
Enclosure 1: Biological and conference opinion on the long-term operations of the Central Valley Project and State Water Project
Appendix 1: Project Description
Appendix 2: Supporting documents for the RPA
Appendix 3: Fall-run and late fall-run Chinook salmon analysis
Appendix 4: Responses to CALFED peer review recommendations
Appendix 5: Technical memorandum for the San Joaquin actions
Enclosure 2: EFH Conservation Recommendations

cc: Copy to file ARN: 151422SWR2004SA9116
NMFS-PRD, Long Beach, CA
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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

June 4, 2009

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BIOLOGICAL OPINION AND CONFERENCE OPINION

ACTION AGENCY: U.S. Bureau of Reclamation
Central Valley Operations Office

ACTIVITY: Long-Term Operations of the Central Valley Project and State Water Project

CONSULTATION CONDUCTED BY: NOAA's National Marine Fisheries Service
Southwest Region

FILE NUMBER: 2008/09022

DATE ISSUED:

1.0 BACKGROUND AND CONSULTATION HISTORY

1.1 Purpose

The purpose of this document is to present NOAA's National Marine Fisheries Service's (NMFS) biological and conference opinion (Opinion), about whether the U.S. Bureau of Reclamation's (Reclamation) proposed long-term operations of the Central Valley Project (CVP), operated in coordination with the State Water Project (SWP; hereafter referred to as CVP/SWP operations, the proposed action, or the project), is likely to jeopardize the continued existence of the following species:

- Endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*, hereafter referred to as winter-run)
- Threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*, hereafter referred to as spring-run)
- Threatened Central Valley (CV) steelhead (*O. mykiss*)
- Threatened Central California Coast (CCC) steelhead (*O. mykiss*)
- Threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*, hereafter referred to as Southern DPS of green sturgeon)
- Endangered Southern Resident killer whales (*Orcinus orca*, hereafter referred to as Southern Residents)

or destroy or adversely modify the designated critical habitat of the above salmon and steelhead species, or proposed critical habitat for Southern DPS of green sturgeon. This Opinion is based on the best scientific and commercial information available.

1.2 Background

Alterations to the natural hydrologic systems of the Sacramento and San Joaquin River basins began in the late 1800s, accelerating in the early 1900s, including the construction of three dams owned and operated by Reclamation, a fourth dam owned and operated by the California Department of Water Resources (DWR), and a multitude of pumps and hundreds of miles of gravity-fed water diversions constructed and operated by private water users and by Reclamation and DWR. None of the major dams were constructed with fish ladders to pass anadromous fish and, as a result, salmon and steelhead have effectively been blocked from accessing the upper reaches of the basin. Beginning in 1993, Shasta and Keswick Dam releases on the upper Sacramento River have been managed to provide cold water to the spawning habitat below Keswick Dam as per requirements of NMFS' winter-run biological opinion on the operations of the CVP and SWP.

1.3 Coordinated Operations Agreement

In November 1986, the U.S. Federal government and DWR signed the Coordinated Operation Agreement (COA), which defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities. Congress, through Public Law 99-546, authorized and directed the Secretary of the Interior to execute and implement the COA. Under the COA, Reclamation and DWR agree to operate the CVP and SWP, respectively, under balanced conditions in a manner that meets Sacramento Valley and Delta needs while maintaining their respective water supplies, as identified in the COA. "Balanced conditions" are defined as periods when the CVP and SWP agree that releases from upstream reservoirs, plus unregulated flow, approximately equal water supply needed to meet Sacramento Valley in-basin uses and CVP/SWP exports. The COA is the Federal nexus for ESA section 7 consultation on operations of the SWP. In this CVP/SWP operations consultation, DWR is considered an applicant.

1.4 Consultation History

On October 22, 2004, NMFS issued its biological opinion on the proposed CVP/SWP operations (NMFS 2004c, hereafter referred to as 2004 CVP/SWP operations Opinion). Within that document was a consultation history that dated back to 1991, which is incorporated here by reference.

On April 26 and May 19, 2006, Reclamation requested reinitiation of consultation on CVP/SWP operations based on new species listings and designated critical habitats. In a June 19, 2006, letter to Reclamation, NMFS stated that there was not enough information in Reclamation's request to initiate consultation. NMFS provided a list of information required to fulfill the initiation package requirements [50 CFR 402.14(c)]. From May 2007, until May 29, 2008, NMFS participated in the following interagency forums, along with representatives from Reclamation, DWR, U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Game (CDFG), in order to provide technical assistance to Reclamation in its development of a biological assessment (BA) and reinitiation package.

- Biweekly interagency CVP/SWP operations meetings;
- Biweekly five agencies management meetings;
- Weekly directors' meetings; and
- Several modeling meetings.

In addition, NMFS provided written feedback on multiple occasions:

- Multiple e-mails from the USFWS (submitted on behalf of USFWS, NMFS, and CDFG) providing specific comments on various chapters of the draft CVP/SWP operations BA, including the legal setting (Chapter 1) and project description (Chapter 2);
- February 15, 2008, e-mails from NMFS to Reclamation, transmitting comments on species accounts for the anadromous salmonid species and green sturgeon (Chapters 3-6, and 8);
- A February 21, 2008, letter providing comments with regard to the development of the draft CVP/SWP operations BA, and in particular, the draft project description; and
- An April 22, 2008, list of threatened and endangered species and critical habitats that occur within areas affected by the proposed action.

On May 19, 2008, NMFS received Reclamation's May 16, 2008, request to reinitiate formal consultation on CVP/SWP operations. On May 30, 2008, Reclamation hand-delivered a revised BA containing appendices and modeling results. On June 10, 2008, NMFS issued a letter to Reclamation indicating that a reinitiation package was received, and that NMFS would conduct a 30-day sufficiency review of the BA received on May 30, 2008. On July 2, 2008, NMFS issued a letter to Reclamation, indicating that the BA was not sufficient to reinitiate formal consultation. NMFS described additional information necessary to reinitiate consultation. In addition, on July 17, 2008, NMFS offered additional comments on the BA via e-mail. Throughout July 2008, NMFS continued to participate in the interagency forums listed above to continue to provide technical assistance to Reclamation on its development of a final BA and complete reinitiation package. In addition, meetings were held between NMFS and Reclamation staff on August 8, September 9, and September 19, 2008, to discuss and clarify outstanding concerns regarding the modeling, Essential Fish Habitat (EFH), and project description information contained in the draft BA. On August 20 and September 3, 2008, NMFS received additional versions of the draft BA, hand-delivered to the NMFS Sacramento Area Office on digital video disc (DVD).

On October 1, 2008, the Sacramento Area Office received a hand-delivered letter from Reclamation, transmitting the following documents: (1) final BA on a DVD (Reclamation 2008a, hereafter referred to as the CVP/SWP operations BA), (2) Attachment 1: Comment Response Matrix, (3) Attachment 2: errata sheet; (4) Attachment 3: Additional modeling simulation information regarding Shasta Reservoir carryover storage and Sacramento River water temperature performance and exceedances; and (5) Attachment 4: American River Flow Management Standard 2006 Draft Technical Report. The letter and enclosures were provided in response to our July 2, 2008, letter to Reclamation, indicating that the BA was not sufficient to reinitiate formal consultation. In its October 1, 2008, letter, Reclamation also committed to providing, by mid-October 2008, the following: responses to comments and reinitiating consultation related to Pacific Coast Salmon EFH within the Central Valley, and (2) a request for conferencing and an analysis of effects of the continued long-term operation of the CVP and

SWP on proposed critical habitat for green sturgeon. On October 20, 2008, Reclamation provided to NMFS via e-mail the analysis of effects on the proposed critical habitat of Southern DPS of green sturgeon. In addition, on October 22, 2008, Reclamation provided to NMFS via e-mail supplemental information regarding the EFH assessment on fall-run Chinook salmon (hereafter referred to as fall-run). On November 21, 2008, NMFS issued a letter to Reclamation, indicating that Reclamation had provided sufficient information to reinitiate formal consultation on the effects of CVP/SWP operations, with the understandings that: (1) Reclamation is committed to working with NMFS staff to provide any additional information NMFS determines necessary to analyze the effects of the proposed action; and (2) NMFS is required to issue a final Opinion on or before March 2, 2009 (see section 1.5.8.2, below).

On December 11, 2008, NMFS issued a draft CVP/SWP operations Opinion for peer review through the CALFED Bay-Delta Program (CALFED) and the Center for Independent Experts (CIE), and also to Reclamation for review and comment. Details about the reviews are provided below in sections 1.5.6.2 and 1.5.6.3. Beginning the week of January 5, 2009, NMFS hosted weekly meetings with representatives from USFWS, CDFG, Reclamation, and DWR at the directors, managers, and technical levels, in addition to scheduling meetings on specific topics, to address, clarify, and resolve Reclamation's and DWR's comments on the draft Opinion and draft reasonable and prudent alternative (RPA).

On January 15, 2009, Reclamation sent NMFS an e-mail, transmitting an attached file with 2 pages to replace the North Bay Aqueduct section of the CVP/SWP operations BA on pages 13-49 and 13-50. In addition, section 3.1 of this Opinion documents additional changes to the CVP/SWP operations BA, specifically in Chapter 2 (project description).

This document is NMFS' Opinion on the proposed action, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.). The request for formal consultation was received on October 1, 2008. This final Opinion supersedes the 2004 CVP/SWP operations Opinion. This Opinion is based on: (1) the reinitiation package provided by Reclamation, including the CVP/SWP operations BA, received by NMFS on October 1, 2008; (2) the supplemental analysis of effects on the proposed critical habitat of Southern DPS of green sturgeon and supplemental information regarding the EFH assessment on fall-run; (3) other supplemental information provided by Reclamation; (4) declarations submitted in court proceedings pursuant to Pacific Coast Federation of Fishermen Association (PCFFA) *et al*. v. Gutierrez *et al*.; and (5) scientific literature and reports. A complete administrative record of this consultation is on file at the NMFS, Sacramento Area Office.

1.5 Key Consultation Considerations

1.5.1 Southern Oregon/Northern California Coast (SONCC) Coho Salmon

This Opinion analyzes the effects of the proposed action, including the Trinity River Division, on listed Central Valley anadromous fish species and Southern Residents (as it pertains to effects on Central Valley Chinook salmon availability as prey). NMFS is analyzing the effects of the proposed action on SONCC coho salmon in a separate biological opinion. Reclamation is currently in consultation with NMFS on this aspect of its operations.

After consideration of the complexity of the SONCC coho salmon consultation and availability of staff resources, NMFS is committed to completing the SONCC coho salmon consultation by September 30, 2009.

1.5.2 ESA Consultation on CVP and SWP Hatcheries

CVP and SWP hatcheries within the Central Valley include the Livingston Stone National Fish Hatchery (LSNFH), Coleman National Fish Hatchery, Feather River Fish Hatchery (FRFH), and Nimbus Fish Hatchery. The USFWS, which manages the LSNFH and Coleman National Fish Hatchery, has requested a separate ESA section 7 consultation on those hatcheries. Therefore, the effects of the ongoing operations of the LSNFH and Coleman National Fish Hatchery are not analyzed as part of the proposed action in this consultation. The FRFH is a mitigation hatchery for the impacts of DWR's Oroville Dam. Currently, the Federal Energy Regulatory Commission (FERC) is in consultation with NMFS on the effects of relicensing Oroville Dam (including the effects of FRFH). Therefore, the FRFH is not considered in this consultation.

The Trinity River Fish Hatchery is part of the Trinity River Division of the CVP. Consistent with how NMFS will address the effects on SONCC coho salmon (see section 1.5.1, above), NMFS will defer the consideration of effects from Trinity River Fish Hatchery, as it pertains to any effects on SONCC coho salmon, to the separate formal consultation currently in process.

The exception to the above consultation considerations on CVP and SWP hatcheries is that all Chinook salmon production from all Central Valley hatcheries (*i.e.,* Coleman National Fish Hatchery, LSNFH, FRFH, Nimbus Fish Hatchery, Mokelumne Fish Hatchery, and Merced Fish Hatchery), in addition to the Trinity River Fish Hatchery, are considered in the analysis of effects on Southern Residents in this Opinion because these runs provide forage for Southern Residents. The Molelume River Hatchery (funded and operated by CDFG) and Merced Fish Hatchery (funded by the East Bay Municipal Utilities District and operated by CDFG) are not CVP or SWP hatcheries, but they make up a portion of hatchery-produced Chinook salmon from the Central Valley.

In summary, of all the CVP and SWP hatcheries, aside from hatchery production for the Southern Residents, the specific operation of Nimbus Fish Hatchery will be analyzed in this consultation. Overall, the combined effects from hatchery-produced fish in the Central Valley are included in the environmental baseline.

Managers for each CVP and SWP hatchery are currently engaged in discussions with NMFS in their development of a Hatchery and Genetic Management Plan (HGMP), pursuant to section 4 of the ESA. The HGMPs will include long-range planning and management of fish species cultured at the hatcheries. To that end, the consultation and exemption of incidental take related to the continued operation of Nimbus Hatchery will sunset 2 years from the date of issuance of this Opinion. As adoption of an HGMP under section 4 of the ESA is a Federal action, NMFS will conduct an intra-agency section 7 consultation prior to adoption of the HGMP.

1.5.3 ESA Consultation Linkage to the Operation of Oroville Dam

The Oroville Complex (Oroville Dam and related facilities, including the FRFH) is part of the SWP. DWR has been operating the Oroville Complex under a FERC license and is currently undergoing a relicensing process with FERC. The FERC license expired in January 2007, and until a new license is issued, DWR operates to the existing FERC license. FERC is currently in consultation with NMFS regarding the effects of relicensing the Oroville Complex for 50 years. Because the effects of the Oroville Complex are considered in the ongoing FERC consultation, the effects of operation of Oroville Dam on listed fish within the Feather River is not considered in this consultation. The analytical cutoff point of the hydrologic effects in the FERC analysis is at the Feather River's confluence with the Sacramento River. The effects of the flows from the Oroville Complex on all listed fish under NMFS jurisdiction in the Sacramento River and Delta are considered in this consultation.

1.5.4 Individual Contracts

This consultation addresses the long-term operations of the CVP and SWP, and does not satisfy Reclamation's ESA section 7(a)(2) obligations for issuance of individual water supply contracts. Reclamation should consult with NMFS separately on their issuance of individual contracts. The analysis of effects of the proposed actions, however, assumes water deliveries under the contracts, as described and modeled in the BA.

NMFS requests that by June 4, 2010, Reclamation provide written notification to NMFS and the State Water Resources Control Board (SWRCB) of any contract that it believes is creates a nondiscretionary obligation to deliver water, including the basis for this determination and the quantity of nondiscretionary water delivery required by the contract. Any incidental take due to delivery of water to such a contractor is not be exempt from the ESA section 9 take prohibition in this Opinion.

1.5.5 Inspector General's Report for the 2004 CVP/SWP Operations Opinion

On October 8, 2004, 19 members of the U.S. House of Representatives submitted a letter to the inspectors general of the departments of Interior and Commerce, requesting a review of allegations that Reclamation, "…in its haste to finalize water contracts in California, has improperly undermined the required NOAA Fisheries environmental review process for the proposed long-term Operations, Criteria, and Plan (OCAP) for the Central Valley Project (CVP) and the State Water Project (SWP)." Subsequent to that request, the Department of Commerce Office of Inspector General (IG), audited the process used by NMFS to develop the 2004 CVP/SWP operations Opinion, with objectives to: (1) identify the review process used to issue the 2004 CVP/SWP operations Opinion on Reclamation's CVP and DWR's SWP, and (2) determine whether NMFS – in developing the 2004 CVP/SWP operations Opinion – followed the consultation process for issuing biological opinions that is defined by its policies, procedures, and normal practices. On July 8, 2005, Johnnie E. Frazier (Office of Audits, Seattle Regional Office) issued Final Report STL-17242-5-0001 to NMFS, which included the following findings: (1) The NMFS southwest regional office deviated from the agency's established consultation initiation process, and (2) The southwest regional office did not follow its process for ensuring the quality of the biological opinion.

Section 1.4 provides details regarding the consultation history leading up to the issuance of this CVP/SWP operations Opinion. In response to IG finding #1, on November 21, 2008, NMFS issued a letter to Reclamation, indicating that Reclamation had provided sufficient information to reinitiate formal consultation on the effects of CVP/SWP operations, with the understanding that: (1) Reclamation is committed to working with NMFS staff to provide any additional information NMFS determines necessary to analyze the effects of the proposed action.

To address IG finding #2, NMFS issued a series of documents to provide a clear and transparent description of the roles and responsibilities of regional staff in the review and clearance process for consultation documents. The review and clearance process for non-routine formal consultations (which includes highly controversial, novel, or precedent-setting biological opinions, including this CVP/SWP operations Opinion) requires signatures of the Area Fffice Section 7 Coordinator, Area Office Supervisor, Regional Section 7 Coordinator, NOAA General Counsel, and Assistant Regional Administrator for Protected Resources on a clearance sheet acknowledging that proper review procedures were followed, prior to final signature by the Regional Administrator. During the review process, consultation documents were reviewed for consistency with applicable policies, procedures and mandates; scientific accuracy; legal sufficiency; clear, effective, and efficient communication of analysis and reasoning; and compliance with required format, style, and tone.

As provided above, the IG's recommendations have been incorporated into NMFS' review process and current formal consultation on the CVP/SWP operations.

1.5.6 Independent Peer Reviews of the 2004 CVP/SWP Operations Opinion

In 2005, NMFS initiated peer reviews of its 2004 CVP/SWP operations Opinion through CALFED and the CIE. In general, the peer reviewers' charge was to evaluate and comment on the technical information, models, analyses, results, and assumptions that formed the basis for the assessment of the proposed long-term water operations of the CVP and SWP. In December 2005, CALFED issued its report and findings to NMFS. Also in 2005, Dr. Thomas E. McMahon (CIE reviewer) and Dr. Jean-Jacques Maguire (CIE reviewer) issued their report and findings to NMFS. Each of the reports had constructive recommendations for the 2004 CVP/SWP operations Opinion. As an added level of review, NMFS requested the NMFS-Southwest Fisheries Science Center (SWFSC) to evaluate the peer reviews. The NMFS-SWFSC issued a report to NMFS-Protected Resources Division on May 25, 2006, concluding that the three peer reviews offered generally valid and helpful critiques of the science underlying the 2004 CVP/SWP operations Opinion. The CVP/SWP operations BA and this Opinion considered and/or incorporated all of the substantive peer review recommendations, as appropriate.

1.5.7 Reviews throughout the Current Reinitiated CVP/SWP Operations Consultation

1.5.7.1 Temperature Management and Modeling Workshop

The peer reviews of the 2004 CVP/SWP operations Opinion identified several temperature-related concerns, with recommendations on how to address those concerns. In February and March, 2008, NMFS convened an interagency planning team, consisting of representatives from Reclamation, DWR, USFWS, CALFED, and NMFS, to develop the scope and agenda for a workshop intended to provide a forum for discussion of issues related to temperature modeling and management on the upper Sacramento River in support of the CVP/SWP operations BA and NMFS' Opinion. On April 1, 2008, CALFED convened the 1-day public workshop, which consisted of a series of presentations and question-and-answer periods with selected local agency representatives, in Sacramento, California. Topics discussed included anadromous species' temperature needs, recovery approach for listed Central Valley salmonids, operational practices to manage temperature of the Sacramento River, modeling and technical tools presently used for CVP stream management, and case studies of temperature management in other watersheds. Following the workshop, CALFED convened a Review Panel of independent subject matter experts to evaluate the technical and scientific approach used to manage temperature in CVP streams as presented in the workshop. The Review Panel provided a written synthesis of topics discussed during the workshop, their perspective of important issues, and available tools (with recommendations for their use) for addressing water temperature management in the upper Sacramento River, in support of NMFS' Central Valley Recovery Plan temperature objectives (Deas *et al*. 2008). The CVP/SWP operations BA and this Opinion considered and incorporated, as appropriate, the recommendations from Deas *et al*. (2008).

1.5.7.2 Peer Review of NMFS' 2008 Draft CVP/SWP Operations Opinion

NMFS sought peer reviews of its 2008 draft CVP/SWP operations Opinion through CALFED and the CIE. Each review involved a different approach and process.

The CALFED review format involves convening of a Panel of independent subject matter experts who review documents provided, then meet in a public workshop format where the Panel may interact with NMFS and other agency staff, ask questions and clarify information regarding their review charge. Following the workshop, the Panel produces a report of their findings and recommendations. This approach is beneficial in that the Panel has the opportunity to clear up potential misunderstandings regarding the information they have been provided so that their product is most likely to provide relevant feedback to NMFS, and there is the potential to discover useful input from attendees at the workshop, as well as from collaboration among reviewers.

The CALFED peer review of the draft CVP/SWP operations Opinion occurred in two phases. The first phase was to evaluate and comment on NMFS analytical framework that would form the basis for this CVP/SWP operations Opinion. On July 22, 2008, NMFS submitted its analytical framework document to CALFED for peer review. On August 5, 2008, CALFED convened a public workshop in Sacramento, California, which consisted of several presentations from NMFS staff on the ESA section 7 consultation process and the proposed analytical approach, followed by a questions-and-answers session from the peer review Panel to the NMFS presenters. At the end of the workshop, the Panel requested additional information from NMFS in order for it to provide meaningful feedback and recommendations to assist us in the development of the CVP/SWP operations Opinion. Specifically, the Panel requested a copy of the CVP/SWP operations BA, making it clear that their intention was not to peer review the CVP/SWP operations BA, but to understand the information presented in the CVP/SWP operations BA in order to better respond to the peer review charge for the analytical framework. In addition, the peer review panel requested two mock analyses to show them how we intended to utilize our analytical framework, and also how the recommendations from the peer review of the 2004 CVP/SWP operations Opinion were addressed in the current reinitiated CVP/SWP operations consultation. After NMFS fulfilled the peer review panel's requests (at the time, the most recent draft of the CVP/SWP operations BA was August 20, 2008), a follow-up public workshop via conference call was held on August 29, 2008, mainly in the form of a questions-and-answers session. On November 4, 2008, NMFS received a letter from CALFED, transmitting the Panel's October 31, 2008, document, "Independent Review of the 2008 NMFS Analytical Framework for its CVP/SWP operations Biological Opinion."

The second phase of the CALFED peer review was the review of a draft of the CVP/SWP operations Opinion in the current consultation. The purpose of this independent review was to obtain the views of experts not involved in the consultation on the use of the best available scientific and commercial information as it pertains to the development of the CVP/SWP operations Opinion. In addition, CIE peer reviewed a draft of the CVP/SWP operations Opinion in the current consultation. On December 11, 2008, NMFS submitted its draft CVP/SWP operations Opinion to CALFED and the CIE for peer review. As NMFS had draft conclusions of jeopardy for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon, and adverse modification of designated critical habitats of winter-run, spring-run, CV steelhead, and proposed critical habitat for Southern DPS of green sturgeon, NMFS also provided the draft reasonable and prudent alternative (RPA) to CALFED for review. On January 8, 2009, CALFED convened a public workshop in Sacramento, California, which consisted of several presentations from NMFS staff, summarizing the effects analysis conducted in this consultation, followed by a questions-and-answers session from the Panel to the NMFS presenters. On January 26, 2009, NMFS received a letter from CALFED, transmitting the Panel's January 23, 2009, document, "Independent Review of a Draft Version of the 2009 NMFS CVP/SWP operations Biological Opinion" (Anderson *et al*. 2009).

The CALFED peer review approach also has been criticized for a potential lack of independence, as NMFS is a CALFED member agency. NMFS fully supports the CALFED criteria for independence in its reviews, but also sought independent peer review through the CIE.

The process for the CIE peer review is that CIE identifies a group of reviewers who will receive the materials for review. They conduct their reviews guided by "Terms of Reference," that is, a list of specific questions that NMFS requested to be answered in the peer review. The reviewers work independently, and after the specified review period, they provide individual review reports to CIE and NMFS.

On January 21, 2009, Dr. E. Eric Knudsen, Dr. Ian A. Fleming, and Dr. Richard A. Marston (CIE reviewers) issued their reports and findings to NMFS. Each of the peer review reports had constructive recommendations towards the development of a more scientifically robust final Opinion. However, in general, all of the peer reviewers and their reports acknowledged the incredibly complex proposed action, and that NMFS applied the best available information in its development of the draft Opinion. This Opinion, and its supporting administrative record, considered and/or incorporated all of the substantive peer review recommendations, as appropriate. NMFS also incorporated many of the suggested line edits from the peer review reports to improve the quality of this Opinion.

1.5.7.3 Reclamation's Review of the Draft CVP/SWP Operations Opinion

In addition to the CALFED and CIE peer reviews, on December 11, 2008, NMFS issued the draft CVP/SWP operations Opinion, draft RPA, and EFH Conservation Recommendations to Reclamation for its review and comments. On January 13, 2009, Reclamation provided its comments, in addition to transmitting comments from DWR. On March 3, 2009, NMFS issued a revised draft of its CVP/SWP operations Opinion and draft RPA to Reclamation for its review and comment. On March 20, 2009, Reclamation provided its comments, in addition to transmitting comments from DWR. DWR provided additional comments on April 20, April 28, and May 1, 2009. Many of Reclamation's and DWR's comments were consistent with and echoed those of the peer review reports. NMFS considered and/or incorporated all of Reclamation's and DWR's substantive comments, as appropriate.

1.5.8 Litigation and Settlement

1.5.8.1 USFWS' CVP/SWP Operations Consultation on Delta Smelt

On December 14, 2007, the United States District Court for the Eastern District of California issued an Interim Remedial Order in Natural Resources Defense Council, *et al*. v. Kempthorne, 1:05-cv-1207 OWW GSA (E.D. Cal. 2007), to provide additional protection of the Federally-listed Delta smelt pending completion of a new biological opinion for the continued operation of the CVP and SWP. The Interim Remedial Order remains in effect until the USFWS issues a new biological opinion for the continued operation of the CVP and SWP, which must be completed by September 15, 2008. A motion to extend the time for completion was filed on July 29, 2008. The court granted USFWS' request to extend its court-ordered deadline to complete the biological opinion to December 15, 2008.

The USFWS issued its biological opinion on December 15, 2008 (USFWS 2008a), with a jeopardy finding for Delta smelt, and adverse modification of Delta smelt designated critical habitat. In its biological opinion, the USFWS proposed an RPA for Reclamation to consider. On December 15, 2008, Reclamation issued a memorandum to the USFWS, provisionally accepting the USFWS' RPA, conditioned upon the further development and evaluation of RPA Components 3 and 4.

1.5.8.2 NMFS' CVP/SWP Operations Consultation

On April 16, 2008, the United States District Court for the Eastern District of California issued a Memorandum Decision and Order on the Cross-Motions for Summary Judgment filed in PCFFA *et al*. v. Gutierrez *et al*, 1:06-cv-245-OWW-GSA (E.D. Cal. 2008). The Court found that the Opinion issued by NMFS in 2004 was invalid. An evidentiary hearing followed, resulting in a Remedies Ruling on July 18, 2008. The ruling concluded that the court needed further evidence to consider the Plaintiffs' proposed restrictions on CVP/SWP operations. A Scheduling Order was filed by the court on July 24, 2008, and a further status conference was set for September 4, 2008. On October 21, 2008, Judge Wanger issued a ruling that California's canal water systems are placing wild salmon "unquestionably in jeopardy." However, he did not issue any court-ordered interim remedies pending a final NMFS Opinion, to be issued by March 2, 2009. A motion to extend the time for completion was filed on January 21, 2009. The court granted NMFS' request to extend its court-ordered deadline to complete the biological opinion to June 2, 2009.

1.6 Term of the Opinion

This biological opinion is effective through December 31, 2030.

2.0 Analytical Approach

2.1 Introduction

This section describes the analytical approach used by NMFS to evaluate the effects of the proposed action on listed species under NMFS jurisdiction. The approach is intended to ensure that NMFS comports with the requirements of statute and regulations when conducting and presenting the analysis. This includes the use of the best available scientific and commercial information relating to the status of the species and critical habitat and the effects of the proposed action.

The following sub-sections outline the specific conceptual framework and key steps and assumptions utilized in the listed species jeopardy risk assessment and the critical habitat destruction or adverse modification risk assessment. Wherever possible, these sections were written to apply to all six listed species, and associated designated and proposed critical habitats, occurring in the action area, which include:

- Endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*);
- Threatened Central Valley steelhead (*O. mykiss*);
- Threatened Central California Coast steelhead (*O. mykiss*);
- Threatened Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*);
- Endangered Southern Resident killer whales (*Orcinus orca*)
- Designated critical habitats for listed salmonids; and
- Proposed critical habitat for Southern DPS of green sturgeon.

In the case of listed salmonids, NMFS has additional data and analytical frameworks that are applied as part of the overall approach. These tools are called out in separate sub-sections. Readers are advised that with the exception of these specific sub-sections, the remainder of the discussion should be read as generally applicable to all affected listed species and critical habitats.

The following discussion of our analytical approach is organized into several sub-sections, with the first sub-section describing the legal framework provided by the ESA and case law and policy guidance related to section 7 consultations. Second, a general overview of how NMFS conducts its section 7 analysis is described, including various conceptual models of the overall approach and specific features of the approach are discussed. This includes information on tools used in the analysis specific to this consultation. We first describe our listed species analysis as it pertains to individual fish species and the physical, chemical, and biotic changes to the ecosystem caused by the proposed action. Description of our critical habitat analysis follows. Third, we discuss the evidence available for the analysis, the related uncertainties, and critical assumptions NMFS made to bridge data gaps in the information provided to initiate consultation. Fourth, we diagram the overall conceptual approach in the assessment to address the integration of all available information and decision frameworks to support our assessment of the effects of the proposed action. Finally, we discuss the presentation of all of these analyses within this Opinion to provide a basic guide to the reader on the relevant sections where the results of specific analytical steps can be reviewed.

2.2 Legal and Policy Framework

The purposes of the ESA, "*…are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section*." To help achieve these purposes, the ESA requires that, "*Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat…*"

Jeopardy Standard. The "jeopardy" standard has been further interpreted in regulation (50 CFR 402.02) as a requirement that Federal agencies insure that their actions are not likely to result in *appreciable reductions in the likelihood of both the survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution*. It is important to note that the purpose of the analysis is to determine whether or not appreciable reductions are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, our assessment often focuses on whether an appreciable reduction is expected or not, but not on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (absolute abundance, for example) that could occur as a result of proposed action implementation.

For the purposes of this analysis, NMFS equates a listed species' probability (or risk) of extinction with the likelihood of both the survival and recovery of the species in the wild for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA. In the case of listed salmonids, we use the Viable Salmonid Populations (VSP) framework (McElhany *et al.* 2000) as a bridge to the jeopardy standard. A designation of "a high risk of extinction" or "low likelihood of becoming viable" indicates that the species faces significant risks from internal and external processes that can drive it to extinction. The status assessment considers and diagnoses both the internal and external processes affecting a species' extinction risk.

For salmonids, the four VSP parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the survival and recovery of the listed salmonid species (McElhany *et al*. 2000). The VSP parameters of productivity, abundance, and population spatial structure are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02) and are used as surrogates for "numbers, reproduction, and distribution." The VSP parameter of diversity relates to all three jeopardy criteria. For example, numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-levels.

NMFS is currently in the process of developing a recovery plan for the listed Central Valley salmon and steelhead species. A technical recovery team (TRT) was established to assist in the effort. One of the TRT products, Lindley *et al*. (2007), provides a "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin." Along with assessing the current viability of the listed Central Valley salmon and steelhead species, Lindley *et al*. (2007) provided recommendations for recovering those species. In addition, a co-managers' review draft of the Central Valley recovery plan was issued, and NMFS received comments from various co-managers. A public review draft of the recovery plan is likely to be issued in 2009. Lindley *et al*. (2007) was relied on to establish the current status of the listed Central Valley salmon and steelhead species, and both Lindley *et al*. (2007) and the draft recovery plan were utilized to evaluate whether the proposed action does not "reduce appreciably the likelihood of survival and recovery."

Destruction or Adverse Modification Standard. For critical habitat, NMFS did not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the analysis with respect to critical habitat. NMFS will evaluate "destruction or adverse modification" of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species.

Additional requirements on the analysis of the effects of an action are described in regulation (50 CFR 402) and our conclusions related to "jeopardy" and "destruction or adverse modification" generally require an expansive evaluation of the direct and indirect consequences of the proposed action, related actions, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected species and critical habitat [for example, see the definitions of "cumulative effects," "effects of the action," and the requirements of 50 CFR 402.14(g)].

Recent court cases have reinforced the requirements provided in section 7 regulations that NMFS must evaluate the effects of a proposed action within the context of the current condition of the species and critical habitat, including other factors affecting the survival and recovery of the species and the functions and value of critical habitat. In addition, the courts have directed that our risk assessments consider the effects of climate change on the species and critical habitat and our prediction of the future impacts of a proposed action.

Consultations designed to allow Federal agencies to fulfill these purposes and requirements are concluded with the issuance of a biological opinion or a concurrence letter. For biological opinions, section 7 of the ESA and the implementing regulations (50 CFR 402), and associated guidance documents (*e.g.,* USFWS and NMFS 1998) require the opinions to present: (1) a description of the proposed Federal action; (2) a summary of the status of the affected species and its critical habitat; (3) a summary of the environmental baseline within the action area; (4) a detailed analysis of the effects of the proposed action on the affected species and critical habitat;

(5) a description of cumulative effects; and (6) a conclusion as to whether it is reasonable to expect the proposed action is not likely to appreciably reduce the species' likelihood of both surviving and recovering in the wild by reducing its numbers, reproduction, or distribution or result in the destruction or adverse modification of the species designated critical habitat.

2.3 General Overview of the Approach and Models Used

NMFS uses a series of sequential analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat. These sequential analyses are illustrated in figure 2-1. The first analysis identifies those physical, chemical, or biotic aspects of proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effects on the environment (we use the term "stressors" for these aspects of an action). As part of this step, we identify the spatial extent of any potential stressors and recognize that the spatial extent of those stressors may change with time (the combined spatial extent of these stressors is the "action area" for a consultation).

The second step of our analyses starts by identifying the endangered species, threatened species, or designated or proposed critical habitat that are likely to occur in the same space and at the same time as these potential stressors. Then we try to estimate the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number and age (or life stage) of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent or the specific areas and primary constituent elements of critical habitat that are likely to be exposed.

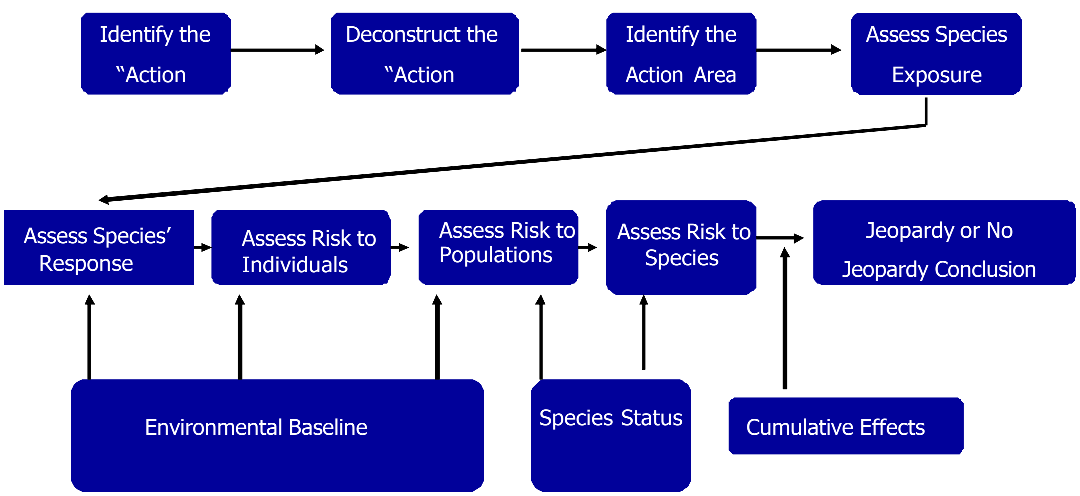


Figure 2-1. General Conceptual Model for Conducting Section 7 as Applied to Analyses for Listed Species.

Once we identify which listed resources (endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, in the third step of our analyses, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*). The final steps of our analyses - establishing the risks those responses pose to listed resources - are different for listed species and designated critical habitat and are further discussed in the following sub-sections (these represent our *risk analyses*).

2.3.1 Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species and how those "species" have been listed (*e.g*., as true biological species, subspecies, or distinct population segments of vertebrate species). Because the continued existence of listed species depends on the fate of the populations that comprise them, the probability of extinction, or probability of persistence of listed species depends on the probabilities of extinction and persistence of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. We identify the probable risks that actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individuals risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an action's effects on the environment (which we identify in our *response analyses*) are likely to have consequences for the individual's fitness.

When individuals, whether they are listed plants or animals, are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for increases in a population's probability of extinction, which is itself a *necessary* condition for increases in a species' probability of extinction.

If we conclude that listed plants or animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness reductions are likely to be sufficient to increase the probability of extinction of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, diversity, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *Status of the Species* section of this Opinion) as our point of reference. Generally, this reference condition is a measure of how near to or far from a species is to extinction or recovery.

An important tool we use in this step of the assessment is a consideration of the life cycle of the species. The consequences on a population's probability of extinction as a result of impacts to different life stages are assessed within the framework of this life cycle and our current knowledge of the transition rates (essentially, survival and reproductive output rates) between stages, the sensitivity of population growth to changes in those rates, and the uncertainty in the available estimates or information. An example of a Pacific salmonid life cycle is provided in figure 2-2.

Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for all species considered in this Opinion; however data from surrogate species may be available for inference. Where available, information on transition rates, sensitivity of population growth rate to changes in these rates, and the relative importance of impacts to different life stages is used to inform the translation of individual effects to population level effects. Generally, however, we assume that the consequences of impacts to older reproductive and pre-reproductive life stages are more likely to affect population growth rates than impacts to early life stages. But it is not always the adult transition rates that have the largest effect on population growth rate. For example, absolute changes in the number of smolts that survive their migration to the ocean may have the largest impact on Chinook salmon population growth rate (Wilson 2003) followed by the number of alevins that survive to fry stage (POPTOOLS add-in to Microsoft Excel sensitivity analysis of simplified Chinook salmon life table).

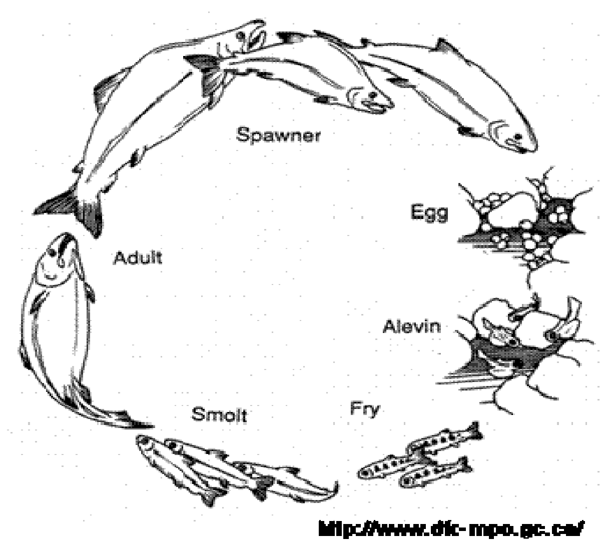


Figure 2-2. Conceptual diagram of the life cycle of a Pacific salmonid.

Similarly, in some sturgeon species, growth rate is most sensitive to young-of-the-year (YOY) and juvenile survival, and less sensitive to annual adult fecundity and survival (Caswell 2001). Thus, habitat alterations that decrease the survival of YOY or any class within the juvenile life stage will more strongly influence the affected population's growth rate than if the alteration will only affect fecundity or survival of adults (Gross *et al*. 2002).

In addition, we recognize that populations may be vulnerable to small changes in transition rates. As hypothetically illustrated in figure 2-3, small reductions across multiple life stages can be sufficient to cause the extirpation of a population through the reduction of future abundance and reproduction of the species.

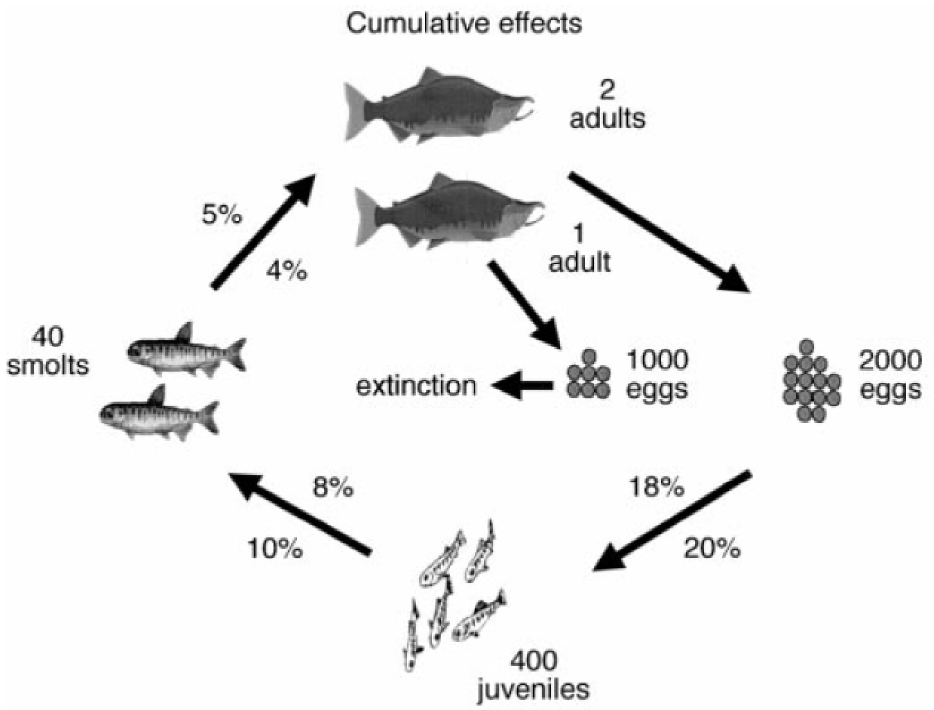
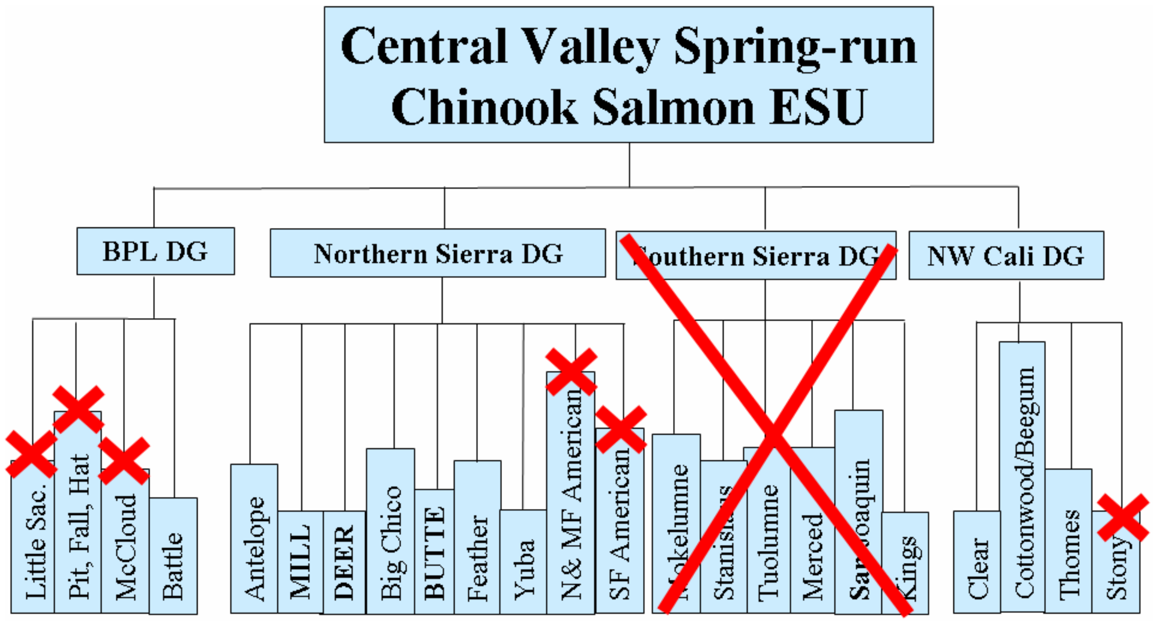


Figure 2-3. Illustration of cumulative effects associated with different life stages of Pacific salmon. It is possible to increase population size or drive the population to extinction by only slight changes in survivorship at each life history stage. Originally figure 9 in Naiman and Turner (2000, reproduced with permission from the publisher).

Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference. We also use our knowledge of the population structure of the species to assess the consequences of the increase in extinction risk to one or more of those populations. Our *Status of the Species* section will discuss the available information on the structure and diversity of the populations that comprise the listed species and any available guidance on the role of those populations in the recovery of the species. An example conceptual model of the population structure of spring-run is provided in figure 2-4. This model illustrates the historic structure of the species and notes those populations that have been extirpated to provide a sense of the existing and lost diversity and structure within the species. Both the existing and lost diversity and structure are important considerations when evaluating the consequences of increases in the extinction risk of an existing population or effects to areas that historically had populations.



BPL – Basalt and Porous Lava
NW Cali - Northwest California
DG – Diversity Group

Figure 2-4. Population structure of the Central Valley spring-run Chinook salmon ESU. Red crosses indicate populations and diversity groups that have been extirpated. Extant independent populations are identified in all capital letters. It should be noted that all four independent populations which historically occurred in the Feather River watershed tributaries (*i.e.*, north, middle, and south forks, and the west branch) are now extinct, however, a hatchery population does currently occur in the Feather River below Oroville Dam. Chinook salmon exhibiting spring-run characteristics occur in the mainstem Sacramento River below Keswick Dam.

NMFS developed a set of tables designed to collect and evaluate the available information on the expected proposed action stressors and the exposure, response and risk posed to individuals of the species. Figure 2-6 outlines the basic set of information we evaluated. We rank the effects to individuals on the basis of the severity of the predicted response and resulting fitness consequence within life stages. As discussed above, in the absence of other information, we assume that fitness consequences to smolts are more likely to have resulting population level effects than impacts to early life stages, like eggs or alevins.

A discussion of the method of determining effects to individuals of the species using listed salmonids.

The first steps in evaluating the potential impacts a project may have on an individual fish would entail: (1) identifying the seasonal periodicity and life history traits and biological requirements of listed salmon and steelhead within the Project area. Understanding the spatial and temporal occurrence of these fish is a key step in evaluating how they are affected by current human activities and natural phenomena; (2) identifying the main variables that define riverine characteristics that may change as the result of project implementation; (3) determining the extent of change in each variable in terms of time, space, magnitude, duration, and frequency; (4) determining if individual listed species will be exposed to potential changes in these variables; and (5) then evaluating how the changed characteristic would affect the individual fish in terms of the fish's growth, survival, and/or reproductive success.

Riverine characteristics may include: flow, water quality, vegetation, channel morphology, hydrology, neighboring channel hydrodynamics, and connectivity among upstream and downstream processes. Each of these main habitat characteristics is defined by several attributes (*i.e*., water quality includes water temperature, dissolved oxygen, ammonia concentrations, turbidity, *etc.*). The degree to which the proposed project may change attributes of each habitat characteristic will be evaluated quantitatively and/or qualitatively, in the context of its spatial and temporal relevance. Not all of the riverine characteristics and associated attributes identified above may be affected by proposed project implementation to a degree where meaningful qualitative or quantitative evaluations can be conducted. That is, if differences in flow with and without the proposed project implementation are not sufficient to influence neighboring channel hydrodynamics, then these hydrodynamics will not be evaluated in detail, either quantitatively or qualitatively. The changed nature of each attribute will then be compared to the attribute's known or estimated habitat requirements for each fish species and life stage. For example, if water temperature modeling results demonstrate that water temperatures during the winter-run spawning season (mid-April through mid-August) would be warmer with implementation of the proposed project, then the extent of warming and associated impact, would be assessed in consideration of the water temperature ranges required for successful winter-run spawning.

NMFS then evaluates the likely response of listed salmonids to such stressors based on the best available scientific and commercial information available, including observations of how similar exposures have affected these species. NMFS assesses whether the conditions that result from the proposed project, in combination with conditions influenced by other past and ongoing activities and natural phenomena as described by the factors responsible for the current status of the listed species, will affect growth, survival, or reproductive success (*i.e.,* fitness) of individual listed salmonids at the life stage scale.

NMFS will then evaluate how the proposed project's effects on riverine characteristics may affect the growth, survival, and reproductive success of individual fish. For example, growth and survival and reproductive success of individual fish may all be affected if the proposed project results in increased water temperatures during multiple life stages. Individual fish growth also may be affected by reduced availability, quantity, and quality of habitats (*e.g*., floodplains, channel margins, intertidal marshes, *etc*.). Survival of an individual fish may be affected by suboptimal water quality, increased predation risk associated with non-native predatory habitats and physical structures (such as gates, weirs), impeded passage, and susceptibility to disease. Reproductive success of individual fish may be affected by impeded or delayed passage to natal streams, suboptimal water quality (*e.g*., temperature), which can increase susceptibility to disease, and reduced quantity and quality of spawning habitats. Instream flow studies (*e.g*., instream flow incremental methodology studies) available in the literature, which describe the relationship between spawning habitat availability and flow, will be used to assess proposed project-related effects on reproductive success. All factors associated with the proposed project that affect individual fish growth, survival, or reproductive success will be identified during the exposure analyses.

For example, the Central Valley Domain TRT recommended that for winter-run, spring-run, and CV steelhead, all extant (still surviving) populations should be secured and that, "…*every extant population be viewed as necessary for the recovery of the ESU [Evolutionarily Significant Unit]*" (Lindley *et al*. 2007). Based on this recommendation, it was assumed that if appreciable reductions in any population's viability are expected to result from implementation of the proposed action, then this would be expected to appreciably reduce the likelihood of both the survival and recovery of the diversity group the population belongs to as well as the listed ESU/DPS.

Figure 2-1 outlined these basic steps in the analysis. Table 2-1 presents the basic set of propositions and consultation outcomes associated with acceptance or rejection of those propositions that we utilize when conducting our evaluation of effects of the proposed action. These follow a logic path and hierarchical structure (figure 2-5) that is used to organize the jeopardy risk assessment.

Table 2-1. Reasoning and decision-making steps for analyzing the effects of the proposed action on listed species. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment	True	End
		False	Go to B
B	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action	True	NLAA
		False	Go to C
C	Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA
		False	Go to D
D	Any responses are not likely to constitute "take" or reduce the fitness of the individuals that have been exposed.	True	NLAA
		False	Go to E
E	Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent.	True	NLJ
		False	Go to F
F	Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species.	True	NLJ
		False	LJ

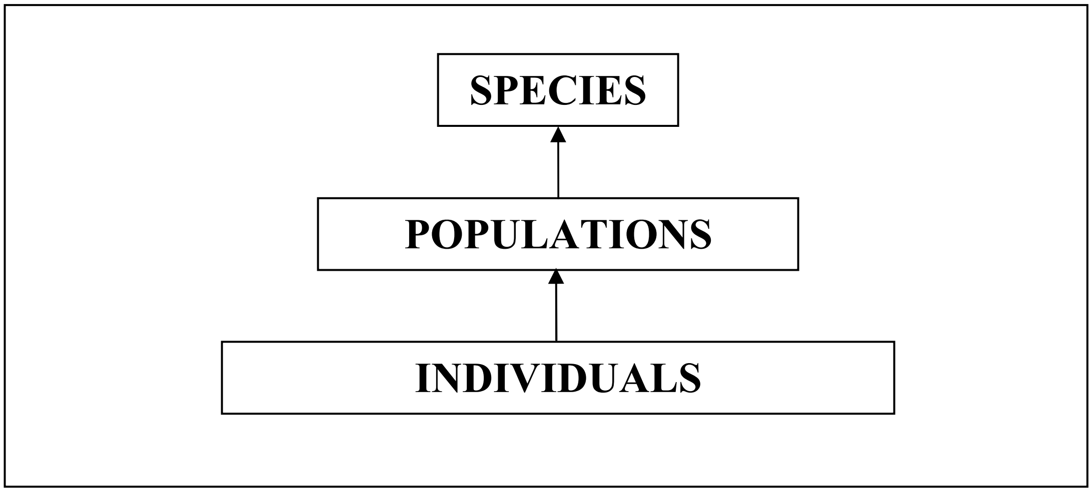


Figure 2-5. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment.

Division of Project, Location, Species	Life history stage	Timing of life history stage	Stressor (freq, intensity, duration)	Existing Stress Regime	Interactions	Response (near term)	Response (long-term)	Probable fitness reduction

Figure 2-6. General set of information collected to track effects of the proposed action and resulting exposure, response, and risk to listed species.

2.3.1.1 The Viable Salmonid Populations Framework in Listed Salmonid Analyses

In order to assess the survival and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. This has been generally defined above. For Pacific salmon, McElhany *et al*. (2000) defines VSP as an independent population that has a negligible probability of extinction over a 100-year time frame. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as ESU or DPS. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (*i.e*., population growth rate); (3) population spatial structure; and (4) diversity (McElhany *et al.* 2000). These four parameters and their associated attributes are presented in figure 2-7. In addition, the condition and capacity of the ecosystem upon which the population (and species) depends plays a critical role in the viability of the population or species. Without sufficient space, including accessible and diverse areas the species can utilize to weather variation in their environment, the population and species cannot be resilient to chance environmental variations and localized catastrophes. As discussed in the *Status of the Species*, salmonids have evolved a wide variety of life history strategies designed to take advantage of varying environmental conditions. Loss or impairment of the species’ ability to utilize these adaptations increases their risk of extinction.

ABUNDANCE (N)

A population should be large enough to survive and be resilient to environmental variations and catastrophes such as fluctuations in ocean conditions, local contaminant spills, or landslides.

Population size must be sufficient to maintain genetic diversity.

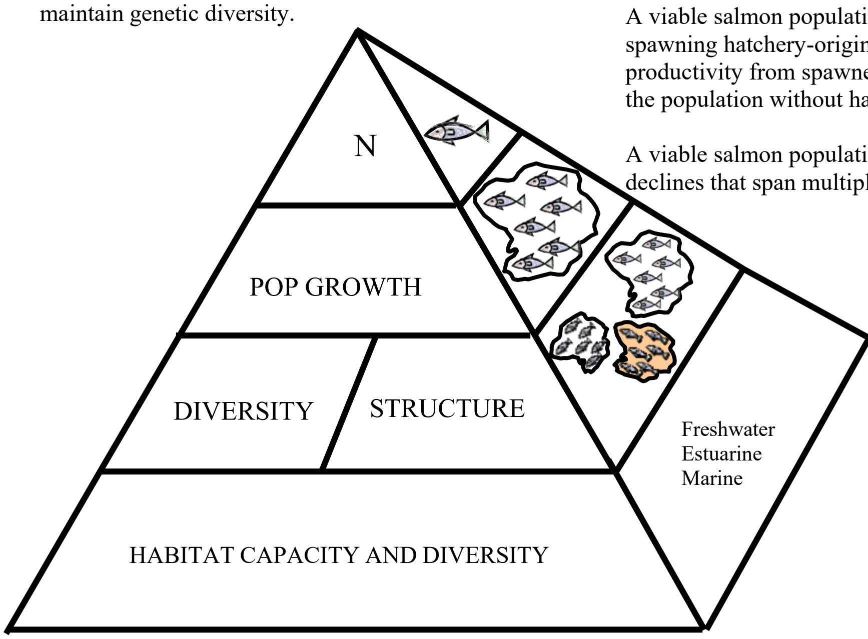
PRODUCTIVITY (POPULATION GROWTH RATE)

Natural productivity should be sufficient to reproduce the population at a level of abundance that is viable.

Productivity should be sufficient throughout freshwater, estuarine, and nearshore life stages to maintain viable abundance levels, even during poor ocean conditions.

A viable salmon population that includes naturally spawning hatchery-origin fish should exhibit sufficient productivity from spawners of natural origin to maintain the population without hatchery subsidy.

A viable salmon population should not exhibit sustained declines that span multiple generations.



DIVERSITY

Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity (birth rate), morphology, behavior, and genetic characteristics.

The rate of gene flow among populations should not be altered by human caused factors.

Natural processes that cause ecological variation should be maintained.

SPATIAL STRUCTURE

Habitat patches should not be destroyed faster than they are naturally created.

Human activities should not increase or decrease natural rates of straying among salmon sub-populations.

Habitat patches should be close enough to allow the appropriate exchange of spawners and the expansion of population into underused patches.

Some habitat patches may operate as highly productive sources for population production and should be maintained.

Due to the time lag between the appearance of empty habitat and its colonization by fish, some habitat patches should be maintained that appear to be suitable, or marginally suitable, even if they currently contain no fish.

Figure 2-7. Viable salmonid population (VSP) parameters and their attributes. In addition, the quality, quantity and diversity of the habitat (habitat capacity and diversity) available to the species in each of its three main habitat types (freshwater, estuarine and marine environments) is a critical foundation to VSP. Salmon cannot persist in the wild and withstand natural environmental variations in limited or degraded habitats.

As presented in Good *et al*. (2005), criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical, because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (*i.e*., population growth rate) provides information on important demographic processes. Genotypic and phenotypic diversity are important in that they allow species to use a wide array of environments, respond to short-term changes in the environment, and adapt to long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats, and can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change.

The VSP concept also identifies guidelines describing a viable ESU/DPS. The viability of an ESU or DPS depends on the number of populations within the ESU or DPS, their individual status, their spatial arrangement with respect to each other and to sources of potential catastrophes, and diversity of the populations and their habitat (Lindley *et al*. 2007). Guidelines describing what constitutes a viable ESU are presented in detail in McElhany *et al*. (2000). More specific recommendations of the characteristics describing a viable Central Valley salmon population are found in table 1 of Lindley *et al.* (2007).

Along with the VSP concept, NMFS uses a conceptual model of the species to evaluate the potential impact of proposed actions. For the species, the conceptual model is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity group, and ESU/DPS (figure 2-8). The guiding principle behind this conceptual model is that the viability of a species (*e.g*., ESU) is dependent on the viability of the diversity groups that compose that species and the spatial distribution of those groups; the viability of a diversity group is dependent on the viability of the populations that compose that group and the spatial distribution of those populations; and the viability of the population is dependent on the four VSP parameters, and on the fitness and survival of individuals at the life stage scale. The anadromous salmonid life cycle (see figure 2-2) includes the following life stages and behaviors, which will be evaluated for potential effects resulting from the proposed action: adult immigration and holding, spawning, embryo incubation, juvenile rearing and downstream movement[1], and smolt outmigration.

2.3.1.2 Approach to Southern DPS of Green Sturgeon

Although McElhany *et al*. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany *et al*. (2000) can also be applied to the Southern DPS of green sturgeon. Therefore, in this consultation, NMFS applies McElhany *et al*. (2000) and the viability parameters in its characterization of the environmental baseline and analysis of effects of the action to the Southern DPS of green sturgeon.

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[1] The juvenile rearing and downstream movement life stage is intended to include fry emergence, and fry and fingerling rearing, which occurs both in natal streams and as these fish are moving downstream through migratory corridors at a pre-smolt stage. The distinction between juveniles and smolts is made because smolts have colder thermal requirements than juveniles that are not undergoing osmoregulatory physiological transformations.

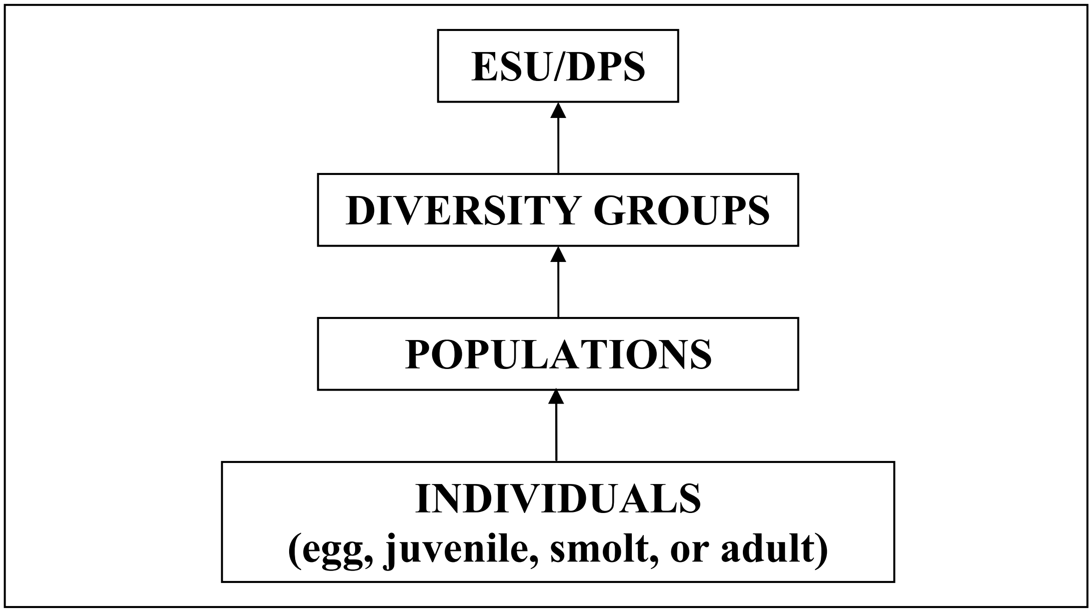

Figure 2-8. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for anadromous salmonids.

2.3.1.3 Approach Specific to Southern Resident Killer Whales

The General Approach (section 2.3) and Application of the Approach to Listed Species Analysis (section 2.3.1) described above also applies to our approach for Southern Residents. The Southern Resident killer whale DPS is a single population. The population is composed of three pods, or groups of related matrilines, that belong to one clan of a common but older maternal heritage (NMFS 2008a). The Southern Residents population is sufficiently small and the probability of quasi-extinction is sufficiently likely that all individuals of the three pods are important to the survival and recovery of the DPS. Representation from all three pods is necessary to meet biological criteria for Southern Resident downlisting and recovery (NMFS 2008). For these reasons, it is NMFS' opinion that any action that is likely to hinder the reproductive success or result in serious injury or mortality of a single individual is likely to appreciably reduce the survival and recovery of the DPS. Therefore, effects on the Southern Resident killer whale DPS are informed by evaluating effects on individual whales.

2.3.2 Application of the Approach to Critical Habitat Analyses

The basis of the "destruction or adverse modification" analysis is to evaluate whether the proposed action results in negative changes in the function and role of the critical habitat in the conservation of the species. Our evaluation of habitat conservation value entails an assessment of whether the essential features are functioning to meet the biological requirements of a recovered species, or how far the features are from this condition. As a result, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential for the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, we ask if constituent elements included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area value for the conservation of the species are likely to respond to that exposure. In particular we are concerned about responses that are sufficient to reduce the quantity, quality, or availability of those constituent elements or physical, chemical, or biotic phenomena.

To conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in figure 2-1 and applies a set of reasoning and decision-making questions designed to aid in our determination. These questions follow a similar logic path and hierarchical approach of the elements and areas within a critical habitat designation. The reasoning and decision-making steps are outlined in table 2-2. Figure 2-9 contains the basic hierarchical organization of critical habitat.

Table 2-2. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Designated Critical Habitat. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Adverse Modification of Critical Habitat (AD MOD).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	The proposed action is not likely to produce stressors that have direct of indirect adverse consequences on the environment	True	End
		False	Go to B
B	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action	True	NLAA
		False	Go to C
C	The quantity, quality, or availability of all constituent elements of critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA
		False	Go to D
D	Any reductions in the quantity, quality, or availability of one or more constituent elements of critical habitat are not likely to reduce the conservation value of the exposed area	True	-
		False	Go to E
E	Any reductions in the conservation value of the exposed area of critical habitat are not likely to reduce the conservation value of the critical habitat designation	True	No AD MOD
		False	AD MOD

To aid our analysis, NMFS developed a set of tables designed to track and combine the stressors, exposure, response, and risk related to the various elements of the proposed action. Figure 2-10 contains the basic set of information we evaluated. These tables allow us to determine the expected consequences of the action on elements and areas of critical habitat, sort or rank through those consequences, and determine whether areas of critical habitat are exposed to additive effects of the proposed action and the environmental baseline. We rank the effects to critical habitat on the basis of the severity of the predicted response of the element or area within the functions provided by various areas of critical habitat (effects ranked within spawning habitat or migratory corridors, for example). In the absence of information regarding the relative importance or vulnerability of different habitat types, we did not find it appropriate to attempt to rank effects across habitat types or functions. We recognize that the conservation value of critical habitat is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, *etc*. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also considered how areas and functions of designated critical habitat are likely to respond to any interactions and synergisms between or cumulative effects of pre-existing stressors and proposed stressors.

At the heart of the analysis is the basic premise that the conservation value of an overall critical habitat designation is the sum of the values of the components that comprise the habitat. For example, the conservation value of listed salmonid critical habitat is determined by the conservation value of the watersheds that make up the designated area. In turn, the conservation value of the components is the sum of the value of the primary constituent elements (PCEs) that make up the area. PCEs are specific areas or functions, such as spawning or rearing habitat, that support different life history stages or requirements of the species. The conservation value of the PCE is the sum of the quantity, quality, and availability of the essential features of that PCE. Essential features are the specific processes, variables, or elements that comprise a PCE. Thus, an example of a PCE would be spawning habitat and the essential features of that spawning habitat would be conditions such as clean spawning gravels, appropriate timing and duration of certain water temperatures, and water free of pollutants.

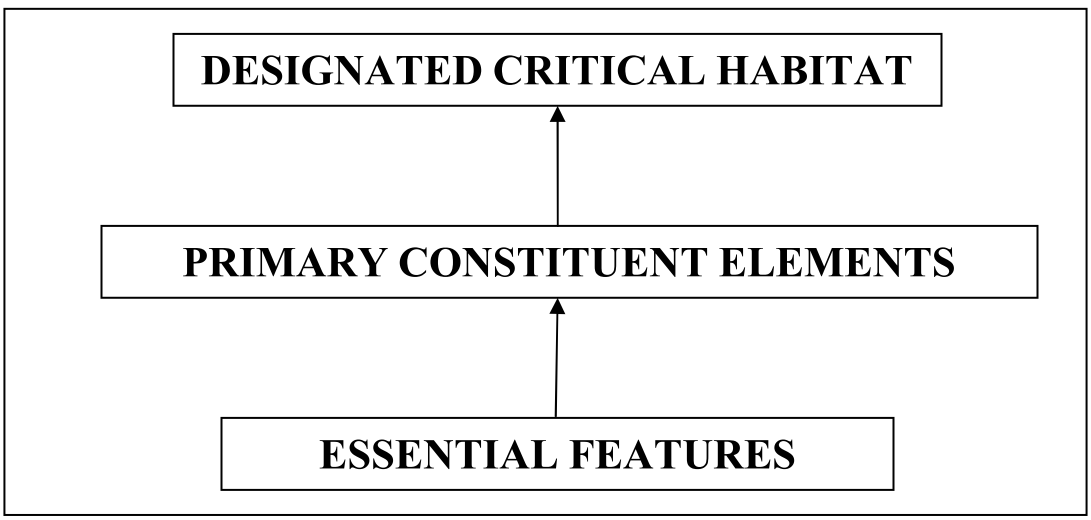

Figure 2-9. Conceptual model of the hierarchical structure that is used to organize the destruction or adverse modification assessment for critical habitat. This structure is sometimes collapsed for actions with very large action areas that encompass more than one specific area or feature.

Division of Project, Location	Critical Habitat Area or Feature	Primary Const. Element	Stressor (freq, intensity, duration)	Existing Stress Regime	Interactions	Response (near term)	Response (long-term)	Probable reduction in quantity, quality, or function

Figure 2-10. General set of information collected to track proposed action effects and resulting exposure, response, and risk to elements of critical habitat.

Therefore, reductions in the quantity, quality, or availability of one or more essential features reduce the value of the PCE, which in turn reduces the function of the sub-area (*e.g.*, watersheds), which in turn reduces the function of the overall designation. In the strictest interpretation, reductions to any one essential feature or PCE would equate to a reduction in the value of the whole. However there are other considerations. We look to various factors to determine if the reduction in the value of an essential feature or PCE would affect higher levels of organization. For example:

- The timing, duration and magnitude of the reduction
- The permanent or temporary nature of the reduction
- Whether the essential feature or PCE is limiting (in the action area or across the designation) to the recovery of the species or supports a critical life stage in the recovery of the species (for example, juvenile survival is a limiting factor in recovery of the species and the habitat PCE supports juvenile survival).

In our assessment, we combine information about the contribution of critical habitat PCEs (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) to the conservation value of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those PCEs in the action area. We use the conservation value of those areas of designated critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment of the consequences of the added effects of the proposed action on that conservation value.

Figure 2-11 illustrates the basic model of the critical habitat analysis following the hierarchical organization of critical habitat and the comparison between the reference (without action) condition of the conservation value of critical habitat and the conservation value of critical habitat with action implementation.

2.3.3 Characterization of the Environmental Baseline

ESA regulations define the environmental baseline as “the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process” (50 CFR 402.02). The "effects of the action” include the direct and indirect effects of the proposed action and of interrelated or interdependent activities, “that will be added to the environmental baseline” (50 CFR 402.02). Implicit in both these definitions is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to natural processes, are part of the future baseline, to which effects of the proposed project are added.

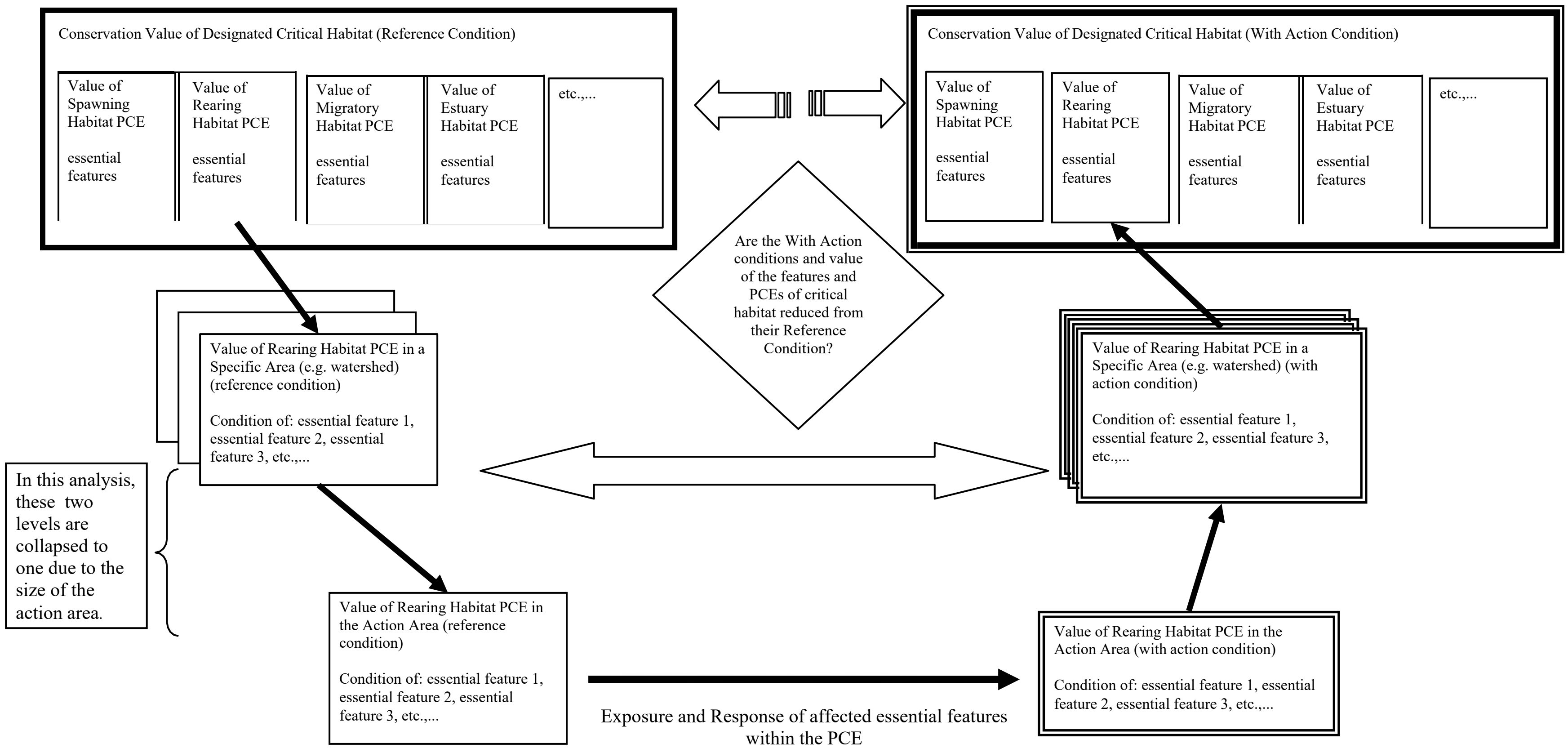

Figure 2-11. Conceptual diagram of the critical habitat analyses presented in this biological opinion. For illustration purposes, the Rearing Habitat PCE for listed salmonids is pulled out to show the basic flow of the analysis. Full analyses consider the effects to all PCEs and essential features of critical habitat.

In consultations on continuing actions such as CVP/SWP operations, it is quite difficult to separate future baseline effects from the anticipated effects of the proposed action. Operations of existing structures, such as dams and gates, for water supply, flood control, and other purposes -- the proposed action -- are integrally related to the existence of the structures themselves, but effects of the mere existence of the structures are not effects of the proposed action. *See National Wildlife Federation v. National Marine Fisheries Service,* 524 F.3d 917, 930-31 (9th Cir. 2008). Similarly, some activities that are part of the proposed project are non-discretionary, and their effects are also not effects of the proposed action. *See id*. at 928-29 (citing *National Ass'n of Home Builders v. Defenders of Wildlife*, 551 U.S. 644 (2007).

Consequently, it is not surprising that in its review of NMFS' December 11, 2008, draft OCAP Opinion, the CALFED Science Review Panel (Anderson *et al*. 2009) commented that a clearly defined baseline was lacking. Reclamation (2009) provided similar comments. NMFS acknowledges that it was not easy to discern a uniform approach to characterizing the environmental baseline in the draft Opinion. NMFS believes, however, that this is due to the nature of the action under consultation and available information, rather than a flawed approach to the analysis. NMFS clarifies its approach here and in relevant sections of the Opinion.

In *National Wildlife Federation*, a case regarding consultation on the effects of operating hydropower dams on the Columbia River, the 9th Circuit Court of Appeals rejected NMFS' attempt to narrow the "effects of the action" by defining the baseline to include operations that NMFS deemed to be "nondiscretionary." The Court observed that many of the actions NMFS deemed "nondiscretionary" actually were subject to the action agencies' discretion, and it held that it was impermissible to create an imaginary "reference operation" excluding these actions, to which the effects of the action could be compared. Rather, the Court said that the regulatory requirement to consider the effects of the action added to the environmental baseline "simply requires NMFS to consider the effects of [the] actions 'within the context of other existing human activities that impact the listed species.' [citations omitted]" *Id*. at 930. In other words, the effects of a particular Federal action are intended to be evaluated not simply on their own, but as they affect the species in combination with other processes and activities.

The question addressed in a consultation is whether the *project* jeopardizes the species' continued existence. As the court stated in *National Wildlife Federation*, even if the baseline itself causes jeopardy to the species, only if the project causes additional harm can the project be found to jeopardize the species' continued existence. *Id.* This determination requires an evaluation of the *project's* effects, separate from the conditions that would exist if the project were not carried out.

NMFS and Reclamation together attempted to isolate the effects of proposed project operations by segregating the activities that are within Reclamation's discretion to change in the future from those that are not. This effort was not fruitful. The CVP/SWP operations BA begins with a summary of legal and statutory authorities, water rights, and other obligations relevant to the action (Chapter 1), all of which are incorporated into the project description (Chapter 2). Neither chapter describes what Reclamation's nondiscretionary operations would be if discretionary aspects of the proposed action were not implemented. In addition, in all of the models and simulations that Reclamation used to prepare the CVP/SWP operations BA, a "no project" scenario was not run. For example, table 2-1 in the CVP/SWP operations BA identifies the major proposed operational actions for consultation, including implementation of the water quality control plan (WQCP), but it is not clear whether implementing the WQCP, or some portion of it, is a non-discretionary action.

Consequently, we determined that if NMFS were to propose a "no project operations" scenario to characterize the environmental baseline, it would be speculative and not supported by the model runs. Following the 9th Circuit's reasoning, with limited exceptions, NMFS assumed that all CVP and SWP operations are subject to the discretion of the project agencies and, thus, that all effects of future operations are effects of the proposed action. The only project effects considered to be within the future baseline (and thus not effects of the proposed action) are those caused by activities that are clearly outside the agencies' authority. For example, as in *National Wildlife Federation,* it is not within the agencies' discretion to remove dams, so the effects of their existence are part of the baseline. Figure 2-12 provides a conceptual diagram of how NMFS characterizes the past and future components of the environmental baseline for consultations on an ongoing action.

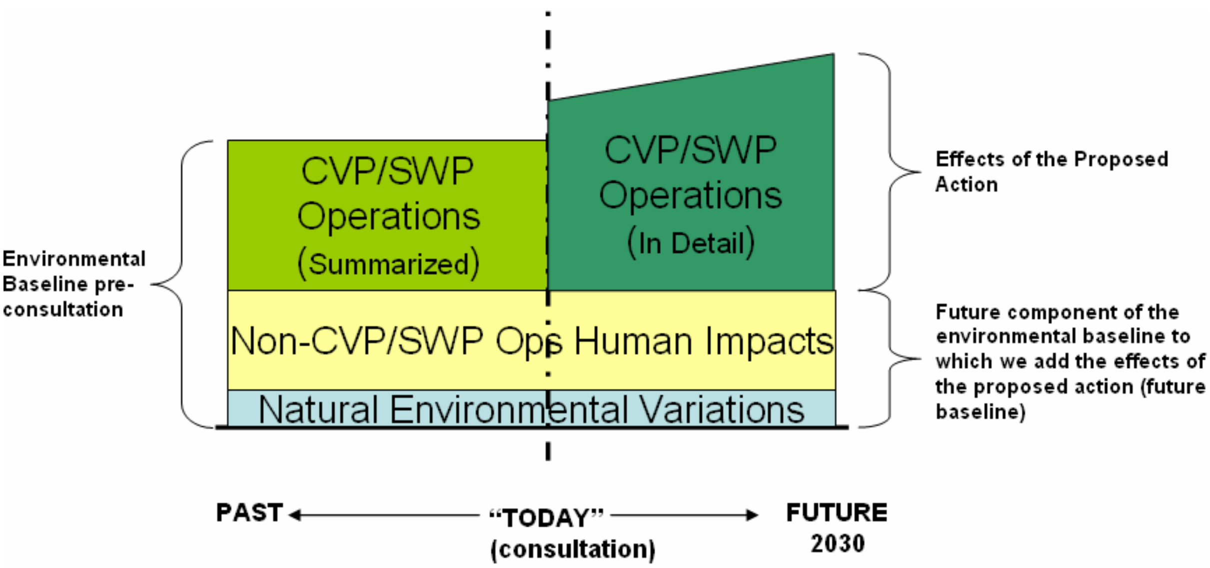

Figure 2-12. Conceptual diagram of how the environmental baseline changes in this NMFS Opinion. The right side of the figure depicts the effects of the proposed action added on top of the baseline into the future (future baseline). Note that the slopes of the curves are only for graphical representation.

In this Opinion, we analyze the entire suite of operational effects, based on the project description and modeled studies. With this approach, we capture as "effects of the action," both the effects of operations that are proposed to continue in the future as they have in the past, and any new effects that result from proposed changes in operation. We then add these effects to the future baseline, in which we have captured anticipated effects of non-project processes and activities.

The analytical approach NMFS used is not different from that which USFWS used in its Delta smelt Opinion (USFWS 2008a). There may be a perceived difference due to the presentation of the material in the biological opinions. In the Delta smelt Opinion, the USFWS provided a more thorough analysis of the past and present effects of ongoing CVP/SWP operations in its Environmental Baseline section (figure 2-13). In the Effects of the Action section, the USFWS summarized the effects from ongoing CVP/SWP operations, then provided a detailed analysis of the effects resulting from the proposed changes in CVP/SWP operations. In NMFS' Opinion, NMFS summarizes in the Environmental Baseline section the past and present impacts leading to the current status of the species in the action area, including the effects of CVP/SWP operations in the past. Also in the Environmental Baseline section, NMFS sets the stage for the analysis of effects of the action by describing the future non-project stressors to which the listed species and their critical habitats will be exposed. In the Effects of the Action section of the Opinion, NMFS provides a detailed analysis of predicted effects of CVP/SWP operations between the time the biological opinion is issued and December 31, 2030. This difference in presentation is of no consequence to the outcomes of the consultations, since both agencies made their ultimate determinations by (1) finding that proposed operations cause additional harm to listed species, and (2) aggregating all future stressors, as regulations and case law require.

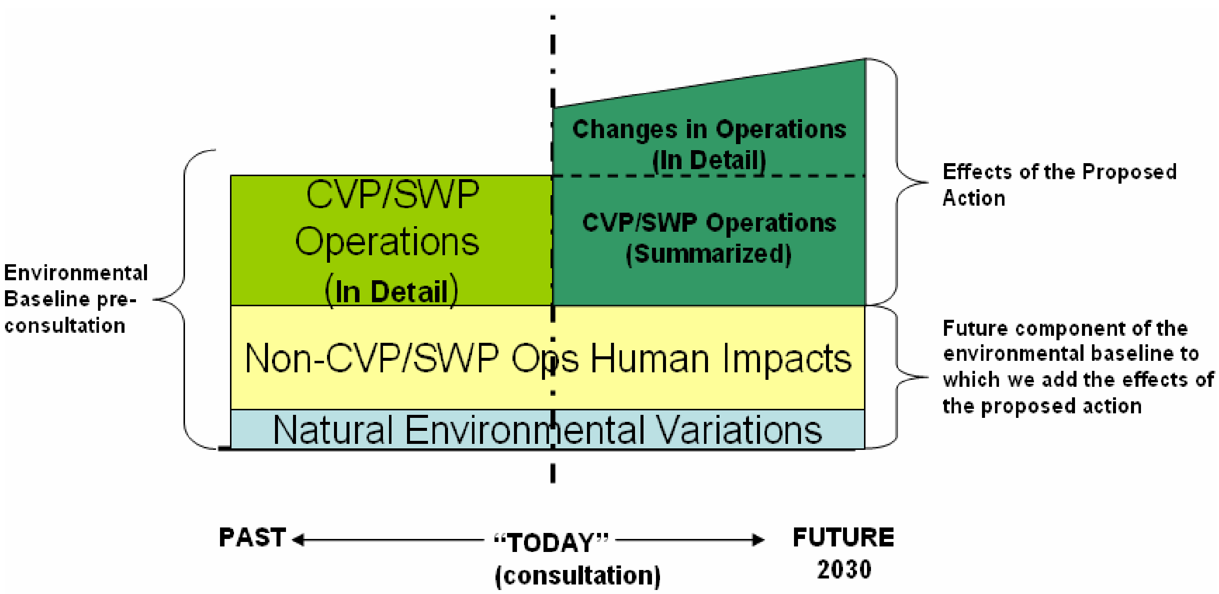

Figure 2-13. USFWS' Delta smelt Opinion baseline: A conceptual model of the effects of the proposed action added on top of the baseline into the future (future baseline). Note that the slopes of the curves are only for graphical representation.

Both Services conduct a separate analysis to determine whether the "effects of the action" reduce either the likelihood of survival and recovery of the species, or the value of critical habitat for the conservation of the species, after the effects of the proposed action have been determined. The Delta smelt opinion states:

> *In accordance with the implementing regulations for section 7 and Service policy, the jeopardy determination is made in the following manner: The effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the delta smelt's current status and, for non-Federal activities in the action area, those actions likely to affect the delta smelt in the future, to determine if*

implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the delta smelt in the wild (USFWS 2008a page 139).

This is precisely the approach used in this Opinion.

2.4 Evidence Available for the Analysis

To conduct these analyses, NMFS considered many lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. The following provides a list of resources that we considered in the development of our analyses:

- Final rules listing the species in this consultation as threatened or endangered;
- Final rules designating critical habitat for the Central Valley salmon and steelhead species and proposed critical habitat for Southern DPS of green sturgeon;
- CVP/SWP operations BA (Reclamation 2008a);
- Previously issued NMFS biological opinions;
- Recommendations from the various reviews and peer review reports (see sections 1.5.5 and 1.5.6, above);
- NMFS-SWFSC reviews (*e.g*., ocean productivity, declarations, climate change);
- Declarations pursuant to PCFFA *et al*. *v*. Gutierrez *et al*.;
- NMFS' draft recovery plans for winter-run and Central Valley salmon and steelhead species;
- Various letters submitted to NMFS, including San Luis & Delta-Mendota Water Authority and State Water Contractors, Inc. (2008);
- California Data Exchange Center (CDEC) data (http://cdec.water/ca/gov/; hereafter referred to as CDEC data);
- U.S. Army Corps of Engineers (Corps) data;
- CDFG's Grand Tab database
- Studies conducted within the Delta. NMFS understands that the use of surrogates in the form of hatchery releases (*e.g*., late fall-run to determine spring-run behavior), different species (*e.g*., Chinook salmon to determine steelhead behavior; Atlantic or shovelnose sturgeon to determine effects of contaminant exposures on green sturgeon), and even the same run and species (*e.g*., hatchery fish and laboratory studies to determine wild/natural fish behavior) may not accurately predict or emulate the exact behavior of the species under analysis in its natural environment in order to determine exact fish routing, timing, duration of migration, and export pumping entrainment patterns. However, when direct evidence or similar evaluations are not available for the species under analysis, NMFS has utilized data and results from the use of surrogates that exhibit strong similarities in physiological needs, in life history stages, and in general behaviors. In the absence of data on salmonids and green sturgeon in the wild, NMFS considers these studies one of the best available sources of information used to determine the potential effects of CVP/SWP operations.
- For purposes of incidental take where the origin of races of Chinook salmon or steelhead cannot be differentiated, uniquely-marked hatchery fish (surrogates) that are released at the same time, location, and size as the listed species may best represent the incidental

take of that listed species. The use of surrogates for this purpose minimizes the amount and extent of take associated with tagging or capturing listed species to monitor take.

The primary source of initial project-related information was the CVP/SWP operations BA produced for this consultation. Included with the CVP/SWP operations BA was an extensive bibliography that served as a valuable resource for identifying key unpublished reports available from state and Federal agencies, as well as private consulting firms. It also provided a robust set of key background papers and reports in the published literature on which to base further literature searches.

We conducted electronic literature searches using several electronic databases available through NMFS' Northwest Fisheries Science Center (NWFSC) and U.C. Davis. NMFS' biologists utilized, among others: (1) the Aquatic Sciences and Fisheries Abstracts (ASFA), Fish & Fisheries Worldwide; (2) Oceanic Abstracts; (3) Waves, the Catalogue of the Libraries of Fisheries and Oceans, Canada; (4) the search engine for the journals published by the American Fisheries Society; and (5) Toxline. When references were found that were deemed to be valuable, Scientific Citation Index was utilized to see what other articles had referenced that paper. NMFS' biologists used keyword searchs (*e.g.*, salmon, salmonids, Chinook salmon, Central Valley, migrations, dams, copper toxicity, survival, thermal tolerance, predation, survival models, Sacramento River, Sacramento Delta, steelhead, green sturgeon, *etc*.) to find potential articles and literature. Searches by author were utilized when an author was found to have published numerous articles and papers within a given area of interest. In addition, physical searches of the extensive electronic holdings of agencies were conducted from their websites, such as Reclamation's Central Valley Operations (CVO) website for the Tracy Fish Facility Reports.

We examined the literature that was cited in documents and any articles we collected through our electronic searches. If, based on a reading of the title or abstract of a reference, the reference appeared to comply with the keywords presented in the preceding paragraph, we acquired the reference. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we identified all (100 percent) of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, and, reports and all of the references cited in the materials and methods, and results sections of those documents. We did not conduct hand searches of published journals for this consultation.

References were collected by individual biologists and shared as a group. Most references were available as electronic copies. However, many of the older reports, articles, or book chapters had to be scanned and converted into electronic copies when feasible.

2.4.1 Other tools used in the analysis

Reclamation and DWR utilized the following models in their analyses and development of the CVP/SWP operations BA. Figure 2-14 provides a schematic of how each model relates to the others.

- Statewide planning model of water supply, stream flow, and Delta export capability:

- CalSim-II: Monthly time step, designed to evaluate the performance of the CVP and SWP systems for: existing and future levels of land development, potential future facilities, current or alternative operational policies and regulatory environments.
- CalLite: A rapid and interactive screening tool that simulates California's water management system for planning purposes.

- Sacramento-San Joaquin Delta hydrodynamics and particle tracking:
  - Delta Simulation Model Version 2 (DSM2): 15-minute time step, used to simulate the flow, velocity, and particle movement in the Delta.

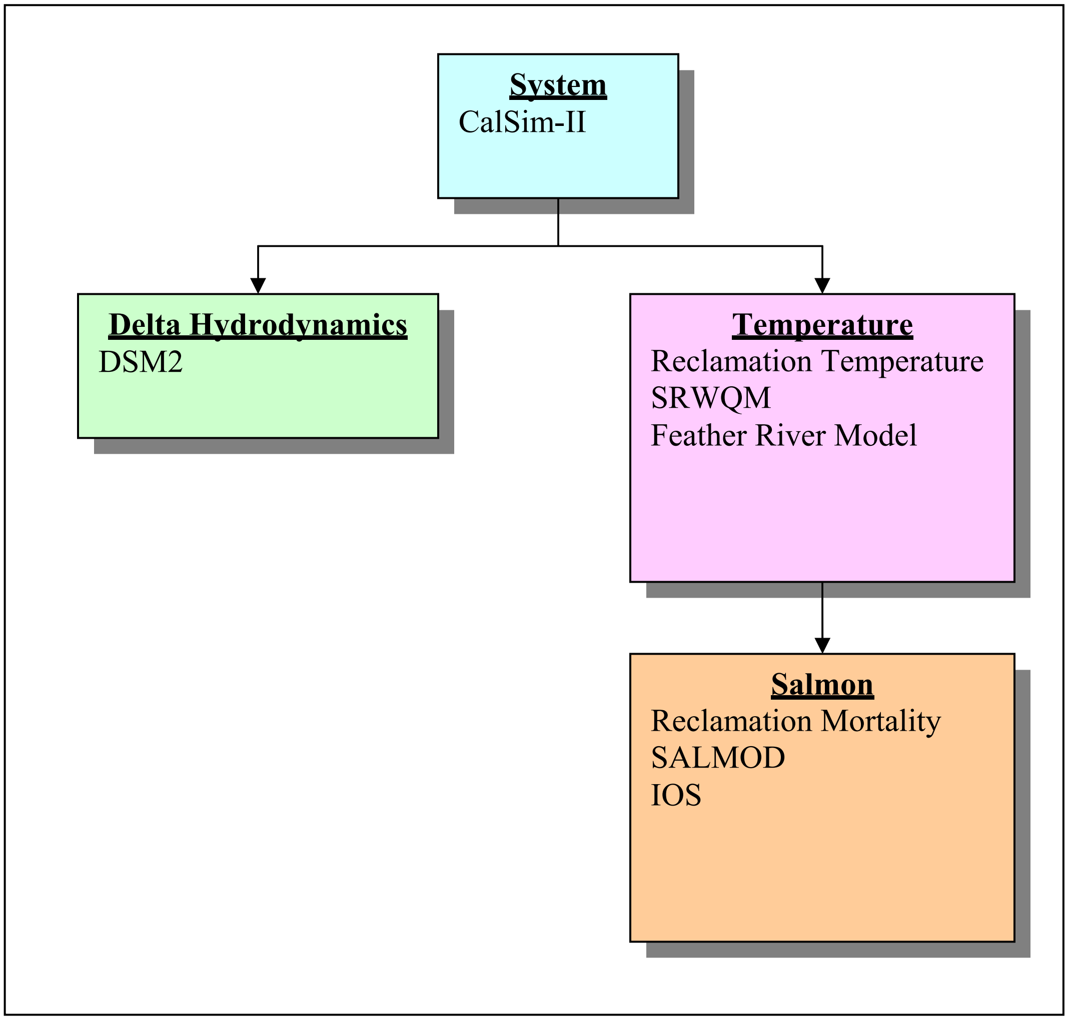

Figure 2-14. Models used in the development of the CVP/SWP operations BA, and their information flow with respect to each other (CVP/SWP operations BA figure 9-1).

- River temperature:
  - Reclamation Temperature: Monthly time step, where the reservoir temperature models simulate monthly mean vertical temperature profiles and release temperatures for Trinity, Whiskeytown, Shasta, Folsom, New Melones, and Tullock Reservoirs based on hydrologic and climatic input data.

- Sacramento River Water Quality Model (SRWQM): 6-hour time step, with mean daily flow inputs, used to simulate daily temperatures on Clear Creek and the Upper Sacramento River.
  - Oroville Facilities Water Temperature Modeling: 1-hour time steps that include reservoir simulations of Oroville Reservoir, the Thermalito Diversion Pool, the Thermalito Forebay, and the Thermalito Afterbay, and a river model of the Feather River between the Thermalito Diversion Dam and the Sacramento River confluence.
- Salmon mortality
  - Reclamation Salmon Mortality Model: Daily time step which computes salmon spawning losses for the Trinity, Sacramento, American, and Stanislaus rivers based on the Reclamation Temperature Model estimates. It is limited to temperature effects on early life stages of Chinook salmon, and does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, ocean harvest, *etc*.
  - SALMOD: Weekly time step simulates population dynamics for all four runs of Chinook salmon in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD).
  - Interactive Object-Oriented Salmon simulation (IOS) Winter-Run Life Cycle Model: Daily time step, used to evaluate the influence of different Central Valley water operations on the life cycle of winter-run using simulated historical flow and water temperature inputs.

In addition, NMFS' biologists utilized an interactive spreadsheet model developed by DWR to estimate interior Delta survival of emigrating salmonids from the Sacramento River. This model, the Delta Survival Model (DSM2), utilized user inputs of export rate and Delta inflow to determine absolute and relative survival of salmonids moving throughout the Delta interior and remaining in the main stem Sacramento River as a proportion of the total salmonid population. Additonal inputs to the model were the fraction of particles entrained at the different channel bifurcations as modeled in the Particle Tracking Model (PTM) module of the DSM2 model, as well as the relative survival in the Delta interior and the export related interior mortality, which were calculated internally in the model.

NMFS did not use the results of the IOS model for our analysis in this Opinion because the intended application of the model in the CVP/SWP operations BA was not useful for estimating, in an overall sense, how winter-run might respond to the proposed action. For example, the CVP/SWP operations BA cautions the use of the IOS model results in making inferences related to how winter-run abundance is affected by the proposed action: "*In evaluating effects of the proposed actions, differences between the three studies rather than absolute trends should be examined"* (Appendix O in CVP/SWP operations BA). Thus, it seems that the IOS model results presented in the CVP/SWP operations BA are not intended to reflect either abundance estimates observed in the past or future abundance with implementation of the proposed Project. Estimates based on observations are much different than estimates based on modeling without observation input. Results of the IOS model presented in the CVP/SWP operations BA show an increasing trend in winter-run escapement throughout the entire simulation period (*i.e*., from 1923 through 2002), such that by 2002, escapement is above 40,000 fish for all CALSIM II studies examined (figure 11-5 in CVP/SWP operations BA). Those results contrast with observed winter-run escapement estimates, which show a dramatic population crash during this period (see Grandtab at http://www.delta.dfg.ca.gov/afrp/), eventually leading to their endangered status under the ESA.

In the Opinion, NMFS must consider how winter-run is expected to respond to implementation of the proposed action. Model results, such as the IOS model results presented in the CVP/SWP operations BA, that are not intended to at least generally approximate past or future conditions, do not inform us in this consideration. If the IOS model results in the CVP/SWP operations BA are intended to be used strictly as an alternatives comparison tool, as the CVP/SWP operations BA indicates, instead of one that produces somewhat meaningful trend information for individual model runs, then the utility of those results for the Opinion is limited, particularly considering that a model alternative representing just baseline conditions does not exist. The CALFED Peer Review Panel stated that, "*The default should be comparing the CALSIM studies of future scenarios (with different scenarios for climate change) to baseline"*(Anderson *et al*. 2009). The context of this statement was that comparisons among alternatives such as those used in the IOS model (*e.g*., CALSIM studies 6, 7, and 8) are inconsistent with the Opinion's analytical approach. As such, NMFS did not use the IOS model results presented in the CVP/SWP operations BA as evidence for analyzing how winter-run will be affected by the proposed action.

Another consideration for not using the IOS model in the Opinion is that the model has not yet been published in peer reviewed scientific literature, and NMFS does not understand either the model's limitations or its extent. As described in Paine *et al*. (2000), mathematical models intended to help guide management of natural populations must be used wisely and with understanding of limitations. One potential limitation associated with applying large scale models over the entire life cycle of a species, as is done in the IOS model, is whether enough data are available to reliably estimate model parameters. Paine *et al*. (2000) state: "*When the data are not available for the needed estimates of parameter values, there is a tendency to insert values based on opinion or expert testimony. This practice is dangerous. The idea that opinion and "expert testimony" might substitute for rigorous scientific methodology is anathema to a serious modeler and clearly represents a dangerous trend.*" With these considerations in mind, NMFS did not utilize the IOS model in this Opinion.

2.4.2 Consideration of a Quantitative Life Cycle Approach to the Analysis

One recommendation made by the CALFED Science Review Panel in its review of NMFS' December 11, 2008, draft Opinion was to analyze the effects of the proposed action using common measures of survival. Ideally, a life cycle approach, in which the effects on individual life stages on the life cycle could be estimated independent of the effects on other stages, would be implemented to assess the relative impacts on abundance. Two potential methods for measuring salmon population levels include the spawner-to-recruit ratio (SRR), which is the ratio of the number of recruits returning to the spawning habitat divided by the number of spawners producing those recruits, and the adult-to-smolt ratio (ASR), which measures the number of young fish exiting the freshwater system divided by the number of adult spawners that produced those young (Anderson *et al.* 2009). Unlike the SRR, which encompasses the full life cycle, including both freshwater and marine environments, the ASR omits the ocean phase and, thus, would provide a more appropriate method for assessing the effects of freshwater environmental conditions and water operations.

The benefits that this type of integrative analysis would provide towards understanding the relative importance of proposed action-related effects at various life stages on overall abundance are apparent. However, completing such an analysis is not practicable at this time for several reasons. For instance, one of the key components in the process would be the establishment of survival rates at various life stages under both natural conditions (*i.e*., "without project") and those conditions observed with the project in place (*i.e*., "with project"). This information is currently lacking for the Central Valley region of California, and is further discussed in section 5 of this Opinion. Considerable efforts have been made in an attempt to develop life stage specific survival rates in the Columbia River Basin with some level of success (Anderson 2002). However, given the major differences that exist between the Columbia River Basin and California's Central Valley (*e.g.*, flows, temperature, *etc*.), it would not be appropriate to apply any values derived for basins in that region toward this analysis in the Central Valley. Instead, site-specific studies within the Central Valley would have to be conducted to establish suitable values.

Information from MacFarlane *et al.*'s (2008a) acoustic tagging study represents some of the first data to be gathered on migration and survival patterns of juvenile salmonids in the Central Valley. Early results indicate different survival patterns between the Central Valley and those observed in the Columbia River Basin. However, these results are still considered preliminary, and the studies will need to continue for some time to provide a more reliable, long-term data series. Still, these preliminary results underscore the need to develop information specific to the unique conditions of the Central Valley region for this type of life cycle analysis.

An alternative approach recommended by the CALFED Science Review Panel for estimating an ASR for the Central Valley includes the use of computer models. In particular, the IOS model (Cavallo *et al.* 2008) and the *Oncorhynchus* Bayesian Analysis (OBAN) model (Hendrix 2008) were referenced as potentially useful tools. IOS is a detailed mechanistic model that describes the entire life cycle of both winter-run and spring-run in the Sacramento River, while the OBAN model is a Bayesian statistical model for winter-run in the Sacramento River. Although the CALFED Science Review Panel identified these models as potentially viable options either in combination or independently, it acknowledged the necessary refinement and implementation of this type of model by NMFS for the Opinion may not have been practical because of time constraints and the need for additional modeling expertise. Further development of mortality rates at different life stages specific to the Central Valley could be incorporated into the model to reduce the amount of assumptions currently required, and lead to more realistic and informative results. However, as previously mentioned, this type of information will not be available in the near term. Moreover, in order to sufficiently address the issue of fish routing through the Delta, identified as a critical component by the CALFED Science Review Panel, additional data collection and modeling over the long term (*i.e*., beyond the timeline allowed for the development of this Opinion) would be required.

As discussed above, this Opinion equates a listed species' probability or risk of extinction with the likelihood of both the survival and recovery of the species, and uses "likelihood of viability" as a standard to bridge between the VSP framework (McElhany *et al*. 2000) and the jeopardy standard. Assessing the viability of salmonid populations requires the consideration of other parameters in addition to population abundance, including productivity (*i.e*., population growth rate), spatial structure, and genetic and life-history diversity (McElhany *et al*. 2000). All four VSP parameters are deemed important in evaluating a population's ability to persist, especially when faced with catastrophic disturbances (Lindley *et al*. 2007). Although the life cycle modeling approaches discussed above have the potential to provide information on all VSP parameters at some point in the future, it would require substantial data collection and model refinement. Any present attempt to complete such an exercise would only address one of those parameters (*i.e*., abundance), and any results would include making many assumptions. Therefore, although a method for evaluating impacts during a specific life stage in terms of the overall loss in numbers of fish would be useful, there are other potential consequences resulting from project operations that need to be considered. For example, are mortalities at different life stages, or the loss of historical habitats, likely to have effects on the other VSP parameters? The analyses within this Opinion, in an attempt to encompass this broader range of effects, focused on determining whether or not appreciable reductions were expected from the proposed action, rather than trying to quantify the absolute magnitude of those reductions.

2.4.3 Critical Assumptions in the Analysis

To address the uncertainties identified above related to the proposed action and the analysis provided in the CVP/SWP operations BA, NMFS established a set of key assumptions we would need to make to bridge the existing data gaps in the CVP/SWP operations BA that are critical to our analysis of effects. Table 2-3 provides the general assumptions that we made in filling those data gaps.

2.5 Integrating the Effects

The preceding discussions describe the various quantitative and qualitative models, decision frameworks, and ecological foundations for the analyses presented in this Opinion. The purpose of these various methods and tools is to provide a transparent and repeatable mechanism for conducting analyses to determine whether the proposed action is not likely to jeopardize the continued existence of the listed species and not likely to result in the destruction or adverse modification of designated critical habitat.

Table 2-3. General assumptions, and their bases, made in analyzing the effects of the proposed action.

Assumption	Basis
We assume that the effects from the near term analysis (Study 7.1) will be in effect from the issuance of this Opinion through year 2019 (which Reclamation stated is the end of the near term, specifically, "Near term refers to the timeframe between now to 2030, a rough midpoint between the two years"). Likewise, we assume that the effects from the full build-out at 2030 analysis (Study 8.0) will be in effect from the end of the near term in 2019 through year 2030.	The CVP/SWP operations BA does not provide an incremental build-out schedule or analyses of incremental effects by year.
A "soft" target of 1.9 million acre-feet (MAF) end of September carryover storage in Shasta Reservoir is met only when conditions allow.	The project description does not explicitly propose an end of September carryover storage in Shasta Reservoir. However, modeling Chapter 9 of the CVP/SWP operations BA (p.9-41) assumes a 1.9 MAF end of September carryover storage target in Shasta Reservoir in non-critical years.
The following are tools, in order of priority that we used to understand the proposed action. -- CVP/SWP operations BA Chapter 2 (project description). -- CVP/SWP operations BA Chapter 9 (Modeling and Assumptions) -- CDEC data: ~10 years of actual data. When the project description is not explicit in fully describing Reclamation's proposed action, CDEC data on recent past operations will be utilized as a tool to help us understand the proposed action.	Chapter 2 (project description) has many gaps regarding the description of the proposed action.
Central Valley Project Improvement Act (CVPIA) 3406 B(2) [hereafter referred to as "b(2)"] is assumed to be implemented as proposed in the project description.	Although b(2) is proposed, there are no operational rules or certainties in order for us to determine that b(2) is reasonably certain to occur in a given location, timing, quantity, and duration.
Use CDEC data for last ~10 years (or more to get critically dry years) as an approximation of water temperature impacts through 2030.	In most cases, Reclamation and DWR have not proposed to meet specific water temperature targets or or operate the CVP/SWP different than they have in the past with respect to water temperature, so we use recent past data as an indicator of future water temperatures.

Many of the methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is an integration of the effects of the proposed action with each other and with the baseline set of stressors to which the species and critical habitat are also exposed. In addition, the final steps of the analysis require a consideration of the effects of the action within the context of the reference (or without action) condition of the species and critical habitat. That is, following the hierarchical approaches outlined above, NMFS rolls up the effects of the action to determine if the action is not likely to appreciably reduce the likelihood of both the survival and recovery of the species and not likely to result in the destruction or adverse modification of critical habitat.

Figure 2-15 is intended to capture the overall conceptual model of the analysis and illustrates the analytical steps within each "rung" of the hierarchical analysis. We provide an example utilizing the approach for listed salmonids.

2.6 Presentation of the Analysis in this Opinion

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the reader of the other sections of this Opinion and the analyses that can be found in each section. Every step of the analytical approach described above will be presented in this Opinion in either detail or summary form.

Description of the Proposed Action – This section contains a basic summary of the proposed Federal action and any interrelated and interdependent actions. This description forms the basis of the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses.

Status of the Species – This section provides the reference condition for the species and critical habitat at the listing and designation scale. For example, NMFS evaluates the current viability of each salmonid ESU/DPS given its exposure to human activities and natural phenomena such as variations in climate and ocean conditions, throughout its geographic distribution. These reference conditions form the basis for the determinations of whether the proposed action is not likely to jeopardize the species or result in the destruction or adverse modification of critical habitat. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and critical habitat and the impacts to species and critical habitat from existing stressors.

Environmental Baseline – This section provides the reference condition for the species and critical habitat within the action area. By regulation, the baseline includes the impacts of past, present, and future actions (except the effects of the proposed action) on the species and critical habitat. In this Opinion, some of this analysis is contained within the *Status of the Species and Critical Habitat* section due to the large size of the action area (which entirely or almost entirely encompasses the freshwater geographic ranges of the listed fish species). This section also contains summaries of the impacts from stressors that will be ongoing in the same areas and times as the effects of the proposed action (future baseline). This information forms part of the foundation of our exposure, response, and risk analyses.

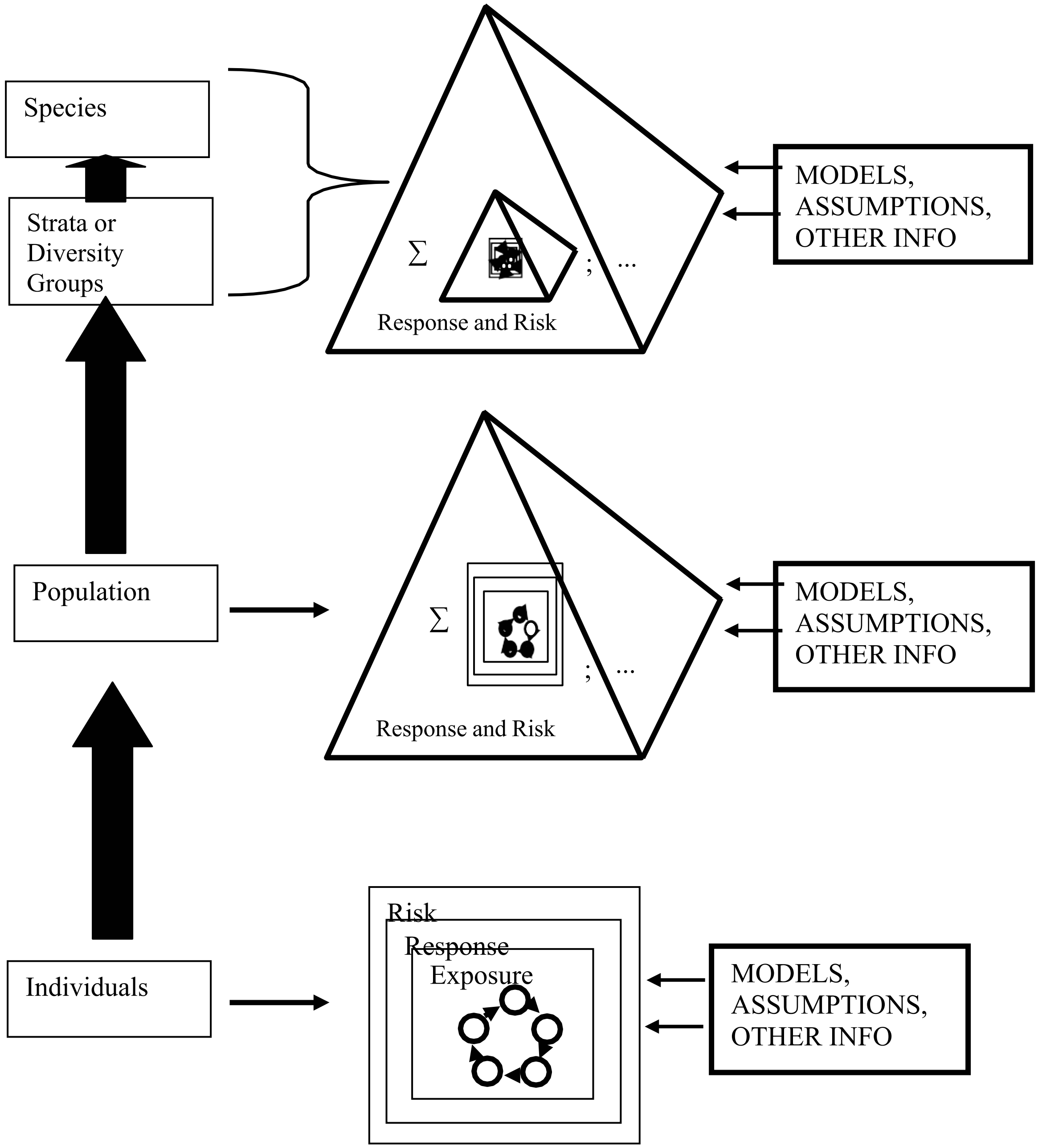

Figure 2-15. Conceptual diagram of the overall analytical approach utilized in this Opinion. The individual level includes exposure, response, and risk to individuals of the species and a consideration of the life cycle and life history strategies. Population level includes consideration of the response of and risk to the population given the risk posed to individuals of the population within the context of the "pyramid" of VSP parameters for the populations. Strata/Diversity Group and Species levels include a consideration of the response of and risk to those levels given the risk posed to the population(s) within the larger context of the VSP "pyramid."

Effects of the Proposed Action – This section details the results of the exposure, response, and risk analyses NMFS conducted for individuals of the listed species and elements, functions, and areas of critical habitat. Given the organization of the proposed action, this section is organized around the various Divisions that comprise the CVP and SWP.

Cumulative Effects – This section summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species and features of critical habitat.

Integration and Synthesis of Effects – In this section of the Opinion, NMFS presents the summary of the effects identified in the preceding sections and then details the consequences of the risks posed to individuals and features of critical habitat to the higher levels of organization. These are the response and risk analyses for the population, diversity group, species, and designated critical habitat. The section is organized around the species and designated or proposed critical habitat and includes the summation of impacts across the proposed action Divisions, as appropriate, and follows the hierarchical organizations of the species and critical habitat summarized in figures 2-8 and 2-9, respectively, of this section.

3.0 PROPOSED ACTION

Reclamation and DWR propose to operate the CVP and SWP, respectively, to divert, store, and convey CVP and SWP (Project) water, consistent with applicable law and contractual obligations, until the year 2030. The CVP and the SWP are two major inter-basin water storage and delivery systems that divert and re-divert water from the southern portion of the Sacramento-San Joaquin Delta (Delta). The CVP's major storage facilities are Shasta, Trinity, Folsom and New Melones reservoirs. The upstream reservoirs release water to provide water for the Delta, that can be exported, a portion through Jones pumping plant to store in the joint San Luis reservoir, or delivered down the Delta Mendota Canal. The SWP owns Lake Oroville upstream and releases water for the Delta that can be exported at Harvey O. Banks Pumping Plant (Banks) for delivery through the California Aqueduct.

The projects are permitted by the California State Water Resources Control Board (SWRCB) to store water during wet periods, divert water that is surplus to the Delta, and re-divert Project water that has been stored in upstream reservoirs. Both projects operate pursuant to water right permits and licenses issued by the SWRCB, authorizing the appropriation of water by diverting to storage or by directly diverting to use and re-diverting releases from storage later in the year. As conditions of the water right permits and licenses, the SWRCB requires the CVP and SWP to meet specific water quality, quantity, and operational criteria within the Delta. Reclamation and DWR closely coordinate the CVP and SWP operations, respectively, to meet these conditions.

In addition to diverting, storing, and conveying water, Reclamation proposed several other actions that are included in this consultation. These actions are: (1) an intertie between the

California Aqueduct (CA) and the Delta-Mendota Canal (DMC); (2) Freeport Regional Water Project (FRWP); (3) the operation of permanent gates, which will replace the temporary barriers in the South Delta; (4) changes in the operation of RBDD; and (5) Alternative Intake Project for the Contra Costa Water District.

3.1 Project Description

Appendix 1 to this Opinion provides a detailed project description of the proposed action. Reclamation and NMFS staff engaged in e-mail exchanges throughout January 2009 to clarify various aspects of the project description, as follows:

- January 15, 2009, for Contra Costa Water District: "In addition to the existing 75-day no-fill period (March 15-May 31) and the concurrent no-diversion 30-day period, beginning in the February following the first operation of the Alternative Intake Project, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90 TAF on February 1; if reservoir storage is at or above 80 TAF on February 1 but below 90 TAF, CCWD shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28; if reservoir storage is at or above 70 TAF on Feb 1, but below 80 TAF CCWD shall not divert water to storage in Los Vaqueros Reservoir for 5 days from February 24 through February 28."; and
- January 28, 2009: Confirmation that the Sacramento River Reliability Project is no longer part of the project description.

Appendix 1 to this Opinion reflects the above changes to the project description, has been coordinated with Reclamation and the USFWS, and is consistent with the project description in the USFWS' December 15, 2008, biological opinion on the effects of CVP/SWP operations on Delta smelt. Hereafter, all reference to the project description refers to Appendix 1 to this Opinion, unless otherwise specified.

3.2 Interrelated or Interdependent Actions

3.2.1 CVP and SWP Fish Hatcheries

In the Central Valley, six hatcheries have been established to offset the loss of salmon and steelhead due to construction of dams. Additionally, Trinity River Fish Hatchery mitigates for salmon and steelhead losses on the Trinity River. The Mokelumne River Hatchery, although not directly related to CVP or SWP dams, does influence fall-run and steelhead populations. Added together, Central Valley hatcheries annually produce approximately 250,000 winter-run, 5 million spring-run, 29.76 million fall-run, and 1.5 million steelhead. Currently, most Central Valley hatcheries truck their salmon production to the Bay-Delta region for release. The exception to this is Coleman National Fish Hatchery, which began trucking a small portion of its fall-run production into San Pablo Bay beginning in 2008. Section 1.5.2, above, describes ESA consultation on the CVP and SWP hatcheries. Listed below are the production goals for Nimbus Fish Hatchery and TRFH.

3.2.1.1 Nimbus Fish Hatchery

The Nimbus Fish Hatchery and the American River Trout Hatchery were constructed to mitigate for the loss of riverine habitat caused by the construction of CVP Nimbus and Folsom dams. The American River Trout Hatchery produces fish for stocking inland areas (*i.e*., above dams) and is, therefore, not considered in the production goals for the Central Valley. Nimbus Fish Hatchery is located below Nimbus Dam and is operated by CDFG to meet annual production goals of 4 million fall-run smolts and 430,000 steelhead yearlings.

3.2.1.2 Trinity River Fish Hatchery

The Trinity River Fish Hatchery was constructed to provide CVP mitigation for the loss of upstream riverine habitat caused by the construction of the Trinity and Lewiston dams. The hatchery, operated by CDFG, produces 1.4 million spring-run, 2.9 million fall-run, 500,000 coho salmon, and 800,000 steelhead annually.

3.2 Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this biological opinion, the action area encompasses: (1) Sacramento River from Shasta Lake downstream to and including the Sacramento-San Joaquin Delta; (2) Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River; (3) Feather River from Oroville Dam downstream to its confluence with the Sacramento River; (4) American River from Folsom Lake downstream to its confluence with the Sacramento River; (5) Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (6) San Joaquin River from the confluence with the Stanislaus River downstream to and including the Sacramento-San Joaquin Delta; (7) San Francisco Bay; and (8) the nearshore Pacific Ocean on the California, Oregon, and Washington coasts.

4.0 STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species and designated critical habitats occur in the action area and may be affected by CVP/SWP operations in this consultation:

- Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*), endangered (June 28, 2005, 70 FR 37160);
- Sacramento River winter-run Chinook salmon designated critical habitat (June 16, 1993, 58 FR 33212);
- CV spring-run Chinook salmon ESU (*O. tshawytscha*), threatened (June 28, 2005, 70 FR 37160);
- CV spring-run Chinook salmon designated critical habitat (September 2, 2005, 70 FR 52488);
- CV steelhead DPS (*O. mykiss*), threatened (January 5, 2006, 71 FR 834);
- CV steelhead designated critical habitat (September 2, 2005, 70 FR 52488);
- CCC steelhead DPS (*O. mykiss*), threatened (January 5, 2006, 71 FR 834);

- CCC steelhead designated critical habitat (September 2, 2005, 70 FR 52488);
- Southern DPS of North American green sturgeon (*Acipenser medirostris*), threatened (April 7, 2006, 71 FR 17757); and
- Southern DPS of North American green sturgeon proposed critical habitat (September 8, 2008, 73 FR 52084);
- Southern Resident killer whales (*Orcinus orca*), endangered (November 18, 2005, 70 FR 69903).

4.1 Species and Critical Habitat not likely to be Adversely Affected by the Proposed Action

4.1.1 Central California Coast Steelhead

The CCC steelhead DPS (*O. mykiss*) was listed as threatened on January 5, 2006 (71 FR 834), and includes all naturally spawned steelhead populations below natural and manmade impassable barriers in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco, San Pablo, and Suisun bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. Tributary streams to Suisun Marsh include Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough, excluding the Sacramento-San Joaquin River Basin, as well as two artificial propagation programs: the Don Clausen Fish Hatchery, and Kingfisher Flat Hatchery/Scott Creek (Monterey Bay Salmon and Trout Project) steelhead hatchery programs.

CCC steelhead adults and smolts travel through the western portion of Suisun Marsh and Suisun Bay as they migrate between the ocean and these natal spawning streams. CVP and SWP water export facilities in the Delta are approximately 40 miles to the southeast of Suisun Marsh. CCC steelhead are unlikely to travel eastward towards the Delta pumping facilities, because their seaward migration takes them westward of their natal streams. Similarly, DWR's Suisun Marsh Salinity Control Gates (SMSCG) in Montezuma Slough are located to the east of these three Suisun Marsh steelhead streams and CCC steelhead are unlikely to travel 10-15 miles eastward through Montezuma Slough to the SMSCG. Therefore, it is unlikely that CCC steelhead will encounter the SMSCG or the Delta pumping facilities during their upstream and downstream migrations, because their spawning streams are located in the western portion of Suisun Marsh.

Operations at CVP and SWP Delta facilities, including the SMSCG, affect water quality and river flow volume in Suisun Bay and Marsh. Delta water exports are expected to cause elevated levels of salinity in Suisun Bay due to reductions in the amount of freshwater inflow from the Sacramento and San Joaquin Rivers. Reduced river flow volumes into Suisun Bay can also affect the transport of larval and juvenile fish. CCC steelhead originating from Suisun Marsh tributary streams will be subject to these changes in salinity and river inflow volumes in Suisun Bay, but are not expected to be negatively affected by these conditions. Estuarine areas, such as Suisun Bay, are transitional habitat between freshwater riverine environments and the ocean. Expected changes in Suisun Bay salinity levels due to CVP and SWP exports are within the range commonly encountered in estuaries by migrating steelhead. River flow volumes may be reduced by water exports, but in an estuary, the tidal cycle of the ocean causes semidiurnal changes to salinity, velocity, temperature, and other conditions. Steelhead generally move through estuaries rapidly (Quinn 2005) and CCC steelhead smolts in Suisun Bay are not dependent on river flow to transport them to the ocean. Thus, reductions in river flow volumes and changes in salinity in Suisun Bay due to CVP/SWP operations are not expected to negatively impact CCC steelhead estuarine residence or migration. In consideration of the above and the distance separating CCC steelhead streams from the Delta pumping facilities and the SMSCG, the proposed action is not likely to adversely affect CCC steelhead.

4.1.2 CCC Steelhead Designated Critical Habitat

The CVP/SWP operations BA determined that CVP/SWP operations will not influence critical habitat for CCC steelhead because Suisun Bay is not a designated area. CCC steelhead critical habitat includes San Francisco Bay and San Pablo Bay, but does not extend eastward into Suisun Bay (September 2, 2005, 70 FR 52488). PCEs of designated critical habitat for CCC steelhead include water quality and quantity, foraging habitat, natural cover including large substrate and aquatic vegetation, and migratory corridors free of obstructions. Due to the location of CCC steelhead critical habitat in San Pablo Bay and areas westward, NMFS concurs with Reclamation's finding that the habitat effects of CVP/SWP operations in this area are insignificant and discountable. Therefore, NMFS has concluded that CVP/SWP facilities and their operations are not likely to adversely affect essential physical or biological features associated with CCC steelhead critical habitat.

4.2 Life Histories, Population Trends, Critical Habitat, and Factors Affecting the Status of the Species

4.2.1 Chinook Salmon

4.2.1.1 General Life History

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). Adult "stream-type" Chinook salmon enter freshwater months before spawning, and juveniles reside in freshwater for a year or more, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing. However, distinct runs also differ in the degree of maturation of the fish at the time of river entry, thermal regime, and flow characteristics of their spawning sites, and the actual time of spawning (Myers *et al.* 1998). Both winter-run and spring-run tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. Fall-run enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38ºF to 56ºF (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 65ºF for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70ºF, and that fish can become stressed as temperatures approach 70ºF.

Information on the migration rates of adult Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin, where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter and Sanford 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter and Sanford (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion, for several days at a time, while migrating upstream (CALFED 2001a). Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook salmon, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations, meaning that they are primarily active during twilight hours. Recent hydroacoustic monitoring conducted by LGL Environmental Research Associates (2006) showed peak upstream movement of adult spring-run in lower Mill Creek, a tributary to the Sacramento River, occurring in the 4-hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. The upper preferred water temperature for spawning Chinook salmon is 55ºF to 57ºF (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, and Snider 2001).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 41ºF to 56ºF [44ºF to 54ºF (Rich 1997), 46ºF to 56ºF (NMFS 1997), and 41ºF to 55.4ºF (Moyle 2002)]. A significant reduction in egg viability occurs at water temperatures above 57.5ºF and total embryo mortality can occur at temperatures above 62ºF (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61ºF and 37ºF, respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins (yolk-sac fry) remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. Fry typically range from 25 mm to 40 mm at this stage. Upon emergence, fry swim or are displaced downstream (Healey 1991). The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and other micro-crustaceans. Some fry may take up residence in their natal stream for several weeks to a year or more, while others are displaced downstream by the stream's current. Once started downstream, fry may continue downstream to the estuary and rear there, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996a). The benefits of shallow water habitats for salmonid rearing have been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001).

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile salmon in the Sacramento River near West Sacramento exhibited larger-sized juveniles captured in the main channel and smaller-sized fry along the margins (USFWS 1997). When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is crepuscular. The daily migration of juveniles passing RBDD is highest in the 4-hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found Chinook salmon fry to travel as fast as 30 km per day in the Sacramento River, and Sommer *et al.* (2001) found travel rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (ppt, Healey 1980, Levy and Northcote 1981).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975, Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54ºF to 57ºF (Brett 1952). In Suisun and San Pablo bays, water temperatures reach 54ºF by February in a typical year. Other portions of the Delta (*i.e*., South Delta and Central Delta) can reach 70ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levings 1982, Levy and Northcote 1982, Levings *et al.* 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run), MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

4.2.1.2 Sacramento River Winter-Run Chinook Salmon

The distribution of winter-run spawning and rearing historically is limited to the upper Sacramento River and its tributaries, where spring-fed streams provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento rivers, and Hat and Battle creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and optimal stream flow in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir; Moyle *et al.* 1989; NMFS 1997, 1998a, 1998b). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

Winter-run exhibit characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run migrate to sea after only 4 to 7 months of river life (ocean-type). Adult winter-run enter San Francisco Bay from November through June (Hallock and Fisher 1985), enter the Sacramento River basin between December and July, the peak occurring in March (table 4-1; Yoshiyama *et al.* 1998, Moyle 2002), and migrate past the RBDD from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (Yoshiyama *et al*. 1998, Moyle 2002). Spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick Dam and RBDD (Vogel and Marine 1991). The majority of winter-run spawners are 3 years old.

Table 4-1. The temporal occurrence of (a) adult and (b) juvenile winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[a]	Medium	Medium	High	Medium	Medium	Medium	Medium					Medium
Sac. River[b]	Medium	Medium	Medium	Medium	Medium	Medium					Medium	Medium
b) Juvenile migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[c]	Low	Low	Low				Low/Medium	Medium	Medium	Medium	Medium	Medium
Sac. River @ Red Bluff[b]	Low	Low	Low				Low	Medium	Medium	Medium	Medium	Medium
Sac. River @ KL.[d]	Medium	Medium	Medium	Low	Low			Low	Low	Low	High	High
Lower Sac. River (seine)e	High	High	Medium	Low	Low					Low	Medium	High
West Sac. River (trawl)e	Medium	Medium	High	Medium	Low						Low	Medium

KL = Knights Landing

Relative Abundance: ■ = High ■ = Medium ■ = Low

Sources: [a]Yoshiyama *et al*. (1998); Moyle (2002); [b]Myers *et al*. (1998); Vogel and Marine (1991) ; [c]Martin *et al.* (2001); [d]Snider and Titus (2000); [e]USFWS (2001, 2001a)

Winter-run fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994). Emigration of juvenile winter-run past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run outmigrating as fry passed

RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile winter-run occur in the Delta primarily from November through early May, based on data collected from trawls in the Sacramento River at West Sacramento [river mile (RM) 57; USFWS 2001, 2001a]. The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run juveniles remain in the Delta until they reach a fork length of approximately 118 millimeters (mm) and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continue through May (Fisher 1994, Myers *et al.* 1998).

4.2.1.2.1 Range-Wide (ESU) Status and Trends

Historical winter-run population estimates, which included males and females, were as high as over 230,000 adults in 1969, but declined to under 200 fish in the 1990s (Good *et al.* 2005, figure 4-1). A rapid decline occurred from 1969 to 1979 after completion of the RBDD (figure 4-1). Over the next 20 years, the population eventually reached a low point of only 186 adults in 1994. At that point, winter-run was at a high risk of extinction, as defined in the most recent guideline for recovery of Central Valley salmonids (Lindley *et al*. 2007). If not for a very successful captive broodstock program, construction of a temperature control device (TCD) on Shasta Dam, having the RBDD gates up for much of the year, and restrictions in the ocean harvest, the population would have likely failed to exist in the wild. In recent years, the carcass survey population estimates of winter-run included a high of 17,205 (table 4-2) in 2006, followed by a precipitous decline in 2007 that continued in 2008, when less than 3,000 adult fish returned to the upper Sacramento River. The preliminary estimate of the winter-run in 2008 is 2,850 (CDFG 2008).

A conservation program at LSNFH located at the base of Keswick Dam annually supplements the in-river production by releasing on average 250,000 winter-run smolts into the upper Sacramento River. The LSNFH operates under strict guidelines for propagation that includes genetic testing of each pair of adults and spawning less than 25 percent of the hatchery returns. This program and the captive broodstock program (phased out in 2007) were instrumental in stabilizing winter-run following very low returns in the 1990s.

The status of winter-run is typical of most endangered species populations, that is, a sharp downward decline followed by years of low abundance (figure 4-1). Since there is only one winter-run population, there are no other populations to act as a reserve should a catastrophic event happen in the mainstem Sacramento River. Four highway bridges cross the upper Sacramento River spawning grounds. One truck overturning could spill enough oil or contaminants to extirpate an entire year class. The winter-run population is completely dependent on coldwater releases from Shasta Dam in order to sustain the remnant population.

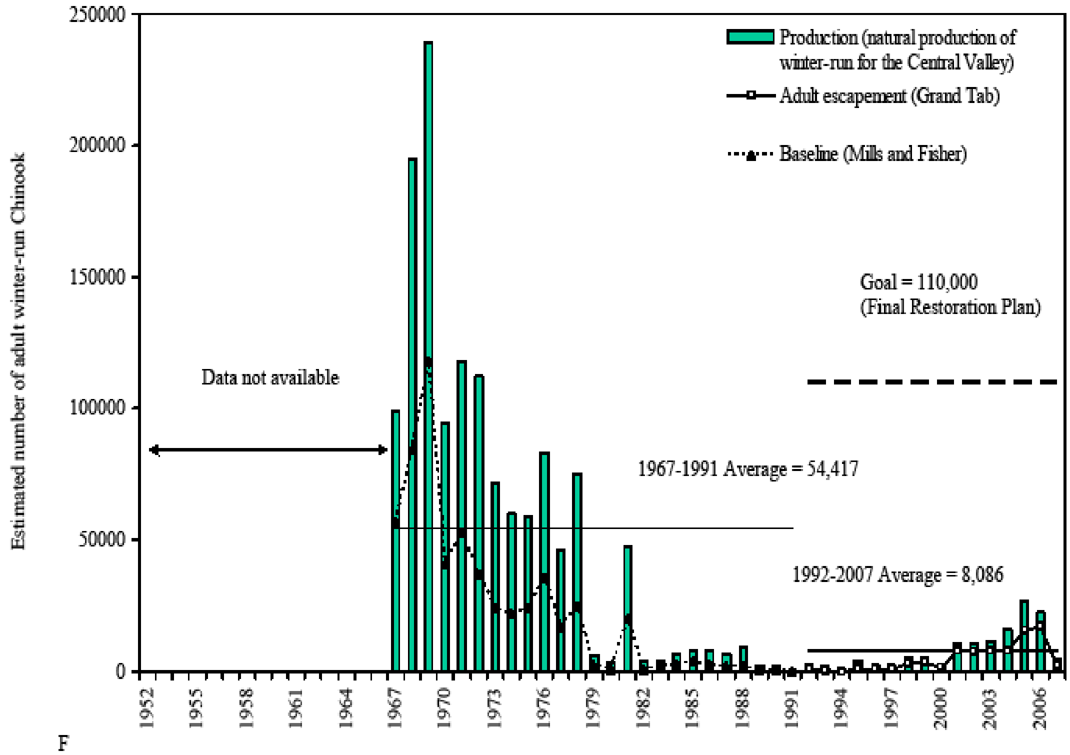

Figure 4-1. Estimated yearly adult natural production and in-river adult escapement of winter-run from 1967 - 2007 based on RBDD ladder counts (Hanson 2008[2]).

The upper Sacramento River is the only spawning area used by winter-run, although occasional strays have been reported in Battle Creek and Clear Creek. Since fish passage was improved in 2001 at the ACID Dam, winter-run spawning has shifted upstream. The majority of winter-run in recent years (*i.e.*, > 50 percent since 2007) spawn in the area from Keswick Dam downstream to the ACID Dam (approximately 5 miles). Keswick Dam re-regulates flows from Shasta Dam and mixes it with water diverted from the Trinity River through the Spring Creek tunnel. When the gates are down at RBDD, or flashboards in at the ACID Dam, access to the upper Sacramento River basin, including tributaries, can only be achieved through the RBDD and ACID Dam fish ladders. Both of these diversions' fish ladders allow salmonids to pass upstream, but completely block green sturgeon.

Table 4-2 provides data on the cohort replacement rate (CRR), which is similar to the SRR recommended by Anderson *et al*. (2009), that is, the ratio of the number of recruits returning to the spawning habitat divided by the number of spawners producing those recruits. As discussed, above, the majority of winter-run spawners are 3 years old. Therefore, NMFS calculated the CRR using the spawning population of a given year, divided by the spawning population 3 years prior.

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[2] Mohr (2008) stated that the source of the 1992–2007 production values from Hanson (2008) was Chinookprod_33108.xls rather than CDFG Grand Tab.

[3] Upper Sacramento River basin is considered the area upstream of RBDD for purposes of this Opinion.

Table 4-2. Winter-run population estimates from RBDD counts (1986 to 2001) and carcass counts (2001 to 2008), and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, CDFG 2007).

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated Juvenile Production Estimate (JPE)[c]
1986	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,556,995
2006	17,205	11,259	2.09	2.70	3,890,534
2007	2,488	10,268	0.32	2.31	1,100,067
2008	2,850[d]	9,195	0.18	1.13	1,152,043[e]
median	**2,488**	**1,961**	**1.54**	**2.31**	**370,221**

[a] Population estimates were based on RBDD counts until 2001. Starting in 2001, population estimates were based on carcass surveys.

[b] The majority of winter-run spawners are 3 years old. Therefore, NMFS calculated the CRR using the spawning population of a given year, divided by the spawning population 3 years prior.

[c] JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers. Only estimated to RBDD, does not include survival to the Delta.

[d] CDFG (2008)

[e] NMFS (2009b) preliminary estimate to Reclamation

Two current methods are utilized to estimate juvenile production of winter-run: the Juvenile Production Estimate (JPE) method, and the Juvenile Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the juvenile population of winter-run exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, Gaines and Poytress (2004) estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003. Averaging these two estimates yields an estimated population size of 3,782,476 juveniles during that timeframe.

4.2.1.2.2 Current Viability of the Sacramento River Winter-Run Chinook Salmon ESU

One prerequisite for predicting the effects of a proposed action on a species is understanding the likelihood of the species in question becoming viable, and whether the proposed action can be expected to reduce this likelihood. The abundance of spawners is just one of several criteria that must be met for a population to be considered viable. McElhany *et al*. (2000) acknowledged that a viable salmonid population at the ESU scale is not merely a quantitative number that needs to be attained. Rather, for an ESU to persist, populations within the ESU must be able to spread risk and maximize future potential for adaptation. ESU viability depends on the number of populations and subunits within the ESU, their individual status, their spatial arrangement with respect to each other and sources of catastrophic disturbance, and diversity of the populations and their habitats (Lindley *et al*. 2007). Populations comprise diversity groups, which are intended to capture important components of habitat, life history or genetic diversity that contribute to the viability of the ESU (Hilborn et al. 2003 *op. cit*. Lindley *et al.* 2007, Bottom *et al*. 2005 *op. cit*. Lindley *et al*. 2007). Lindley *et al*. (2007) suggest that at least two viable populations within each diversity group are required to ensure the viability of the diversity group, and hence, the ESU.

In order to determine the current likelihood of winter-run becoming viable, we used the historical population structure of winter-run presented in Lindley *et al*. (2004) and the concept of VSP for evaluating populations described by McElhany *et al.* (2000). While McElhany *et al.* (2000) introduced and described the concept of VSP, Lindley *et al*. (2007) applied the concept to the winter-run ESU. Lindley *et al.* (2004) identified four historical populations within the winter-run ESU, all independent populations, defined as those sufficiently large to be historically viable-in isolation and whose demographics and extinction risk were minimally influenced by immigrants from adjacent populations (McElhany *et al*. 2000). All four independent populations, however, are extinct in their historical spawning ranges. Three (Little Sacramento; Pit, Fall, Hat; and McCloud River) are blocked by the impassable Keswick and Shasta Dams (Lindley *et al*. 2004), and the Battle Creek independent population is no longer self-sustaining (Lindley *et al*. 2007).

Although Lindley *et al*. (2007) did not provide numerical goals for each population of Pacific salmonid to be categorized at low risk for extinction, they did provide various quantitative criteria to evaluate the risk of extinction (table 4-3). A population must meet all the low-risk thresholds to be considered viable. The following provides the evaluation of the likelihood of winter-run becoming viable based on the VSP parameters of population size, population growth rate, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany *et al.* 2000).

Table 4-3. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids (reproduced from Lindley *et al*. 2007).

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
[b] Decline within last two generations to annual run size ≤ 500 spawners, or run size > 500 but declining at ≥ 10% per year. Historically small but stable population not included.
[c] Run size has declined to ≤ 500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline < 90% but biologically significant.
[f] See Figure 1 for assessing hatchery impacts.

4.2.1.2.2.1 Population Size

Information about population size provides an indication of the type of extinction risk that a population faces. For instance, smaller populations are at a greater risk of extinction than large populations because the processes that affect populations operate differently in small populations than in large populations (McElhany *et al.* 2000). One risk of low population sizes is depensation. Depensation occurs when populations are reduced to very low densities and per capita growth rates decrease as a result of a variety of mechanisms [*e.g.,* failure to find mates and therefore reduced probability of fertilization, failure to saturate predator populations (Liermann and Hilborn 2001)]. As provided in table 4-2, the winter-run population, as represented by the 5-year moving average for adult escapement, was following an increasing trend from the mid-1990s until 2006. In 2007, the winter-run population declined precipitously. Low adult escapement was repeated in 2008. Likewise, the 5-year moving average cohort replacement rate was relatively stable since the late 1990s, with each cohort approximately doubling in size. However, the cohort replacement rate of 6.08 in 2003 buffered the effect of the significant decline in the cohort replacement rate of 0.32 in 2007. This is evident in the 5-year moving average cohort replacement rate ending in 2008, when the 6.08 cohort replacement rate in 2003 is not factored in. At the time of publication, Lindley *et al*. (2007) indicated that winter-run satisfies the low-risk criteria for population size, population decline, and catastrophe. However, they also acknowledged that the previous precipitous decline to a few hundred spawners per year in the early 1990s would have qualified it as high risk at that time, and the 1976-77 drought would have qualified as a high-risk catastrophe. In consideration of the almost 7-fold decrease in population in 2007, coupled with the dry water year type in 2007, followed by the critically dry water year type in 2008 (which could be qualified as a high-risk catastrophe) and likely a similar forecast for 2009, NMFS concludes that winter-run are at a high risk of extinction based on population size.

4.2.1.2.2.2 Population Growth Rate

The productivity of a population (*i.e.,* production over the entire life cycle) can reflect conditions (*e.g.,* environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). In general, declining productivity equates to declining population abundance. McElhany *et al.* (2000) suggested a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). This guideline seems reasonable in the absence of numeric abundance targets.

Winter-run have declined substantially from historic levels. The one remaining population of winter-run on the mainstem Sacramento River is also the entire current ESU. Although the population growth rate (indicated by the cohort replacement rate) increased since the late 1990s, it drastically decreased in 2007 and 2008, indicating that the population is not replacing itself, and is at a high risk of extinction in the foreseeable future.

4.2.1.2.2.3 Spatial Structure

In general, there is less information available on how spatial processes relate to salmonid viability than there is for the other VSP parameters (McElhany *et al.* 2000). Understanding the spatial structure of a population is important because the population structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment (McElhany *et al*. 2000). The spatial structure of winter-run resembles that of a panmictic population, where there are no subpopulations, and every mature male is equally likely to mate with every other mature female. The four historical independent populations of winter-run have been reduced to one population, resulting in a significant reduction in their spatial diversity. An ESU comprised of one population is not viable because it is unlikely to be able to adapt to significant environmental changes. A single catastrophe (*e.g*., volcanic eruption of Lassen Peak, prolonged drought which depletes the cold water pool at Lake Shasta, or some related failure to manage cold water storage, spill of toxic materials, or a disease outbreak) could extirpate the entire winter-run ESU if its effects persisted for 3 or more years. The majority of winter-run return to spawn in 3 years, so a single catastrophe with effects that persist for at least 3 years would affect all of the winter-run cohorts. Therefore, NMFS concludes that winter-run are at a high risk of extinction based on spatial structure.

4.2.1.2.2.4 Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany *et al.* 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The primary factor affecting the diversity of winter-run is the limited area of spawning habitat available on the mainstem Sacramento River downstream of Keswick Dam. This specific and narrow spawning habitat limits the flexibility and variation in spawning locations for winter-run to tolerate environmental variation. For example, a catastrophe on the mainstem Sacramento River could affect the entire population, and therefore, ESU. However, with the majority of spawners being 3 years old, winter-run do reserve some genetic and behavioral variation in that in any given year, two cohorts are in the marine environment, and therefore, not exposed to the same environmental stressors as their freshwater cohorts.

Although LSNFH is characterized as one of the best examples of a conservation hatchery operated to maximize genetic diversity and minimize domestication of the offspring produced in the hatchery, it still faces some of the same diversity issues as other hatcheries in reducing the diversity of the naturally-spawning population. Therefore, Lindley *et al*. (2007) characterizes hatchery influence as a looming concern with regard to diversity. Even with a small contribution of hatchery fish to the natural spawning population, hatchery contributions could compromise the long term viability and extinction risk of winter-run.

NMFS concludes that the current diversity in this ESU is much reduced compared to historic levels, and that winter-run are at a high risk of extinction based on the diversity VSP parameter.

4.2.1.2.2.5 Summary of the Current Viability of the Sacramento River Winter-Run Chinook Salmon ESU

An age-structured density-independent model of spawning escapement by Botsford and Brittnacker (1998 *op. cit.* Good *et al*. 2005) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures. This analysis found a biologically significant expected quasi-extinction probability of 28 percent. There is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al*. 2005).

Recently, Lindley *et al.* (2007) determined that the winter-run population, which is confined to spawning below Keswick Dam, is at a moderate extinction risk according to population viability analysis (PVA), and at a low risk according to other criteria (*i.e.*, population size, population decline, and the risk of wide ranging catastrophe). However, concerns of genetic introgression with hatchery populations are increasing. Hatchery-origin winter-run from LSNFH have made up more than 5 percent of the natural spawning run in recent years and in 2005, it exceeded 18 percent of the natural run. If this proportion of hatchery origin fish from the LSNFH exceeds 15 percent in 2006-2007, Lindley *et al*. (2007) recommends reclassifying the winter-run population extinction risk as moderate, rather than low, based on the impacts of the hatchery fish over multiple generations of spawners. In addition, data used for Lindley *et al*. (2007) did not include the significant decline in adult escapement numbers in 2007 and 2008, and thus, does not reflect the current status of the population size or the recent population decline. Furthermore, the current drought conditions in the Central Valley were not incorporated into the analysis of the winter-run population status in Lindley *et al*. (2007) as a potential catastrophic event.

Lindley *et al.* (2007) also states that the winter-run ESU fails the "representation and redundancy rule" because it has only one population, and that population spawns outside of the ecoregion in which it evolved. In order to satisfy the "representation and redundancy rule," at least two populations of winter-run would have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley *et al*. 2007). Based on the above descriptions of the population viability parameters, NMFS believes that the winter-run ESU is currently not viable.

4.2.1.2.3 Status of Sacramento River Winter-Run Chinook Salmon Critical Habitat

4.2.1.2.3.1 Summary of Designated Critical Habitat

The designated critical habitat for winter-run includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay

Bridge (June 16, 1993, 58 FR 33212). In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone (limited to those areas above a streambank that provide cover and shade to the nearshore aquatic areas) used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile emigration or adult spawning migration.

In designating critical habitat, NMFS considers the following requirements of the species: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species [see 50 CFR 424.12(b)]. In addition to these factors, NMFS also focuses on the known physical and biological features (essential features) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Within the range of winter-run, biological features of the designated critical habitat that are considered vital for winter-run include unimpeded adult upstream migration routes, spawning habitat, egg incubation and fry emergence areas, rearing areas for juveniles, and unimpeded downstream migration routes for juveniles.

4.2.1.2.3.2 Factors Affecting Critical Habitat

A wide range of activities may affect the essential habitat requirements of winter-run.
Water quantity and quality have been altered by the continued operations of Reclamation's CVP and DWR's SWP. In addition, small and large water diversions by private entities, such as the ACID and the GCID, withdraw incremental amounts of water directly from the Sacramento River, many of which are not screened, resulting in the direct loss of (mostly) juveniles to the diversions.

Habitat quantity and quality have also been altered. Keswick Dam precludes access to all of the historical spawning habitat for three independent populations of winter-run. In addition, access for the Battle Creek independent population has been blocked by the Coleman National Fish Hatchery weir and various hydropower dams and diversions (Lindley *et al*. 2004). Corps permitting activities that authorize dredging and other construction-related activities in the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay have modified aquatic habitat, including increasing sedimentation, simplifying streambank and riparian habitat, reducing connectivity to floodplain habitat, and modifying hydrology. All of these activities result in changes to the value of the essential features of winter run critical habitat that are necessary for their conservation.

4.2.1.2.3.3 Current Condition of Critical Habitat at the ESU Scale

The final rule designating critical habitat for winter-run (June 16, 1993, 58 FR 33212) identifies the following physical and biological features that are essential for the conservation of winter-run: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, (2) the availability of clean gravel for spawning substrate, (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5°F for successful spawning, egg incubation, and fry development, (5) habitat areas and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from spawning grounds to San Francisco Bay and the Pacific Ocean.

4.2.1.2.3.3.1 Access to Spawning Areas in the Upper Sacramento River

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adult winter-run generally migrate in the winter and spring months to spawning areas. During that time of year, the migration route is mostly free of obstructions. However, during the annual May 15 through September 15 gates in position, RBDD reduces the value of the migratory corridor.

4.2.1.2.3.3.2 The Availability of Clean Gravel for Spawning Substrate

Spawning habitat for winter-run is restricted to the Sacramento River primarily between Keswick Dam and RBDD. This reach was not historically utilized by winter-run for spawning. Because Shasta and Keswick dams preclude spawning gravel recruitment, Reclamation injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the reach of the upper Sacramento River continues to support the current populations of winter-run.

4.2.1.2.3.3.3 Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

An April 5, 1960, Memorandum of Agreement (MOA) between Reclamation and the DFG originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the flow releases required in Water Rights Order (WRO) 90-05. Table 5 of the project description provides the flow requirements in the 1960 MOA and WRO 90-05. Flow releases for agriculture and other consumptive uses during the winter-run egg incubation, fry development, and emergence life history stages, rather than minimum flow requirements, drive operations of Shasta and Keswick dams.

4.2.1.2.3.3.4 Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development

Reclamation releases cold water from Shasta Reservoir to provide for adult winter-run migration, spawning, and egg incubation. However, the extent winter-run habitat needs are met depends on Reclamation's other operational commitments, including those to settlement contractors, water service contractors, D-1641 requirements, and projected end of September storage volume. Based on these commitments, and Reclamation's modeled February and subsequent monthly forecasts, Reclamation determines how far downstream 56ºF can be maintained and sustained throughout the winter-run spawning, egg incubation, and fry development stages. Although WRO 90-05 and 91-1 require Reclamation to operate Keswick and Shasta dams, and the Spring Creek Powerplant, to meet a daily average water temperature of 56ºF at RBDD, they also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. In every year since the SWRCB issued WRO 90-05 and 91-1, operations plans have included modifying the RBDD compliance point to make best use of the coldwater resources based on the location of spawning Chinook salmon (CVP/SWP operations BA page 2-40). Once a TCP has been identified and established, it generally does not change, and therefore, water temperatures are typically adequate for successful, egg incubation, and fry development for those redds constructed upstream of the TCP. However, the annual change in TCP has degraded the conservation value of spawning habitat (based on water temperature).

4.2.1.2.3.3.5 Habitat Areas and Adequate Prey that are not Contaminated

Current water quality conditions are better than in previous decades, however legacy contaminants such as mercury (and methyl mercury), polychlorinated biphenyls (PCB), heavy metals, and persistent organochlorine pesticides continue to be found in watersheds throughout the Central Valley. Although most of these contaminants are at low concentrations in the food chain, they continue to work their way into the base of the food web, particularly when sediments are disturbed and previously entombed compounds are released into the water column. Exposure to these contaminated food sources may create delayed sublethal effects that reduce fitness at a time when the animal is physiologically stressed, *i.e.*, during smoltification or ocean entry.

Contaminants are typically associated with areas of urban development or other anthropogenic activities (*e.g.*, mercury contamination as a result of gold mining or processing). Areas with low human impacts frequently have low contaminant burdens, and therefore lower levels of potentially harmful toxicants in the aquatic system.

4.2.1.2.3.3.6 Riparian Habitat that Provides for Successful Juvenile Development and Survival

The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependant on the function of this habitat for successful survival and recruitment.

Some complex, productive habitats with floodplains remain in the system [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, Yolo and Sutter bypasses). Nevertheless, the current condition of riparian habitat for winter-run is degraded.

4.2.1.2.3.3.7 Access Downstream so that Juveniles can Migrate from Spawning Grounds to San Francisco Bay and the Pacific Ocean

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the mainstem of the Sacramento River. These corridors allow the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Currently, when the gates are in, RBDD reduces the value of the migratory corridor for downstream migration. In addition, although predators of juvenile Chinook salmon are prominent throughout the Sacramento River and Delta, they concentrate around structures, and therefore, a higher concentration of striped bass, and especially Sacramento pikeminnow, congregate downstream of RBDD when the gates are in, resulting in increased mortality of juvenile Chinook salmon from predation.

Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River. Although actual entrainment rates are not known, the CVP/SWP operations BA provided calculations of estimated entrainment of salmonids through unscreened diversions along the Sacramento River. According to the calculations, over 7,000 juvenile winter-run are lost to unscreened diversions annually.

D-1641 provides for 45 days of discretionary gate closures of the DCC between November 1 and January 31, which leaves the DCC gates open half the time during those 3 months. When the DCC gates are open during winter-run outmigration, a portion of the flow, and therefore, a portion of the outmigrating winter-run, is entrained through the DCC into the interior Delta, where their chances of survival and successful migration to San Francisco Bay and the Pacific Ocean are reduced.

Based on the impediments caused by the RBDD, unscreened diversions, and the opening of the DCC gates during the winter-run outmigration period, the current condition of the freshwater migration corridor in the Sacramento River is much degraded.

4.2.1.2.3.3.8 Sacramento River Winter-Run Chinook Salmon Critical Habitat Summary

Critical habitat for winter-run is composed of physical and biological features that are essential for the conservation of winter-run, including up and downstream access, and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these physical and biological features are impaired, and provide limited conservation value. For example, when the gates are in, RBDD reduces the value of the migratory corridor for upstream and downstream migration. Unscreened diversions throughout the mainstem Sacramento River, and the DCC when the gates are open during winter-run outmigration, do not provide a safe migratory corridor to San Francisco Bay and the Pacific Ocean.

In addition, the annual change in TCP has degraded the conservation value of spawning habitat (based on water temperature). The current condition of riparian habitat for winter-run rearing is degraded by the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system. However, some complex, productive habitats with floodplains remain in the system (*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and flood bypasses (*i.e.*, Yolo and Sutter bypasses).

Based on the impediments caused by RBDD when the gates are in, unscreened diversions, annual changes to the TCP, the time when the DCC gates are open during the winter-run outmigration period, and the degraded condition of spawning habitat and riparian habitat, the current condition of winter-run critical habitat is degraded, and has low value for the conservation of the species.

4.2.1.3 Central Valley Spring-Run Chinook Salmon

Historically, spring-run occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929).

Spring-run exhibit a stream-type life history. Adults enter freshwater in the spring, hold over the summer, spawn in the fall, and the juveniles typically spend a year or more in freshwater before emigrating. Adult spring-run leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (table 4-4; Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2007) indicate that adult spring-run migrate from the Sacramento River into spawning tributaries primarily between mid April and mid June. Typically, spring-run utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998). Reclamation reports that spring-run holding in upper watershed locations prefer water temperatures below 60°F, although salmon can tolerate temperatures up to 65°F before they experience an increased susceptibility to disease.

Spring-run spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994).

Spring-run fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as YOY or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2007). Studies in Butte Creek (Ward *et al*. 2002, 2003; McReynolds *et al*. 2005) found the majority of spring-run migrants to be fry occurring primarily from December through February, and that these movements appeared to be influenced by flow. Small numbers of spring-run remained in Butte Creek to rear and migrated as yearlings later in the year, typically the next fall. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later YOY migration and an earlier yearling migration (Lindley *et al*. 2007).

Once juveniles emerge from the gravel, they seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper, faster, water as they grow larger. Microhabitat use can be influenced by the presence of predators, which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). The emigration period for spring-run extends from November to early May, with up to 69 percent of the YOY fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998). Spring-run juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Peak movement of juvenile (yearling) spring-run in the Sacramento River at Knights Landing occurs in December, and again in March and April for YOY juveniles. However, juveniles also are observed between November and the end of May (Snider and Titus 2000). Based on the available information, the emigration timing of spring-run appears highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998).

4.2.1.3.1 Range-Wide (ESU) Status and Trends

Historically, spring-run were the second most abundant salmon run in the Central Valley (CDFG 1998). The Central Valley drainage as a whole is estimated to have supported spring-run runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers extirpated spring-run from these watersheds. Naturally-spawning populations of spring-run currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998). However, only Deer, Mill, and Butte creeks are considered to be independent spring-run populations. The other tributary populations are considered dependent populations, which rely on the three independent populations for continued existence at this time.

Table 4-4. The temporal occurrence of adult (a-c) and juvenile (d) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance. Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. YOY spring-run Chinook salmon emigrate during the first spring after they hatch.

(a) Adult migration																								
Location	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Sac.River basin[a,b]					M	M	M	M	H	H	H	H	M	M	M	M	M	M	L	L				
Sac. River mainstem[c]	L	L	L	L	M	M	M	M	M	M	M	M	M	M	L	L								
Mill Creek[d]					L	L	M	H	H	H	H	M	M	L	L									
Deer Creek[d]					L	L	M	H	H	H	H	M	M											
Butte Creek[d]			M	M	M	M	M	H	H	H	H	M	L											
(b) Adult Holding			M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	M	M	L				
(c) Adult Spawning															L	M	H	H	M	L				
(d) Juvenile migration																								
Location	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Sac. River Tribs[e]	M	M	M	M	M	M													M	M	H	H	H	H
Upper Butte Creek[f]	H	H	H	H	M	M	M	M	M	M	L	L							L	L	L	L	H	H
Mill, Deer, Butte Creeks[d]	H	H	H	H	M	M	M	M	M	M	L	L							L	L	L	L	L	L
Sac. River at RBDD[c]	H	H	L	L	L	L	L	L	L												H	H	H	H
Sac. River at KL[g]											L	L									M	M	H	H

Relative Abundance: H = High; M = Medium; L = Low

Sources: [a]Yoshiyama *et al*. (1998); [b]Moyle (2002); [c]Myers *et al*. (1998); [d]Lindley *et al*. (2007); [e]CDFG (1998); [f]McReynolds *et al*. (2005); Ward *et al*. (2002, 2003); [g]Snider and Titus (2000)

On the Feather River, significant numbers of spring-run, as identified by run timing, return to the FRFH. From 1986 to 2007, the average number of spring-run returning to the FRFH was 3,992, compared to an average of 12,888 spring-run returning to the entire Sacramento River Basin (table 4-5). CWT information from these hatchery returns indicates substantial introgression has occurred between spring-run and fall-run populations within the Feather River system due to hatchery practices. Because Chinook salmon have not always been temporally separated in the hatchery, spring-run and fall-run have been spawned together, thus compromising the genetic integrity of the spring-run and early fall-run stocks. The number of naturally spawning spring-run in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run (Good *et al*. 2005). For the reasons discussed above, and the importance of genetic diversity as one of the VSP parameters, the Feather River spring-run population numbers are not included in the following discussion of ESU abundance.

The spring-run ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982 (table 4-5, figure 4-2). Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the spring-run ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of spring-run remains well below estimates of historic abundance. In 2008, adult escapement of spring-run declined in several of the region's watersheds. Butte Creek had an estimated 6,000 adults return to the watershed, while more significant decreases occurred on Mill Creek (362 fish), Deer Creek (140 fish), and Antelope Creek (2 fish). In contrast, Clear Creek had a modest increase in returning spring-run adults with an estimated 199 adults returning in 2008. These fluctuations may be attributable to poor ocean conditions that existed when the returning 2008 adults entered the ocean as smolts (spring of 2006) and led to poor ocean survival in the critical ocean entry phase of their life history. Additional factors that have limited adult spawning populations are in-river water quality conditions. In 2002 and 2003, mean water temperatures in Butte Creek exceeded 21ºC for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of columnaris disease (*Flexibacter columnaris*) and ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run in Butte Creek.

Recent actions by fishery management agencies have improved habitat conditions on Clear Creek for spring-run. The Clear Creek population of spring-run appears to be increasing in abundance, albeit modestly. Significant efforts have beeen made to enhance oversummering flows in the upper reaches below Whiskeytown Dam, maintain suitable water temperatures in those reaches, enhance spawning habitat through gravel augmentation, and prevent genetic introgression with fall-run which utilize the same watershed. Concern exists over the timing of the RBDD gate closures and whether this action delays spring-run bound for Clear Creek to the extent that adults cannot access the watershed due to thermal barriers forming in the lower reaches of the creek near its confluence with the Sacramento River.

The Butte, Deer, and Mill Creek populations of spring-run are in the Northern Sierra Nevada diversity group. Lindley *et al*. (2007) indicated that spring-run populations in Butte and Deer Creeks had a low risk of extinction, according to their PVA model and the other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence). The Mill Creek population of spring-run is at moderate extinction risk according to the PVA model, but appears to satisfy the other viability criteria for low-risk status. However, the spring-run ESU fails to meet the "representation and redundancy rule," since the Northern Sierra Nevada is the only diversity group in the spring-run ESU that contains demonstrably viable populations out of at least 3 diversity groups that historically contained them. Independent populations of spring-run only occur within the Northern Sierra Nevada diversity group. The Northwestern California diversity group contains a few ephemeral populations of spring-run that are likely dependent on the Northern Sierra Nevada populations for their continued existence. The spring-run populations that historically occurred in the Basalt and Porous Lava, and Southern Sierra Nevada, diversity groups have been extirpated. Over the long term, the three remaining independent populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the spring-run populations in the Deer, Mill, and Butte Creek watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Table 4-5. Central Valley spring-run Chinook salmon population estimates with corresponding cohort replacement rates (CRR) for years since 1986 (CDFG 2008).

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average of Tributary Population Estimate	Trib CRR[b, c]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	25,696	1,433	24,263						
1987	13,888	1,213	12,675						
1988	18,933	6,833	12,100						
1989	12,163	5,078	7,085		0.29			0.47	
1990	7,683	1,893	5,790	12,383	0.46		15,673	0.55	
1991	5,927	4,303	1,624	7,855	0.13		11,719	0.31	
1992	3,044	1,497	1,547	5,629	0.22		9,550	0.25	
1993	6,075	4,672	1,403	3,490	0.24	0.27	6,978	0.79	0.48
1994	6,187	3,641	2,546	2,582	1.57	0.52	5,783	1.04	0.59
1995	15,238	5,414	9,824	3,389	6.35	1.70	7,294	5.01	1.48
1996	9,082	6,381	2,701	3,604	1.93	2.06	7,925	1.49	1.72
1997	5,086	3,653	1,433	3,581	0.56	2.13	8,334	0.82	1.83
1998	31,471	6,746	24,725	8,246	2.52	2.58	13,413	2.07	2.09
1999	9,835	3,731	6,104	8,957	2.26	2.72	14,142	1.08	2.09
2000	9,234	3,657	5,577	8,108	3.89	2.23	12,942	1.82	1.46
2001	17,698	4,135	13,563	10,280	0.55	1.96	14,665	0.56	1.27
2002	17,409	4,189	13,220	12,638	2.17	2.28	17,129	1.77	1.46
2003	17,570	8,662	8,908	9,474	1.60	2.09	14,349	1.90	1.43
2004	13,986	4,212	9,774	10,208	0.72	1.78	15,179	0.79	1.37
2005	16,117	1,771	14,346	11,962	1.09	1.22	16,556	0.93	1.19
2006	10,652	1,952	8,700	10,990	0.98	1.31	15,147	0.61	1.20
2007	10,571	2,752	7,819	9,909	0.80	1.04	13,779	0.76	1.00
Median	10,652	3,731	7,819	8,246	0.98	1.96	13,413	0.82	1.43

[a] NMFS included both the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River and its tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.

[b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

[c] The majority of spring-run spawners are 3 years old. Therefore, NMFS calculated the CRR using the spawning population of a given year, divided by the spawning population 3 years prior.

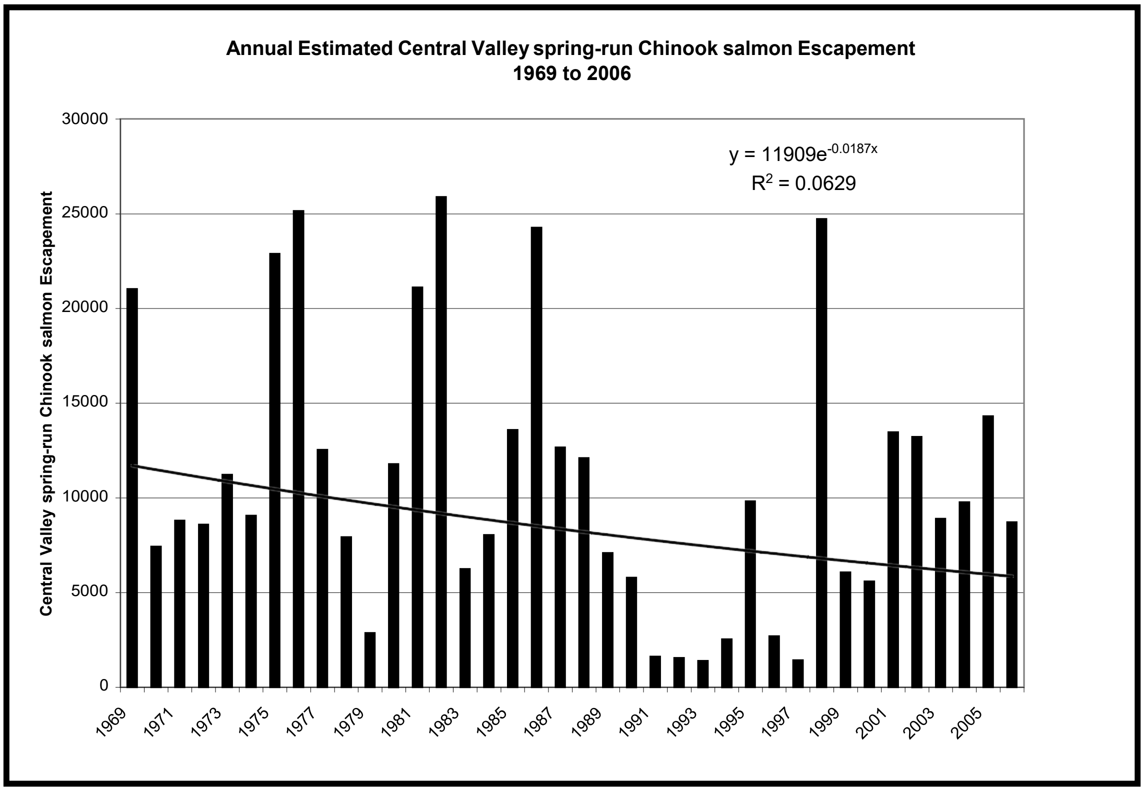


Figure 4-2. Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1969 through 2006 (PFMC 2002, 2004, CDFG 2004b, Yoshiyama 1998, GrandTab 2006).

4.2.1.3.2 Current Viability of the Central Valley Spring-Run Chinook Salmon ESU

The earlier analysis to determine the likelihood of winter-run becoming viable described the process that NMFS uses to apply the VSP concept in McElhany *et al*. (2000). In order to determine the current likelihood of the spring-run ESU becoming viable, we used the historical population structure of spring-run presented in Lindley *et al*. (2007, figure 4-3) and the concept of VSP for evaluating populations described by McElhany *et al.* (2000). While McElhany *et al.* (2000) introduced and described the concept of VSP, Lindley *et al*. (2007) applied the concept to the spring-run ESU. Lindley *et al*. (2004) identified 26 historical populations within the spring-run ESU; 19 were independent populations, and 7 were dependent populations. Of the 19 independent populations of spring-run that occurred historically, only three remain, in Deer, Mill, and Butte creeks. Extant dependent populations occur in Battle, Antelope, Big Chico, Clear, Beegum, and Thomes creeks, as well as in the Yuba River, the Feather River below Oroville Dam, and in the mainstem Sacramento River below Keswick Dam.

Table 4-3 provides various quantitative criteria to evaluate the risk of extinction. The following provides the evaluation of the likelihood of the threatened spring-run ESU becoming viable based on the VSP parameters of population size, population growth rate, spatial structure, and diversity.

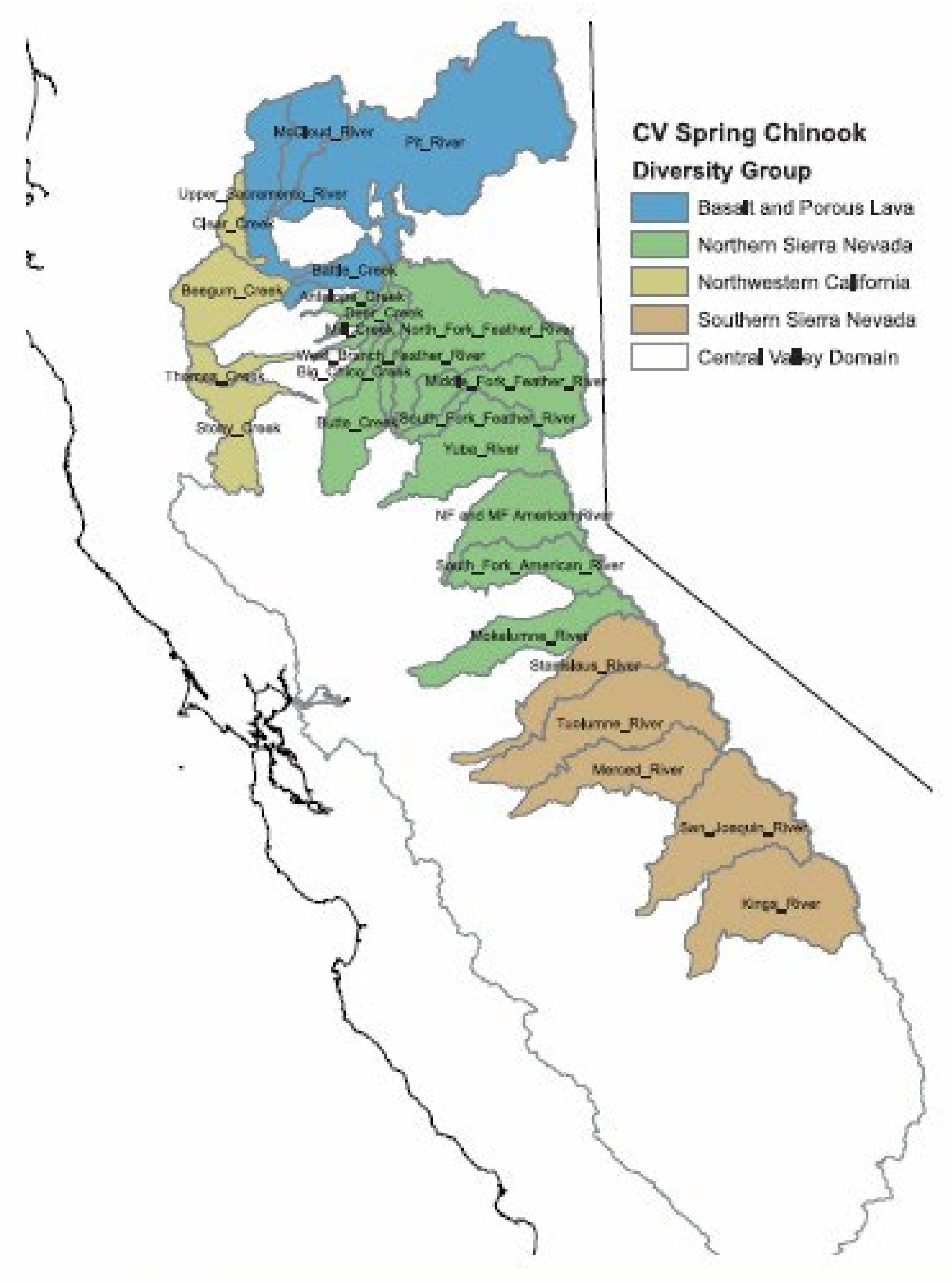


Figure 4-3. CV spring-run Chinook salmon diversity groups (replicated from Lindley *et al*. 2007).

4.2.1.3.2.1 Population Size

As provided in table 4-5, spring-run declined drastically in the mid to late 1980s before stabilizing at very low levels in the early to mid 1990s. Since the late 1990s, there does not appear to be a trend in basin-wide abundance, having fluctuated from approximately 25,000 fish in 1999 to slightly more than 10,000 fish in 2008. Abundance is generally dominated by the Butte Creek population. Other independent and dependent populations are smaller. The cohort replacement rate behaved similarly, falling below 1.0 in the 3 of the previous 4 years, in parallel with the reduced escapement numbers. The 5-year moving average cohort replacement rate, however, has remained above 1.0 since 1995.

4.2.1.3.2.2 Population Growth Rate

Cohort replacement rates are indications of whether a cohort is replacing itself in the next generation. As mentioned in the previous subsection, the cohort replacement rate since the late 1990s has fluctuated, and does not appear to have a pattern. Since the cohort replacement rate is a reflection of population growth rate, there does not appear to be an increasing or decreasing trend. The 5-year moving average of population estimate indicated an increasing population trend since the mid 1990s until very recently (2006), at which point the population has decreased in two consecutive years.

4.2.1.3.2.3 Spatial Structure

Lindley *et al*. (2007) indicated that of the 19 independent populations of spring-run that occurred historically, only three (Butte, Mill, and Deer creeks) remain, and their current distribution makes the spring-run ESU vulnerable to catastrophic disturbance. Butte, Mill, and Deer Creeks all occur in the same biogeographic region (diversity group), whereas historically, independent spring-run populations were distributed throughout the CV among at least three diversity groups (*i.e*., basalt and porous lava, northern Sierra Nevada, and southern Sierra Nevada). In addition, dependent spring-run populations historically persisted in the Northwestern California diversity group (Lindley *et al*. 2004). Currently, there are dependent populations of spring-run in the Big Chico, Antelope, Clear, Thomes, Battle, and Beegum creeks, and in the Sacramento, Feather, and Yuba rivers. As mentioned earlier, the extant Feather River and mainstem Sacramento River populations probably do not represent historical entities (Lindley *et al*. 2007).

4.2.1.3.2.4 Diversity

Diversity, both genetic and behavioral, provides a species the opportunity to track environmental changes. As a species' abundance decreases, and spatial structure of the ESU is reduced, a species has less flexibility to track changes in the environment. Spring-run have been entirely extirpated from the basalt and porous lava region and the southern Sierra Nevada region. The only viable and independent populations (*i.e*., Mill, Deer, and Butte creeks) of spring-run are limited to the northern Sierra Nevada region, and a few ephemeral or dependent populations are found in the Northwestern California region. A single catastrophe, for example, the eruption of Mount Lassen, a large wildland fire at the headwaters of Mill, Deer, and Butte creeks, or a drought, poses a significant threat to the extinction risk of the ESU that otherwise would not be there if the ESU's spatial structure and diversity were greater. As with winter-run, spring-run do reserve some genetic and behavioral variation in that in any given year, at least two cohorts are in the marine environment, and therefore, not exposed to the same environmental stressors as their freshwater cohorts.

Although spring-run produced at the FRFH are part of the spring-run ESU (June 28, 2005, 70 FR 37160), they compromise the genetic diversity of naturally-spawned spring-run. More than

523,000 FRFH spring-run fry were planted at the base of Whiskeytown Dam during the 3-year period 1991−1993 (CDFG 1998 *op. cit*. CVP/SWP operations BA). The fact that these hatchery fish behave more like fall-run (spawn later than spring-run in Deer, Mill, and Butte creeks), likely increases introgression of the spring- and fall- runs, and reduces diversity.

4.2.1.3.2.5 Summary of the Current Viability of the Central Valley Spring-Run Chinook Salmon ESU

Butte Creek and Deer Creek spring-run are at low risk of extinction, satisfying both the population viability analysis (PVA) and other viability criteria. Mill Creek is at moderate extinction risk according to the PVA, but appear to satisfy the other viability criteria for low-risk status (Lindley *et al*. 2007). Spring-run fail the representation and redundancy rule for ESU viability, as the current distribution of independent populations has been severely constricted to only one of their former geographic diversity groups. Therefore, the spring-run ESU are at moderate risk of extinction in 100 years.

4.2.1.3.3 Status of Central Valley Spring-Run Chinook Salmon Critical Habitat

4.2.1.3.3.1 Summary of Designated Critical Habitat

Critical habitat was designated for spring-run on September 2, 2005 (70 FR 52488), and includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series; Bain and Stevenson 1999; September 2, 2005, 70 FR 52488).

In designating critical habitat, NMFS considers the following requirements of the species: (1) space for individual and population growth, and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing offspring; and, generally, (5) habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species [see 50 CFR 424.12(b)]. In addition to these factors, NMFS also focuses on the known physical and biological features (essential features) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation.

Critical habitat for spring-run is defined as specific areas that contain the PCEs and physical habitat elements essential to the conservation of the species. Within the range of the spring-run ESU, biological features of the designated critical habitat that are considered vital for spring-run include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. The following describe the current conditions of the freshwater PCEs for spring-run.

4.2.1.3.3.2 Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Spring-run spawn in the mainstem Sacramento River between RBDD and Keswick Dam (however, little spawning activity has been recorded in recent years) and in tributaries such as Mill, Deer, and Butte creeks. Operations of Shasta and Keswick Dams on the mainstem Sacramento River that are focused primarily to ensure an adequate quantity and quality of water for successful adult winter-run migration, holding, spawning, and incubation may at the same time be limiting the amount of cold water needed to ensure successful incubation of any spring-run eggs spawned on the mainstem Sacramento River.

4.2.1.3.3.3 Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system are much degraded, and typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. However, some complex, productive habitats with floodplains remain in the system [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, Yolo and Sutter bypasses). Juvenile life stages of salmonids are dependant on the function of this habitat for successful survival and recruitment.

4.2.1.3.3.4 Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower reaches of the spawning tributaries, the mainstem of the Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. The RBDD creates an upstream migratory barrier during its May 15 through September 15 "gates in" configuration. Approximately 10 percent of the spring-run spawn upstream of RBDD. Of those, approximately 72 percent of them attempt to migrate past RBDD during the gates in period [Tehama-Colusa Canal Authority (TCCA) and Reclamation 2002]. Less than 1 percent of spring-run juveniles are potentially impacted by passing under the dam during their downstream migration (TCCA and Reclamation 2002). Juvenile spring-run that try to migrate past RBDD in its gates down position are subjected to disorientation. In addition, although predators of juvenile spring-run are prominent throughout the Sacramento River and Delta, they concentrate around structures, and therefore, a higher concentration of striped bass, and especially Sacramento pikeminnow, reside downstream of RBDD and prey on outmigrating juvenile salmonids.

Significant amounts of flow and many juvenile spring-run enter the DCC (when the gates are open) and Georgiana Slough, especially during increased Delta pumping. Mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. This difference in mortality could be caused by a combination of factors: the longer migration route through the central Delta to the western Delta, exposure to higher water temperatures, higher predation rates, exposure to seasonal agricultural diversions, water quality impairments due to agricultural and municipal discharges, and a more complex channel configuration making it more difficult for salmon to successfully migrate to the western Delta and the ocean. In addition, the State and Federal pumps and associated fish facilities increase mortality of juvenile spring-run through various means, including entrainment into the State and Federal canals, handling, trucking, and release.

The current condition of freshwater migration corridors in the Sacramento River is much degraded.

4.2.1.3.3.5 Estuarine Areas

Ideal estuarine areas are free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are necessary for juvenile and adult foraging. Current estuarine areas are degraded as a result of the operations of the CVP and SWP. Spring-run smolts are drawn to the central and south Delta as they outmigrate, and are subjected to the indirect (*e.g.,* predation, contaminants) and direct (*e.g*., salvage, loss) effects of the Delta and both the Federal and State fish facilities.

The current condition of the estuarine habitat in the project area has been substantially degraded from historic conditions. Over 90 percent of the fringing fresh, brackish, and salt marshes have been lost to human actions. This loss of the fringing marshes reduces the availability of forage species and eliminates the cycling of nutrients from the marsh vegetation into the water column of the adjoining waterways. The channels of the Delta have been modified by the raising of levees and armoring of the levee banks with stone riprap. This reduces habitat complexity by reducing the incorporation of woody debris and vegetative material into the nearshore area, minimizing and reducing local variations in water depth and velocities, and simplifying the community structure of the nearshore environment. Delta hydraulics has been modified as a result of CVP and SWP actions. Within the central and southern Delta, net water movement is towards the pumping facilities, altering the migratory cues for emigrating fish in these regions. Operations of upstream reservoir releases and diversion of water from the southern Delta have been manipulated to maintain a "static" salinity profile in the western Delta near Chipps Island (the X2 location). This area of salinity transition, the low salinity zone (LSZ), is an area of high productivity. Historically, this zone fluctuated in its location in relation to the outflow of water from the Delta and moved westwards with high Delta inflow (*i.e.*, floods and spring runoff) and eastwards with reduced summer and fall flows. This variability in the salinity transition zone has been substantially reduced by the operations of the projects. The project's long-term water diversions also have contributed to reductions in the phytoplankton and zooplankton populations in the Delta itself as well as alterations in nutrient cycling within the Delta ecosystem. Heavy urbanization and industrial actions have lowered water quality and introduced persistent contaminants to the sediments surrounding points of discharge (*i.e.*, refineries in Suisun and San Pablo bays, creosote factories in Stockton, *etc*.)

4.2.1.3.3.6 Central Valley Spring-Run Chinook Salmon Critical Habitat Summary

The current condition of spring-run critical habitat is degraded, and does not provide the conservation value necessary for the recovery of the species. Spring-run critical habitat has suffered similar types of degradation as winter-run critical habitat.

4.2.2 Steelhead

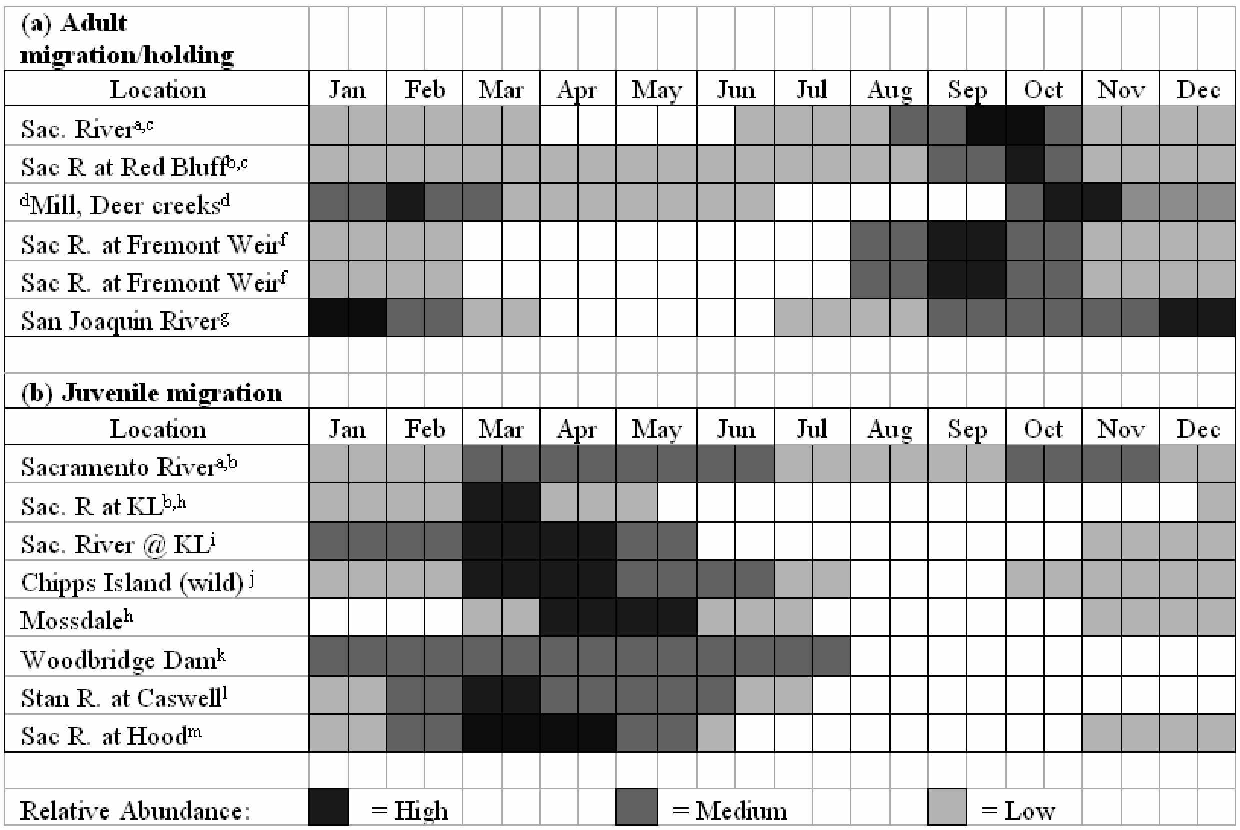
4.2.2.1 General Life History

Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter steelhead are currently found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s [Interagency Ecological Program (IEP) Steelhead Project Work Team 1999]. At present, summer steelhead are found only in northern California coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

4.2.2.2 Central Valley Steelhead

CV steelhead generally leave the ocean from August through April (Busby *et al.* 1996), and spawn from December through April, with peaks from January though March, in small streams and tributaries where cool, well oxygenated water is available year-round (table 4-6; Hallock *et al.* 1961, McEwan and Jackson 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches at river mouths, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Barnhart 1986, Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

Table 4-6. The temporal occurrence of (a) adult and (b) juvenile Central Valley steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.



Sources: [a]Hallock *et al*. (1961); [b]McEwan (2001); [c]USFWS (unpublished data); [d]CDFG (1995); [e]Hallock *et al.* (1957); [f]Bailey (1954); [g]CDFG Steelhead Report Card Data; [h]CDFG (unpublished data); [i]Snider and Titus (2000); [j]Nobriga and Cadrett (2003); [k]Jones & Stokes Associates, Inc. (2002); [l]S.P. Cramer and Associates, Inc. (2000, 2001); [m]Schaffter (1980, 1997)

Spawning occurs during winter and spring months. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51°F. Fry emerge from the gravel usually about 4 to 6 weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can affect emergence timing (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although YOY also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating CV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CV steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some juvenile steelhead may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island, Suisun Bay.

4.2.2.2.1 Range-Wide (DPS) Status and Trends

Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially (figure 4-4). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of approximately 8,000 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2003) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. Good *et al.* (2005) made the following conclusion based on the Chipps Island data:

> "If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s."

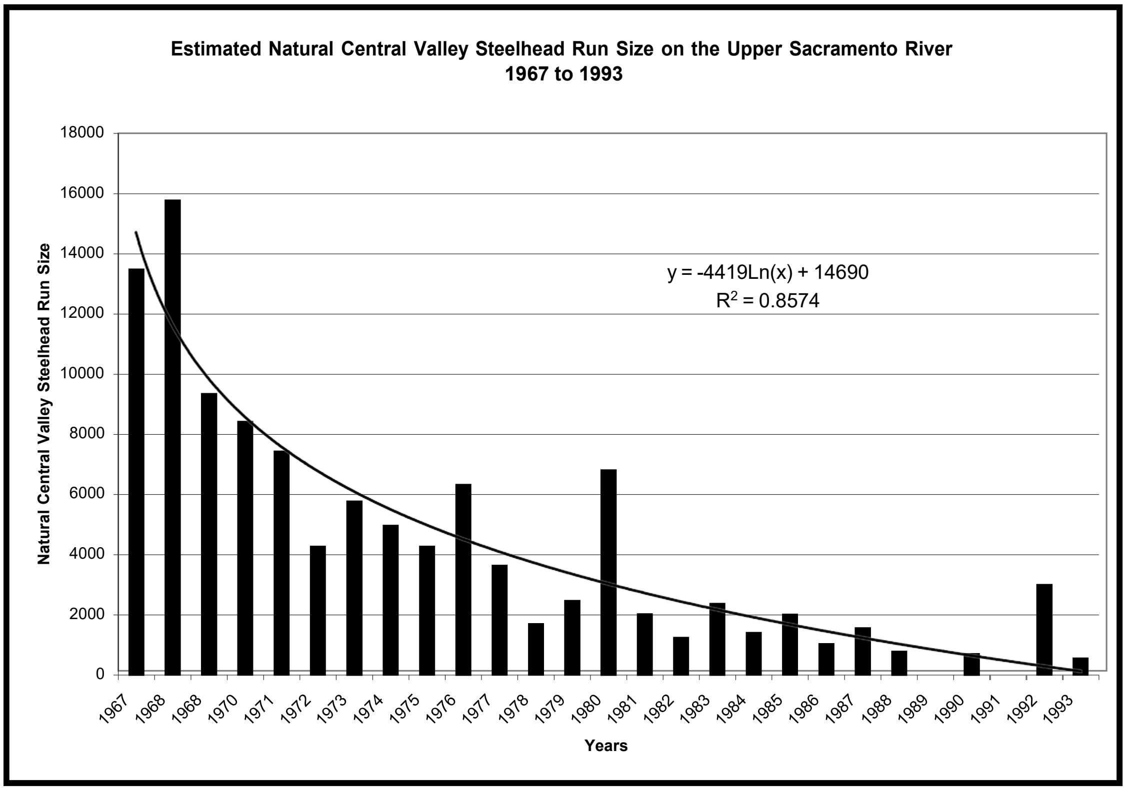


Figure 4-4. Estimated natural Central Valley steelhead escapement in the upper Sacramento River based on RBDD counts. Note: Steelhead escapement surveys at RBDD ended in 1993 (from McEwan and Jackson 1996).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Snorkel surveys from 1999 to 2002 indicate that steelhead are present in Clear Creek (Newton 2002 *op. cit*. Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Recent monitoring has detected small, self-sustaining populations (*i.e*., non-hatchery origin) of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). Zimmerman *et al.* (2008) documented CV steelhead in the Stanislaus, Tuolumne and Merced rivers based on otilith microchemistry.

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of juvenile steelhead also have occurred on the Tuolumne and Merced Rivers during fall-run monitoring activities, indicating that steelhead are widespread throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff have prepared catch summaries for juvenile migrant CV steelhead on the San Joaquin River near Mossdale, which represents migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG (2003) stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River" (figure 4-5). The documented returns on the order of single fish in these tributaries suggest that existing populations of CV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed.

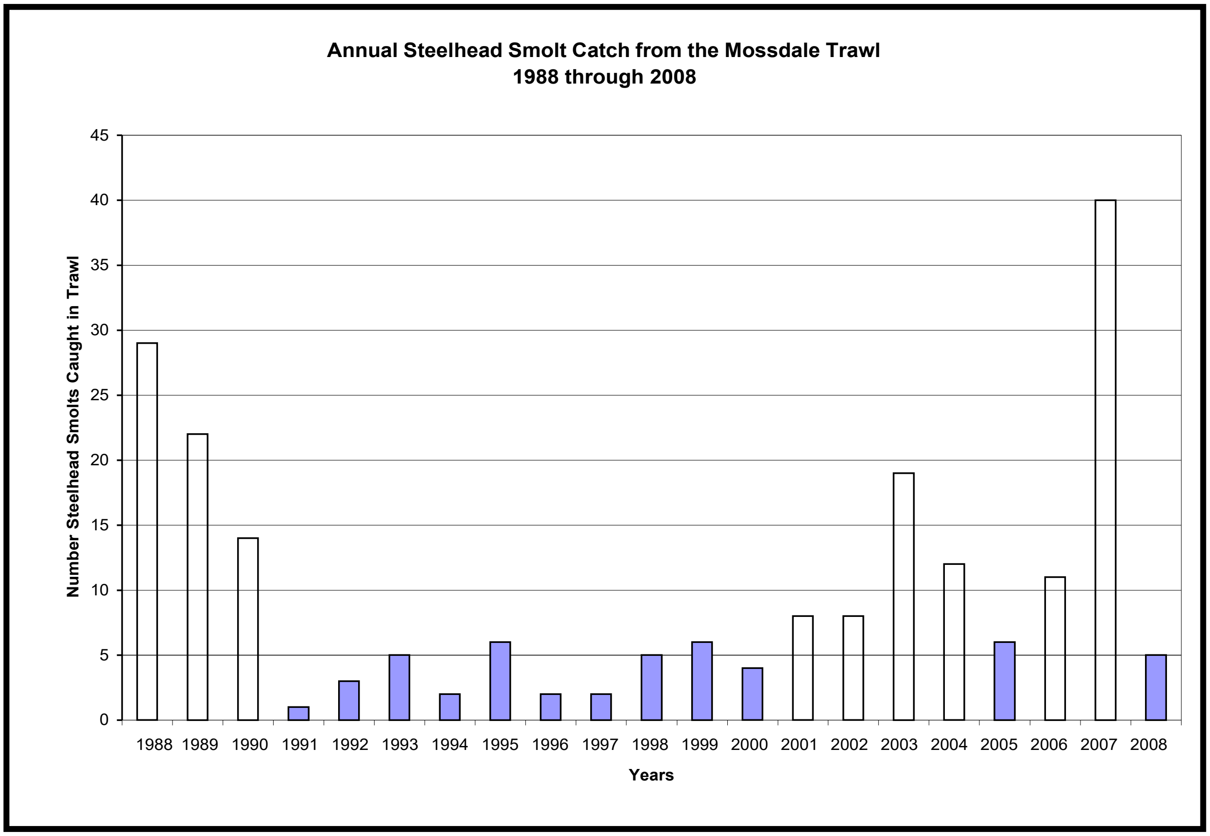


Figure 4-5. Annual number of Central Valley steelhead smolts caught while Kodiak trawling at the Mossdale monitoring location on the San Joaquin River (Marston 2004, SJRGA 2007, Speegle 2008).

4.2.2.2.2 Current Viability of the Central Valley Steelhead DPS

The earlier analysis to determine the likelihood of winter-run becoming viable described the process that NMFS uses to apply the VSP concept in McElhany *et al*. (2000). In order to determine the current likelihood of the CV steelhead DPS becoming viable, we used the historical population structure of CV steelhead presented in Lindley *et al*. (2006, 2007; figure 4-6) and the concept of VSP for evaluating populations described by McElhany *et al.* (2000). While McElhany *et al.* (2000) introduced and described the concept of VSP, Lindley *et al*. (2007) applied the concept to the CV steelhead DPS.

Table 4-3 provides various quantitative criteria to evaluate the risk of extinction. The following provides the evaluation of the likelihood of the threatened CV steelhead DPS becoming viable based on the VSP parameters of population size, population growth rate, spatial structure, and diversity.

4.2.2.2.2.1 Population Size

As provided above and in figure 4-4, estimated natural CV steelhead escapement in the upper Sacramento River has declined substantially from 1967 through 1993. There is still a nearly complete lack of steelhead monitoring in the Central Valley (Good *et al*. 2005), and therefore, data are lacking regarding a definitive population size for CV steelhead. However, the little data that exist indicate that the CV steelhead population continues to decline (Good *et al*. 2005).

4.2.2.2.2.2 Population Growth Rate

CV steelhead has shown a pattern of a negative growth rate since the late 1960s (figure 4-4). Good *et al*. (2005) provided no indication that this trend has changed since the last CV steelhead population census in 1993.

4.2.2.2.2.3 Spatial Structure

Lindley *et al*. (2006) identified 81 historical and independent populations within the CV steelhead DPS. These populations form 8 clusters, or diversity groups, based on the similarity of the habitats they occupied for spawning and rearing. About 80 percent of the habitat that was historically available to CV steelhead is now behind impassable dams, and 38 percent of the populations have lost all of their habitats. Although much of the habitat has been blocked by impassable dams, or degraded, small populations of CV steelhead are still found throughout habitat available in the Sacramento River and many of the tributaries, and some of the tributaries to the San Joaquin River.

4.2.2.2.2.4 Diversity

Diversity, both genetic and behavioral, provides a species the opportunity to track environmental changes. CV steelhead naturally experience the most diverse life history strategies of the listed Central Valley anadromous salmonid species. In addition to being iteroparous, they reside in freshwater for 2-4 years before emigrating to the ocean. However, as the species' abundance decreases, and spatial structure of the DPS is reduced, it has less flexibility to track changes in the environment. CV steelhead abundance and growth rate continue to decline, largely the result of a significant reduction in the diversity of habitats available to CV steelhead (Lindley *et al*. 2006). The genetic diversity of CV steelhead is also compromised by hatchery-origin fish, which likely comprise the majority of the natural spawning run, placing the natural populations at high risk of extinction (Lindley *et al*. 2007). Consistent with the life history strategy of winter-run and spring-run, some genetic and behavioral variation is conserved in that in any given year, there are additional cohorts in the marine environment, and therefore, not exposed to the same environmental stressors as their freshwater cohorts.

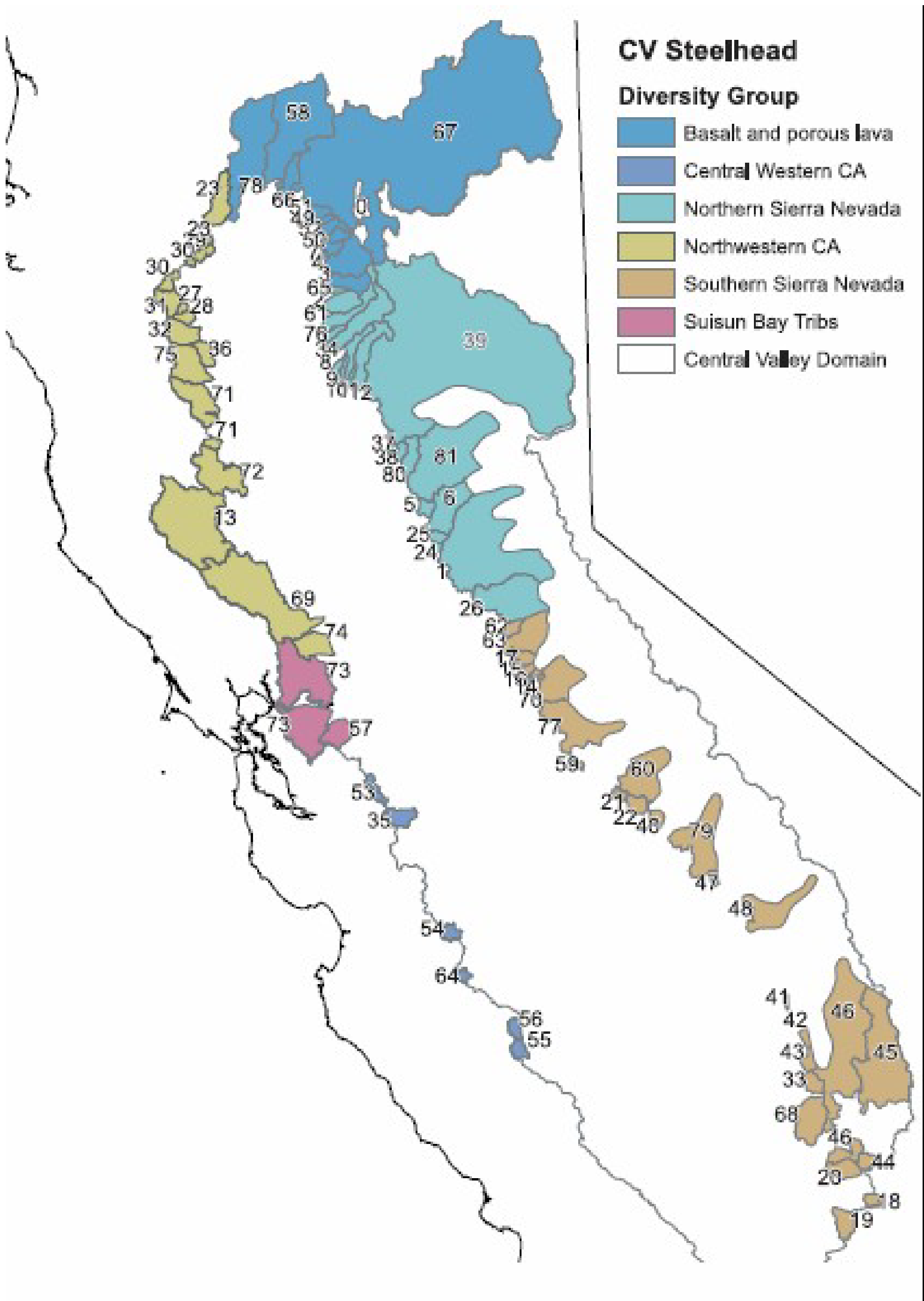


Figure 4-6. CV steelhead[4] diversity groups (replicated from Lindley *et al.* 2007).

[4] Note that the Suisun Bay Tribs identified in the figure (in pink) belong in the CCC steelhead DPS (see section 4.1.1).

4.2.2.2.2.5 Summary of the Current Viability of the CV Steelhead DPS

Lindley *et al*. (2007) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. The future of CV steelhead is uncertain due to limited data concerning their status. However, Lindley *et al.* (2007) concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction.

4.2.2.2.3 Status of CV Steelhead Critical Habitat

4.2.2.2.3.1 Summary of Designated Critical Habitat

Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488). Critical habitat for CV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the lower San Joaquin River to the confluence with the Merced River, including its tributaries, and the waterways of the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series; Bain and Stevenson 1999; September 2, 2005, 70 FR 52488). Critical habitat for CV steelhead is defined as specific areas that contain the PCE and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CV steelhead.

4.2.2.2.3.2 Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for CV steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e*., above RBDD, but below Keswick Dam, on the Sacramento River) on perennial watersheds throughout the Central Valley. These reaches can be subjected to variations in flows and temperatures, particularly over the summer months, which can have negative effects upon salmonids spawning below them.

4.2.2.2.3.3 Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system [*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependant on the function of this habitat for successful survival and recruitment. Steelhead are more susceptible to the negative effects of degraded rearing habitat, as they rear in freshwater longer than winter-run and spring-run.

4.2.2.2.3.4 Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Currently, RBDD gates are down from May 15 through September 15, and impede the upstream and downstream migration of a portion of each adult and juvenile cohort. Juvenile CV steelhead that try to migrate past RBDD when its gates are down are subjected to disorientation. In addition, although predators of juvenile CV steelhead are prominent throughout the Sacramento River and Delta, they concentrate around structures, and therefore, a higher concentration of striped bass, and especially Sacramento pikeminnow, reside downstream of RBDD and prey on outmigrating juvenile salmonids.

Juvenile CV steelhead that outmigrate from the San Joaquin River tributaries are exposed to degraded migration corridors, just as they are exposed to degraded water quality in the lower San Joaquin River basin and the Stockton DWSC. Significant amounts of flow and many juvenile CV steelhead from the Sacramento River enter the DCC (when the gates are open) and Georgiana Slough into the central Delta. Likewise, some juvenile CV steelhead from the San Joaquin River are diverted into the southern Delta through Old River and Turner and Columbia Cuts. Mortality of juvenile CV steelhead entering the central Delta is higher than for those continuing downstream in the Sacramento and San Joaquin rivers. This difference in mortality could be caused by a combination of factors: the longer migration route through the central Delta to the western Delta, exposure to higher water temperatures, higher predation rates, exposure to seasonal agricultural diversions, water quality impairments due to agricultural and municipal discharges, and a more complex channel configuration making it more difficult for CV steelhead to successfully migrate to the western Delta and the ocean. In addition, the State and Federal pumps and associated fish facilities increase mortality of juvenile CV steelhead through various means, including entrainment into the State and Federal facilities, handling, trucking, and release. The current condition of freshwater migration corridors in the Sacramento River, San Joaquin River, and Delta are very degraded.

4.2.2.2.3.5 Estuarine Areas

Ideal estuarine areas are free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Current estuarine areas are degraded as a result of the operations of the CVP and SWP. CV steelhead smolts are drawn to the central and south Delta as they outmigrate, and are subjected to the indirect (*e.g.,* predation, contaminants) and direct (*e.g*., salvage, loss) effects of the Delta and both the Federal and State fish facilities.

The location of X2 has also been modified from natural conditions. Historically, the Delta provided the transitional habitat for CV steelhead to undergo the physiological change to salt water. However, as X2 was modified to control Delta water quality, and competing species' needs (*i.e*., Delta smelt), the Delta served more as a migratory corridor for outmigrating anadromous salmonids. The current condition of the estuarine area has been described in section 4.2.1.3.3.5 for spring-run critical habitat.

4.2.2.2.3.6 Central Valley Steelhead Critical Habitat Summary

The current condition of CV steelhead critical habitat is degraded, and does not provide the conservation value necessary for the recovery of the species. CV steelhead critical habitat has suffered similar types of degradation as winter-run critical habitat. In addition, the Sacramento-San Joaquin River Delta, as part of CV steelhead designated critical habitat, provides very little function necessary for juvenile CV steelhead rearing and physiological transition to salt water.

4.2.3 Southern DPS of North American Green Sturgeon

4.2.3.1 General Life History

In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (Erickson and Hightower 2007). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991, Moser and Lindley 2007). Particularly large concentrations of green sturgeon from both the northern and southern populations occur in the Columbia River estuary, Willapa Bay, Grays Harbor and Winchester Bay, with smaller aggregations in Humboldt Bay, Tillamook Bay, Nehalem Bay, and San Francisco and San Pablo bays (Emmett *et al* 1991, Moyle *et al.* 1992, and Beamesderfer *et al.* 2007). Lindley *et al.* (2008) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska. Individual fish from the Southern DPS of green sturgeon have been detected in these seasonal aggregations. Information regarding the migration and habitat use of the Southern DPS of green sturgeon has recently emerged. Lindley (2006) presented preliminary results of large-scale green sturgeon migration studies, and verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. This work was further expanded by recent tagging studies of green sturgeon conducted by Erickson and Hightower (2007) and Lindley *et al.* (2008). To date, the data indicate that North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River estuary. This information also agrees with the results of previous green sturgeon tagging studies (CDFG 2002), where CDFG tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 commercial fisheries recoveries were in the Columbia River estuary (CDFG 2002).

The Southern DPS of green sturgeon includes all green sturgeon populations south of the Eel River, with the only known spawning population being in the Sacramento River. Green sturgeon life history can be broken down into four main stages: eggs and larvae, juveniles, sub-adults, and sexually mature adults. Sexually mature adults are those fish that have fully developed gonads and are capable of spawning. Female green sturgeon are typically 13 to 27 years old when sexually mature and have a total body length (TL) ranging between 145 and 205 cm at sexual maturity (Nakamoto *et al*. 1995, Van Eenennaam *et al.* 2006). Male green sturgeon become sexually mature at a younger age and smaller size than females. Typically, male green sturgeon reach sexual maturity between 8 and 18 years of age and have a TL ranging between 120 cm to 185 cm (Nakamoto *et al.* 1995, Van Eenennaam *et al.* 2006). The variation in the size and age of fish upon reaching sexual maturity is a reflection of their growth and nutritional history, genetics, and the environmental conditions they were exposed to during their early growth years. Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid shrimp, grass shrimp, and amphipods (Radtke 1966). Adult sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992). It is unknown what forage species are consumed by adults in the Sacramento River upstream of the Delta.

Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to spawn every 2 to 5 years (Beamesderfer *et al.* 2007). Upon maturation of their gonadal tissue, but prior to ovulation or spermiation, the adult fish enter freshwater and migrate upriver to their spawning grounds. The remainder of the adult's life is generally spent in the ocean or near-shore environment (bays and estuaries) without venturing upriver into freshwater. Younger females may not spawn the first time they undergo oogenesis and subsequently they reabsorb their gametes without spawning. Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al*. 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The outside of the eggs are adhesive, and are more dense than than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009). Adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July (CDFG 2002. Heublin 2006, Heublin *et al.* 2009, Vogel 2008). Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, while the male releases its milt (sperm) into the water column. Fertilization occurs externally in the water column and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005, Heublin *et al.* 2009).

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004, Adams *et al*. 2007). Currently, Keswick and Shasta dams on the mainstem of the Sacramento River block passage to the upper river. Although no historical accounts exist for identified green sturgeon spawning occuring above the current dam sites, suitable spawning habitat existed and based on habitat assessments done for Chinook salmon, the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river.

Spawning on the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate to upstream spawning areas now blocked by the dam, which was constructed in 1968.

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River and its tributaries (Stanislaus, Tuolumne, and Merced rivers) occurred early in the European settlement of the region. During the latter half of the 1800s, impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. Additional impacts to the watershed include the increased loads of selenium entering the system through agricultural practices in the western side of the San Joaquin Valley. Green sturgeon have recently been identified by University of California at Davis (U.C. Davis) researchers as being highly sensitive to selenium levels. Currently, only white sturgeon have been encountered in the San Joaquin River system upstream of the Delta, and adults have been captured by sport anglers as far upstream on the San Joaquin River as Hills Ferry and Mud Slough (2007 sturgeon report card - CDFG 2008). These locations are near the confluence of the Merced River with the mainstem San Joaquin River.

Kelly *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn (table 4-7). The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature, and Kelly *et al*. (2007) surmised that they are related to resource availability and foraging behavior. Recent acoustical tagging studies on the Rogue River (Erickson *et al*. 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15ºC and 23ºC. When ambient temperatures in the river dropped in autumn and early winter (<10ºC) and flows increased, fish moved downstream and into the ocean. Erickson *et al.* (2002) surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Benson *et al.* (2007) found similar behavior on the Klamath and Trinity River systems with adult sturgeon acoustically tagged during their spawning migrations. Most fish held over the summer in discrete locations characterized by deep, low velocity pools until late fall or early winter when river flows increased with the first storms of the rainy season. Fish then moved rapidly downstream and out of the system. Recent data gathered from acoustically tagged adult green sturgeon revealed comparable behavior by adult fish on the Sacramento River based on the positioning of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205). Recent acoustic tag data indicate that adult green sturgeon migrate upstream as far as the mouth of Cow Creek, near Bend Bridge, in May. Adults prefer deep holes at the mouths of tributary streams, where they spawn and rest on the bottom. After spawning, the adults hold over in the upper Sacramento River between RBDD and GCID until November (Klimley 2007). Heublin (2006, 2009) and Vogel (2008) have documented the presence of adults in the Sacramento River during the spring and through the fall into the early winter months. These fish hold in upstream locations prior to their emigration from the system later in the year. Like the Rogue and Klamath river systems, downstream migration appears to be triggered by increased flows, decreasing water temperatures, and occurs rapidly once initiated. Some adults rapidly leave the system following their suspected spawning activity and re-enter the ocean in early summer (Heublin 2006). This behavior has also been observed on the other spawning rivers (Benson *et al. 2007)* but may have been an artifact of the stress of the tagging procedure in that study.

During the spring and summer, the main processes influencing green sturgeon are in the freshwater environment (figure 4-7). Spawning requires sufficient instream flows for passage of reproductive adults and effective fertilization. Temperature, DO, and suitable in-river habitats influence larval survival. Ecological processes and stressors begin to influence green sturgeon immediately during their first summer (figure 4-7). These stressors are cumulative to the effects of temperature, salinity, and flow during green sturgeon's first fall and winter. Currently spawning appears to occur primarily above RBDD, based on the recovery of eggs and larvae at the dam in monitoring studies (Gaines and Martin 2002, Brown 2007). Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15ºC (Van Eenennaam *et al.* 2001, Deng *et al.* 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14ºC and 17ºC. Temperatures over 23ºC resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5ºC and 22 ºC resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14ºC, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

Table 4-7. The temporal occurrence of (a) adult, (b) larval (c) juvenile and (d) subadult coastal migrant Southern DPS of green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult-sexually mature (≥145 – 205 cm TL for females and ≥ 120 – 185 cm TL old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Sac. River[a,b,c,i]	Low	Low	Medium	Medium/High	High	High/Medium	Medium	Medium	Medium	Low	Low	Low
SF Bay Estuary[d,h,i]	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low

(b) Larval and juvenile (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RBDD, Sac River[e]					Medium	High	High	Medium	Medium			
GCID, Sac River[e]					Medium	High	High	Medium	Medium/Low	Low		

(c) Older Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South Delta*[f]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[f]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[e]				Medium	Medium	Medium	Medium	Medium	Medium	Medium		
Suisun Bay[e]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

(d) Sub-Adult/non-sexually mature (approx. 75 cm to 145 cm for females and 75 to 120 cm for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pacific Coast[c,g]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

Relative Abundance: = High = Medium = Low

* Fish Facility salvage operations

Sources: [a]USFWS (2002); [b]Moyle *et al*. (1992); [c]Adams *et al*. (2002) and NMFS (2005); [d]Kelly *et al*. (2007); [e]CDFG (2002); [f]IEP Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [g]Nakamoto *et al*. (1995); [h]Heublein (2006); [i]CDFG Draft Sturgeon Report Card (2007)

Survival of eggs and larvae requires specific water quality parameters like temperature, DO, and turbidity. These parameters likely constrain the current area available as larval nursery and juvenile foraging areas. Increased water quantity has a positive influence on spawning, and since flow in spawning segments of the Sacramento River is controlled by Shasta Dam, the predictability of flows is high, and project operations can directly influence the successful production of larvae and juveniles. Large flow rates of greater than 14,000 cfs between February 1 and May 31 are similar to what are necessary for producing strong year classes of white sturgeon at spawning sites in the Sacramento River, but not in the Feather or Yuba rivers (Neuman *et al*. 2007).

Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. These yolksac larvae are less developed in their morphology than older juveniles and external morphology resembles a “tadpole” with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation.

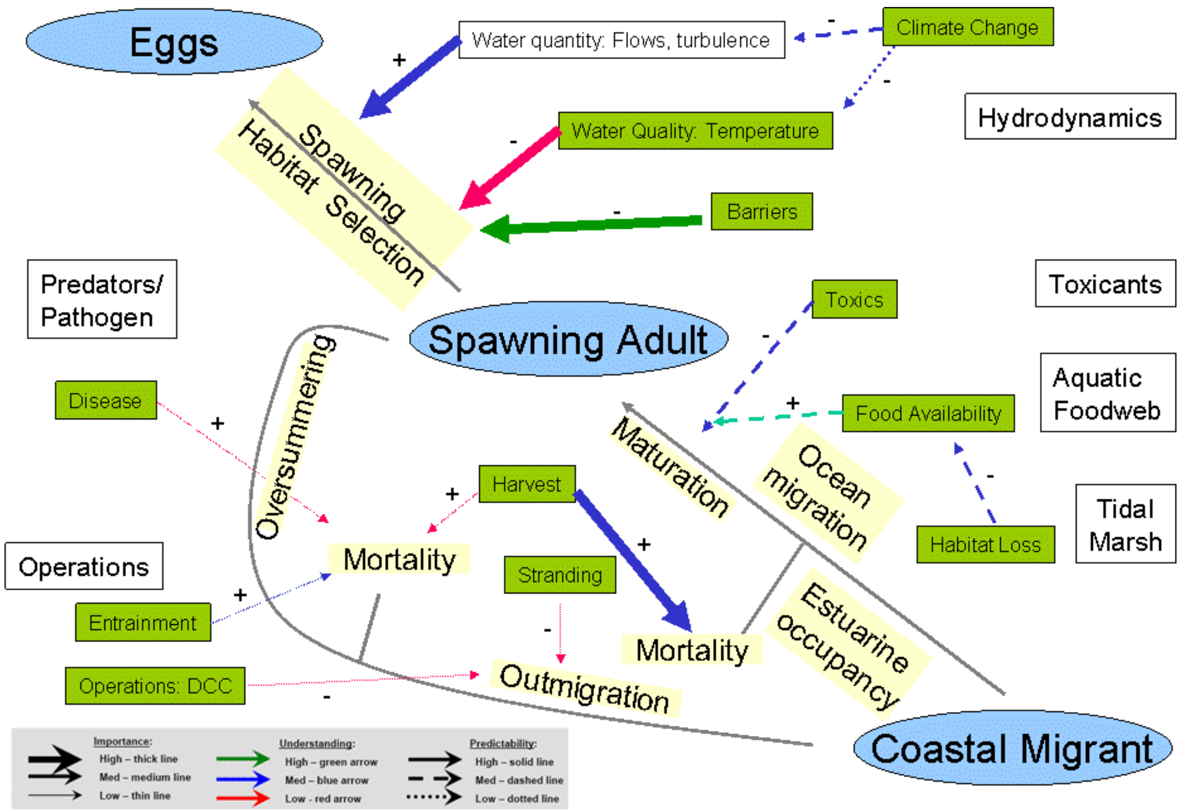


Figure 4-7. Life history conceptual model for green sturgeon: Coastal Migrant to Eggs Submodel (Israel and Klimley 2008).

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al*. 2002) and are approximately 75 mm TL.

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *acipenseridae*. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8°C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.* growth, food conversion, swimming ability) between 15ºC and 19ºC under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath River systems range from 4ºC to approximately 24ºC. The Sacramento River has similar temperature profiles and, like the previous two rivers, is a regulated system with dams controlling flows on its mainstem (Shasta and Keswick dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus dams).

Larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005). This study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

Larval and juvenile sturgeon have been caught in traps at two sites in the upper Sacramento River: below RBDD (RM 342) and from the GCID pumping plant (RM 205, CDFG 2002). Larvae captured at the RBDD site are typically only a few days to a few weeks old, with lengths ranging from 24 to 31 mm. This body length is equivalent to 15 to 28 days post hatch as determined by Deng *et al.* (2002). Recoveries of larvae at the RBDD rotary screw traps (RSTs) occur between late April/early May and late August with the peak of recoveries occurring in June (1995-1999 and 2003–2008 data). The mean yearly total length of post-larval green sturgeon captured in the GCID RST, approximately 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, 2002) indicating they are approximately 3-4 weeks old (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Taken together, the average length of larvae captured at the two monitoring sites indicate that fish were hatched upriver of the monitoring site and drifted downstream over the course of 2 to 4 weeks of growth. According to the CDFG document commenting on the NMFS proposal to list the Southern DPS (CDFG 2002), some green sturgeon rear to larger sizes above RBDD, or move back to this location after spending time downstream. Two sturgeon between 180 and 400 mm TL were captured in the RST during 1999 and green sturgeon within this size range have been impinged on diffuser screens associated with a fish ladder at RBDD (K. Brown, USFWS, pers. comm. as cited in CDFG 2002).

Juvenile green sturgeon migrate downstream and feed mainly at night. Larvae and YOY are small enough to be entrained in water diversions. During the day, their benthic behavior likely limits this impact. However, their nocturnal swim up behavior may place them at risk for entrainment by local agricultural diversions in the upper river reaches.

Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Collection Facility (Fish Facilities) in the South Delta, and captured in trawling studies by CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm, indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates that juveniles of the

Southern DPS of green sturgeon likely hold in the mainstem Sacramento River, as suggested by Kynard *et al.* (2005).

4.2.3.2 Range-Wide (DPS) Status and Trends

Population abundance information concerning the Southern DPS of green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish in 1993 to more than 8,421 in 2001, and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable, since the population estimates are based on small sample sizes, intermittent reporting, and inferences made from white sturgeon catches. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile Southern DPS of green sturgeon per year (Adams *et al*. 2002).

Green sturgeon larvae and juveniles are routinely observed in rotary screw traps at RBDD and GCID, indicating spawning occurs above both these sites. Adults have been observed as far down as Hamilton City (RM 200). RST data from RBDD and GCID show a declining trend in juvenile production since the 1990s (figure 4-8). Recent data indicate that very little production took place in 2007 and 2008 (13 and 3 larval green sturgeon captured in the RST monitoring sites at RBDD, respectively; Poytress 2008, Poytress *et al*. 2009). Newly hatched larvae in the 30-40 mm range peak at RBDD and GCID in July, indicating they are at least 10 days old (figure 4-9). Length data from GCID do not show the same general increase in size over the sampling season as observed at RBDD, which may indicate less favorable growing conditions in the river between RBDD and GCID (CDFG 2002). Juvenile green sturgeon migrate downstream and feed mainly at night. Larvae and YOY are small enough to be entrained in water diversions. During the day, their benthic behavior likely limits this impact. However, their nocturnal swim up behavior may place them at risk for entrainment by local agricultural diversions in the upper river reaches.

The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Collection Facility between 1968 and 2006 (figures 4-10 and 4-11, table 4-8). The average number of Southern DPS of green sturgeon entrained per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (April 5, 2005, 70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (April 5, 2005, 70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of green sturgeon is declining. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (April 5, 2005, 70 FR 17386). Catches of sub-adult and adult Northern and Southern DPS of green sturgeon, primarily in San Pablo Bay, by the IEP ranged from 1 to 212 green sturgeon per year between 1996 and 2004 (212 occurred in 2001).

However, the portion of the Southern DPS of green sturgeon is unknown. Recent spawning population estimates using sibling-based genetics by Israel (2006) indicate spawning populations of 32 spawner pairs in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71).

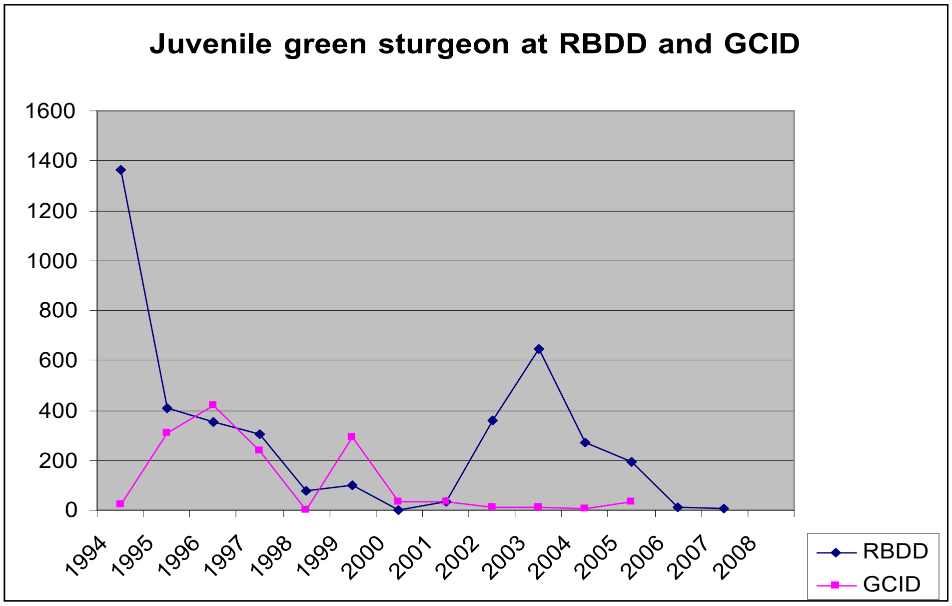


Figure 4-8. Rotary screw trap data of juvenile green sturgeon caught at RBDD and GCID from 1994-2008 (OCAPCVP/SWP operations BA).

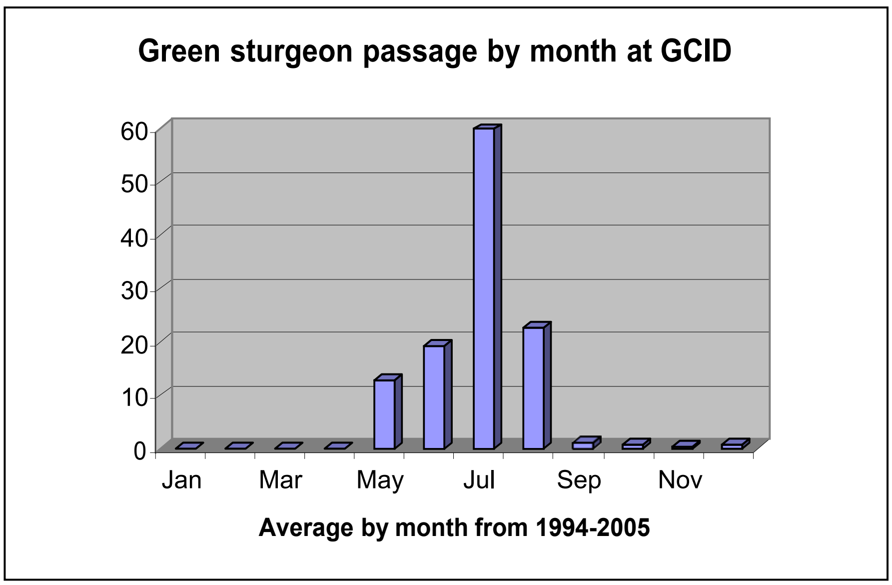


Figure 4-9. Juvenile green sturgeon average catch by month at GCID (1994-2005, CVP/SWP operations BA).

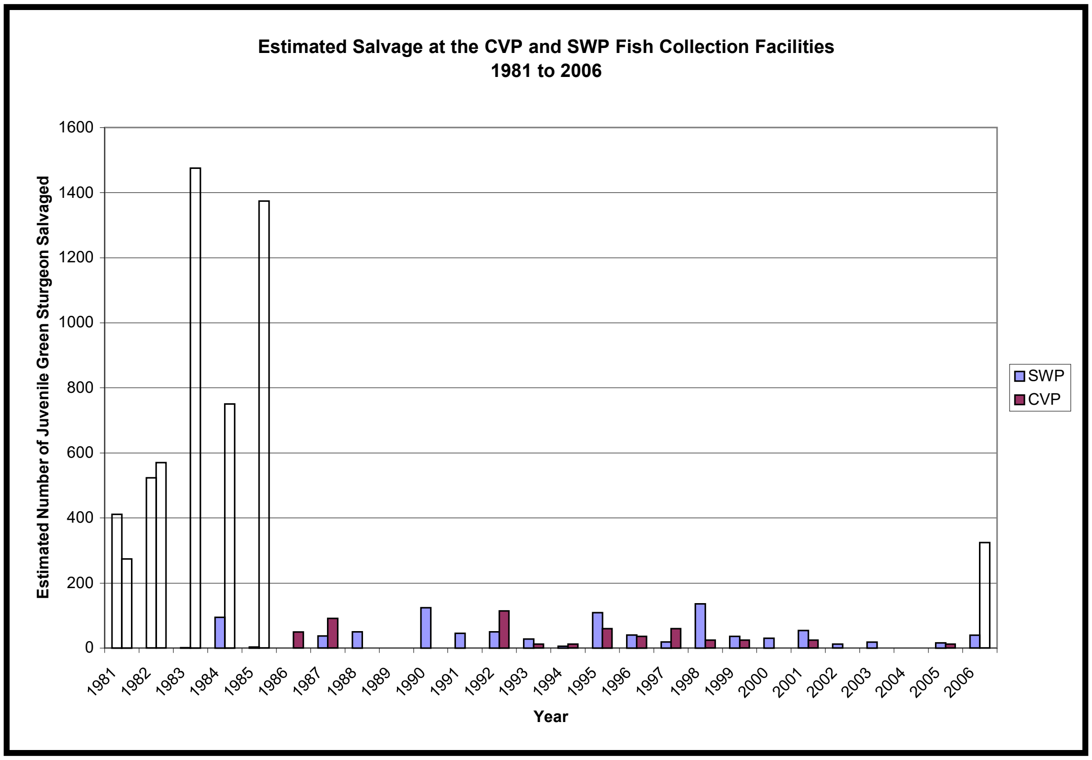


Figure 4-10. Estimated number of juvenile Southern DPS of green sturgeon salvaged from the SWP and the CVP fish collection facilities (Beamesderfer *et al.* 2007, CDFG 2002, and Adams *et al.* 2007). Measured fish lengths from 1981 through 2006 ranged from 136 mm to 774 mm with an average length of 330 mm.

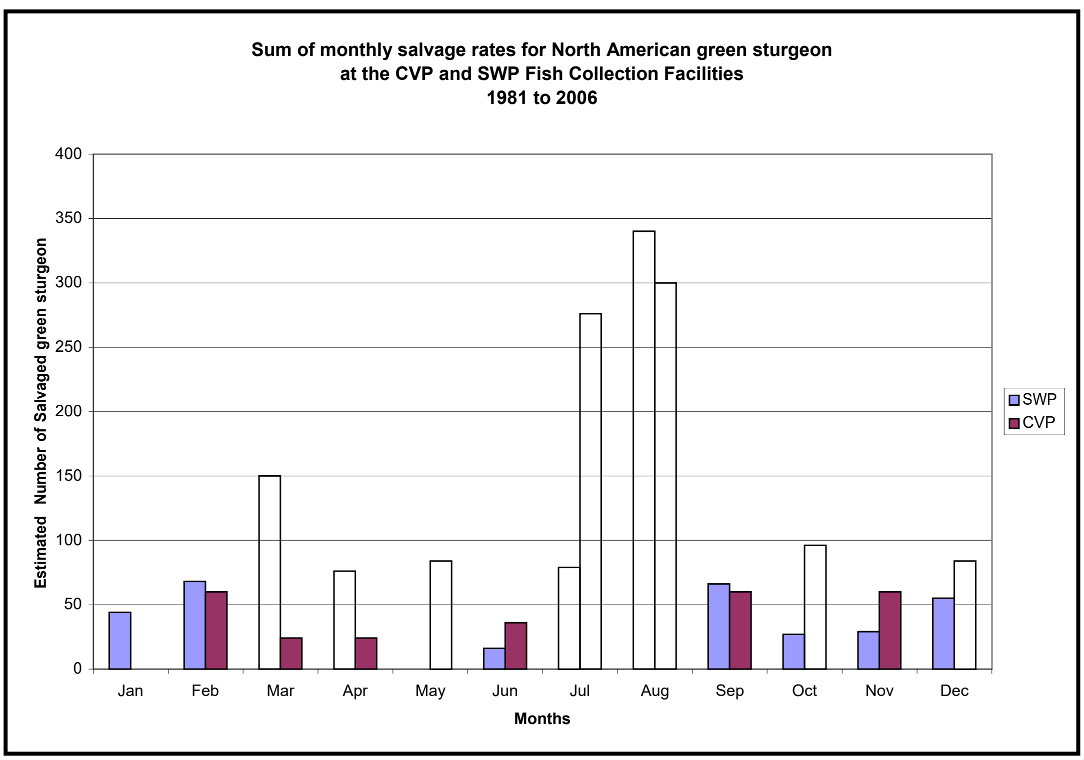


Figure 4-11. Estimated total number of Southern DPS of green sturgeon salvaged monthly from the SWP and the CVP fish collection facilities (CDFG 2002, unpublished CDFG records). Measured fish lengths from 1981 through 2006 ranged from 136 mm to 774 mm with an average length of 330 mm.

Table 4-8. The annual occurrence of juvenile[a] Southern DPS of North American green sturgeon at the CVP and SWP fish collection facilities in the South Delta. (Adams *et al*. 2007, CDFG 2002).

Year	State Facilities		Federal Facilities	
	Salvage Numbers	Numbers per 1000 acre feet	Salvage Numbers	Numbers per 1000 acre feet
1968	12	0.0162		
1969	0	0		
1970	13	0.0254		
1971	168	0.2281		
1972	122	0.0798		
1973	140	0.1112		
1974	7313	3.9805		
1975	2885	1.2033		
1976	240	0.1787		
1977	14	0.0168		
1978	768	0.3482		
1979	423	0.1665		
1980	47	0.0217		
1981	411	0.1825	274	0.1278
1982	523	0.2005	570	0.2553
1983	1	0.0008	1475	0.653
1984	94	0.043	750	0.2881
1985	3	0.0011	1374	0.4917
1985	0	0	49	0.0189
1987	37	0.0168	91	0.0328
1988	50	0.0188	0	0
1989	0	0	0	0
1990	124	0.0514	0	0
1991	45	0.0265	0	0
1992	50	0.0332	114	0.0963
1993	27	0.0084	12	0.0045
1994	5	0.003	12	0.0068
1995	101	0.0478	60	0.0211
1996	40	0.0123	36	0.0139
1997	19	0.0075	60	0.0239
1998	136	0.0806	24	0.0115
1999	36	0.0133	24	0.0095
2000	30	0.008	0	0
2001	54	0.0233	24	0.0106
2002	12	0.0042	0	0
2003	18	0.0052	0	0
2004	0	0	0	0
2005	16	0.0044	12	0.0045
2006	39	0.0078	324	0.1235

[a] Measured fish lengths from 1981 through 2006 ranged from 136 mm to 774 mm with an average length of 330 mm.

As described previously, the majority of spawning by green sturgeon in the Sacramento River system appears to take place above the location of RBDD. This is based on the length and estimated age of larvae captured at RBDD (approximately 2-3 weeks of age) and GCID (downstream, approximately 3-4 weeks of age) indicating that hatching occurred above the sampling location. Note that there are many assumptions with this interpretation (*i.e*., equal sampling efficiency and distribution of larvae across channels) and this information should be considered cautiously.

Available information on green sturgeon indicates that, as with winter-run, the mainstem Sacramento River may be the last viable spawning habitat (Good *et al.* 2005) for the Southern DPS of green sturgeon. Lindley *et al.* (2007) pointed out that an ESU represented by a single population at moderate risk is at a high risk of extinction over the long term. Although the extinction risk of the Southern DPS of green sturgeon has not been assessed, NMFS believes that the extinction risk has increased because there is only one known population, within the mainstem Sacramento River.

4.2.3.3 Current Viability of the Southern DPS of North American Green Sturgeon

4.2.3.3.1 Population Size

The current population status of Southern DPS green sturgeon is unknown (Beamesderfer *et al.* 2007, Adams *et al.* 2007). It is believed, based on captures of green sturgeon during surveys for the sympatric white sturgeon in the San Francisco Bay estuary that the population is relatively small (USFWS 1995), ranging from several hundred to a few thousand adults. However, these estimates are very uncertain, and limited by the inherent biases of the sampling methods. The sole population of Southern DPS of green sturgeon spawns within the Sacramento River basin and is believed to spawn primarily in the mainstem of the Sacramento River between Keswick Dam (RM 302) and Hamilton City (RM 200). Israel (2006) indicated that between 2002 and 2005, a range of 18 to 42 adult green sturgeon were estimated to have bred above RBDD, based on genetic analysis of captured larvae in the Sacramento River.

4.2.3.3.2 Population Growth Rate

Recruitment data for the Southern DPS of green sturgeon are essentially nonexistent. Incidental catches of larval green sturgeon in the mainstem Sacramento River and juvenile fish at the CVP and SWP pumping facilities in the South Delta suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al*. 2007, Adams *et al*. 2005). Recent declines in the number of larvae captured in the RSTs near the RBDD may indicate a reduction in spawning success in the past several years, with resulting depressions in the year class strengths for those years. Green sturgeon are iteroparous and long-lived, so that spawning failure in any 1 year may be rectified in a succeeding spawning year. This would give the potential for a succesion of multiple, strong year classes, interspersed with weaker year classes.

4.2.3.3.3 Spatial Structure

Like the winter-run population, the Southern DPS of green sturgeon population has been relegated to a single spawning area, which is, for the most part, outside of its historical spawning area. The recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery suggest that significant spawning habitat was made inaccessible or altered by dams (Lindley *et al.* 2004, 2006; Adams *et al.* 2007). The historical spawning habitat may have extended up into the three major branches of the upper Sacramento above the current location of Shasta Dam; the Little Sacramento River, the Pitt River, and the McCloud River. Additional spawning habitat is believed to have once existed above the current location of Oroville Dam on the Feather River. Other watersheds, including the San Joaquin River basin may also have supported opportunistic green sturgeon spawning in the past (Adams *et al.* 2007*,* Beamesderfer *et al.* 2007)

Green sturgeon are found throughout the Sacramento – San Joaquin Delta and the San Francisco Bay estuary. Coastal migrants, which include both adult and subadult life stages, are found from approximately Central California to southeastern Alaska with aggregations of Southern DPS of green sturgeon occurring in several estuaries along the West Coast from California northwards to Washington during the late summer and early fall. An aggregation of green sturgeon has also recently been identified off of the northwestern tip of Vancouver Island. Although both northern and southern populations mix in the ocean and coastal estuaries, it is believed that each DPS maintains a high fidelity to their natal watershed and little straying occurs between the two DPSs.

The reduction of the Southern DPS of green sturgeon spawning habitat into one reach on the Sacramento River between Keswick Dam and Hamilton City increases the vulnerability of this spawning population to catastrophic events. One spill of toxic materials into this reach of river, similar to the Cantara Loop spill of herbicides on the upper Sacramento River, could remove a significant proportion of the adult spawning broodstock from the population, as well as reduce the recruitment of the exposed year class of juvenile fish. Likewise, the necessary water temperatures required for normal egg development in the spawning reach is reliant on the cold-water releases for winter-run. Extended drought conditions could imperil the spawning success for green sturgeon, particularly those that are restricted to the river reaches below RBDD.

4.2.3.3.4 Diversity

Diversity, both genetic and behavioral, provides a species the opportunity to track and adapt to environmental changes. As a species' abundance decreases, and spatial structure of the ESU/DPS is reduced, a species has less flexibility to track changes in the environment. The reduction of the Southern DPS of green sturgeon population to one extant population reduces the potential variation of life history expression and genetic diversity within this population. Like winter-run, the Southern DPS of green sturgeon face greater risks to long term persistence of the population due to the lack of this flexibilty in their current condition.

4.2.3.3.5 Summary of the Current Viability of the Southern DPS of North American Green Sturgeon DPS

The Southern DPS of green sturgeon is at substantial risk of future population declines (Adams *et al*. 2007). The potential threats faced by the green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and Delta systems, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult life stages.

4.2.3.4 Status of Southern DPS of Green Sturgeon Proposed Critical Habitat

4.2.3.4.1 Summary of Proposed Critical Habitat

Critical habitat was proposed for Southern DPS of green sturgeon on September 8, 2008 (73 FR 52084). Proposed critical habitat for Southern DPS of green sturgeon includes approximately 325 miles of riverine habitat and 1,058 square miles of estuarine habitat in California, Oregon, and Washington, and 11,927 square miles of coastal marine habitat off California, Oregon, and Washington within the geographical area presently occupied by the Southern DPS of green sturgeon. In addition, approximately 136 square miles of habitat within the Yolo and Sutter bypasses, adjacent to the Sacramento River, California, are proposed for designation.

4.2.3.4.2 For Freshwater Riverine Systems

4.2.3.4.2.1 Food Resources

Abundant food items for larval, juvenile, subadult, and adult life stages should be present in sufficient amounts to sustain growth (larvae, juveniles, and subadults) or support basic metabolism (adults). Although we lack specific data on food resources for green sturgeon within freshwater riverine systems, nutritional studies on white sturgeon suggest that juvenile green sturgeon most likely feed on macro benthic invertebrates, which can include plecoptera (stoneflies), ephemeroptera (mayflies), trichoptera (caddis flies), chironomid (dipteran fly larvae), oligochaetes (tubifex worms) or decapods (crayfish). These food resources are important for juvenile foraging, growth, and development during their downstream migration to the Delta and bays. In addition, subadult and adult green sturgeon may forage during their downstream post-spawning migration or on non-spawning migrations within freshwater rivers. Subadult and adult green sturgeon in freshwater rivers most likely feed on benthic invertebrates similar to those fed on in bays and estuaries, including freshwater shrimp and amphipods. Many of these different invertebrate groups are endemic to and readily available in the Sacramento River from Keswick Dam downstream to the Delta. Heavy hatches of mayflies, caddis flies, and chironomids occur in the upper Sacramento River, indicating that these groups of invertebrates are present in the river system. NMFS anticipates that the aquatic life stages of these insects (nymphs, larvae) would provide adequate nutritional resources for green sturgeon rearing in the river.

4.2.3.4.2.2 Substrate Type or Size

Suitable critical habitat in the freshwater riverine system should include substrate suitable for egg deposition and development (*e.g*., cobble, gravel, or bedrock sills and shelves with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (*e.g*., substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adult life stages (*e.g*., substrates for holding and spawning). For example, spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett *et al.* 1991, Moyle *et al.* 1995). Eggs likely adhere to substrates, or settle into crevices between substrates (Deng 2000, Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Both embryos and larvae exhibited a strong affinity for benthic structure during laboratory studies (Van Eenennaam *et al.* 2001, Deng *et al.* 2002, Kynard *et al.* 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2007). Recent stream surveys by USFWS and Reclamation biologists have identified approximately a 54 suitable holes and pools between Keswick Dam and approximately GCID that would support spawning or holding activities for green sturgeon, based on the identified physical criteria. Many of these locations are at the confluence of tributaries with the mainstem Sacramento River or at bend pools. Observations of channel type and substrate compositions during these surveys indicate that appropriate substrate is available in the Sacramento River between Keswick Dam and GCID. Ongoing surveys are anticipated to further identify river reaches with suitable substrate characteristics in the upper river and their utilization by green sturgeon.

4.2.3.4.2.3 Water Flow

An adequate flow regime (*i.e*., magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11-19°C) (Cech *et al.* 2000, Mayfield and Cech 2004, Van Eenennaam *et al.* 2005, Allen *et al.* 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning success is most certainly associated with water flow and water temperature compared to other variables. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs (average daily water flow during spawning months: 6,900-10,800 cfs; Brown 2007). Post-spawning downstream migrations are triggered by increased flows, ranging from 6,150-14,725 cfs in the late summer (Vogel 2005) and greater than 3,550 cfs in the winter (Erickson *et al.* 2002, Benson *et al.* 2007). The current suitability of these flow requirements is almost entirely dependent on releases from Shasta Dam. High winter flows associated with the natural hydrograph do not occur within the section of the river utilized by green sturgeon with the frequency and duration that was seen in pre-dam conditions. Continued operations of the project are likely to further attenuate these high flow events. Rearrangement of the river channel and the formation of new pools and holes are unlikely to occur given the management of the river's discharge to prevent flooding downstream of the dam.

4.2.3.4.2.4 Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages are required for the proper functioning of the freshwater habitat. Suitable water temperatures would include: stable water temperatures within spawning reaches (wide fluctuations could increase egg mortality or deformities in developing embryos); temperatures within 11-17°C (optimal range = 14-16°C) in spawning reaches for egg incubation (March-August) (Van Eenennaam *et al.* 2005); temperatures below 20°C for larval development (Werner *et al.* 2007); and temperatures below 24°C for juveniles (Mayfield and Cech 2004, Allen *et al.* 2006). Due to the temperature management of the releases from Keswick Dam for winter-run in the upper Sacramento River, water temperatures in the river reaches utilized currently by green sturgeon appear to be suitable for proper egg development and larval and juvenile rearing. Suitable salinity levels range from fresh water [< 3 parts per thousand (ppt)] for larvae and early juveniles [about 100 days post hatch (dph)] to brackish water (10 ppt) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Salinity levels are suitable for green sturgeon in the Sacramento River and freshwater portions of the Delta for early life history stages. Adequate levels of DO are needed to support oxygen consumption by early life stages (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1} for juveniles, Allen and Cech 2007). Current mainstem DO levels are suitable to support the growth and migration of green sturgeon in the Sacramento River. Suitable water quality would also include water free of contaminants (*i.e.*, pesticides, organochlorines, elevated levels of heavy metals, *etc*.) that may disrupt normal development of embryonic, larval, and juvenile stages of green sturgeon. Water free of such contaminants would protect green sturgeon from adverse impacts on growth, reproductive development, and reproductive success (*e.g.*, reduced egg size and abnormal gonadal development, abnormal embryo development during early cleavage stages and organogenesis) likely to result from exposure to contaminants (Fairey *et al.* 1997, Foster *et al.* 2001a, Foster *et al.* 2001b, Kruse and Scarnecchia 2002, Feist *et al.* 2005, and Greenfield *et al.* 2005). Legacy contaminants such as mercury still persist in the watershed and pulses of pesticides have been identified in winter storm discharges throughout the Sacramento River basin.

4.2.3.4.2.5 Migratory Corridor

Safe and unobstructed migratory pathways are necessary for passage within riverine habitats and between riverine and estuarine habitats (*e.g.*, an unobstructed river or dammed river that still allows for passage). Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. Unobstructed passage throughout the Sacramento River up to Keswick

Dam (RM 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

Green sturgeon adults that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam. Therefore, 5 miles of spawning habitat are inaccessible upstream of the diversion dam. It is unknown if spawning is occurring in this area. Adults that pass upstream of ACID dam before April are forced to wait 6 months until the stop logs are pulled before returning downstream to the ocean. Upstream blockage forces sturgeon to spawn in approximately 12 percent less habitat between Keswick Dam and RBDD. Newly emerged green sturgeon larvae that hatch upstream of the ACID diversion dam would be forced to hold for 6 months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the dam, thus rendering the larvae and juvenile green sturgeon more susceptible to predation.

Closure of the gates at RBDD from May 15 through September 15 precludes all access to spawning grounds above the dam during that time period. Adult green sturgeon that cannot migrate upstream past the RBDD either spawn in what is believed to be less suitable habitat downstream of the RBDD (potentially resulting in lower reproductive success) or migrate downstream without spawning, both of which would reduce the overall reproductive success of the species.

Adult green sturgeon that were successful in passing the RBDD prior to its closure have to negotiate the dam on their subsequent downstream migration following spawning during the gates down period. Recent acoustic tag data indicate that some fish are successful in passing the dam when the gates are in the “closed” position. Typically the gates are raised slightly from the bottom to allow water to flow underneath the radial gates and fish apparently can pass beneath the radial gates during this period. However, recent observed mortalities of green sturgeon during an emergency gate operation (2007) indicate that passage is not without risk if the clearance is too narrow for successful passage.

Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in May, June, and July, during the RBDD gates down period. Juvenile green sturgeon would likely be subjected to the same predation and turbulence stressors caused by RBDD as the juvenile anadromous salmonids, leading to diminished survival through the structure and waters immediately downstream.

4.2.3.4.2.6 Depth

Deep pools of ≥ 5 m depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River above GCID. The significance and purpose of these aggregations are unknown at the present time, although it is likely that they are the result of an intrinsic behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al.* 2002, Benson *et al.* 2007). As described above, approximately a 54 pools with adequate depth have been identified in the Sacramento River above the GCID location.

4.2.3.4.2.7 Sediment Quality

Sediment should be of the appropriate quality and characteristics necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants [*e.g.*, elevated levels of heavy metals (*e.g.*, mercury, copper, zinc, cadmium, and chromium), PAHs, and organochlorine pesticides] that can result in negative effects on any life stages of green sturgeon. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of green sturgeon. The Sacramento River and its tributaries have a long history of contaminant exposure from abandoned mines, separation of gold ore from mine tailings using mercury, and agricultural practices with pesticides and fertilizers which result in deposition of these materials in the sediment horizons in the river channel. Disturbance of these sediment horizons by natural or anthropogenic actions can liberate the sequestered contaminants into the river. This is a continuing concern in the river's watershed.

4.2.3.4.3 For Estuarine Habitats

4.2.3.4.3.1 Food Resources

Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries. Currently, the estuary provides these food resources, although annual fluctuations in the population levels of these food resources may diminish the contribution of one group to the diet of green sturgeon relative to another food source. The recent spread of the Asian overbite clam has shifted the diet profile of white sturgeon to this invasive species. The overbite clam now makes up a substantial proportion of the white sturgeon's diet in the estuary. NMFS assumes that green sturgeon have also altered their diet to include this new food source based on its increased prevalence in the benthic invertebrate community.

4.2.3.4.3.2 Water Flow

Within bays and estuaries adjacent to the Sacramento River (*i.e.*, the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river. Currently, flows provide the necessary attraction to green sturgeon to enter the

Sacramento River. Nevertheless, these flows are substantially less than what would have been available historically to stimulate the spawning migration.

4.2.3.4.3.3 Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24°C (75°F). At temperatures above 24°C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen *et al.* 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas subadults and adults tolerate a wide range of salinities (Kelly *et al.* 2007). Subadult and adult green sturgeon occupy a wide range of DO levels, but may need a minimum DO level of at least 6.54 mg O_2/l (Kelly *et al.* 2007, Moser and Lindley 2007). As described above, adequate levels of DO are also required to support oxygen consumption by juveniles (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1}, Allen and Cech 2007). Suitable water quality also includes water free of contaminants (*e.g*., pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages. In general, water quality in the Delta and estuary meets these criteria, but local areas of the Delta and downstream bays have been identified as having deficiencies. Water quality in the areas such as the Stockton turning basin and Port of Stockton routinely have depletions of DO and episodes of first flush contaminants from the surrounding industrial and urban watershed. Discharges of agricultural drain water have also been implicated in local elevations of pesticides and other related agricultural compounds within the Delta and the tributaries and sloughs feeding into the Delta. Discharges from petroleum refineries in Suisun and San Pablo Bay have been identified as sources of selenium to the local aquatic ecosystem (Linville *et al.* 2002).

4.2.3.4.3.4 Migratory Corridor

Safe and unobstructed migratory pathways are necessary for the safe and timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta, and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Rearing fish need the ability to freely migrate from the river through the estuarine waterways of the delta and bays and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San Francisco bays, safe and unobstructed passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean. Currently, safe and unobstructed passage has been diminished by human actions in the Delta and bays. The CVP and SWP water projects alter flow patterns in the Delta due to export pumping and create entrainment issues in the Delta at the pumping and Fish Facilities.

Power generation facilities in Suisun Bay create risks of entrainment and thermal barriers through their operations of cooling water diversions and discharges. Installation of seasonal barriers in the South Delta and operations of the radial gates in the DCC facilities alter migration corridors available to green sturgeon. Actions such as the hydraulic dredging of ship channels and operations of large ocean going vessels create additional sources of risk to green sturgeon within the estuary. Hydraulic dredging can result in the entrainment of fish into the dredger's hydraulic cutterhead intake. Commercial shipping traffic can result in the loss of fish, particularly adult fish, through ship and propeller strikes.

4.2.3.4.3.5 Water Depth

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy deep ($\geq$ 5 m) holding pools within bays and estuaries as well as within freshwater rivers. These deep holding pools may be important for feeding and energy conservation, or may serve as thermal refugia for subadult and adult green sturgeon (Benson *et al*. 2007). Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly *et al*. 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 3-8 feet deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966). Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

Currently, there is a diversity of water depths found throughout the San Francisco Bay estuary and Delta waterways. Most of the deeper waters, however, are comprised of artificially maintained shipping channels, which do not migrate or fluctuate in response to the hydrology in the estuary in a natural manner. The channels are simplified trapezoidal shapes with little topographical variation along the channel alignment. Shallow waters occur throughout the Delta and San Francisco Bay. Extensive "flats" occur in the lower reaches of the Sacramento and San Joaquin River systems as they leave the Delta region and are even more extensive in Suisun and San Pablo bays. In most of the region, variations in water depth in these shallow water areas occur due to natural processes, with only localized navigation channels being dredged (*e.g.*, the Napa River and Petaluma River channels in San Pablo Bay).

4.2.3.4.3.6 Sediment Quality

Sediment quality (*i.e*., chemical characteristics) is necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g*., elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of green sturgeon (see description of *Sediment quality* for riverine habitats above).

4.2.3.4.4 For Nearshore Coastal Marine Areas

4.2.3.4.4.1 Migratory Corridor

Safe and unobstructed migratory pathways are necessary for passage within marine coastal zones along the west coast of North America and between estuarine and marine habitats. Subadult and adult green sturgeon spend as much as 13 years out at sea before returning to their natal rivers to spawn. Safe and unobstructed passage within near shore marine waters is critical for subadult and adult green sturgeon to access over-summering habitats within coastal estuaries and over-wintering habitats within coastal estuaries and coastal waters off of Vancouver Island, British Columbia. Passage is also necessary for subadults and adults to migrate back to San Francisco Bay and to the Sacramento River for spawning. Potential conflicts may occur in shipping corridors, areas with commercial bottom trawl fisheries, and coastal discharge of wastewater from sanitation facilities.

4.2.3.4.4.2 Water Quality

Nearshore marine waters should have adequate DO levels and be free of contaminants (*e.g.*, pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon. Based on studies of tagged subadult and adult green sturgeon in the San Francisco Bay estuary, California, and Willapa Bay, Washington, subadults and adults may need a minimum DO level of at least 6.54 mg O_2/l (Kelly *et al.* 2007, Moser and Lindley 2007). As described above, exposure to and bioaccumulation of contaminants may negatively affect the growth, reproductive development, and reproductive success of subadult and adult green sturgeon. Thus, waters free of such contaminants would benefit the normal development of green sturgeon for optimal survival and spawning success.

4.2.3.4.4.3 Food Resources

Abundant food items for subadults and adults, which may include benthic invertebrates and fish, are important to the growth and viability of subadult and adult green sturgeon. Green sturgeon spend from 3-13 years in marine waters, migrating long distances of up to 100 km per day (NMFS 2005a). Although most tagged individuals swim at speeds too fast for feeding, some individuals swam at slower speeds and resided in areas over several days, indicating that they may be feeding. Abundant food resources are important to support subadults and adults over long-distance migrations, and may be one of the factors attracting green sturgeon to habitats farther to the north (off the coast of Vancouver Island and Alaska) and to the south (Monterey Bay, California, and off the coast of southern California) of their natal habitat. Although direct evidence is lacking, prey species are likely to include benthic invertebrates and fish species similar to those fed upon by green sturgeon in bays and estuaries (*e.g.*, shrimp, clams, crabs, anchovies, sand lances). Concentrations of these species in the near shore environment are likely to attract congregations of adult and sub-adult green sturgeon.

4.2.3.4.5 Southern DPS of North American Green Sturgeon Proposed Critical Habitat Summary

The current condition of proposed critical habitat for the Southern DPS of green sturgeon is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which the Southern DPS of green sturgeon evolved. The habitat values proposed for green sturgeon critical habitat have suffered similar types of degradation as already described for winter-run critical habitat. In addition, the alterations to the Sacramento-San Joaquin River Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to the protracted rearing time in the delta and estuary. Loss of individuals during this phase of the life history of green sturgeon represents losses to multiple year classes rearing in the Delta, which can ultimately impact the potential population structure for decades to come.

4.2.4 Factors Responsible for the Current Status of Winter-Run, Spring-Run, CV Steelhead, and the Southern DPS of Green Sturgeon

Although the geographic extent of winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon are different, much of their freshwater habitat overlap, and therefore, most of the factors responsible for their current statuses are similar. Therefore, each of the following factors applies to winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon, unless specified..

4.2.4.1 Habitat Blockage

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today. The percentage of habitat loss for steelhead is presumable greater, because steelhead were more extensively distributed upstream than Chinook salmon.

As a result of migrational barriers, winter-run, spring-run, and steelhead populations have been confined to lower elevation mainstems that historically only were used for migration and rearing. Population abundances have declined in these streams due to decreased quantity, quality, and spatial distribution of spawning and rearing habitat (Lindley *et al*. 2009). Higher temperatures at these lower elevations during late-summer and fall are also a major stressor to adult and juvenile salmonids. According to Lindley *et al.* (2004), of the four independent populations of winter-run that occurred historically, only one mixed stock of winter-run remains below Keswick Dam.

Similarly, of the 19 independent populations[5] of spring-run that occurred historically, only three independent populations remain in Deer, Mill, and Butte Creeks. Dependent populations of spring-run continue to occur in Big Chico, Antelope, Clear, Thomes, and Beegum creeks and the Yuba River, but rely on the extant independent populations for their continued survival. CV steelhead historically had at least 81 independent populations based on Lindley *et al.*'s (2006) analysis of potential habitat in the Central Valley. However, due to dam construction, access to 38 percent of all spawning habitat has been lost, as well as access to 80 percent of the historically available habitat.

Juvenile downstream migration patterns have been altered by the presence of dams. Juvenile winter-run, and spring-run on the mainstem Sacramento River, arrive at any given location downstream of Keswick Dam earlier than historical, since they are hatched much further downstream and have less distance to travel. Therefore, in order smolt at the same size and time as historical, they must rear longer within the Sacramento River. However, as will be discussed in sections 4.2.4.2, 4.2.4.4 through 4.2.4.7, and 4.2.4.10, below, the mainstem Sacramento River is not conducive to the necessary habitat features that provide suitable rearing habitat for listed anadromous fish species, especially for an extended duration of time.

The SMSCG, located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, DWR 2002a). As a result of the SMSCG fish passage study and a term and condition in NMFS' 2004 CVP/SWP operations Opinion, the boat lock has remained open since the 2001-2002 control season (CVP/SWP operations BA), and adult fish passage has improved.

RBDD impedes adult salmonid passage throughout its May 15 through September 15 gates in period. Although there are fish ladders at the right and left banks, and a temporary ladder in the middle of the dam, they are not very efficient at passing fish. The range of effects resulting from upstream migrational delays at RBDD include delayed, but eventually successful spawning, to prespawn mortality and the complete loss of spawning potential in that fraction of the population.

4.2.4.2 Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement

[5] Lindley *et al*. (2007) identified evidence supporting the Deer and Mill Creek populations as individual independent populations, and also as one combined independent population. For the purpose of this Opinion, we treat the Deer and Mill Creek populations as individual independent populations.

(Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. The storage of unimpeded runoff in these large reservoirs also has altered the normal hydrograph for the Sacramento and San Joaquin River watersheds. Rather than seeing peak flows in these river systems following winter rain events (Sacramento River) or spring snow melt (San Joaquin River), the current hydrology has truncated peaks with a prolonged period of elevated flows (compared to historical levels) continuing into the summer dry season.

Water withdrawals, for agricultural and municipal purposes, have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Elevated water temperatures in the Sacramento River have limited the survival of young salmon in those waters. Juvenile fall-run survival in the Sacramento River is also directly related to June streamflow and June and July Delta outflow (Dettman *et al*. 1987).

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP and SWP facilities. Specifically, juvenile salmonid survival has been reduced by: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel (DCC); (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.) within the waterways of the Delta while moving through the Delta under the influence of CVP/SWP pumping.

4.2.4.3 Anderson-Cottonwood Irrigation District (ACID) Dam

The ACID operates a diversion dam across the Sacramento River located 5 miles downstream from Keswick Dam. ACID is one of the 3 largest diversions on the Sacramento River and has senior water rights of 128 thousand acre feet (TAF) of water since 1916 for irrigation along the west side of the Sacramento River. The installation and removal of the diversion dam flashboards requires close coordination between Reclamation and ACID. The diversion dam is operated from April through October. Substantial reductions in Keswick releases to install or remove the flashboards have resulted in dewatered redds, stranded juveniles, and higher water temperatures. Based on run timing (table 5-1), the diversion dam operations could impact winter-run, spring-run, fall-run and green sturgeon. Redd dewatering would mostly likely affect spring-run and fall-run in October, however, the reductions in flows are usually short-term, lasting less than 8 hours. Such short-term reductions in flows may cause some mortality of incubating eggs and loss of stranded juveniles. Reductions in Keswick releases are limited to 15 percent in a 24-hour period and 2.5 percent in any 1 hour. Experience with real-time operations has shown that the most significant reductions occur during wet years when Shasta releases are higher than 10,000 cubic feet per second (cfs). Average April releases from Keswick are 6,000 to 7,000 cfs. The likelihood of a flow fluctuation occurring (when Shasta storage > 4.5 MAF in April) is 17 percent, or 14 out of the 82-year historical record. During wet years, flows released from Shasta Dam are typically higher than in drier water year types. The amount of flow that needs to be reduced to get to safe operating levels for the installation of the flashboards at the ACID dam is therefore greater and the wetted area reduction downstream of Keswick Dam is thus greater. The likelihood of an October reduction in flows that could dewater redds is even lower, since average releases are 6,000 cfs in all water year types.

Green sturgeon adults that migrate upstream in April, May, and June are are completely blocked by the ACID diversion dam. Therefore, 5 miles of spawning habitat are inaccessible upstream of the diversion dam. It is unknown if spawning is occurring in this area. Adults that pass upstream of the diversion dam before April are forced to wait 6 months until the stop logs are pulled before returning downstream to the ocean. Upstream blockage forces sturgeon to spawn in approximately 12 percent less habitat between Keswick Dam and RBDD. Newly-emerged green sturgeon larvae that hatch upstream of the ACID diversion dam would be forced to hold for 6 months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the dam, thus rendering the larvae and juvenile green sturgeon more susceptible to predation.

The ACID diversion dam was improved in 2001 with the addition of new fish ladders and fish screens around the diversion. Since upstream passage was improved a substantial shift in winter-run spawning has occurred. In recent years, more than half of the winter-run redds have typically been observed above the ACID diversion dam (Killam 2008). This makes flow fluctuations more a concern since such a large proportion of the run is spawning so close to Keswick Dam.

4.2.4.4 Red Bluff Diversion Dam (RBDD)

RBDD is owned and operated by Reclamation. The TCCA operates the Corning Canal and Tehama-Colusa Canal, which divert up to 328 TAF from the Sacramento River. RBDD is located 59 miles downstream of Keswick Dam. It blocks or delays adult salmonids and sturgeon migrating upstream to various degrees, depending on run timing. Based on various studies (Vogel *et al*. 1988; Hallock 1989; and CDFG 1998), the CVP/SWP operations BA states, "Problems in salmonid passage at RBDD provide a well-documented example of a diversion facility impairing salmon migration."

A portion of the winter-run adults encounter the gates down and are forced to use the fish ladders. There are 3 fish ladders on RBDD, one on each side and one temporary ladder in the middle of the dam. The RBDD fish ladders are not efficient at passing adult salmonids due to the inability of salmon to find the entrances. Water released from RBDD flows through a small opening under 11 gates across the river, causing turbulent flows that confuse fish and keep them from finding the ladders. The fish ladders are not designed to allow enough water through them to attract adult salmonids towards them. Previous studies (Vogel, USFWS) have shown that salmon can be delayed up to 20 days in passing the dam. These delays can reduce the fitness of adults that expend their energy reserves fighting the flows beneath the gates, and increase the chance of prespawn mortality. Run timing is critical to salmon, as it is what distinguishes one race from another. Delays of a week or even days in passage likely prevents some spring-run adults (those that encounter gates down in May and June) from entering tributaries above RBDD that dry up or warm up in the spring (*e.g*., Cottonwood Creek, Cow Creek). These delays have the potential of preventing these fish from accessing summer holding pools in the upper areas of the creeks.

4.2.4.5 Water Conveyance and Flood Control

The development of the water conveyance system in the Delta has resulted in the construction of armored, rip-rapped levees on more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As Mount (1995) indicates, there is an “underlying, fundamental conflict inherent in this channelization.” Natural rivers strive to achieve dynamic equilibrium to handle a watershed’s supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects, including isolation of the watershed’s natural floodplain behind the levee from the active river channel and its fluctuating hydrology.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al*. 2002). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and to escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996b). However, it is now recognized that too much LWD was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996b). Areas that were subjected to this removal of LWD are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of the debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996b). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990). Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases, affecting salmonid food supply.

4.2.4.6 Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). Starting with the gold rush, these vast riparian forests were cleared for building materials, fuel, and to clear land for farms on the raised natural levee banks. The degradation and fragmentation of riparian habitat continued with extensive flood control and bank protection projects, together with the conversion of the fertile riparian lands to agriculture outside of the natural levee belt. By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The clearing of the riparian forests removed a vital source of snags and driftwood in the Sacramento and San Joaquin River basins. This has reduced the volume of LWD input needed to form and maintain stream habitat that salmon depend on in their various life stages. In addition to this loss of LWD sources, removal of snags and obstructions from the active river channel for navigational safety has further reduced the presence of LWD in the Sacramento and San Joaquin Rivers, as well as the Delta.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is one of the primary causes of salmonid habitat degradation (NMFS 1996a). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc.* Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998a).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999). Even more extensive losses of wetland marshes occurred in the Sacramento and San Joaquin River Basins. Little of the extensive tracts of wetland marshes that existed prior to 1850 along the valley's river systems and within the natural flood basins exist today. Most has been "reclaimed" for agricultural purposes, leaving only small remnant patches.

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley. Starting in the mid-1800s, the Corps and private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bedload in the riverine system as well as the local flow velocity in the channel (Mount 1995). The Sacramento Flood Control Project at the turn of the nineteenth century ushered in the start of large scale Corps actions in the Delta and along the rivers of California for reclamation and flood control. The creation of levees and the deep shipping channels reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations during the wet winter season and the spring snow melt periods. These annual inundations provided necessary habitat for rearing and foraging of juvenile native fish that evolved with this flooding process. The armored riprapped levee banks and active maintenance actions of Reclamation Districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWD from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Urban stormwater and agricultural runoff may be contaminated with pesticides, oil, grease, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other organics and nutrients [California Regional Water Quality Control Board-Central Valley Region (Regional Board) 1998] that can destroy aquatic life necessary for salmonid survival (NMFS 1996a, b). Point source (PS) and non-point source (NPS) pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*., concrete, asphalt, and buildings) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996a, b). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. In addition to the PS and NPS inputs from urban runoff, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

Past mining activities routinely resulted in the removal of spawning gravels from streams, the straightening and channelization of the stream corridor from dredging activities, and the leaching of toxic effluents into streams from mining operations. Many of the effects of past mining operations continue to impact salmonid habitat today. Current mining practices include suction dredging (sand and gravel mining), placer mining, lode mining and gravel mining. Present day mining practices are typically less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for concrete to construct buildings and highways.

Most aggregate is derived principally from pits in active floodplains, pits in inactive river terrace deposits, or directly from the active channel. Other sources include hard rock quarries and mining from deposits within reservoirs. Extraction sites located along or in active floodplains present particular problems for anadromous salmonids. Physical alteration of the stream channel may result in the destruction of existing riparian vegetation and the reduction of available area for seedling establishment (Stillwater Sciences 2002). Loss of vegetation impacts riparian and aquatic habitat by causing a loss of the temperature moderating effects of shade and cover, and habitat diversity. Extensive degradation may induce a decline in the alluvial water table, as the banks are effectively drained to a lowered level, affecting riparian vegetation and water supply (NMFS 1996b). Altering the natural channel configuration will reduce salmonid habitat diversity by creating a wide, shallow channel lacking in the pools and cover necessary for all life stages of anadromous salmonids. In addition, waste products resulting from past and present mining activities, include cyanide (an agent used to extract gold from ore), copper, zinc, cadmium, mercury, asbestos, nickel, chromium, and lead.

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions have contributed to increased mortality of juvenile Chinook salmon and steelhead as they move through the Delta.

The following are excerpts from Lindley *et al*. (2009):

> "The long-standing and ongoing degradation of freshwater and estuarine habitats and the subsequent heavy reliance on hatchery production were also likely contributors to the collapse of the [fall-run] stock. Degradation and simplification of freshwater and estuary habitats over a century and a half of development have changed the Central Valley Chinook salmon complex from a highly diverse collection of numerous wild populations to one dominated by fall Chinook salmon from four large hatcheries."
>
> "In conclusion, the development of the Sacramento-San Joaquin watershed has greatly simplified and truncated the once-diverse habitats that historically supported a highly diverse assemblage of populations. The life history diversity of this historical assemblage would have buffered the overall abundance of Chinook salmon in the Central Valley under varying climate conditions."

4.2.4.7 Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. Some common pollutants include effluent from wastewater treatment plants and chemical discharges such as dioxin from San Francisco bay petroleum refineries (McEwan and Jackson 1996 *op cit*. CVP/SWP operations BA). In addition, agricultural drain water, another possible source of contaminants, can contribute up to 30 percent of the total inflow into the Sacramento River during the low-flow period of a dry year (CVP/SWP operations BA). The Regional Board, in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides [aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan and toxaphene], mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand *et al*. 1995, Goyer 1996). For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

In the aquatic environment, most anthropogenic chemicals and waste materials, including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995). Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids and green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations [Environmental Protection Agency (EPA) 1994]. However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids to contaminated sediments is similar to water borne exposures once the contaminant has entered the body of the fish.

4.2.4.8 Hatchery Operations and Practices

Five hatcheries currently produce Chinook salmon in the Central Valley, and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley are primarily caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels [U.S. Department of the Interior (DOI) 1999]. For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that spring-run and early fall-run were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. Spring-run from the FRFH have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run, an indication that FRFH spring-run may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Fish Hatchery and FRFH, can directly impact spring-run and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring-run and fall-run adults. This concurrent spawning has led to hybridization between the spring-run and fall-run in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally-produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally-produced fish currently (Nobriga and Cadrett 2003). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Winter-run produced in the LSNFH are considered part of the winter-run ESU. Spring-run produced in the FRFH are considered part of the spring-run ESU. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios. Artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels, as was the case with the winter-run population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

4.2.4.9 Over Utilization

4.2.4.9.1 Ocean Commercial and Sport Harvest – Chinook Salmon and Steelhead

Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Northern and Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI) harvest index. The CVI harvest index is the ocean harvest landed south of Point Arena divided by the CVI. The CVI is the sum of ocean fishery Chinook salmon harvested in the area south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught), plus the Central Valley adult Chinook salmon escapement. Coded wire tag (CWT) returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI harvest index for winter-run generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest index was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of winter-run. In addition, the final rule designating winter-run critical habitat (June 16, 1993, 58 FR 33212) stated that commercial and recreational fishing do not appear to be significant factors in the decline of the species. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). NMFS (1996) and NMFS (1997b) concluded that incidental ocean harvest of winter-run represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these biological opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001, the CVI harvest index dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of salmonids originating from the Central Valley (Good *et al*. 2005).

Ocean fisheries have affected the age structure of spring-run through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Winter-run spawners have also been affected by ocean fisheries, as most spawners return as 3-year olds. As a result of very low returns of fall-run to the Central Valley in 2007, there was a complete closure of the commercial and recreational ocean Chinook salmon fishery in 2008. As a result of not having been subjected to fishing pressure, there will likely be more 4- and 5-year old winter-run and spring-run returning to spawn in 2009.

Harvest rates of spring-run ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of winter-run. The drop in the CVI harvest index to 0.27 in 2001 as a result of high fall-run escapement also resulted in reducing the authorized harvest of spring-run. There is essentially no ocean harvest of steelhead.

4.2.4.9.2 Inland Sport Harvest – Chinook Salmon and Steelhead

Historically in California, almost half of the river sport fishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult winter-run are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on winter-run caused by recreational angling in freshwater. In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run caused by trout anglers. That same year, the Commission also adopted regulations, which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken spring-run throughout the species' range. During the summer, adult spring-run are easily targeted by anglers when they congregate and hold in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate. However, the significance of poaching on the adult population is unknown. Specific regulations for the protection of spring-run in Mill, Deer, Butte, and Big Chico creeks and the Yuba River have been added to the existing CDFG regulations. The current regulations, including those developed for winter-run, provide some level of protection for spring-run (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally produced adult steelhead. However, the total number of CV steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

4.2.4.10 Disease and Predation

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996a, 1996b, 1998a). Specific diseases such as bacterial kidney disease, *Ceratomyxosis shasta*, columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect Chinook salmon and steelhead (NMFS 1996a, 1996b, 1998a). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish. Nevertheless, wild salmonids may contract diseases that are spread through the water column (*i.e.*, waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

Accelerated predation also may be a factor in the decline of winter-run and spring-run, and to a lesser degree CV steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, ACID diversion dam, Glenn-Colusa Irrigation District (GCID) diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at South Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run is believed to be higher than natural due to flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. The Sacramento pikeminnow is a species native to the Sacramento River basin and has co-evolved with the anadromous salmonids in this system. However, rearing conditions in the Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, and water diversions) compared to its natural state and function decades ago in the pre-dam era, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than to native salmonids. Tucker *et al.* (1998) reported that Sacramento pikeminnow predation on juvenile salmonids during the summer months increased to 66 percent of the total weight of stomach contents in the predatory pikeminnow. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also indicated that the percent frequency of occurrence for juvenile salmonids nearly equaled other fish species in the stomach contents of the predatory fish. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area were directly related to RBDD operations (predators congregated when the dam gates were in, and dispersed when the gates were removed).

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997). More recent studies by DWR (2008) have verified this level of predation also exists for steelhead smolts within Clifton Court Forebay, indicating that these predators were efficient at removing salmonids over a wide range of body sizes.

Predation on juvenile salmonids has increased as a result of water development activities which have created ideal habitats for predators and non-native invasive species (NIS). Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile salmonid migrants and increase their predator avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time. Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the CVP and SWP Fish Facilities, and the SMSCG. Striped bass and pikeminnow predation on salmon at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982). However, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (Edwards *et al.* 1996, Tillman *et al.* 1996, NMFS 1997).

Avian predation on fish contributes to the loss of migrating juvenile salmonids by constraining natural and artificial production. Fish-eating birds that occur in the California Central Valley include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*), and bald eagles (*Haliaeetus leucocephalus*, Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Mammals can also be an important source of predation on salmonids within the California Central Valley. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. In the marine environment, pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) can also prey on adult salmonids in the nearshore marine environment, and at times become locally important. Southern Residents, in particular, target Chinook salmon as their preferred prey (96 percent of prey consumed during spring, summer and fall, from long-term study of resident killer whale diet; Ford and Ellis 2006). Although harbor seal and sea lion predation primarily is confined to the marine and estuarine environments, they are known to travel well into freshwater after migrating fish and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin rivers. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable, such as the large water diversions in the South Delta.

4.2.4.11 Environmental Variation

4.2.4.11.1 Natural Environmental Cycles

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996b). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean [El Niño Southern Oscillation (ENSO)] resulting in reductions or reversals of the normal trade wind circulation patterns. El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes to coastal currents and upwelling patterns. Principal ecosystem alterations include decreased primary and secondary productivity in affected regions and changes in prey and predator species distributions. Cold-water species are displaced towards higher latitudes or move into deeper, cooler water, and their habitat niches are occupied by species tolerant of warmer water that move upwards from the lower latitudes with the warm water tongue.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult life stage.

The freshwater life history traits and habitat requirements of juvenile winter-run and fall-run are similar. Therefore, the unusual and poor ocean conditions that caused the drastic decline in returning fall-run populations coast wide in 2007 (Varanasi and Bartoo 2008) are suspected to have also caused the observed decrease in the winter-run spawning population in 2007 (Oppenheim 2008). Lindley *et al*. (2009) reviewed the possible causes for the decline in Sacramento River fall-run in 2007 and 2008 for which reliable data were available. They concluded that a broad body of evidence suggested that anomalous conditions in the coastal ocean in 2005 and 2006 resulted in unusually poor survival of the 2004 and 2005 broods of fall-run. However, Lindley *et al.* (2009) recognize that the rapid and likely temporary deterioration in ocean conditions acted on top of a long-term, steady degradation of the freshwater and estuarine environment.

4.2.4.11.2 Ocean Productivity

The time at which juvenile salmonids enter the marine environment marks a critical period in their life history. Studies have shown the greatest rates of growth and energy accumulation for Chinook salmon occur during the first 1 to 3 months after they enter the ocean (Francis and Mantua 2003, MacFarlane *et al*. 2008). Emigration periods and ocean entry can vary substantially among, and even within, races in the Central Valley. For example, winter-run typically rear in freshwater for 5-9 months and exhibit a peak emigration period in March and April. Spring-run emigration is more variable and can occur in December or January (soon after emergence as fry), or from October through March (after rearing for a year or more in freshwater; CVP/SWP operations BA). In contrast to Chinook salmon, steelhead tend to rear in freshwater environments longer (anywhere from 1 to 3 years) and their period of ocean entry can span many months. Juvenile steelhead presence at Chipps Island has been documented between at least October and July (CVP/SWP operations BA). While still acknowledging this variability in emigration patterns, the general statement can be made that Chinook salmon typically rear in freshwater environments for less than a year and enter the marine environment as subyearlings in late spring to early summer. Likewise, although steelhead life histories are more elastic, they typically enter the ocean in approximately the same time frame. This general timing pattern of ocean entry is commonly attributed to evolutionary adaptations that allow salmonids to take advantage of highly productive ocean conditions that typically occur off the California coast beginning in spring and extending into the fall (MacFarlane *et al*. 2008). Therefore, the conditions that juvenile salmonids encounter when they enter the ocean can play an important role in their early marine survival and eventual development into adults.

It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Behrenfeld *et al.* 2006, Wells *et al.* 2006). Peterson *et al.* (2006) provide evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions. An evaluation of conditions in the California Current since the late 1970s reveals a generally warm, unproductive regime that persisted until the late 1990s. This regime has been followed by a period of high variability that began with colder, more productive conditions lasting from 1999 to 2002. In general, salmon populations increased substantially during this period. However, this brief cold cycle was immediately succeeded by a 4-year period of predominantly warm ocean conditions beginning in late 2002, which appeared to have negatively impacted salmon populations in the California Current (Peterson *et al*. 2006). Evidence suggests these regime shifts follow a more or less linear pattern beginning with the amount and timing of nutrients provided by upwelling and passing “up” the food chain from plankton to forage fish and eventually, salmon. There are also indications that these same regime shifts affect the migration patterns of larger animals that prey on salmon (*e.g*., Pacific hake, sea birds) resulting in a “top-down” effect as well (Peterson *et al*. 2006).

Peterson *et al*. (2006) evaluated three sets of ecosystem indicators to identify ecological properties associated with warm and cold ocean conditions and determine how those conditions can affect salmon survival. The three sets of ecosystem indicators include: (1) large-scale oceanic and atmospheric conditions [specifically, the Pacific Decadal Oscillation (PDO) and the Multivariate ENSO Index]; (2) local observations of physical and biological ocean conditions off northern Oregon (*e.g*., upwelling, water temperature, plankton species compositions, *etc*.); and (3) biological sampling of juvenile salmon, plankton, forage fish, and Pacific hake (which prey on salmon). When used collectively, this information can provide a general assessment of ocean conditions in the northern California Current that pertain to multi-year warm or cold phases. It can also be used to develop a qualitative evaluation for a particular year of the effect these ocean conditions have on juvenile salmon when they enter the marine environment and the potential impact to returning adults in subsequent years.

The generally warmer ocean conditions in the California Current that began to prevail in late 2002 have resulted in coastal ocean temperatures remaining 1-2˚C above normal through 2005. A review of the previously mentioned indicators for 2005 revealed that almost all ecosystem indices were characteristic of poor ocean conditions and reduced salmon survival. For instance, in addition to the high sea surface temperatures, the spring transition, which marks the beginning of the upwelling season and typically occurs between March and June, was very late, postponing upwelling until mid-July. In addition, the plankton species present during that time were the smaller organisms with lower lipid contents associated with warmer water, as opposed to the larger, lipid-rich organisms believed to be essential for salmon growth and survival throughout the winter. The number of juvenile salmon collected during trawl surveys was also lower than any other year previously sampled (going back to 1998, Peterson *et al*. 2006). Furthermore, although conditions in 2006 appeared to have improved somewhat over those observed in 2005 (*e.g*., sea surface temperature was cooler, the spring transition occurred earlier, and coastal upwelling was more pronounced), not all parameters were necessarily "good." In fact, many of the indicators were either "intermediate" (*e.g*., PDO, juvenile Chinook salmon presence in trawl surveys) or "poor" (*e.g*., copepod biodiversity, Peterson *et al.* 2006).

Updated information provided by Peterson *et al*. (2006) on the NWFSC Climate Change and Ocean Productivity website[6] shows the transition to colder ocean conditions, which began in 2007, has persisted throughout 2008. All ocean indicators point toward a highly favorable marine environment for those juvenile salmon that entered the ocean in 2008. After remaining neutral through much of 2007, PDO values became negative (indicating a cold California Current) in late 2007 and remained negative through at least August, 2008, with sea surface temperatures also remaining cold. Coastal upwelling was initiated early and will likely be regarded as average overall. Furthermore, the larger, energy-rich, cold water plankton species have been present in large numbers in 2007 and 2008. Therefore, ocean conditions in the broader California Current appear to have been favorable for salmon survival in 2007 and to a greater extent in 2008, which bodes well for Chinook salmon populations returning in 2009 and 2010[3]. These ecosystem indicators can be used to provide an understanding of ocean conditions, and their relative impact on marine survival of juvenile salmon, throughout the broader, northern portion of the California Current. However, they may not provide an accurate assessment of the conditions observed on a more local scale off the California coast.

Wells *et al*. (2008a) developed a multivariate environmental index that can be used to assess ocean productivity on a finer scale for the central California region. This index (also referred to as the Wells Ocean Productivity Index) has also tracked the Northern Oscillation Index, which can be used to understand ocean conditions in the North Pacific Ocean in general. The divergence of these two indices in 2005 and 2006 provided evidence that ocean conditions were worse off the California coast than they were in the broader North Pacific region. The Wells *et al.* (2008a) index incorporates 13 oceanographic variables and indices and has correlated well with the productivity of zooplankton, juvenile shortbelly rockfish, and common murre production along the California coast (MacFarlane *et al*. 2008). In addition to its use as an indicator of ocean productivity in general, the index may also relate to salmon dynamics due to their heavy reliance on krill and rockfish as prey items during early and later life stages. For instance, not only did the extremely low index values in 2005 and 2006 correlate well with the extremely low productivity of salmon off the central California coast in those years, but the index also appears to have correlated well with maturation and mortality rates of adult salmon from 1990-2006 in that region (Wells and Mohr 2008). Although not all of the data are currently available to determine the Wells *et al*. (2008a) index values for 2007 and 2008, there is sufficient information to provide an indication of the likely ocean conditions for those 2 years, which can then be compared to 2005 and 2006.

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[6] http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm

A review of the available information suggests ocean conditions in 2007 and 2008 have improved substantially over those observed in 2005 and 2006. For instance, the spring transition, which marks the beginning of the upwelling season and typically occurs between March and June, was earlier in 2007 and 2008 compared to 2005 and 2006. An early spring transition is often indicative of greater productivity throughout the spring and summer seasons (Wells and Mohr 2008, Peterson *et al*. 2006). Coastal upwelling, the process by which cool, nutrient rich waters are brought to the surface (perhaps the most important parameter with respect to plankton productivity), was also above average in 2007 and 2008. Moreover, coastal sea surface temperature and sea level height (representative of the strength of the California current and southern transport) values were also characteristic of improved ocean productivity (Wells and Mohr 2008). Thus, contrary to the poor ocean conditions observed in the spring of 2005 and 2006, the Wells *et al*. (2008a) index parameters available at this time indicate spring ocean conditions have been generally favorable for salmon survival off California in 2007 and 2008.

In contrast to the relatively "good" ocean conditions that occurred in the spring, the Wells *et al*. (2008a) index values for the summer of 2007 and 2008 were poor in general, and similar to those observed in 2005 and 2006. Summer sea surface temperature followed a similar pattern in both 2007 and 2008, starting out cool in June, and then rising to well above average in July before dropping back down to average in August (Wells and Mohr 2008). The strong upwelling values observed in the spring of 2007 and 2008 were not maintained throughout the summer, and instead dropped to either at or below those observed in 2005 and 2006. Finally, sea level height and spring curl values (a mathematical representation of the vertical component of wind shear which represents the rotation of the vector field), which are negatively correlated with ocean productivity, were both poor (Wells and Mohr 2008). Therefore, during the spring of 2007 and 2008, ocean conditions off California were indicative of a productive marine environment favorable for ocean salmon survival (and much improved over 2005 and 2006). However, those conditions did not persist throughout the year, as Wells *et al*. (2008a) index values observed in the summer of 2007 and 2008 were similar to those experienced in the summer of 2005 and 2006, 2 years marked by extremely low productivity of salmon off the central California coast.

Evidence exists that suggests early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, when discussing the potential extinctions of salmon populations, Francis and Mantua (2003) point out that climate patterns would not likely be the sole cause but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans. Thus, the efforts to try and gain a greater understanding of the role ocean conditions play in salmon productivity will continue to provide valuable information that can be incorporated into the management of these species and should continue to be pursued. However, the highly variable nature of these environmental factors makes it very difficult, if not impossible, to accurately predict what they will be like in the future. Because the potential for poor ocean conditions exists in any given year, and there is no way for salmon managers to control these factors, any deleterious effects endured by salmonids in the freshwater environment can only exacerbate the problem of an inhospitable marine environment. Therefore, in order to ensure viable populations, it is important that any impacts that can be avoided prior to the period when salmonids enter the ocean must be carefully considered and reduced to the greatest extent possible.

4.2.4.11.3 Global Climate Change

Climate change is postulated to have had a negative impact on salmonids throughout the Pacific Northwest due to large reductions in available freshwater habitat (Battin *et al.* 2007). Widespread declines in springtime snow-water equivalents (SWE) have occurred in much of the North American West since the 1920s, especially since mid-century (Knowles and Cayan 2004, Mote 2006). This decrease in SWE can be largely attributed to a general warming trend in the western United States since the early 1900s (Mote *et al.* 2005, Regonda *et al.* 2005, Mote 2006), even though there have been modest upward precipitation trends in the western United States since the early 1900s (Hamlet *et al.* 2005). The largest decreases in SWE are taking place at low to mid elevations (Mote 2006, Van Kirk and Naman 2008) because the warming trend overwhelms the effects of increased precipitation (Hamlet *et al.* 2005, Mote *et al.* 2005, Mote 2006). These climactic changes have resulted in earlier onsets of springtime snowmelt and streamflow across western North America (Hamlet and Lettenmaier 1999, Regonda *et al.* 2005, Stewart *et al.* 2005), as well as lower flows in the summer (Hamlet and Lettenmaier 1999, Stewart *et al.* 2005).

The projected runoff-timing trends over the course of the 21st century are most pronounced in the Pacific Northwest, Sierra Nevada, and Rocky Mountain regions, where the eventual temporal centroid of streamflow (*i.e.* peak streamflow) change amounts to 20–40 days in many streams (Stewart *et al.* 2005). Although climate models diverge with respect to future trends in precipitation, there is widespread agreement that the trend toward lower SWE and earlier snowmelt will continue (Zhu *et al*. 2005, Vicuna *et al*. 2007). Thus, availability of water resources under future climate scenarios is expected to be most limited during the late summer (Gleick and Chalecki 1999, Miles *et al*. 2000). A 1-month advance in timing centroid of streamflow would also increase the length of the summer drought that characterizes much of western North America, with important consequences for water supply, ecosystem, and wildfire management (Stewart *et al.* 2005). These changes in peak streamflow timing and snowpack will negatively impact salmonid populations due to habitat loss associated with lower water flows, higher stream temperatures, and increased human demand for water resources.

The global effects of climate change on river systems and salmon are often superimposed upon the local effects within river systems of logging, water utilization, harvesting, hatchery interactions, and development (Bradford and Irvine 2000, Mayer 2008, Van Kirk and Naman 2008). For example, total water withdrawal in California, Idaho, Oregon and Washington increased 82 percent between 1950 and 2000, with irrigation accounting for nearly half of this increase (MacKichan 1951, Hutson *et al.* 2004), while during the same period climate change was taking place.

4.2.4.12 Non-Native Invasive Species

As currently seen in the San Francisco estuary, non-native invasive species (NIS) can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well-being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants have certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

4.2.4.13 Ecosystem Restoration

4.2.4.13.1 CALFED

Two programs included under CALFED, the Ecosystem Restoration Program (ERP) and the Environmental Water Account (EWA), were created to improve conditions for fish, including listed salmonids, in the Central Valley (CALFED 2000). Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for spring-run and steelhead production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by CALFED-ERP have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Bay in conjunction with tidal wetland restoration.

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant in anadromous salmonid reaches of priority streams controlled by dams.

This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five priority watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users, particularly South of Delta water users. In early 2001, the EWA released 290 TAF of water from San Luis Reservoir at key times to offset reductions in South Delta pumping implemented to protect winter-run, Delta smelt, and splittail. However, the benefit derived by this action to winter-run in terms of number of fish saved was very small. The anticipated benefits to other Delta fish from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

4.2.4.13.2 Central Valley Project Improvement Act

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From the CVPIA act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward recovery of all anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the DOI’s ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for spring-run and steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

Although the above highlights the benefits of the CVPIA, Cummins *et al*. (2008) documented that DOI fell considerably short in implementing the CVPIA. Cummins *et al*. (2008) acknowledge that the specific “doubling” mission itself may make little scientific or policy sense, especially within the time frames demanded (2002). However, they also stated that it is far from clear that the agencies (Reclamation and USFWS) have done what is possible and necessary to improve freshwater conditions to help these species weather environmental variability, halt their decline and begin rebuilding in a sustainable way. In their executive summary, Cummins *et al*. (2008) state the following:

> “The program effectively ignores the larger system problems that inhibit the natural production of anadromous fish:
>
> - headwaters dams that have taken away most of the spawning and rearing capacity in the valley;
> - highly regulated flows and diversions completely out of balance with natural flow regimes to which these species are adapted;

- rivers levied and channeled and disconnected from floodplains to such an extent that natural river habitats and rearing conditions are largely absent; and
- environmentally degraded conditions for fish in the Delta due to water exports, degraded water quality, entrainment, and predation that are a significant source of poorly addressed mortality.

The agencies need to fully use their authorities to understand and address the system problems, or ask Congress for additional authorities and guidance."

4.2.4.13.3 Iron Mountain Mine Remediation

EPA's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a state-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s (see Reclamation 2004 Appendix J). Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

4.2.4.13.4 State Water Project Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement)

The Four Pumps Agreement Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento and San Joaquin basins and Delta since the agreement inception in 1986. Four Pumps projects that benefit spring-run and steelhead include water exchange programs on Mill and Deer creeks; enhanced law enforcement efforts from San Francisco Bay upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead (see Reclamation 2004 Chapter 15).

4.2.4.14 Additional Water Quality

In addition to the factors, above, the following provides additional information on the effect of water quality resulting from water development in the San Joaquin River basin that affect the current status of CV steelhead. Low DO levels are frequently observed in the portion of the Stockton deep water ship channel (DWSC) extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/l DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River (table 4-9). CDEC data indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed CV steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (table 4-6).

Table 4-9. Monthly occurrences of dissolved oxygen depressions below the 5mg/L criteria in the Stockton deep water ship channel (Rough and Ready Island DO monitoring site), water years 2000 to 2004.

Month	Water Year					Monthly Sum
	2000-01	2001-02	2002-03	2003-04	2004-05	
September	0	26 [b]	30 [b]	16 [b]	30 [b]	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2 [a]	0	2	4	0	8
Annual Sum	11	70	124	42	50	**Total=297**

[a]Suspect Data – potentially faulty DO meter readings

[b]Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of water in the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the negative effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Hallock *et al.* (1970) reported that levels of DO below 5 mg/L delay or block fall-run.

4.2.4.15 Summary

For winter-run, spring-run, and CV steelhead, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected salmonid populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/or rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species. Steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. Winter-run, spring-run, and CV steelhead have all been negatively affected by the production of hatchery fish associated with the mitigation for the habitat lost to dam construction (*e.g.*, from genetic impacts, increased competition, exposure to novel diseases, *etc*.).

Land-use activities such as road and levee construction, urban development, logging, mining, agriculture, and recreation are pervasive and have significantly altered fish habitat quantity and quality for Chinook salmon and steelhead through alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and removal of riparian vegetation resulting in increased streambank erosion. Human-induced habitat changes, such as: alteration of natural flow regimes; installation of bank revetment; and building structures such as dams, bridges, water diversions, piers, and wharves, often provide conditions that both disorient juvenile salmonids and attract predators. Harvest activities, ocean productivity, and drought conditions provide added stressors to listed salmonid populations. In contrast, various ecosystem restoration activities have contributed to improved conditions for listed salmonids (*e.g.*, various fish screens). However, some important restoration activities (*e.g.*, Battle Creek Restoration Project) have not yet been implemented and benefits to listed salmonids from the EWA have been less than anticipated.

Figure 4-12. Geographic Range (light shading) of the Southern Resident Killer Whale DPS. Source: Wiles (2004).

4.2.5 Southern Resident Killer Whales

4.2.5.1 Current Rangewide Status of the Species

The Southern Resident killer whales DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). Southern Residents are designated as "depleted"[7] under the Marine Mammal Protection Act (MMPA; May 29, 2003, 68 FR 31980). This section summarizes information taken largely from the final recovery plan for Southern Residents (NMFS 2008a), as well as new data that became available more recently.

4.2.5.2 Range and Distribution

Southern Residents are found throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia (figure 4-12). There is limited information on the distribution and habitat use of Southern Residents along the outer Pacific Coast. Southern Residents are highly mobile and can travel up to 86 nautical miles (nmi, or 10 miles) in a single day (Erickson 1978, Baird 2000). To date, there is no evidence that Southern Residents travel further than 31 miles offshore (Ford *et al*. 2005).

Southern Residents spend considerable time from late spring to early autumn in inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound; Bigg 1982, Ford *et al*. 2000, Krahn *et al*. 2002; table 4-10). Typically, J, K and L pods are increasingly present in May or June and spend considerable time in the core area of Georgia Basin and Puget Sound until at least September. During this time, pods (particularly K and L) make frequent trips from inland waters to the outer coasts of Washington and southern Vancouver Island, which typically last a few days (Ford *et al*. 2000).

Table 4-10. Average number of days spent by Southern Resident killer whales in inland and coastal waters by month, 2003-2007 (Hanson and Emmons, unpubl. report).

Months	Lpod		Jpod		Kpod	
	Days Inland	Days Coastal	Days Inland	Days Coastal	Days Inland	Days Coastal
Jan	5	26	3	29	8	23
Feb	0	28	4	24	0	28
March	2	29	7	24	2	29
April	0	30	13	17	0	30
May	2	29	26	5	0	31
June	14	16	26	5	12	18
July	18	13	24	7	17	14
Aug	17	15	17	15	17	14
Sep	20	10	19	11	17	13
Oct	12	19	14	17	8	24
Nov	5	25	13	17	7	23
Dec	1	30	8	23	10	21

[7] Defined by the MMPA as any case in which (1) the Secretary, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals established under MMPA title II, determines that a species or population stock is below its optimum sustainable population; (2) a State, to which authority for the conservation and management of a species or population stock is transferred under section 109, determines that such species or stock is below its optimum sustainable population; or (3) a species or population stock is listed as an endangered species or a threatened species under the ESA.

Late summer and early fall movements of Southern Residents in the Georgia Basin have remained fairly consistent since the early 1970s, with strong site fidelity shown to the region as a whole, however presence in inland waters in the fall has increased in recent years (NMFS 2008a). During early autumn, J pod in particular expands their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Osborne 1999). During late fall, winter, and early spring, the ranges and movements of the Southern Residents are less well known. Sightings through the Strait of Juan de Fuca in late fall suggest that activity shifts to the outer coasts of Vancouver Island and Washington (Krahn *et al*. 2002).

The Southern Residents were formerly thought to range southward along the coast to about Grays Harbor (Bigg *et al*. 1990) or the mouth of the Columbia River (Ford *et al*. 2000). However, recent sightings of members of K and L pods in Oregon (in 1999 and 2000) and California (in 2000, 2003, 2005, 2006 and 2008) have considerably extended the southern limit of their known range (NMFS 2008b). There have been 45 verified sightings or strandings of J, K or L pods along the outer coast from 1975 to present with most made from January through April (table 4-11). These include 16 records off Vancouver Island and the Queen Charlottes, 15 off Washington, 4 off Oregon, and 10 off central California. Most records have occurred since 1996, but this may be because of increased viewing effort along the coast in recent years. Some sightings in Monterey Bay, California have coincided with large runs of salmon, with feeding witnessed in 2000 (Black *et al*. 2001). However, when Southern Residents were sighted in Monterey Bay during 2008, salmon runs were expected to be very small. L pod was also seen feeding on unidentified salmon off Westport, Washington, in March 2004 during the spring Chinook salmon run in the Columbia River (M. B. Hanson, pers. obs. *op. cit*. Krahn *et al*. 2004).

4.2.5.3 Factors Responsible for the Current Status of Southern Residents

Several potential factors identified in the final recovery plan for Southern Residents may have caused the decline or may be limiting recovery of the DPS. These are: quantity and quality of prey; toxic chemicals, which accumulate in top predators; and disturbance from sound and vessel effects. Oil spills are also a potential risk factor for this species. Research has yet to identify which threats are most significant to the survival and recovery of Southern Residents. It is likely that multiple threats are acting in concert to impact the whales.

4.2.5.3.1 Prey

Healthy killer whale populations depend on adequate prey levels. A discussion of the prey requirements of Southern Residents is followed by an assessment of threats to the quality and quantity of prey available.

Table 4-11. Known sightings of Southern Resident killer whales along the outer Pacific Ocean coast (NMFS 2008a).

Date	Location	Identification	Source	Comments
British Columbia outer coast				
31 Jan 1982	Barkley Sound, west coast of Vancouver Island	L pod	J. Ford, PBS/DFO	Off shore of Sound
21 Oct 1987	Coal Harbor, north Vancouver Island	Part of L pod	J. Ford, PBS/DFO	Were way up inlet a long distance from open ocean
3 May 1989	Tofino, west coast of Vancouver Island	K pod	WMSA	--
4 July 1995	Hippa Is., south Queen Charlotte Islands	Southern Resident	J. Ford PBS/DFO	Carcass found on beach, ID only by genetics
May 1996	Cape Scott, north Vancouver Island	Southern Resident	J. Ford PBS/DFO	Carcass found on beach, ID only by genetics
4 Sep 1997	Off Carmanah Point, sw Vancouver Island	L pod	Observed by P. Gearin, NMML	Identified by D. Ellifrit
14 Apr 2001	Tofino, west coast of Vancouver Island	L pod	J. Ford PBS/DFO	
27 Apr 2002	Tofino, west coast of Vancouver Island	L pod	J. Ford PBS/DFO	
12 May 2002	Tofino, west coast of Vancouver Island	L pod	J. Ford PBS/DFO	
30 May 2003	Langara Is., Queen Charlotte Islands	L pod	M. Joyce, DFO	
17 May 2004	Tofino, west coast of Vancouver Island	K and L pods	M. Joyce, DFO	
9 June 2005	West of Cape Flattery, Washington in Canadian waters	L pod	SWFSC	Whales were exiting the Strait of Juan de Fuca
7 Sep 2005	West of Cape Flattery, Washington in Canadian waters	L pod	NWFSC	Whales were exiting the Strait of Juan de Fuca
18 Mar 2006	North of Neah Bay, Washington in Canadian waters	J pod	NWFSC	Whales were exiting the Strait of Juan de Fuca
8 May 2006	Off Brooks Peninsula, west coast of Vancouver Island	L pod	J. Ford PBS/DFO	
1 Dec 2006	Johnstone Strait	L pod	J. Ford PBS/DFO	
Washington Outer Coast				
4 Apr 1986	Off Westport/Grays Harbor	L pod	J. Ford, PBS/DFO	
13 Sep 1989	West of Cape Flattery	L pod	J. Calambokidis, Cascadia Research	

Date	Location	Identification	Source	Comments
17 Mar 1996	3 km offshore Grays Harbor	L pod	J. Calambokidis, Cascadia Research	
20 Sep 1996	Off Sand Point (29 km south of Cape Flattery)	L pod	Observed by P. Gearin, NMML	Identified by D. Ellifrit
15 Apr 2002	Long Beach	L60	D. Duffield, Portland State Univ.	Stranded whale identified by K. Balcomb, CWR
11 Mar 2004 **13 Mar 2004**	Grays Harbor Off Cape Flattery	L pod J pod	B. Hanson, NWFSC B. Hanson, NWFSC	Whales were exiting Strait of Juan de Fuca
22 Mar 2005	Fort Canby-North Head	L pod	J. Zamon, NWFSC	
23 Oct 2005	Off Columbia River	K pod	SWFSC, Cscape	
29 Oct 2005	Off Columbia River	K and L pods	SWFSC, Cscape	
1 Apr 2006	Westport	L pods	PAL	
6 Apr 2006	Westport	K and L pods	Cascadia Research	
13 May 2006	Westport	K and L pods	PAL	
26 May 2006	Westport	K pod	PAL	
29 May 2006	Westport	K pod	PAL	
Oregon				
Apr 1999	Off Depoe Bay	L pod	J. Ford, PBS/DFO	
Mar 2000	Off Yaquina Bay	L pod	J. Ford, PBS/DFO	Seen week of Mar 20
14 Apr 2000	Off Depoe Bay	Southern Residents	K. Balcomb, CWR	
30 Mar 2006	Off Columbia River	K and L pods	B. Hanson, NWFSC	
California				
29 Jan 2000	Monterey Bay	K and L pods	N. Black, MBWW	Seen and photographed feeding on fish
13 Mar 2002	Monterey Bay	L pod	N. Black, MBWW	
16 Feb 2005	Farallon Is	L pod	K. Balcomb, CWR	
26 Jan 2006	Pt. Reyes	L pod	S. Allen	
24 Jan 2007	San Francisco Bay	K pod	N. Black, MBWW	
18 Mar 2007	Fort Bragg	L pod		Reported on CWR website
24-25 Mar 2007	Monterey	K and L pods		Reported on CWR website
30 Oct 2007	Bodega Bay	L pod	Cascadia Research	
27 Jan 2008	Monterey	L pod	N. Black/K. Balcomb	
2 Feb 2008	Monterey	K and L pods	N. Black/K. Balcomb	

4.2.5.3.1.1 Prey Requirements

Southern Residents consume a variety of fish species (22 species) and one species of squid (Scheffer and Slipp 1948; Ford *et al*. 1998, 2000; Ford and Ellis 2006; Saulitis *et al*. 2000), but salmon are identified as their preferred prey (96 percent of prey consumed during spring, summer and fall, from long-term study of resident killer whale diet; Ford and Ellis 2006). Feeding records for Southern and Northern Residents show a strong preference for Chinook salmon (72 percent of identified salmonids) during late spring to fall (Ford and Ellis 2006). Chum salmon (23 percent) are also taken in significant amounts, especially in autumn. Other salmonids eaten include coho salmon (2 percent), pink salmon (3 percent), steelhead (<1 percent), and sockeye salmon (*O. nerka* < 1 percent). The non-salmonids included Pacific herring, sablefish, Pacific halibut, quillback and yelloweye rockfish. Chinook salmon were preferred despite the much lower abundance of Chinook salmon in the study area in comparison to other salmonids (primarily sockeye salmon), probably because of the species' large size, high fat and energy content and year-round occurrence in the area. Killer whales also captured older (*i.e*., larger) than average Chinook salmon (Ford and Ellis 2006).

Southern Residents are the subject of ongoing research, including direct observation, scale sampling and fecal sampling. Preliminary results of this research provide the best available scientific information on diet composition of Southern Residents in inland waters – the results are specific to Southern Residents, are based on direct observation, and produce three different lines of evidence. This research provides information on (1) the percentage of Chinook salmon in the whales' diet, (2) the predominant river of origin of those Chinook salmon, and (3) the age and/or size of the Chinook salmon. Some of this information is supported by other research and analysis. The results are specific to inland waters.

4.2.5.3.1.2 Percentage of Chinook Salmon

From May to September, when Southern Residents spend a high proportion of their time in the "core summer area" (San Juan Islands), their diet consists of approximately 86 percent Chinook salmon and 14 percent other salmon species (n=125 samples; Hanson *et al*. 2007, NWFSC unpubl. data). During all sampling months combined (roughly May to December) their diet is approximately 69 percent Chinook salmon and 31 percent other salmon species (n=160 samples in inland waters). During fall months in inland waters, when some Southern Residents are sighted inside Puget Sound, preliminary results indicate an apparent shift to chum salmon (Hanson *et al.* 2007, NWFSC unpubl. data).

These data on the predominance of Chinook salmon in the killer whales' diet are consistent with all previous studies of Southern and Northern Resident killer whales diet composition, described above. Killer whales may favor Chinook salmon because Chinook salmon have the highest lipid content (Stansby 1976, Winship and Trites 2003), largest size, and highest caloric value per kilogram of any salmonid species (Osborne 1999, Ford and Ellis 2006). The preference of

Chinook salmon may also relate to size-selectivity. When available, Chinook salmon tend to be consumed more often than chum salmon (2nd largest, Ford and Ellis 2006), and chum salmon appear to be favored over pink salmon (Saulitus *et al*. 2000).

4.2.5.3.1.3 River of Origin

The ongoing research provides insight into the river of origin of Chinook salmon consumed by the Southern Residents. Genetic analysis of fecal and prey samples from the research indicates that Southern Residents consume Fraser River origin Chinook salmon, as well as salmon from Puget Sound, Washington and Oregon coasts, the Columbia River, and Central Valley California (Hanson *et al.* 2007, NWFSC unpubl. data).

4.2.5.3.1.4 Age and/or Size

The ongoing research discussed above also collected salmon scales from killer whale feeding events and used them to evaluate the age of the salmon consumed, finding that Southern Residents prefer older (hence larger) Chinook salmon (NWFSC unpubl. data). This finding is consistent with that of Ford and Ellis (2006) who also evaluated the age of prey from killer whale feeding events. Ford and Ellis (2006) estimated size selectivity by comparing the age of fish consumed to the age distribution of fish in the area based on catch data obtained from the Pacific Salmon Commission (table 3 and figure 5 in Ford and Ellis 2006). NWFSC evaluated the age of kills relative to the age distribution of Chinook salmon in a fisheries management model, FRAM (table 4-12; NMFS 2008, Ward *et al.* unpubl. report).

Table 4-12. Mean abundance by age class (%) and kills by age class (%).

Age	NWFSC (n=75)		Ford & Ellis (2006; n=127)	
	% Abundance	% Kills	% Abundance	% Kills
Age 2	59.0	-	9.6	0.7
Age 3	25.8	10.4	35.7	11.3
Age 4	13.4	45.5	48.0	55.9
Age 5	1.7	41.6	6.5	31.5

There is also theoretical support for size-selective prey preferences. Optimal foraging theory predicts that animals maximize the rate and efficiency of energy intake (reviewed by Pyke *et al.* 1977), this is generally done by consuming prey that maximize the energy intake relative to handling time (Charnov 1976). For apex predators, like killer whales, there are few risks associated with foraging (smaller organisms face risk of predation, killer whales do not), and prey choice is likely determined by the encounter rate of preferred species relative to sub-optimal species. Additional empirical evidence supporting the selection of large prey items has been found in a variety of species, including selection of sockeye salmon by brown bears (Ruggerone *et al*. 2000, Carlson and Quinn 2007).

Less is known about diet preferences of Southern Residents off the Pacific Coast. Although there are no fecal or prey samples or direct observations of predation events (where the prey was identified to species) in coastal waters, it is likely that salmon are also important when the whales are in coastal waters. Chemical analyses support the importance of salmon in the year-round diet of Southern Residents (Krahn *et al.* 2002, Krahn *et al.* 2007). Krahn *et al*. (2002) examined the ratios of DDT (and its metabolites) to various PCB compounds in the whales, and concluded that the whales feed primarily on salmon throughout the year rather than other fish species. Krahn *et al*. (2007) analyzed stable isotopes from tissue samples collected in 1996 and 2004/2006. Carbon and nitrogen stable isotopes indicated that J and L pods consumed prey from similar trophic levels in 2004/2006 and showed no evidence of a large shift in the trophic level of prey consumed by L pod between 1996 and 2004/2006. The preference of Southern Residents for Chinook salmon in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that Southern Residents likely prefer Chinook salmon when available in coastal waters.

4.2.5.3.1.5 Quantity of Prey

It is uncertain to what extent long-term or more recent declines in salmon abundance contributed to the decline of the Southern Resident DPS, or whether current salmon levels are adequate to support the survival and recovery of the Southern Residents. When prey is scarce, whales must spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation could lead to lower reproductive rates and higher mortality rates. Food scarcity could cause whales to draw on fat stores, mobilizing contaminants stored in their fat and affecting reproduction and immune function (discussed further below).

Ford *et al*. (2005) correlated coastwide reduction in Chinook salmon abundance (Alaska, British Columbia, and Washington) with decreased survival of resident killer whales (Northern and Southern Residents), but changes in killer whale abundance have not been definitively linked to local areas or changes in specific salmon stock groups. Ward *et al*. (in review) correlated Chinook salmon abundance trends with changes in fecundity of Southern Residents, and reported the probability of calving increased by 50 percent between low and high Chinook salmon abundance years. Results indicate the Chinook salmon abundance indices from the West Coast of Vancouver Island are an important predictor of the relationship.

NMFS estimated that the Southern Resident population could need approximately 3.74 billion kilocalories annually from Chinook salmon across their coastal range (NMFS 2008). This estimate incorporated the 2008 age and sex structure of the Southern Resident population, and assumed a high diet composition of Chinook salmon (86 percent, as referenced above). The size and energy content of Chinook salmon vary by age, stock, and season, amoung other factors. We provide a simplified estimate of Chinook salmon needed by the Southern Resident population in their coastal range based on a size range of Chinook salmon (fork length: 465 to 777 mm) that Southern Residents are likely to select (Table 7.9.2.1-1 in NMFS 2008). We use the size range to evaluate a range in kilocalories per Chinook salmon (2,121 to 10,531 kilocalories) based on a regression model of fork length to kilocalories (O'Neill *et al*. in prep). Based on these estimates, Southern Residents may need from approximately 356,000 to 1.76 million to Chinook salmon annually across their coastal range.

Human influences have had profound impacts on the abundance of many prey species in the northeastern Pacific during the past 150 years, including salmon. The health and abundance of wild salmon stocks have been negatively affected by altered or degraded freshwater and estuarine habitat (*i.e*., hydro-power systems, urbanization, forestry and agriculture), harmful artificial propagation practices, and overfishing (see Status sections for Chinook salmon, above). Predation in the ocean also contributes to natural mortality of salmon. Salmonids are prey for pelagic fish, birds, and marine mammals, including killer whales.

While wild salmon stocks have declined in many areas, hatchery production has been generally strong. Hatchery production contributes a significant component of the salmon prey base returning to watersheds within the range of Southern Residents (Pacific Salmon Commission Joint Chinook Technical Committee 2008). Although hatchery production has off-set some of the historical declines in the abundance of wild salmon within the range of Southern Residents, hatcheries also pose risks to wild salmon populations. In recent decades, managers have been moving toward hatchery reform, and are in the process of reducing risks identified in hatchery programs, through region-wide recovery planning efforts and hatchery program reviews. Healthy wild salmon populations are important to the long-term maintenance of prey populations available to Southern Residents, because it is uncertain whether a hatchery only stock could be sustained indefinitely.

Salmon abundance is also substantially affected by climate variability in freshwater and marine environments, particularly by conditions during early life-history stages of salmon (review in NMFS 2008b). Sources of variability include inter-annual climatic variations (*e.g*., El Niño and La Niña), longer-term cycles in ocean conditions (*e.g*., PDO, Mantua *et al*. 1997), and ongoing global climate change. For example, climate variability can affect ocean productivity in the marine environment and water storage (*e.g*., snow pack) and in-stream flow in the freshwater environment. Early life-stage growth and survival of salmon can be negatively affected when climate variability results in conditions that hinder ocean productivity (*e.g*., Scheurell and Williams 2005) and/or water storage (*e.g*., Independent Scientific Advisory Board 2007) in marine and freshwater systems, respectively. However, severe flooding in freshwater systems may constrain salmon populations (NMFS 2008b). The availability of adult salmon – prey of Southern Residents – may be reduced in years following unfavorable conditions to the early life-stage growth and survival of salmon. The effects of large-scale environmental variation on salmon populations are discussed in more detail in section 4.2.4.11.

4.2.5.3.1.6 Quality of Prey

Contaminant levels in salmon affect the quality of Southern Resident prey. Contaminants enter fresh and marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Recent studies have documented high concentrations of PCBs, DDTs, and polybrominated diphenylethers (PBDE) in killer whales (Ross *et al*. 2000, Ylitalo *et al*. 2001, Reijnders and Aguilar 2002, Krahn *et al*. 2004). As top predators, when killer whales consume contaminated prey they accumulate the contaminants in their blubber. When prey is scarce, killer whales metabolize their blubber and the contaminants are mobilized (Krahn *et al*. 2002). Nursing females transmit large quantities of contaminants to their offspring. The mobilized contaminants can reduce the killer whales' resistance to disease and can affect reproduction. Chinook salmon contain higher levels of some contaminants (*i.e*., PCBs) than other salmon species (O'Neill *et al*. 2005). Only limited information is available for contaminant levels of Chinook salmon along the west coast (*i.e*., higher PCB and PBDE levels may distinguish Puget Sound origin stocks, whereas higher DDT-signature may distinguish California origin stocks; Krahn *et al*. 2007).

Size of individual salmon could affect the foraging efficiency required by Southern Residents. As discussed above, available data suggests that Southern Residents prefer larger prey. In general, the literature indicates a historical decrease in salmon age, size, or size at a given age. Hypotheses advanced to explain declining body size are density-dependent growth and selection of larger, older fish by selective fisheries. Bigler *et al*. (1996) found a decreasing average body size in 45 of 47 salmon populations in the Northern Pacific. They also found that body size was inversely related to population abundance, and speculated that hatchery programs during the 1980s and 1990s increased population sizes, but reduced growth rates due to competition for food in the ocean. Fish size is influenced by factors such as environmental conditions, selectivity in fishing effort through gear type, fishing season or regulations, and hatchery practices. The available information on size is also confounded by factors including inter-population difference, when the size was recorded, and differing data sources and sampling methods (review in Quinn 2005).

Southern Residents likely consume both natural and hatchery salmon (Barre 2008). The best available information does not indicate that Southern Residents would be affected differently by consuming natural or hatchery salmon [*i.e*., no general pattern of differences in size, run-timing, or ocean distribution (*e.g*., Nickum *et al*. 2004, NMFS 2008c, Weitkamp and Neely 2002)]. Therefore, there is no scientific evidence to generally distinguish the quality of hatchery salmon from natural salmon as prey of Southern Residents across their range.

4.2.5.3.2 Contaminants

Many types of chemicals are toxic when present in high concentrations, including organochlorines, PAHs, and heavy metals. Emerging contaminants such as brominated flame retardants (BFRs) and perfluorinated compounds are increasingly being linked to harmful biological impacts as well.

Persistent contaminants, such as organochlorines, are ultimately transported to the oceans, where they enter the marine food chain. Organochlorines are also highly fat soluble, and accumulate in the fatty tissues of animals (O'Shea 1999, Reijnders and Aguilar 2002). Bioaccumulation through trophic transfer allows relatively high concentrations of these compounds to build up in top-level marine predators, such as marine mammals (O'Shea 1999). Killer whales are candidates for accumulating high concentrations of organochlorines because of their high position in the food web and long life expectancy (Ylitalo *et al*. 2001, Grant and Ross 2002). Their exposure to these compounds occurs exclusively through their diet (Hickie *et al*. 2007).

High levels of persistent organic pollutants (POPs) such as PCBs and DDT are documented in Southern Resident (Ross *et al*. 2000, Ylitalo *et al*. 2001). These and other chemical compounds have the ability to induce immune suppression, impair reproduction, and produce other adverse physiological effects, as observed in studies of other marine mammals (review in NMFS 2008a). Immune suppression may be especially likely during periods of stress and resulting weight loss, when stored organochlorines are released from the blubber and become redistributed to other tissues (Krahn *et al*. 2002). Although the ban of several contaminants, such as DDT, by Canada and the United States in the 1970s resulted in an initial decline in environmental contamination, Southern Residents may be slow to respond to these reductions because of their body size and the long duration of exposure over the course of their life spans, which is up to 80-90 years for females and 60-70 years for males (Hickie *et al*. 2007).

4.2.5.3.3 Sound and Vessel Effects

Vessels have the potential to affect whales through the physical presence and activity of the vessel, increased underwater sound levels generated by boat engines, or a combination of these factors. Vessel strikes are rare, but do occur and can result in injury or mortality (Gaydos and Raverty 2007). In addition to vessels, underwater sound can be generated by a variety of other human activities, such as dredging, drilling, construction, seismic testing, and sonar (Richardson *et al*. 1995, Gordon and Moscrop 1996, National Research Council 2003). Impacts from these sources can range from serious injury and mortality to changes in behavior.

Killer whale mortalities from vessel strikes have been reported in both Northern and Southern Resident killer whale populations. Although rare, collisions between vessels and killer whales could result in serious injury. Other impacts from vessels are less obvious, but may negatively affect the health of killer whales. The presence of vessels may alter killer whale behavior, including faster swimming, less predictable travel paths, shorter or longer dive times, moving into open water, and altering normal behavioral patterns at the surface (Kruse 1991, Williams *et al.* 2002a, Bain *et al*. 2006, Luseau et al. 2009, Williams et al. 2009, Noren In Review). Chemicals such as unburned fuel and exhaust may be inhaled or ingested, which could contribute to toxic loads (Bain *et al*. 2006). Noise from vessel traffic may mask echolocation signals (Bain and Dahlheim 1994, Holt 2008), which reduces foraging efficiency or interferes with communication. The sound from vessels may also contribute to stress (Romano *et al*. 2003) or affect distribution of animals (Bejder *et al*. 2006).

Southern Residents are the primary driver for a multi-million dollar whale watching industry in the Pacific Northwest. Commercial whale watching vessels from both the U.S. and Canada view Southern Residents when they are in inland waters in summer months. Mid-frequency sonar generated by military vessels also has the potential to disturb killer whales. To date, there are no directed studies concerning the impacts of military mid-frequency sonar on killer whales, but observations of unusual whale behavior during an event that occurred in the Strait of Juan de Fuca and Haro Strait in 2003 illustrate that mid-frequency sonar can cause behavioral disturbance (NMFS 2004).

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. Increased levels of anthropogenic sound from vessels and other sources have the potential to mask echolocation and other signals used by the species, as well as to temporarily or permanently damage hearing sensitivity. Exposure to sound may therefore be detrimental to survival by impairing foraging and other behavior, resulting in a negative energy balance (Bain and Dahlheim 1994; Gordon and Moscrop 1996; Erbe 2002; Williams *et al*. 2002a, 2002b, 2006; Holt 2008). In other cetaceans, hormonal changes indicative of stress have been recorded in response to intense sound exposure (Romano *et al*. 2003). Chronic stress is known to induce harmful physiological conditions including lowered immune function, in terrestrial mammals and likely does so in cetaceans (Gordon and Moscrop 1996).

4.2.5.3.4 Oil Spills

Exposure to petroleum hydrocarbons released into the marine environment from oil spills and other discharge sources represents another potentially serious health threat to killer whales in the northeastern Pacific. Oil spills are also potentially destructive to prey populations and therefore may adversely affect killer whales by reducing food availability.

Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but acute or chronic exposure poses greater toxicological risks (Grant and Ross 2002). In marine mammals, acute exposure can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Geraci and St. Aubin 1990). Vapors inhaled at the water's surface and hydrocarbons ingested during feeding are the likely pathways of exposure. Matkin (1994) reported that killer whales did not attempt to avoid oil-sheened waters following the Exxon Valdez oil spill in Alaska. Retrospective evaluation shows it is highly likely that oil exposure contributed to deaths of resident and transient pods of killer whales that frequented the area of the massive Exxon Valdez oil spill in Prince William Sound, Alaska, in 1989 (Matkin *et al*. 2008). The cohesive social structure of the Southern Residents puts them at risk for a catastrophic oil spill that could affect the entire DPS when they are all in the same place at the same time.

4.2.5.4 Range-Wide Status and Trends

Southern Residents are a long-lived species, with late onset of sexual maturity (review in NMFS 2008a). Females produce a low number of surviving calves over the course of their reproductive life span (an average of 5.3 surviving calves over an average reproductive lifespan of 25 years; Olesiuk *et al*. 2005). Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg *et al*. 1990, Baird 2000, Ford *et al*. 2000). Groups of related matrilines form pods. Three pods – J, K, and L – make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of the J clan.

The historical abundance of Southern Residents is estimated from 140 to 200 whales. The minimum estimate (~140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time of the captures. The maximum estimate (~200) is based on a recent genetic analysis of microsatellite DNA (May 29, 2003, 68 FR 31980).

At present, the Southern Resident population has declined to essentially the same size that was estimated during the early 1960s, when it was likely depleted (Olesiuk *et al*. 1990, figure 4-13). Since censuses began in 1974, J and K pods steadily increased; however, the population suffered an almost 20 percent decline from 1996-2001, largely driven by lower survival rates in L pod. There were increases in the overall population from 2002-2007, however, the population declined in 2008 with 85 Southern Residents counted, 25 in J pod, 19 in K pod and 41 in L pod. Two additional whales have been reported missing since the 2008 census count. Representation from all three pods is necessary to meet biological criteria for Southern Resident killer whale downlisting and recovery (NMFS 2008a).

4.2.5.5 Extinction Risk

A PVA for Southern Residents was conducted by the BRT (Krahn *et al*. 2004). Demographic information from the 1970s to fairly recently (1974-2003, 1990-2003, and 1994-2003) were considered to estimate extinction and quasi-extinction risk. "Quasi-extinction" was defined as the stage at which 10 or fewer males or females remained, or a threshold from which the population was not expected to recover. The model evaluated a range in Southern Resident survival rates, based on variability in mean survival rates documented from past time intervals (highest, intermediate, and lowest survival). The model used a single fecundity rate for all simulations. The study considered seven values of carrying capacity for the population ranging from 100 to 400 whales, three levels of catastrophic event (*e.g*., oil spills and disease outbreaks) frequency ranging from none to twice per century, and three levels of catastrophic event magnitude in which 0, 10, or 20 percent of the animals died per event. Analyses indicated that the Southern Residents have a range of extinction risk from 0.1 to 18.7 percent in 100 years and 1.9 to 94.2 percent in 300 years, and a range of quasi-extinction risk from 1 to 66.5 percent in 100 years and 3.6 to 98.3 percent in 300 years (table 4-13). The population is generally at greater risk of extinction over a longer time horizon (300 years) than over a short time horizon

(100 years). There is a greater extinction risk associated with increased probability and magnitude of catastrophic events.

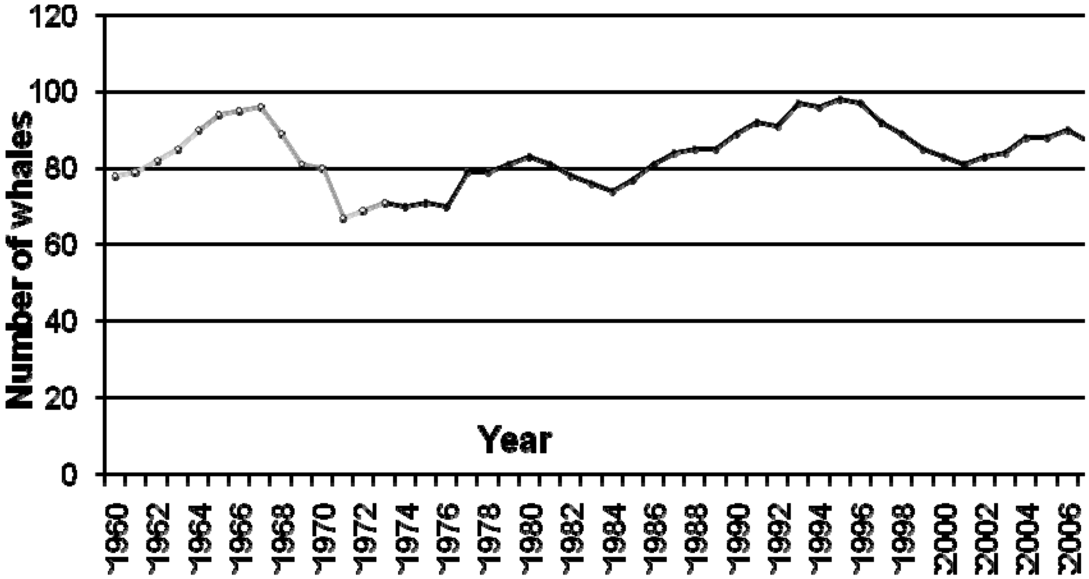


Figure 4-13. Population size and trend of Southern Resident killer whales, 1960-2008. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk *et al.* (1990). Data from 1974-2008 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpubl. data). Data for these years represent the number of whales present at the end of each calendar year except for 2008, when data extend only through July.

Table 4-13. Range of extinction and quasi-extinction risk for Southern Resident killer whales in 100 and 300 years, assuming a range in survival rates (depicted by time period), a constant rate of fecundity, between 100 and 400 whales, and a range catastrophic probabilities and magnitudes (Krahn *et al.* 2004).

Time Period	Extinction Risk (%)		Quasi-Extinction Risk (%)	
	100 yrs	300 yrs	100 yrs	300 yrs
highest survival	0.1 – 2.8	1.9 – 42.4	1 – 14.6	3.6 – 67.7
intermediate survival	0.2 – 5.2	14.4 – 65.6	6.1 – 29.8	21.4 – 85.3
lowest survival	5.6 – 18.7	68.2 – 94.2	39.4 – 66.5	76.1 – 98.3

5.0 ENVIRONMENTAL BASELINE

The environmental baseline includes “the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02). The environmental baseline provides a past, present, and future condition to which we add the effects of operating the proposed action, as required by regulation ("Effects of the action" in 50 CFR 402.02). Section 2.3.3 describes our approach to characterizing the environmental baseline for the proposed ongoing action.

The action area for the proposed action encompasses the entire freshwater range or a large portion of the freshwater range of the listed fish species and their proposed or designated critical habitat in this consultation. Therefore, we refer the reader to the *Status of the Species* section for general information on the species' biology, ecology, status, and population trends at the species scale. We organized this section of the Opinion consistent with how Reclamation presented the analysis in the CVP/SWP operations BA, that is, by division. The first part of each division section is a description and characterization of the current status of the species and proposed or designated critical habitat. In order to understand the current stress regime that the listed species and their critical habitats are subjected to, the second part of each division section is a description of the historical condition of the species and their habitats. Finally, each division has a section titled "Future Baseline Excluding CVP/SWP Effects." This is not NMFS' attempt to describe a "no project operations" scenario. Rather, this section identifies many of the major existing stressors that the listed species and their proposed or designated critical habitats are exposed to at the same time they will be exposed to the stressors of the proposed operations. The exception to the above organization is climate change, which is a large scale phenomenon that does not fit within the geographic boundaries of the divisions. Therefore, this environmental baseline section begins with a discussion of climate change, which is part of the future baseline. The action area encompasses a portion of the marine range of Southern Residents, however, the status of Southern Residents in the action area is the same as that described for the species as a whole and so is not repeated in this section. The species status section on Southern Residents describes the stressors that affect their likelihood of survival and recovery in the wild.

5.1 Climate Change as Part of the Future Baseline

Climate change is a global environmental phenomenon that would occur irrespective of any operations of the CVP or SWP. Appendix R of the CVP/SWP operations BA provides an analysis of potential climate change implications for the proposed action. The analysis was scoped to illustrate how future operations and system conditions are sensitive to a range of future climate and sea level possibilities that may occur during the consultation horizon of the proposed action (*i.e.*, 2030). The base model for the climate change scenarios is study 8.0, that is, the effects of climate change are added to the effects of the future full build-out scenario in year 2030.

Study 9 suite encompasses a range of the following five climate change projections: (1) Study 9.1: 1 foot sea level rise; (2) Study 9.2: wetter, less warming; (3) Study 9.3: wetter, more warming; (3) Study 9.4: drier, less warming; and (4) Study 9.5: drier, more warming. In general, Study 9.2 shows relatively more available water for storage, instream flows, and Delta pumping. That scenario also shows less negative effects to the listed species and their proposed or designated critical habitats. The other four studies showed more negative effects to the listed species and their proposed and designated critical habitats relative to the base model of future full buildout in 2030.

The impact of climate change in the future introduces greater uncertainty into the way in which water is managed in California. The historic hydrologic pattern represented by CALSIM II modeling in CVP/SWP operations (past 82 years of record) can no longer be solely relied upon to forecast the future. Precipitation and runoff patterns are changing, creating increased uncertainty for ecosystem functions. The average snowpack in the Sierra Nevada decreased by 10 percent in the last century, which translates into a loss of 1.5 MAF of snowpack storage (DWR 2008). California's air temperature has already increased by 1ºF, mostly at night in winter, with the higher elevations experiencing the highest increase. A corresponding increase in water temperature is likely to reduce the available habitat for species that depend on cold water like spring-run that require over summer holding pools. Increasing water temperatures will also accelerate biological processes that impact anadromous fish like increased algae growth and decreased dissolved oxygen. Climate change will affect the entire life cycle of salmonids and sturgeon through warmer ocean periods, changes in age and size at maturity, decline in prespawn survival and fertility due to higher stream temperatures, and a loss of lower elevation habitat (Crozier *et al*. 2008).

Regardless of the base model used to analyze the effects of climate change in the CVP/SWP operations BA, the best available information indicates that climate change will negatively affect the Central Valley listed species and their proposed or designated critical habitats. The following are general statements in Lindley *et al*. (2007), based on their analyses of recent climate change modeling:

- The average precipitation will decline over time, while the variation in precipitation is expected to increase substantially. Extreme discharge events are predicted to become more common, as are critically dry water years. Peak monthly mean flows will generally occur earlier in the season due to a decline in the proportion of precipitation falling as snow, and earlier melting of the (reduced) snowpack (Dettinger *et al.* 2004 *op. cit*. Lindley *et al*. 2007, VanRheenen *et al*. 2004 *op. cit*. Lindley *et al*. 2007);
- Temperatures in the future will warm significantly, total precipitation may decline, and snowfall will decline significantly.
- Spring-run are likely to be negatively impacted by the shift in peak discharge (needed for smolt migration), and juvenile steelhead are likely to be negatively impacted by reduced summer flows. All Central Valley salmonids are likely to be negatively affected by warmer temperatures, especially those that are in freshwater during the summer.
- Increased frequency of scouring floods might be expected to reduce the productivity of populations, as egg scour becomes a more common occurrence. The flip side of frequent flooding is the possibility of more frequent and severe droughts.
- Uncertainties abound at all levels. We have only the crudest understanding of how salmonid habitats will change and how salmonid populations will respond to those changes, given a certain climate scenario.

NMFS agrees with the above general statements, and adopt them as our assessment of the future impacts of climate change for the purposes of the analysis in this Opinion.

5.2 Status of the Species and Critical Habitat in Clear Creek

Clear Creek is a tributary to the upper Sacramento River (figure 5-1) and provides habitat for spring-run, and CV steelhead.

5.2.1 Spring-Run

Since 1998, spring-run have shown an increasing trend in abundance from 50 in 1998 to approximately 200 adults in 2008 (figure 5-2). Juvenile spring-run from the Feather River Fish Hatchery were stocked into Clear Creek in 2002 and 2003 with the hope of imprinting them to return 3 years later. These fish returned as adults in 2005 and 2006. In addition, spring-run strays from Feather River Fish Hatchery have been observed spawning in Clear Creek.

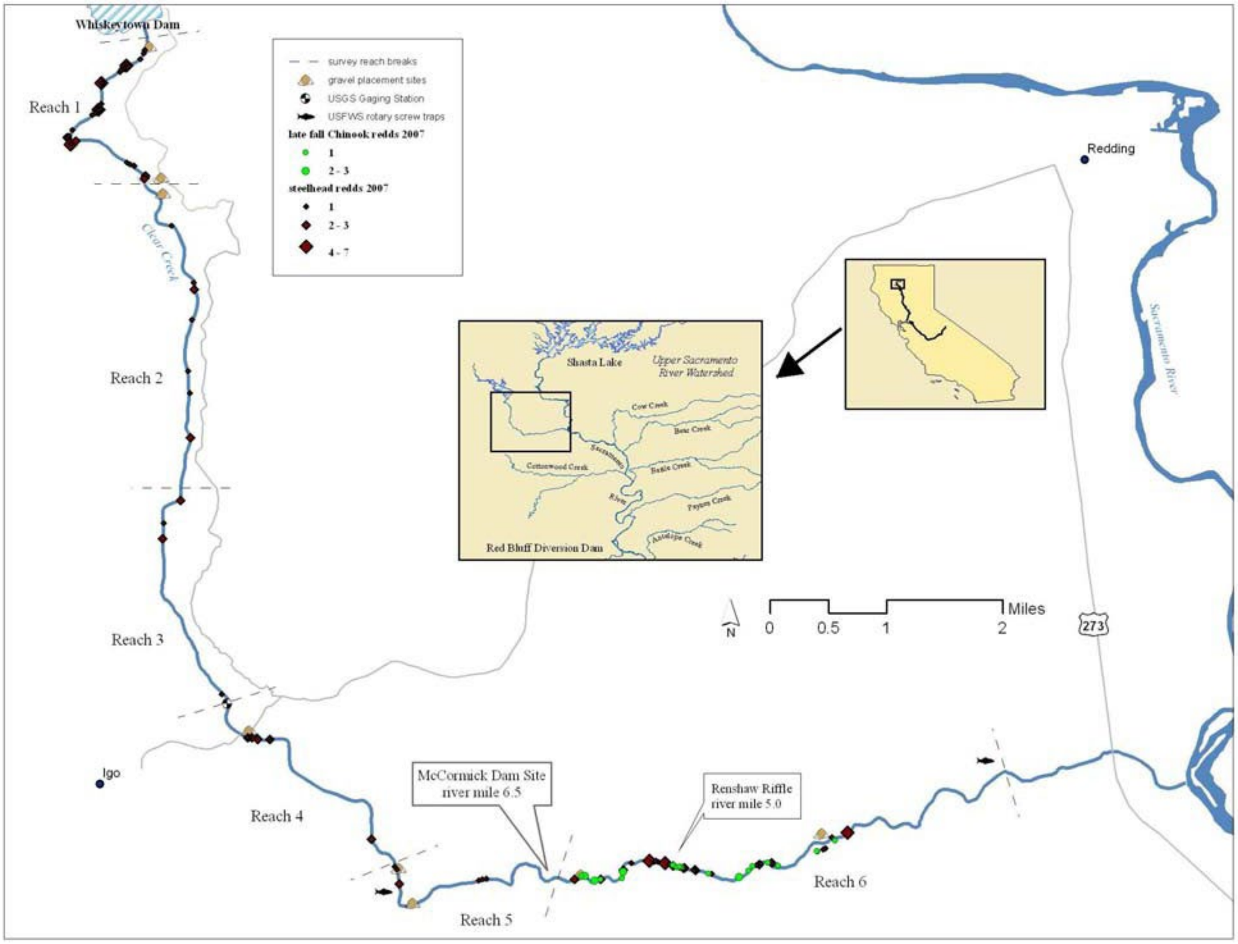


Figure 5-1. Map of Clear Creek and the distribution of steelhead and late fall-run redds in 2007 (USFWS 2008).

5.2.1.1 Spring-Run Critical Habitat

Whiskeytown Dam at RM 18.1 is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential spring-run habitat. Prior to 2000, the McCormick-Saeltzer Dam presented a barrier to upstream migration for anadromous salmonids. Following removal of the Dam in 2000, access to approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam was restored. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Gravel injection projects are conducted to make up for this loss of spawning gravel recruitment, but limited spawning habitat availability is a problem in Clear Creek.

Currently the release schedule from Whiskeytown Dam calls for flows of 200 cfs from October 1 to June 1 and 150 cfs, or less, from July through September in order to maintain water temperatures below 60°F. Under dry and warm climate conditions, water temperatures above 60° F occur in Clear Creek. Lindley *et al*. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to spring-run, having limited area at higher elevations and being highly dependent on rainfall.

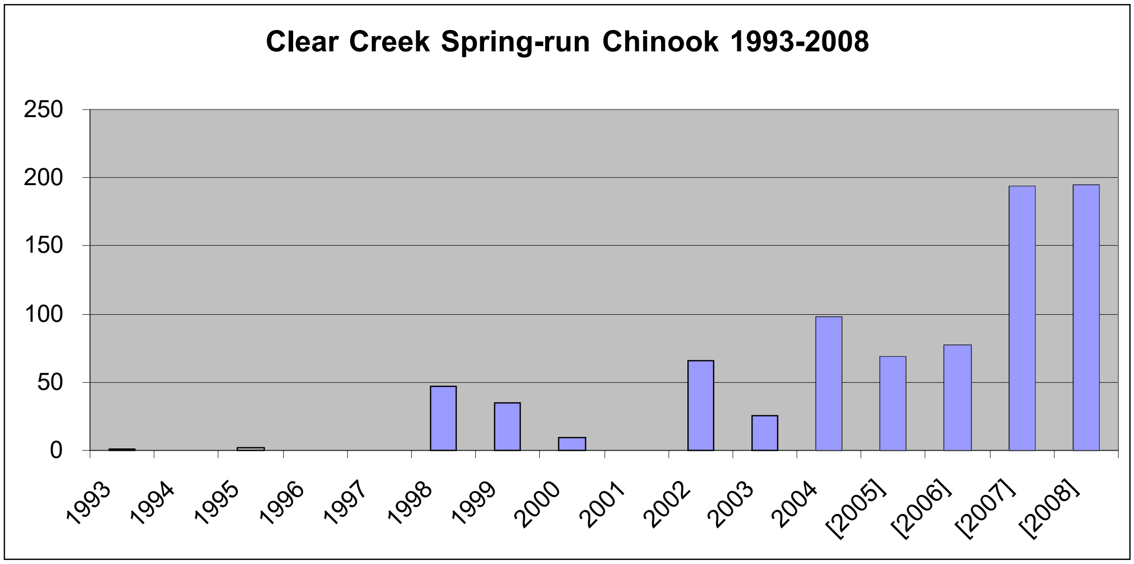


Figure 5-2. Clear Creek spring-run escapement 1993-2008 (CDFG data).

5.2.2 CV Steelhead

CV steelhead in Clear Creek have responded well to restoration efforts, which began in 1995 with increased water releases from Whiskeytown Dam, and gravel augmentation. These efforts have been funded primarily by the CVPIA and CALFED ERP. The McCormick-Saeltzer Dam was removed in 2000, providing access to an additional 12 miles of salmonid habitat. CV steelhead have re-colonized this area and taken advantage of newly added spawning gravels. Recent redd surveys conducted since 2003 indicate a small but increasing population resides in Clear Creek (figure 5-3), with the highest density in the first mile below Whiskeytown Dam (USFWS 2007). Spawning gravel is routinely added every year at various sites to compensate for channel down cutting. Spawning distribution has recently expanded from the upper 4 miles to throughout the 17 miles of Clear Creek, although it appears to be concentrated in areas of newly added spawning gravels. In addition to the anadromous form of *O. mykiss*, many resident trout reside in Clear Creek, making it difficult to identify CV steelhead except when they are spawning (*i.e.*, resident trout spawn in the spring and have smaller-size redds). Large riverine *O. mykiss* that reside in the Sacramento River can migrate up Clear Creek to spawn with either the anadromous or resident forms. No hatchery steelhead (*i.e.*, presence of adipose fin-clip) were observed during the 2003-2007 kayak and snorkel surveys (USFWS 2007, figure 5-3), indicating that straying of hatchery steelhead is probably low in Clear Creek.

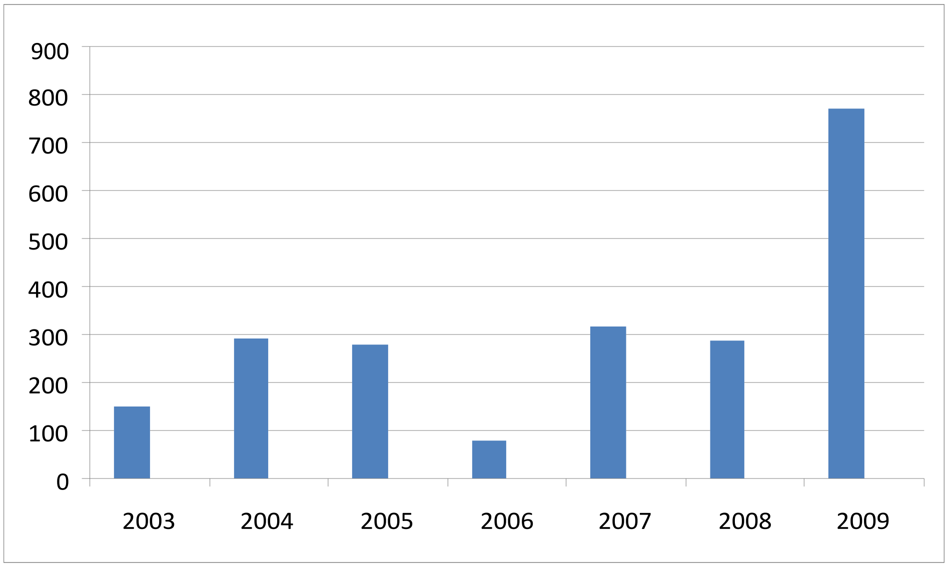


Figure 5-3. Abundance of CV steelhead in Clear Creek based on annual redd counts 2003-2009. Spawning population based on average 1.23 males per female on the American River (Hannon and Deason 2007). 2009 estimate is preliminary based on 4 surveys (USFWS 2008, Brown 2009).

5.2.2.1 CV Steelhead Critical Habitat

Whiskeytown Dam at RM 18.1 is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential steelhead habitat. Prior to 2000, the McCormick-Saeltzer Dam presented a barrier to upstream migration for anadromous salmonids. Following removal of the Dam in 2000, access to approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam was restored. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Gravel injection projects are conducted to make up for this loss of spawning gravel recruitment, but limited spawning habitat availability is a problem in Clear Creek.

Currently the release schedule from Whiskeytown Dam calls for flows of 200 cfs from October 1 to June 1 and 150 cfs, or less, from July through September in order to maintain water temperatures below 60°F. Under dry and warm climate conditions, water temperatures above 60°F occur in Clear Creek. Lindley *et al*. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to steelhead, having limited area at higher elevations and being highly dependent on rainfall.

5.2.3 Historical Conditions

The historic pre-Whiskeytown Dam hydrograph shows a much different flow pattern than the current hydrograph (figure 5-4). Average monthly flows decreased 75 percent in the winter/spring (600 cfs to 150 cfs), and increased 40 percent during the summer/fall (<30 cfs to 50 cfs).

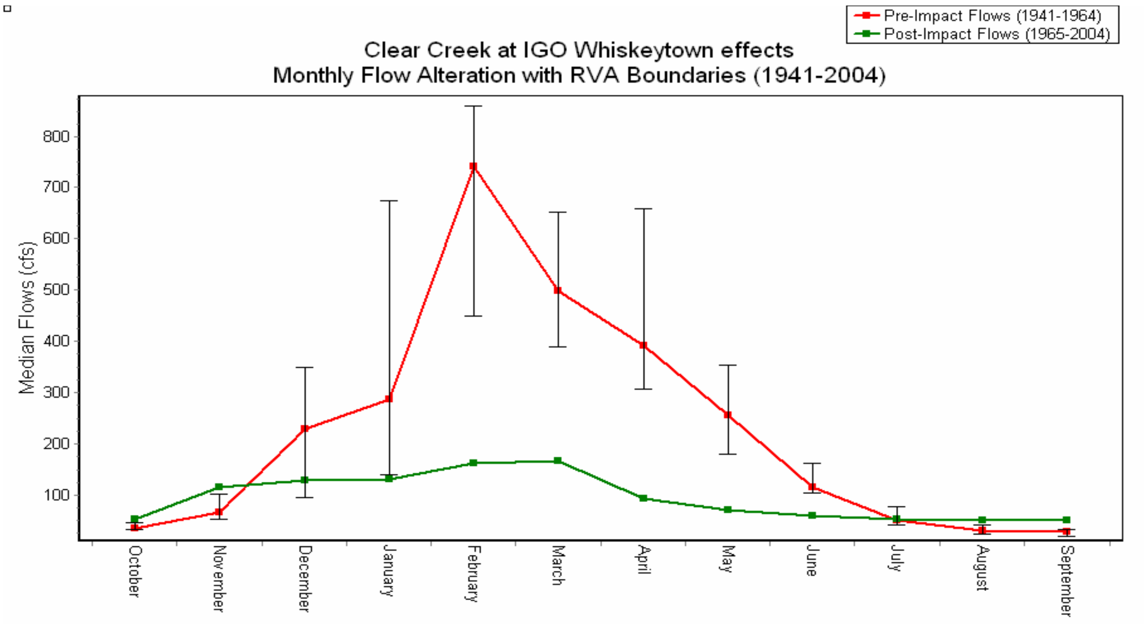


Figure 5-4. Clear Creek monthly flows comparing pre-Whiskeytown Dam (1941-1964) to post dam (1965-2004) flows. The vertical lines represent the range of variability analysis boundaries (CVP/SWP operations BA figure 3-21).

Reclamation operates Whiskeytown Dam to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel. On average, 1.2 MAF (up to 2,000 cfs) of water from the Trinity River is diverted each year into Keswick Reservoir compared to 200 cfs released to Clear Creek for fishery needs. The Trinity River diversion represented 17 percent of the average flows in the Sacramento River (CVP/SWP operations BA). However, since implementing the Trinity Record of Decision (ROD) flows in 2004, the Trinity River diversion has provided a smaller proportion (than 17 percent) of the average flows to the Sacramento River. Hydroelectric power is generated 5 times from the inter-basin transfer of water: (1) Trinity Dam, (2) Lewiston Dam, (3) through a tunnel to the Carr Powerhouse where water is received into Whiskeytown Reservoir, (4) through another tunnel into Spring Creek Power Plant where water joins the Keswick Reservoir, and (5) Keswick Dam. Reclamation releases water from Whiskeytown Dam into Clear Creek to support anadromous fish. On average, 200 cfs is released during the fall and winter, and is supported by b(2) flows. Releases are reduced to 80 cfs in the summer to install the fish barrier weir (figure 5-5). Since 2004, the USFWS has separated fall-run adults from spring-run adults holding in the upper reaches of Clear Creek with the use of a picket weir located at RM 8.0. The weir is operated from August 1 to November 1 to prevent the hybridization of spring-run and fall-run. After November 1, fall-run have access to the entire river for spawning. Spawning gravel augmentation in the upper reaches has improved suitable habitat for spring-run.

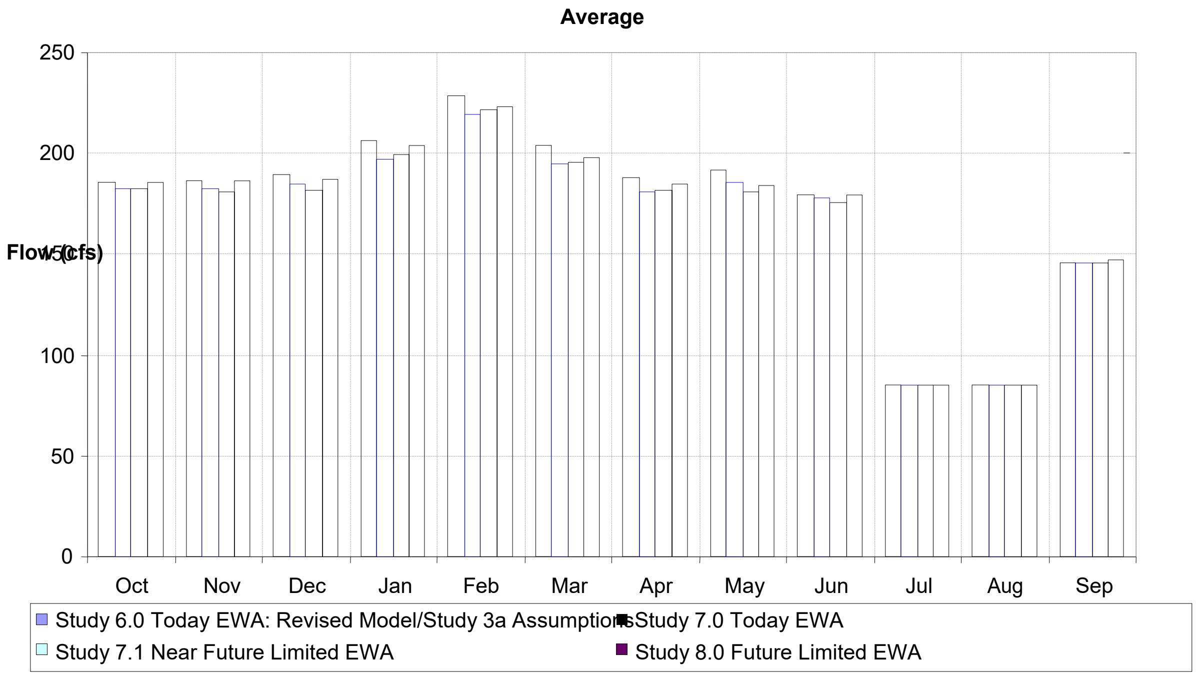


Figure 5-5. Clear Creek long-term average monthly flows as modeled in CALSIM 1923-2003 (CVP/SWP operations BA figure 10-30).

The average mean daily flow from 2003-2007 was 281 cfs (range: 212 - 493 cfs), and the average mean daily water temperatures ranged from 43°F to 52°F during the spawning period (December – June, figure 5-6). Flows increase starting in September for Chinook salmon spawning and to provide cooler water temperatures (*i.e.,* 56°F for spring-run September 15 – October 30 required from the 2004 CVP/SWP operations Opinion). Flows that scour redds and mobilize gravel usually occur at 3,000 cfs or more (CVP/SWP operations BA). Clear Creek flows are managed to maintain water temperatures for juvenile CV steelhead and spring-run adults holding in the upper reaches. Flows are maintained with b(2) water and usually are at the lowest (*i.e*., 80-90 cfs in a dry year) in the fall (figure 5-7) before spawning starts.

5.2.4 Future Baseline Excluding CVP/SWP Effects

The future baseline for Clear Creek includes the presence of Whiskeytown Dam and its associated stressors, including the loss of natural riverine function and morphology. The effects of habitat blockage were described in section 4.2.4.1. The dam also limits the contribution of course sediment, which result in riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and considerable loss of spawning gravels, and as such, the availability of spawning habitat. In addition, Whiskeytown Dam modifies the stream channel morphology of Clear Creek, resulting in the lack of suitable habitat during the summer for juvenile rearing and adult holding.

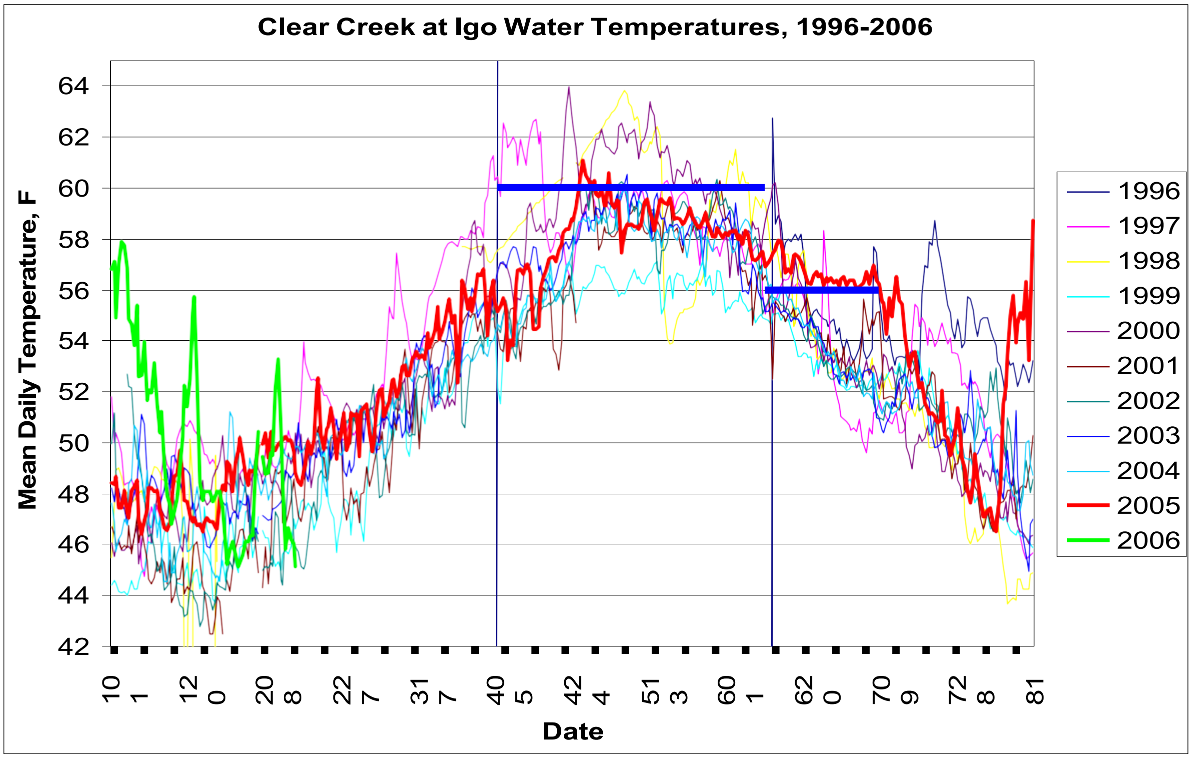


Figure 5-6. Clear Creek historical mean daily water temperatures 1996 – 2006 (CVP/SWP operations BA figure 3-12). Temperature objectives (horizontal dark blue lines) are 60°F from June 1 through September 15 and 56°F from September 15 through October 31, pursuant to the 2004 CVP/SWP operations Opinion.

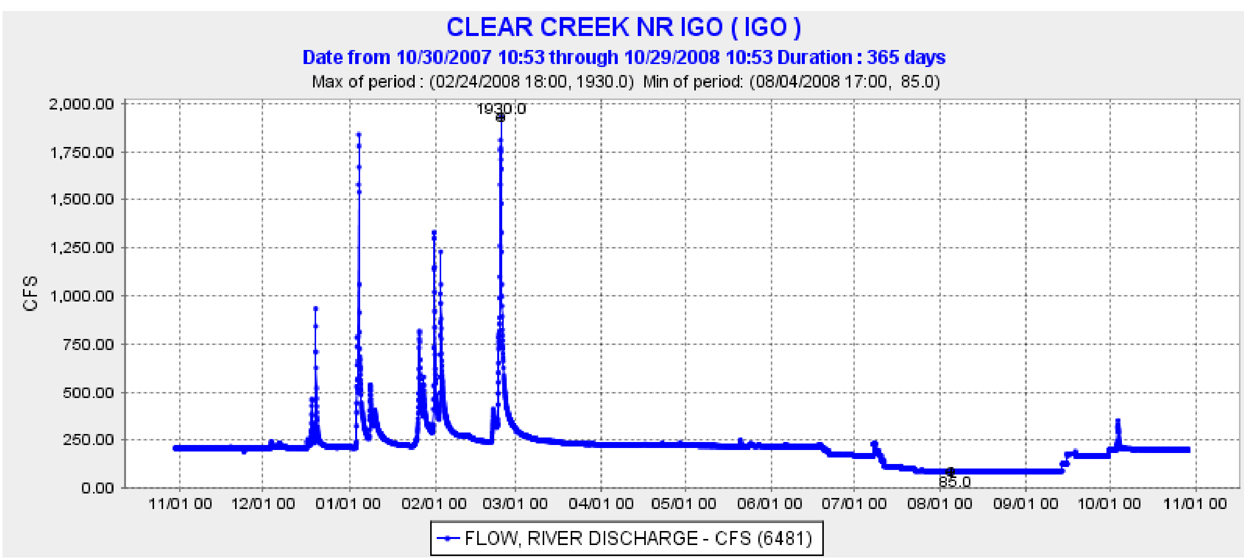


Figure 5-7. Clear Creek average daily flows measured at Igo gage 10/30/07 – 10/30/08 (CDEC data).

Whiskeytown Dam precludes access to historic spring-run and CV steelhead spawning and rearing habitat. In addition, spring-run historically spawned earlier and higher upstream in Clear Creek than fall-run. However, since the construction of Whiskeytown Dam, there was likely a high degree of spatial overlap between spawning spring-run and fall-run, and therefore, a higher probability of introgression of the 2 runs.

5.3 Status of the Species and Critical Habitat in the Shasta Division and Sacramento River Division

The Shasta Division and Sacramento River Division of the CVP are located in the upper Sacramento River (figure 5-8), and provide habitat for winter-run, spring-run, fall-run, late-fall run, CV steelhead, and Southern DPS of green sturgeon. Table 5-1 provides the life history timing of these species in the upper Sacramento River.

Table 5-1. Life history timing for anadromous fish species in the upper Sacramento River.

Species	Adult Immigration	Adult Holding	Typical Spawning	Egg incubation	Juvenile rearing	Juvenile emigration
Winter-run	Dec - Jul	Jan - May	Apr - Aug	Apr - Oct	Jul - Mar	Jul - Mar
Spring-run	Apr - Jul	May - Sept	Aug - Oct	Aug - Dec	Oct - Apr	Oct - May
Fall-run	Jul - Dec	n/a	Oct - Dec	Oct - Mar	Dec - Jun	Dec - Jul
Late fall-run	Oct - Apr	n/a	Jan - Apr	Jan - Jun	Apr - Nov	Apr - Dec
Steelhead	Aug - Mar	Sept - Dec	Dec - Apr	Dec - Jun	year round	Jan - Oct
Green sturgeon	Feb - Jun	Jun - Nov	Mar - Jul	Apr - Jun	May - Aug	May - Dec

5.3.1 Winter-Run

The upper Sacramento River is the only spawning area used by winter-run. The status of winter-run in the Sacramento River Division is the same as its status in the entire winter-run ESU, which was presented in section 4.2.1.2.1.

5.3.1.1 Winter-Run Critical Habitat

Critical habitat for winter-run is composed of physical and biological features that are essential for the conservation of winter-run, including up and downstream access, and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these physical and biological features are impaired, and provide limited conservation value. For example, when the gates are in, RBDD reduces the value of the migratory corridor for upstream and downstream migration. Unscreened diversions throughout the mainstem Sacramento River, and the DCC when the gates are open during winter-run outmigration, do not provide a safe migratory corridor to San Francisco Bay and the Pacific Ocean.

In addition, the annual change in TCP has degraded the conservation value of spawning habitat (based on water temperature). The current condition of riparian habitat for winter-run rearing is degraded by the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system. However, some complex, productive habitats with floodplains remain in the system (*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and flood bypasses (*i.e.*, Yolo and Sutter bypasses).

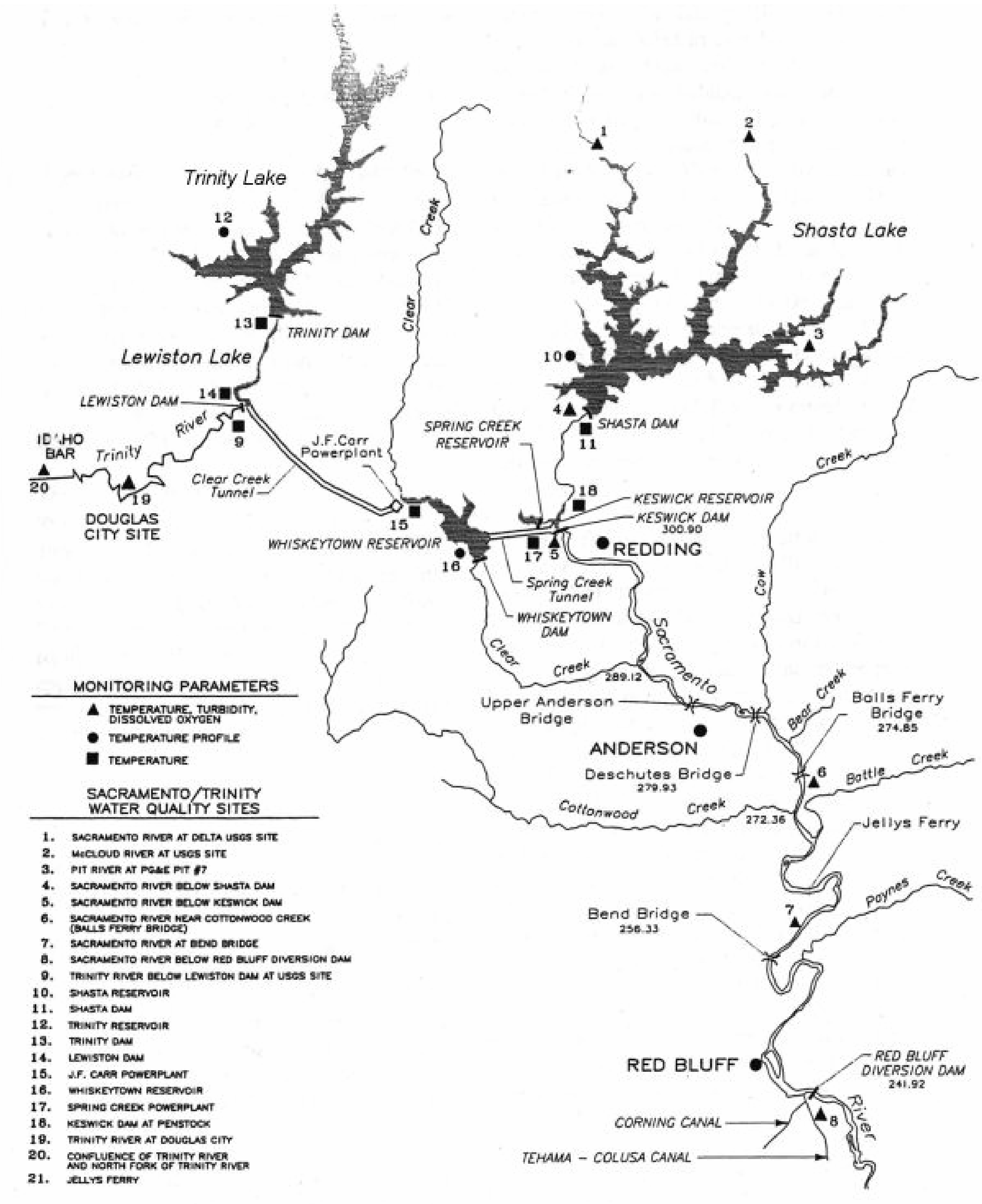


Figure 5-8. Map of the upper Sacramento River, including various temperature compliance points and river miles (CVP/SWP operations BA figure 6-2).

Based on the impediments caused by RBDD when the gates are in, unscreened diversions, when the DCC gates are open during the winter-run outmigration period, and the degraded condition of spawning habitat and riparian habitat, the current condition of winter-run critical habitat in the Sacramento River Division is degraded, and has low value for the conservation of the species.

5.3.2 Spring-Run

The abundance of the spring-run population within the mainstem Sacramento River has declined from a high of over 75,000 in 1982 to the current low of less than 800 counted at RBDD (figure 5-9). Significant hybridization with fall-run has made identification of spring-run in the mainstem very difficult to determine. There is speculation as to whether a true spring-run still exists in the mainstem below Keswick Dam. The population structure of the ESU has shifted from being mainly made up of Sacramento River fish to one dominated by returns to Butte Creek (figure 5-10). This shift may have been an artifact of the manner in which spring-run were identified at RBDD. Fewer spring-run are counted today at RBDD because an arbitrary date, September 1, is used to determine spring-run, and gates are opened longer for winter-run passage. It is unknown if spring-run still spawn in the Sacramento River mainstem. Current redd surveys have observed 20-40 salmon redds in September, typically when spring-run spawn, however, there is no peak that can be separated out from fall-run spawning. Salmon redds observed in September could be early spawning fall-run. These redds are distributed from Keswick Dam to below RBDD.

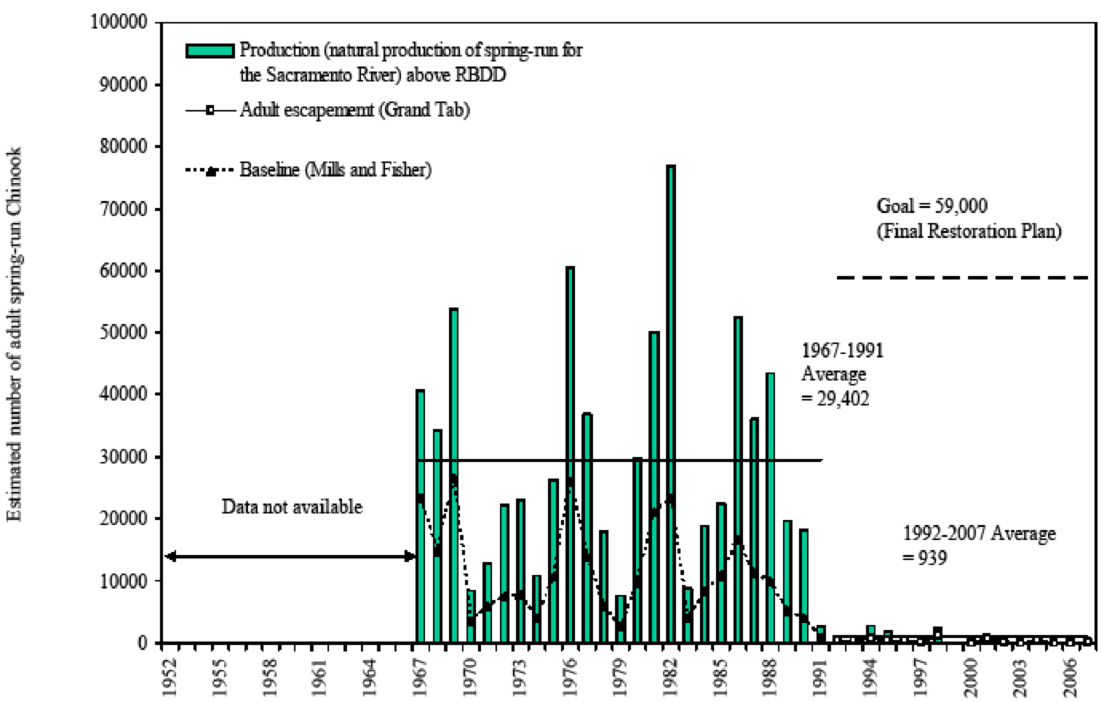


Figure 5-9. Estimated yearly spring-run escapement and natural production above RBDD (Hanson 2008).

Since 2000, the spring-run counts at RBDD have fluctuated after the RBDD gates were installed on May 15, from years where 0 fish were observed (2003 and 2006), to 767 adults in 2007 (figure 5-11). This variability in abundance is typical of random chance events in small salmon populations subjected to large stress regimes. These numbers do not reflect the current abundance of spring-run in the tributaries above RBDD (*i.e*., Battle Creek, Clear Creek, Cottonwood Creek, and Cow Creek). For example, Clear Creek escapement in 2006 was 197 spring-run, yet the RBDD ladder count was 0 that year. This is because the RBDD gates were open when the majority of those fish entering Clear Creek passed upstream, therefore, none were counted in the fish ladders.

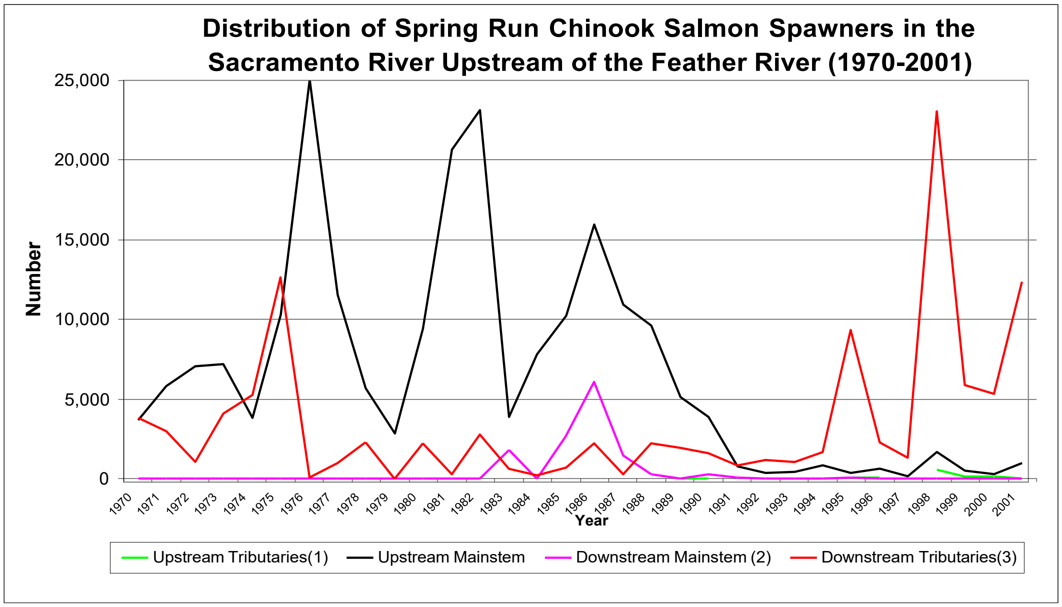


Figure 5-10. Distribution of spring-run above and below RBDD from 1970 -2001 (CDFG Grand Tab).

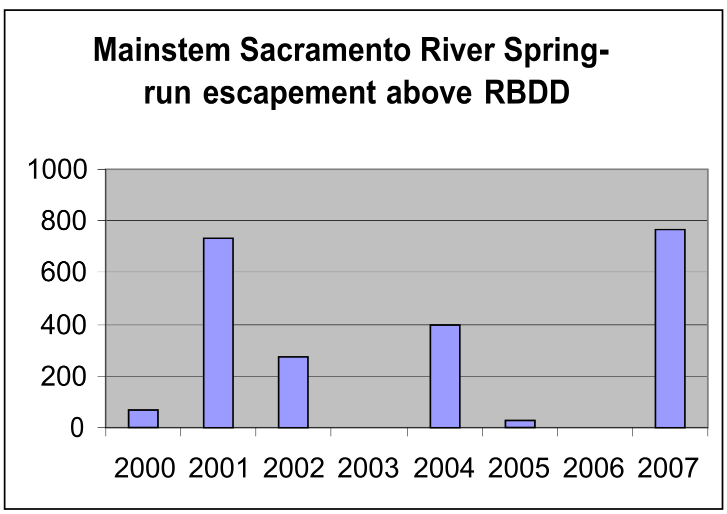


Figure 5-11. Spring-run escapement counted at Red Bluff Diversion Dam from 2000 – 2007 (CDFG GrandTab 2008).

5.3.2.1 Spring-Run Critical Habitat

Within the range of the spring-run ESU, biological features of the designated critical habitat that are considered vital for spring-run include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. As generally described above in section 4.2.1.3.3, the status of critical habitat in each of these biological features is considered to be highly degraded, particularly with respect to habitats within the mainstem Sacramento River and the Delta. The quality of spawning habitat used by spring-run in the mainstem Sacramento River is diminished when fall-run, which commence spawning later than but still during spring-run spawning, arrive at the spawning grounds and physically disturb spring-run redds during their redd construction. Spawning habitat for spring-run in the mainstem Sacramento River is often adversely affected by operation of the CVP through warm water releases from Shasta Reservoir. Freshwater rearing and migration habitats have been degraded by RBDD operations which delay upstream migration, reduce the availability of quality rearing habitat through the related seasonal creation of Lake Red Bluff, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional adverse effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

5.3.3 CV Steelhead

Estimates of CV steelhead abundance in the mainstem Sacramento River typically use the RBDD counts from historical trend data. Since 1991, the RBDD gates have been opened after September 15, making estimates of CV steelhead pass RBDD unreliable. Based on counts at RBDD, adult migration into the upper Sacramento River can occur from July through May, but peaks in September, with spawning occurring from December through May (Hallock 1998). Since operation of the RBDD gates started in 1967, the CV steelhead abundance in the upper Sacramento River has declined from almost 20,000 to less than 1,200 (figure 5-12). We note that figure 5-12 shows a definite and continuing decline over time and that there is a change in the species trajectory since 1979, similar to the winter-run decline in the Sacramento River Division.

Actual estimates of CV steelhead spawning in the mainstem Sacramento River below Keswick Dam have never been made, due to high flows and poor visibility during the winter time. Aerial redd surveys conducted for winter-run have observed resident *O. mykiss* spawning in May and late fall-run spawning in January. Since resident trout redds are smaller than steelhead redds, and late fall-run spawn at the same time as steelhead, it would seem likely that CV steelhead redds could be observed. A CV steelhead monitoring plan is being developed by CDFG with a goal of determining abundance in the Sacramento River (Hopelain 2008). CV steelhead prefer to spawn in tributaries, but are known to spawn in mainstem rivers below impassable dams when access to spawning habitat is blocked (*e.g.,* Feather River, American River, Stanislaus River).

5.3.3.1 CV Steelhead Critical Habitat

Within the range of CV steelhead, biological features of the designated critical habitat that are considered vital for steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. As generally described above in section 4.2.3.4, the status of critical habitat in each of these biological features is considered to be degraded. Freshwater rearing and migration habitats have been degraded by RBDD operations which delay upstream migration, reduce the availability of quality rearing habitat through the related seasonal creation of Lake Red Bluff, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional adverse effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

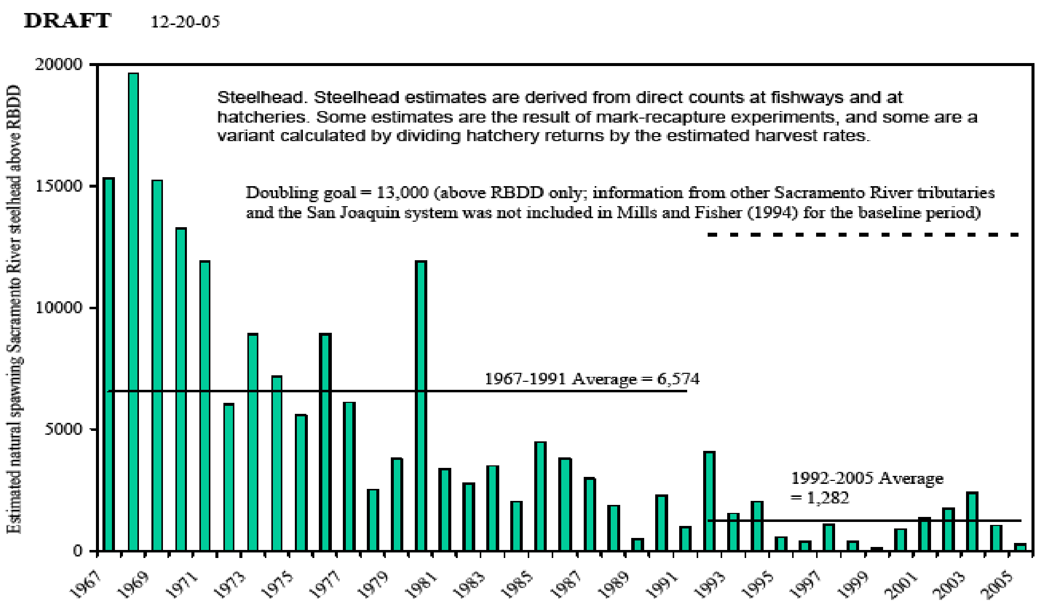


Figure 38. Estimated yearly number of natural spawning of steelhead on the Sacramento River, upstream of the RBDD (Mills and Fisher, 1994). Data for 1992-2005 is from CDFG, Red Bluff.

Figure 5-12. Estimated yearly number of natural spawning CV steelhead on the Sacramento River upstream of the RBDD 1967-2005. Data from 1992 to 2005 is based on tributary counts from CDFG, Red Bluff (Hanson 2008).

5.3.4 Southern DPS of Green Sturgeon

Currently, the installation and operation of the RBDD gates blocks access to 53 miles of upper river with suitable water quality conditions for green sturgeon spawning and rearing from May 15 through September 15 of each year. Water temperature for spawning and egg incubation is near optimal (15ºC) from RBDD upriver during the spawning season. Below the RBDD, the water temperature begins to become warmer and exceeds the thermal tolerance level for egg incubation at Hamilton City. The spawning area left for green sturgeon between RBDD and Hamilton City after the gates are lowered has the thermal regime gradually increase from optimal (15ºC/59ºF) to sub optimal where egg hatching success decreases and malformations in embryos increase above 17ºC/62ºF.

The installation of the RBDD impairs the function of the Sacramento River as a migratory corridor for both green sturgeon adults and larvae/juveniles. With the RBDD gates closed, there is no longer unobstructed access to river habitat above the RBDD, which changes the function of the river to such an extent that fish survival and viability are compromised. The closed gates block green sturgeon access to approximately 53 river miles above the dam for approximately 35 to 40 percent of the spawning population that arrive after May 15. The closed gates also decrease the conservation value of critical habitat around the dam by: (1) increasing the potential for predation on downstream emigrating larvae in the slow moving water upstream of the RBDD (Lake Red Bluff), (2) increasing predation below RBDD due to the turbulent boil created below the structure and the concentration of predators in that area, and (3) creating increased potential for adults to be injured while attempting to pass beneath the gates during their downstream migration. The closed gate configuration also has the potential to alter the genetic diversity of the population by separating the population into upstream and downstream spawning groups based on run timing.

The installation of the RBDD blocks green sturgeon from known holding pools above the structure. Although known holding areas exist below the RBDD, such as the hole just above the GCID diversion, the RBDD decreases the number of deep holding pools the adult fish can access through its operation. This affect is a result of blockage of the migratory corridor.

5.3.4 Historical Conditions

The historical pre-Shasta Dam hydrograph shows a much different flow pattern than the current hydrograph (figure 5-13). The current hydrograph shows reduced average monthly springtime flows (historical: 16,000 cfs; current: 12,000 cfs) and much higher average monthly summer flows (historical: 5,000 cfs; current: 12,000 cfs). Releases of water for irrigation and other Project purposes are timed to occur during summer months when demand is high. This dual purpose is practical because it provides benefits to both listed species (which can no longer access the upper Sacramento River basin) and water users, but is also ecologically unsound because it prevents riverine processes and natural succession of riparian communities as well as the full expression of life history strategies in the basin's fish populations that evolved in unison with the natural flow fluctuations. Lindley *et al*. (2006) suggest that dams may exert selective effects on anadromous *O. mykiss,* culling the anadromous offspring produced, and modifying the thermal regime and food web structure of the river below the dam in ways that may provide fitness advantages to resident forms. Recent modeling by The Nature Conservancy (2007) found that the health of the river and ESA-listed species would benefit more from a natural flow regime that mimics the historical hydrograph.

5.3.5 Future Baseline Excluding CVP/SWP Effects

The upper Sacramento River mainstem contains 4 listed anadromous fish that use this area for migration, spawning, and rearing (*i.e.*, winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon). These fish will be subjected to a host of future baseline stressors (figure 5-14) to which the project effects are added.

In the Shasta Division and Sacramento River Division, future baseline stressors include the following, followed by references in parentheses to where the effects of these stressors on the listed species and their habitats are described:

- habitat blockage by Shasta and Keswick dams (section 4.2.4.1);
- bank stabilization (rip rap, armoring, revetment), which result in river narrowing, less channel complexity, less food production, less cover and shelter, loss of shaded aquatic habitat, and the loss of LWD recruitment (section 4.2.4.5);

- agricultural return flows, which include pesticides, herbicides, and other contaminants (sections 4.2.4.6 and 4.2.4.7);
- predation (pike minnow, smallmouth bass, striped bass) and competition from introduced species better suited to regulated rivers (section 4.2.4.10); and
- climate change (sections 5.1, 5.3.6.1).

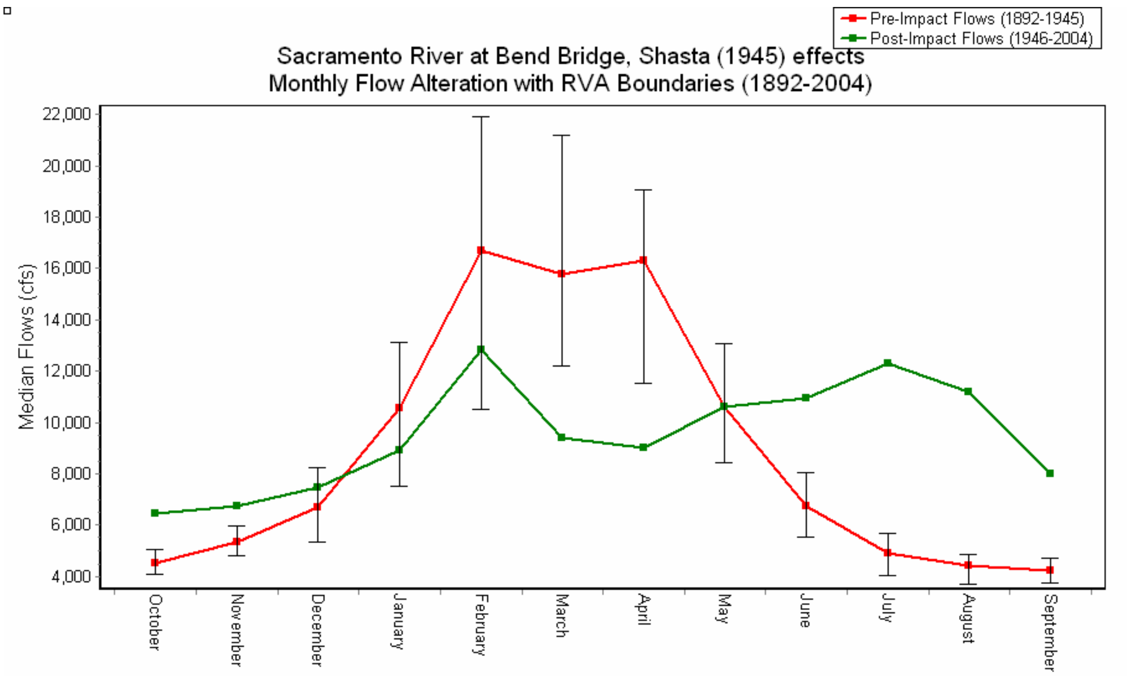


Figure 5-13. Sacramento River at Bend Bridge monthly flows comparing pre-Shasta Dam (1892-1945) and post Shasta (1946 -2004) flows. Vertical lines represent the range of variability analysis boundaries (CVP/SWP operations BA figure 3-20).

Some of the above stressors (*e.g*., predation) will work individually to affect the fitness of the listed species and critical habitat, while others will work together (*e.g*., temperature and contaminants) to reduce the ability of the individual to respond to important cues, like when to feed, migrate, or flee a predator. Regardless, the combination of all of the above stressors will result in fitness consequences to individuals of all of the listed species, including, but not limited to: reduced growth from the effects of reduced water quality, lack of rearing habitat, and increased competition from introduced species; reduced survival as a result of predation; and reduced reproductive success resulting from habitat blockage. In addition, although critical habitat is designated or proposed up to Keswick Dam, the other stressors, above, limit the conservation value of the PCEs that the Shasta Division and Sacramento River Division provide, including uncontaminated habitat areas, adequate prey, riparian habitat, freshwater rearing habitat, and suitable water quality.

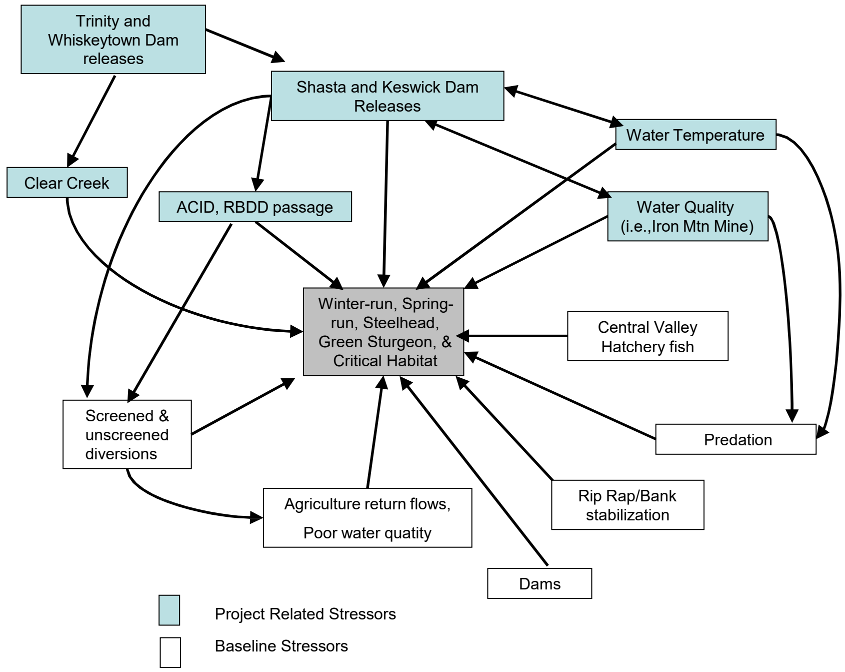


Figure 5-14a. Conceptual model of future baseline stressors and project-related stressors on listed species in the upper Sacramento River mainstem.

5.3.5.1 Climate Change

As discussed in section 2.3.3, a "no project" scenario was not run. Climate change is an environmental phenomenon that is part of the future baseline and would occur irrespective of any operations of the CVP or SWP. The effects of climate change would have certainly been included in a "no project" scenario. Section 5.1 briefly described Reclamation's use of the Study 9 suite, which uses the Study 8.0 future full build out as the base case. NMFS understands that the results of Study 9 suite are not appropriate to use in this discussion of future baseline, as it includes operations. However, NMFS believes that a relative comparison between the various studies within the Study 9 suite will provide valuable insight regarding the effects of climate change on the aquatic ecosystem and fishery resources.

In the Sacramento River, comparing climate change scenarios (Study 9.0 base vs Study 9.5 drier, more warming) shows that average winter-run and fall-run mortality increases from 15 percent to 25 percent, and average spring-run mortality increases from 20 percent to 55 percent (figure 5-14b). Reclamation's mortality model was not run for CV steelhead because steelhead have a shorter incubation period than salmon, and the model would have to be changed. However, late-fall salmon can be used as a surrogate for CV steelhead since they spawn at similar times in the winter. Late fall-run mortality increases in Study 9.5 (drier, more warming) and Study 9.3 (wetter, more warming) under all water year types on average 4 percent over the future full build out scenario (Study 9.0). Under these conditions, winter-run and spring-run would experience a loss of spawning habitat, as water temperatures below dams becomes harder to control and the cold water pool in Shasta diminishes.

CV steelhead would experience less of a loss on the mainstem Sacramento River, since they spawn in the late winter when water temperatures are not as critical to incubation. However, resident forms of *O. mykiss* spawn in May, when water temperatures exceed 56ºF at Bend Bridge in 25 percent of future water years (CVP/SWP operations BA figure 10-83). This resident life history pattern represents a reserve that anadromous fish can interbreed with if there are too few CV steelhead (Zimmerman *et al*. 2008). It is likely that given warmer water temperatures resident *O. mykiss* would move upstream closer to Keswick Dam where temperatures are cooler, or into smaller tributaries like Clear Creek, which would limit steelhead life history diversity in Clear Creek.

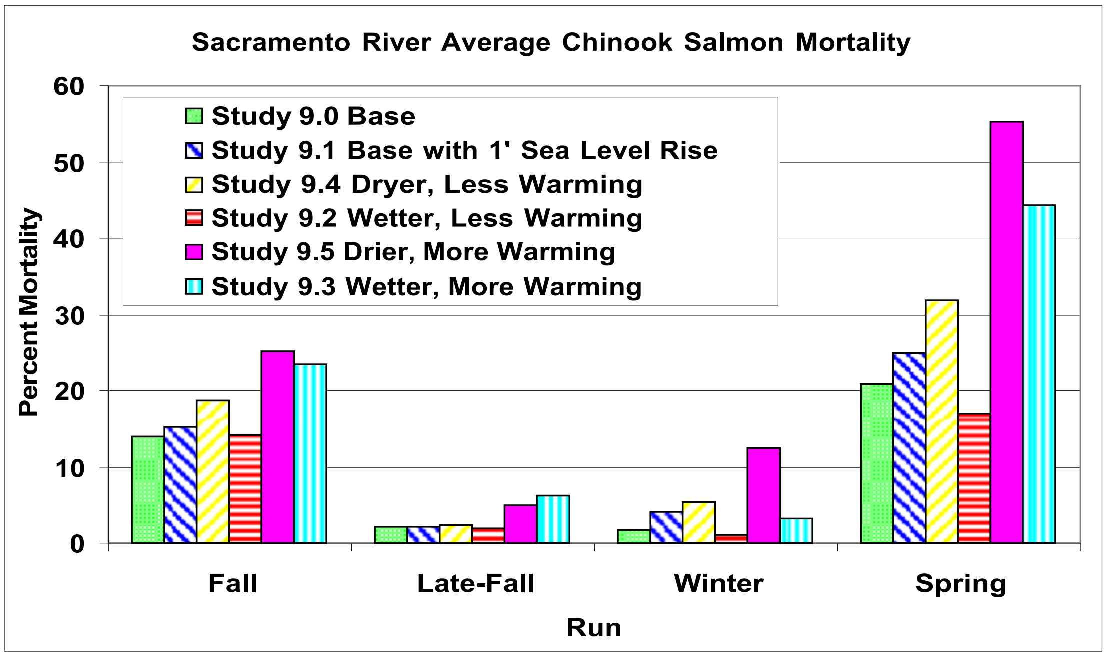


Figure 5-14b. Sacramento River average Chinook salmon mortality by run and climate change scenario from Reclamation salmon egg mortality model. All studies except 9.0 include 1-foot sea level rise. Study 9.0 is future conditions with D-1641 (CVP/SWP operations BA figure 11-82).

Similar climate change modeling was conducted using a quantitative model (WEAP21) of the Sacramento River flow and temperature regime downstream to Hamilton City (Yates *et al*. 2008). This model compared water temperatures at Shasta Dam with and without managed releases for temperature control. In the unmanaged regime, the model assumes that Shasta Dam does not exist and that there is no irrigation demand. Using the observed historical record for years before the TCD was installed, Yates *et al*. (2008) used the WEAP21 model to calculate effects on winter-run, spring-run, and fall-run under a 3.5º F and 7ºF water temperature warming change. Under a 3.5ºF warming scenario, water temperatures at Keswick would be at or below the optimum upper temperature of 56ºF for spawning and rearing, and then increase from that point downstream, except in the driest years. Under a 7ºF warming scenario, even in wet years, spawning and rearing water temperature requirements would be exceeded in September and October from Keswick Dam to Hamilton City (Yates *et al*. 2008). The results of the WEAP21 modeling suggest that even with the use of the TCD on Shasta Dam, water managers will be challenged to maintain suitable water temperatures in the upper Sacramento River (*i.e.*, Keswick to Hamilton City). Yates *et al*. (2008) concluded that cold water releases from Shasta Reservoir play a role in maintaining suitable habitat for spawning and rearing Chinook salmon as far downstream as Hamilton City, and that climate change could be a major determinant of the future viability of adult and juvenile reproduction and migration strategies. Winter-run and spring-run were shown to be most at risk due to the timing of their reproduction. Without the cold water releases from Shasta Dam, water temperatures would exceed the physiological tolerances by 5°F or more, and winter-run and spring-run populations would not likely persist in the mainstem. The study also found that the availability of cold water releases is reduced as warming increases the demand for water and evaporative losses in Shasta Reservoir.

5.4 Status of the Species and Critical Habitat in the American River Division

5.4.1 CV Steelhead

The American River (figure 5-15) is a tributary to the Sacramento River and provides habitat for a dependent population of CV steelhead. The CV steelhead DPS includes naturally-spawned steelhead in the American River (and other Central Valley stocks) and excludes steelhead spawned and reared at Nimbus Fish Hatchery. Population abundance estimates of naturally spawning steelhead in the American River were 305, 1,462 and 255 for the 1991, 1992 and 1993 spawning seasons, respectively (Water Forum 2005a), although the methodology for how these estimates were obtained was not stated.

From 2002 through 2007, annual population abundance estimates for American River steelhead spawning in the river have been low, ranging from about 160 to about 240 (Hannon and Deason 2008, figure 5-16). Populations at low abundance levels, such as those estimated for naturally spawning steelhead in the American River, could become extinct due to demographic stochasticity - seemingly random effects of variation in individual survival or fecundity with little or no environmental pressure (Shaffer 1981, Allendorf *et al*. 1997, McElhany *et al*. 2000). The naturally spawning population of steelhead is mostly composed of fish originating from Nimbus Fish Hatchery (Water Forum 2005a). This means that the listed population (*i.e.*, naturally-spawned fish) spawning in the lower American River is at an abundance level lower than the estimates provided by Hannon and Deason (2008) and is likely on the order of tens.

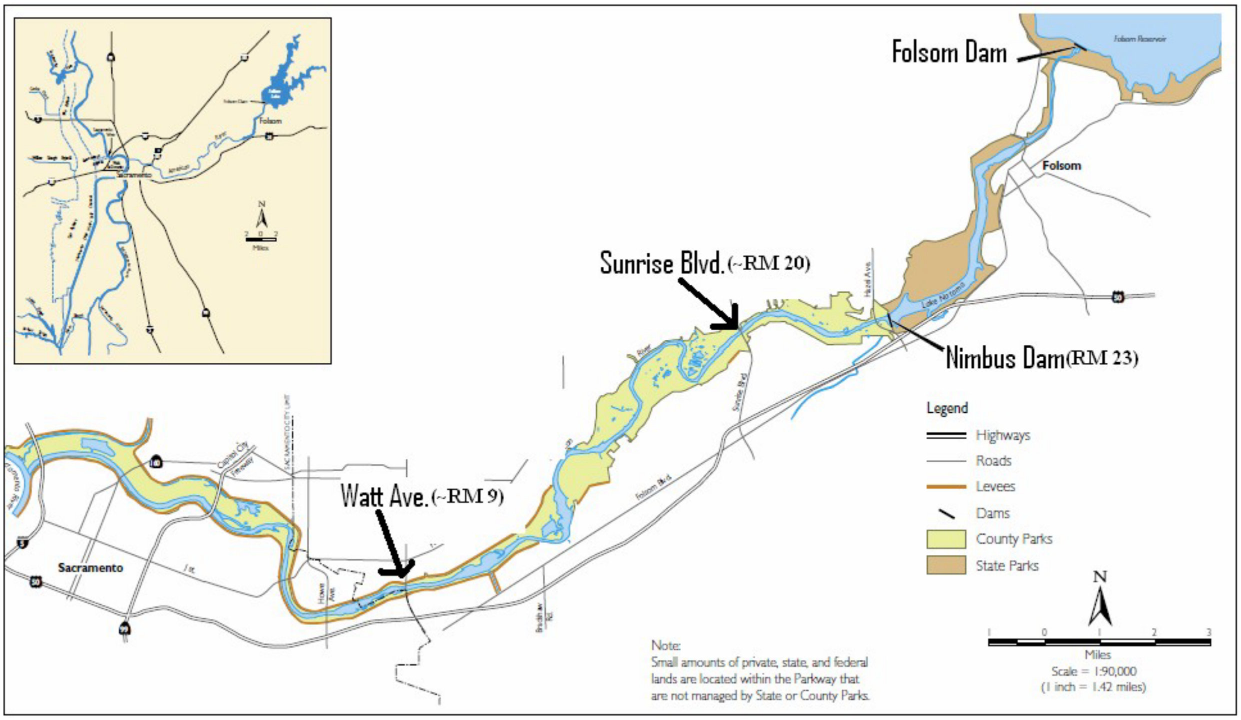


Figure 5-15. Map of lower American River (Modified from Water Forum 2005a).

In addition to small population size, other major factors influencing the status of naturally spawning steelhead in the American River include: (1) a 100 percent blockage of historic spawning habitat resulting from the construction of Nimbus and Folsom dams (Lindley *et al*. 2006), which has obvious and extreme implications for the spatial structure of the population; and (2) the operation of Nimbus Fish Hatchery, which has completely altered the diversity of the population. Specific information on how these factors have affected (and continue to affect) naturally-spawned steelhead in the American River are presented below in section 6.4 titled *American River Division.*

Lindley *et al*. (2007) classifies the listed (*i.e*., naturally spawning) population of American River steelhead at a high risk of extinction because this population is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. The small population size and complete loss of historic spawning habitat and genetic composition further support this classification.

5.4.1.1 CV Steelhead Critical Habitat

The PCEs of steelhead critical habitat in the lower American River include freshwater spawning, freshwater rearing, and freshwater migration habitats. There is a general consensus in the available literature suggesting that habitat for steelhead in the American River is impaired (CVP/SWP operations BA; Water Forum 2005a,b; SWRI 2001; CDFG 1991, 2001). Of particular concern are warm water temperatures during embryo incubation, rearing, and migration, flow fluctuations during embryo incubation and rearing, and limited flow-dependent habitat availability during rearing. All of these concerns are related to water management operations of the CVP.

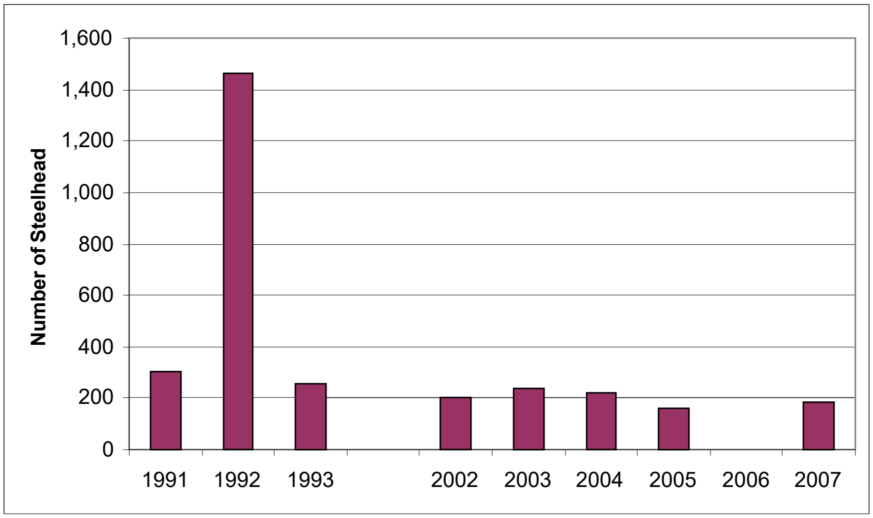


Figure 5-16. Population estimates of steelhead spawning in the lower American River. Estimates from the early 1990s were reported in Water Forum (2005a), and estimates for 2002 through 2007 were obtained through redd survey monitoring assuming each female steelhead had two redds (Hannon and Deason 2008).

5.4.2 Historical Conditions

Including the mainstem, and north, middle, and south forks, historically, over 125 miles of riverine habitat were available for anadromous salmonids in the American River watershed (Yoshiyama *et al*. 1996). Anadromous salmonids that utilized this habitat included spring-run and fall-run Chinook salmon, and summer-run, fall-run and winter-run steelhead (Gerstung 1971). Sumner and Smith (1940 *op. cit*. SWRI 2001) estimated that the American River historically may have supported runs exceeding 100,000 Chinook salmon annually, prior to habitat degradation from mining and creation of migration barriers from dam construction. Composition of the anadromous salmonid runs in the American River has changed over time due to habitat degradation and elimination resulting from the construction of dams (Yoshiyama *et al*. 1996). Between 1850 and 1885, hydraulic mining deposited large amounts of sediment in the American River (Yoshiyama *et al.* 1996). As reported in SWRI (2001), "An estimated 257 million yards of gravel, silt and debris were washed into the river from hydraulic mining (Gilbert 1917 cited in Sumner and Smith 1940)."

Between 1944 and 1947, annual counts of summer-run steelhead passing through the fish ladder at Old Folsom Dam (RM 27) during May, June, and July ranged from 400 to 1,246 fish (Gerstung 1971). After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead perished in the warm water in areas below Old Folsom Dam. By 1955, summer-run steelhead (and spring-run Chinook salmon) were completely extirpated and only remnant runs of fall- and winter-run steelhead and fall-run Chinook salmon persisted in the American River (Gerstung 1971).

Estimates of historic run sizes for summer-, fall-, and winter-run steelhead in the American River were not identified in the available literature. However, all three runs of steelhead were likely historically abundant in the American River, considering: (1) the extent of available habitat; (2) the historic run size estimates of Chinook salmon before massive habitat degradation occurred;

and (3) the reported historic run size estimates for summer-run steelhead in the 1940s which occurred even after extensive habitat degradation and elimination.

Operation of Sacramento Municipal Utility District's Upper American River Project (UARP) since 1962, as well as Placer County Water Agency's Middle Fork Project (MFP) since 1967, altered inflow patterns to Folsom Reservoir (SWRI 2001). In addition, development of the American River watershed has modified the seasonal flow and temperature patterns that occur in the lower American River. Operation of the Folsom-Nimbus project significantly altered downstream flow and water temperature regimes.

Completion and operation of Folsom and Nimbus dams resulted in higher flows during fall, significantly lower flows during winter and spring, and significantly higher flows during summer (figure 5-17).

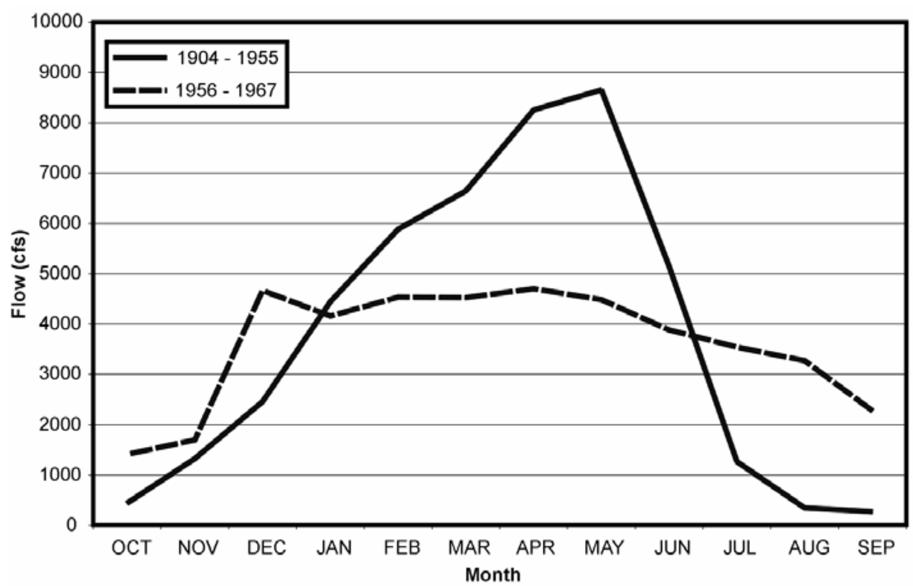


Figure 5-17. Mean monthly flow of the lower American River at the Fair Oaks gage (1904-1955) and after (1956-1967) operation of Folsom and Nimbus dams (Gerstung 1971).

Seasonal water temperature regimes also have changed with development in the American River watershed, particularly with construction and operation of Folsom and Nimbus dams (figure 5-18). Prior to the completion of Folsom and Nimbus dams in 1955, maximum water temperatures during summer frequently reached temperatures as high as 75°F to 80°F in the lower American River (Gerstung 1971). It is important to note that the water temperature data presented in figure 5-18 is from the Fair Oaks gage[8] in the lower part of the river. Although summer water temperatures are cooler in the lower river since Folsom Dam was constructed as compared to the pre-dam conditions, prior to habitat elimination by dams, rearing fish had access to cooler habitats throughout the summer at higher elevations.

[8] Data from the Fair Oaks location is presented because that is the only site where pre-Folsom Dam water temperatures were identified.

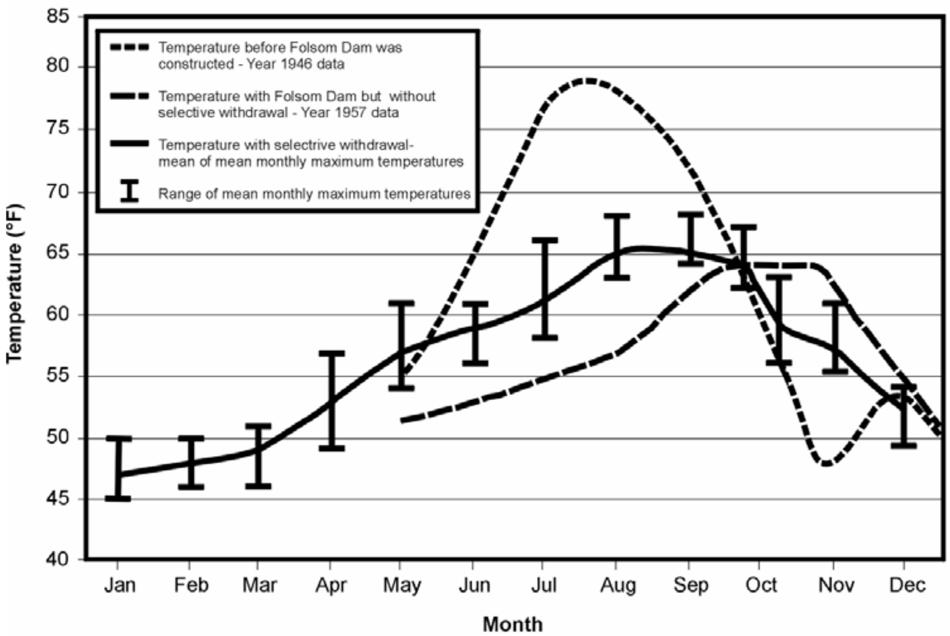


Figure 5-18. Water temperatures recorded at the Fair Oaks gage on the lower American River prior to and after construction of Folsom and Nimbus dams (Gerstung 1971).

5.4.3 Future Baseline Excluding CVP/SWP Effects

Baseline stressors to American River steelhead include the presence of Folsom and Nimbus dams, loss of natural riverine function and morphology, predation, and water quality (figure 5-19).

The physical structures of Folsom and Nimbus dams are part of the future baseline. Dams produce extensive ecological disruptions, including alteration of flow regimes, sedimentation, and nutrient fluxes, modification of stream-channel morphology, spatial decoupling of rivers and their associated floodplains, disruption of food webs, and fragmentation and loss of habitat (Ligon *et al*. 1995, Levin and Tolimieri 2001). Nimbus Dam was completed in 1955, blocking steelhead and spring-run from all of their historic spawning habitat in the American River (Lindley *et al*. 2006). Hydrological and ecological changes associated with the construction of the dams contributed to the extirpation of summer steelhead and spring-run, which were already greatly diminished by the effects of smaller dams (*e.g*., Old Folsom Dam and the North Fork Ditch Company Dam) and mining activities (Yoshiyama *et al*. 1996).

Loss of natural river function and morphology is a major stressor to the aquatic resources of the American River, including steelhead. Past habitat alterations that have taken place within the American River watershed continue to limit natural river processes. The following discussion on the habitat alterations in the American River watershed was slightly modified from Water Forum (2005a). Prior to 1849, the riparian vegetation along the river formed extensive, continuous forests in the floodplain, reaching widths of up to 4 miles. Settlement of the lower American River floodplain by non-indigenous peoples and the resulting modifications of the physical processes shaping the river and its floodplain have drastically altered the habitats along the river. Early settlers removed trees and converted riparian areas to agricultural fields. Hydraulic gold mining in the watershed caused deposits of 5-30 feet of sand, silt, and fine gravels on the riverbed of the lower American River. These deposits resulted in extensive sand and gravel bars in the lower river and an overall raising of the river channel and surrounding floodplain. This was later exacerbated by gravel extraction activities. As a result, the floodplain's water table has dropped, reducing the growth and regeneration of the riparian forest.

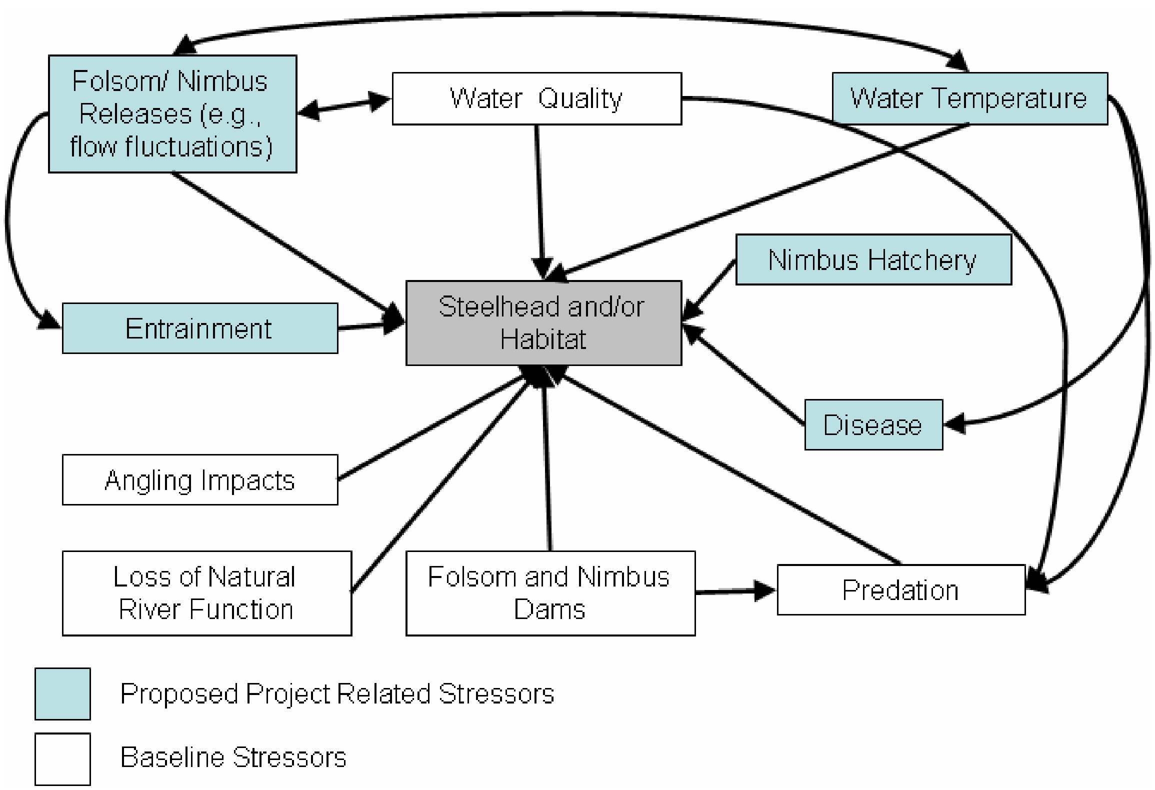


Figure 5-19. Conceptual model of the future baseline stressors and proposed project-related stressors affecting naturally-produced American River steelhead.

Additional habitat impacts resulted from the construction of Folsom and Nimbus dams. These structures have blocked the main upstream sediment supply to the lower American River. This sediment deficit reduces the amount of material that can deposit into bars in the lower reaches, resulting in less substrate for growth of cottonwoods and other riparian vegetation.

Since the 1970s, bank erosion, channel degradation and creation of riprap revetments have contributed to the decline of riparian vegetation along the river's edge, loss of soft bank and channel complexity, and reduced amounts of large woody debris in the river that are used by fish and other species. In particular, there has been a decrease in overhanging bank vegetation called shaded riverine aquatic (SRA) habitat. SRA habitat provides multiple benefits to both fish and wildlife. In particular, it provides shade along the river to moderate water temperatures in the summer. Overhanging vegetation also provides cover to aquatic species, creating areas where they can feed and rest while being sheltered from predators. Living and dead vegetation provides habitat and food for many species of insects and other organisms, which can then be eaten by fish species, including salmonids (Water Forum 2005a).

Predators of juvenile steelhead in the lower American River include both native (*e.g.*, pikeminnow) and non-native (*e.g.*, striped bass) fish, as well as avian species. Striped bass, which were introduced in California in 1879 and 1882 (SWRI 2001), have been shown to be effective predators of steelhead in the Central Valley (DWR 2008). Some striped bass reportedly reside in the lower American River year-round, although their abundance greatly increases in the spring and early summer as they migrate into the river at roughly the same time that steelhead are both emerging from spawning gravels as vulnerable fry and are migrating out of the river as smolts (SWRI 2001).

Poor water quality can affect steelhead in the lower American River. Tierney *et al*. (2008) demonstrated that environmentally observed pesticide mixtures can injure rainbow trout olfactory tissue, thereby affecting their ability to detect predators. Similarly, Sandahl *et al*. (2007) showed that runoff from urban landscapes has the potential to cause chemosensory deprivation and increased predation mortality in exposed salmon. Urbanization throughout the greater Sacramento area has led to a replacement of agricultural land uses within the American River floodplain with urban land uses, and a corresponding increase in urban runoff (SWRI 2001). Based on data from 1992 through 1998 collected by the Ambient Monitoring Program, lower American River water quality exceeded State (California Toxics Rule) or Federal (EPA) criteria with respect to concentrations of four metals – lead, copper, zinc, and cadmium (SWRI 2001).

The open season for angling in the lower American River encompasses nearly the entire steelhead spawning season. The only steelhead spawning potentially occurring during the closed fishing season would occur for early spawners during late-December from Hazel Avenue bridge piers to the SMUD power line crossing at the south-west boundary of Ancil Hoffman Park (CDFG 2008). The entire lower river is open for fishing starting in January, although reach-specific gear and harvest restrictions apply. Although only hatchery steelhead may be harvested, catch and release of wild spawners may result in mortality if hooking injures critical organs (*e.g.*, gills; Cowen *et al*. 2007). Steelhead fishing report card results show that the American River receives the third most angling effort in the State, with only the Trinity and Smith rivers receiving more (CDFG 2007). From 2003 through 2005, over 3,500 steelhead fishing trips were reported for the American River. During those years, anglers reportedly caught 1,840 wild steelhead and illegally harvested 31 of those; 1,440 hatchery steelhead were caught and released and 359 hatchery steelhead were harvested. In addition to the direct effects associated with catch and release fishing, steelhead eggs incubating in redds may be damaged by wading anglers or other recreationalists.

5.5 Status of the Species and Critical Habitat in the East Side Division

The New Melones Dam operates in conjunction with Tulloch Reservoir and Goodwin Dam on the Stanislaus River (figure 5-20). Goodwin Dam, completed in 1912, is an impassible barrier to upstream fish migration at RM 59. Water is released from New Melones to satisfy senior water right entitlements, instream and Delta water quality standards specified under D-1641, CDFG fish agreement flows, CVP water contracts and b(2) or CVPIA 3406(b)(3) [hereafter referred to b(3)] fishery flows.

5.5.1 CV Steelhead

CV steelhead is the only anadromous ESA-listed species that occurs in the Stanislaus River. Fall-run also occur in this river. Spring-run and summer steelhead have been extirpated from this watershed (Yoshiyama *et al*. 1996). Steelhead populations in the Stanislaus, Tuolumne, Merced, and Calaveras rivers are the only remaining representatives of the Southern Sierra Nevada diversity group of the CV steelhead. None of these populations are considered to be viable at this time (Lindley *et al*. 2007). Anadromous *O. mykiss* populations may have been extirpated from their entire historical range in the San Joaquin Valley owing to dam construction, but current populations survive in these rivers in tailwater conditions controlled by the dams. The Calaveras River is not a direct tributary to the mainstem San Joaquin River, in that it enters a network of sloughs and channels in the Delta east of the mainstem of the San Joaquin River. Additionally, the primary flow metric for the San Joaquin River is the flow at Vernalis, and Calaveras River flows enter the Delta further downstream. For the purposes of this document, tributaries to the San Joaquin River are defined as the Merced River, the Tuolumne River and the Stanislaus River. Based on information from a variety of sources (rotary screw trap sampling, trawling at Mossdale, direct and angler observations) in all three tributaries of the San Joaquin River, CDFG (2003) stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River." The documented returns on the order of single digit numbers of fish into the tributaries suggest that existing populations of CV steelhead on the Stanislaus, Tuolumne, Merced, Calaveras, and lower San Joaquin rivers are severely depressed.

Information regarding steelhead numbers on the Stanislaus River is very limited and has typically been gathered incidental to existing monitoring activities for fall-run. A counting weir for fall-run also has recorded passage of steelhead. In the 2006-7 counting season, 12 steelhead were observed passing through the counting weir, coincidental with the observation of 3,078 adult salmon (Anderson *et al*. 2007). An adipose fin-clipped steelhead was observed at the counting weir, indicating some opportunity for genetic introgression from hatchery operations on other Central Valley rivers. On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001), but the numbers are very low, ranging from 10 to 30 annually, compared to annual catches of fall-run in the range of hundreds. The low juvenile steelhead numbers likely indicate a much smaller steelhead population than fall-run, but steelhead smolts are considerably larger than fall-run smolts, and can avoid capture by the traps (Stillwater Sciences 2000). Most of the steelhead smolts are captured from January to mid-April, and are 175 to 300 mm fork length. The raw data from rotary screw trapping show *O. mykiss* in a smolted stage being trapped in late May at both the Oakdale and Caswell trap locations. These fish are physiologically prepared to leave the river at a time well after the scheduled Vernalis Adaptive Management Plan (VAMP) pulse flows, but not later than when historical unimpaired rain-on-snow events would have provided outmigration flows. Zimmerman *et al.* (2008) have documented CV steelhead in the Stanislaus, Tuolumne and Merced rivers based on otolith microchemistry.

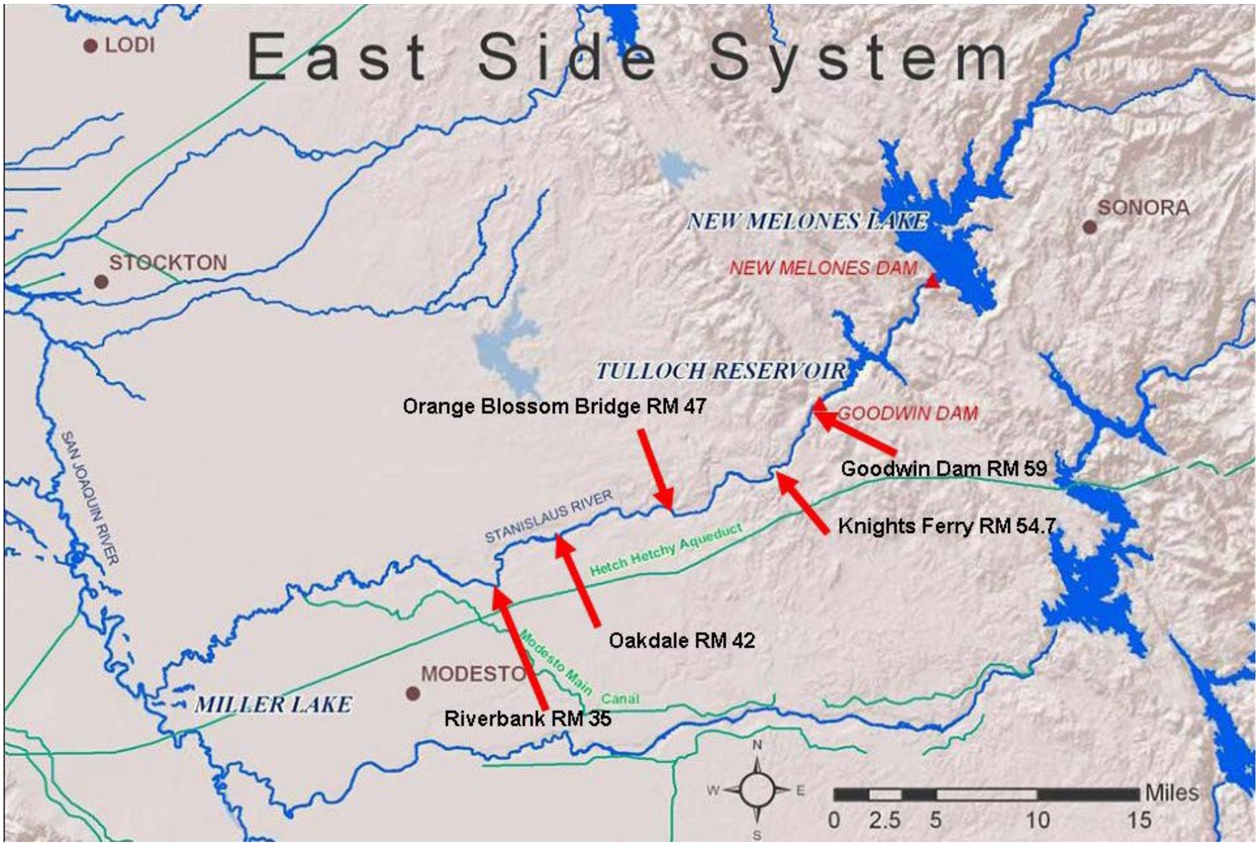


Figure 5-20. Map of the East Side Division (adapted from the CVP/SWP operations BA figure 2-10).

Juvenile steelhead reside in freshwater for a year or more, so they are more dependent on freshwater rearing habitat than are the ocean type fall-run. Steelhead rearing in the Stanislaus River occurs upstream of Orange Blossom Bridge (RM 47) where gradients are highest. The highest rearing densities are upstream of Knights Ferry (RM 54.7, Kennedy and Cannon 2002).

Juvenile steelhead migrate during the winter and spring from the above-described rearing areas downstream through the rivers and the Delta to the ocean. The habitat conditions they encounter from the upstream reaches of the rivers downstream to the Delta become generally further from their preferred habitat requirements with respect to cover, temperature, water quality, and exposure to predatory fishes such as striped bass and non-native black bass. Emigration conditions for juvenile steelhead in the Stanislaus River down through the San Joaquin River and the south Delta tend to be less suitable than conditions for steelhead emigrating from the Sacramento River and its tributaries.

CDFG staff has prepared catch summaries for juvenile migrant steelhead on the San Joaquin River near Mossdale, which represents migrants from the Stanislaus, Tuolumne, and Merced rivers. These trawl recoveries at Mossdale between 1988 and 2002 ranged from a minimum of 1 fish per year to a maximum of 29 fish in 1 year (figure 4-5).

Adult steelhead migrate upstream from the ocean to their spawning grounds near the terminal dams primarily during the fall and winter months. Flows are generally lower during the upstream migrations than during the outmigration period. Adult steelhead may occur in the

Stanislaus River earlier than in other Central Valley rivers when fall attraction flows are released in October for the benefit of fall-run. The general temporal occurrence of steelhead and fall-run in the Stanislaus River at various life history stages is illustrated in figure 5-21.

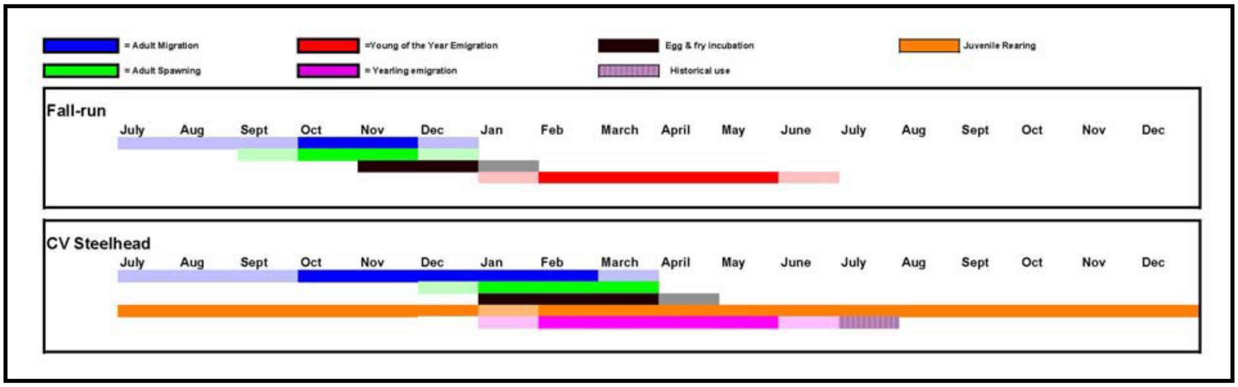


Figure 5-21. Temporal occurrence of fall-run and steelhead in the Stanislaus River, California. Darker shading indicates peak use.

Construction of Goodwin Dam in 1912 has excluded steelhead from 100 percent of its historical spawning and rearing habitat on the Stanislaus River (Lindley *et al*. 2006). Critical habitat has been designated up to Goodwin Dam, to include currently occupied areas. Extension of critical habitat above the dams was deemed premature until recovery planning determines a need for these areas in the recovery of the DPS (September 2, 2005, 70 FR 52488).

The construction of the East Side Division Dams (New Melones, Tulloch, and Goodwin) blocks the downstream transport of spawning gravel that would replenish gravel below the dams. Past East Side Division operations have mobilized gravel remaining below the dams, which has led to a degradation of the quality and quantity of available steelhead spawning gravels (Kondolf *et al*. 2001). Gravel replenishment projects funded by CVPIA have offset some of this habitat loss, but the rate of replenishment is not sufficient to offset ongoing loss rates, nor to offset losses from past years of operations.

Past operations of the East Side Division have eliminated channel forming flows and geomorphic processes that maintain and enhance steelhead spawning beds and juvenile spawning areas associated with floodplains and channel complexity. Since the construction and operation of New Melones Dam, operational criteria have resulted in channel incision, as much as 1-3 feet (Kondolf *et al*. 2001). This downcutting, combined with operational criteria, have effectively cut off overbank flows which would have inundated floodplain rearing habitat, as well as providing areas for fine sediment deposition, rather than within spawning gravels, as occurs now. Operational flow patterns in late spring and summer, combined with lack of overbank flows has severely constrained recolonization of large riparian trees that are needed for riparian shading and LWD contribution.

5.5.1.1 CV Steelhead Critical Habitat

Steelhead critical habitat on the Stanislaus River has been designated up to Goodwin Dam. The PCEs of critical habitat for Stanislaus River steelhead include freshwater spawning, freshwater rearing, freshwater migration, and estuarine habitats. Although Stanislaus River water temperatures are generally suitable for spawning and rearing, during the smolt emigration life stage (January through June), steelhead are exposed to water temperatures that would prohibit successfully completing transformation to the smolt stage. In addition, steelhead spawning and rearing habitat on the Stanislaus River is affected by the limited occurrence of flows that are sufficient to carry out natural geomorphic processes. As such, sediment deposition on spawning habitats has decreased the availability of suitable spawning areas. The relatively low and uniform releases in the Stanislaus River reduces the conservation value of rearing habitat by reducing habitat complexity and decreasing connectivity with floodplains, which are proven to be high quality rearing habitats (Sommer *et al*. 2005).

5.5.2 Historical Conditions

The unimpaired hydrograph of the Stanislaus River followed the pattern of low flows at the end of the summer, increasing flows in the fall as upstream evapotranspiration rates declined, which continued to increase with the onset of seasonal rainfall in late fall, followed by rain plus snowmelt through the end of spring (table 5-2). The winter hydrograph was punctuated with storm related freshets, peak flows correlated with large storm events, and periodic large instream flow events later in winter and spring, owing to rain-on-snow events in the higher elevations of the watershed.

Table 5-2. Comparison of unimpaired average monthly flows, Stanislaus River from various timeframes, with post-New Melones Dam regulated flows (Kondolf *et al*. 2001 table 4.4).

FLOWS (AF)													
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	TOTAL
*Pre-dam Flows **:*													
AVG 1901-1926 *:	11,777	18,377	32,542	83,746	108,923	166,938	232,181	318,454	230,462	76,638	16,988	7,296	1,304,323
AVG 1901-1957:	9,711	23,199	46,870	70,297	93,698	140,970	216,955	304,186	203,184	62,223	13,850	5,851	1,190,995
AVG 1901-2000:	10,372	26,041	48,973	85,392	101,490	141,154	203,571	292,266	193,353	61,051	14,032	6,962	1,184,657
Post-dam Flows:													
AVG 1979-1998:	38,737	32,670	49,969	71,851	72,881	97,478	77,369	77,732	55,313	51,479	45,059	38,034	708,573
*Δ post NM/preOM *:*	*329%*	*178%*	*154%*	*86%*	*67%*	*58%*	*33%*	*24%*	*24%*	*67%*	*265%*	*521%*	*54%*

FLOWS (cfs)													
Water Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	TOTAL
*Pre-dam Flows **:*													
AVG 1901-1926 *:	192	309	530	1,364	1,965	2,720	3,909	5,188	3,880	1,249	277	123	21,705
Post-dam Flows:													
AVG 1979-1998:	631	550	814	1,171	1,315	1,588	1,303	1,266	931	839	734	640	11,782
*Δ post NM/preOM *:*	*329%*	*178%*	*154%*	*86%*	*67%*	*58%*	*33%*	*24%*	*24%*	*67%*	*265%*	*521%*	*54%*

**: 1901-1926 represents the "Pre - Old Melones" dam flow records and is graphed in Figure 4-9.*

***: Unimpaired flow data from "Full Natural Flow" data, USGS gauge at Stanislaus R-Goodwin (SNS), Sensor #65, Elev. 252'.*

The life history strategy of CV steelhead evolved with this hydrologic pattern. The adults return from the ocean to spawn in the rivers when fall flows have increased and water temperatures in the valley are past their summer peak. Historically they would continue far upstream to spawn, allowing their offspring rearing areas that are cooler year round than lower elevation reaches nearer the valley floor. Young steelhead would rear in these areas for at least a full year, beginning their seaward migration during the winter and spring freshets and storm pulses that helped their seaward movement and created a succinct signature of Stanislaus River water through to the Delta.

5.5.3 Future Baseline Excluding CVP/SWP Effects

Future baseline stressors to CV steelhead include the presence of Goodwin, Tulloch and New Melones dams, loss of natural riverine function and morphology, agricultural and urban land uses, gravel mining, predation, and water quality, particularly temperature, contaminants and suspended sediment (figure 5-22).

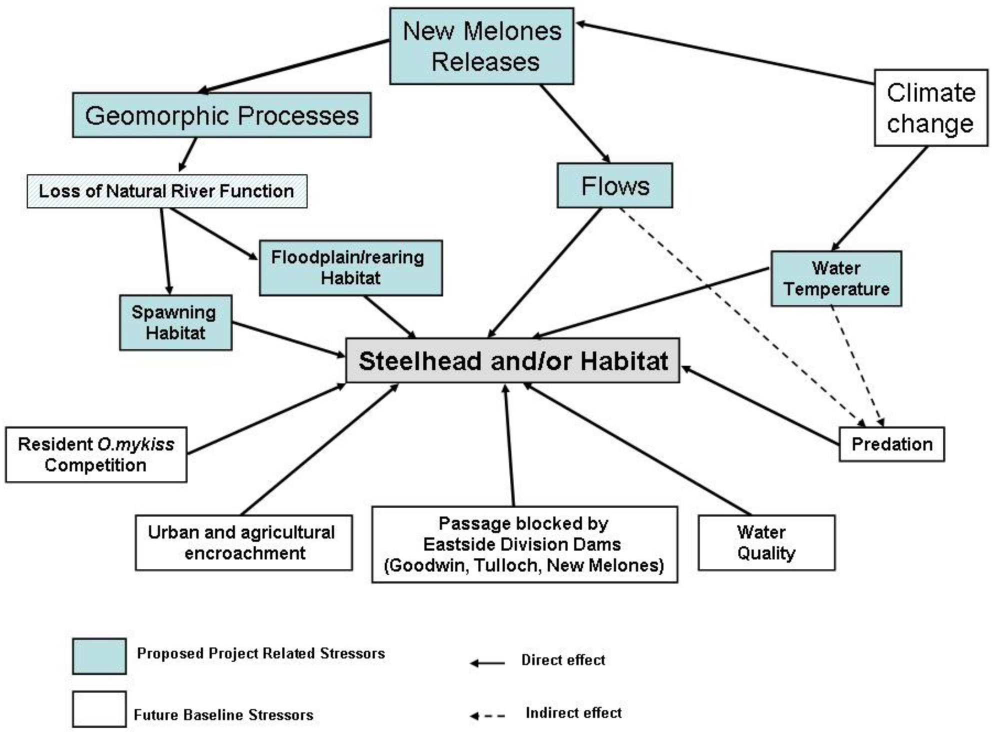


Figure 5-22. Conceptual model of and future baseline stressors and project-related stressors of CV steelhead and habitat in the Stanislaus River, California.

Dams produce extensive ecological disruptions, including sedimentation, and nutrient fluxes, modification of stream-channel morphology, spatial decoupling of rivers and their associated floodplains, disruption of food webs, and fragmentation and loss of habitat (Ligon *et al*. 1995, Levin and Tolimieri 2001). Lindley *et al*. (2006) also suggest that dams may exert selective effects on anadromous *O. mykiss,* culling the anadromous offspring produced, and modifying the thermal regime and food web structure of the river below the dam in ways that may provide fitness advantages to resident forms, which means that the population shifts more towards residency and further from a viable anadromous species.

Loss of natural river function and morphology is a major stressor to the aquatic resources of the Stanislaus River, including steelhead. Bank erosion, channel degradation and creation of riprap revetments have contributed to the decline of riparian vegetation along the river's edge, loss of soft bank and channel complexity, and reduced amounts of LWD in the river that are used by fish and other species. Living and dead vegetation provide habitat and food for many species of insects and other organisms, which can then be eaten by fish species, including salmonids.

Flood attenuation has allowed for encroachment of agriculture and homes up to the river's edge. Although floodway easements were acquired on many farmed terraces when New Melones Dam was constructed, much of this agricultural activity consists of permanent orchards, which are not flood resistant. This agricultural practice is averse to overbank flooding and creates opposition to dam operational practices that would flood habitat terraces.

Poor water quality can affect steelhead in the lower Stanislaus River. The lower Stanislaus River is considered an impaired water body for Diazinon and Group A pesticides attributed to agricultural uses. Tierney *et al*. (2008) demonstrated that environmentally observed pesticide mixtures can injure rainbow trout olfactory tissue, thereby affecting their ability to detect predators. Similarly, Sandahl *et al*. (2007) showed that runoff from urban landscapes has the potential to cause chemosensory deprivation and increased predation mortality in exposed salmon. There is an increasing trend toward urbanization of the lower Stanislaus River.

Gravel mining, including in-river skimming and flood terrace pit mines, is currently less active in the watershed, but has left a legacy of reduced instream gravel abundance and deep excavation pits captured by the river that provide habitat for non-native predatory fishes, like largemouth bass and striped bass that prey on steelhead. The lower Stanislaus River is considered an impaired water body for mercury as a result of past gravel and gold mining activity [2006 Clean Water Act section 303(d) list], although it is not clear how much of that contaminant is present in the biologically active methylated form.

5.6 Status of the Species and Critical Habitat in the Delta Division

The overall statuses of the four listed species in the Central Valley (winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon) were described in section 4 of this Opinion. Since all of the sub-populations that comprise the listed populations at the ESU or DPS level must pass through the Delta (figure 5-23), further description of the status of each individual sub-population beyond that already given in section 4 is unnecessary.

5.6.1 Critical Habitat

5.6.1.1 Status of Winter-Run Critical Habitat

Critical habitat within the Delta largely serves as a migratory corridor. However, juvenile winter-run likely rear while they migrate downstream, therefore, rearing habitat is an important component within the mainstem Sacramento River in the Delta. The current condition of riparian habitat for winter-run in the Delta is degraded as a result of the channelized, leveed, and riprapped river reaches and sloughs, which typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Some complex, productive habitats with floodplains remain in the system [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypass (*i.e.*, Yolo bypass).

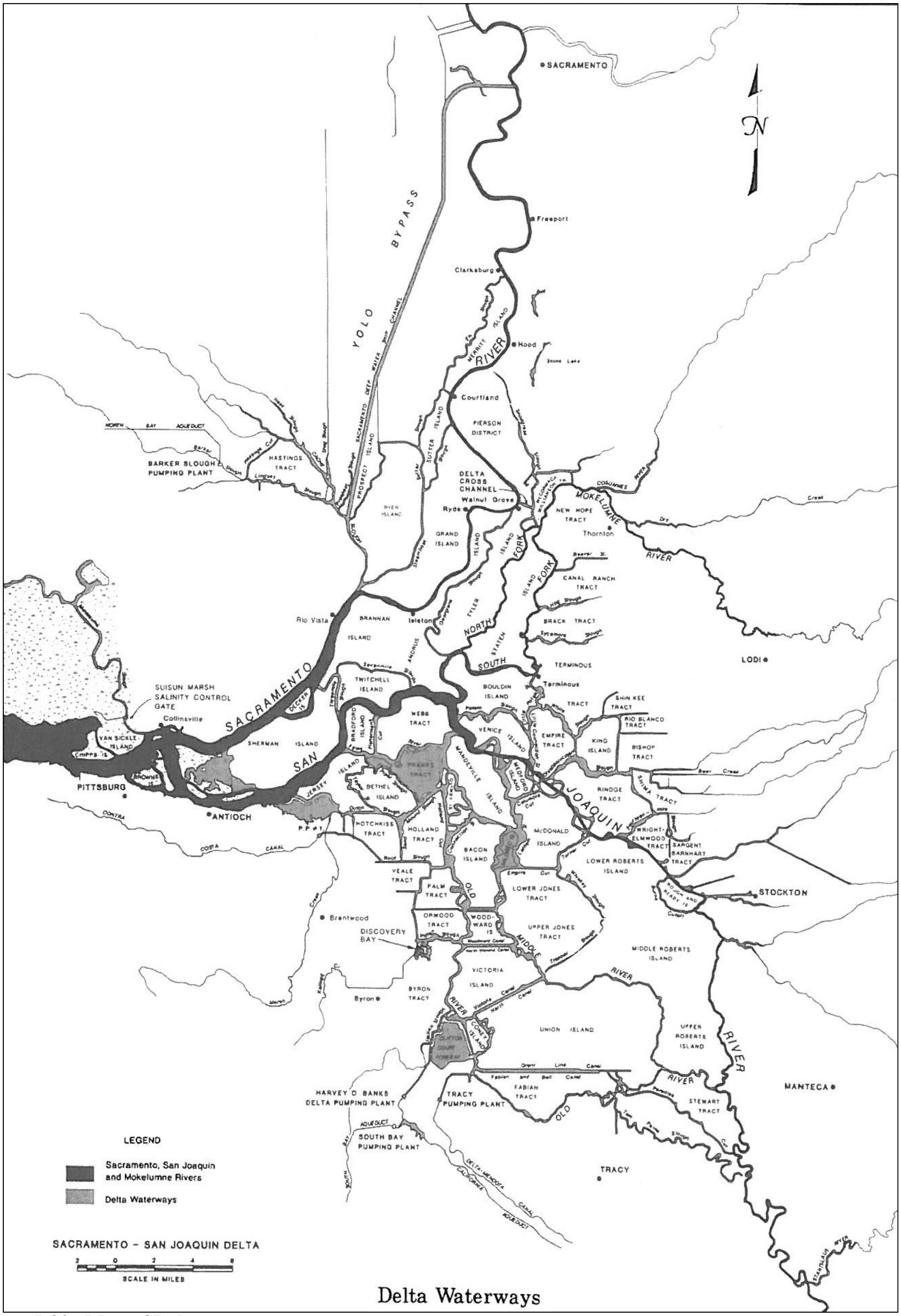


Figure 5-23. Map of Delta waterways.

The final rule designating winter-run critical habitat explicitly excludes the rivers and sloughs of the Delta, with the goal of minimizing diversion of winter-run through the DCC (June 16, 1993, 58 FR 33212). When the DCC gates are open during winter-run outmigration, a portion of the flow, and therefore, a portion of the outmigrating winter-run, is entrained through the DCC into the interior Delta, where their chances of survival and successful migration to San Francisco Bay and the Pacific Ocean are reduced. In addition, unscreened diversions that entrain juvenile salmonids are prevalent throughout the Delta and do not provide a safe migration corridor.

Based on the impediments caused by unscreened diversions, and the opening of the DCC gates during the winter-run outmigration period, the current condition of the migration corridor through the Delta for juvenile winter-run is much degraded.

5.6.1.2 Status of Spring-Run Critical Habitat

The status of estuarine habitats for spring-run also is considered to be highly degraded as is evident by the collapse of pelagic organisms in the Delta (Sommer *et al*. 2007, IEP 2008). It is not immediately clear how the changes in the Delta ecosystem affect spring-run, but it is certain that substantial changes to spring-run estuarine habitat are occurring.

5.6.1.3 Status of CV Steelhead Critical Habitat

In addition, the status of estuarine habitats for steelhead is considered to be highly degraded as is evident by the collapse of the pelagic community in the Delta. This collapse is, in part, related to dramatic habitat changes in recent years related to water quality, toxic algae blooms (*e.g*., Microcystis), and invasive species (*e.g*., the aquatic macrophyte *Egeria densa*). It is not immediately clear how the changes in the Delta ecosystem affect steelhead, but it is certain that substantial alterations to steelhead estuarine habitat are occurring.

5.6.1.4 Status of Southern DPS Green Sturgeon Proposed Critical Habitat

The effects of combined exports present an entrainment issue that could delay migration or decrease survival or population viability through entrainment into the facilities itself. These effects increase in magnitude the closer to the export facilities the fish are located. Likewise, the installation of the barriers under the South Delta Temporary Barriers Program (TBP) enhances the potential to delay movement and migratory behavior in the channels of the South Delta. Juvenile and adult green sturgeon may be trapped behind the barriers after installation/ operation for varying periods of time. The rock barriers of the TBP present the greatest obstacle to movement during their installation and operation, but are removed from the channels each winter.

5.6.2 Delta Hydrodynamics

5.6.2.1 Historical Hydrograph

Substantial changes have occurred in the hydrology of the Central Valley's watersheds over the past 150 years. Many of these changes are linked to the ongoing actions of the CVP and SWP in their pursuit of water storage and delivery of this water to their contractors.

Prior to the construction of dams on the tributaries surrounding the Central Valley, parts of the valley floor hydrologically functioned as a series of natural reservoirs seasonally filling and draining every year with the cycles of rainfall and snow melt in the surrounding watersheds. These reservoirs delayed and muted the transmission of floodwaters traveling down the length of the Sacramento and San Joaquin rivers. Historically, there were at least six distinct flood basins in the Sacramento Valley. The east side of the Sacramento Valley was topographically subdivided into the Butte Basin, the Sutter Basin, the American River Basin, and the Sacramento Basin. The west side of the valley contained the Colusa Basin and the Yolo Basin. The Colusa Basin drained through Sycamore Slough above Knight's Landing, the Yolo Basin drained through Cache Slough at the foot of Grand Island, and the eastern basins drained through the Feather and the American rivers. The Sacramento Basin drained southwards towards the San Joaquin River. Some of these basins retained floodwaters for many months after the flood event, allowing the basins to slowly drain back into the river or to evaporate in the summer heat. Others, like the Yolo Basin, drained relatively quickly. Overflow into these basins significantly reduced flood peaks and flow velocities in the bypassed reaches. For example, the Yolo Basin was believed to capture over two-thirds of the flood flows on the Sacramento River and divert them around the main channel near Sacramento towards the Delta. These extensive flood basins created excellent shallow water habitat for fish such as juvenile Chinook salmon, steelhead, and sturgeon to grow and rear before moving downstream into the Delta (The Bay Institute 1998). The magnitude of the seasonal flood pulses were reduced before entering the Delta, but the duration of the elevated flows into the Delta were prolonged for several months, thereby providing extended rearing opportunities for emigrating Chinook salmon, steelhead and green sturgeon to grow larger and acquire additional nutritional energy stores before entering the main Delta and upper estuarine reaches.

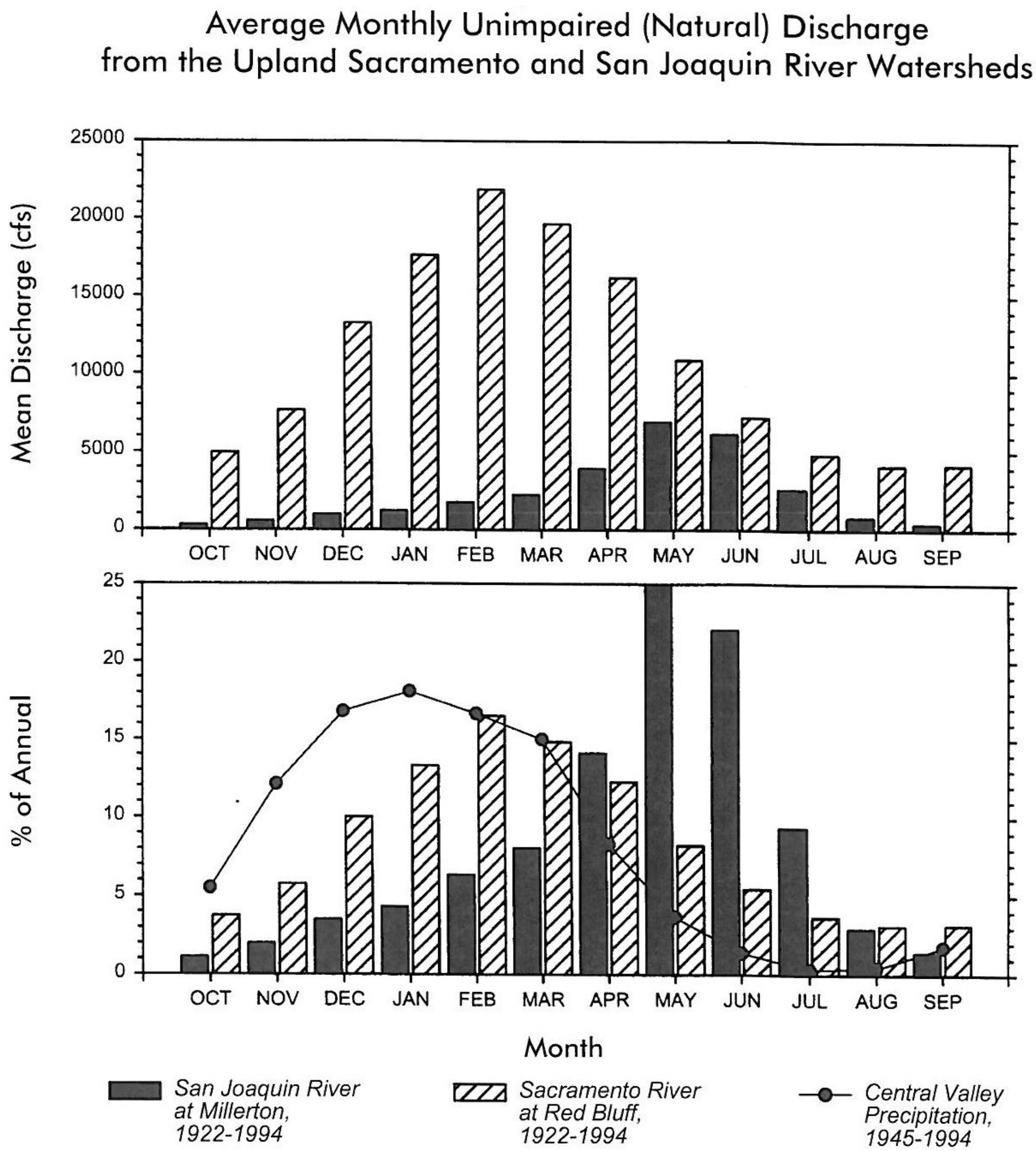
Prior to the construction of dams, there were distinct differences in the natural seasonal flow patterns between the northern Sacramento River watershed and the southern San Joaquin River watershed. Furthermore, the natural unimpaired runoff in the Central Valley watersheds historically showed substantial seasonal and inter-annual variability. Watersheds below 5,000 feet in elevation followed a hydrograph dominated by rainfall events with peak flows occurring in late fall or early winter (northern Sierra Nevada, Cascade Range, and most of the western coastal mountains). Conversely, those watersheds with catchment areas above 5,000 feet, such as the Central and Southern Sierras, had hydrographs dominated by the spring snowmelt runoff period and had their highest flows in the late spring/early summer period. Summertime flows on the valley floor were considerably reduced after the seasonal rain and snowmelt pulses were finished (figures 5-24), with base flows supported by the stored groundwater in the surrounding alluvial plains. Since the construction of the more than 600 dams in the mountains surrounding the Central Valley, the variability in seasonal and inter-annual runoff has been substantially reduced and the peak flows muted, except in exceptional runoff years. Currently, average winter/spring flows are typically reduced compared to natural conditions, while summer/fall flows have been artificially increased by reservoir releases. Wintertime releases are coordinated for preserving flood control space in the valley's large terminal storage dams, and typically do not reach the levels necessary for bed load transport and reshaping of the river channels below the dams. Summertime flows have been scheduled for meeting water quality goals and consumptive water demands downstream (figures 5-25 and 5-26). Mean outflow from the Sacramento River during the later portion of the 19th century has been reduced from nearly 50 percent of the annual discharge occurring in the period between April and June to only about 20 percent of the total mean annual outflow under current dam operations (The Bay Institute 1998). Currently, the highest mean flows occur in January, February, and March. The San Joaquin River has seen its snowmelt flood peak essentially eliminated, and the total discharge to the valley floor portion of the mainstem greatly reduced during the spring. Only in very wet years is there any marked late spring outflow peak (The Bay Institute 1998).

These changes in the hydrographs of the two main river systems in the Central Valley are also reflected in the inflow and outflow of water to the Delta. Releases of water to the Delta during the normally low-flow summer period have had several impacts on Delta ecology and hydrology. Prior to dam construction in the Central Valley and operations of the CVP and SWP, the Delta had normal variability in the hydrology. Annual incursions of saline water into the Delta still occur each summer, but have been substantially muted compared to their historical levels by the release of summer water from the reservoirs (Herbold and Moyle 1989, figures 5-27 and 5-28). The Delta has thus become a conveyance apparatus to move water from the Sacramento side of the Delta to the southwestern corner of the Delta where the CVP and SWP pumping facilities are located. The Delta has become a stable freshwater body, which is more suitable for introduced and invasive exotic freshwater species of fish, plants, and invertebrates than for the native organisms that evolved in a fluctuating and "unstable" Delta environment.

Furthermore, Delta outflow has been reduced by approximately 14 percent from the pre-dam period (1921-1943) when compared to the project operations period (1968-1994). When differences in the hydrologic year types are accounted for and the "wet" years are excluded, the comparison between similar year types indicates that outflow has been reduced by 30 to 60 percent (The Bay Institute 1998, also see Delta Atlas, DWR), with most of this "lost" water going to exports.

5.6.2.1.2 Current Flow Patterns in the Delta

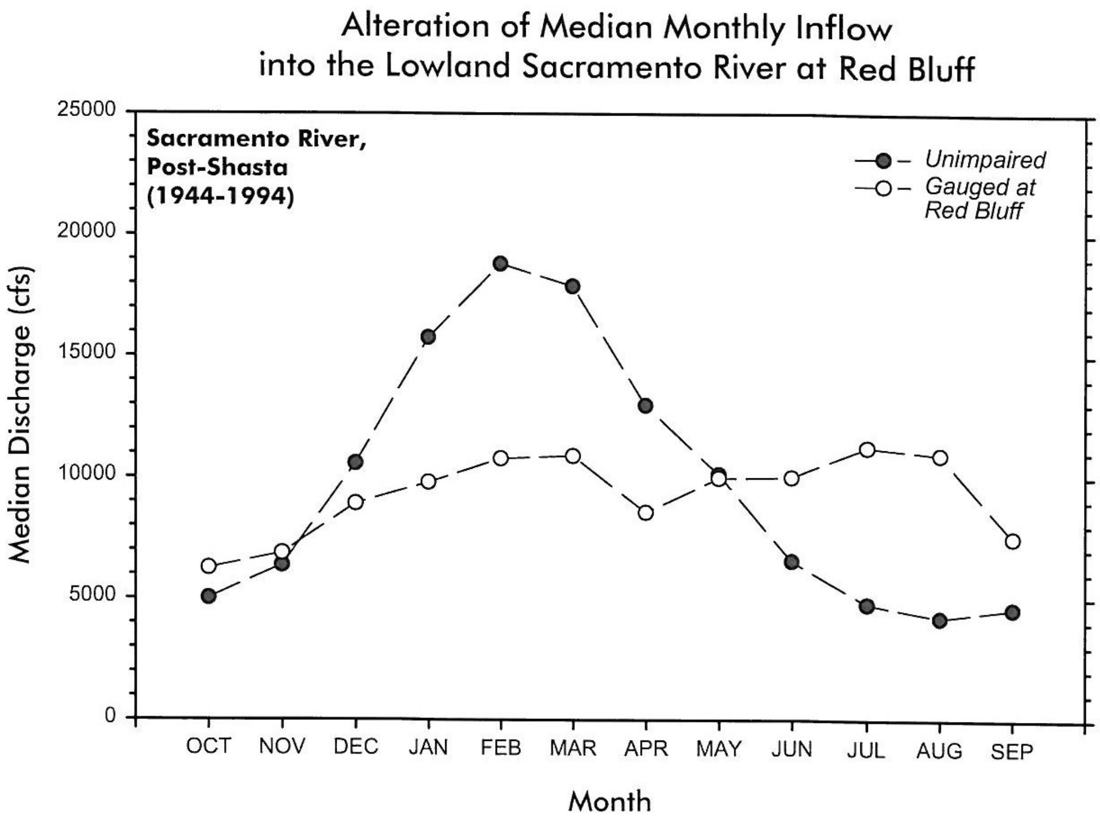
The Delta is a complex system of over 1,000 miles of waterways (Delta Atlas, DWR). The flow pattern within these waterways is also complex due to the interactions of river flows, tides, and water diversions. In order to explain in general terms the pattern of flows within the Delta, it will be divided into four regions, the North Delta, the Central Delta, the South Delta, and the Western Delta.



The annnual Sacramento River runoff at Red Bluff is on average nearly four times greater than the San Joaquin River at Millerton. Temporal differences in the pattern of runoff of the two rivers is due to differences in the amount of precipitation received as rain (dominant on the Sacramento), versus snow (dominant on the San Joaquin) and differences in underlying geology. The lower graph also plots the pattern of Central Valley precipitation to illustrate how precipitation and runoff are out of phase.

Data from California Department of Water Resources.

Figure 5-24. Average monthly unimpaired (natural) discharge from the upland Sacramento and San Joaquin River watersheds (The Bay Institute 1998).



Unimpaired Data: median annual discharge, 7,278,000 acre feet.
Gauged Data: median annual discharge, 7,541,236 acre feet.
Median monthly values calculated for each month from period of record.
Median annual values calculated from annual runoff record.

Shasta Dam and associated water project operations have redistributed and dampened median monthly flows on the Sacramento River downstream of Red Bluff. The slightly greater annual median gauged value is due to the diversion of Trinity River flows into the Sacramento River.
Data from California Department of Water Resources and U.S. Geological Survey.

Figure 5-25. Alteration of median monthly inflow into the lowland Sacramento River at Red Bluff (The Bay Institute 1998).

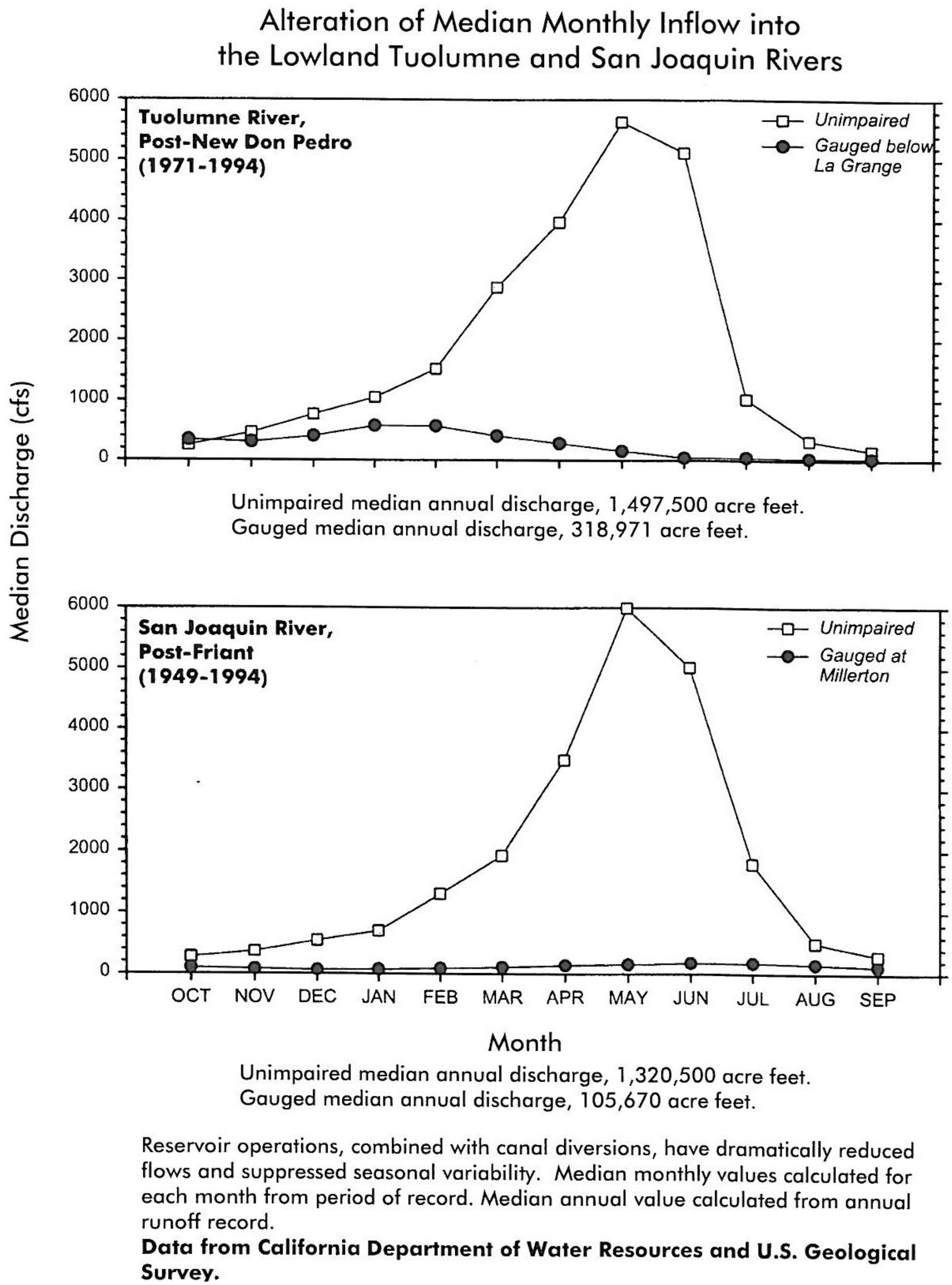


Figure 5-26. Alteration of median monthly inflow into the lowland Tuolumne and San Joaquin rivers (The Bay Institute 1998).

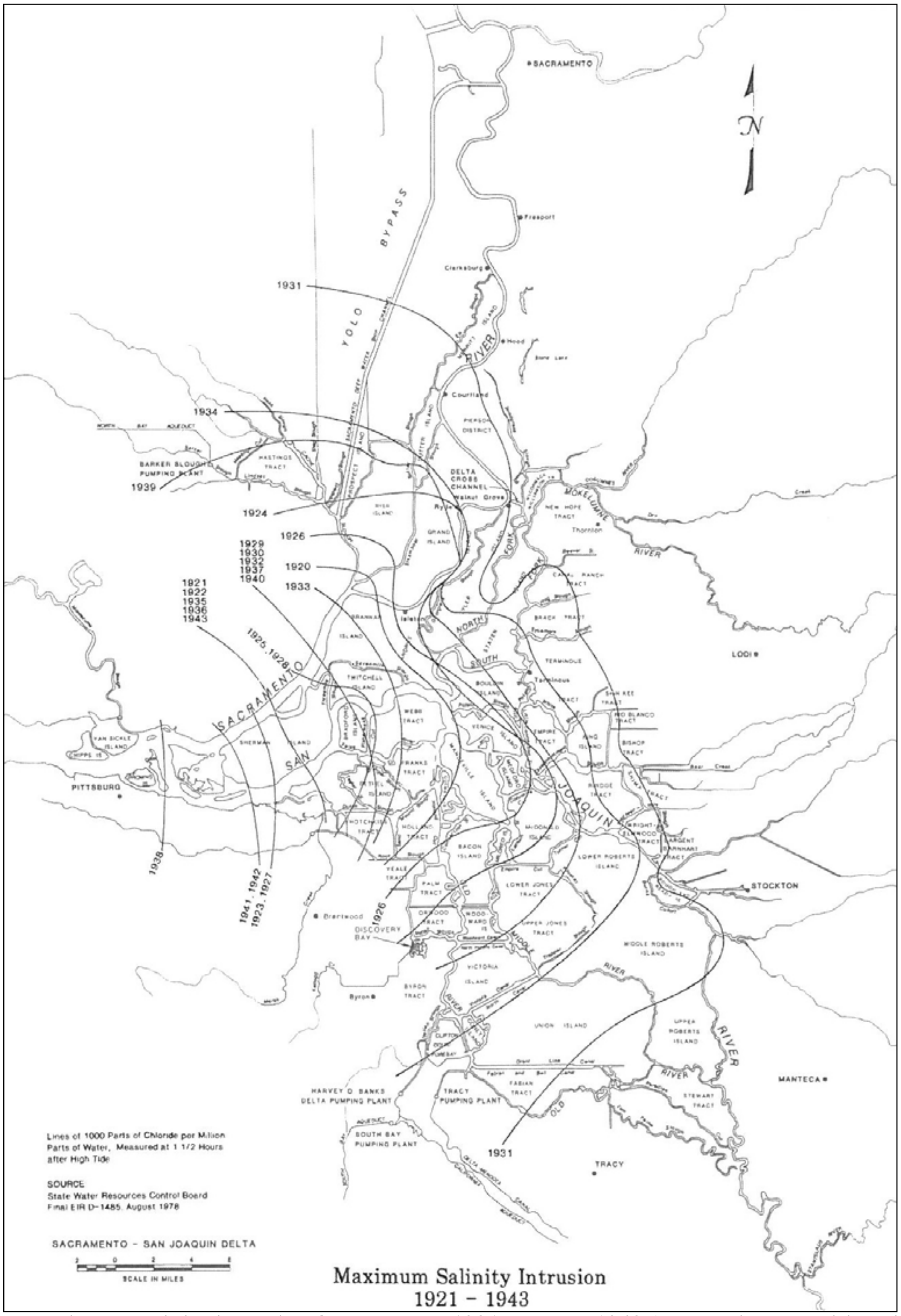


Figure 5-27. Maximum salinity intrusion for the years 1921 through 1943 (Pre-project conditions in Central Valley –Shasta and Friant Dams non-operational; Sacramento-San Joaquin Delta Atlas, DWR).

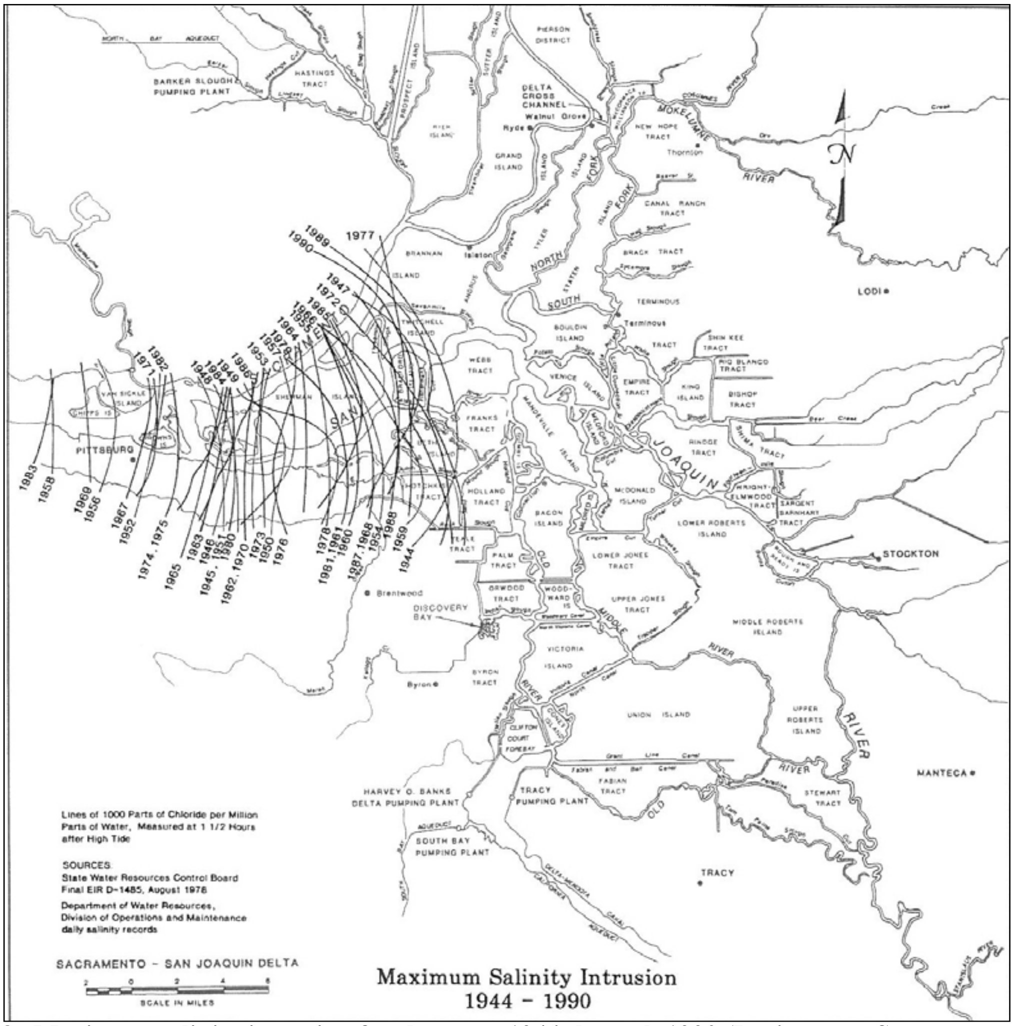


Figure 5-28. Maximum salinity intrusion for the years 1944 through 1990 (Project era; Sacramento-San Joaquin Delta Atlas, DWR).

The North Delta is primarily fed by the Sacramento River, which feeds into the Delta below the community of Freeport in Sacramento County. During high flow events, the Yolo bypass redirects flood flows southwards through the flood bypass, around the reach of the Sacramento River that flows through the City of Sacramento, before discharging the water into Cache Slough near the southern tip of Liberty Island. Downstream of Freeport, small natural channels branch off of the main channel of the Sacramento River and head southwesterly through the north Delta. Although smaller, these channels carry a substantial proportion of the Sacramento River's discharge through several farmed Delta Islands towards the Cache Slough region. Together, Sutter and Steamboat sloughs can convey approximately 35 percent of the Sacramento River's flow at Freeport when the Delta Cross channel gates are open and approximately 45 percent when the gates are closed (Burau *et al.* 2007 appendix A). Elk Slough branches off of the mainstem Sacramento River near the town of Clarksburg and flows in a southwesterly direction, separating Merritt Island from Prospect Island. Its connection to the mainstem Sacramento River is through gated culverts, which are operated on an as needed basis. Typically they are closed. Sutter Slough is the next channel that splits from the Sacramento River near Courtland and flows southwesterly between Sutter Island and Prospect Island. It picks up Elk Slough shortly after branching off of the Sacramento River. Miner Slough branches off of Sutter Slough at the Northern tip of Ryer Island and flows along the western side of Ryer Island, separating it from Prospect Island. Farther downstream past the community of Painterville, Steamboat Slough branches off of the Sacramento River and travels in a southwesterly direction between Sutter and Grand Islands. Miner Slough discharges into Cache Slough near the entrance to the Sacramento DWSC. Sutter Slough joins Steamboat Slough at the southern tip of Sutter Island and the slough eventually terminates between Cache Slough and the mainstem Sacramento River between Ryer Island and Grand Island (see figure 5-23). The waterways in this region are still tidally influenced and water levels rise with the incoming tide. Flow velocity drops with the corresponding increase in tidal stage, particularly during low flow conditions. Below the confluence of Cache Slough, Steamboat Slough, and the Sacramento River, the main river channel becomes much wider and deeper, partially due to the commercial shipping channel that leads to the Port of Sacramento. Tidal influence is strong in this portion of the North Delta near Rio Vista.

The mainstem of the Sacramento River below the mouth of Steamboat Slough carries the main flow of water southwards into the Delta. Near the town of Walnut Grove, two channels bifurcate from the main Sacramento River channel and flow southwards. The first is an artificial channel, the DCC, constructed in 1953 to transport high quality freshwater from the Sacramento River into the interior Delta (CALFED 2001). Two radial gates are positioned at the head of the channel to block off flow into the channel as needed. When the gates are open, the channel conveys Sacramento River water into Snodgrass Slough and subsequently into the Mokelumne River system. Burau *et al.* (2007) estimated that when the DCC gates are open, approximately 45 percent of the Freeport flow is redirected into the Delta interior through the DCC and Georgiana Slough. This water eventually discharges into the San Joaquin River near RM 22 and is then available to be drawn southwards towards the CVP and SWP pumps in the South Delta. When the radial gates are open, the net water flow moves southwards in the DCC, and into Snodgrass Slough and the Mokelumne River system. This channel however, is still influenced by river and tidal flow and oscillations in flow velocity and stage are tidally driven on a daily basis. Tidal stage and river flow also determine the magnitude and timing of river flows that enter into the DCC from the Sacramento River (Horn and Blake 2004). Maximum flows in the DCC are seen during the incoming flood tide when increasing downstream stage redirects the flow of Sacramento River water into the mouth of the DCC. This physical condition greatly influences the probability of juvenile salmonids entering the DCC channel when the gates are in their open configuration.

When the radial gates of the DCC are closed, flows through the cross channel are prevented and hydraulics in the Sacramento River are altered. With the DCC gates closed, water remains in the main channel of the Sacramento River. Flows increase in Sutter and Steamboat sloughs upstream of the location of the DCC (35 percent of Freeport flows in the open configuration to 45 percent in the DCC closed configuration). Water remaining in the main channel of the Sacramento River flows downstream until it encounters the mouth of Georgiana Slough. Georgiana Slough is a natural channel, which is also located on an outside bend of the Sacramento River. On average, approximately 15 to 20 percent of the natural flow of the Sacramento River (as measured at Freeport) is redirected into Georgiana Slough, depending on tides, river flows, and the status of the DCC gates. As explained previously, percentages of redirected flow into Georgiana Slough can be much higher during flood stages of the incoming tide, compared to ebb tidal situations. Flows move in a net southerly direction within Georgiana Slough towards the interior of the Delta, although tidal patterns may create periods of upstream flow in the channel during flood tides. Water moving down Georgiana Slough eventually discharges into the lower portion of the Mokelumne River before the combined flows enter the San Joaquin River at RM 22. At this point, depending on flows in the San Joaquin River and the diversion rates of the combined CVP and SWP pumping facilities, a significant portion of the Sacramento River water that entered Georgiana Slough can move southwards through either the Old River or Middle River channels towards the pumps. When pumping rates are low, or the flows in the San Joaquin River are high, "Sacramento River" water will be pushed westwards in the San Joaquin River mainstem and out of the Delta rather than moving southwards towards the pumps.

The Central Delta is roughly regarded as those waterways surrounding the San Joaquin River from Stockton westwards to Webb Tract and Twitchell Island. These waterways include the mainstem of the lower San Joaquin River itself, the lower Mokelumne River complex and its associated waterways (*i.e*., Potato, Disappointment, and Fourteenmile sloughs as well as other channels) and the lower reaches of Old River and Middle River with their interconnecting waterways and channels. Under natural hydrological conditions, net flow in these channels would always have been in a downstream direction towards the ocean. Those waterways to the north of the San Joaquin River would have had a net southerly flow until they entered the San Joaquin River, after which net flows would have been westward towards Suisun Bay. Likewise, net water movement in channels to the south of the San Joaquin River would have flowed northwards to the main river channel and thence towards the ocean. Overlying this net seaward flow would have been a bidirectional tidal signature. Under current project conditions, net flow in many of these channels is towards the pumps, particularly when river flows are low and pumping rates are high.

Water flow patterns in the South Delta are also determined by the water diversion actions of the CVP and SWP, and the operations of the seasonal temporary barriers, as well as tides and river inflows to the Delta. Under natural conditions with no pumping, water flows downstream in a net positive direction towards the ocean. Under current conditions, the flow patterns have become much more complex. When pumping rates are high at the project facilities, water is drawn towards the two points of diversion, *i.e.*, the SWP's Clifton Court Forebay and the CVP's Tracy intake. Water moves downstream through the Head of Old River and through the channels of Old River and Grantline/ Fabian-Bell Canal towards the pumps. Conversely, water to the north of the two facilities' diversion points moves southwards (upstream) and the net flow is negative. This pattern is further complicated when the temporary barriers are installed from April through November, and internal reverse circulation is created within the channels isolated by the barriers from the rest of the South Delta (discussed later in the Temporary Barriers Section). These conditions are most evident during late spring through fall when river inflows are lower and water diversion rates are high. Dry hydrological years also exacerbate the loss of net downstream flows in the South Delta.

The western Delta is less affected by the actions of the projects due to their downstream location. Typically, net flows in this region of the Delta are positive and flow towards the ocean.

However, under certain conditions, such as low Delta outflow during the summer and fall, high export pumping rates, and negative QWEST (a measurement of flow in the western Delta), particle tracking models have demonstrated that a significant portion of the water in the west Delta can be drawn to the pumps over a period of 10 to 30 days. Water originating in the Sacramento River can be entrained into the lower reaches of the San Joaquin River and be redirected upstream towards the pumps. Water enters the San Joaquin River system from both Three Mile Slough near Decker Island, Sherman Lake (the flooded island at the western terminus of Sherman Island), and through Broad Slough (the confluence of the San Joaquin River with the Sacramento River) farther downstream. Strong tidal influence can then push the water upstream into the zone of influence created by the project's pumping actions near the mouth of Old River and the waterways passing through Franks Tract (False River and Fisherman's Cut).

5.6.3 Future Baseline Excluding CVP/SWP Effects

The Delta is likely to continue experiencing reduced habitat value within the waterways of the Delta due to the ongoing habitat modifications created by the construction and maintenance of the armored levees. The construction of the levees has resulted in the loss of riparian zones and shallow water habitat adjacent to the levees. The placement of rock riprap prevents the establishment of riparian vegetation, particularly woody vegetation. This inherently reduces the incorporation of large woody material from downed trees and brush into the channel margins, and the "armored" levee banks reduce the ability of LWD to become lodged along the banks during high water events when LWD enters the system from upstream. Levees also prevent the rivers from having any connection with the adjacent historical floodplains and, thus, reduce the input of allochthonous material from the upland areas and eliminate the availability of rearing habitat during high water episodes. Levees also enhance the loss of fringing marshlands and emergent vegetation by reducing the shallow water margins along the channels to a narrow band.

Predation of juvenile listed salmonids and green sturgeon will continue at an unknown level due to the presence of native and non-native species present in the Delta ecosystem. Interactions with non-native species will continue. The infestation of Delta waterways with non-native plants such as *Egeria densa* and water hyacinth is likely to continue, unless changes in chemical and biological parameters change to reduce the biomass of these plants (*e.g.*, increased salinity intrusions). The presence of invasive species such as Asian overbite clams, non-native copepods, and non-native gobies is likely to continue.

The discharge of contaminants into Delta waters from urban and agricultural sources is likely to continue into the future. The perimeter of the Delta region is becoming more urbanized, which increases the likelihood of urban discharges entering the Delta waterways. Likewise, regional agriculture will continue to discharge agricultural return waters from irrigation practices into surrounding waterways, which eventually flow into Delta waters. The continued subsidence of Delta islands and the predicted increase in sea level height will place additional pressure on agriculture within the Delta region proper. Many islands are 10 to 20 feet below sea level and, without pumping the soils, would eventually become saturated. Farmers must continue to pump water from the irrigation return ditches on their lands to keep Delta water from seeping in from the surrounding waterways. This practice carries chemicals used on the fields into the irrigation return water and eventually into the Delta.

Entrainment of fish, zooplankton, and phytoplankton by agricultural water diversions not associated with CVP/SWP operations will continue into the future. Screening of all agricultural water diversion intakes in the Delta would be necessary to reduce or eliminate the entrainment of fish due to these diversions. Larger regional water intakes, such as the City of Stockton water intake on Empire Tract, will continue to divert water for consumptive use in the future. These facilities are screened to prevent entrainment of fish.

In support of commercial shipping in the Delta, continued dredging of the Stockton DWSC and the Sacramento Ship Channel will continue into the future. Effects associated with dredging include noise, resuspension of sediments and any associated contaminants and potential entrainment into the dredger head will continue. Impacts to listed salmonids and green sturgeon and their habitats associated with shipping activities, including pollution from shipping, introduction of non-native species via ballast water discharges, ship strikes, and propeller entrainment, are likely to continue.

Recreational boating in the Delta will continue into the future. Impacts to listed salmonids and green sturgeon and their habitats associated with recreational boating, including the installation of boat docks and pilings, noise from boat engines, pollutants (engine combustion byproducts, spilled fuel, refuse, *etc.*), increased turbidity from wakes, increased shore erosion, and the fragmentation of invasive water plants such as *E. densa* that increase the spread of the plant, are likely to continue.

The TBP involves the temporary placement of rock barriers in four separate locations in the South Delta on a seasonal basis that coincides with the agricultural irrigation season, typically running from April through November. This program has been in place since 1991. The temporary rock barriers installed in Old River near Tracy, Middle River near Victoria Canal, Grant Line Canal near the Tracy Boulevard Bridge, and at the Head of Old River. In 2008, NMFS completed formal consultation by issuing a biological opinion for the installation of the barriers through the end of 2010. That consultation was reinitiated based on a change in action to implement a non-physical barrier project. NMFS completed the formal consultation and issued a biological opinion on April 3, 2009 (NMFS 2009). Based on NMFS' analysis, the TBP would likely result in: changes to flow patterns in the South Delta, increasing the potential for migrational delays in conjunction with the barriers placement; hydraulic conditions that will impede free passage of fish through the channels of the South Delta; entrainment of a proportion of the fish that remain in the mainstem of the San Joaquin River into the channels leading southwards under the influence of the CVP/SWP water diversion pumps; increasing the risk of predation on juvenile listed salmonids and green sturgeon; and impacts to the functioning of the South Delta waterways as critical habitat for steelhead and green sturgeon by impacting the value of the channels for migration and rearing. A complete analysis of the effects of the TBP is provided in NMFS (2009).

5.7 Southern Resident Killer Whales

All of the categories of human activities discussed in the *Status of the Species* section (section 4.2.5.3) have contributed to the current status of Southern Residents within the action area. The following discussion summarizes the principal human and natural factors within the action area (other than the proposed action) that affect the likelihood that Southern Residents will survive and recover in the wild.

5.7.1 Natural Mortality

Seasonal mortality rates among Southern and Northern Residents are believed to be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk *et al*. (2005) identified high neonate mortality that occurred outside of the summer field research seasons. At least 12 newborn calves (9 Southern Residents and 3 Northern Residents) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whales in Washington and Oregon (Norman *et al*. 2004). Southern Residents strandings in coastal waters offshore include three separate events (1995 and 1996 off of Northern Vancouver Island and the Queen Charlotte Islands, and 2002 offshore of Long Beach, Washington State), and the causes of death are unknown (NMFS 2008a).

In recent years, sighting reports indicate anecdotal evidence of thin Southern Residents returning to inland waters in the spring. For example, in March 2006, a thin female from the Southern Residents population (L54) with a nursing calf was sighted off Westport, Washington. The sighting report indicated she had lost so much blubber that her ribs were showing under the skin (Cascadia Research Collective 2008).

The official 2008 census for Southern Residents was 85 whales (annually conducted and reported by The Center for Whale Research, down from 87 whales in 2007). After the official census, two additional whales were observed missing. However, a whale is not declared dead until found missing in the following year during the census. In total, seven Southern Residents were declared dead or suspected missing in the current year (Balcomb 2008). None of these whales were recovered and cause of death is unknown. Two of the seven were calves that by convention had not been counted as part of the population prior to their deaths. Death of calves is not unusual. Two of the mortalities were old whales (K7 and L21, 98 and 56 years old, respectively), and mortality in this age group is not surprising. The remaining dead or declared missing whales were in age groups with typically low mortality. Two were reproductive females (J11 and L67, 35 and 32 years old, respectively). It is more unusual to see mortality of reproductive females. One was a sub-adult male (L101, 5 years old). However, L101's death may have been related to the condition of L67 (mother of L101). Reportedly, L67 did not look well (identified as a thin whale during aerial survey, Durban 2008) when last seen in September.

5.7.2 Human Related Activities

5.7.2.1 Prey Availability

Based on persuasive scientific information that Southern Residents prefer Chinook salmon in inland waters (see further discussion in section 4.2.5.3.1), Southern Residents may also prefer Chinook salmon when available in coastal waters of the action area. This analysis therefore focuses on Chinook salmon abundance in coastal waters. Focusing on Chinook salmon provides a conservative estimate of potential effects of the proposed action on Southern Residents, because the total abundance of all salmon and other potential prey species is orders of magnitude larger than the total abundance of Chinook salmon.

When prey is scarce, whales must spend more time foraging than when it is plentiful, leading to increased energy expenditure and decreased fitness, which can result in relatively lower reproductive rates and relatively higher mortality rates. Food scarcity would cause whales to draw on fat stores, mobilizing contaminants stored in their fat. It is uncertain to what extent long term or more recent declines in salmon abundance contributed to the decline of the Southern Residents DPS, or whether current levels are adequate to support the survival and recovery of the Southern Residents (more details are available in the section 4.2.5.3.1, which discusses the correlative relationships between Southern Residents survival and fecundity and Chinook salmon abundance).

The availability of Chinook salmon to Southern Residents is affected by a number of natural and human actions. Details regarding baseline conditions of those Chinook salmon affected in the action area that are listed under the ESA are described above in this section. As discussed above, adult salmon are affected by fisheries harvest in fresh and marine waters, dams that impede passage, other habitat modifications, and poor water quality. In addition, climate effects from PDO and the ENSO conditions and events cause changes in ocean productivity which can affect natural mortality of salmon, as described in more detail in section 4.2.4.11. Predation in the ocean also contributes to natural mortality of salmon. Salmonids are prey for pelagic fishes, birds, and marine mammals (including Southern Residents).

NMFS has previously consulted on the effects of fishery harvest actions on Southern Residents, including 10-year terms of the Pacific Salmon Treaty (term of biological opinion from 2009-2018, NMFS 2008) and the *United States v. Oregon* 2008 Management Agreement (term of biological opinion from 2008-2017; NMFS 2008d), and the Pacific Coast Salmon Plan fisheries (NMFS 2009a). These are abundance-based harvest programs that allow for increased harvest when runs are abundant and reduced harvest when runs are lower. The Pacific Salmon Treaty and Pacific Coast Salmon Plan harvest programs will reduce Chinook salmon prey available to Southern Residents in any given year. NMFS analyzed the likely reductions based on good and poor years of Chinook salmon abundance, in both the coastal range of the whales and inland waters of Puget Sound. For Pacific Salmon Treaty fisheries, in 6 out of 12 cases (years and locations), using the most conservative assumptions about the whales' prey needs and preferences, the reductions are less than 2 percent of the Chinook salmon that would otherwise have been available to the whales. In 10 out of 12 cases they are less than 5 percent. The greatest reduction of 10.5 percent occurs in coastal waters, July to September, during good Chinook salmon years. For Pacific Coast Salmon Plan fisheries, which were included as part of the Pacific Salmon Treaty analysis, in 7 out of 12 cases (years and locations), using the most conservative assumptions about the whales' prey needs and preferences, the reductions are less than 1 percent of the Chinook salmon that would otherwise have been available to the whales. In 10 out of 12 cases they are less than 2 percent. The greatest reduction of 6.2 percent occurs in coastal waters, July to September, during good Chinook salmon years. The largest reductions in both cases occur when the ratio of prey available compared to prey needed is relatively large. Under the *United States v. Oregon* Agreement, harvest occurs in the Columbia River and does not affect short-term availability of the whales' prey. In the long term, NMFS concluded that all three of these harvest actions allow sufficient escapement of spawning adults to meet the conservation objectives of listed and unlisted harvested stocks.

We have also previously consulted on the effects of hydro-power dams and flood control programs on Southern Residents (NMFS 2008g, NMFS 2008h). in the action area. As part of the proposed action for the Federal Columbia River Power System and the Willamette Flood Control Program, action agencies proposed funding hatchery programs in addition to their proposals for dam operations and maintenance. For both programs, the proposed actions did not result in a net decrease in Chinook salmon prey for Southern Residents in the short term. To mitigate for the harmful effects of hatchery production on long-term Chinook salmon viability (and thus killer whale prey availability) the action agencies committed to a schedule of future hatchery reforms.

5.7.2.2 Prey Quality

Contaminants enter marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by Southern Residents in marine habitats. Chinook salmon contain higher levels of some contaminants than other salmon species, but only limited information is available for contaminant levels of Chinook salmon along the west coast (Krahn *et al*. 2007). As discussed in the *Status of the Species* section, recent studies have documented high concentrations of PCBs, DDTs, and PBDEs in killer whales (Ross *et al*. 2000, Ylitalo *et al*. 2001, Reijnders and Aguilar 2002, Krahn *et al*. 2004). Killer whales accumulate and store the contaminants in their blubber when they consume contaminated prey. The whales can metabolize their blubber when prey is scarce, which mobilizes and redistributes the contaminants to other tissues, increasing risk of immune or reproductive effects during weight loss from reductions in prey (Krahn *et al*. 2002).

5.7.2.3 Vessel Activity and Sound

Commercial, military, recreational and fishing vessels traverse the coastal range of Southern Residents. Vessels may affect foraging efficiency, communication, and/or energy expenditure by their physical presence and by creating underwater sound (Williams *et al*. 2006, Holt 2008). Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality. Large ships that traverse coastal waters of the whales' range move at relatively slow speeds and are likely detected and avoided by Southern Residents.

Vessel sounds in coastal waters are most likely from large ships, tankers and tugs. Sound generated by large vessels is a source of low frequency (5 to 500 Hz) human-generated sound in the world's oceans (National Research Council 2003). While larger ships generate some broadband noise in the hearing range of whales, the majority of energy is below their peak hearing sensitivity. At close range large vessels can still be a significant source of background noise at frequencies important to the whales (Holt 2008). Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (National Research Council 2003). Frequencies fall between 1 and 500 kHz, which is within the hearing range of some marine mammals, including killer whales, and may have masking effects.

5.7.2.4 Non-Vessel Sound

Anthropogenic (human-generated) sound in the range of Southern Residents is generated by other sources besides vessels, including oil and gas exploration, construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (*e.g.*, hearing, echolocation, communication).

In-water construction activities are permitted by the Corps under section 404 of the CWA and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval program. Consultations on these permits have been conducted and conservation measures have been included to minimize or eliminate potential effects of in-water activities, such as pile driving, on marine mammals. Military sonar also has the potential to disturb killer whales.

5.7.2.5 Oil Spills

Oil spills have occurred in the coastal range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Numerous oil tankers transit through the range of Southern Residents throughout the year. The magnitude of risk posed by oil discharges in the action area is difficult to precisely quantify, but improvements in oil spill prevention procedures since the 1980s likely provide some reduced risk of spill.

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes negative effects; however, long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Geraci and St. Aubin 1990). In addition, oil spills have the potential to negatively impact habitat and prey populations, and, therefore, may negatively affect Southern Residents by reducing food availability.

5.7.2.6 Scientific Research

Although research activities are typically conducted between May and October in inland waters, some permits include authorization to conduct research in coastal waters. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. In 2006, NMFS issued scientific research permits to seven investigators who intend to study Southern Residents (NMFS 2006). Additionally in 2008, NMFS issued another scientific permit to one investigator intending to study Southern Residents (NMFS 2008i). In the biological opinions NMFS prepared to assess the impact of issuing the permits, we determined that the effects of these disturbances on Southern Residents were likely to adversely affect, but not likely to jeopardize the continued existence of, the Southern Residents (NMFS 2006, 2008i). A small portion of the authorized take would occur in the coastal range of Southern Residents.

5.7.2.7 Recovery Planning

The final recovery plan for Southern Residents was issued in January 2008 (NMFS 2008a). Implementation of the Southern Residents recovery plan is currently in progress. To date, recovery planning and implementation has incorporated a range of actions, including additional scientific research to better understand threats to recovery, and directed actions to reduce the risk associated with identified threats. Actions that reduce the risk associated with identified threats will benefit Southern Residents. Additionally, recovery planning for salmon will benefit Southern Residents, where actions improve the quantity and quality of prey available to Southern Residents.

5.7.3 Summary of Southern Residents Environmental Baseline

Southern Residents are exposed to a wide variety of past and present state, Federal or private actions and other human activities in the coastal waters that comprise the action area, as well as Federal projects in this area that have already undergone formal section 7 consultation, and state or private actions that are contemporaneous with this consultation. All of the activities discussed in the above section are likely to have some level of impact on Southern Residents when they are in coastal waters of their range.

No single threat has been directly linked to or identified as the cause of the recent decline of the Southern Residents, although the three primary threats are identified as prey availability, environmental contaminants, and vessel effects and sound (Krahn *et al*. 2002). Researchers are unsure about which threats are most significant. There is limited information on how these factors or additional unknown factors may be affecting Southern Residents when in coastal waters. For reasons discussed earlier, it is possible that two or more of these factors may act together to harm the whales. The small size of the population increases the level of concern about all of these risks (NMFS 2008a).

6.0 EFFECTS OF THE PROPOSED ACTION

6.1 Approach to the Assessment

Section 2 of this Opinion describes our approach to analyzing the effects of the action. The primary information used in this assessment include the list of resources provided in section 2.4, fishery information described earlier in the "Status of the Species and Critical Habitat" and "Environmental Baseline" sections of this Opinion; studies and accounts of the impacts of water diversions on anadromous species; and documents prepared in support of the proposed action.

The analysis of effects on Southern Residents considers the short- and long-term effects of CVP/SWP operations on naturally- and hatchery-produced Chinook salmon. The analysis of effects begins by utilizing the analysis of effects on winter-run and spring-run. For short-term effects, NMFS analyzed the effects of the action on naturally- and hatchery-produced Chinook salmon in the Central Valley, and also the production of hatchery-produced Chinook salmon at Nimbus Fish Hatchery and Trinity River Fish Hatchery. For the long-term effects, NMFS considers the sustainability of hatcheries in the production of Chinook salmon.

6.2 Clear Creek and Whiskeytown Dam

6.2.1 Deconstruct the Action

In order to understand the action, certain assumptions have been made (see table 2-3). The assumption for Clear Creek is that the Trinity River Division will continue operations as modeled. As stated in section 1.5.1, NMFS will analyze the effects of the Trinity River Division portion of the proposed action on SONCC coho salmon in a separate biological opinion. All of the water diverted from the Trinity River (1.2 MAF annually), plus a portion of Clear Creek flows (*i.e.*, the flows entering above Whiskeytown Lake) is diverted through the Spring Creek Power Conduit to Keswick Reservoir. Therefore, this section only addresses that portion of the Trinity River Division that is diverted through Whiskeytown Reservoir and becomes a part of the Clear Creek releases. Due to the diversions of Trinity River water, flows are greater during parts of the year and temperatures are cooler than what was present in Clear Creek prior to the construction of Whiskeytown Dam (section 5.2.3, figure 5-5). There is no temperature control device (TCD) on Whiskeytown Dam (however, there is a temperature control curtain that reduces mixing of cold water near the dam). Therefore, water temperature can only be controlled by changing releases.

Reclamation's operations follow the CVPIA AFRP guidelines (USFWS 2001) which, for Clear Creek, are: "200 cfs October 1 to June 1 from Whiskeytown dam for spring-run, fall-run, and late fall-run salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; and release 150 cfs or less, from July through September to maintain < 60°F temperatures in stream sections utilized by spring-run Chinook salmon." Until a Fishery Management Plan is developed, Reclamation proposes an adaptive management approach to higher releases during the summer, which involves recommendations from the Clear Creek Technical Team and the B2 Interagency Team.

The USFWS is currently conducting an IFIM flow study to determine the habitat suitability of the current release pattern for rearing juvenile salmon and CV steelhead. Given the small size of Clear Creek, the flows are comparable to the Stanislaus River, which supports far fewer CV steelhead and fall-run.

6.2.2 Assess Species Exposure

The purposes of this analysis are to define the temporal and spatial co-occurrence of spring-run and CV steelhead life stages and their stressors associated with the proposed project. First we identify the life stages and associated timings for spring-run and CV steelhead in Clear Creek.

Adult CV steelhead immigration into Clear Creek usually occurs from August through March with a peak occurring from September to November (USFWS 2008). Steelhead adults tend to hold in the upper reaches of Clear Creek from September to December, when spawning starts, and goes through early March. Peak spawning occurs from late January to early Febraury (USFWS 2007). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through April.

For spring-run, adult emigration into Clear Creek occurs from April through September. Over summer holding occurs from May through September. Spawning begins in September through October. Egg incubation occurs from September through December. Juveniles rear from October through April.

The second step in assessing spring-run and CV steelhead exposure is to identify the spatial distribution of each life stage. Adult CV steelhead hold and spawn from Whiskeytown downstream to RM 3 in the lower reaches (USFWS 2007, figure 5-1). Spawning is spread out and expands downstream where adults can find suitable areas of newly augmented gravels. The juvenile life stage occurs throughout the entire river, with rearing generally occurring near spawning areas.

Adult spring-run tend to move as far upstream as possible to access cooler temperatures below Whiskeytown Dam, then spread downstream prior to spawning. Juvenile spring-run emigration in Clear Creek appears to be as YOY only, as identified in RSTs from May through December (USFWS 2008). Peak emigration occurs in November and December before the start of juvenile fall-run emigration. Trap data indicates that 93 percent of the juveniles identified as spring-run leave as fry, measured at 30-39 millimeters (USFWS 2008).

The last step in assessing spring-run and CV steelhead exposure is to overlay the temporal and spatial distributions of proposed action-related stressors on top of the temporal and spatial distributions of Clear Creek spring-run and CV steelhead. This overlay represents the completed exposure analysis and is described in the first three columns of tables 6-1 and 6-2.

6.2.3 Assess the Species Response

This section will assess how spring-run and CV steelhead in Clear Creek will likely respond to the proposed action-related stressors. Life stage-specific responses to specific stressors related to the proposed action are summarized in the last two columns of tables 6-1 and 6-2 and described in detail below.

Table 6-1. Summary of proposed action-related effects and responses on Clear Creek spring-run.

Life Stage/ Location	Life stage Timing	Stressor	Response	Probable fitness reduction
Adult immigration,	April - July	Smaller spawning area due to temperature management down to Igo Gage and physical barrier at fish weir	Introgression/hybridization w/fall-run; density dependency effects & redd superimposition; limited carrying capacity of stream will dictate population size, possible loss of some individuals that spawn below Igo TCP, or come in late and spawn below weir with fall-run	Reduced reproductive success and reduce survival
Adults, immigration	same	Lack of attraction flows	Fail to migrate far enough upstream to avoid unsuitable temperatures while spawning	
Adults, holding	May - August	Temp > 60ºF during summer holding period	None expected - temp control to Igo; possibly some pre-spawn mortality in critically dry years when not enough cold water in Whiskeytown Lake	Reduced reproductive success
Adults, spawning	Sept - Oct	Loss of spawning gravel below Whisketown Dam	Reduced spawning areas; spawning success diminishes	Reduced reproductive success
Adults, spawning	Sept - Oct	Temp > 56ºF during spawning, due to low flow conditions	Loss of eggs and sac-fry; fewer juveniles survive	Reduced reproductive success
Egg incubation	Sept - Dec	Exposure to temp. > 56ºF in September only for fish that spawn below TCP	Mortality varies with exceedance rate and number of redds; loss of some portion of those eggs	Reduced reproductive success
Juvenile rearing	October-April	Exposure to temp. > 65ºF during rearing period	Truncated emigration timing, reduced survival; poor in-river survival, reduced numbe of juveniles produced	Reduced survival and growth

All modeled runs assume the use of CVPIA b(2) water would continue into the future. In critically dry years, modeled releases decrease to 40 to 70 cfs from October through May, but would not be significant because they occur during the winter. Releases in dry years (*i.e.*, 20 percent probability of occurring) in June drop to 100 cfs, which may impact the ability to control water temperatures. Low flows in June would be expected to limit the space available to juvenile CV steelhead and Chinook salmon that are rearing in Clear Creek. However, since water temperatures have been maintained at lower flows in July and August (*i.e.*, typically 85 cfs in recent years), low flows in June of 100 cfs are not expected to cause significant temperature related effects.

Table 6-2. Summary of proposed acton-related effects and responses on Clear Creek steelhead.

Life Stage/ Location	Life stage timing	Stressor	Response	Probable fitness reduction
Adults	August - March	Water temp. > 65ºF for migration rarely occurs due to temp. control at Igo, possible in lower reach near confluence with Sacramento River during August and September	Some adults may not enter mouth of Clear Creek, 1) delayed run timing, 2) seek other tributaries, 3) spawn in mainstem Sac. R.	Reduced reproductive success
Adults	Dec - March	Lack of adequate spawning gravels	Adults spawn in same areas, greater competition for suitable sites	Reduced reproductive success
Adults	April -June	Lack of channel forming flows due to presence of dam, reduces gravel transport	Less diversity, adults tend to spawn in same areas every year, reduced egg and fry production, competition for redd sites with other species (fall/late fall-run)	Reduced reproductive success
Egg incubation	Dec - March	Water temp. < 56ºF during spawning and incubation	Late hatch, lower growth rate to fry stage	None expected
Juvenile rearing	May - Sept	Low summer flows (< 80 cfs)	Higher water temp., less food, less space, less growth, > predation	Reduced survival
Smolts	same	High water temps > 60ºF in July and August	Move to cooler areas, perish, or more likely to be predated upon	
all stages	adults August - March, juveniles all year	Nimbus Fish Hatchery releases steelhead juveniles into the river as mitigation for loss habitat above Folsom Dam	Hatchery smolts compete with wild fish for food and space in river, also cause wild fish to immigrate at same time (Pied Piper effect), increased straying rate	Reduced fitness, reduce growth rates of wild fish

The higher flow rates [in part due to the additional water provided through b(2)], along with channel restoration, McCormick-Saeltzer Dam removal, and gravel augmentation have lead to increasing populations of spring-run (figure 5-2) and CV steelhead (figure 5-3) in Clear Creek. It is uncertain how much is attributable to just the increase in flows (proposed action). Low flows and warm temperatures during 10 percent of years (critical drought year conditions) will limit steelhead and spring-run recruitment because it depends completely on cold water releases from Whiskeytown (an artifact of diverting colder water through the reservoir from Trinity River). During extended drought periods, when the cold water reserve in Whiskeytown is exhausted, temperatures could be lethal for spring-run eggs and steelhead juveniles. Flows drop to their lowest point during the summer, typically to about 85 cfs, and temperatures limit juvenile steelhead rearing. The 1986 IFIM studies found optimum rearing flows for steelhead and salmon during May through October are 300 cfs (CVP/SWP operations BA figure 5-4). Existing operations tend to flat-line flows at 200 cfs throughout the year, which reduces the habitat variability and diversity of life stages essential for survival (*i.e.*, diverse habitats and variable flows tend to buffer fish populations from changes in the environment).

6.2.3.1 Whiskeytown Releases to Clear Creek

All modeled runs in the CVP/SWP operations BA assume the use of b(2) water. Reclamation proposes to maintain flows at 200 cfs throughout the year, except during the summer months. However, CALSIM modeling (CVP/SWP operations BA figures 6.1 and 6.3) shows that slightly less than the AFRP guidelines will be released over the long-term (*i.e.*, approximately 180 cfs). Flow releases less than 200 cfs are expected to occur in 25 percent of years during steelhead upstream migration. During the driest years (4 percent of historical years modeled), the flows could drop to as low as 30 cfs without b(2) water to support releases. Historical flow studies showed optimal spawning flows for steelhead were estimated to be 87 cfs in the upstream reaches and 250 cfs for rearing downstream of the old Saeltzer Dam site (CVP/SWP operations BA). In the worst-case scenario, flows would be below 87 cfs in the upstream areas 4-5 percent of historically modeled conditions (figure 6-1). However, since steelhead spawning has currently been observed expanding throughout the 17 miles of Clear Creek (USFWS 2007a, 2008a), it is reasonable to assume that spawning habitat would be reduced by low flows more often in dry years. The CVP/SWP operations BA states that, "during dry years flows for attraction, holding, and upstream migration could be less than optimal" for steelhead on Clear Creek.

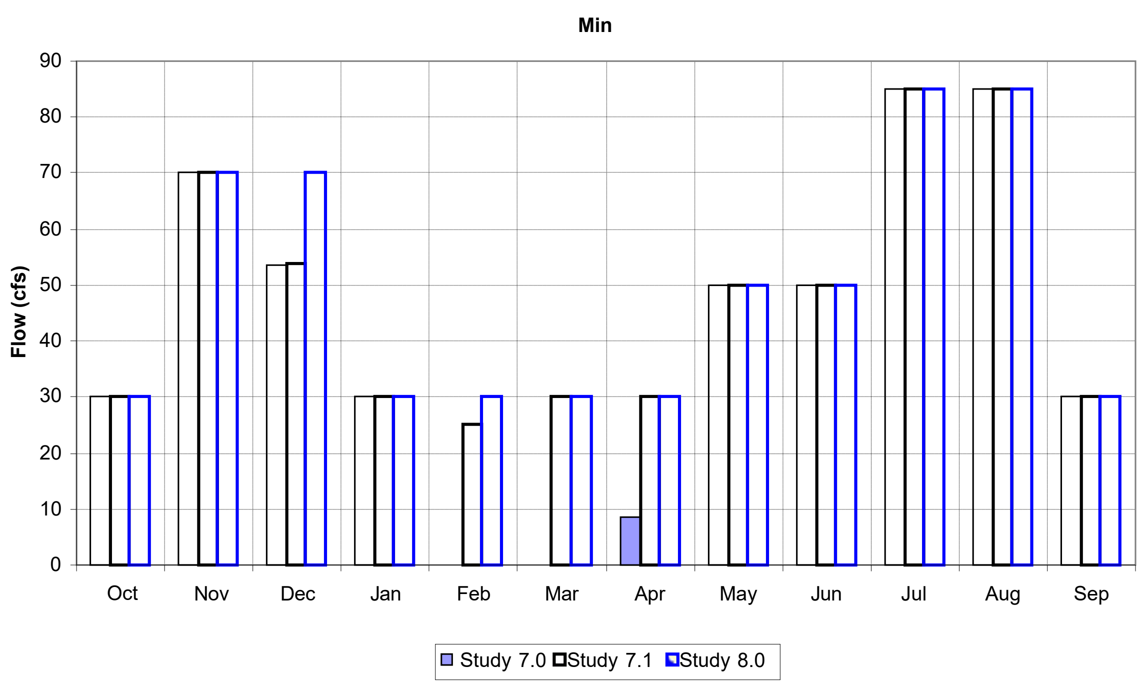


Figure 6-1. Clear Creek minimum flow conditions based on historical conditions (CVP/SWP operations BA).

Spring-run enter Clear Creek from April through September and spawn from September through October. Modeled and actual flows in July and August are 85 cfs in all years (figure 5-5 and 5-7). Flows in September would be 150 cfs, except in critically dry years when minimum flows could drop to as low as 30 cfs in 4-5 percent of historical conditions. During the driest of years, low flows would be expected to cause competition for suitable spawning sites and redd superimposition. In the past, Instream Flow Incremental Methodology (IFIM) studies based on

Physical Habitat Simulation (PHABSIM) developed for fall-run[9] estimated optimum flows in the upstream reach to be 62 cfs for spawning and 75 cfs for rearing, provided incubation and rearing temperatures were provided (CVP/SWP operations BA). Flows of 30 cfs in September during dry years would limit suitable spawning habitat and block upstream migration, since a bedrock chute limits access to the upper reaches of Clear Creek at low flow levels. Spawning attraction flows of 500 cfs were recommended by Denton (1986 *op. cit*. CVP/SWP operations BA) in October and November for fall-run. Similar attraction or pulse flows could be used in April and May to attract spring-run spawners. The interim flow schedule (CVP/SWP operations BA figure 5-4) developed for Clear Creek in the 1980s (pre-AFRP guidelines) was intended to maintain salmon and steelhead habitat until the current studies, described below, could be conducted to fine-tune the releases.

Recent IFIM studies using an improved 2-dimensional hydraulic and habitat model (RIVER2D) showed that the current AFRP guidelines are significantly limiting the amount of habitat available for spring-run spawning (Gard 2006, 2008). The RIVER2D model more accurately predicts depths and velocities over a range of flows than the traditional PHABSIM component of IFIM. In addition, RIVER2D modeling can handle complex habitat types and alternative habitat suitability criteria. Spawning habitat for spring-run salmon and CV steelhead was calculated at a range of flows from 50 cfs (minimum required) to 900 cfs (75 percent of the outlet capacity from Whiskeytown Dam) using the weighted useable area (WUA) developed from habitat suitability curves (HSCs). The HSCs are used to translate hydraulic data into indices of habitat quality. The results of the 2007 flow study indicated that flows greater than 600 cfs in the upper canyon reaches are needed from September through December to increase spring-run habitat availability and productivity (*i.e.*, based on providing 96 percent of the WUA). At the current maintenance flows (*i.e.,* 200 cfs), only 50 percent of the habitat in the upper reach, and only 30 percent of the habitat in the lower reach (to Clear Creek Road Bridge) are available for spring-run spawning. The same study found for steelhead that flows of 200 cfs achieved maximum habitat availability and productivity (*i.e*., > 91 percent of the WUA) for spawning from January through June (Gard 2008). Based on the results of these new studies, the current releases from September through June are limiting the available spawning habitat for spring-run, but are maximizing suitability for CV steelhead spawning. Although the current success of spring-run spawning does not appear to be limited by spawning habitat availability, as the number of spring-run in Clear Creek increases, the availability of spawning habitat will be limited by the lack of suitable flows, which, in turn, reduces the reproductive success of an individual and eventually results in a decrease or suppression in the population.. Additional flow studies are planned for 2009 and 2010 that evaluate juvenile rearing habitat.

Ramping rates for non-flood control releases are limited to 14-16 cfs per hour up to 600 cfs. Ramping rates for releases greater than 300 cfs must be made after consultation with the Clear Creek Technical Team, which is made up of inter-agency fisheries biologists and non-governmental organizations. Uncontrolled flood releases are made through a Glory Hole into Clear Creek. These flows have the potential to strand and/or isolate salmon and CV steelhead juveniles, but they also provide channel-forming flows that move spawning gravel that is added annually at the base of the dam as part of the restoration projects.

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[9] Fall-run are used here as a surrogate for spring-run since they have similar life history stages and temperature requirements, and specific flows requirements for spring-run are still being developed by the USFWS.

Historically, releases from Whiskeytown Dam were greater than the minimum instream flows proposed in table 6-3, until water year 1995 when the flow requirements switched to the b(2) flows, and water was being released through the spillway. Without the addition of b(2) flows throughout the year, Clear Creek flows could revert back to schedule in table 6-3, below, as described in the project description. Based on the more recent IFIM studies, minimum flows of 50 cfs in September and October (table 6-3) would not be sufficient to support water temperature objectives and instream habitat needs for spring-run spawning and incubation. For modeling purposes, CALSIM II assumed no b(2) water is available for Clear Creek when Trinity Reservoir drops below 600 TAF (worst case). This would only occur in the driest 10 percent of years (CVP/SWP operations BA figure 10-12).

Table 6-3. Minimum flow schedule at Whiskeytown Dam from 1963 USFWS proposal and 2001 CVPIA AFRP flow guideline (Appendix 1 to this Opinion table 4).

Period	1963 Minimum flow (cfs)	2001 AFRP flows (cfs)
Normal year flow:		*All water year types:*
January 1 - October 31	50	200 cfs October - June
November 1 - December 31	100	150 cfs July- September
Critical year flow:		
January 1 - October 31	30	
November 1 - December 31	70	

When not spilling through the Glory Hole, Whiskeytown Dam buffers Clear Creek from the impact of high flow events that might cause stranding and isolation of juveniles and redds. Releases typically remain at a constant rate during the majority of flood events. The probability of an uncontrolled spill from Whiskeytown Dam is 50 percent, or every other year (CVP/SWP operations BA). The reservoir also acts to spread out the change in flow rate following rapidly declining river stage.

6.2.3.2 Water Temperatures

Since 1999, mean daily water temperatures have been maintained at 60°F or less down to the USGS gage at Igo (RM 10.9) consistent with the 2004 NMFS Opinion for CV steelhead over summering requirements. Although temperatures may exceed 60°F downstream of the Igo gage, mean daily temperatures near the confluence with the Sacramento River (RM 1.7) rarely exceed 70°F (USFWS 2007a). Since 2002, Reclamation has managed releases to meet a daily average water temperature of 56°F at the Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30, to provide for spring-run spawning (figure 5-6). In 2004, an additional daily average temperature of 60°F was implemented from June 1 to September 15 to protect over-summering juvenile CV steelhead and holding adult spring-run. There is no TCD on Whiskeytown Dam, and storage capability is limited to 700 TAF. Therefore, water temperature can only be managed by controlling releases (figure 6-2).

In general, the water temperature objectives are met in each month that was modeled except from August through October, which is the spring-run spawning period. September is shown as an example because it has the lowest objective (56°F at Igo) and therefore, would be the hardest to meet (figure 6-3). For each month, there is little difference between the current operations and future conditions (Study 7.0 vs Study 8.0) because there is little change in the flows (figure 5-5). The analysis shows difficulty meeting water temperature objectives in 5 percent to 10 percent of the water years. In the more recent years, since the Trinity ROD flows have been implemented, real time operations have experienced difficulty in meeting the temperature objectives due to longer residency time in Whiskeytown Reservoir (*i.e.*, water is not transported through to Spring Creek tunnel in the volume and pattern that it used to be, causing warming). These changes in water diversion pattern indicate that the model results probably underestimated achievable water temperatures in Clear Creek. Therefore, NMFS would expect water temperatures to be exceeded more often in the future. In addition, climate change, as a future baseline stressor, will likely result in an increased reliance on Whiskeytown Dam and Shasta Dam releases for temperature control instead of Trinity River diversions. Unfortunately, the Salmon Mortality Model could not be used on Clear Creek. However, since the water temperature objective would be exceeded in September and October in 10 percent of years, NMFS would anticipate some egg mortality for spring-run during dry water years.

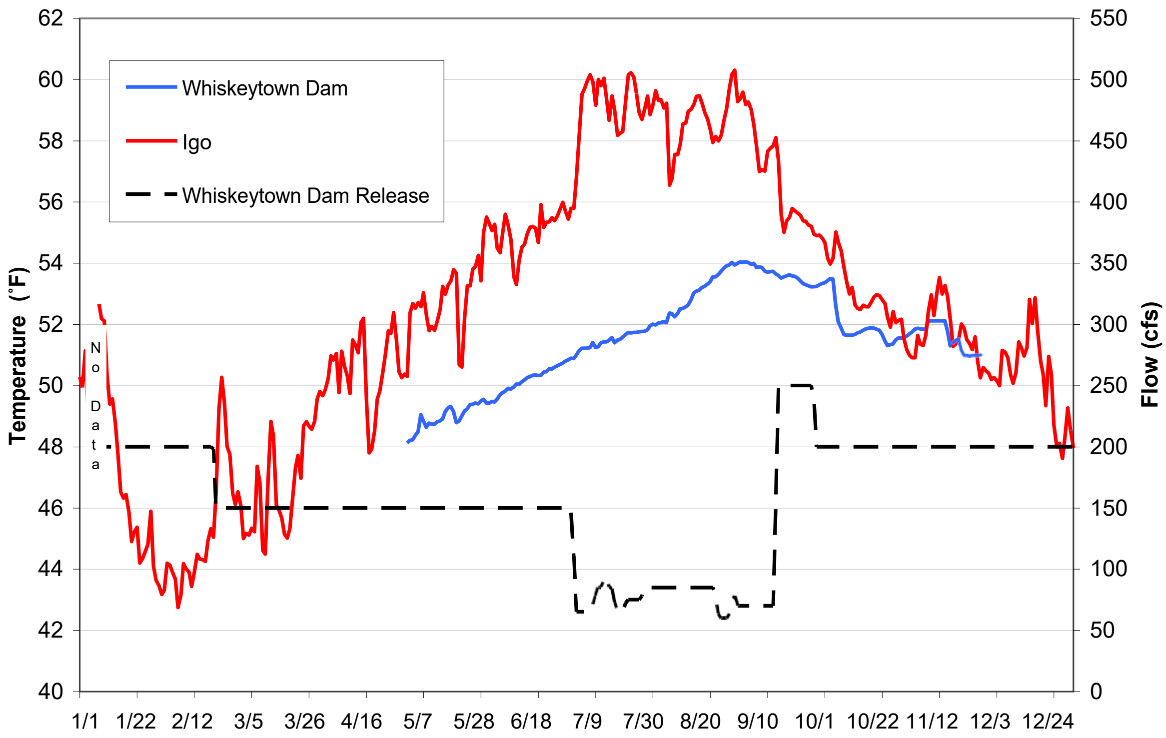

Figure 6-2. Actual Clear Creek mean daily temperatures at Igo (red), Whiskeytown (blue), and flow (dashed line) measured in 2002, a dry year (CVP/SWP operations BA figure 11-12).

Water temperature in Clear Creek is maintained with b(2) releases. Typically, flows are increased after September 15 to meet the temperature objectives in NMFS' 2004 CVP/SWP operations Opinion. In order to meet the 200 cfs flow objective, Reclamation uses approximately 60-70 TAF of b(2) water that is dedicated for upstream uses (*i.e.*, anadromous fish species are considered for primary purposes). NMFS assumes that most of the b(2) water in the future will be available for this purpose, as described in the CVP/SWP operations BA, however, there is considerable uncertainty regarding this assumption, given the new restrictions put on Delta exports by the USFWS' December 15, 2008, Delta smelt biological opinion (USFWS 2008). For example, based on the actual operations that occurred in 2008, b(2) water was used to offset Delta pumping restrictions (court ordered) and the balance of b(2) water held for upstream purposes was uncertain. Realizing this uncertainty in b(2) water, but also realizing the need for additional flows down Clear Creek, Reclamation made water available on Clear Creek through re-operations at Shasta Reservoir. It is unknown how (b)2 water will be apportioned between the Delta and upstream areas given the new USFWS RPA.

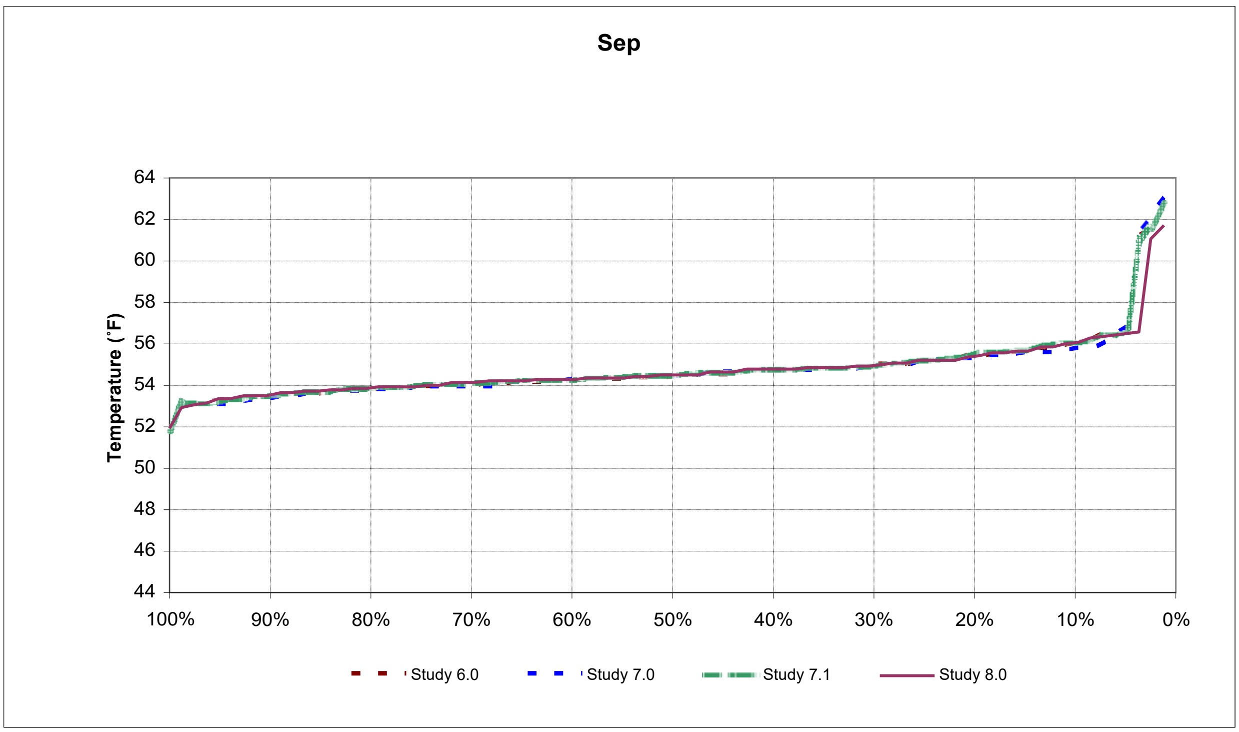

Figure 6-3. Clear Creek September water temperature exceedence plot at Igo gauge (CVP/SWP operations BA figure 10-42).

Restoration efforts have been implemented on Clear Creek to target the recovery of salmonids. These projects have been funded by the CVPIA Clear Creek Fish Restoration Program and the CALFED ERP. These programs have focused on channel restoration that has filled in gold mining ponds (reducing predation from warm water predators), added LWD, and augmented spawning gravel. Results of a recent monitoring study (USFWS 2007a) suggest that these restoration programs and gravel supplementation have benefited CV steelhead and Chinook salmon. Gravel supplementation has substantially increased the amount of available spawning habitat. In 2007, injection gravel was found in an average of 40 percent of the CV steelhead redds, as compared with an average of 30 percent in 2001 and 2002. Smaller gravel size of 1-2 inches was specifically added for CV steelhead in the Whiskeytown Dam injection site. Two of the three areas with the highest CV steelhead redd density were found below injection sites.

6.2.3.3 Geomorphic Effects of Altered Hydrology

Extensive studies on Clear Creek have shown the negative impacts to habitat below Whiskeytown Dam from years of reduced magnitude and duration of flood events [McBain and Trush 1999, 2001; USFWS 2007, 2008; Graham Mathews & Associates (GMA) 2007]. Clear Creek is basically starved of sediment by Whiskeytown Dam and has loss its ability to contribute spawning gravel to the Sacramento River. The reduction in flood events has lead to channel down cutting and a loss of spawning gravel. To compensate for the loss in spawning gravel, Reclamation has annually funded a gravel augmentation program through the CVPIA. This program provides gravel at key locations below Whiskeytown Dam, but leaves it up to the flows in Clear Creek to move gravels downstream so that they can be utilized for spawning. However, the gravel augmentation program does not provide enough gravel to make up the deficit caused by Whiskeytown Dam. Over 100,000 tons of gravel have been injected since 1996, but GMA (2007) estimated that it would take 560,000 tons to recharge the length of Clear Creek from Whiskeytown Dam to the Sacramento River.

The impact of reduced high flow events in Clear Creek has decreased channel geometry and increased riparian encroachment (Vizcaino *et al*. no date). The loss of high flows and immobilization of sediments has resulted in reductions in fish habitat and establishment of introduced warm water fish species better adapted to the new conditions. Effects of reduced coarse sediment supply include: riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and a reduction in the amount and quality of spawning gravels available for anadromous salmonids (GMA 2006 *op. cit*. USFWS 2008).

The importance of these high flows (*i.e*., flood control releases or Glory Hole spills) for providing sediment transport and channel morphology cannot be overstated. In Clear Creek, gravels are mobilized at 2,000 cfs, and channel bed mobilization occurs at 3,000 cfs (McBain and Trush 2001). Only three channel bed mobilization events have occurred since gravel injection began in 1998 (GMA 2007).

Overall, the loss of these channel-forming flows is reducing the temporal and spatial diversity for both spring-run and CV steelhead in Clear Creek.

6.2.4 Assess the Risk to Individuals

Spring-run and steelhead abundances in Clear Creek are increasing as a result of passage improvements, gravel augmentation, restoration projects, temperature control, and the addition of b(2) water. However, continuing the proposed release pattern (*i.e.,* 200 cfs through most of the year) does not allow for habitat diversity and the expression of multiple life-history traits essential for spring-run and steelhead survival and recovery. Therefore, the future risk to the individuals in Clear Creek is that they will most likely experience reduced fitness, reduced reproductive success, and reduced growth rates (tables 6-1 and 6-2). The consequence of the lack of variability in flows is less complexity in the habitat, leading to truncated run timing and ultimately, a loss of diversity (VSP parameters). In the worst-case scenario, flows would drop to 30 to 50 cfs in a dry year, which would prevent passage upstream to spring-run spawning areas below Whiskeytown Dam and in turn, result in reduced reproductive success. Current flows may limit the carrying capacity of spring-run and result in the underutilization of the existing amount of habitat available for spring-run spawning (USFWS 2007b), and suppress the potential for population increases. Redd superimposition would likely result. The proposed flow pattern, as described, lacks the high flows necessary to move spawning gravel downstream. The lack of spawning gravel limits the reproductive success of individuals and, as a consequence, reduces the potential for the population to increase.

Implementation of the Trinity ROD flow schedule will cause water temperatures to increase slightly in Clear Creek. Higher water temperatures in September will cause some spring-run egg mortality in 10 percent of the years (dry years) and reduce reproductive success in those years. Progeny of those individuals that spawn in the middle to lower reaches due to improvements in spawning gravel will likely die from lethal temperatures in dry to critical years. Studies on the American River have shown that juvenile steelhead exhibit site fidelity during over-summer rearing and do not move upstream into cooler habitats when temperatures warm to levels exceeding physiological tolerances (Water Forum 2005a). Therefore, the proposed flow regime is likely to reduce the chances of an individual surviving in the future as the habitat upstream is fully utilized, forcing individuals into less suitable habitat downstream (*i.e*., lower reaches below the TCP at Igo). The impact of drought years is likely to increase in the future with climate change impacts. The consequence to individuals is that spawning is less likely to be successful in approximately 20 percent of years (*i.e*., dry years). Whiskeytown Dam operations will continue to prevent the spatial and temporal separation of spring-run from fall-run, thus reducing the individual's expression of life history traits that are unique to that species (*e.g*., anadromy in steelhead, and over-summer holding in spring-run).

6.2.5 Effects of the Action on Spring-Run and CV Steelhead Critical Habitat in Clear Creek

Clear Creek is designated critical habitat for spring-run and CV steelhead. The PCEs of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. This analysis on the effects of the proposed action on spring-run and CV steelhead critical habitat is based on information presented in the preceding sections regarding the effects of project operations, and are summarized below as they relate to the PCEs of critical habitat.

Spawning and rearing habitat in Clear Creek is expected to be negatively affected by flow and water temperature conditions associated with the proposed action. The value of critical habitat for the conservation of the species is reduced by not providing sufficient flows to maintain the suitability and availability of spawning habitat for spring-run. Reducing the depth and velocity of flows will reduce the suitability and availability of both spawning and rearing sites for both spring-run and steelhead. The lack of high enough flows (*i.e*., from flood control releases stored behind Whiskeytown Dam) will limit the space available for salmonids downstream of Whiskeytown Dam and reduce the ability of the populations to increase.

For CV steelhead, the conservation value of critical habitat will be further reduced in dry years by unsuitable water temperatures in the lower reaches of Clear Creek during the summer rearing period. Recent steelhead spawning surveys (USFWS 2008a) indicate that the use of the lower reaches below the TCP is increasing. Juveniles that rear over the summer in these lower reaches (*i.e*., downstream of the Igo Guage) are much more vulnerable to high water temperatures. As a result, the ability of the habitat to support the current population and future recovering population is reduced or nullified.

Recent studies on Clear Creek (USFWS 2007) using smaller gravel size suitable for steelhead have found that steelhead have utilized all newly added injection sites. Spawning habitat on Clear Creek is improving with restoration efforts, gravel augmentation, and increased flows from b(2) water for temperature control. However, the value of spawning habitat for the conservation of the species is reduced under future operations in critically dry years when cold water releases cannot be maintained from Whiskeytown Dam (*i.e*., years when Trinity River diversions are reduced).

6.3 Shasta Division and Sacramento River Division

Figure 5-8 provides a map of the upper Sacramento River. Table 5-1 provides the life history timing for anadromous fish species, including winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon in the upper Sacramento River. Figure 5-14 provides a conceptual model of the future baseline stressors and project-related stressors that act on the listed anadromous species and their proposed and designated critical habitats in the upper Sacramento River mainstem.

Life stage-specific responses to specific stressors related to the proposed action are summarized in the following tables; for winter-run, table 6-4; for spring-run, table 6-5; for CV steelhead, table 6-6; and for green sturgeon, table 6-7. Major project-related stressors are analyzed in the following sections. Due to the large number of stressors and species, this effects analysis intends to identify and describe the most important project-related stressors, prioritized by the greatest magnitude and duration of effects, and based on a literature review, knowledge and experience with project operations.

Table 6-4. Summary of proposed action-related effects and responses on winter-run in the Sacramento River.

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Adult Immigration RBDD	May – Jul.	RBDD gate closures from May 15 - Sept 15 every year until 2019	~15 % of adults delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity; continues every year until 2019	Reduced survival and reduced reproductive success
Adult Immigration RBDD	May – Jul.	RBDD emergency 10 day gate closures prior to May 15	Greater proportion of run blocked or delayed; sub lethal effects on eggs in fish and energy loss. These emergency gate closures have occurred twice in the past 10 years and the frequency of occurrence may increase with climate change.	Reduced survival and reduced reproductive success
Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year	Introgression or hybridization with spring/fall run/late-fall Chinook salmon; loss of genetic integrity and expression of life history	Reduced reproductive success
Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year	Density dependency - aggressive behavior among spawning fish could cause higher prespawn mortality, increased fighting for suitable spawning sites, adults forced downstream into unsuitable areas	Reduced survival and reduced reproductive success
Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year	Redd superimposition - spawning on top of other redds, destroys eggs	Reduced egg survival and reduced reproductive success
Spawning Primarily upstream of RBDD	Apr. – Aug.	Water temperatures warmer than life history stage requirements below TCP	Prespawn mortality; reduced fecundity, reduced spawning habitat available, less likely to re-colonize and expand into areas below TCP, reduces likelihood of recovery	Reduced survival and reduced reproductive success

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Embryo Incubation Primarily upstream of RBDD	Apr. – Oct.	Water temperatures warmer than life history stage requirements, every year. (No carry-over storage target designed for fish protection is included in the proposed action. Without such a target, the risk of running out of coldwater in Shasta Reservoir increases.)	Egg mortality - 16 % in critically dry years and increases to 65% in critically dry years with climate change. On average, for all water year types, mortality is 5-12% with climate change and 2-3% without. 56ºF is exceeded at Balls Ferry in 30% of the years in August and 55% of the years in September Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of winter-run to survive during subsequent life stages (Campbell et al. 1998). Campbell et al. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	Reduced survival
Embryo Incubation Primarily upstream of RBDD	Apr. – Nov	Flow fluctuations for ACID dam installation, 2 x /year	Redd dewatering and stranding; loss of a portion, or all eggs in redd	Reduced reproductive success
Juvenile rearing Upstream of & including RBDD	Jul. – Mar.	Water temperatures warmer than life stage requirements	Increased susceptibility to predation and disease in passing through Lake Red Bluff, gates at RBDD, fish screens, and bypass	Reduced survival
Juvenile rearing Upstream of & including RBDD	Jul. – Mar.	RBDD passage downstream through dam gates May 15 - Sept 15	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 10% of winter-run would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Juvenile rearing Upstream of & including RBDD	Jul. – Mar.	Lake Red Bluff, river impounded May 15 - Sept 15	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	Reduced survival and reduced growth
Juvenile rearing Upstream of & including RBDD	Jul. – Mar.	Flow fluctuations caused by ACID dam removal in November	Fry standing and juvenile isolation; juveniles killed or subjected to predation and higher temps in side channels. Flow fluctuations from the dam removal occur over a short time period, limiting the exposure to potential fry stranding and juvenile isolation.	Reduced reproductive success
Juvenile rearing Upstream of & including RBDD	Jul. – Mar.	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency)	Reduced survival
Juvenile rearing/smolt emigration RBDD to Colusa	Sep. – Nov.	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment and greater predation	Reduced survival
Juveniles and smolts RBDD to Colusa	Sep. – Nov.	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Loss of rearing and riparian habitat and natural river function impaired (*e.g.*, formation of side channels, sinuosity); loss of cottonwood recruitment = less food available, juveniles hang up and don't migrate downstream until appropriate cues (*i.e.*, first storm > turbidity, < temp); juveniles spend longer time in areas of poor water quality, greater predation, less growth from less food sources, greater stress reduces response to predators	Reduced survival and reduced growth
Juveniles and smolts Colusa to Sacramento	Sep. – Nov.	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few winter-run are expected to be in this area during the fall.	Reduced survival

Table 6-5. Summary of proposed action-related effects and responses on mainstem Sacramento River spring-run.

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Adult immigration RBDD	Mar. – Sep.	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) force fish to use inefficient ladders	~70% of the spring-run that spawn upstream of RBDD are delayed by approximately 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	Reduced reproductive success
Spawning Sacramento River	Sep. – Oct.	No temporal separation between spring-run and fall-run spawning due to delays at RBDD (no spatial separation due to Keswick and Shasta dams)	Introgression -Hybridization with fall run and competition for habitat	loss of genetic integrity and expression of life history
Embryo incubation	Sep. – Dec.	Water temperatures warmer than life history stage requirements, during September and October	Under near-term operations (Study 7.1) mortality is expected to range from approximately 9% in wet years up to approximately 66 % in critically dry years, with an average of approximately 21 % over all water year types; under modeled climate change projections, average egg mortality over all water year types is expected to be 50 % and during the driest 15 % of years is expected to be 95 %. Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of spring-run to survive during subsequent life stages (Campbell *et al*. 1998). Campbell *et al*. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	Reduced survival
Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 5 percent of the spring-run ESU that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	Reduced survival and reduced growth
Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (e.g., 95% efficiency).	Reduced survival
Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment and greater predation	Reduced survival
Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Loss of rearing habitat and riparian habitat and natural river function impaired (*e.g.*, formation of side channels, sinuosity); loss of cottonwood recruitment = less food available, juveniles hang up and don't migrate downstream until appropriate cues (*i.e.*, first storm > turbidity, < temp); juveniles spend longer time in areas of poor water quality, greater predation, less growth from less food sources, greater stress reduces response to predators	Reduced survival and reduced growth
Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few spring-run are expected to be in this area during the fall.	Reduced survival

Table 6-6. Summary of proposed action-related effects and responses on mainstem Sacramento River steelhead.

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Adult immigration RBDD	Aug. – Mar.	RBDD gate closures from May15 – Sept. 15 force adults to use inefficient fish ladders	17 % of those that spawn above RBDD, delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity	Reduced reproductive success
Spawning Sacramento River	Dec. – Mar.	Straying of Nimbus Hatchery steelhead to mainstem Sacramento River spawning habitats	Reduced genetic fitness of Sacramento River steelhead through the spread of Eel River genes and potentially hatchery rainbow trout genes to many below-barrier sites in the Central Valley (Garza and Pearse 2008).	Reduced genetic fitness
Egg incubation Sacramento River	Dec. - May	Water temperatures warmer than life history stage requirements	Sub-lethal effects - reduced early life stage viability; direct mortality in critically dry years; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar.).	Reduced survival
Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Reduction in rearing habitat quality and quantity; delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	Reduced survival and reduced growth
Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 1 % of the steelhead DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	Reduced survival
Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency).	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Provision of higher flows and cooler water temps during the summer than occurred prior to the construction of Shasta Dam	Potential fitness advantage for resident *O.mykiss* over the anadromous form, which would drive an evolutionary (*i.e.*, genetic) change if life history strategy is heritable (Lindley *et al*. 2007).	Reduced reproductive success
Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	Reduced survival
Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process	Loss of rearing habitat and riparian habitat and natural river function impaired (e.g., formation of side channels, sinuosity); loss of cottonwood recruitment impacting food availability, juveniles spend longer time in areas of poor water quality, greater predation, less growth from less food sources, greater stress reduces response to predators	Reduced survival and reduced growth
Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. However, few steelhead are expected to be in this area during the fall.	Reduced survival

Table 6-7. Summary of proposed action-related effects and responses on the Southern DPS of green sturgeon in the Sacramento River.

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Adult Immigration Delta to KeswickDam	Feb. – Sep. (peak in Apr.)	Low flows during March - June	Adults need large spring flows to trigger movement upstream to spawn, low flows may delay migration enough that they encounter RBDD closed gates and are forced to spawn downstream in less suitable habitat	Reduced survival and reduced reproductive success

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Adult Immigration & emmigration RBDD	Mar. - Dec.	RBDD gate closures from May 15 - Sept 15 (every year until 2019).	Passage blocked, 55 miles of spawning habitat made inaccessible upstream of RBDD after May 15. Large aggragations (25-30) of adults observed below RBDD gates. Estimate 30 percent of run blocked based on run timing. Also, mortalities associated with downstream paasage under gates post-spawn, or after fish move above gates. Mortality greater on larger, more fecund females that cannot fit through 18” opening.	Reduced survival and reduced reproductive success.
Adult Immigration RBDD	Apr. – May 15.	Emergency 10 day gate closures prior to May 15	Greater proportion of run blocked or delayed (40 -50%) based on run timing; Greater mortalities associated with downstream passage under gates post spawn, or after moving above gates, sub lethal effects on eggs in fish and energy loss. Occurred twice in the past 10 years, but the frequency of occurrence may increase with climate change.	Reduced survival and reduced reproductive success. (note: 12 adults were observed killed by gates in 2006)
Adult Immigration ACID	Apr. – May 15.	ACID installed April to November	Passage blocked to 5 miles of spawning habitat below Keswick Dam.	Reduced habitat and reduced spawning success.
Adult Holding	Jun. – Dec.	Water temperature and low flows	Some adults may hold for up to 9 months in the upper Sacramento River post-spawn waiting for an increase in flows to move downstream. Water temperatures in September and October may stress individuals after the cold water pool is depleted. Dam controlled releases reduce the first pulse flow in the fall that may trigger adults to move out, so they stay longer in upstream areas. Delayed emigration, reduced fitness, longer periods between spawning runs.	Reduced probability of repeat spawning
Spawning	Apr. – Jul.	Blocked access to individuals above RBDD	Spawners that are blocked by RBDD are prevented from spawning with the portion of the run already above RBDD. Reduced genetic variability, may reduce fecundity, or size of fish if smaller adults arrive first.	Reduced survival and reduced reproductive success
Embryo Incubation	Apr. – Aug.	Water temperatures warmer than life history stage requirements below Hamilton City.	For eggs and fry that are spawned in areas from RBDD to Hamilton water quality is less suitable than above RBDD where temperatures are controlled for winter-run. Eggs suffocate from less flow, physiological effects, delayed hatch, greater predation on eggs due to presence of non-native introduced warm-water species.	Reduced egg survival and reduced reproductive success
Juvenile rearing to Hamilton City	Jun. – Nov.	Water temperatures warmer than life history stage requirements.	Juveniles move downstream immediately after hatching and encounter sub-optimum temperatures below Hamilton City due to truncated spawning distribution. May reduce growth, feeding, delay emigration, and increase predation from warm water species.	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Probable Fitness Reduction
Juvenile rearing Upstream of and including RBDD	Jun. – Nov.	Lake Red Bluff, river impounded May15 - Sept 15	Reduction in rearing habitat quality and quantity; increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967.	Reduced survival and reduced growth
Juvenile rearing Upstream of and including RBDD	Jun. – Nov.	RBDD passage downstream through dam gates May15 - Sept 15	Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 100% of the green sturgeon DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008). Approximately 70% of the entire green sturgeon DPS spawns above RBDD. Mortality of juvenile salmon emigrating past RBDD when the gates are in ranges from 5 -50% (Vogel *et al*. 1988; Tucker 1998); mortality of juvenile green sturgeon emigrating past RBDD has not been estimated, but is expected to increase when the gates are in.	Reduced survival
Juvenile rearing RBDD to Colusa	Jul. - Nov.	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Loss of rearing and riparian habitat and natural river function impaired (*e.g*., formation of side channels, sinuosity); loss of cottonwood recruitment = less food available, juveniles hang up and don't migrate downstream until appropriate cues (*i.e*., first storm > turbidity, < temp); juveniles spend longer time in areas of poor water quality, greater predation, less growth from less food sources, greater stress reduces response to predators	Reduced survival and reduced growth
Juveniles Colusa to Sacramento and enter Delta	Jun. – Nov.	Low fall flows	Emigration delayed, higher predation; fewer juveniles survive to the Delta	Reduced survival

6.3.1 Red Bluff Diversion Dam

6.3.1.1 Deconstruct the Action

The RBDD gates are proposed to be operated in the open position from September 15 through May 15 until a new pumping plant can be built just upstream (table 6-8). This is the same 8 months out, 4 months in operation that has occurred for the last 10 years. The CVP/SWP operations BA proposed this operation throughout the near term (up to year 2019)[10]. Once the new pumping plant becomes operational, the gates will be opened for 10 months, closed for 2 months plus closed for 10 days in May to accommodate boat race in Lake Red Bluff (table 6-8). Future operations will close the gates 5 days later (*i.e*., May 20 instead of May 15) which would allow unimpeded passage to more adult winter-run at the tail end of their spawning migration in the long term. The delay in closure will also improve passage for spring-run spawning above RBDD. Currently, an estimated 35-40 percent of the green sturgeon in the mainstem Sacramento River are completely blocked from passing RBDD by the May 15 gate closure.

Table 6-8. Proposed Red Bluff Diversion Dam Gate Closures (CVP/SWP operations BA).

Near-Term (2009-2019)	**Full Build Out (2020-2030) with new Pumping Plant**
May 15 – Sept. 15	4 days prior to through 3 days following Memorial Day weekend; and July 1 through the end of Labor Day weekend
10-day emergency closure	*[11]
4 months gates in	2 ½ months gates in

Interim gate operations in 2009 were ordered by Federal court[12] to cover the period prior to NMFS' issuance of the new CVP/SWP operations Opinion. These interim gate operations specify gate closures no earlier than June 15, and gate opening on September 1, to protect listed salmonids and green sturgeon. TCCA has installed temporary pumps at RBDD to continue diverting water while the gates are not in place (May 15-June 15).

6.3.1.2 Assess Species Exposure and Response to RBDD

Based on recent RBDD ladder counts, the percentage of adults encountering delays when the gates go down on May 15 are approximately 15 percent for winter-run, 72 percent of spring-run, 17 percent for CV steelhead, and 35 percent for green sturgeon (TCCA 2008 Appendix B1; figure 6-4). Delays will impact adults spawning in the mainstem or tributaries above RBDD, and especially in Clear Creek, Cow Creek, and Cottonwood Creek. Spring-run that are delayed at RBDD and cannot access tributaries as a result of low flows end up spawning in the mainstem Sacramento River with the fall-run.

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[10] Subsequent to Reclamation's request to initiate formal consultation on the CVP/SWP operations, Reclamation, TCCA, and NMFS engaged in discussions to expedite the time frame to construct and implement the new pumping plant. However, the Reclamation has not modified the CVP/SWP operations BA to reflect any change in schedule for the new pumping plant.

[11] Although Reclamation proposes to reoperate the RBDD after the near term, it did not mention the need (or lack of need) to retain its provision for a 10-day emergency pre-irrigation gate closure. However, with the approximately 10-day closure for the Lake Red Bluff boat races, and a pumping plant in place, NMFS did not see a need for Reclamation to retain the 10-day emergency pre-irrigation gate closure provision, and likewise, did not analyze the effect of that provision beyond the near term.

[12] Judge Wanger issued interim gate orders as part of ongoing litigation (*PCFFA et al. vs. Gutierrez et al.)*

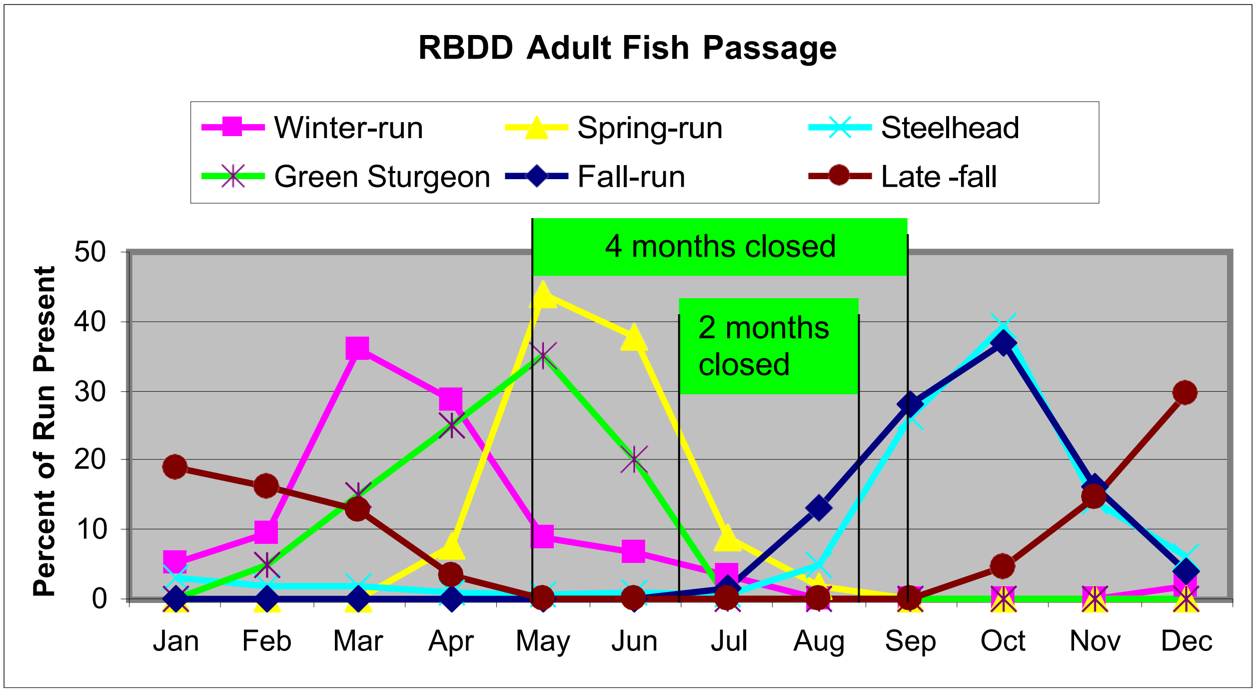


Figure 6-4. Run timing by month at Red Bluff Diversion Dam for adult winter-run, spring-run, fall-run, late fall-run, CV steelhead, and Southern DPS of green sturgeon (TCCA 2008).

Adult CV steelhead encountering RBDD in the gates down position in September may also experience delays in migration. Approximately 20 percent of those adult CV steelhead spawning in tributaries above RBDD (*i.e*., Battle Creek, Clear Creek, Cow Creek; figure 5-12) would experience delays in passage. However, since CV steelhead spawn later in January and February, a delay of 1-2 weeks (September 1-15) at RBDD is not expected to reduce appreciably their ability to enter tributaries and successfully spawn. The pattern of delays for winter-run and spring-run adults at RBDD is expected to continue for the next 11 years until a new pumping plant increases the gates open from 8 months to 10 months per year. After the new Red Bluff Pumping Plant is built and operational, delays to Chinook salmon migration would be reduced, but still present for spring-run. Green sturgeon will still be completely blocked from upstream spawning areas during the 10-day May closure for the Red Bluff boat races in both the near-future and future operation, since they are not able to use the fish ladders (Heublein 2006, Brown 2007). Overall, the problems with passage at RBDD have been studied for years and are summarized in TCCA (2008, Appendix B1), as follows: "The biological consequences of blockage or passage delay at RBDD results in changes in spawning distribution (Hallock 1987), hybridization with fall chinook (CDFG 1998), increased adult pre-spawning mortality (Reclamation 1985), and decreased egg viability (Vogel *et al*.1988), all of which result in the reduction of annual recruitment of this species."

Adult green sturgeon migrate upstream from March through July, with the peak of spawning occurring from April through June (September 8, 2008, 73 FR 52084). Spawning habitat for green sturgeon occurs both above and below RBDD and ACID (Heublein 2006, Brown 2007, Poytress *et al*. 2009). The RBDD gate closure blocks approximately one-third of the spawning adults from accessing the upper Sacramento River. Large aggregations of green sturgeon have been observed in the pool below the diversion dam during May and June after the gates are closed (Brown 2007, Corwin 2008, Urkov 2008). The upper Sacramento River is the only known spawning area for the Southern DPS of green sturgeon. Those individuals that do not pass RBDD before May 15 are forced to spawn downstream in habitat that is less suitable (*i.e*., higher temperatures, less water velocity, and less bedrock habitat). Heublein (2006) and Lindley (2006) indicate that adult green sturgeon drop back downstream after encountering RBDD to as far as the GCID diversion, a distance of 41 miles. A large aggregation of adults has been observed holding through the summer in a 15-foot deep pool at GCID (Vogel 2008). Acoustic tag studies from 2004-2006 showed an increase in sturgeon density in reaches below RBDD after the May 15 closure truncated upstream migration (Heublein 2006).

In 2007, approximately 10-12 adult green sturgeon were observed killed (figure 6-5) before they could spawn by the RBDD gates due to an early gate closure (USFWS 2007). Early gate closures before May 15 are allowed during extreme dry conditions when not enough water can be pumped from the Sacramento River into the Tehama-Colusa Canal. Emergency closures have occurred twice in the last 10 years. It is unknown how many adult green sturgeon are killed during normal operations. However, the loss of 10 adult spawners represents a significant reduction in the only known spawning population in the Sacramento River (*i.e*., represents 10 percent of the adults counted below RBDD in tagging studies). Reclamation proposes to change the opening under the gates (figure 6-6) from 6 inches to 12 inches during all gate closures to allow downstream passage of adults that have passed above RBDD. This change in the gate opening has not been evaluated and may eliminate the installation of the temporary fish ladder in the middle of RBDD, which would further reduce the ability of Chinook salmon and CV steelhead to pass RBDD with the gates in. The CVP/SWP operations BA asserts that adult green sturgeon can pass through a 6- to 10-inch opening based on limited (*i.e*., 3 acoustically-tagged adults) data and undefined body depth. However, experts in green sturgeon from U.C. Davis have stated that a 12-inch opening is not large enough to pass green sturgeon adults without injury. Regardless of whether the opening is large enough to avoid impingement (since adults can reach a length of 5-6 feet they have to be perfectly lined up to pass through a 12-inch opening) the gates would still injure fish due to the turbulence after they pass through. Therefore, even though mortality may be reduced with the proposed 12-inch opening, NMFS anticipates some green sturgeon adults will be killed and/or injured in passing downstream while the RBDD gates are in operation from May through September.

Figure 6-5. Adult female green sturgeon still with eggs, removed by divers after being found lodged under RBDD gate #6 on May 21, 2007 (USFWS 2007).

Juvenile salmonids and green sturgeon that encounter the RBDD (figure 6-7) experience higher predation rates from predatory fish that wait below the dam for fish that are swept under the gates and through the fish screen bypass. Vogel *et al.* (1988) have shown that predation may be as high as 50 percent for those juveniles that encounter the gates down (table 6-9). However, a more recent study (Tucker 1998) has shown that since the RBDD gates have been operating to the current 4 months (May 15 –September 15) closure, fewer predatory fish are present at the gates when juvenile salmonids are migrating downstream (figures 6-7 and 6-8, table 6-10). Thus, although not quantified, the predation rates are believed to be less than 50 percent. Predation on juvenile salmonids is expected to be greatest when they encounter the gates in. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007 *op cit*. TCCA 2008), approximately 99 percent of green sturgeon, 39 percent of winter-run, 1 percent of spring-run, and 37 percent of CV steelhead would be exposed to higher concentrations of predators when the gates are in (figure 6-7, table 6-10). These percentages represent only the proportion of the runs that spawn above RBDD and not the entire populations. The presence of predators below RBDD is most abundant from April to July when large numbers of juvenile spring-run, steelhead, and green sturgeon are migrating downstream (figure 6-8).

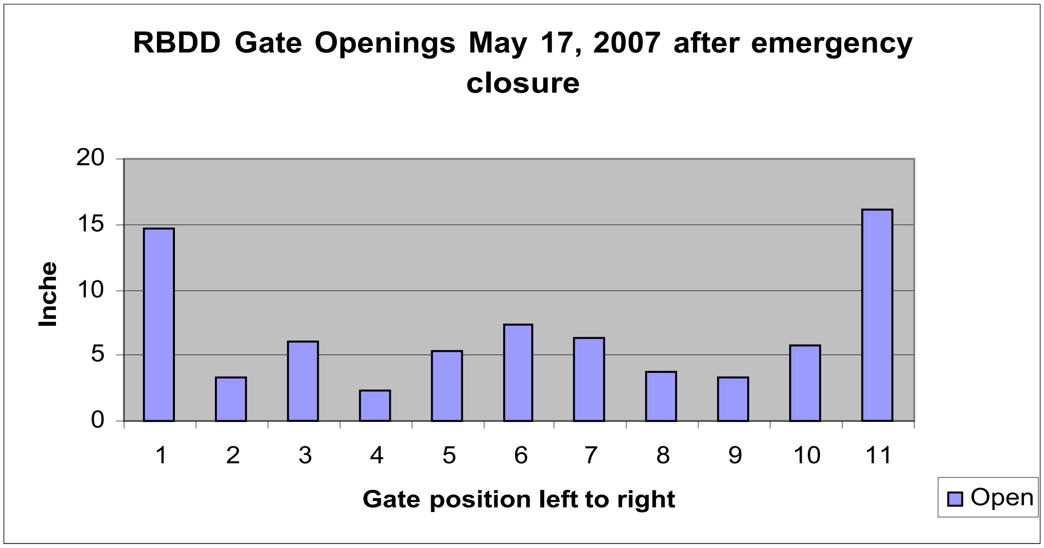


Figure 6-6. Red Bluff Diversion Dam gate position and size of openings after May 15 closure, data from Reclamation Daily Reservoir Operations Report May 2007. Note gates #5, 6, and 7 where green sturgeon mortalities were reported by Reclamation (USFWS 2007)

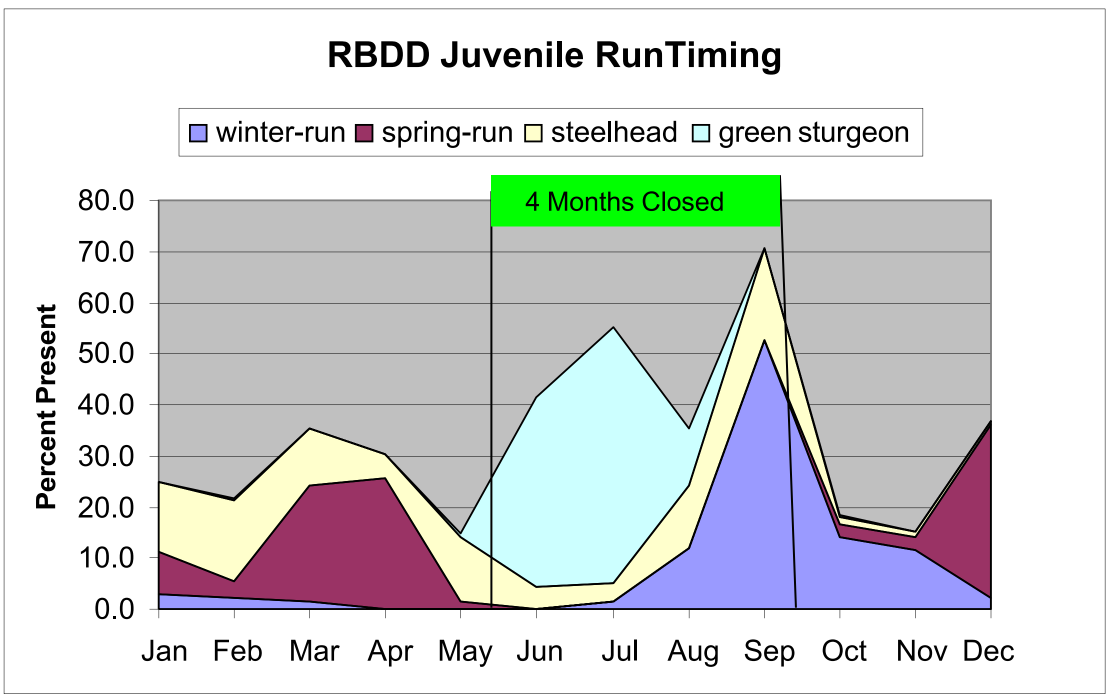


Figure 6-7. Juvenile run timing and exposure by month at Red Bluff Diversion Dam for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon based on USFWS trapping data (TCCA 2008).

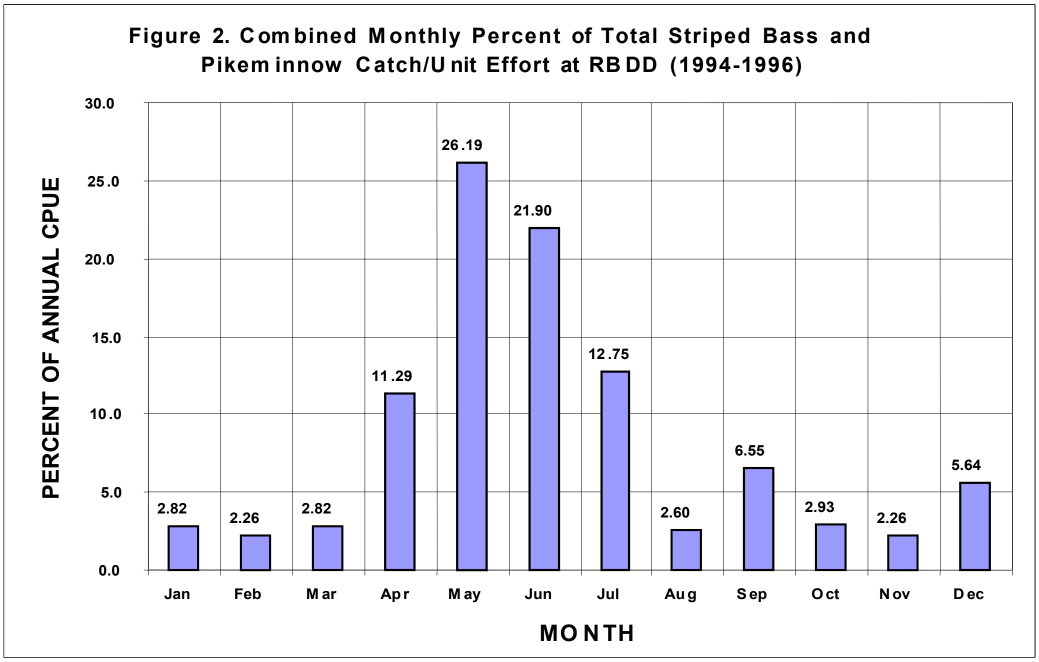


Figure 6-8. Presence of predators at RBDD by month from 1994-1996 (TCCA 2008).

Table 6-9. Estimated monthly hazard estimate used to assess predation in the *E.A. Gobbler* sub-routine of the Fishtastic! juvenile analysis model (Tucker 1998, Vogel *et al*. 1988).

Month	CPUE (% of yearly total)	Scaled Predation Rate (%)	Hazard Multiplier (0-1)
Jan	2.82	5.88	0.94
Feb	2.26	4.83	0.95
Mar	2.82	5.88	0.94
Apr	11.29	23.72	0.76
May	26.19	55.00	0.45
Jun	21.90	45.97	0.54
Jul	12.75	26.87	0.73
Aug	2.60	5.46	0.95
Sept	6.55	13.85	0.86
Oct	2.93	6.09	0.94
Nov	2.26	4.83	0.95
Dec	5.64	11.76	0.88

Table 6-10. Percent of juveniles exposed to RBDD gates closed condition (*e.g*., increased predation, disorientation, *etc*.).

Species	May (16-30)	Jun	Jul	Aug	Sep (1-15)	Total
Winter-run	0.0	0.0	1.3	11.8	26.3	39.4
Spring-run	0.6	0.1	0.0	0.0	0.0	0.7
Steelhead	6.2	4.4	3.7	12.3	10.0	36.6
Green Sturgeon	0.5	37.1	50.1	11.1	0.0	98.8

"Operation of the gates at RBDD may not directly adversely affect populations of most of the resident species, but operations may seasonally limit their access into optimal habitats. Rates of predation on juveniles of species such as rainbow trout and other native species near RBDD may be affected by the operations of the RBDD because of the congregation of adult pikeminnows and striped bass. Except for juvenile rainbow trout, predation on juvenile resident native and non-native fish may be inconsequential, as these species are less-preferred prey." (TCCA 2008)

6.3.2 Shasta/Keswick Dam Water Releases

6.3.2.1 Carryover Storage in Shasta Reservoir

6.3.2.1.1 Deconstruct the Action

Carryover storage in September will be significantly reduced in the long-term (-121 TAF) future compared to current operations (Study 8.0 vs 7.0, table 6-11). The loss in carryover storage is due to less water diverted from the Trinity River (- 42 TAF in dry years), increased demand on the American River (800 TAF), and increased demand throughout the Central Valley. The long-term trend indicates that as water management changes in other CVP reservoirs and demand increases to 2030, the summertime releases from Keswick increase incrementally.

Table 6-11. End of September storage differences for Shasta storage, Spring Creek Tunnel flow, and Keswick release for the long-term annual average and the 1928 to 1934 drought period (CVP/SWP operations BA table 10-3).

Long term Annual Average

Difference in Thousands of Acre-feet [TAF]	Study 7.0 - Study 6.0	Study 7.1 - Study 7.0	Study 8.0 - Study 7.0	Study 8.0 - Study 7.1
Shasta End-of-September Storage	26	-121	-121	0
Annual Keswick Release	1	8	6	-2
Annual Spring Creek Powerplant Flows	3	-1	-2	-2

29- 34 Difference

Difference in Thousands of Acre-feet [TAF]	Study 7.0 - Study 6.0	Study 7.1 - Study 7.0	Study 8.0 - Study 7.0	Study 8.0 - Study 7.1
Shasta End-of-September Storage	-24	-258	-100	158
Annual Keswick Release	59	-18	-92	-74
Annual Spring Creek Powerplant Flows	45	-18	-42	-24

Before the TCD was built, NMFS required that a 1.9 MAF end-of-September (EOS) minimum storage level be maintained to protect the cold water pool in Shasta Reservoir, in case the following year was critically dry (drought year insurance). This was because a relationship exists between EOS storage and the cold water pool. The greater the EOS storage level, typically the greater the cold water pool. The requirement for 1.9 MAF EOS was a reasonable and prudent alternative (RPA) in NMFS' winter-run opinion (NMFS 1992). Since 1997, Reclamation has been able to control water temperatures in the upper Sacramento River through use of the TCD. Therefore, NMFS changed the RPA to a target, and not a requirement, in the 2004 CVP/SWP operations Opinion.

Reclamation proposes continuation of the 90 percent exceedence forecast for determining water allocations early in the year, starting with the February 15 forecast. However, Reclamation has proposed not to manage Shasta operations to a 1.9 MAF EOS target, although CALSIM assumes this target in all studies. Given the increased demands for water by 2030 and less water being diverted from the Trinity River, it will be increasingly difficult to meet the various temperature compliance points, even with a TCD, especially since Reclamation is not proposing any EOS storage target. Based on the historical 82-year period, CALSIM II results show that there will be about a 4 percent increase in the number of years that 1.9 MAF will not be met (figure 6-9). Overall, there is not much difference between model runs. In about 10 percent of years (typically the driest water years) a 1.9 MAF EOS would not be met. Additional modeled runs using higher carry over storage targets were provided to NMFS after the BA was completed (this run assumed conditions today with EWA or 7.0 Study). These runs revealed that a higher target of 2.2 MAF EOS improved the probability of meeting the Balls Ferry temperature target about 10 percent over the previous 1.9 MAF target (figure 6-10). There was no difference in meeting the Bend Bridge temperature target. At the higher carry over target Shasta Reservoir would have to be 75 percent full (volume > 3.6 MAF) by the end of April in each year. This would mean that Shasta Reservoir would be kept higher through the winter months and be more likely to spill for flood control.

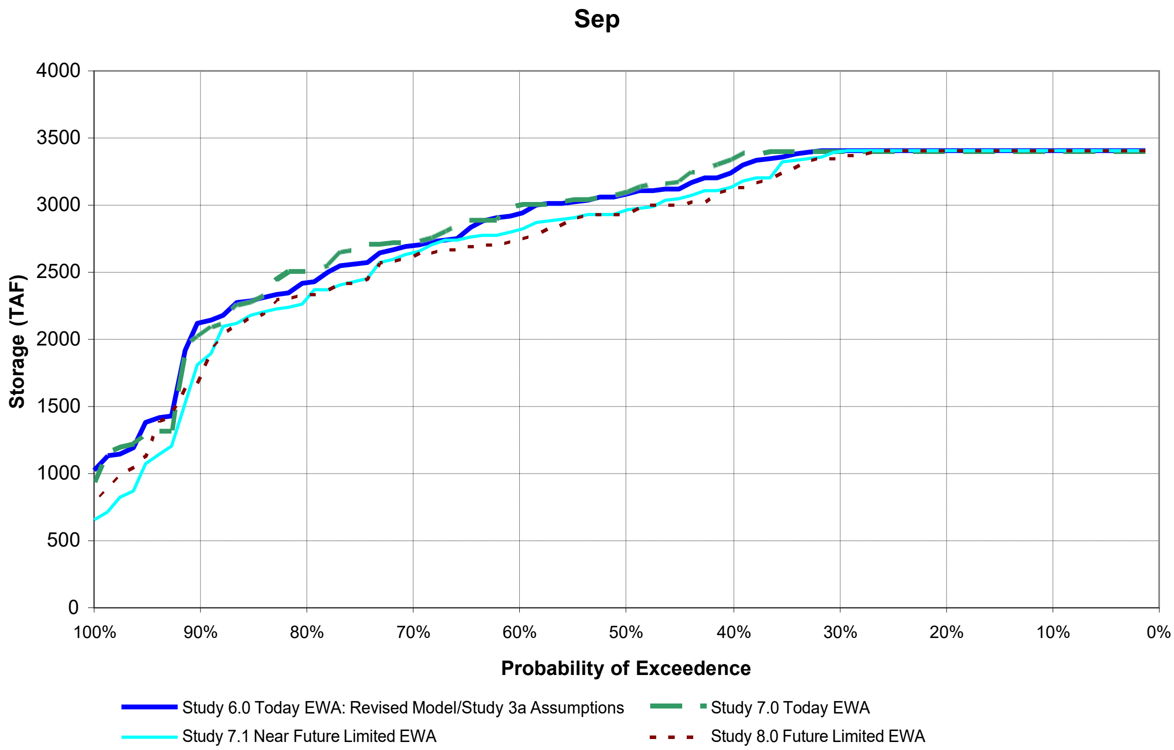


Figure 6-9. Exceedance plot of Shasta 1.9 MAF target September storage in Shasta Reservoir. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and study 8.0 represents future operations (CVP/SWP operations BA figure 11-37).

Reclamation has not proposed any alternative EOS storage target, but instead relies on the TCD capabilities to maintain cold water throughout the summer spawning period. Typically, by April 15, the amount of cold water in Shasta Reservoir is determined by the amount of snowmelt and inflow into the reservoir. Figure 6-9 shows that end of September storage would be reduced in the future compared to current operations in the drier 70 percent of years. EOS storage would be below 1.9 MAF in about 10-12 percent of the years in the future (Studies 7.1 and Study 8.0). With climate change, the long-term average September storage levels will be reduced by approximately 800 TAF in Study 9.5 drier, more warming (CVP/SWP operations BA table 9-23). Model results indicate that climate change will reduce EOS storage to below 1.9 MAF in about 25 percent of the years in all but the wetter, less warming scenario (figure 6-11). What this means for fish is a loss in the ability to control water temperatures, which will in turn result in greater egg and fry mortality for winter-run, spring-run, and fall-run in the future (see also temperature related effects of climate change in section 6.3.3.2, figure 6-20). With climate change, coldwater storage at the end of April in Shasta Reservoir is reduced in the future for all water year types under all but the wettest scenario (Study 9.4) wetter, less warming (figure 6-12). Climate change will put additional stressors on the already limited coldwater pool. The impact on winter-run and spring-run is greater mortality of eggs and pre-emergent fry in the spawning habitat.

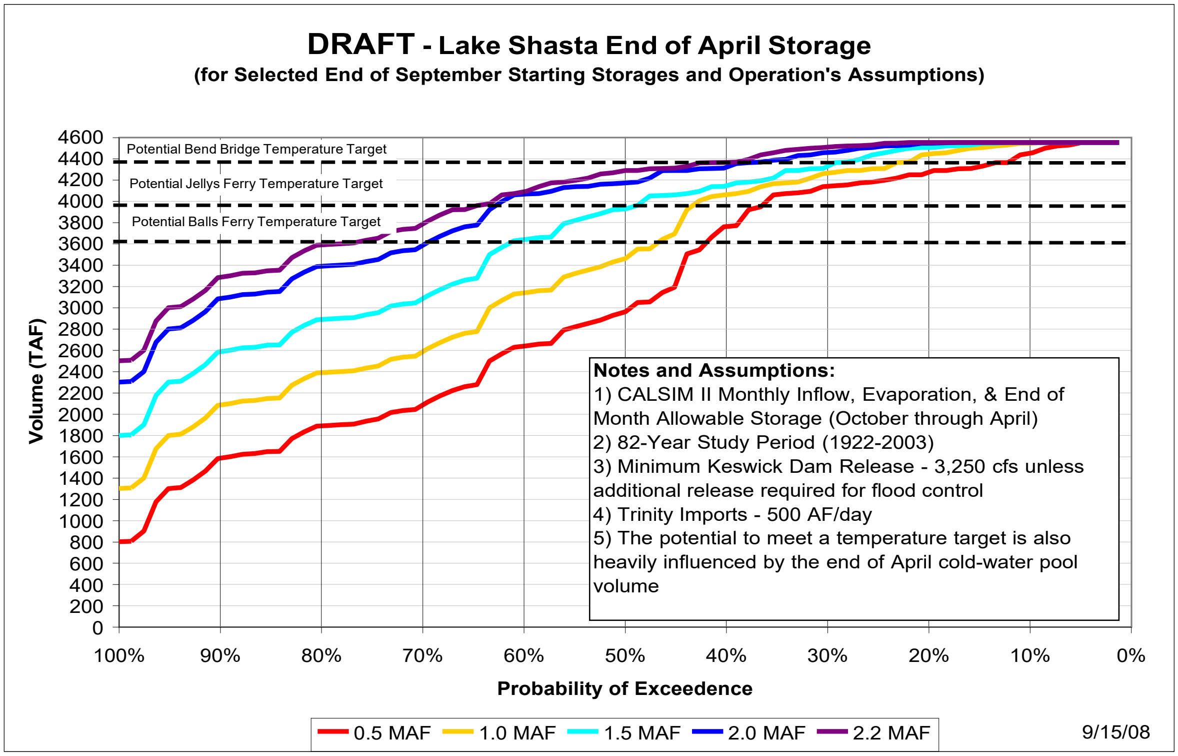


Figure 6-10. Draft exceedance plot of Shasta End of April Storage using selected End of September starting storages and operational assumptions (Supplemental data included with Reclamation's October 1, 2008, transmittal letter).

The minimum flows proposed in the CVP/SWP operations BA are 3,250 cfs from September to February and 2,300 cfs in a critically dry year (table 6-12). Typically, flows are much higher than 3,250 cfs in the spring and summer (April through September) because releases are made to support temperature control, irrigation demand (releases average between 10,000 and 14,000 cfs), and D-1641 requirements in the Delta (*e.g.*, water quality standards, Delta outflow).

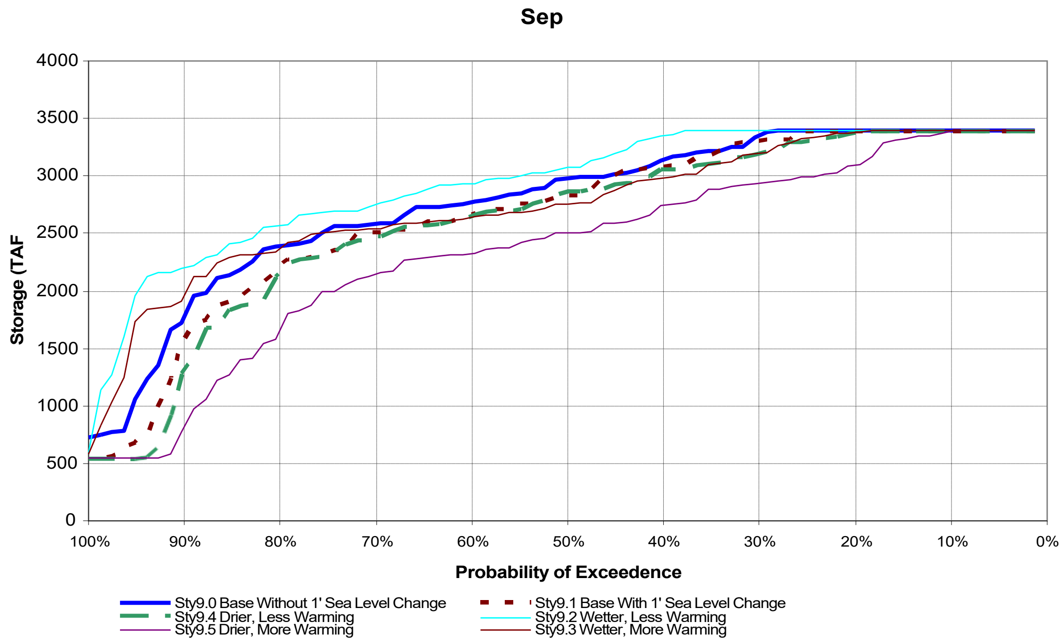


Figure 6-11. Exceedance plot of Shasta 1.9 MAF target September storage in Shasta Reservoir. Under future climate change scenarios (CVP/SWP operations BA, Appendix R, figure 37).

6.3.2.1.2 Assess Species Exposure and Response to Carryover Storage

Therefore, since b(2) water is not reasonably certain to be available, fall releases would most likely reduce fall-run spawning habitat and potentially dewater redds that were spawned at higher flows. The worst-case scenario, which is a rapid reduction in flows from 7,000 cfs in September to 3,250 cfs in November without b(2) water to conserve storage, could also strand newly emerged spring-run fry (note: spring-run juveniles start showing up in the RBDD trap data in November).

Flow studies using IFIM and PHABSIM have shown that winter-run salmon WUA peaked around 10,000 cfs when the ACID gates are in (usually from April to November), and 4,000 - 5,000 cfs with the gates out. Therefore, proposed and modeled releases provide suitable flows for winter-run spawning and rearing. In-stream flow objectives from October 1 to April 15 (April 15 is the start of temperature control for winter-run) are usually selected to minimize dewatering of redds and provide suitable habitat for salmonid spawning, incubation, rearing, and migration. These flows are generally suitable for spring-run, except in the worst-case scenario mentioned above for dry years when conserving storage drives the flows to minimums in the fall. The impact flows have on water temperatures will be discussed in section 6.3.3.2.

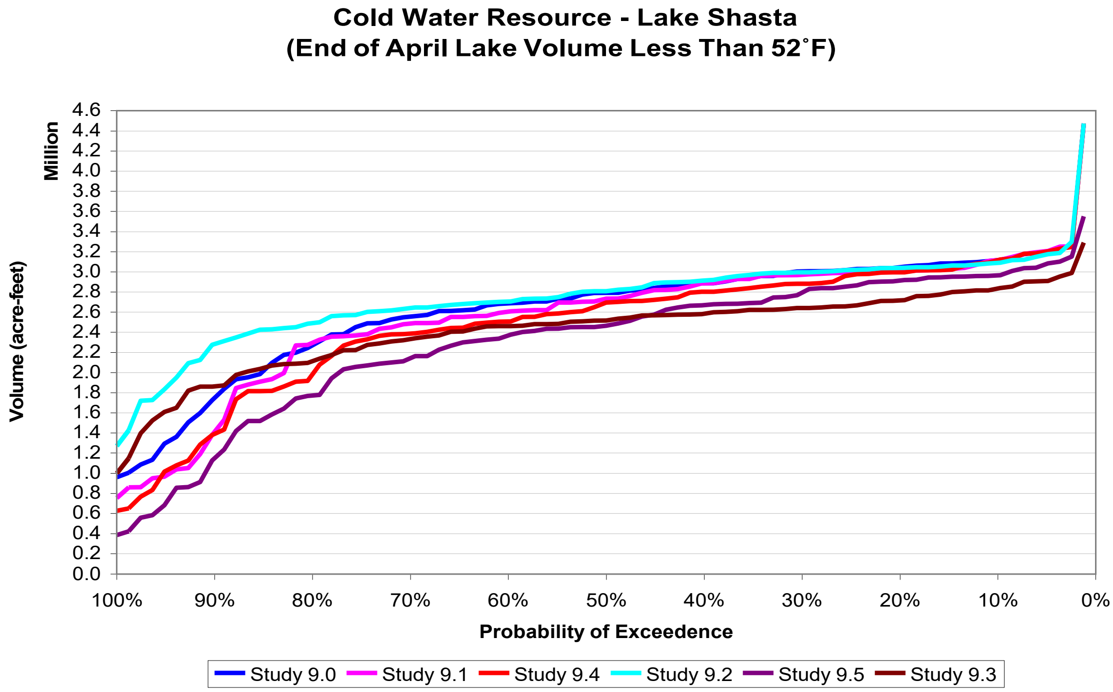


Figure 6-12. Shasta Lake coldwater pool volume at end of April with climate change scenarios. All studies except 9.0 include 1 foot sea level rise. Study 9.0 is future conditions with D-1641. (CVP/SWP operations BA figure 11-83).

Further downstream, Reclamation proposes to continue managing Sacramento River flows to the discontinued Wilkins Slough Navigation Requirement at Chico Landing (RM 118) in all but the most critical water supply conditions. Historically, a minimum flow of 5,000 cfs was required to support commercial boat traffic. However, the Corps has not dredged this reach to maintain channel depth since 1972. The flow requirement is now used to support long-time water diversions that have set their intake pumps just below this level. Diverters are able to operate for extended periods at flows as low as 4,000 cfs and for short periods at 3,500 cfs. Releases are made to meet the Wilkins Slough requirement in the spring and fall that impact the carryover storage and cold water pool in Shasta. Operating to flows less than 5,000 cfs would conserve storage in Shasta Reservoir in critically dry years.

Table 6-12. Proposed minimum flow requirements and objectives (cfs) on the Sacramento River below Keswick Dam (project description table 5).

Water year type	MOA	WR 90-5	MOA and WR 90-5	Proposed Flow Objectives below Keswick
Period	**Normal**	**Normal**	**Critically dry**	**All**
January 1 - February 28(29)	2600	3250	2000	3250
March 1 - March 31	2300	2300	2300	3250
April 1 - April 30	2300	2300	2300	---*
May 1 - August 31	2300	2300	2300	---*

September 1 - September 30	3900	3250	2800	---*
October 1 - November 30	3900	3250	2800	3250
December 1 - December 31	2600	3250	2000	3250

* No regulation. NMFS assumes that D-1641 standards, temperature control, and water allocations would result in higher flows.

In addition, Reclamation proposed to meet Delta water quality and flow standards contained in D-1641 with releases from Shasta Dam. Delta outflow and salinity requirements both require significant volumes of water to be released from upstream reservoirs. These releases are coordinated with releases from Oroville Dam and Folsom Dam, but the majority of flow usually comes from Shasta Dam. In accordance with the COA between the CVP and the SWP, Reclamation provides 75 percent of the required flows into the Delta and the SWP provides 25 percent. At times during critical years and after extremely wet months, the Delta standards can have significant upstream effects on water temperature control. The effect of the SWRCB Delta standards on upstream ESA-listed fish species was never analyzed during the 1995 Delta Accord, and has since become a greater problem as additional species have been listed (*i.e.* spring-run, CV steelhead, and long-fin smelt). For example, Delta outflow and salinity standards required in D-1641 are met with reservoir releases in dry springs when natural runoff cannot support the standards. These releases can account for a significant portion of storage that influences the total cold water volume available for release later in the summer.

6.3.2.2 Water Temperatures in the Sacramento River

6.3.2.2.1 Deconstruct the Action

A TCD has been in operation at Shasta Dam since 1998. TCD operations are capable of maintaining 56°F water downstream to Balls Ferry Bridge in most years through the summer spawning period for winter-run (table 6-13). The State Water Resources Control Board Water Rights Order 90-5 requires temperature control for winter-run salmon downstream to the RBDD, "to the extent controllable." The ability to control water temperatures depends on a number of factors and usually ends in October when the cold water in Shasta Reservoir is used up. The general factors that influence water temperature management are: (1) the volume of cold water available by April 15; (2) TCD operational flexibility; (3) mixing of Shasta releases with flows from Spring Creek Power Plant in Keswick Reservoir (*i.e.*, Trinity River diversions); and (4) designation of the temperature compliance location. As explained above, NMFS has already analyzed Spring Creek Power Plant and Shasta carryover storage and expects the capability of both to be limited by Trinity River operations, increased future demands for water, and climate change. Real time experience operating the TCD has found that it is most efficient within normal lake levels. However, in wet years, warm surface water over tops the TCD, and in very dry years, leakage allows warmer water to mix with the cold water at the bottom. In 2008 (a critically dry year) a test of the lower river outlets for temperature control concluded that they were ineffective at providing temperature benefits (Manza 2008). In addition, a warm water bypass conducted in the spring of 2008 to conserve cold water provided less than one degree of temperature benefit (Fugitani 2008).

Table 6-13. Temperature targets from the 2004 CVP/SWP operations Opinion used as evaluation criteria. Temperature targets are mean daily degrees F. Target points in the Sacramento and American River are determined yearly with input from the SRTTG and American River Operations Group.

River	Target Species and Lifestage	Temperature Target Point	Miles Below Dam	Date	Temperature Target	Comment
Sacramento	Winter run egg incubation	Balls Ferry	26	4/15 - 9/30	56	Location depends on coldwater availability
	Winter run egg incubation	Bend Bridge	44	4/15 - 9/30	56	Location depends on coldwater availability
	Spring run and winter run	Balls Ferry	26	10/1 - 10/31	60	Location depends on coldwater availability
	Spring run and winter run	Bend Bridge	44	10/1 - 10/31	60	Location depends on coldwater availability
Clear Creek	Spring run prespawn and steelhead rearing	Igo	7.5	6/1 - 9/15	60	
	Spring run spawning and steelhead rearing	Igo	7.5	9/15 - 10/31	56	
Feather River	steelhead rearing	Robinson's Riffle	6	6/1 - 9/30	65	
American River	steelhead rearing	Watt Avenue	13.4	plan May 1	68	Target based on yearly plan
Stanislaus River	steelhead rearing	Orange Blossom	12	6/1 - 11/30	65	

6.3.2.2.2 Assess Species Exposure and Response to Water Temperatures

Table 6-14 shows the relationship between water temperature and mortality of Chinook salmon eggs and pre-emergent fry compiled from a variety of studies. This is the relationship used for comparing egg mortality between scenarios. USFWS (1998) conducted studies to determine winter-run and fall-run early life temperature tolerances. It found that higher alevin mortality can be expected for winter-run between 56°F and 58°F. Mortality at 56°F was low and similar to fall-run mortality at 50°F. The relationships between egg and pre-emergent fry mortality and water temperature determined by USFWS (1998) were about the same as that used by Reclamation in the salmon mortality model.

For purposes of this analysis, NMFS used the Balls Ferry temperature compliance point to evaluate effects, since most winter-run (98 percent) spawning distribution has shifted upstream of this point in recent years (CVP/SWP operations BA figure 11-38). Water temperatures exceed the 56ºF objective at Balls Ferry in 50 percent of years in September and 10 percent of years from May through June under future conditions (Study 8.0, figure 6-13). Using the incremental exposure rates in table 6-14 and the modeled temperatures in figure 6-13, the loss rates for winter-run would be 8 percent egg mortality for those eggs exposed to 57ºF in 50 percent of the years, 15 percent egg mortality for those eggs exposed to 58ºF in 25 percent of years, 25-50 percent egg mortality for those eggs exposed to 59-60ºF, in 10 percent of years, and 50-100 percent egg mortality for those eggs exposed to 60-62ºF in 5 percent of years. In addition, exposure of newly hatched fry to lethal thermal stress would occur from 5-25 percent of years during August and September under future conditions. These conditions do not include the future baseline projected temperature increases resulting from climate change.

Table 6-14. Relationship between water temperature and mortality of Chinook salmon eggs and pre-emergent fry used in the Reclamation egg mortality model (CVP/SWP operations BA table 6-2).

Water Temperature (EF)[a]	Egg Mortality[b]	Instantaneous Daily Mortality Rate (%)	Pre-Emergent Fry Mortality[b]	Instantaneous Daily Mortality Rate (%)

Water Temperature (EF)[a]	Egg Mortality[b]	Instantaneous Daily Mortality Rate (%)	Pre-Emergent Fry Mortality[b]	Instantaneous Daily Mortality Rate (%)
41-56	Thermal optimum	0	Thermal optimum	0
57	8% @ 24d	0.35	Thermal optimum	0
58	15% @ 22d	0.74	Thermal optimum	0
59	25% @ 20d	1.40	10% @ 14d	0.75
60	50% @ 12d	5.80	25% @ 14d	2.05
61	80% @ 15d	10.70	50% @ 14d	4.95
62	100% @12d	38.40	75% @ 14d	9.90
63	100% @11d	41.90	100% @ 14d	32.89
64	100% @ 7d	65.80	100% @10d[c]	46.05

[a] This mortality schedule was compiled from a variety of studies each using different levels of precision in temperature measurement, the lowest of which was whole degrees Fahrenheit (±0.5ºF). Therefore, the level of precision for temperature inputs to this model is limited to whole degrees Fahrenheit.

[b] These mortality schedules were developed by the USFWS and CDFG for use in evaluation of Shasta Dam temperature control alternatives in June 1990 (Richardson *et al*. 1990)

[c] This value was estimated similarly to the preceding values but was not included in the biological assumptions for Shasta outflow temperature control FES (Reclamation 1991b).

This temperature analysis (table 6-15) shows for all four CALSIM II Studies that water temperature control is problematic from May through October, with the most significant (over half of the 82 years modeled) exceedance occurring in September when Shasta Reservoir runs out of cold water. At that point, temperature control is reliant on ambient air temperatures and shorter days to cool down the river. Cold water availability is a significant factor in 15 to 20 percent of the Keswick release cases by September, and 20 to 30 percent of cases by late October.

There is a great deal of uncertainty in the temperature model results used for the Sacramento River. The above CALSIM II monthly model is disaggregated into a weekly time step (a sizable improvement since 2004), but it is unable to show the actual operational strategies used when adaptively managing temperature objectives. In addition, there is uncertainty in the performance of the TCD on Shasta Dam. Due to hydraulic characteristics of the TCD such as leakage, overflow, and performance of the side intakes, the typical modeled releases are cooler than what can be achieved, therefore, Reclamation has modeled a more conservative approach than what it can realistically operate to.

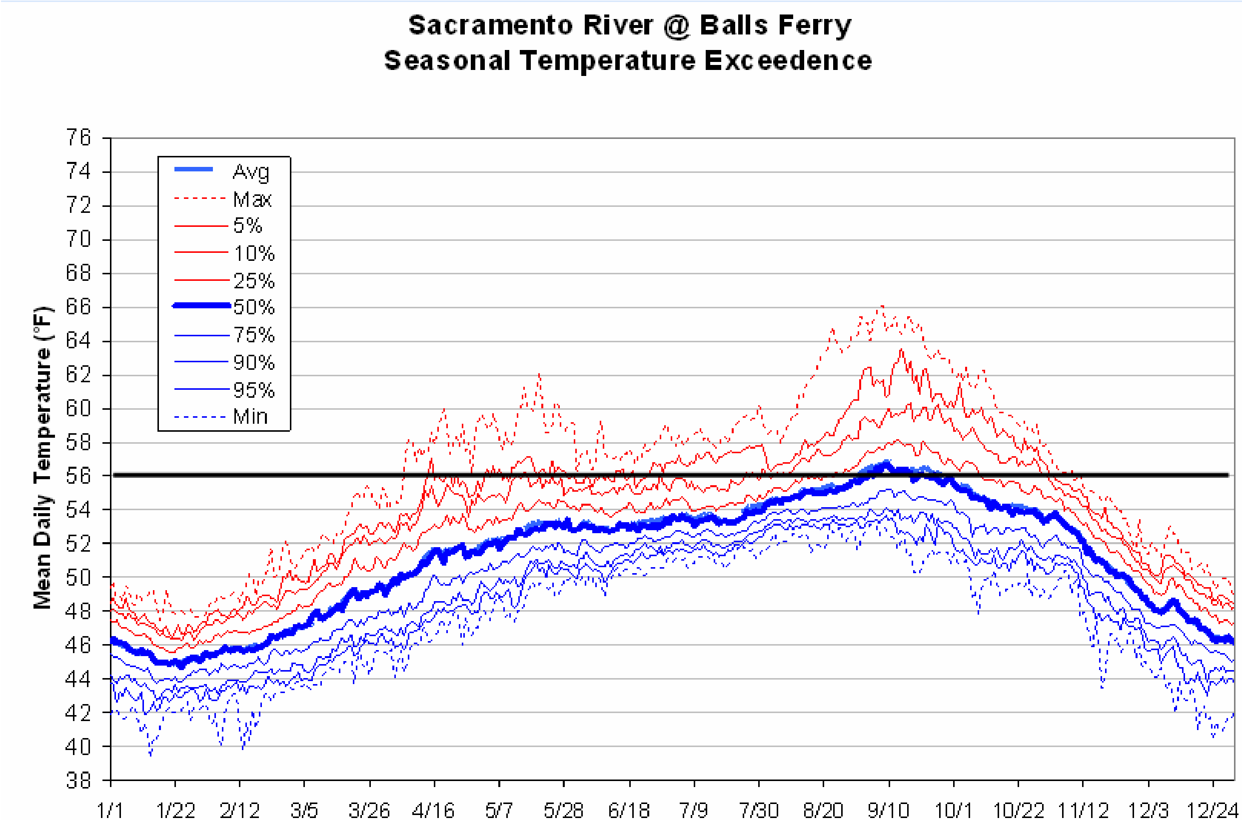


Figure 6-13. Water temperature exceedence at Balls Ferry under Study 8.0 from CALSIM and weekly temperature modeling results (CVP/SWP operations BA figure 11-35). For this analysis, the bold black line indicates the 56°F temperature compliance line.

Table 6-15. Balls Ferry water temperature exceedance by month from SRWQCM.

Month	Temperature (F)	Probability of Exceedance (%)	CALSIM Study
April 15	56		6.0, 7.0, 7.1, 8.0
May	56	5	6.0, 7.0, 7.1, 8.0
June	56	8	6.0, 7.0, 7.1, 8.0
July	56	11	6.0, 7.0, 7.1, 8.0
August	56	30	6.0, 7.0, 7.1, 8.0
September 15	56	40	6.0, 7.0 (base)
September 15	56	55	7.1, 8.0 (future)
October	60	4	6.0, 7.0, 7.1, 8.0

Reclamation's salmon mortality model shows the average percent mortality of eggs and pre-emergent fry while in the gravel for all years modeled (1922-2003). In comparison to the above temperature exposure analysis, Reclamation's model shows far less mortality due to water temperatures in all years. When comparing 2008 results at Balls Ferry with the same analysis performed in 2004, the 2008 results show approximately 5 percent less mortality on average, and in critical years, 30 percent less mortality (figure 6-14 compared to figure 6-15). This difference in mortality results is due to improvements in the SRWQM, which is the main driver for the mortality model. The temperature model disaggregates the monthly results into a weekly time-step. Therefore, the more realistic time-step should make the mortality model results more accurate. In most years, average mortality is now predicted to be 1-2 percent due to water temperature effects. During critically dry years, mortality under near future operations (study 7.1) is about 15 percent, while under future operations (study 8.0), mortality is about 10 percent (figure 6-14). The critically dry years represent 15 percent of the years modeled.

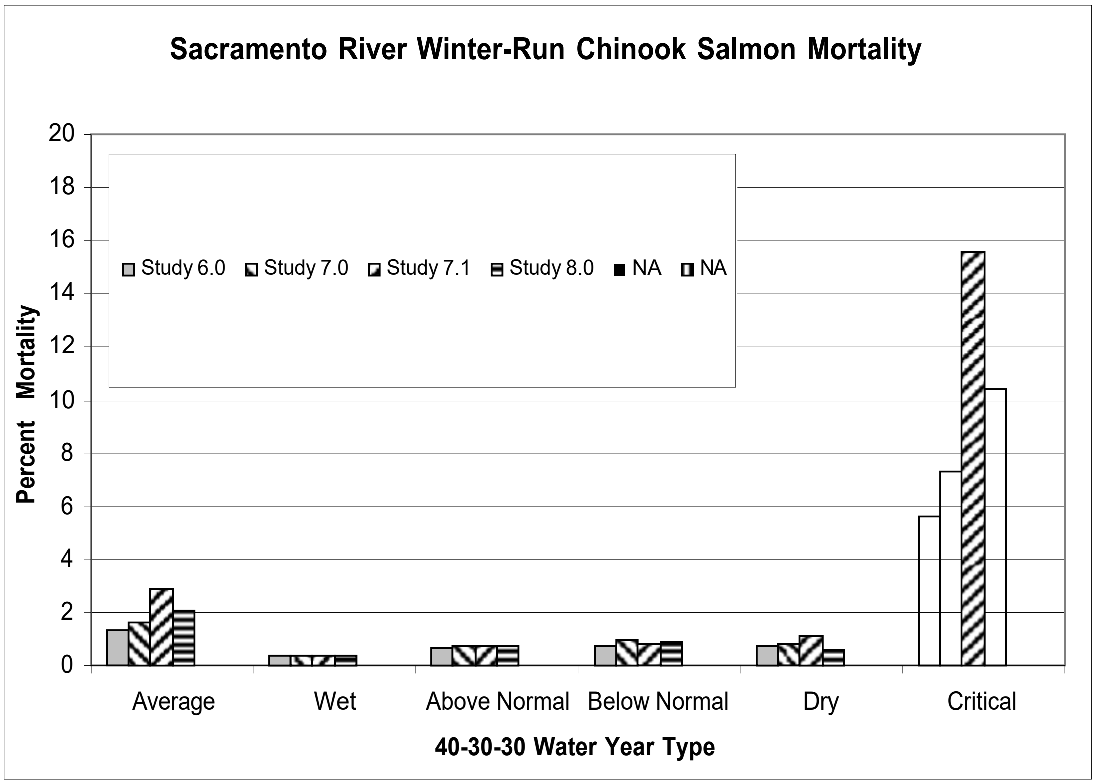


Figure 6-14. 2008 Winter run average egg mortality by water year type at Balls Ferry. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (CVP/SWP operations BA figure 11-39).

Water temperatures at Bend Bridge would be unsuitable for spawning and incubation (exceed 56ºF) in 80 percent of the years in August and September. Bend Bridge is used as the most downstream temperature compliance point. Therefore, it is unlikely that through the adaptive management process the compliance point would move downstream of Balls Ferry except in extremely wet year types. The constriction of the available habitat for winter-run and spring-run only in an upstream direction as water temperatures increase may limit these fish from expanding their population size. Spring-run show a similar pattern of egg mortality, based on Reclamation's egg mortality model (figure 6-16). However, their egg mortality rates are just slightly less than twice that of winter-run, likely owing to the fact that they spawn later in the year, and Shasta Reservoir runs out of cold water for temperature control.

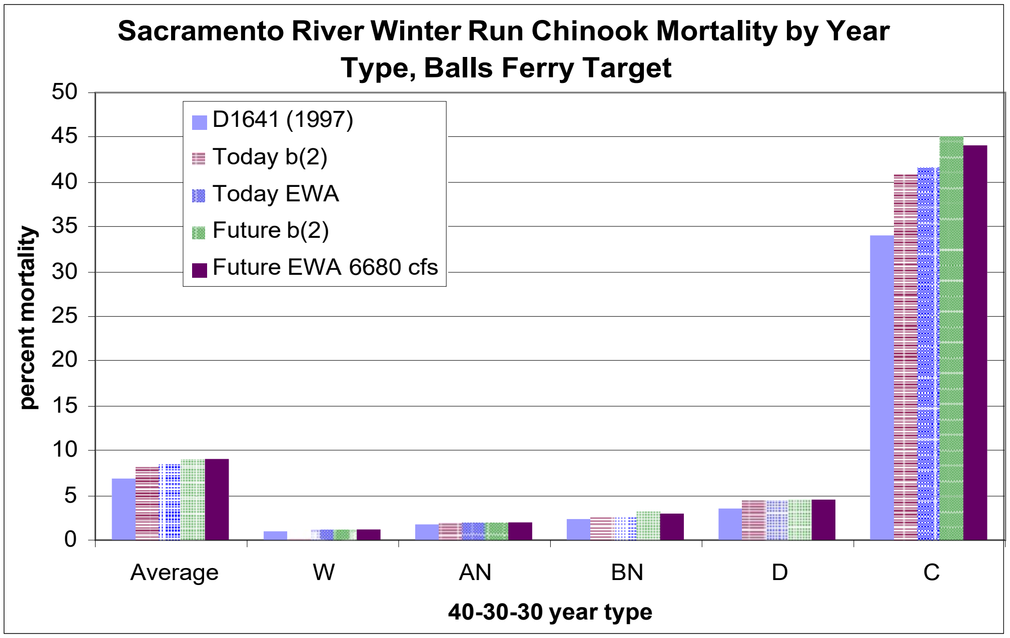


Figure 6-15. 2004 winter-run average egg mortality by water year type at Balls Ferry temperature target, with 5 model runs represented (CVP/SWP operations BA).

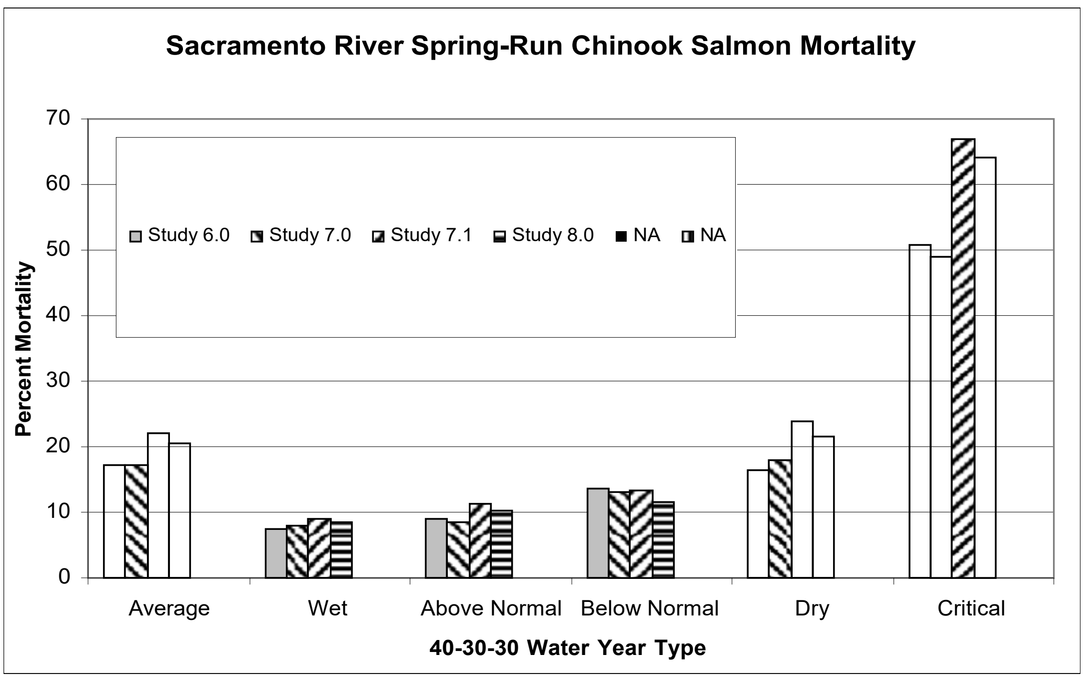


Figure 6-16. Spring-run egg mortality from Reclamation egg mortality model by water year type. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (CVP/SWP operations BA figure 11-41).

Juvenile winter-run typically leave the upper Sacramento River (Keswick Dam to RBDD) between September and October (figure 6-17), when they are beyond the reach of temperature control. Temperature control is usually not necessary after October 30, as ambient air temperatures cool the river.

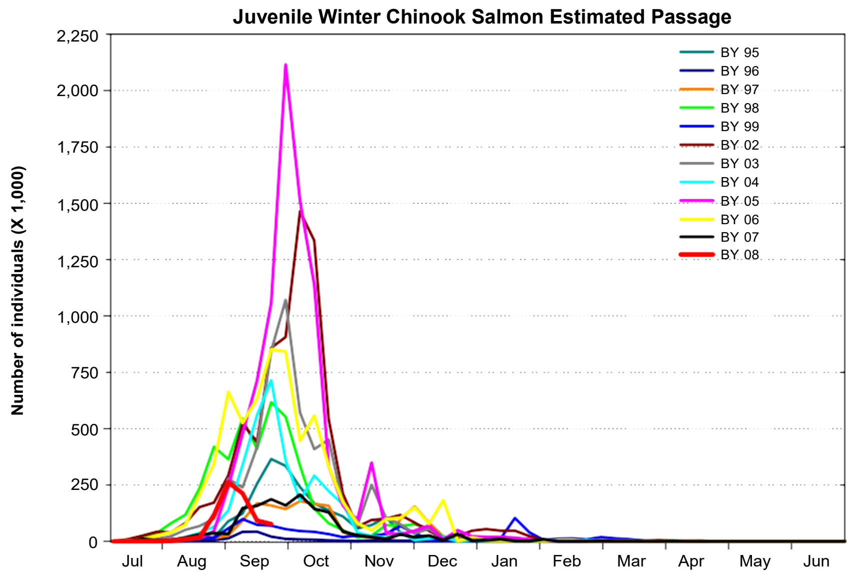


Figure 1. Weekly estimated passage of juvenile winter Chinook salmon at Red Bluff Diversion Dam (RK391), by brood-year (BY). Fish were sampled using rotary-screw traps for the period July 1, 1995 through June 2000 and July 1, 2002 to present.

Figure 6-17. Juvenile winter-run passage at Red Bluff Diversion Dam 1995 through 2008 (USFWS BDAT 2008).

CV steelhead mortality was not estimated using Reclamation's Mortality Model, but using late fall-run as a surrogate (since they spawn at the same time of year), the water temperature effects would be minimal. Late fall-run show on average a 4 percent increase in egg and fry mortality from temperature increases. With climate change, mortality of CV steelhead on the mainstem Sacramento River would increase 2-3 percent. Therefore, temperature related mortality is not considered a significant stressor because it would not occur every year. However, the lack of suitable habitat (*i.e*., small gravel, small side channels, access to higher elevation tributaries) limits reproductive success, and the current coldwater management encourages the expression of only one life history pattern (residency).

In almost all years since the TCD has been installed, the TCP has been moved upstream by the SRTTG in response to one of the 4 factors above to protect winter-run eggs and fry (figure 6-18). Multiple day exceedences have become the norm and can be expected to continue under future operations. The SRTTG is responsible for adaptively managing the compliance point based on real-time data (*i.e.,* Shasta Reservoir temperature profiles, aerial redd counts, carcass surveys, and predictive temperature model runs). The SRTTG priorities are to provide enough cold water through the summer to protect: (1) winter-run spawning (April 15 - September 30), (2) spring-run spawning (September - October), and (3) fall-run spawning (October – November). This adaptive management process works well for protecting winter-run, but typically creates tradeoffs when considering how much cold water is left for spring-run and fall-run.

Water temperatures at Colusa are 64-66°F in both wet and dry years in September (figure 6-19) when the peak of the juvenile winter-run are emigrating downstream. The preferred optimum water temperature for juvenile rearing is 53-57°F, and water temperatures less than 64°F are required for smoltification (CVP/SWP operations BA table 6-1). Therefore, for roughly half of their juvenile emigration (Colusa to the Delta), winter-run are exposed to sub-lethal temperature effects and greater predation due to nonindigenous (Sanderson *et al.* 2009). Once they reach the Delta, tidally-influenced flows cool the water temperatures to the range a juvenile can begin the process of smolting (64°F) by November (CVP/SWP operations BA figure 6-6). Past studies using CWT (such as CVPIA, Delta Action 8 Studies) showed poor survival rates for hatchery released fall-run and late-run juveniles from the upper Sacramento River (Battle Creek) to Chipps Island (Brandes and McLain 2001, USFWS 2003 and 2006, Newman 2008). Delta Action 8 studies, Newman 2008). Recent studies using acoustic tags on hatchery late-fall and CV steelhead showed both species had average survival rates of only 10 percent to the Delta, and 1-2 percent to the Golden Gate Bridge (MacFarlane 2008). These low survival rates indicate rearing habitat has been degraded by a whole suite of stressors such as; increased concentration of introduced warm-water predators, unscreened diversions, sublethal water temperatures, contaminants, agricultural return water, wastewater treatment plant discharges, shortened emigration timing, and smaller size.

Upper Sacramento River Temperature Control History

Water Year	Oct. 1 Shasta Storage (TAF)	April 30 Shasta Storage (TAF)	Starting Compliance Point	Month	Action	Change in Compliance Point
1987-1996					Use of low-level outlets, power costs	
1992					CVPIA passed, construct TCD	
1993	1683	4263	Bend Bridge			
1994	3102	3534	Jelly's Ferry			
1995	2102	4165	Bend Bridge	July	Conserve cold water	Jelly's Ferry
1996	3136	4308	Bend Bridge	April	Exceed 56 °F 4/26	
				May	Exceed 56 °F 5/27	
				July	Conserve cold water	Jelly's Ferry
				August	Conserve cold water	Ball's Ferry
				Sept	Transition to stable min flow	Clear Creek
					for fall-run salmon by Oct 15	
1997*	3089	3937	Bend Bridge	May	Exceed 56 °F at Bend 3 days	
				July	Exceed 56 °F at Bend 4 days	
	*First year that TCD was used				Conserve cold water	Jelly's Ferry
				Sept	Exceed 56 °F at Jelly's 8/29	
					to 9/13	
				Oct	Exceed 56 °F at Jelly's 9/20-9/30	
1998	2308	4061	Bend Bridge	June	Exceed 56 °F at Bend 3 days	
				June	Exceed 56 °F at Bend 4 days	
				Sept	temp exceed 56 since Sep 12	Jelly's Ferry
1999	3441	4256	Bend Bridge	August	Exceed 56 °F at Bend 4 days	
2000	3327	4153	Bend Bridge	June	Exceed 56 °F at Bend 3 days	
				July	Conserve cold water	Jelly's Ferry
				August	Conserve cold water	Ball's Ferry
				Oct	Exceed 56 °F at Balls 3 days	
2001	2985	4020	Jelly's Ferry	July	Exceed 56.5 °F at Jelly's 2 days	
				August	Exceed 56 °F at Jelly's 8/28/2001	
					to 9/1/2001 and 9/152001 to	
				Sept	9/30/2001	
2002	2200	4297	Jellys' Ferry	May	Exceed 56 °F at Jelly's 5/18/2003	
2003	2558	4537	Bend Bridge	May	Exceed 56 °F at Bend 5/14/2003	
				Aug. 6		Jellys Ferry
				Aug. 8		Balls Ferry
				Aug. 28	Conserve cold water	
2004	3159	4060	Bend Bridge	May 7.	Exceed 56 °F at Bend	Jellys Ferry
				May 27.		Balls Ferry
2005	2183	4207	Balls Ferry	May 8.		Jellys Ferry
				Aug. 5		Balls Ferry
2006	3035	4057	Balls Ferry	May 1.		Bend Bridge
2007	3205	3901	Balls Ferry	May 7.		Jellys Ferry
				June 8.		Balls Ferry
2008	1879	3066	Balls Ferry	Apr.15	Conserve cold water	Jellys Ferry
			Airport Road	May 8.	Exceed 56 °F at Bend 3 days	Airport Road
			(below Clear Creek)			

Key:
- Above Normal & Wet (green)
- Below Normal & Dry (yellow)
- Critical (orange)

Figure 6-18. Historical exceedances and temperature control point locations in the upper Sacramento River from 1992 through 2008.

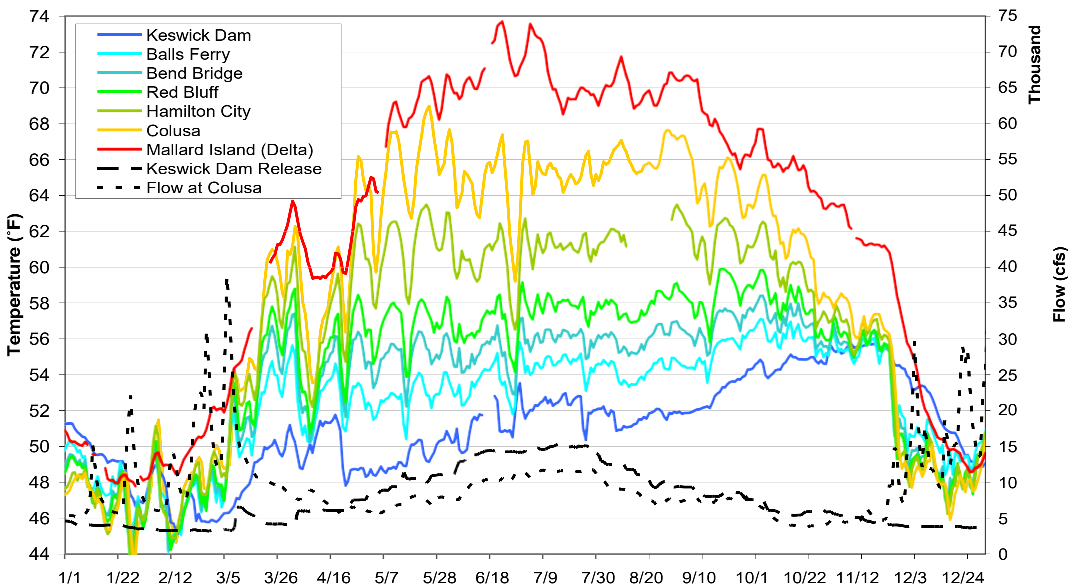


Figure 6-19. Sacramento River mean daily temperature and flow at selected locations in a dry water year, actual measured temperatures in 2001 (CVP/SWP operations BA figure 11-1).

6.3.2.2.2.1 Green Sturgeon

Based on table 6-16, water temperatures are unsuitable for green sturgeon spawning and rearing downstream of Hamilton City, which is also the location of the GCID diversion. Recent studies by Vogel (2008) indicated that large aggregations of adult green sturgeon have been observed congregating near Hamilton City.

Table 6-16. Temperature norms for green sturgeon life stages in the Central Valley (Mayfield and Cech 2004, NMFS 2006).

General Life Stage	Suitable	Tolerable[a]	Lethal
adult immigration	52 to 59°F	61 to 66°F	80°F
spawning & incubation	46 to 57°F	57 to 65°F	72°F
rearing	59 to 61°F	61 to 65°F	72°F
Juvenile emigration	60 to 65°F	65 to 69°F	77°F

[a]Sublethal effects occur in this temperature range

Adult green sturgeon blocked by RBDD are known to drop back downstream and hold in large pools below at the confluence of Deer and Mill creeks (Heublein et al. 2009). It is unknown how far downstream spawning occurs, but the conditions at Hamilton City are most likely suboptimal for developing eggs, larval, and rearing juveniles from March through September (figure 6-19). Water temperatures are tolerable for adults that may hold after spawning between RBDD and GCID.

6.3.3 Losses from Screened and Unscreened Diversions on the Sacramento River

Listed juvenile salmonids and green sturgeon are entrained in both screened and unscreened diversions on the Sacramento River. The loss is greatest in the upstream areas close to the spawning habitat where life stages are the smallest. The entrainment rate for screened diversions is small (< 1 percent) based on monitoring at RBDD. There are approximately 68 screened diversions in the Sacramento River (Calfish database). NMFS assumes if fish screens are meeting current screening criteria they are 95 percent effective, or that it is likely that 5 percent of the fish that come in contact with the fish screen could be killed through repeated contact with the screen, impingement, or contact with the cleaning mechanism. Actual mortality to screens is probably much less, as measured at the RBDD Pilot Pumping Plant (Borthwick and Corwin 2001 *op.cit*. CVP/SWP operations BA) and are more likely to represent less than one percent of the fish that come in contact with the screen (table 6-17). If the mortality from all screened diversions in the Sacramento River were summed it would be an insignificant amount when compared at the population level. Reclamation, as part of its mitigation responsibility under CVPIA section 3406(b)(21), funds the AFSP. The AFSP has screened most of the larger diversions in the Sacramento River. However, a few remain to have screens completed.

Estimates of the mortality at unscreened diversions in the Sacramento River (*i.e*., 792 unscreened diversions listed in the Calfish data base and AFSP annual work plan 2009) are small, but when taken together, the cumulative impact is likely to reach the level where they would impact ESA species at the population level (table 6-17). The AFSP has screened most of the diversions larger than 250 cfs, and is now focusing on monitoring the losses occurring at smaller unscreened diversion to guide future fish screen projects. On the Sacramento River, losses of juvenile salmon are likely to continue at the following large diversions that are unscreened; Natomas Mutual, Reclamation District 2035, Meridian Farms, and Pleasant Grove-Verona.

Table 6-17. Estimated annual entrainment at water diversions based on size (volume of water diverted) and fish monitoring data (RBDD pumping plant) summarized from CVP/SWP operations BA tables 11-12 through 11-16).

Number of juvenile fish entrained	Screened Diversions*(ACID, TCCA, GCID)	123 unscreened Diversions (Project water only)	Percentage of juvenile population impacted by unscreened diversions**
Winter-run	50	7,440	0.37
Spring-run	5	537	0.0537
Fall-run/late fall-run	126	18,775	0.00653
CV steelhead	2	393	0.00677
Green sturgeon	unknown	199	unknown

* screened diversion calculated from 11 year average mortality observed at TCCA times number of screens in upper Sacramento River (3 largest).

** number of juveniles entrained at unscreened diversion/JPI average from 1994-1999 May through October passage at RBDD (Gaines and Martin 2002 *op. cit*. CVP.SWP operations BA).

Juvenile salmonids are more vulnerable to unscreened diversions than adults due to their size and behavior (*i.e*., moving downstream with the flow). Unscreened diversions in the upper

Sacramento River are more likely to kill juvenile salmonids and green sturgeon due to their close proximity to spawning areas where newly hatched fry and larvae have weak swimming abilities. For green sturgeon, newly hatched larvae are subject to impingement on screened diversion, if they are located near areas where adults are spawning. Mefford and Sutphin (2009) have shown that for pallid sturgeon, which are smaller in size than green sturgeon, larvae in the 25-60 mm range became impinged on fish screens built to salmonid criteria. Juvenile green sturgeon that pass RBDD are typically within that range, therefore, likely some are likely loss to screened diversions at and above RBDD. Juvenile green sturgeon are also more likely to be impinged on fish screens because of the location of the intake near the bottom or in deep water.

6.3.4 Sacramento River Water Reliability Project (SRWRP)

The project description in the October 1, 2008, final CVP/SWP operations BA included the construction of a new water diversion intake structure, fish screen, water treatment plant and support facilities with a 365 cfs capacity in the Sacramento River at RM 74.6 (north of Elverta Road between the confluences of American and Feather River). However, as discussed in section 3.1 of this Opinion, in January 2009, Reclamation transmitted to NMFS an edited form of the CVP/SWP operations project description (Appendix 1 to this Opinion) that is consistent with that of the USFWS' Delta smelt biological opinion (USFWS 2008a). That project description did not contain the SRWRP, however, it did not remove the water associated from the SRWRP from the modeling.

Impacts considered under the CVP/SWP operations consultation from the SRWRP include impacts to aquatic species throughout the CVP and SWP due to the increase in the total amount of water being diverted from the Sacramento and American rivers relative to existing conditions. Although this project is not ready to be constructed, NMFS assumes, for modeling purposes, that there will be a decrease in the amount of water available on the Sacramento River from this project.

NMFS considers any further withdrawals of water from the Sacramento River will negatively impact the amount of freshwater that enters the Delta and the availability of cold water in Shasta Reservoir since this project shifts water demands from the American River to the Sacramento River. Such a shift creates tradeoffs between ESA-listed species (*i.e.*, steelhead on the American River v. winter-run and spring-run on the Sacramento River). When the project design is completed and Reclamation requests consultation on the SRWRP, the operational impacts to both upstream and Delta areas must be included, in addition to the construction-related impacts.

6.3.5 Climate Change

As discussed in sections 2.3.3 and 5.1, climate change is an environmental phenomenon that is part of the future baseline and would occur irrespective of any operations of the CVP or SWP. Although parts of section 6.3.2, above, discusses the climate change stressor on water storage at Shasta Reservoir, water temperature management in the Sacramento River, and mortality of early life stages of anadromous species, this section focuses on the effect of climate change on the larger ecosystem, and as modeled by Reclamation in study suite 9.

The impact of climate change in the future introduces greater uncertainty into the way in which water is managed in California. The historic hydrologic pattern represented by CALSIM II modeling in CVP/SWP operations (past 82 years of record) can no longer be solely relied upon to forecast the future. Precipitation and runoff patterns are changing, creating increased uncertainty for ecosystem functions. The average snowpack in the Sierra Nevada decreased by 10 percent in the last century, which translates into a loss of 1.5 MAF of snowpack storage (DWR 2008). California's air temperature has already increased by 1°F, mostly at night in winter, with the higher elevations experiencing the highest increase. A corresponding increase in water temperature is likely to reduce the available habitat for species that depend on cold water like spring-run that require over summer holding pools. Increasing water temperatures will also accelerate biological processes that impact anadromous fish like increased algae growth and decreased dissolved oxygen. Climate change will affect the entire life cycle of salmonids and sturgeon through warmer ocean periods, changes in age and size at maturity, decline in prespawn survival and fertility due to higher stream temperatures, and a loss of lower elevation habitat (Crozier *et al*. 2008).

In the Sacramento River, comparing climate change scenarios (Study 9.0 base vs Study 9.5 drier, more warming) shows that average winter-run and fall-run mortality increases from 15 percent to 25 percent, and average spring-run mortality increases from 20 percent to 55 percent (figure 6-20). Reclamation's mortality model was not run for CV steelhead because steelhead have a shorter incubation period than salmon, and the model would have to be changed. However, late-fall salmon can be used as a surrogate for CV steelhead since they spawn at similar times in the winter. Late fall-run mortality increases in Study 9.5 (drier, more warming) and Study 9.3 (wetter, more warming) under all water year types on average 4 percent over the future full build out scenario (Study 9.0). EOS carryover storage at Shasta is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming (CVP/SWP operations BA table 9-23). Under these conditions, winter-run and spring-run would experience a loss of spawning habitat, as water temperatures below dams becomes harder to control and the cold water pool in Shasta diminishes.

CV steelhead would experience less of a loss on the mainstem Sacramento River, since they spawn in the late winter when water temperatures are not as critical to incubation. However, resident forms of *O. mykiss* spawn in May, when water temperatures exceed 56°F at Bend Bridge in 25 percent of future water years (CVP/SWP operations BA figure 10-83). This resident life history pattern represents a reserve that anadromous fish can interbreed with if there are too few CV steelhead (Zimmermen *et al.* 2008). It is likely that given warmer water temperatures resident *O. mykiss* would move upstream closer to Keswick Dam where temperatures are cooler, or into smaller tributaries like Clear Creek.

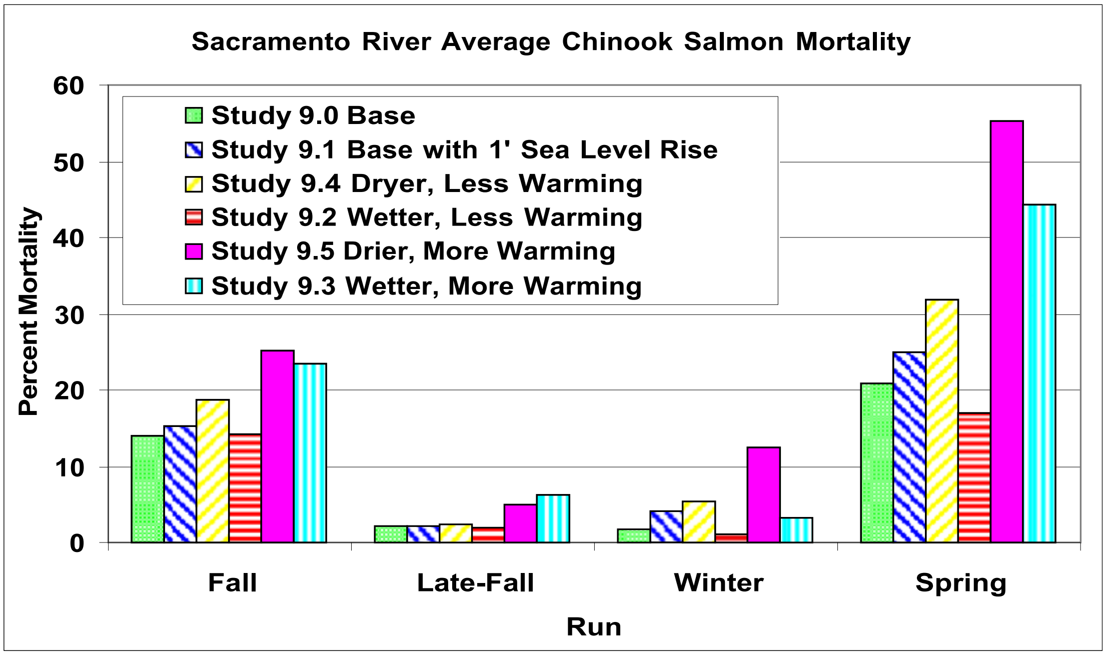


Figure 6-20. Sacramento River average Chinook salmon mortality by run and climate change scenario from Reclamation salmon egg mortality model. All studies except 9.0 include 1-foot sea level rise. Study 9.0 is future conditions with D-1641 (CVP/SWP operations BA figure 11-82).

Water temperatures in the Sacramento River at Balls Ferry increase under all climate change scenarios except for Study 9.2 (wetter, less warming). Temperatures exceed the 56 ºF objective at Balls Ferry in July, August, September, and October. The highest water temperatures approach 60ºF in September in Study 9.5 (drier, more warming), which is when spring-run salmon begin spawning. The climate change scenarios do not incorporate day-to-day adaptive management decisions of the SRTTG. Given the current prioritization of using cold water first for winter-run salmon during the summer, it would be logical to assume that spring-run and fall-run would experience greater impacts than those modeled.

Similar climate change modeling was conducted using a quantitative model (WEAP21) of the Sacramento River flow and temperature regime downstream to Hamilton City (Yates *et al.* 2008). This model compared water temperatures at Shasta Dam with and without managed releases for temperature control. In the unmanaged regime, the model assumes that Shasta Dam does not exist and that there is no irrigation demand. Using the observed historical record for years before the TCD was installed, Yates *et al*. (2008) used the WEAP21 model to calculate effects on winter-run, spring-run, and fall-run under a 3.5º F and 7ºF water temperature warming change. Under a 3.5ºF warming scenario, water temperatures at Keswick would be at or below the optimum upper temperature of 56ºF for spawning and rearing, and then increase from that point downstream, except in the driest years. Under a 7ºF warming scenario, even in wet years, spawning and rearing water temperature requirements would be exceeded in September and October from Keswick Dam to Hamilton City (Yates *et al*. 2008). The results of the WEAP21 modeling suggest that even with the use of the TCD on Shasta Dam, water managers will be challenged to maintain suitable water temperatures in the upper Sacramento River (*i.e*., Keswick to Hamilton City). Yates *et al*. (2008) concluded that cold water releases from Shasta Reservoir play a role in maintaining suitable habitat for spawning and rearing Chinook salmon as far downstream as Hamilton City, and that climate change could be a major determinant of the future viability of adult and juvenile reproduction and migration strategies. Winter-run and spring-run were shown to be most at risk due to the timing of their reproduction. Without the cold water releases from Shasta Dam, water temperatures would exceed the physiological tolerances by 5°F or more, and winter-run and spring-run populations would not likely persist in the mainstem. The study also found that the availability of cold water releases is reduced as warming increases the demand for water and evaporative losses in Shasta Reservoir.

6.3.6 Assess the Risk to the Individuals

Based on the effects of the proposed action on winter-run, spring-run, CV steelhead and the Southern DPS of green sturgeon in the mainstem Sacramento River, as described above, fitness consequences to individuals include loss of genetic integrity and expression of life history, reduced reproductive success during spawning, reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration (see tables 6-4 through 6-7).

6.3.7 Population Response to Project Effects Using SALMOD Modeling Winter-Run, Spring-Run, and CV Steelhead in the Upper Sacramento River

SALMOD modeling was used only on the Sacramento River to simulate population level responses to habitat changes caused by project operations. The study area extended from Keswick Dam downstream to the point at which the RBDD inundates riverine habitat upstream (53 miles). The pool backed up by RBDD has not been modeled for habitat value. The study area includes winter-run, spring-run, steelhead and green sturgeon spawning and rearing habitat. SALMOD uses PHABSIM and RIVER2D modeling to analyze habitat that has been classified according to mesohabitat type (*i.e.* pool, riffle, run). Unlike Northcoast streams, most Central Valley rivers and streams have not been habitat typed, limiting the use of SALMOD to just the upper Sacramento River. SALMOD functions to integrate microhabitat and mesohabitat limitations to a fish population through time and space. It is a spatially explicit model, which means the model tracks a population as it grows from one life stage to another. SALMOD uses a weekly time step derived from CALSIM monthly averages and HEC-5Q models. The SALMOD model is capable of processing spawning losses due to redd superimposition, redd scouring, dewatering, mortality due to water temperature, and seasonally induced changes in habitat. Habitat quality is categorized by channel structure, hydraulic geometry, and fish cover using changes in response to discharge. Habitat area is quantified using WUA described previously for PHABSIM and RIVER2D. Tributary production was also added to the upper Sacramento River as fry and juveniles. The SALMOD model takes density dependence into account down to Red Bluff, but the mortality model and delta survival make no adjustments for density dependence. Since density dependence is overlooked in the rivers (other than the Sacramento) and in the Delta the estimates of survival are lower than what would occur with compensatory mortality, where it occurs.

Uncertainty in the model comes from input values. Input variables include weekly average streamflow derived from monthly average CALSIM model results. Water temperature values are derived from the SRWQM daily results, which are disaggregated from monthly averages.

Numbers and distribution of fish were based on average escapement from 1999 to 2006 and may not accurately represent current populations. SALMOD is designed to represent population means based on large numbers. When populations are low (which they are now), they are more sensitive to individual variability and environmental stochasticity. SALMOD is not designed to address small population characteristics. Populations under 500 spawners were identified as being too low for accurate results. SALMOD used a starting population of 1,000 spring-run even though current redd surveys indicate less than 100 spawners in the mainstem. 8,591 winter-run spawners were used to start even though current population estimates are less than 3,000. Each year the population is reset to the starting level making it difficult to ascertain trend information. Confidence intervals or other measures of uncertainty have not been estimated for any of the models used in the CVP/SWP operations BA.

Steelhead were not used in SALMOD, however, NMFS assumed that late fall-run could be used as a surrogate, since they have similar life history stages and spawn at the same time of year. Additional uncertainty comes from not using the most recent years (*i.e.*, 2003-2008), which incorporate adaptive management, EWA, Trinity ROD flows, and changes in operations due to ESA-listed fish species not represented in the historical data.

Most model runs using SALMOD showed that there was not much difference between current and future operations (CVP/SWP operations BA Figures 11-44 through 11-54) except during critical years when juvenile production is reduced by up to 40 percent. Years of low production were 1925, 1932, 1935, 1977, and 1992 when cold water releases are limited. Most mortality occurred during the more sensitive egg and fry stage rather than presmolts and smolts. Winter-run fry mortality due to habitat limitations from water project operations increased gradually over time from less than 400,000 in 1923 to greater than 800,000 in 2002 (figure 6-21).

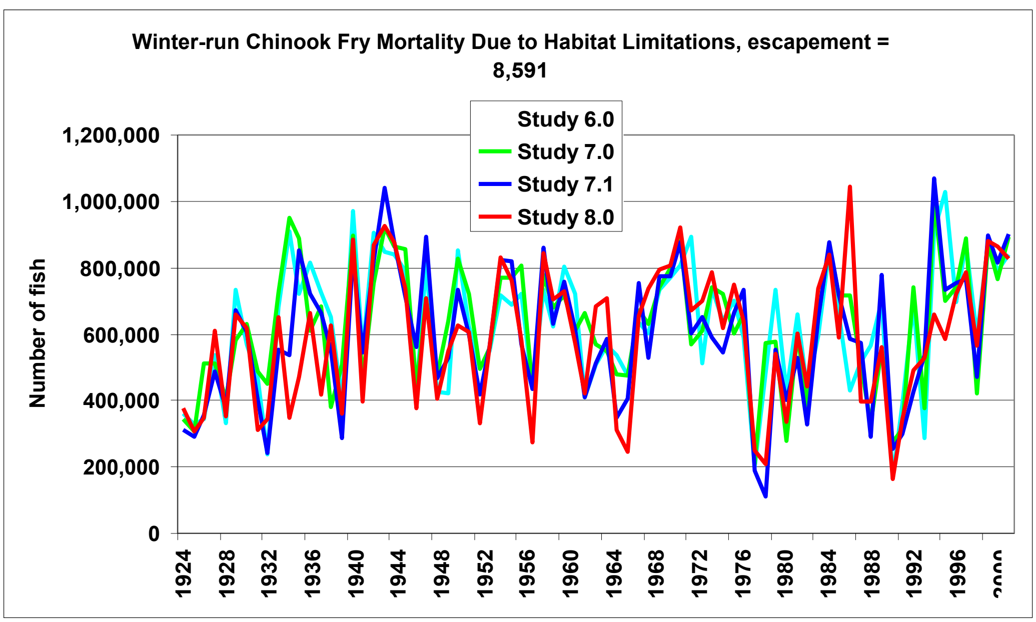


Figure 6-21. Winter-run Chinook salmon fry mortality due to habitat limitations by water operational scenario, 1923-2002 from SALMOD model. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (CVP/SWP operations BA figure 11-49).

Spring-run model results using SALMOD were similar to winter-run in that most of the mortaility due to project operations occurred in the egg and pre-emergent fry stage. There was no mortality of fry, presmolts or smolts due to water temperatures. Most spring-run and winter-run are classified as pre-smolts upon passing the downstream end of the study area (RBDD). Spring-run egg mortality due to water temperature reached 2,200,000 of 2,400,000 potential eggs modeled (or 92 percent) in critically dry years (figure 6-22) indicating most of the spring-run would not survive the effects of the proposed action. Since the SALMOD model resets the number of adults each year, it is difficult to predict what would happen in the years following this significant reduction.

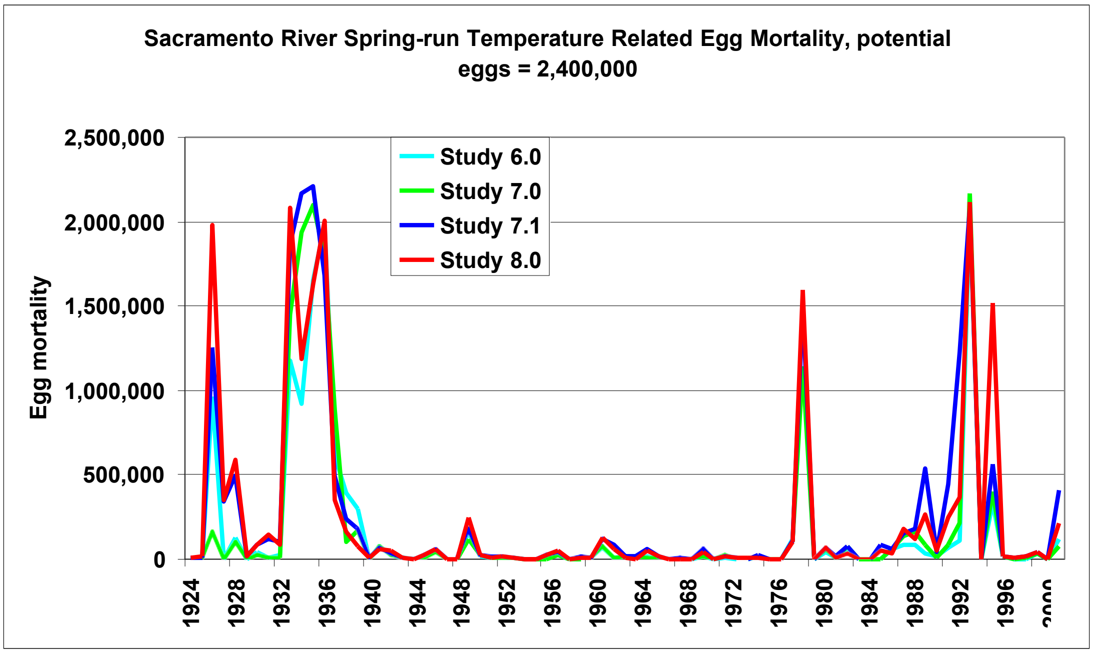


Figure 6-22. Sacramento River spring-run egg mortality due to water temperature by operational scenario with 2,400,000 total potential eggs, 1923-2002 from SALMOD model. Study 6.0 represents 2004 operations, 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (CVP/SWP operations BA figure 11-53).

Using SALMOD results for late fall-run as a surrogate, steelhead showed, on average, juvenile production was reduced by 10 percent during most years, but some years experienced up to a 60 percent reduction. The reduction in juveniles compared to the maximum production per year is shown in figure 6-23 for each operational scenario.

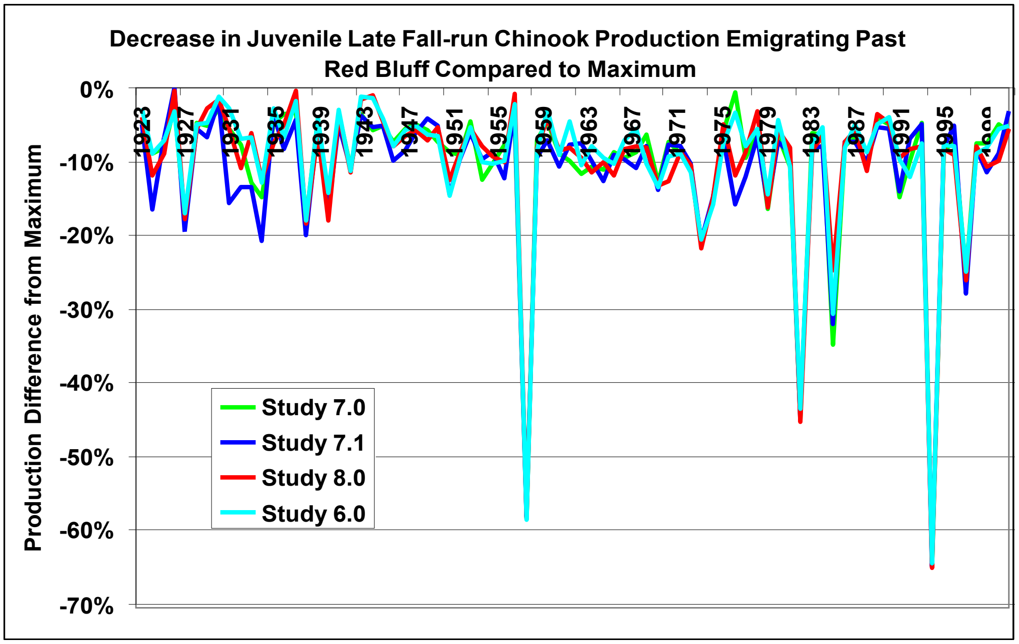


Figure 6-23. Reduction in upper Sacramento River juvenile late fall-run Chinook salmon production during each year of the CALSIM II modeling period relative to the maximum production year. Production was based on 12,051 adults and an average of 7 million juveniles produced in most years.

The SALMOD model shows a reduction in juvenile production resulting from project operations. The differences between Studies 6.0, 7.0, 7.1 and 8.0 are not apparent, however, when taken together and added to the existing stress regime. However, winter-run and spring-run on the mainstem Sacramento River never recover from critical years. The CVP/SWP operations BA concluded, "that episodic reduction in juvenile survival (particularly in critically dry years) leads to an average annual reduction of 6,200 adult spawners for 7.1 and 3,600 for 8.0 (relative to study 7.0). The effect of this reduced escapement through an 80-year period of simulation is sensitive to effects external to the proposed action (*e.g*., increased harvest rate or loss of hatchery supplementation)."

6.3.8 Effects of the Action on Critical Habitat in the Sacramento River

As described in the critical habitat designation final rules (June 16, 1993, 58 FR 33212; September 2, 2005, 70 FR 52488), critical habitat provides PCEs, which are physical or biological elements essential for the conservation of the species. The Sacramento River provides 3 of the 6 PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run, spring-run, and CV steelhead. The Sacramento River is also proposed for critical habitat for Southern DPS of green sturgeon (proposed September 8, 2008, 73 FR 52084). Critical habitat impacted by the proposed action includes the Sacramento River from Keswick Dam to the Delta (302 miles).

6.3.8.1 Spawning Habitat

Steelhead spawning in the mainstem Sacramento River is probably limited to the area upstream of RBDD where spawning gravel has been added for Chinook salmon. However, surveys have never been conducted to determine where or when CV steelhead spawn in the mainstem. Most steelhead prefer to spawn in smaller tributaries, except where blocked by impassible dams. Similar habitat conditions found in the upper Sacramento River exist in all core populations of CV steelhead, such as on the American River, Feather River, and Stanislaus River. Based on redd surveys conducted in other rivers, it is plausible that CV steelhead could utilize some areas as spawning habitat. The CVPIA spawning gravel program has historically used larger size gravel suitable for salmon, therefore, spawning gravel of suitable size for steelhead may be limiting in this area.

For winter-run and spring-run, potential spawning habitat is constrained by temperature control to smaller and smaller areas below Keswick Dam. The impacts of operations on cold water have already been described above. However, the changes to the habitat downstream are far more widespread and difficult to detect. The volume of water stored in Shasta reservoir tends to dampen the seasonal variation in water temperatures. This moderation of water temperatures, combined with a loss in spawning habitat above Shasta and Keswick dams, may have profound effects on life history patterns. Warmer water temperatures during the spring-run and CV steelhead egg incubation have resulted in earlier emergence time. Spawning habitat, which is now located 60 to 240 miles downstream from historical sites above Shasta Dam, truncates the juvenile emigration timing by 2-3 months. Therefore, juveniles leave the spawning area at much smaller size and are less likely to survive downstream. For steelhead the cold summer-time flow regime favors residency over anadromy, which reduces the variability in life history that distinguished runs. In addition, with more spatial and temporal overlap between the listed anadromous salmonid species, competition for space reduces the value of the spawning habitat for the conservation of any one species.

The value of spawning habitat for the conservation of the species is also reduced by flow fluctuations twice a year every year to install and remove the ACID diversion dam. These sudden drops in flow strand and/or isolate juveniles rearing along 5 miles of habitat above the diversion dam, and likely for miles downstream. Flow fluctuations can also dewater winter-run and fall-run redds. Since the majority of winter-run have shifted to spawning above the ACID diversion dam (*e.g*., 62 percent in 2006), flow fluctuations are likely to have greater impacts in future years.

Climate change, as a modeled future baseline stressor, is likely to reduce the conservation value of the spawning habitat PCE of critical habitat by increasing water temperatures, which will reduce the availability of suitable spawning habitat. Cold water in Shasta Reservoir will run out sooner in the summer, impacting winter-run and spring-run spawning habitat. This reduction in an essential feature of the spawning habitat PCE will reduce the spatial structure, abundance, and productivity of salmonids.

6.3.8.2 Rearing Habitat

Stream flows within the Sacramento River have been altered by the operations of Shasta and Keswick dams. Generally, the changes have increased flows during the summer and fall, and decreased flows in the winter and spring compared to historical conditions (figure 5-13). The result of the change in historical flow patterns has been a decrease in the hydrologic variability and a loss of complexity in the freshwater aquatic habitat. Specific areas of rearing habitat loss due to changes in the flow pattern include fewer oxbows, side channels, braided channels, less LWD, and less shaded aquatic riparian habitat. The Nature Conservancy (2007) model shows that these are necessary for proper functions of riverine ecosystems. A more natural flow regime with higher spring flows and lower summer flows would support riverine functions like the creation of oxbows, side channels and more varied riparian communities. In turn, this would increase cottonwood regeneration, shaded aquatic habitat, food supply, rearing areas, and LWD recruitment, all important components that are being degraded under continued project operations.

The decrease in the biological value of the rearing habitat is due to the simplification of the processes that create these important areas. The CVP and SWP have for years used the river as a conveyance system, neglecting the natural processes that are necessary to support river dependent species. This altered stream flow pattern has indirectly led to an increase in bank stabilization, levees, riprap, and armoring to keep the river in place. The reduction in rearing habitat quality has decreased the survival of juvenile salmonids and favored the proliferation of introduced non-native species that prey or compete with juvenile salmonids. Due to the stream flow changes, introduced warm water predators are much more numerous today than historically. Therefore, the conservation value of rearing habitat along the entire 300 miles has been degraded by project operations.

Rearing habitat for CV steelhead has been modified in the Sacramento River to cooler summer time releases for winter-run spawning. This change in summer temperature regime has increased the resident rainbow trout population. The change in summer temperatures may reduce the number of steelhead that choose to migrate to the ocean because conditions are too favorable. If the resident trout population is as large as the trout population above Shasta dam (*i.e.,* estimated at 10,300 trout per mile), then competition for food and space could reduce the value of the rearing habitat PCE.

Climate change, as modeled future baseline stressor, is likely to reduce availability of rearing habitat, and in turn, the value of the rearing habitat PCE of critical habitat, by increasing water temperatures. As the juveniles migrate downstream, they will emigrate earlier, encounter thermal barriers sooner, and be subjected to predators for longer periods of time. This reduction in the essential elements of critical habitat will reduce the spatial structure, abundance, and productivity of salmonids. Juveniles would be expected to concentrate in areas of cold water refugia, like in the few miles below Keswick Dam, where competition for food, space, and cover would be intense. Those individuals that stayed to over summer would be forced into one life history pattern consistent with project operations (*i.e.*, yearling life history and emigration during the following spring). Those juveniles that did emigrate early would be exposed to greater stress regimes as they encounter higher water temperatures and greater concentrations of predators downstream.

6.3.8.3 Migratory Corridors

The conservation value of the migratory corridor along the mainstem Sacramento River for all 4 listed species is degraded by the presence of barriers to upstream and downstream migrations.

An essential feature of the migratory corridor PCE is unobstructed passage of emigrating fish through the upper Sacramento River to the spawning areas. This characteristic of the PCE will continue to be degraded by the continued operation of the RBDD and ACID diversion dam. Adult salmonids are blocked and/or delayed in passing these obstructions. Juveniles are subjected to higher concentrations of predators at these locations. Entrainment losses will continue into the future from operation of fish screens at these diversions.

RBDD backs up water on the Sacramento River to form Lake Red Bluff during the summer months, when juvenile winter-run are migrating downstream. This action reduces the conservation value of the critical habitat within the 6–mile lake (or 15 miles of shoreline) for winter-run, spring-run and CV steelhead (TCCA 2008). The inundation of the Sacramento River slows down flows, covers riparian areas, warm water predators become more numerous, and the value of the habitat is reduced. Juvenile salmon and steelhead are disoriented and confused as they migrate downstream through the lake, similar to what happens on the Columbia River above its dams. Stranding and isolation occur in sloughs adjacent to the lake when the gates come out in September (USFWS 1998). The rising waters in the spring kill any vegetation along the sides by submerging it underwater and covering it with silt. Water temperatures increase in the lake as flows are slowed and surface water is heated by the sun. Large shade trees and riparian areas are prevented from becoming established leaving the near shore areas devoid of vegetation. Food supply, shelter and cover are reduced by this action and will continue to be reduced under future operations until a new pumping plant is built and operational.

Approximately, 8 miles of river habitat is modified (or 13.3 percent of the available habitat above RBDD) to less suitable lake habitat for 4 to 6 months of every year when the diversions are in place (*i.e*., 6 miles above RBDD, and 2 miles above ACID). This seasonal loss of habitat reduces food availability, shelter, and cover, and causes permanent changes that reduce the value of that habitat for the rest of the year (*i.e.,* from sedimentation, loss of shaded aquatic habitat, loss of riffle areas that produce food). The loss of habitat value leads to a reduction in the abundance of juvenile winter-run and spring-run that enter the Delta. Productivity and growth are also reduced from modified habitat and reduced complexity. Juvenile salmonids reach the Delta sooner and at a smaller size, making them more vulnerable to predation. Larger fish are more likely to survive the stressful transition into the marine environment than smaller fish, which have less energy reserves stored in their bodies. Therefore, salmonids with life history stages (representing a year in freshwater) like spring-run yearlings and CV steelhead smolts are less likely to be affected by these habitat changes in the migratory corridor, since they move through mainstem quickly prior to entering the ocean.

6.3.8.4 Green Sturgeon Proposed Critical Habitat

The installation and operation of the RBDD gates on May 15 of each year in the near term (through year 2019) blocks access to 53 miles of the Sacramento River to approximately 35 to 40 percent of the spawning population that arrive after May 15, and as a result, impairs the function of the Sacramento River as a migratory corridor for both green sturgeon adults and larvae/juveniles. After May 15, the river no longer has unobstructed access to habitat above RBDD, and changes the function of the river to such an extent that fish survival and viability are compromised. Reclamation proposes to reoperate RBDD in the future full build out scenario (beginning in year 2020), so the RBDD gates would be in for approximately 2½ months each year rather than the current 4 months. After the near term (beginning in year 2020), the value of the migratory corridor PCE will improve each year through 2030 with the gates out longer, however, it will still be degraded.

RBDD backs up water on the Sacramento River to form Lake Red Bluff during the summer months, when some green sturgeon are migrating downstream. The inundation of the Sacramento River slows down flows, covers riparian areas, warm water predators become more numerous, and the value of the habitat is reduced. Juvenile green sturgeon are disoriented and confused as they migrate downstream through the lake, similar to what happens on the Columbia River above its dams. Stranding and isolation occur in sloughs adjacent to the lake when the gates come out in September (USFWS and Reclamation 1998). The rising waters in the spring kill any vegetation along the sides by submerging it underwater and covering it with silt. Water temperatures increase in the lake as flows are slowed and surface water is heated by the sun. Large shade trees and riparian areas are prevented from becoming established leaving the near shore areas devoid of vegetation. Food supply, shelter and cover are reduced by this action and will continue to be reduced under future operations until a new pumping plant is built and operational.

Approximately, 8 miles of river habitat is modified (or 13.3 percent of the available habitat above RBDD) to less suitable lake habitat for 4 to 6 months of every year when the diversions are in place (*i.e*., 6 miles above RBDD, and 2 miles above ACID). This seasonal loss of habitat reduces food availability, shelter, and cover, and causes permanent changes that reduce the value of that habitat for the rest of the year (*i.e.,* from sedimentation, loss of shaded aquatic habitat, loss of riffle areas that produce food). The loss of habitat value leads to a reduction in the abundance of juvenile green sturgeon that enter the Delta. Productivity and growth are also reduced from modified habitat and reduced complexity.

The near term and long term operation of RBDD decreases the conservation value of suitable water quality conditions for green sturgeon spawning and rearing. Water temperature for spawning and egg incubation is near optimal (15ºC/ 59ºF)) from RBDD upriver during the spawning season. Below RBDD, water quality, in terms of water temperature, gradually degrades and eventually exceeds the thermal tolerance level for egg incubation, when egg hatching success decreases and malformations in embryos increase above 17 ºC/62 ºF, at Hamilton City.

The closed gates also decrease the conservation value of proposed critical habitat by: (1) increasing the potential for predation on downstream emigrating larvae in the slow moving water upstream of the RBDD (Lake Red Bluff), (2) increasing predation below the location of the RBDD due to the turbulent boil created below the structure and the concentration of predators located, and (3) creating increased potential for adults to be injured as they try to pass beneath the gates during the closed operations. The closed gate configuration also has the potential to alter the genetic diversity of the population by separating the population into upstream and downstream spawning groups based on run timing.

The installation of the RBDD blocks green sturgeon from known holding pools above the structure. Although known holding areas exist below the RBDD, such as the hole just above the GCID diversion, the RBDD decreases the number of deep holding pools the adult fish can access through its operation, thereby degrading the conservation value of the water depth PCE.

6.4 American River Division

6.4.1 Deconstruct the Action

This section is intended to describe how we have deconstructed the proposed action into stressors that affect CV steelhead, the only ESA-listed species that occurs within the American River. Naturally-produced CV steelhead in the lower American River are affected by many different stressors, which, for the purpose of this analysis, are categorized into two groups based on whether they do, or do not result from CVP operations (figure 5-19). The "future baseline" characterizes those stressors which are not the result of CVP operations, although CVP operations may exacerbate the effect of the stressor. An example of a future baseline stressor that is exacerbated by CVP operations is predation. Steelhead co-evolved with predators such as pikeminnow, but exposure to both elevated water temperatures and limited flow-dependent habitat availability resulting from CVP operations make juvenile steelhead more susceptible to predation (Water Forum 2005a). A detailed description of the future baseline is provided above in section 5.4.3, while project-related stressors are discussed below in section 6.4.3.

6.4.2 Assess Species Exposure

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of a natural origin steelhead life stage and the stressors associated with the proposed action. A few steps are involved in assessing steelhead exposure. First, the steelhead life stages and associated timings are identified. Adult steelhead immigration in the American River generally occurs from November through April with a peak occurring from December through March [Surface Water Resources, Inc. (SWRI) 2001]. Spawning reportedly occurs in late December to early April, with the peak occurring in late February to early March (Hannon and Deason 2008). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through May, although, in some years incubation can occur into June (SWRI 2001). Juvenile steelhead rear in the American River for a year or more before emigrating as smolts from January through June (SWRI 2001).

The second step in assessing steelhead exposure is to identify the spatial distribution of each life stage. The steelhead immigration life stage occurs throughout the entire lower American River with adults holding and spawning from approximately RM 5 to Nimbus Dam at RM 23 (Hannon and Deason 2008). Approximately 90 percent of spawning occurs upstream of the Watt Avenue bridge area located at about RM 9.4 (Hannon and Deason 2008). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Most juvenile steelhead are believed to migrate through the lower sections of the American River into the Sacramento River as smolts.

The last step in assessing steelhead exposure is to overlay the temporal and spatial distributions of proposed action-related stressors on top of the temporal and spatial distributions of lower American River steelhead. This overlay represents the completed exposure analysis and is described in the first three columns of table 6-18. Unless otherwise specified in table 6-18, the temporal and spatial distributions of proposed action-related stressors are the same as the temporal and spatial distributions of steelhead life stages as specified in table 6-18.

6.4.3 Assess Species Response

Now that the exposure of American River steelhead to the proposed action has been described, the next step is to assess how these fish are likely to respond to the proposed action-related stressors. In general, responses to stressors fall on a continuum from slight behavioral modifications to certain death. Life stage-specific responses to specific stressors related to the proposed action are described in detail in the following paragraphs and are summarized in table 6-18. There may be other project stressors acting on lower American River steelhead than those identified in table 6-18. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish. These stressors were identified based on a comprehensive literature review, which included the following documents:

- Lower American River State of the River Report (Water Forum 2005a);
- Aquatic Resources of the Lower American River: Baseline Report (SWRI 2001);
- Impacts on the Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations To Meet Delta Water Quality Objectives and Demands (Water Forum 2005a);
- American River Steelhead Spawning 2001 – 2007 (Hannon and Deason 2008);
- Steelhead Restoration and Management Plan for California (McEwan and Jackson 1996);
- Evaluation of Effects of Flow Fluctuations on the Anadromous Fish Populations in the Lower American River (CDFG 2001); and
- The CVP/SWP operations BA.

Table 6-18. Exposure and summary of responses of American River steelhead to the proposed action.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Spawning Primarily upstream of Watt Ave. area	Late-Dec. - early Apr	Folsom/Nimbus releases – flow fluctuations	Redd dewatering and isolation prohibiting successful completion of spawning	Reduced reproductive success
Spawning Primarily upstream of Watt Ave. area	Late-Dec. - early Apr.	Nimbus Hatchery – hatchery *O. mykiss* spawning with natural-origin steelhead	Reduced genetic diversity. Garza and Pearse (2008) showed that genetic samples from the population spawning in the river and the hatchery population were "extremely similar".	Reduced genetic diversity
Embryo incubation Primarily upstream of Watt Ave. area	Late-Dec - May	Water temperatures warmer than life stage requirements, particularly occurring upstream of Watt Ave. in April and May	Sub-lethal effects - reduced early life stage viability; direct mortality; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar. and Apr.)	Reduced survival
Embryo incubation Primarily upstream of Watt Ave. area	Late-Dec. - May	Folsom/Nimbus releases – flow fluctuations	Redd dewatering and isolation. Hannon *et al.* (2003) reported that 5 steelhead redds were dewatered and 10 steelhead redds were isolated at the lower Sunrise side channel when Nimbus Dam releases were decreased on February 27, 2003. When releases were decreased on March 17, 2003, seven steelhead redds were dewatered and five additional redds were isolated from flowing water at the lower Sunrise side channel. In April 2004 at the lower Sunrise side channel, five steelhead redds were dewatered and "many" redds were isolated (Water Forum 2005a). Redd dewatering at Sailor Bar and Nimbus Basin occurred in 2006 (Hannon and Deason 2008).	Reduced survival

Life Stage/ Location	**Life Stage Timing**	**Stressor**	**Response**	**Probable Fitness Reduction**
Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Folsom/Nimbus releases – flow fluctuations; low flows, particularly during late summer and early fall	Fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat	Reduced survival
Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Water temperatures warmer than life stage requirements, particularly occurring upstream of Watt Ave. during June through September	Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation. Visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F (Water Forum 2005a). With the exception of 2005, from 1999 through 2007, daily mean water temperatures at Watt Avenue from August through September were warmer than 65°F for approximately 81 percent of the days, and during 2001, 2002, 2004, 2006, and 2007, water temperatures were often over 68°F (figure 30a). Under a drier and warmer climate change scenario (Study 9.5), modeled water temperatures at Watt Avenue from June through September under full build out of the proposed Project range from 65°F to 82°F (Reclamation 2009). Even if no regional climate change is assumed (Study 9.1), water temperatures at this location during this time period are expected to range from 63°F to 79°F.	Reduced growth; Reduced survival
Smolt emigration Throughout entire river	Jan. - Jun.	Water temperatures warmer than life stage requirements, particularly occurring downstream of Watt Ave. during March through June	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Reduced growth; Reduced survival

This effects analysis assumes that impacts on lower American River steelhead expected to occur with implementation of the proposed action will be similar to, or more severe than, the impacts associated with the recent past operations of the American River Division of the CVP. This assumption is reasonable because the proposed action includes the continued operation of the American River Division through 2030 to meet increasing water demands. From 2000 through 2006, annual water deliveries from the American River Diversion ranged from 196 TAF in 2000 to 297 TAF in 2005. In the CVP/SWP operations BA, present level water demands for the American River Division were modeled at 325 TAF per year and the 2030 water demands are modeled at nearly 800 TAF per year, an annual demand about 2.7 to 4.0 times higher than the annual deliveries from 2000 through 2006.

Although the CVP/SWP operations BA indicates that Reclamation intends to operate to a new flow management standard whenever additional b(2) water is available - a change in operations from the recent past - the major stressors included in this effects analysis associated with Folsom Reservoir operations are not expected to be minimized. That is, Reclamation's conditional implementation of the new flow management standard, whenever additional b(2) water is available [see table 2-3 for NMFS' assumption on b(2)], is not expected to reduce water temperature-related or flow fluctuation impacts.

The CVP/SWP operations BA states that the "*project description…is consistent with the proposed flow management standard*." Based on the information provided in the CVP/SWP operations BA, it is unclear whether Reclamation intends to achieve this consistency by adhering to the water temperature standards described in the flow management standard (Water Forum 2004):

- "*Reclamation shall operate Folsom Dam and Reservoir and Nimbus Dam to meet daily average water temperatures of 60ºF or less, striving to achieve 56°F or less as early in the season as possible, in the lower American River at Watt Avenue from October 16 through December 31 for fall-run Chinook salmon spawning and egg incubation; and*

- *Reclamation shall operate Folsom Dam and Reservoir and Nimbus Dam to maintain daily average water temperatures that do not exceed 65°F in the lower American River at Watt Avenue from June 1 through October 15 for juvenile steelhead over-summer rearing*."

Reclamation does not identify lower American River water temperature standards, objectives, or targets in the CVP/SWP operations BA. NMFS assumes that, even if Reclamation intends to do so, they will not achieve the water temperature standards described in the flow management standard with implementation of the proposed action because: (1) the availability of b(2) water that would allow Reclamation to "*operate to the proposed flow management standard*" is uncertain (see general assumption in section 2.4.3); (2) operational (*e.g*., Folsom Reservoir operations to meet Delta water quality objectives and demands and deliveries to M&I users in Sacramento County) and structural (*e.g*., limited reservoir water storage and coldwater pool) factors not associated with the flow management standard limit the availability of coldwater for water temperature management; (3) in most years since the late 1990s, Reclamation has not achieved the temperatures specified in the flow management standard (see section 6.4.3.2 Water

Temperature below); and (4) annual water demands for full build-out (year 2030) of the proposed action are expected to substantially increase from present day levels, which will likely further constrain lower American River water temperature management.

6.4.3.1 Folsom/Nimbus Releases

Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. Releases from Nimbus Dam to the American River affect the quantity and quality of steelhead habitat (Water Forum 2005a, CDFG 2001), water quality, water temperature, and entrainment[13]. Water quality can affect steelhead embryo incubation if Nimbus Dam releases are too low to flush silt and sediment from redds (Lapointe *et al.* 2004, Greig *et al.* 2005, Levasseur *et al.* 2006). Conversely, if instream flows are too high, scour and increased sedimentation could result in egg mortality (Kondolf *et al.* 1991). Steelhead egg and alevin mortality associated with high flows in the American River has not been documented, although flows high enough to mobilize spawning gravels do occur during the spawning and embryo incubation periods (*i.e*., late-December through early-April).

As described in the CVP/SWP operations BA, Ayres Associates (2001) indicated that spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization occurring at flows of 50,000 cfs or greater. Flood frequency analysis for the American River at Fair Oaks gauge shows that, on average, flood control releases will exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (CVP/SWP operations BA). During flood control releases made in January 1997, considerable morphological changes occurred in the American River, including streambed alterations at several salmonid spawning sites that caused redd scouring (USFWS 2003a).

Releases from Folsom Reservoir, are made, in part, for flood control and to meet Delta water quality objectives and demands. These operations can result in release events during the winter and spring that are characterized by rapid flow increases for a period of time followed by rapid flow decreases. A few examples of these types of flow fluctuations can be seen in the Nimbus Dam release pattern, which occurred in 2004 (figure 6-24).

Flow fluctuations in the lower American River have been documented to result in steelhead redd dewatering and isolation (Hannon *et al*. 2003, Water Forum 2005, Hannon and Deason 2008). Redd dewatering can affect salmonid embryos and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker *et al.* 1982, Reiser and White 1983). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. Hannon *et al*. (2003) reported that five steelhead redds were dewatered and 10 steelhead redds were isolated in a backwater pool at the lower Sunrise side channel when

[13] In general, a positive relationship exists between upstream reservoir releases (*e.g*., Folsom Reservoir) and the volume of water exported from the Delta through the Jones and Banks pumping plants (SWRCB 2000). Because a positive relationship between water exported from these pumping plants and juvenile salmonid entrainment has also been reported (Kimmerer 2008), it is reasonable to assume that releases from Nimbus Dam likely contribute to the entrainment of juvenile salmonids in the Delta, including American River steelhead. Additionally, some level of entrainment may occur in the lower American River, but it is not believed to be a major stressor to steelhead and will not be further discussed in this effects analysis.

Nimbus Dam releases were decreased on February 27, 2003. When releases were decreased on March 17, 2003, seven steelhead redds were dewatered and five additional redds were isolated from flowing water at the lower Sunrise side channel. In April 2004 at the lower Sunrise side channel, five steelhead redds were dewatered and "*many*" redds were isolated (Water Forum 2005a). Redd dewatering at Sailor Bar and Nimbus Basin occurred in 2006, with most of the redds being identified as Chinook salmon redds, at least one was positively identified as a steelhead redd, and several more redds were of unknown origin (Hannon and Deason 2008) (figure 6-25).

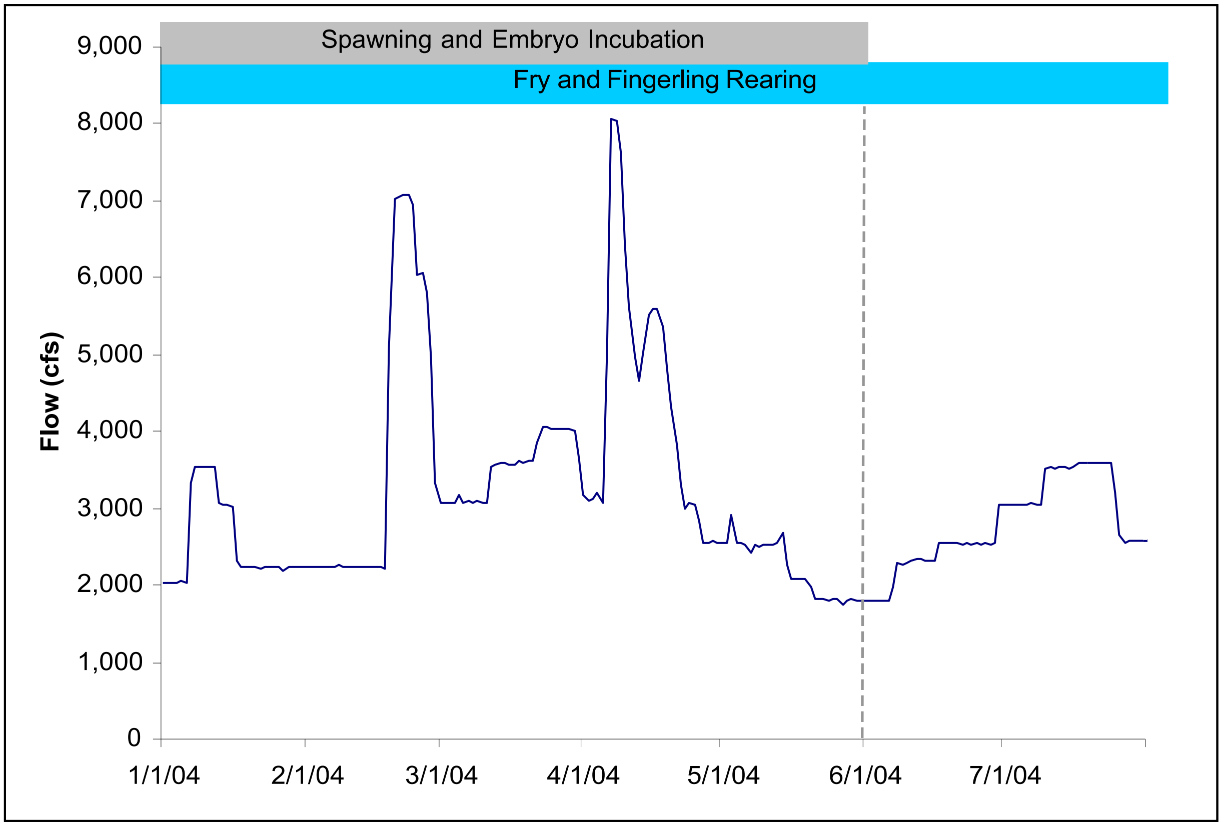


Figure 6-24. Mean daily release rates from Nimbus Dam in January through July of 2004. The timing of the steelhead life stages that are most vulnerable to flow fluctuations during these months are displayed.

Although reports of steelhead redd dewatering and isolation in the American River are limited to 2003, 2004, and 2006, these effects have likely occurred in other years because: (1) the pattern of high releases followed by lower releases which occurred during the steelhead spawning period (*i.e.*, primarily January through March) in 2003, 2004, and 2006, is similar to the pattern observed during the spawning period in many other years [CDEC data (http://cdec.water/ca/gov/) from 1994 through 2007]; and (2) monitoring was not conducted during many release events and, consequently, impacts were not documented. Impacts associated with flow fluctuations are expected to continue to occur with implementation of the proposed project through 2030 because changes from past operations that would address this stressor were not identified in the project description

Juvenile steelhead isolation has also been reported to occur in the lower American River. For example, Water Forum (2005a) reported that juvenile steelhead became isolated from the river channel in both 2003 and 2004 following a flow increase and decrease event associated with meeting Delta water quality objectives and demands (Water Forum 2005a).

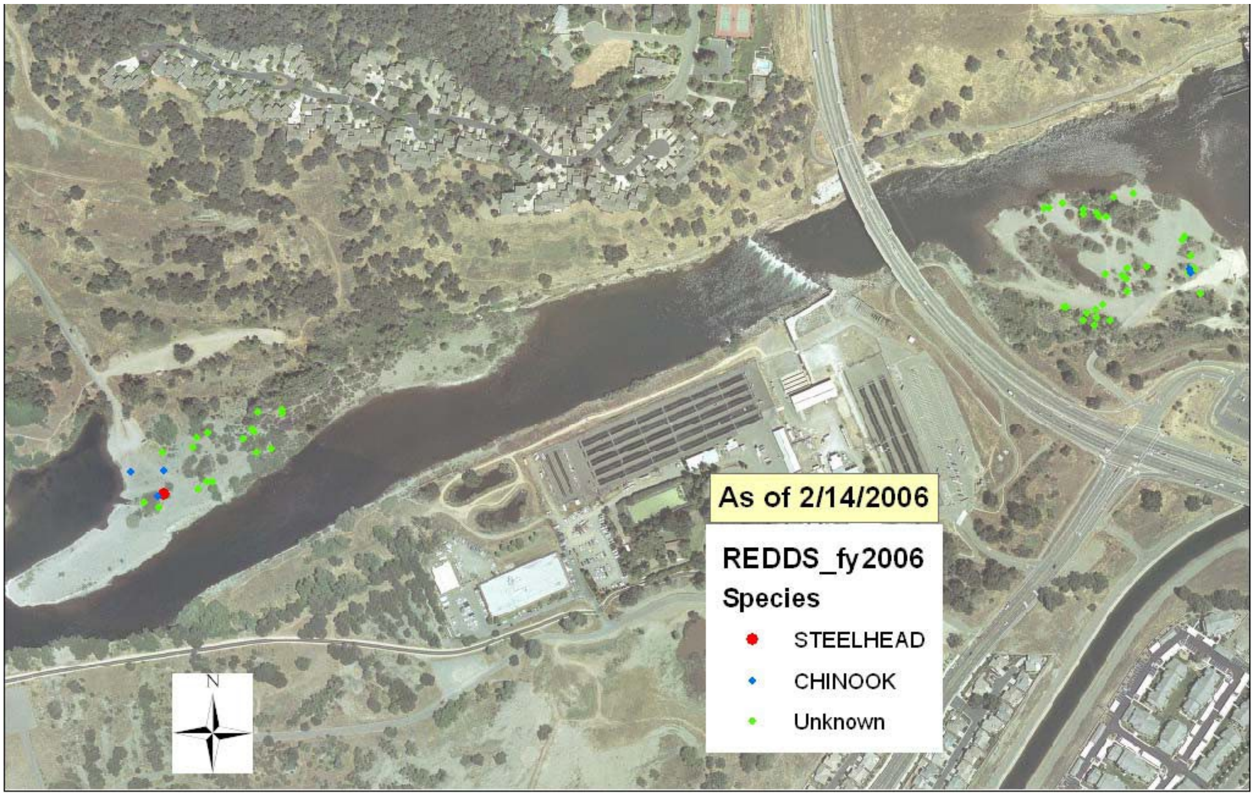


Figure 6-25. Dewatered redds at Nimbus Basin and Sailor Bar, February 2006 (figure was modified from Hannon and Deason 2008).

In addition to flow fluctuations, low flows also can negatively affect lower American River steelhead. Yearling steelhead are found in bar complex and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover (SWRI 2001). At low flow levels, the availability of these habitat types becomes limited, forcing juvenile steelhead densities to increase in areas that provide less cover from predation. With high densities in areas of relatively reduced habitat quality, juvenile steelhead become more susceptible to predation as well as disease. Exposure of juvenile steelhead to these low flow conditions is expected to continue to occur with implementation of the proposed Project through 2030."

6.4.3.2 Water Temperature

Water temperature is perhaps the physical factor with the greatest influence on American River steelhead. Water temperature directly affects survival, growth rates, distribution, and developmental rates. Water temperature also indirectly affects growth rates, disease incidence, predation, and long-term survival (Myrick and Cech 2001). Water temperatures in the lower American River are a function of the timing, volume, and temperature of water being released from Folsom and Nimbus dams, river distance, and environmental heat flux (Bartholow 2000). Thus, water temperatures in the lower American River are influenced by proposed action operations.

Myrick and Cech (2001) examined the effects of water temperature on steelhead (and Chinook salmon) with a specific focus on Central Valley populations and reported that steelhead egg survival declines as water temperature increases past 50°F. In a summary of technical literature examining the physiological effects of temperature on anadromous salmonids in the Pacific Northwest, EPA (2001) reported that steelhead egg and alevin survival would decline with exposure to constant water temperatures above 53.6°F. Although supporting references were not provided, the CVP/SWP operations BA states that: "*Temperatures of 52°F or lower are best for steelhead egg incubation. However temperatures less than 56 F are considered suitable*." Rombough (1988) as cited in EPA (2001) found less than four percent embryonic mortality of steelhead incubated at 42.8, 48.2, and 53.6°F, but noted an increase to 15 percent mortality at 59°F. In this same study, alevin mortality was less than five percent at all temperatures tested, but alevins hatching at 59°F were considerably smaller and appeared less well developed than those incubated at the lower test temperatures.

In a recent laboratory study examining survival and development of steelhead eggs incubated at either 46.4°F or 64.4°F, Turner *et al*. (2007) found that eggs incubated at the higher temperature experienced higher mortality, with 100 percent mortality of eggs from one of three treatments at the higher temperature. Also, those fish incubated at the higher temperature that did survive exhibited greater structural asymmetry than fish incubated at the lower temperature. Similar to Turner *et al.* (2007), Myrick and Cech (2001) reported an increase in physical deformities in steelhead that were incubated at higher water temperatures. Structural asymmetry has been negatively correlated with fitness in rainbow trout (Leary *et al.* 1984).

Based on the thermal requirements reported above and the temporal distribution of steelhead egg incubation (*i.e*., January through May), some level of egg mortality and/or reduced fitness of those individuals that survive is expected with exposure to the water temperatures that are expected to occur with implementation of the proposed action. For example, mean water temperatures at Watt Avenue from 1999 through 2008 ranged from about 48°F to 54°F in March, 50°F to 59°F in April, and 56°F to 64°F in May (figure 6-26).

Modeled water temperatures also demonstrate that steelhead eggs will be exposed to stressful conditions with implementation of the proposed action. Exceedence plots of water temperatures near Sunrise are expected to always be at or above 50°F during March, April, and May (figures 6-27, 6-28, and 6-29). Water temperatures during these months are expected to be over 54°F for about 30, 95, and 100 percent of the cumulative water temperature distribution, respectively; water temperatures are expected to be above 56°F for about 10, 70, and 100 percent. During the warmest 10 percent of the cumulative water temperature distribution during April and May, water temperatures are expected to exceed 62°F and 66°F, respectively. It is important to note that these modeled water temperature results do not incorporate effects of climate change.

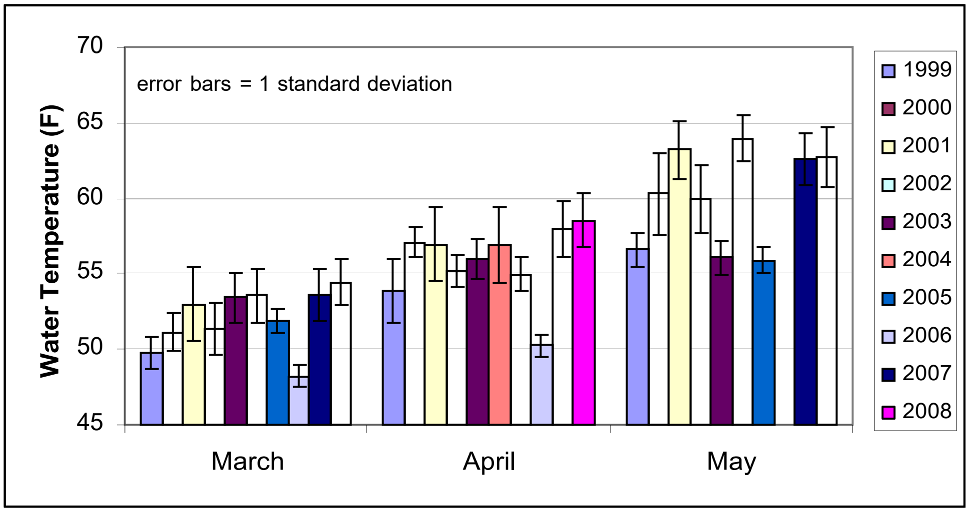


Figure 6-26. Lower American River water temperature during March, April, and May from 1999 through 2008 represented as the mean of the daily average at the Watt Avenue gage (Original data were obtained from http://cdec.water.ca.gov/).

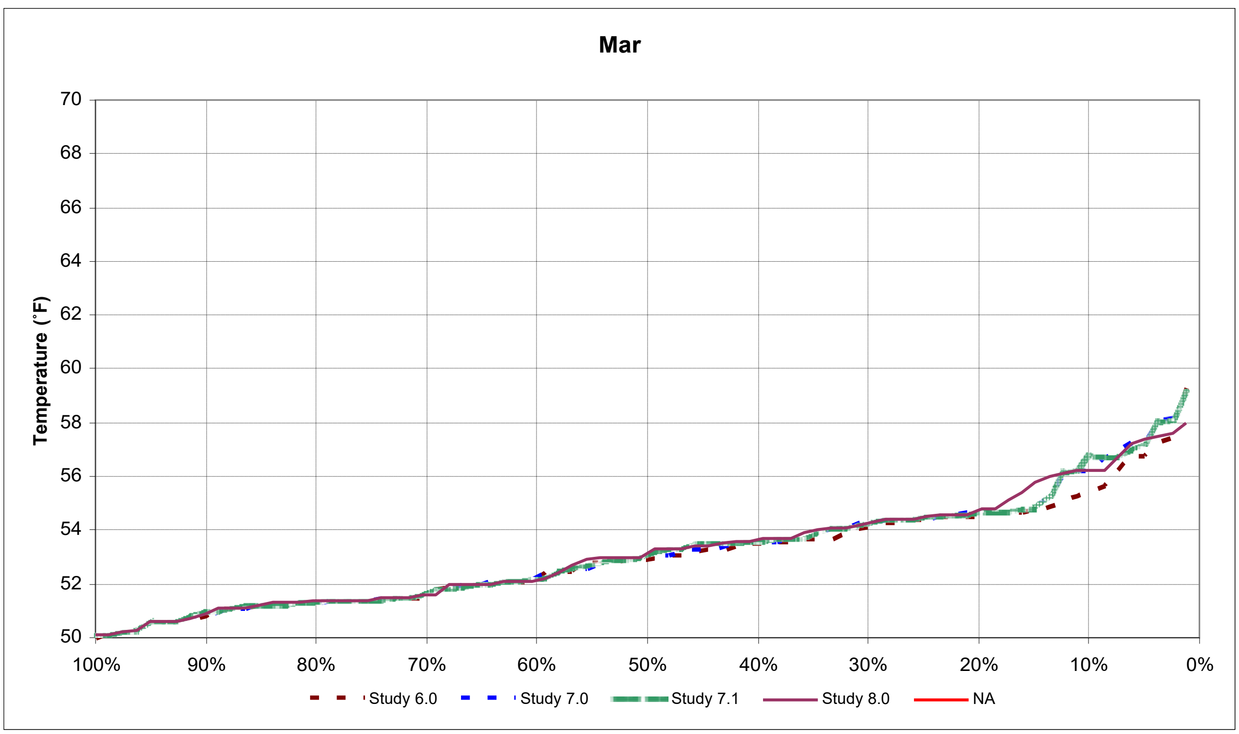


Figure 6-27. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during March (CVP/SWP operations BA appendix I).

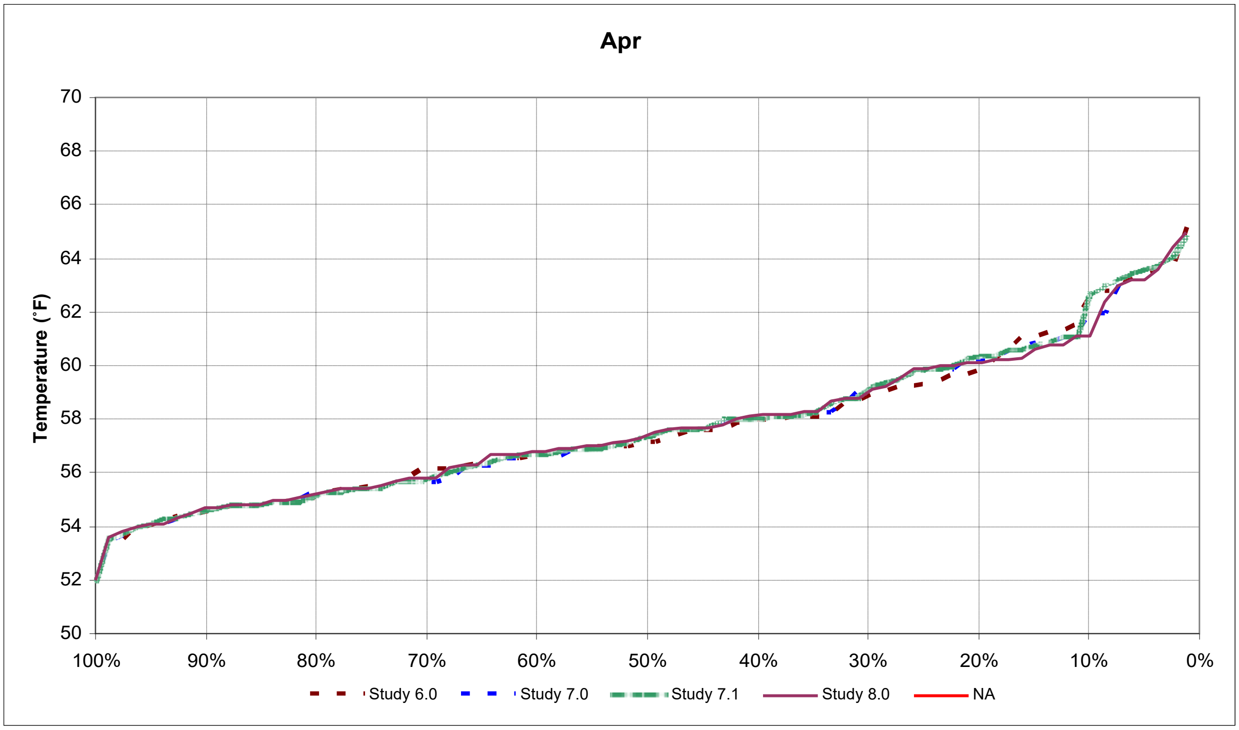


Figure 6-28. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during April (CVP/SWP operations BA appendix I).

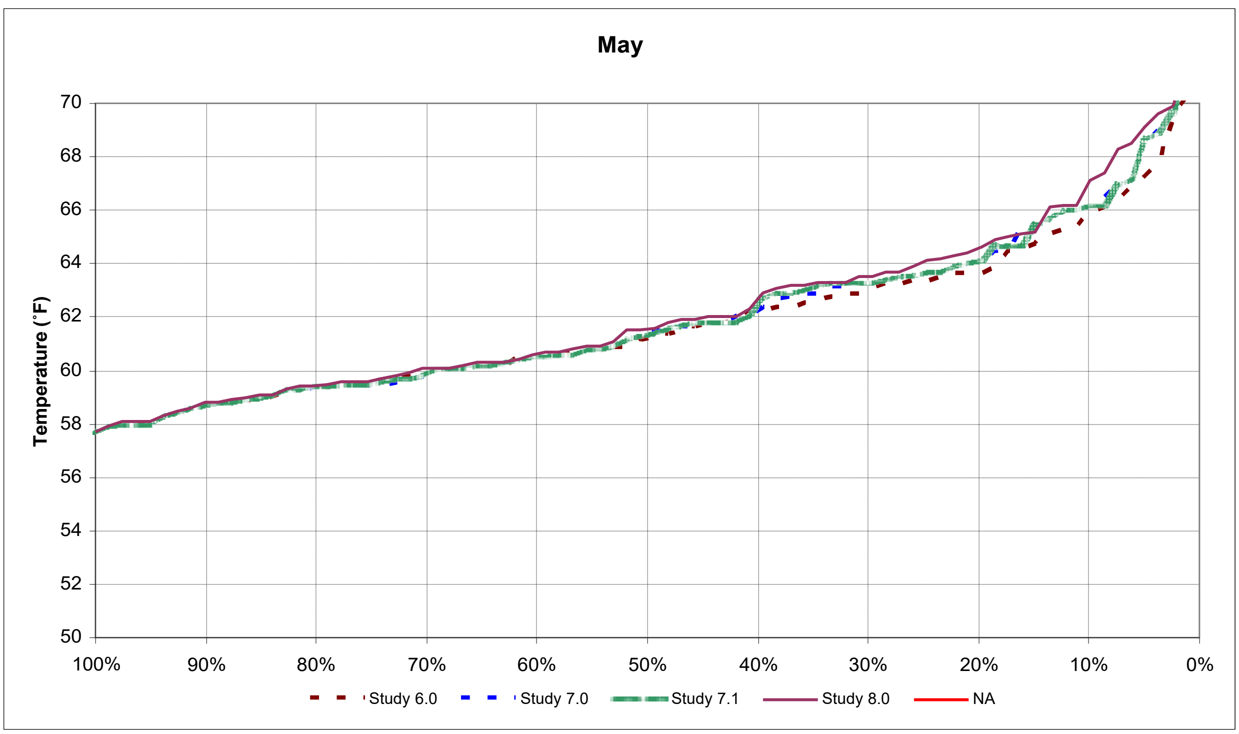


Figure 6-29. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during May (CVP/SWP operations BA appendix I).

For the purposes of this analysis, NMFS assumes that climate change could account for a 1-3°F increase in water temperatures within the time frame of the proposed action (see Appendix R of the CVP/SWP operations BA). If this level of warming occurs, mean water temperatures in the lower American River could range from about 51°F to 57°F in March, about 53°F to 62°F in April, and 59°F to 67°F in May (figure 6-30). Under these conditions, higher egg mortality and increased fitness consequences would occur for steelhead eggs and alevins that were spawned later in the spawning season (*e.g.*, spawned in March rather than January). This selective pressure towards earlier spawning and incubation would truncate the temporal distribution of spawning, resulting in a decrease in population diversity, and consequently a likely decrease in abundance.

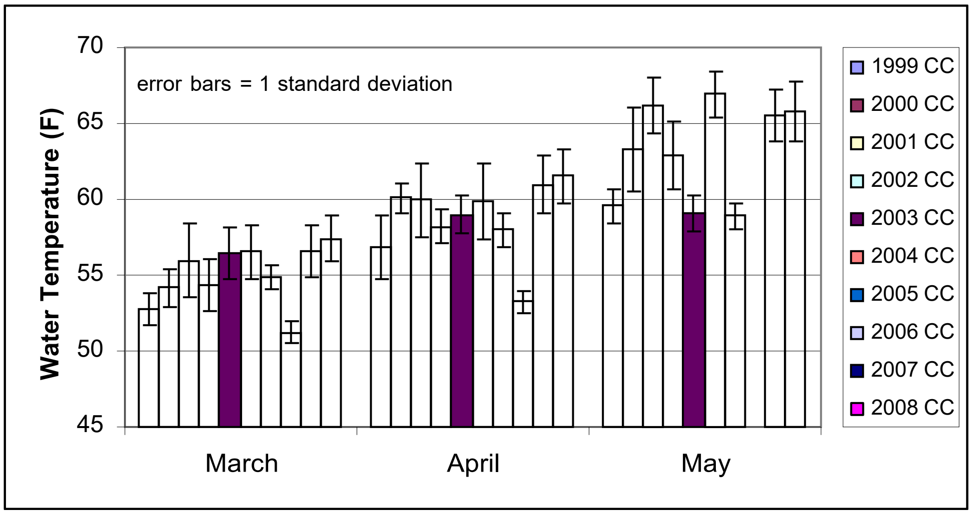


Figure 6-30. Lower American River water temperature during steelhead from 1999 through 2008 represented as the mean of the daily average at the Watt Avenue gage plus 3°F to incorporate potential climate change effects (see Key Assumptions in section 2). Years are labeled in the legend with "CC" to denote the intended application of this figure as an analysis of climate change effects. Original data were obtained from http://cdec.water.ca.gov/.

High water temperatures are a stressor to juvenile rearing steelhead in the American River, particularly during the summer and early fall. Unfortunately, assessing the response of American River steelhead juveniles to water temperatures is not straightforward, as no studies of the effects of temperature on Central Valley juvenile steelhead have yet been published in the primary literature (Myrick and Cech 2004). Myrick and Cech (2004) state that, "*The scarcity of information on the effects of temperature on the growth of juvenile steelhead from central valley systems is alarming, and should be rectified as quickly as possible.*"

The available information suggests that American River steelhead may be more tolerant to high temperatures than steelhead from regions further north (Myrick and Cech 2004). Cech and Myrick (1999) reported that when American River steelhead were fed to satiation at constant temperatures of 51.8°F, 59.0°F, and 66.2°F, growth rates increased with temperature, whereas Wurtsbaugh and Davis (1977) found that maximal growth of juvenile steelhead from North Santiam River in Oregon occurred at a cooler temperature (*i.e.*, 62.6°F). Both of these studies were conducted in a controlled laboratory setting with unlimited food availability. Under more variable conditions, such as those experienced in the wild, the effect of water temperature on juvenile steelhead growth would likely be different.

Even with this tolerance for warmer water temperatures, steelhead in the American River exhibit symptoms of thermal stress. For example, the occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as "rosy anus") of American River steelhead has been reported by CDFG to be associated with warm water temperatures (figure 6-31). Sampling in the summer of 2004 showed that this vent inflammation was prevalent in steelhead throughout the river and the frequency of its occurrence increased as the duration of exposure to water temperatures over 65°F increased. At one site, the frequency of occurrence of the anal vent inflammation increased from about 10 percent in August, to about 42 percent in September, and finally up to about 66 percent in October (Water Forum 2005a).

Figure 6-31. Anal vent inflammation in a juvenile steelhead from the American River (Water Forum 2005a).

The juvenile steelhead immune system properly functions up to about 60°F, and then is dramatically compromised as water temperatures increase into the upper 60°Fs (Water Forum 2005a). CDFG reports that, in 2004, the anal vent inflammation occurred when juvenile steelhead were exposed to water temperatures above 65°F (Water Forum 2005a). With the exception of 2005, from 1999 through 2007, daily mean water temperatures during the summer at Watt Avenue were most often above 65°F, and during 2001, 2002, 2004, 2006, and 2007, water temperatures were often over 68°F (figure 6-32a).

If the assumed effects of climate change (*i.e.*, a 1°F to 3°F increase in water temperatures) are applied to these data, water temperatures would be even more stressful for juvenile steelhead (figure 6-32b), with levels over 65°F throughout August and September in all years if temperatures increase by 3°F (figure 6-32c). Figures 6-32a, b, and c are likely conservative general representations of the range of summer water temperatures that are expected with implementation of the proposed action given that annual water demands from 2000 through 2006 ranged from 196 TAF in 2000 to 297 TAF in 2005 and under full build-out conditions in 2030 annual water demands are modeled in the CVP/SWP operations BA to be 800 TAF.

Based on water temperature modeling results presented in the CVP/SWP operations BA, water temperatures associated with visible symptoms of thermal stress in juvenile steelhead (*i.e.*, >65°F) are expected to occur from June through September with implementation of the propose Project. Exceedence plots of monthly water temperatures at Watt Avenue show that temperatures are expected to be at or above 65°F for about 70 percent of the cumulative distribution in June, 100 percent in July and August, and about 95 percent in September (figures 6-33 and 6-34). It should be noted that the modeled water temperatures presented in figures 6-33 and 6-34 are monthly estimates, which do not capture diurnal variation. As such, NMFS assumes that with the continued implementation of the proposed action, juvenile steelhead will be exposed to daily mean and maximum temperatures warmer than those presented in these figures. This is significant, as the monthly estimates during the warmest conditions in July and August are approaching the lethal limits (~77.0 °F) of Nimbus Fish Hatchery steelhead under laboratory conditions (Myrick and Cech 2004).

To successfully complete the parr-smolt transformation, a physiological and morphological adaptation to life in saline water, steelhead require cooler water temperatures than for the rearing life stage. Adams *et al*. (1975) reported that steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at warmer water temperatures. In a report focusing on the thermal requirements of Central Valley salmonids, Myrick and Cech (2001) came to a similar conclusion stating that steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range. Others have suggested that water temperatures up to about 54°F will allow for successful steelhead smoltification (Zaugg *et al*. 1972, Wedemeyer *et al.* 1980, EPA 2001).

Steelhead smolt emigration in the American River occurs from January through June (SWRI 2001). Monitoring data from 1999 through 2008 showed that lower American River water temperatures frequently exceeded 52°F by March and exceeded 54°F in all but 2 years by April (figure 6-26). Based on the thermal requirements for steelhead smolts described above, smolt transformation is likely inhibited by exposure to lower American River water temperatures. With increased warming associated with climate change, it is likely that by March steelhead parr will not be able to successfully transform to smolts in the American River (figure 6-30).

Modeled water temperatures demonstrate that even without warming associated with climate change, the proposed action is expected to result in conditions that will inhibit the successful transformation from parr to smolts. For example, exceedence plots show that water temperatures at Watt Avenue will be warmer than 54°F for 30 percent of the cumulative water temperature distribution during March (figure 27) and for 95 percent of the distribution in April (figure 6-28). By May water temperatures are expected to nearly always be warmer than about 58°F (figure 6-29) and in June modeling results suggest that they will always be over 62°F (figure 6-33a).

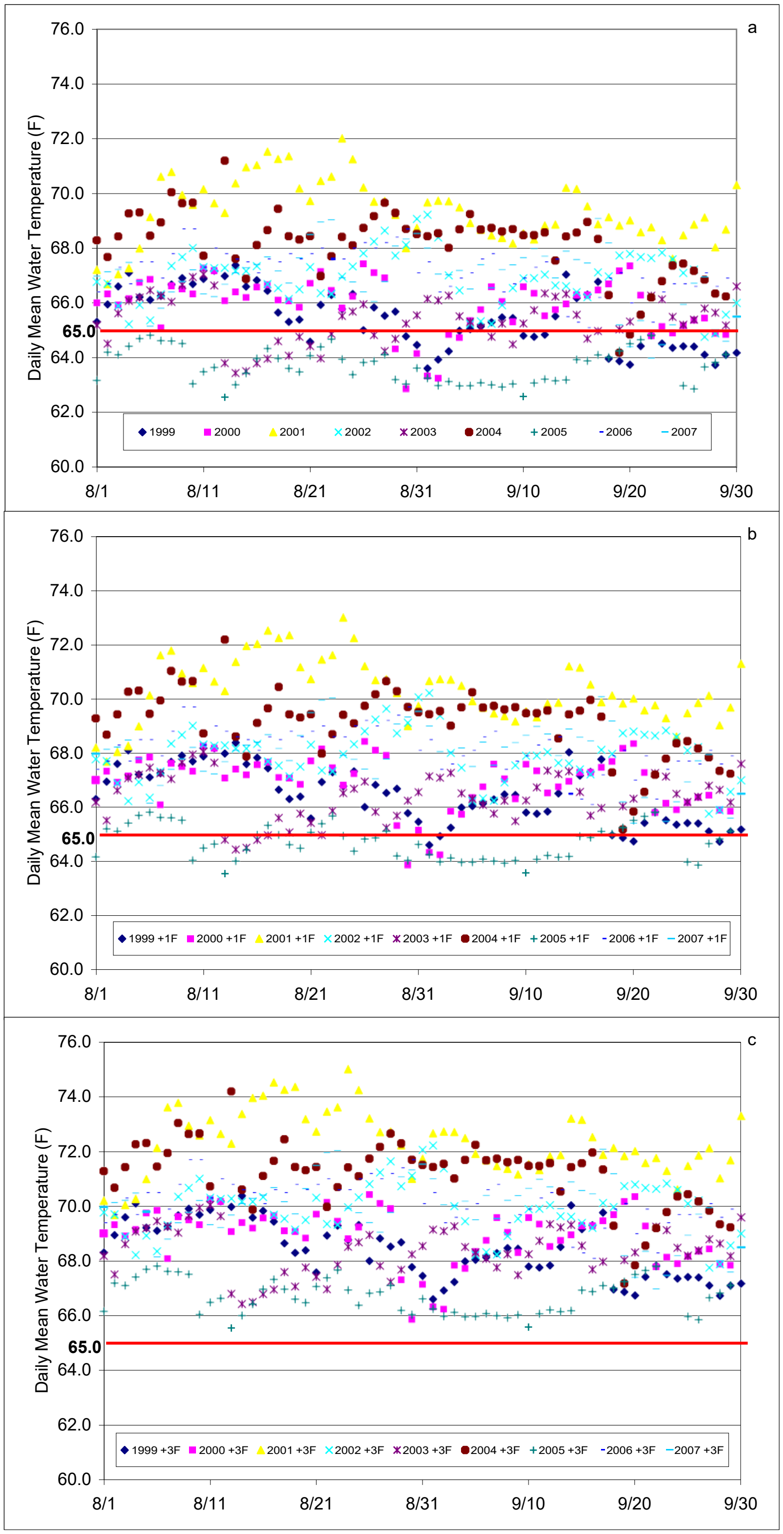


Figure 6-32 a, b, and c. Lower American River water temperature during August and September from 1999 through 2007 represented as the daily mean at the Watt Avenue gage (a). Figures b and c show these same water temperatures plus 1°F and 3°F, respectively, to incorporate potential climate change effects (see Key Assumptions in Chapter 2). The 65°F line is indicated in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F. Data were obtained from http://cdec.water.ca.gov/.

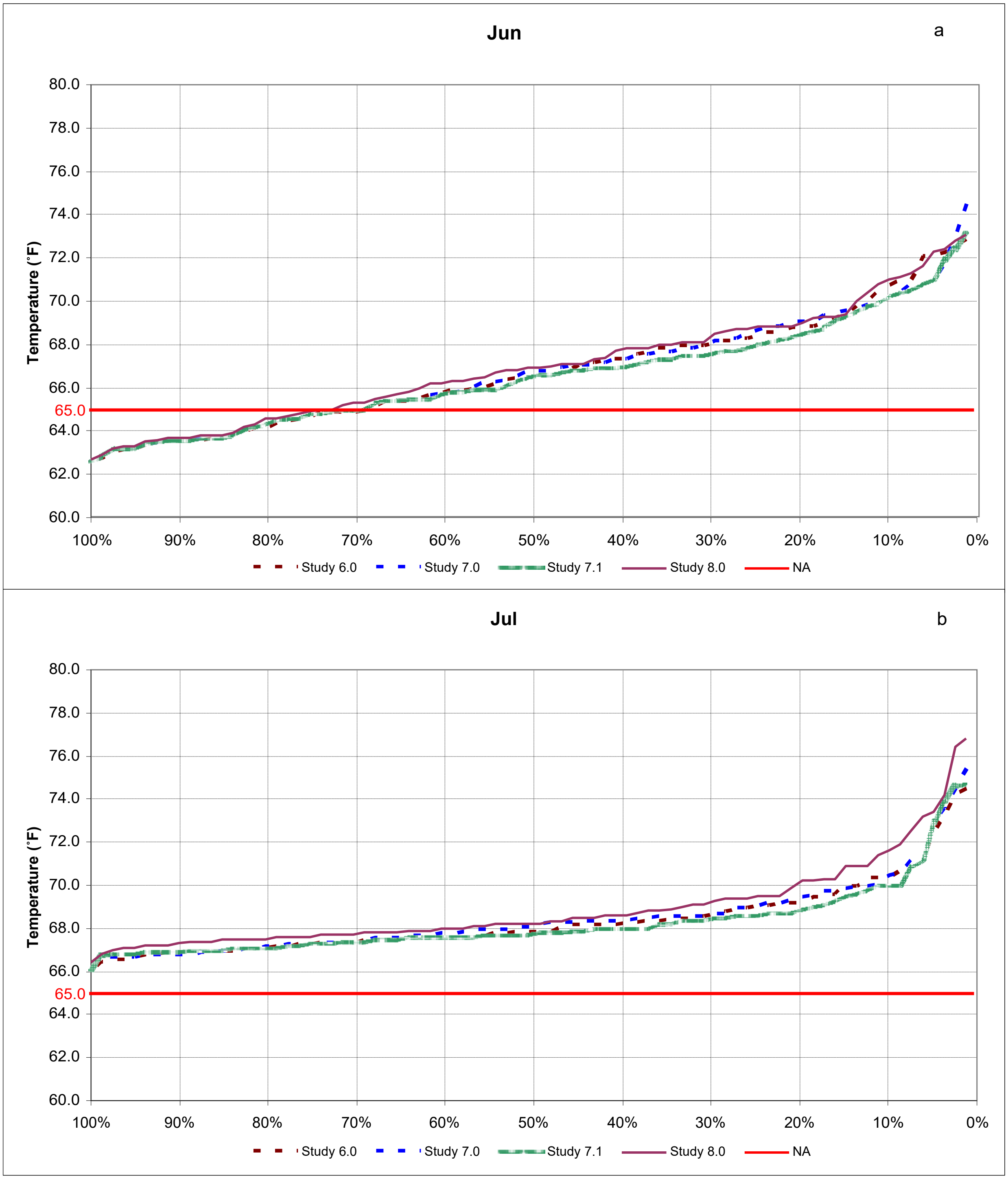
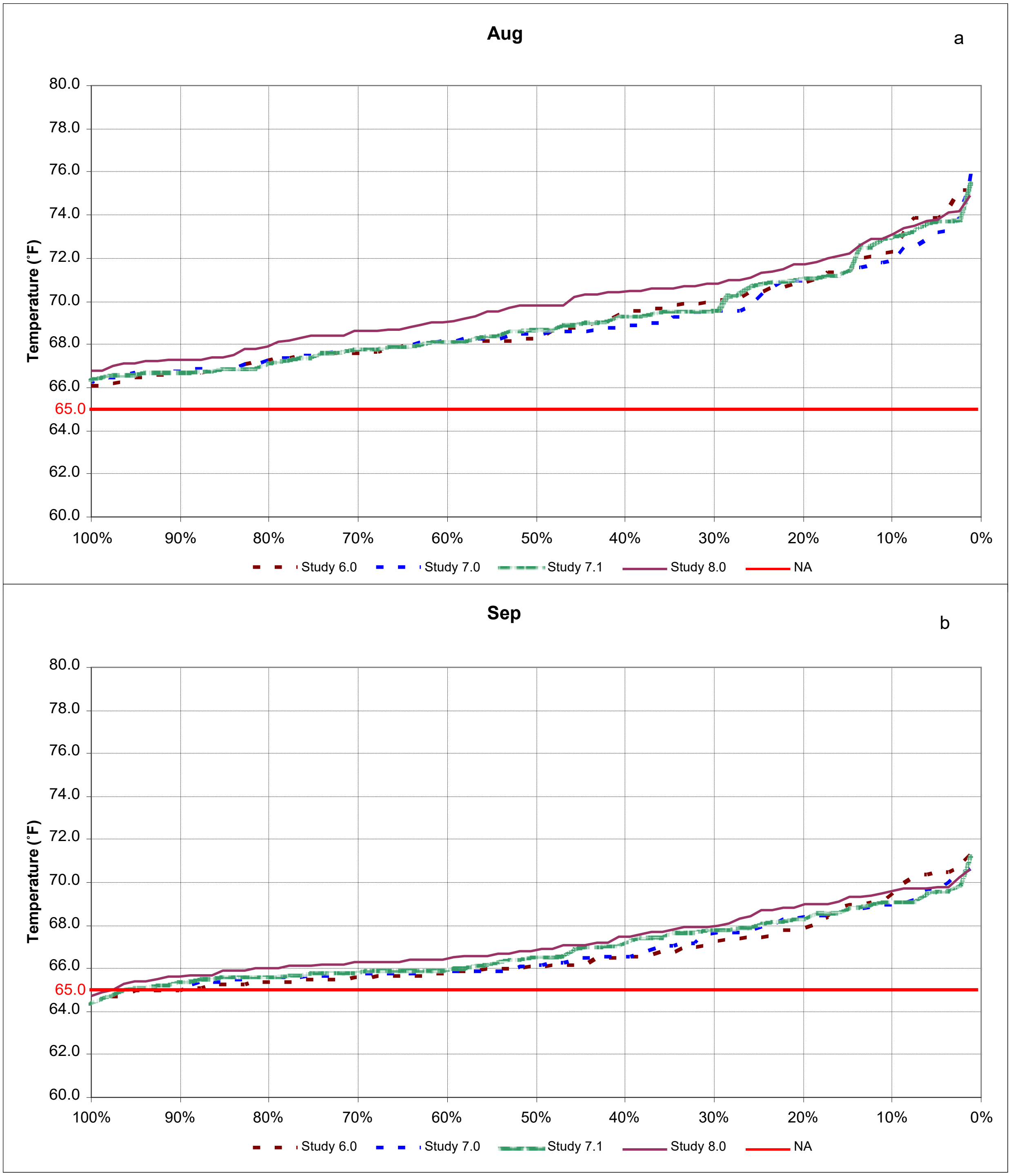


Figure 6-33a and b. Exceedence plots of modeled water temperatures in the lower American River near Watt Avenue during June (a) and July (b) (CVP/SWP operations BA figures 10-114 and 10-115, respectively). For this analysis, the 65°F line was added in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F.



Figures 6-34a and b. Exceedence plots of modeled water temperatures in the lower American River near Watt Avenue during August (a) and September (b) (CVP/SWP operations BA figures 10-116 and 10-117, respectively). For this analysis, the 65°F line was added in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F.

6.4.3.3 Predation

As described in Water Forum (2005a), Folsom Reservoir is commonly operated to meet water quality objectives and demands in the Delta. These operations limit coldwater pool availability in Folsom Reservoir, thereby potentially resulting in elevated water temperatures in the lower American River, which likely results in increased predation rates on juvenile rearing steelhead. According to CDFG (2005 *op. cit*. Water Forum 2005a), water temperatures above 65°F are associated with a large (*i.e*., 30-40 species) complex warmwater fish community, including highly piscivorous fishes such as striped bass (*Morone saxatilis)*, largemouth bass (*Micropterus salmoides*), and Sacramento pikeminnow (*Ptychocheilus grandis*). Juvenile rearing steelhead may be exposed to increased predation due to both increased predator abundance and increased digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg *et al*. 1991).

Some striped bass reportedly reside in the lower American River year-round, although their abundance greatly increases in the spring and early summer as they migrate into the river at roughly the same time that steelhead are both emerging from spawning gravels as vulnerable fry and migrating out of the river as smolts (SWRI 2001). Striped bass are opportunistic feeders, and almost any fish or invertebrate occupying the same habitat eventually appears in their diet (Moyle 2002). Empirical data examining the effect of striped bass predation on steelhead in the American River have not been collected, although one such study was recently conducted in the Delta (DWR 2008). Results of this study concluded that steelhead of smolt size had a mortality rate within Clifton Court Forebay that ranged from 78 ± 4 percent to 82 ± 3 percent over the various replicates of the study. The primary source of mortality to these steelhead is believed to be predation by striped bass. Although Clifton Court Forebay and the lower American River are dramatically different systems, this study does demonstrate that striped bass are effective predators of relatively large-sized steelhead. Considering that striped bass are abundant in the lower American River during the spring and early summer (SWRI 2001), when much of the steelhead initial rearing and smolt emigration life stages are occurring, striped bass predation on juvenile steelhead is considered to be a very important stressor to this population. Although predation by striped bass is considered a baseline stressor, the proposed action is expected to exacerbate the stressor. As described above, low releases from Nimbus Dam force juvenile steelhead into areas that provide less cover from predation.

6.4.3.4 Nimbus Fish Hatchery

The Nimbus Fish Hatchery stock is not part of the CV steelhead DPS, and its impacts to the natural American River population include both genetic and behavioral effects (Myers *et al*. 2004). As described in Pearsons *et al*. (2007), the selective pressures in hatcheries are dramatically different than in the natural environment, which can result in genetic differences between hatchery and wild fish (Weber and Fausch 2003), and subsequently differences in behavior (Metcalfe *et al*. 2003). Early Nimbus Fish Hatchery broodstock included naturally-produced fish from the American River and stocks from the Wahougal (Washington), Siletz (Oregon), Mad, Eel, Sacramento and Russian Rivers, with the Eel River stock being the most heavily used (Staley 1976, McEwan and Jackson 1996).

There is additional concern regarding the effects of Nimbus Fish Hatchery on naturally-spawned steelhead. Analysis of genotype data collected from 18 highly variable microsatellite molecular markers from adult *O. mykiss* entering Nimbus Fish Hatchery showed that over one third of the fish were identified as hatchery rainbow trout (Garza and Pearse 2008). NMFS does not know whether these trout were used as broodstock for steelhead production, although they could have been, considering that there was overlap in length between the trout and steelhead that entered the hatchery. Garza and Pearse (2008) state that, "*Integration of these trout into steelhead production is likely to have a number of detrimental effects, because of their reduced genetic variation, genetic predisposition against anadromy and past hatchery selection pressures*." The authors also suggest that Nimbus Fish Hatchery operations may have affected the genetic integrity of other Central Valley populations:

> "*Since Eel River origin broodstock were used for many years at Nimbus Hatchery on the American River, it is likely that Eel River genes persist there and have also spread to other basins by migration, and that this is responsible for the clustering of the below-barrier populations with northern California ones. This, in combination with the observation of large numbers of hatchery rainbow trout entering Nimbus Hatchery and potentially spawning as steelhead, suggest that the below-barrier populations in this region appear to have been widely introgressed by hatchery fish from out of basin broodstock sources* (Garza and Pearse 2008)."

6.4.4 Assess Risk to Individuals

Based on the responses of steelhead exposed to the proposed action described above, fitness consequences to individuals include reduced reproductive success during spawning, reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration (see table 6-12).

6.4.5 Effects of the Action on CV Steelhead Designated Critical Habitat in the American River Division

The lower American River is designated critical habitat for CV steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. This analysis on the effects of the proposed action on steelhead critical habitat is based on information presented in preceding sections regarding its effects on CV steelhead, and are summarized below as they relate to the PCEs of critical habitat.

Spawning and rearing PCEs in the American River are expected to be negatively affected by flow and water temperature conditions associated with the proposed action. High flows during flood control operations can negatively affect steelhead spawning habitat by mobilizing gravels. Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization occurring at flows of 50,000 cfs or greater (CVP/SWP operations BA, Ayres Associates 2001). Flood frequency analysis for the American River at Fair Oaks gauge shows that, on average, flows will exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (CVP/SWP operations BA).

Rearing habitat in the lower American River is negatively affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation. Additionally, steelhead egg incubation and juvenile rearing habitat quality is expected to be reduced by the occurrence of warm water temperatures. These relatively warm water temperatures also increase susceptibility of juvenile steelhead to predation due to both increased predator abundance and increased digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg *et al*. 1991).

Freshwater migration corridors also are PCEs of critical habitat. They are located downstream of spawning habitat allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions for steelhead smolt emigration are expected to be impaired with implementation of the proposed action, because of exposure to water temperatures that are too warm to allow for successful transformation from parr-to-smolt life stages.

Based on the above discussion, the conservation value of spawning, rearing, and migratory habitats are negatively affected as a result of the proposed action

6.5 East Side Division, New Melones Reservoir

Operational effects of dams on rivers and the species that live in them are multi-faceted and complex. This analysis focuses on key elements of Reclamation's operations of the New Melones Dam, and related dams of the East Side Division, that may affect particular life history stages of CV steelhead when they are in the Stanislaus River. CV steelhead are the only listed anadromous fish in the Stanislaus River.

6.5.1. Deconstruct the Action

The action elements analyzed for proposed operations of the East Side Division can be broken down into two general categories: management of proposed operational releases of water, and modification of the hydrograph of the lower Stanislaus River.

Dam operations typically alter the downstream hydrograph from the unimpaired hydrograph. The CVP/SWP operations BA is inconsistent regarding the current and proposed operations of New Melones Reservoir. The project description indicates that New Melones has been operating under an Interim Plan of Operations (IPO), although frequently, these operational criteria are not met. There are references to a New Melones Draft Transitional Operation Plan in CVP/SWP operations BA chapters 9 and 10, but no narrative description was provided. New Melones appears to be operated within the bounds of the fundamental operating criteria (project description starting on page 74), and the actual annual allocations are negotiated through a stakeholder group process. For modeling purposes, Reclamation selected a monthly flow allocation based on a look up table, which assumes a distribution of flows linked to an unspecified process. This is suitable to make some comparisons among model runs, but does not realistically assess operations. Consequently this analysis makes the following assumptions about the proposed New Melones operations:

1. Operations will continue to apply the fundamental operating criteria (appendix 1 to this Opinion, starting on page 74), which, as written, include poorly defined decision trees and adaptive management processes;
2. Poorly defined decision trees and adaptive management processes limit the utility of model runs to assess likely operational conditions;
3. Recent operations (10-20 years) reflect a pattern that closely resembles the IPO, although the CVP/SWP operations BA suggests that many operational criteria of the IPO were not met;
4. Future operations under the New Melones Transitional Operation Plan (NMTP) will reflect a pattern that closely resembles the IPO, except the only discernable difference appears to be that in Mid-Allocation years under the NMTP, if b(2) water is provided to fish, an equal amount is also provided to contract deliveries. The step change of these allocations is not described in the text of the CVP/SWP operations BA, but the model outputs are driven by a look-up table that sets monthly flow levels for 6 different scenarios in mid-allocation years;
5. Because (NMTP) operational criteria are not substantially different from IPO operational criteria, recent operational data are used to assess likely instream conditions, rather than relying on model outputs alone; and
6. The amount, timing, and duration of b(2) water, is not secured in any year, unless end of year storage exceeds 1.7 MAF (High Allocation Years).

6.5.2 Assess the Species Exposure

For the purposes of this analysis, “exposure” is defined as the temporal and spatial co-occurrence of a CV steelhead life stage and the stressors associated with the proposed action. A few steps are involved in assessing CV steelhead exposure. First, the CV steelhead life stages and associated timings are identified. The second step in assessing CV steelhead exposure is to identify the spatial distribution of each life stage. The last step is to overlay the temporal and spatial distributions of proposed action-related stressors on top of the temporal and spatial distributions of Stanislaus River CV steelhead. This overlay represents the completed exposure analysis and is described in table 6-19.

Table 6-19. Summary of proposed action-related effects on Stanislaus River steelhead.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult Immigration Delta to Riverbank	Oct-Dec	Water temperatures warmer than life history stage requirements	Delayed entry into river; pre-spawn mortality; reduced condition factor	Reduced reproductive success; Reduced survival to spawn
Spawning Goodwin Dam to Riverbank	Dec-Feb	Unsuitable flows restrict spawnable habitat and dewater redds	Limited spawning habitat availability; egg mortality resulting from dewatered redds.	Reduced reproductive success
Spawning Goodwin Dam to Riverbank	Dec-Feb	Excessive fines in spawning gravel resulting from lack of overbank flow	Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	Reduced reproductive success
Egg incubation and emergence Goodwin Dam to Riverbank	Dec-May	Excessive fines in spawning gravel resulting from lack of overbank flow	Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other CV steelhead or fall-run; suppressed growth rates	Reduced survival
Egg incubation and emergence Goodwin Dam to Riverbank	Dec-May	Water temperatures warmer than life history stage requirements	Egg mortality, Embryonic deformities	Reduced survival
Juvenile rearing Goodwin Dam to Riverbank	Year round	Contaminants (particularly dormant sprays) from land uses made possible by operations	Reduced food supply; suppressed growth rates; smaller size at time of emigration, starvation; indirect: loss to predation; poor energetics; indirect stress effects.	Reduced growth rates; Reduced survival
Juvenile rearing Goodwin Dam to Riverbank	Year round	Lack of overbank flow to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival
Juvenile rearing Goodwin Dam to Riverbank	Year round	Reduction in rearing habitat complexity due to reduction in channel forming flows	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival

Juvenile rearing Goodwin Dam to Riverbank	Year round	Unsuitable flows for maintaining juvenile habitat	Crowding and density dependent effects relating to reduced habitat availability. Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Reduced growth rates; Reduced survival
Juvenile rearing and out-migration Stanislaus River	All year with increase Feb-May during out-migration	Predation by non-native fish predators because rearing habitat is lacking	Juvenile mortality; Reduced juvenile production	Reduced survival
Juvenile rearing Stanislaus River	Year round Jan-April (14 months)	End of summer water temperatures warmer than life history stage requirements	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Reduced growth rates; Reduced survival
Smoltification and emigration Stanislaus River at mouth	Jan. - Jun.	Water temperatures warmer than life history stage requirements (Mar - June)	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	Reduced diversity.
Smolt emigration Stanislaus River	Jan. – Jun.	Suboptimal flow (March – June)	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Reduced survival; Reduced diversity

As information on CV steelhead in the San Joaquin River system is limited, we assume that CV steelhead life history timing is similar throughout the Central Valley streams, although timing for CV steelhead use on the Stanislaus River is used where known (figure 5-21 above). A map of the lower Stanislaus River and key reaches is presented in figure 5-20. The CV steelhead adult immigration life stage occurs throughout the entire lower Stanislaus River. Because CV steelhead are unable to reach their historical spawning areas above Goodwin Dam, they are dependent on East Side Division operations maintaining instream temperatures suitable for spawning below the dam where appropriate gravel and gradient conditions occur. No CV steelhead spawning surveys have been conducted on the Stanislaus River, but fall-run surveys indicate that spawning may occur from Goodwin Dam (RM 59) almost to the city of Riverbank (RM 33), with the highest use occurring above Knights Ferry (RM 55). During fall-run redd surveys in 1995, Mesick (2001) observed the highest fall-run redd density between Goodwin Dam and Knights Ferry (6 to 50 redds/riffle), an average of 5 redds/riffle from Knights Ferry to Orange Blossom Bridge (RM 47), and an average of less than 2 redds/riffle between Orange Blossom Bridge and Riverbank. Fall-run spawning use is a reasonable indicator of likely CV steelhead early spawning activity in mid-December to January as there is some overlap in spawning timing, more overlap in egg incubation timing, and the temperature requirements for egg incubation is comparable for both species. Based on observations of trout fry, most spawning occurs upstream of Orange Blossom Bridge (Kennedy and Cannon 2002). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Most juvenile CV steelhead are believed to migrate through the lower sections of the Stanislaus River into the San Joaquin River as smolts.

6.5.3 Assess the Species Response

Now that the exposure of Stanislaus River CV steelhead to the deconstructed action has been described, the next step is to assess how these fish are likely to respond to the proposed action-related stressors. In general, responses to stressors fall on a continuum from slight behavioral modifications to certain death. Life stage-specific responses to specific stressors related to the proposed action are described in detail in the following paragraphs and are summarized in table 6-19. There may be other project stressors acting on Stanislaus River CV steelhead than those identified in table 6-19. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish.

This effects analysis assumes that impacts on CV steelhead in the Stanislaus River (figure 54-20) expected to occur with implementation of the proposed NMTP action will be similar to, or more severe than, the impacts associated with the East Side Division operations under the IPO to this point of consultation, which have occurred in the recent past (*e.g.*, within the last 10-28 years). This assumption is reasonable because the proposed action includes the continued operation of the East Side Division through 2030 to meet increasing water demands.

The future baseline of the existing dams prevents access to historical habitat, but the proposed operations of the dams control the quality and quantity of available alternative habitat below Goodwin Dam and the suitability of the physical conditions to support CV steelhead at various life history stages. Survival of CV steelhead may be affected by operations of the East Side Division in the following ways:

- Operational releases control extent of cool water habitat available below Goodwin Dam.
- Operational release levels control the quantity and functionality of instream habitat for spawning, egg incubation, juvenile rearing and smoltification.
- Operational releases are typically lower than unimpaired flows, requiring smolting juveniles to expend more energy to outmigrate and lower stream velocities increase the exposure of juveniles and smolts to predation.

The proposed operation of the East Side Division modifies the hydrograph from the unimpaired flow pattern with which CV steelhead evolved. Such modifications may affect survival and critical habitat for CV steelhead in the following ways:

- Peak flood flows are dampened, reducing floodplain inundation and impairing rearing ability;
- Flow variability is muted, eliminating migratory cues that prompt migration and anadromy;
- Flow variability is muted, causing channel incision, reducing available rearing habitat, simplifying channel complexity and allowing land use encroachment into riverside habitats; and
- Channel forming flows are reduced or eliminated, resulting in fossilization of gravel bars and degradation of spawning habitat.

The proposed New Melones operations will create an altered hydrograph as compared to the unimpaired flows and as compared to the future baseline. The dampening of flood events and freshets eliminates the geomorphic processes that are important to CV steelhead to replenish and rejuvenate spawning riffles and to inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. The Corps has limited controlled flood releases from New Melones Dam to 8,000 cfs. The dampening of flood events also eliminates or reduces the intensity and duration of freshets and storm flows that would otherwise convey smolting CV steelhead to the ocean and create a clear signature for the river. A more moderated hydrograph has eliminated periodic channel forming flows. The dams (a future baseline condition) capture sediment that would otherwise be transported downstream for geomorphic processes. Operations of the dams result in channel incision that further reduces the chance of inundated floodplain habitat and degrades spawning habitat quality. Releases from New Melones can affect downstream temperatures at critical times to affect adult migration, spawning, egg incubation success, juvenile survival and anadromy. Predicted increases in temperature as a result of climate change will affect instream water temperatures directly, and will affect New Melones operations as more precipitation will fall as rain, rather than snow, and as storm event intensity is expected to increase. Climate change may affect the types and cover rates of vegetation upslope of the river, potentially increasing the rate of fine sediment transport to the river and to spawning areas. Future baseline stressors that are exacerbated by the proposed East Side Division operations include increased vulnerability to non-native fish predators owing to flow velocities and downstream temperatures conducive to these species and competition from resident *O. mykiss,* which may be more abundant as a result of less variability in instream conditions.

6.5.3.1 Temperature Effects

Water temperature can be a stressor in the Central Valley floor segments of the rivers of the San Joaquin Basin, particularly in summer months. The literature and scientific basis for life stage related temperature requirements for CV steelhead are described in section 6.4.3.2. A summary of those requirements relevant to CV steelhead use of the Stanislaus River is presented in table 6-20.

Table 6-20. CV steelhead temperature requirements by life stage and probability of exceedance under proposed action at relevant locations on the Stanislaus River.

Life Stage and Temperature Requireiment (EPA 2003)	Criterion and Temperature Compliance Location	Probability of Exceedance Study 8					
Adult migration		Oct	Nov	Dec			
<64°F	Temperature below 64°F at Orange Blossom Bridge (OBB)	1%	0%	0%			
	Temperature below 64°F at Confluence	0%	0%	0%			
Smoltification		Jan	Feb	Mar	Apr	May	
<57°F or <52°F	Temperature below 52°F at Knights Ferry	0%	1%	17%	32%	60%	
	Temperature below 57°F at OBB	0%	0%	1%	1%	15%	
Spawning and incubation		Jan	Feb	Mar	Apr	May	
<55°F	Temperature Below 55°F at OBB	0%	0%	1%	5%	32%	
	Temperature Below 55°F at Riverbank	0%	2%	21%	46%	80%	
Juvenile rearing		Jun	Jul	Aug	Sept		
<61°F (early)	Temperature below 61°F at OBB	62%	80%	85%	75%		
<64°F (late)	Temperature below 65°F at OBB	4%	19%	14%	9%		

Modeled temperatures under the proposed action are likely to be suitable for adult CV steelhead migration into the Stanislaus River. Modeled temperatures indicate temperature exceedances for juvenile rearing, both early and late criteria, through most of the summer months at Orange Blossom Bridge. This can result in sublethal effects including increased susceptibility to disease, increased metabolic demands and poorer condition if food resources are not more available, as well as lethal effects. Cooler temperatures may be found further upstream and juveniles could conceivably move upstream. This would increase the net density in the upper reaches, resulting in increased crowding in available habitat, density dependent competition with resident *O. mykiss,* and increased risk of predation by adult resident *O. mykiss* and other predatory fishes. These factors would reduce the survival and fitness of juveniles CV steelhead.

The literature regarding appropriate criteria for smoltification is varied and suggests optimal temperatures of less than 52 °F (Adams *et al*. 1975, Myrick and Cech 2001) to less than 57°F

(EPA 2003). This life history stage is uniquely important for the expression of anadromy in *O. mykiss*. This analysis looked at the modeled likelihood of achieving 57°F or less at Orange Blossom Bridge, which is lower in the system, and of achieving 52°F or less at Knights Ferry where temperatures are typically cooler. The 52°F criterion at Knights Ferry is not achieved 17-60 percent of the time in the months of March through May. The warmer 57°F criterion is not achieved 15 percent of the time in May at Orange Blossom Bridge, but is generally achievable in other critical months. Although the precise temperature required for smoltification is uncertain, even with a warmer criterion of 57°F, the proposed operations will truncate the successful smoltification of late developing smolts.

Salmonid spawning occurs from below Goodwin Dam to Riverbank. Consequently, specific temperature criteria of 55ºF or less at Riverbank should be met from December through May to ensure that temperatures are suitable for all available spawning habitat and for incubating eggs. However, modeled results and CDEC data (figure 6-35) indicate that temperatures at Riverbank are likely to exceed this level from March through May. Appropriate incubation temperatures are generally exceeded at Orange Blossom Bridge in May. This combination of conditions increases the likelihood that CV steelhead that spawn later in the season, or farther downstream will have reduced to failed reproductive success. In addition to this individual and population effect, it affects the diversity of the population by truncating the timing and area available for successful spawning.

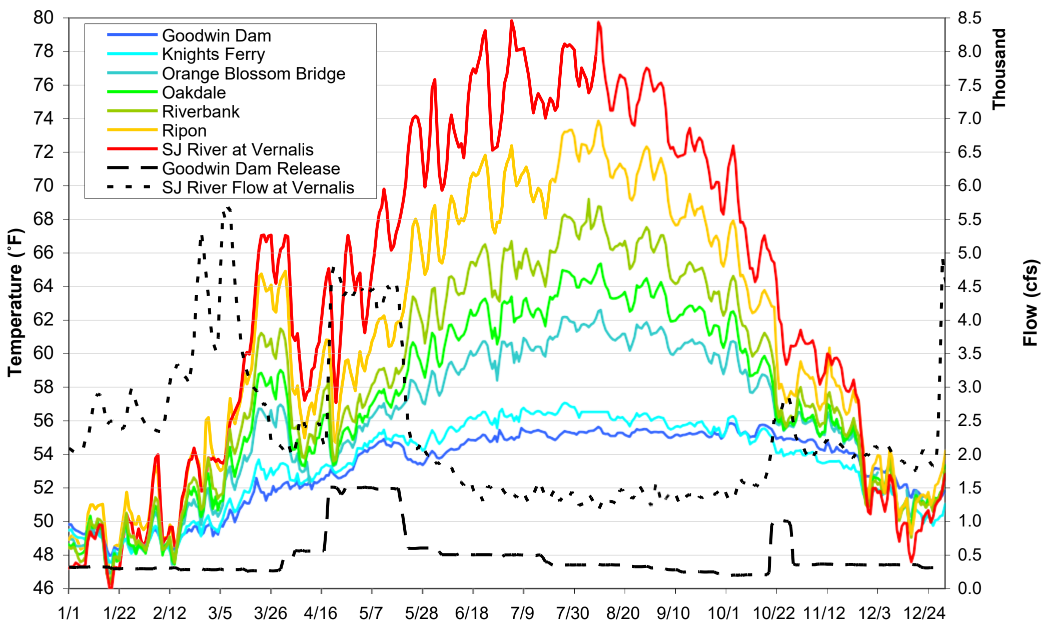


Figure 6-35. Stanislaus and San Joaquin river temperatures and flow at selected locations in a dry year, actual measured water temperatures (2001, CVP/SWP operations BA figure 11-20).

Modeling results provide information that may indicate how a system may perform if operated under a particular set of rules and conditions. In practice, the actual operations are usually somewhat different than what was modeled and the system response is different. The CDFG has petitioned the California State Water Resources Control Board to list the Stanislaus River, along with the Merced, Tuolumne and San Joaquin rivers as impaired under the Clean Water Act [303(d)] with respect to temperature suitability for anadromous fish (CDFG 2007a). Based on actual temperature data from 2000 through 2006, it concluded that "water temperatures in all four river systems are too warm for anadromous fish during all four of thir life stages" (CDFG 2007a page 9). That report does identify that modeling results include levels of uncertainty and that actual operational conditions may have greater or lesser effects on CV steelhead.

Lindley *et al*. (2007) has identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for CV steelhead on the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that are historically unsuitable habitat because of high summertime temperatures.

Construction of the dams on the Stanislaus River has prevented anadromous *O. mykiss* from accessing its entire historical habitat. The population persists in a reach of the river that historically was unsuitable because of high temperatures (Lindley 2006) only if dam operations are managed to maintain suitable temperatures for all life history stages of CV steelhead. There are no temperature control devices on any of the East Side Division facilities, so the only mechanism for temperature management is direct flow management. This has been achieved in the past through a combination of augmenting baseline water operations, for meeting senior water right deliveries and D-1641 water quality standards, with additional flows from (1) the CDFG fish agreement, and (2) from b(2) or b(3) water acquisitions. The analysis of temperature effects presented in the CVP/SWP operations BA, Appendix I, assumes that these augmentations will be available. If water for fish needs is indeed allocated as their model suggests, future operations likely would meet CV steelhead temperature needs, except in July through September in dry or critical years, when the average temperature would exceed 65ºF at Orange Blossom Bridge by 1-4°F, depending on the future climate change.

The project pescription does not specify how b(2) or b(3) water are committed for fishery uses of any particular amount, timing or duration. The CVP/SWP operations BA analysis does not evaluate their assumptions without the addition of CVPIA assets for fish, so the change in temperature of these reduced flows for fish cannot be quantified with available data. Table 6-21 compares the flow schedule used for critically dry years in the model Study 7.0 [current conditions, including use of b(2) and b(3)] with the September 2008 50 percent flow projection, which expresses the real-time operation plan [current conditions, but with b(2) and b(3) assets committed to other uses]. The projection identifies significantly lower flows than what are modeled for a similar year type, and likely resulting in unsuitable temperatures for CV steelhead. Given that the allocation process for b(2) and b(3) assets in the project description does not differ from current application practices, it is reasonable to expect that access to these resources to offset operational temperature effects on CV steelhead in the Stanislaus River will continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years, and the effect is likely to be greater than what is modeled.

Table 6-21. Comparison of projected monthly Stanislaus River flows (cfs) from September 2008 50 percent forecast and CVP/SWP operations BA Study 7.0, 50 percent projected flows from look-up table.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep

Sept 2008 50% forecast	200	210	200	135	135	268	754	739	556	396	352	240
Modeled 50% forecast *	494	340	351	298	362	401	1122	1299	286	267	267	240

If future conditions are warmer, drier or both, summer temperature conditions at Orange Blossom Bridge will be more likely to exceed 65˚F, resulting in a constriction of suitable rearing habitat, encroachment of warm-water predatory fishes into more of the freshwater migration habitat, and decreased CV steelhead survival owing to temperature stress, increased disease, and increased competition for food and space with resident *O. mykiss*.

The CVP/SWP operations BA modeled the effect of future climate scenarios on Chinook salmon egg mortality, as a surrogate to assess the effect of future project operations on CV steelhead in the Stanislaus River. As modeled, temperature caused salmon egg mortality will increase by approximately 1 to 5 percent in wet years and by 1 to 14 percent in critically dry years (figure 6-36). CV steelhead eggs require lower incubation temperatures than Chinook salmon, so this analysis presents an underestimate of the project effect.

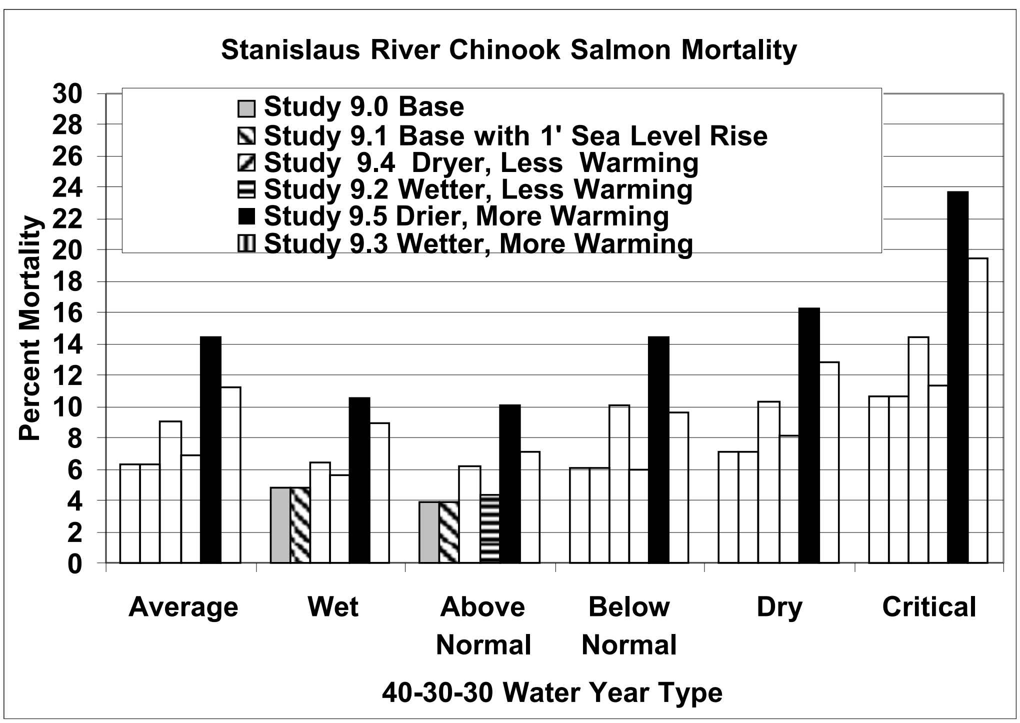


Figure 6-36. Stanislaus River fall-run Chinook salmon egg mortality with climate change scenarios from Reclamation salmon egg mortality model. All studies except 9.0 include 1-foot sea level rise. Study 9.0 is future conditions with D-1641 (CVP/SWP operations BA figure 11-89).

The CVP/SWP operations BA noted that under actual operational conditions in 2001, a dry year, the temperature at Orange Blossom Bridge did exceed 65°F, but not for extended periods of time (figure 6-35). A limitation of the modeling studies is that, while they were improved to use a daily time step in the BA, these daily temperatures were derived from disaggregated monthly temperatures. Consequently the frequency and duration of temperature exceedances in a month cannot be evaluated. Short duration exceedances as measured in 2001 would have less effect on the species than extended exposure to unsuitable temperatures. Temperature exceedances of short duration and low magnitude can also be addressed with minor operational changes. Without clearer operational criteria to ensure that instream temperature standards are met, CV steelhead will be subjected to increased sublethal and lethal temperature effects in the Stanislaus River from the egg through smolt stages and potentially as adults.

6.5.3.2 Instream Flow and Seasonal Hydrograph

Aceituno (1993) applied the instream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) and determined that 155 TAF was needed to maximize weighted usable habitat area for salmon, not including outmigration flows or fall attraction flows. This study also identified that instream flow needs for each life history stage are somewhat different between CV steelhead and fall-run (table 6-22). CV steelhead flow needs are somewhat lower than fall-run needs for some life stages, but potentially higher for adult migration. The total amount of water needed for maximum instream habitat support is equal to or greater than 155 TAF, which is also greater than the fishery agreement allottment to CDFG in Mid-Allocation Year, and probably Conference Year, categories (table 6-23).

Table 6-22. Comparison by life stage of instream flows which would provide maximum weighted usable area of habitat for steelhead and Chinook salmon in the Stanislaus River, between Goodwin Dam and Riverbank, California (adapted from Aceituno 1993). No value for Chinook salmon adult migration flows was reported.

Life Stage	Steelhead Flow	Steelhead Timing	Fall-Run Flow	Fall-Run Timing
Spawning	200	Dec-Feb	300	Oct 15-Dec 31
Egg incubation/fry rearing	50	Jan - Mar	150	Jan. 1-Feb 15
Juvenile rearing	150	all year	200	Feb 15-Oct 15
Adult migration	500	Oct-April	-	

The proposed allocation year strategy for the East Side Division fundamental operating principles only commits to providing sufficient water for fisheries in 41 percent of the years, based on operations since 1982 (table 6-23). The CDFG Fish Agreement allotment alone is less than what CV steelhead need, and the CDFG allocation schedule is predominantly directed by Chinook salmon needs. Consequently, CV steelhead are likely to have unmet flow needs in 59 percent of years, based on actual operations since 1982, and may also be negatively affected by operations that target higher flows for salmon than are appropriate for CV steelhead, unless channel complexity is sufficient to provide a range of instream flow conditions for a set release flow from the dams. If b(2) or b(3) water is available, this effect could be reduced in some Mid-Allocation years. Because the guidance for allocation of b(2) and b(3) water for the Stanislaus River is not specific, the magnitude of this reduction cannot be determined.

Table 6-23. Occurrence of High Allocation, Mid-Allocation and Conference Year types for New Melones Transitional Operation Plan, based on New Melones Operations since 1982 (CDEC data).

Allocation Year Type	Fishery Allocation	% occurrence 1982-2008
High Allocation Years New Melones Index is greater than 1.7 MAF	457 TAF	41 %
Mid-Allocation	98.3 TAF	33%
"Conference Year" conditions - New Melones Index is less than 1.0 MAF	unspecified	26%

The IFIM analysis did not include an assessment of the volume of water needed for a spring pulse flow to convey CV steelhead or fall run from the Stanislaus River into the Delta. The San Joaquin River Agreement (SJRA) and associated VAMP were agreed upon by the SWRCB and the signatory parties as a mechanism to address this fishery need in the context of refining the understanding of what specific flow standards are needed to meet the requirements of the 1995 Water Quality Control Plan. The SJRA will conclude in 2011 and the funding for VAMP studies and flows is scheduled to end in 2009. The project description indicates that Reclamation and DWR intend to "continue VAMP-like flows" but the description of these flows lacks critical fish benefits now provided by the SJRA and VAMP. Under the SJRA, operators on the Tuolumne River and the Merced River release spring pulse flows in a manner coordinated with Stanislaus River pulse flows to convey salmonids from these tributaries into the San Joaquin River and to the Delta. When the SJRA concludes, there will be no commitment by operators on the Merced and Tuolumne Rivers to continue with spring pulse flows. This will affect CV steelhead in the Stanislaus in two ways: modification of New Melones operations to affect conditions on the Stanislaus and modification of conditions on the Merced and Tuolumne Rivers that affect the diversity group.

Without the SJRA in effect, Reclamation is solely responsible to meet water quality standards (flow and salinity) at Vernalis. Without the contribution from rivers upstream of the Stanislaus, Reclamation likely will be required to release more water from New Melones in order to meet that standard. This can result in unsuitable flows and temperatures for CV steelhead, dewatering of redds, and reduction of storage volumes at the end of September. This last factor will result in more years falling into the Conference Year or Mid-Allocation Year categories, which provide less suitable conditions for CV steelhead as described above on a more frequent basis.

CV steelhead in all three of these rivers represent three of the four populations of the Southern Sierra Diversity Group of the Central Valley steelhead DPS. Straying of individuals among these rivers likely occurs at some level and is a mechanism for recolonization of populations within the diversity group, should a catastrophic event eliminate one or more. Lack of spring flows to encourage anadromy from the other San Joaquin River tributaries will further reduce those CV steelhead populations and reduce the diversity potential of the Stanislaus River CV steelhead population.

As indicated above, the SJRA and VAMP flows provide benefit to enable outmigrating CV steelhead smolts. However, the pulse flow period is constrained to occur only in a 31-day period during April and May. As indicated in the CVP/SWP operations BA (page 11-81), rotary screw traps on the Stanislaus capture *O. mykiss* with smolting characteristics from January through mid-April. This represents the majority of the captures. *O. mykiss* with smolting characteristics have also been captured as late as the end of May. McEwan (2001) infers that CV steelhead would normally have exhibited a protracted outmigration period, peaking in March but extending as late as June. Although the CVP/SWP operations BA suggests that CV steelhead smolts are sufficiently strong swimmers to exit the river at any time, trawl sampling at Mossdale collects CV steelhead at times that coincide with pulse flow releases. Thus, while the VAMP pulse flows provide more benefit to CV steelhead than no pulse flow at all, the narrow window of time when it occurs also constrains diversity and plasticity that are important to the survival of the species.

6.5.3.3 Geomorphic Effects of Altered Hydrograph

Past operations of the East Side Division have eliminated channel forming flows and geomorphic processes that maintain and enhance CV steelhead spawning beds and juvenile rearing areas associated with floodplains and channel complexity. The reduction in peak, channel-forming, flows over time is summarized in table 6-24 (from Kondolf *et al.* 2001). Since the operation of New Melones Dam, channel-forming flows above 8,000 cfs have been reduced to zero and mobilizing flows in the 5,000-8,000 cfs range have only occurred twice in the past 10 years. Channel-forming flows are important to rejuvenate spawning beds and floodplain rearing habitat and to recruit allochthonous nutrients and large wood into the river. Floodplain and side channel habitats provide important juvenile refugia and food resources for juvenile salmonid growth and rearing (Sommers *et al.* 2001a, 2001b, 2005; Jeffres *et al.* 2008; Heady and Merz 2007).

Salmonid spawning habitat availability and quality has been reduced on the order of 40 percent since 1994 (Kondolf *et al*. 2001). Mesick (2001) hypothesized that this reduction is likely underestimated based on the sampling methodology of that assessment. His results indicated that higher concentrations of fine sediments and low intragravel dissolved oxygen in riffles downstream of Orange Blossom Bridge would be expected to reduce fall-run egg survival by 23 percent, as compared to the natural riffles at the Orange Blossom Bridge and upstream. CV steelhead prefer spawning gravels with a greater proportion of smaller gravels than fall-run (Kondolf and Wolman 1993). As smaller particles are mobilized at lower flows than larger particles, the degradation of spawning gravels has a greater proportionate effect on CV steelhead, although not quantified by the study. Operational criteria have resulted in channel incision of 1-3 feet since the construction and operation of New Melones Reservoir (Kondolf *et al*. 2001). This downcutting, combined with operational criteria, have effectively cut off overbank flows which would have inundated floodplain rearing habitat, as well as providing areas for fine sediment deposition, rather than within spawning gravels, as occurs now. Additionally, the flow reductions in late spring and early summer are too rapid to allow recruitment of large riparian trees such as Fremont cottonwoods. Consequently, within 10 to 20 years as existing trees scenesce and fall, there will be no younger riparian trees to replace them, resulting in less riparian shading, higher instream temperatures, less food production from allochtonous sources, and less LWD for nutrients and channel complexity

Table 6-24. Summary of flow conditions on the Stanislaus River during historical periods from 1904-1998. New Melones Dam construction was completed in 1979. Goodwin Dam was completed in 1912 and the first dam in the basin dates at 1853 (Kondolf *et al.* 2001, table 5.2).

Period	Years	Total Years	% Years Peak over 8,000 cfs	% Years Peak over 16,000 cfs	Max Flow (cfs)	Max Flow (date)
I.	1904-1937	34	68%	32%	64,500	3/19/1907
II.	1938-1957	20	60%	25%	62,900	12/23/1955
III.	1958-1978	21	29%	14%	40,200	12/24/1964
III.	1979-1998	20	0%	0%	7,350	1/03/1997

Status quo operations will result in further degradation of spawning habitat and rearing habitat. Reduction and degradation of spawning gravels directly reduces the productivity of the species by reducing the amount of usable habitat area and causing direct egg mortality. Lower productivity leads to a reduction in abundance. The specific population decrement cannot be measured owing to the very low numbers of CV steelhead observed in the Stanislaus River.

6.5.3.4 Effects of Climate Change

Lindley *et al*. (2007) has identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for CV steelhead on the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that are historically unsuitable habitat because of high summertime temperatures. If future conditions are warmer, drier or both, summer temperature conditions at Orange Blossom Bridge are likely to exceed 65˚F, resulting in a constriction of suitable rearing habitat, encroachment of warm-water predatory fishes into more of the freshwater migration habitat, and decreased CV steelhead survival owing to temperature stress, increased disease, and increased competition for food and space with resident *O. mykiss*.

If future conditions are drier, warmer or a combination of both, temperature caused egg mortality will increase by approximately 2 percent in wet years to 13 percent in critically dry years (figure 6-36).

6.5.4 Assess Risk to Individuals

Based on the effects to CV steelhead associated with the proposed action described above, fitness consequences to individuals include reduced reproductive success during spawning, reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration (see table 6-19).

6.5.5 Effects of the Action on CV Steelhead Critical Habitat

Critical habitat has been designated up to Goodwin Dam, to include currently occupied areas. Extension of critical habitat above the dams was deemed premature until recovery planning determines a need for these areas in the recovery of the DPS (September 2, 2005, 70 FR 52488). Lindley (2006) identifies that these habitat areas are intrinsically unsuitable habitat owing to high water temperatures, but suitable and occupied habitat does occur below the East Side Division dams as a result of dam operations that can be managed to maintain suitable temperature regimes. The remaining areas below major dams also may not have optimal habitat characteristics. For example, lower elevation rivers have substantially different flow, substrate, cover, nutrient availability, and temperature regimes than headwater streams.

The PCEs of critical habitat include sites essential to support one or more life stages of the DPS (sites for spawning, rearing, migration, and foraging). The specific PCEs relevant to the Stanislaus River and San Joaquin River to Vernalis include:

1. Freshwater spawning sites
2. Freshwater rearing sites
3. Freshwater migration corridors

Where specific information regarding CV steelhead habitat use in the Stanislaus River is not available, relevant information for fall-run may be used as a surrogate comparison, where comparisons are appropriate.

6.5.5.1 Spawning Sites

CV steelhead spawning habitat on the Stanislaus River is affected by East Side Division operations in four categories: (1) flow releases may not maintain appropriate temperatures for spawning and egg incubation, particularly in April and May; (2) flow releases are not operated to maximize the amount of spawnable habitat available or prevent reductions that could dewater redds; (3) gravel replenishment is too little to offset the lost spawnable material blocked by the dams or to offset material transported away from spawnable riffles and list to in-river pits; and (4) flow releases do not support geomorphic processes that would remove fine sediment from spawning gravels and maintain interstitial flows to attract spawners and allow egg incubation.

6.5.5.2 Temperature

Because CV steelhead are unable to reach their historical spawning areas above Goodwin Dam, they are dependent on East Side Division operations maintaining instream temperatures suitable for spawning below the dam where appropriate gravel and gradient conditions occur. No CV steelhead spawning surveys have been conducted on the Stanislaus River, but fall-run surveys indicate that spawning may occur from Goodwin Dam (RM 59) almost to the city of Riverbank (RM 33), with the highest use occurring above Knights Ferry (RM 55). Based on observations of trout fry, most spawning occurs upstream of Orange Blossom Bridge (Kennedy and Cannon 2002). Modeling results indicate that temperature conditions for spawning CV steelhead likely cannot be met in April and May for future operations, even without climate change, and reduction in available coldwater for spawning habitat could occur in critically dry water years in the future if conditions are drier, warmer or a combination of both. This would result in reducing the amount of suitable spawning habitat, and compressing it further upstream closer to the terminal dams. Operational criteria are not clearly described in the CVP/SWP operations BA to assure that modeled conditions reflect proposed operations.

6.5.5.3 Spawnable Area

Aceituno (1993) applied the IFIM to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) to help to determine instream flow needs for Chinook salmon and CV steelhead. The PHABSIM results indicated CV steelhead spawning was maximized at 200 cfs. Using the CALSIM II results presented in the CVP/SWP operations BA Appendix E and CV steelhead habitat area curves from Aceituno (1993), we assessed that flows that fall below that level between December and February are projected to occur 50 percent of the time in January and 10 percent of the time in February and would reduce spawnable area by approximately 30 percent. December flows are projected to exceed 200 cfs in all years reducing spawnable area 15 percent in 50 percent of years. Flows that exceed 400 cfs are projected to occur in all months 25 percent of the time and could result in reduction of spawnable habitat from 60-95 percent.

Flows to maximize fall-run spawning are higher than CV steelhead needs, thus management actions to protect both species may conflict. Channel complexity can allow for greater variety in meso habitats, so that for a given flow release level at the dam, some portions of the river will have higher velocities than other areas. Thus more channel complexity could avoid adverse effects to CV steelhead as a result of implementing optimal flows for fall-run, such as those called for in the CVPIA. Unfortunately, past and continuing operations have reduced channel forming and channel maintaining flows, which have resulted in channel incision and loss of channel complexity (Kondolf *et al*. 2001). Therefore, the conservation value of spawning habitat in the form of gravel bedded reaches has been, and will continue to be, reduced with the implementation of the proposed action.

6.5.5.4 Spawning Gravel Quality and Quantity

Pebble counts and sediment size analysis of spawning areas has shown an increase in sand and fine material in spawning beds since construction of New Melones Dam (Kondolf *et al.* 2001, Mesick 2001). Most non-enhanced riffles had sufficient fine material to impair egg incubation and survival.

Gravel replenishment actions below Goodwin Dam add suitably-sized gravel for CV steelhead spawning, but it is rapidly mobilized at flows as low as 280 cfs (Kondolf *et al*. 2001). CVPIA spawning gravel additions have targeted 3,000 cubic yards per year. This is not of sufficient volume to offset the deficits created by the loss of recruitment from upstream sources (over 1 million cubic yards, Kondolf *et al*. 2001). At best, these additions may strategically maintain the quality of few spawning riffles. The project description does not specify a level of spawning gravel addition to be performed on the Stanislaus River.

6.5.5.5 Spawning Habitat Quality and Geomorphic Processes

Since the construction of New Melones Dam, channel-mobilizing flows of 5,000 cfs have increased in return interval from 1.5 years to over 5 years. Overbank flows are critical for redistributing fine sediments out of spawning beds and onto the floodplain terrace. Current operations have also caused channel incision of up to 1-3 feet since the construction of New Melones Dam. Channel incision further increases the flows needed to obtain overbank flow and decreases the likelihood of occurrence. Without sufficient flows for geomorphic processes to manage fine sediment deposition in spawning gravels, spawning beds will be increasingly choked with sediment and unsuitable for spawning.

Lack of flow fluctuation and channel forming flows has also resulted in the stabilization of gravel bars by thick riparian vegetation at the river edges. Lack of scouring prevents mobilization of spawnable material to refresh degraded riffles. Proposed operations will continue this degradation of spawning habitat conditions.

6.5.5.6 Freshwater Rearing Sites

The project operations would not change rearing habitat availability, but current operations do not allow for overbank flow to maintain floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility. Since the construction of New Melones Dam, channel-mobilizing flows of 5,000 cfs have increased from a return interval of 1.5 years to over 5 years. Lack of flow fluctuation and channel forming flows has also resulted in the stabilization of gravel bars by thick riparian vegetation at the river edges. Lack of scouring prevents introduction of LWD, which provides cover, nutrients and habitat complexity, including undercut banks and side channels. Additionally, the flow reductions in late spring and early summer are too rapid to allow recruitment of large riparian trees such as Fremont cottonwoods. Consequently, within 10 to 20 years as existing trees scenesce and fall, there will be no younger riparian trees to replace them, resulting in less riparian shading, higher instream temperatures, less food production from allochtonous sources, and less LWD for nutrients and channel complexity. Proposed operations will continue this degradation of rearing habitat conditions.

6.5.5.7 Freshwater Migration Corridors

Under proposed operations the freshwater migration corridors on the Stanislaus River will continue to require juvenile CV steelhead to pass through predator-rich abandoned mining pits, incised channels that limit channel complexity and water temperatures that may be physiologically lethal or sublethal. The spring pulse flows defined in VAMP are generally less than the spring pulse flows measured in 1989, a critically dry year (Kondolf *et al.* 2001), hence the operational assistance provided to assist CV steelhead outmigrants is only representative of the lowest migratory volumes historically experienced by CV steelhead.

Channel incision resulting from post New Melones operations has produced overhanging large wood and river edge aquatic vegetation but the lack of scouring and channel forming flows has effectively channelized and simplified the corridor. The variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner has been limited by operational conditions. Obstruction of access to historic spawning and rearing habitat requires CV steelhead to utilize these freshwater migration corridors at times that may not be optimal with respect to temperature, forage availability and exposure to predators.

Adult CV steelhead migrating upstream frequently are delayed entering the river owing to poor water quality conditions in the Delta. Fall attraction flows released for Fall Run typically improve conditions for steelhead migration also, hence steelhead tend to be observed on the Stanislaus River earlier in the year than in other Central Valley streams.

6.6 Delta Division

6.6.1 Deconstruct Actions in the Delta Division

The proposed action within the Delta is comprised of several different elements. Some of the elements, such as the proposed intertie between the Delta Mendota Canal and the California Aqueduct, were integrated into the assumptions for the CALSIM II modeling for the near future conditions (Study 7.1) and the future conditions (Study 8.0) and thus could not be analyzed separately without running the models individually with the explicit actions separated out from the combined assumptions. Others aspects of the action were modeled, such as export rates and gross channel hydraulics (flow rates, flow percentages, *etc.*) and could be assessed for their effects. NMFS chose to look at modeled water diversion actions in total, without disaggregating individual components of the water demands on the CVP and SWP actions in the Delta. NMFS assumed that the baseline conditions included the current natural and anthropogenic conditions in the Delta region (levees, dredging, contaminants, urban development, non-native species, predation, *etc*.) without the effects of the ongoing operations (*i.e.*, discretionary actions) of the Project.

In general, the effects of the actions in the Delta will result in: (1) increased export rates at the CVP and SWP facilities, resulting in increased salvage and loss at the CVP and SWP fish collection facilities, (2) alterations to the hydrodynamics in the Delta, resulting in increased vulnerabilities to entrainment into the central and southern Delta water ways, exposure to predation losses within the central and southern Delta waterways, delays in migration, increased residence time in the Delta due to delays in migration, and loss of migratory cues due to flow alterations, (3) exposure of green sturgeon to herbicides in Clifton court forebay, and (4) installation and operation of physical structures in the South Delta that will alter hydraulics, increase predation vulnerability and degrade habitat functions for listed salmonids and green sturgeon in the affected waterways.

The action elements analyzed by NMFS for the Delta Division are:

1. Exports from the CVP and SWP water diversions facilities which include changes in delta hydrodynamics, direct entrainment of listed fish at the project facilities, and indirect mortality within the delta related to exports and non-export factors;

2. Application of the copper based herbicide Komeen® to Clifton Court Forebay as part of the SWP aquatic weed control program;
3. The effects of the South Delta Improvement Program, Stage 1;
4. The effects of the Delta Cross Channel;
5. Contra Costa Water District diversions from delta facilities;
6. North Bay Aqueduct on Barker Slough; and
7. Vernalis Adaptive Management Plan effects.

In addition to the elements of the project action, the effects of climate change are assessed in conjunction with the implementation of the project actions. NMFS utilized the output of the climate change modeling presented in the BA to conduct this evaluation.

6.6.2 Proposed Delta Exports and Related Hydrodynamics

6.6.2.1 Deconstruct the Action

The proposed action will result in increased levels of water diversions from the CVP and SWP export facilities in the near future (Study 7.1) and future (Study 8.0) conditions over the current export levels (Study 7.0). Increased exports result in increased net flows towards the export facilities through the waterways of the central and south Delta. The effects of these increased exports are analyzed below in relation to the current level of exports. The effects of the current exports are discussed in both the environmental baseline and the current effects section. The temporal and spatial occurrence of listed fish in the Delta region as well as the baseline stressors have been described in Section 5.5, "*Status of the Species and Critical Habitat in the Delta Division.*"

6.6.2.2 Elements of the Action

6.6.2.2.1 Modeling Results for Proposed Delta Actions

Reclamation used the computer simulation models CALSIM II and DSM2 to model the effects of the proposed action. The effects modeled are based on the assumptions in the changes in operations and demands between the four CVP/SWP operations studies (6.0, 7.0, 7.1, and 8.0) as well as five climate change scenarios modeled in the future Study 9 series. (See CVP/SWP operations BA page 9-32 and 9-107, and table 9-4 for a more complete description of the models)

6.6.2.2.2 Delta Inflow

Total Delta inflow in the models is calculated as the sum of water entering the Delta from the Yolo bypass, the Sacramento River, the Mokelumne River, the Calaveras River, the Cosumnes River, and the San Joaquin River (at Vernalis). Historical Delta inflow for the period between 1980 and 1991 averaged 28 MAF, with the inflow from the Sacramento and San Joaquin rivers contributing approximately 75 percent of the inflow (DWR 1995). Based on the four modeling comparisons done for the CVP/SWP operations BA, the annual average Delta inflow decreases in all study comparisons when future long term annual average conditions are compared to current conditions (table 6-25). Although not specifically called out, north of Delta demands increase in the future with the addition of the Freeport Regional Water Project intake as well as increases in future demands for municipal and industrial (M&I) water deliveries and settlement contracts. The overall result is more water is diverted for upstream demands prior to reaching the Delta in the near future and future conditions.

Table 6-25. Differences in long-term average annual Delta inflow and the 1929 – 1934 drought as modeled under the four CVP/SWP operations studies (CVP/SWP operations BA table 12-1).

Difference in Thousand acre feet (TAF)	Study 7.0 – Study 6.0	Study 7.1 – Study 7.0	Study 8.0 – Study 7.0	Study 8.0 – Study 7.1
Long-term annual average Total Delta Inflow	-69	-201	-270	-70
1929 -34 Annual average Total Delta Inflow	136	-272	-403	-130

The differences between studies 6.0, 7.0, 7.1, and 8.0 show relatively little difference in the 50th percentile flows (Total Delta inflow) when compared on a monthly basis (figure 6-37). The highest modeled inflows occur in the period from December through March due to flood flows and increased runoff in the basin. However, in all four modeling studies, there are distinct increases in Delta inflow during July to support increased pumping in below normal, dry, and critically dry year types (figures 6-38 through 6-43). Reclamation has stated that "current" model runs (6.0 and 7.0) have slightly higher inflow than the future runs (7.1 and 8.0) during the summer of dry and critically dry years due to the extra pumping required for EWA transfers being wheeled between the facilities. Since the future studies have limited EWA assets, this additional inflow is not required. Conversely, more water arrives in the Delta in June and July during above normal and below normal years in the future operations, apparently for export purposes. Summer time Delta inflow may have an effect on emigrating juvenile green sturgeon or their distribution in the Delta following emigration, based on the occurrence of juvenile green sturgeon at the South Delta salvage facilities in July and August. However, the lack of data concerning the movements of juvenile sturgeon during their downstream migration make definitive assessments difficult at best concerning the role of Delta inflow on their movements.

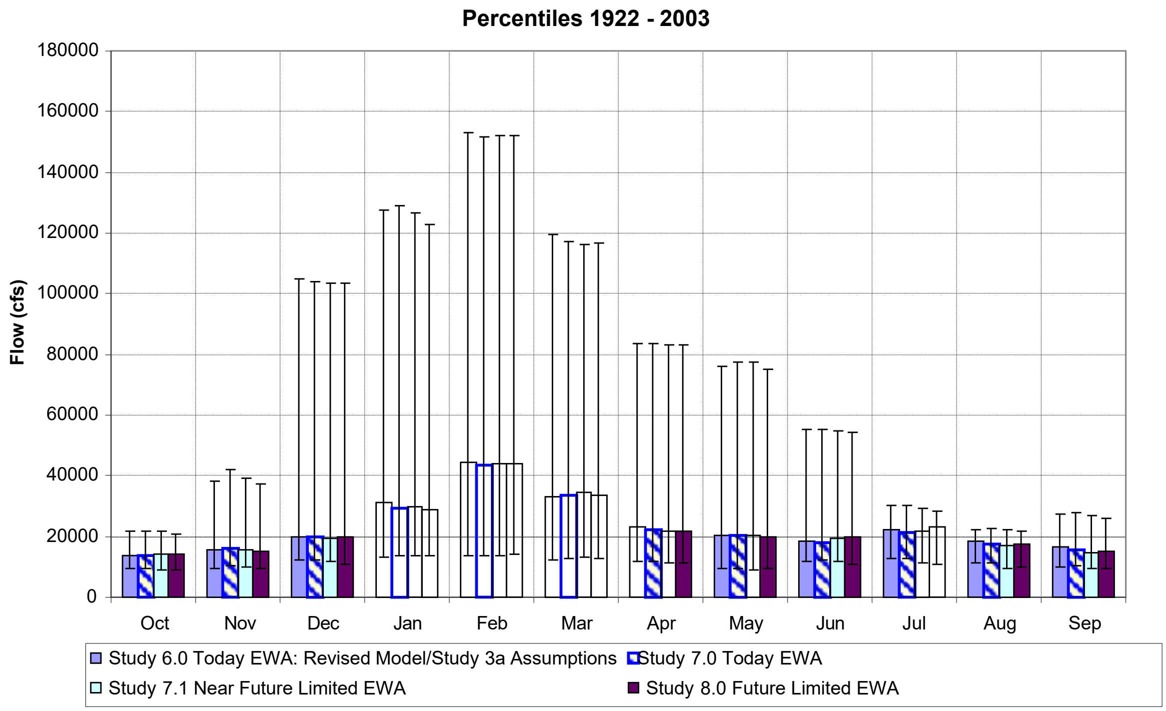


Figure 6-37. Monthly Delta inflow as measured at the 50th Percentile with 5th and 95th percentile whisker bars shown (CVP/SWP operations BA figure 12-2).

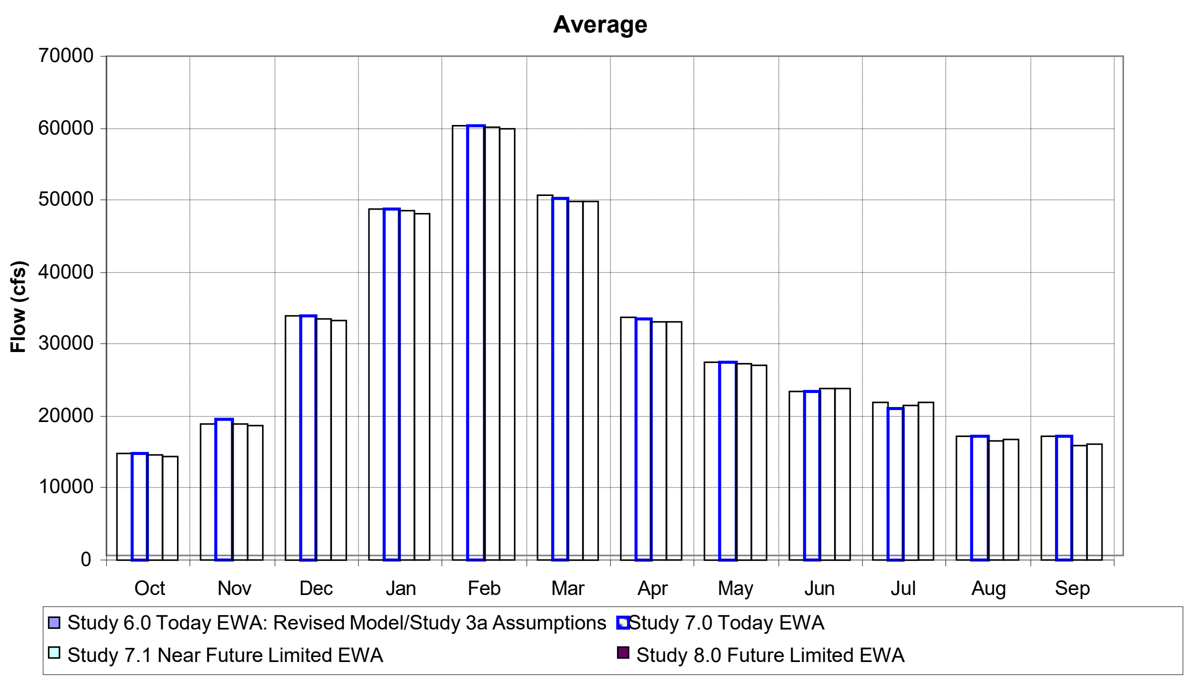


Figure 6-38. Average monthly Total Delta Inflow (CVP/SWP operations BA figure 12-3).

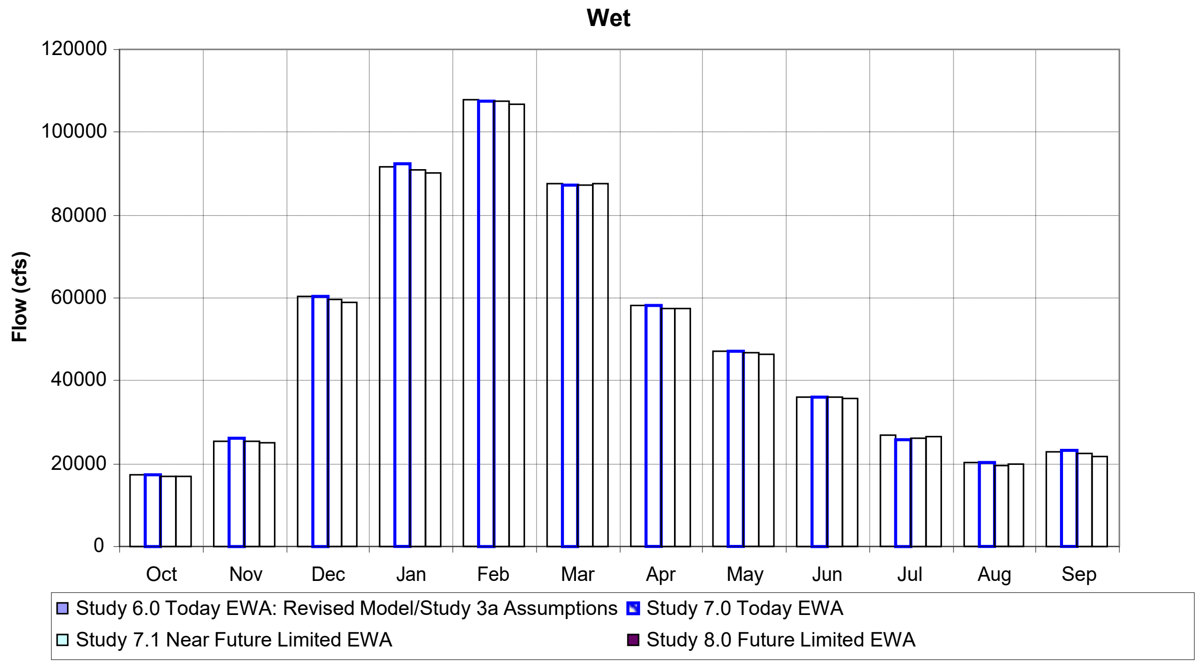


Figure 6-39: Average wet year (40-30-30[14]) monthly total Delta inflow (CVP/SWP operations BA figure 12-4).

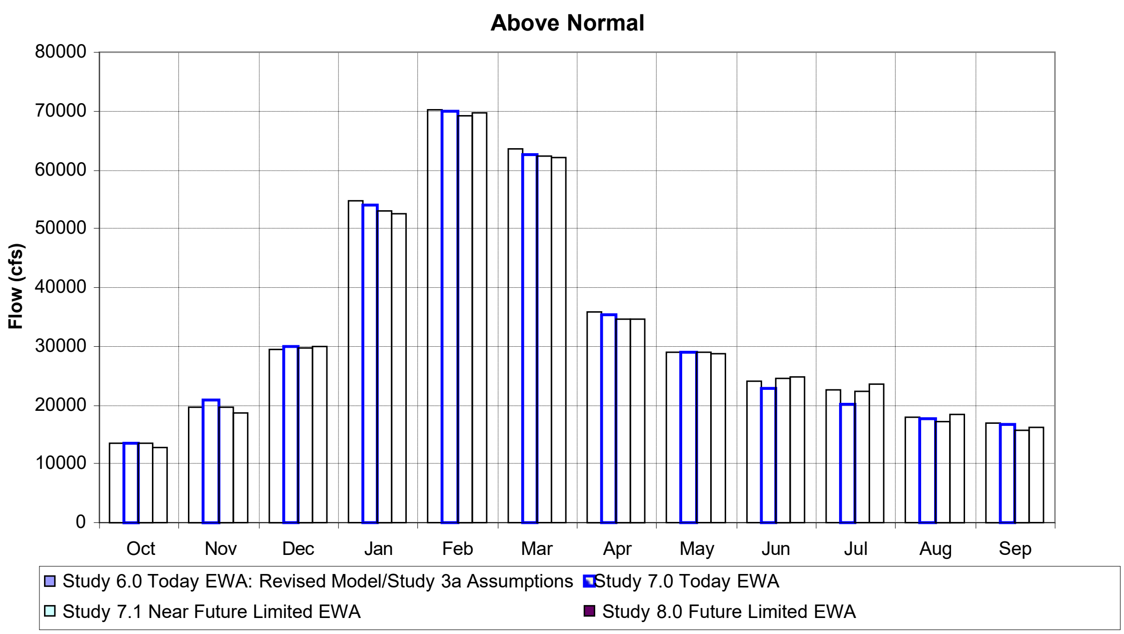


Figure 6-40: Average above normal year (40-30-30) monthly total Delta inflow (CVP/SWP operations BA figure 12-5).

[14] 40-30-30, also known as the "Sacramento River Index," was "previously used to determine year type classifications under SWRCB Decision 1485," and is equal to 0.4 * Current Apr-Jul Runoff + 0.3 * Current Oct-Mar Runoff + 0.3 * Previous Year's Index, where runoff is the sum of unimpaired flow in MAF at: Sacramento River above Bend Bridge, Feather River at Oroville (aka inflow to Lake Oroville), Yuba River near Smartville, and American River below Folsom Lake; and previous year's index is a maximum 10.0 (http://cdec.water.ca.gov/cgi-progs/iodir/wsi).

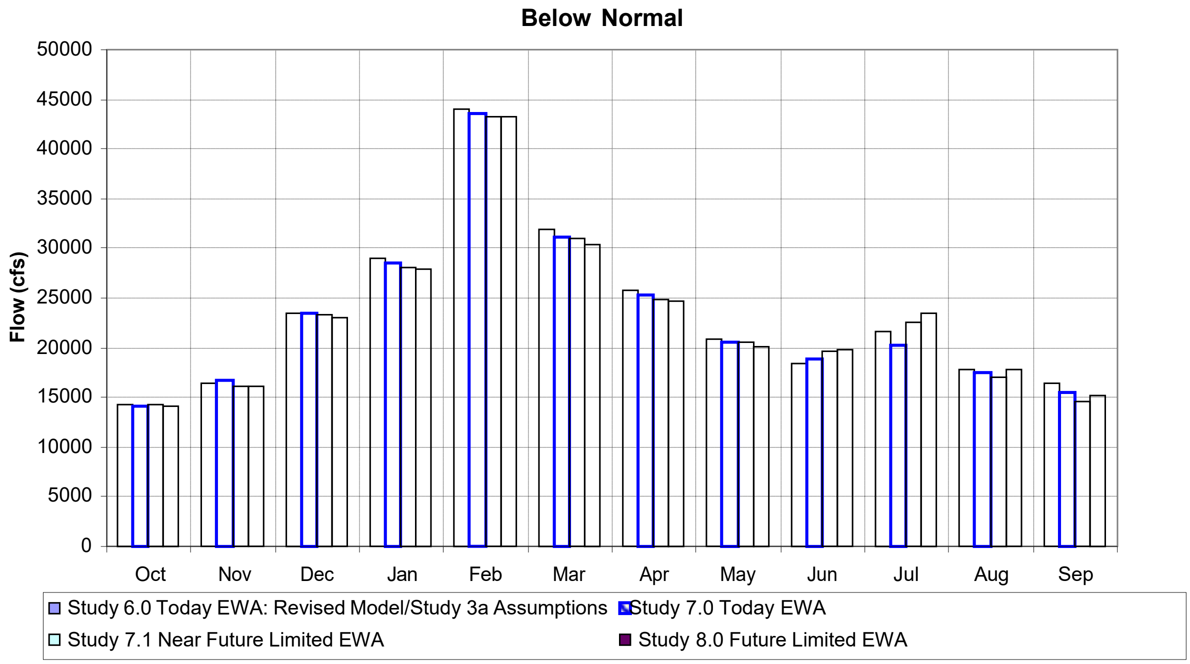


Figure 6-41: Average below normal year (40-30-30) monthly total Delta inflow (CVP/SWP operations BA figure 12-6).

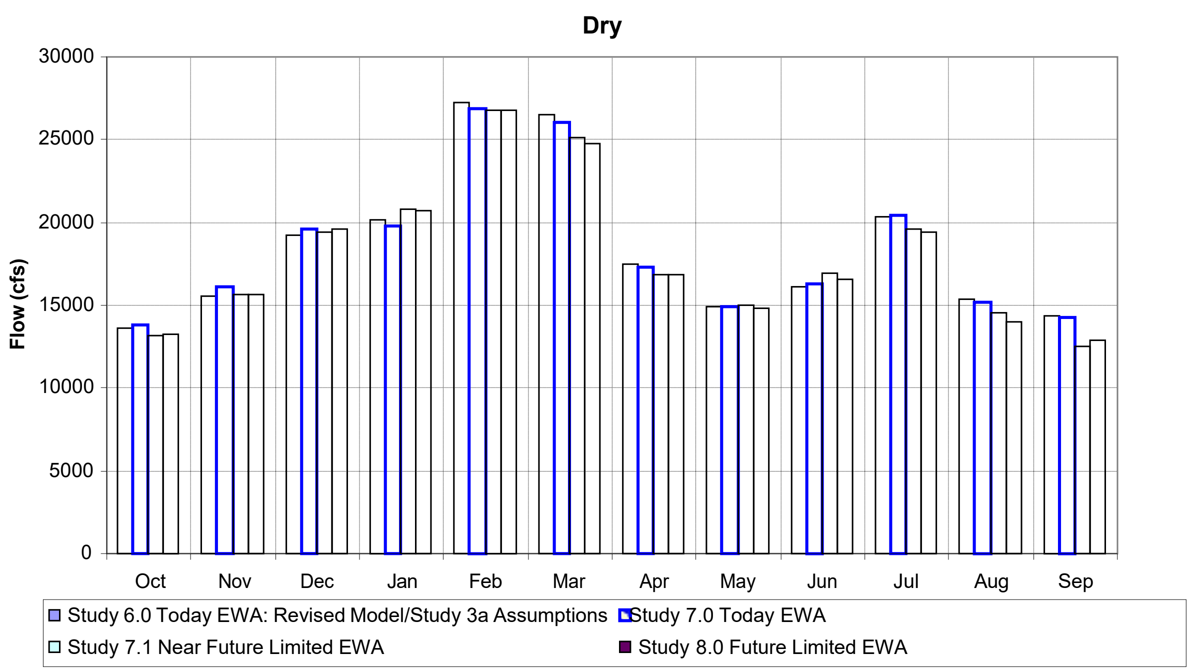


Figure 6-42: Average dry year (40-30-30) monthly total Delta inflow (CVP/SWP operations BA figure 12-7).

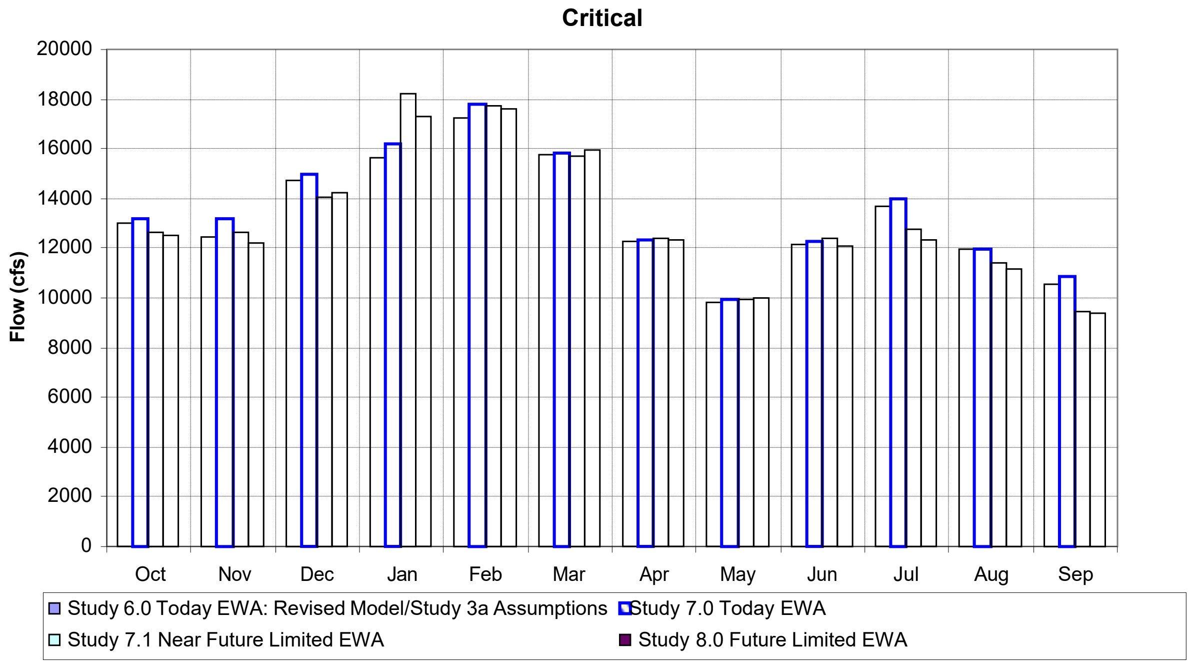


Figure 6-43: Average critically dry year (40-30-30) monthly total Delta inflow (CVP/SWP operations BA figure 12-8).

6.6.2.2.3 Delta Outflow

Historical Delta outflow values are described in DWR's Delta Atlas (DWR 1995). Of the 28 MAF of Delta inflow, approximately 19 MAF flows out to the ocean through the Delta. The remaining 9 MAF is captured by water diversions in the Delta, of which the CVP and SWP account for approximately 6 to 8 MAF (or 20 to 28 percent of the inflow) depending on water year type (DWR 1995; Healey *et al*. 2008; California, State of 2008). When comparing the differences between the future studies (7.1 and 8.0) with the current conditions (study 7.0), the average annual Delta outflow decreases by 300 to 400 TAF. Most of this decrease is seen in the immediate future (Study 7.1 compared to Study 7.0) with a reduction of 296 TAF. Study 8.0 reduces the delta outflow average an additional 104 TAF (see table 6-26). This represents an increase of approximately 5 percent in water "lost" in the Delta to diversions over historic conditions.

Table 6-26. Differences in long-term average annual Delta outflow and the 1929 – 1934 drought as modeled under the four CVP/SWP operations studies (CVP/SWP operations BA table 12-2).

Differences in Thousands of Acre-Feet (TAF)	Study 7.0 – Study 6.0	Study 7.1 – Study 7.0	Study 8.0 – Study 7.0	Study 8.0 – Study 7.1
Long-term Annual Average Total Delta Outflow	-149	-296	-400	-104
1929 -34 Annual average Total Delta Outflow	-93	-195	-164	32

The studies indicate that there are seasonal differences in the outflow, particularly in winter and spring. The biggest differences occur in below normal, dry, and critically dry years. The obvious differences are seen in late winter, where outflow increases are seen in Studies 6.0 and 7.0, when pumping reductions for "fish actions" are taken and thus, more water is allowed to flow out of the Delta. Conversely, these pumping reductions are not taken in the future since the models were designed with limited EWA assets available to the Projects. In general, the Delta outflow decreases during the winter and spring seasons are greater for the future studies (7.1 and 8.0) than they are for the current studies (6.0 and 7.0), indicating that less water is available to assist emigrating fish to leave the Delta during this period (figures 6-44 through 6-50).

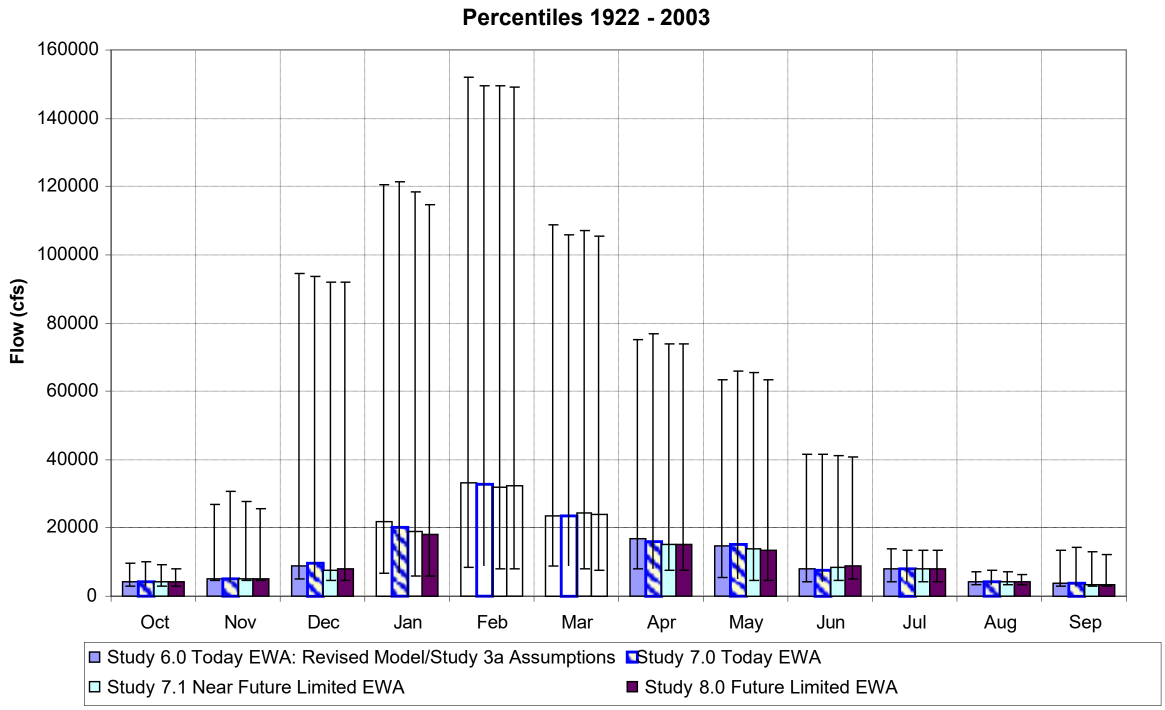


Figure 6-44. Monthly Delta outflow as measured at the 50th percentile with 5th and 95th percentile whisker bars shown (CVP/SWP operations BA figure 12-10).

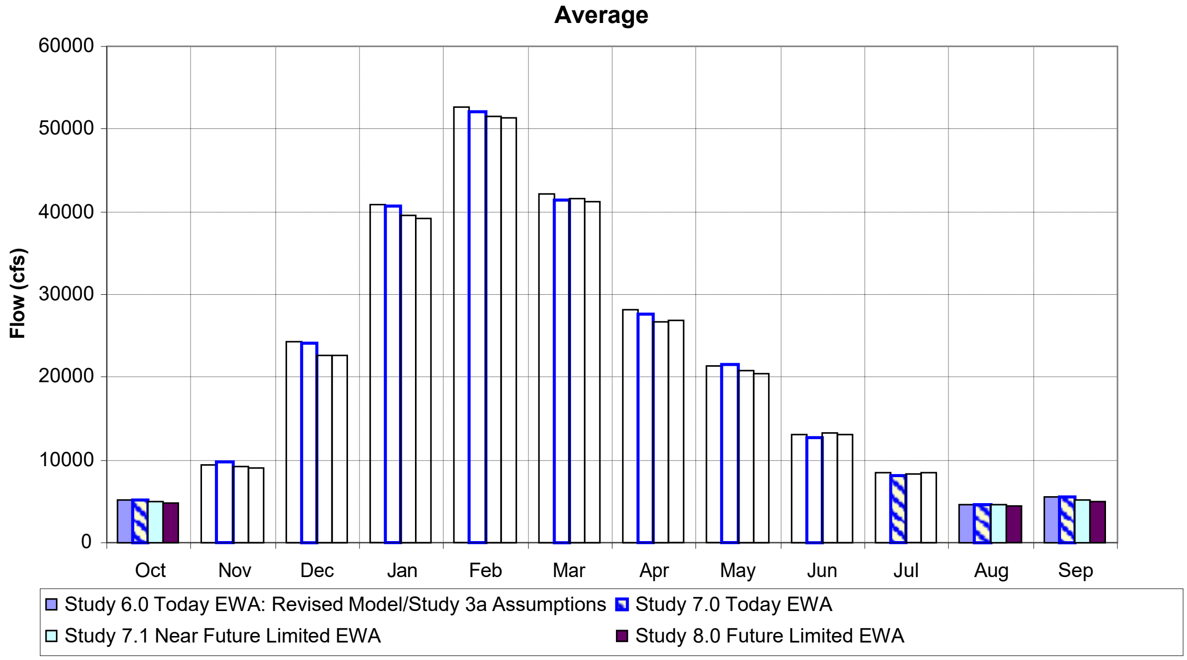


Figure 6-45. Average monthly total Delta outflow (CVP/SWP operations BA figure 12-11).

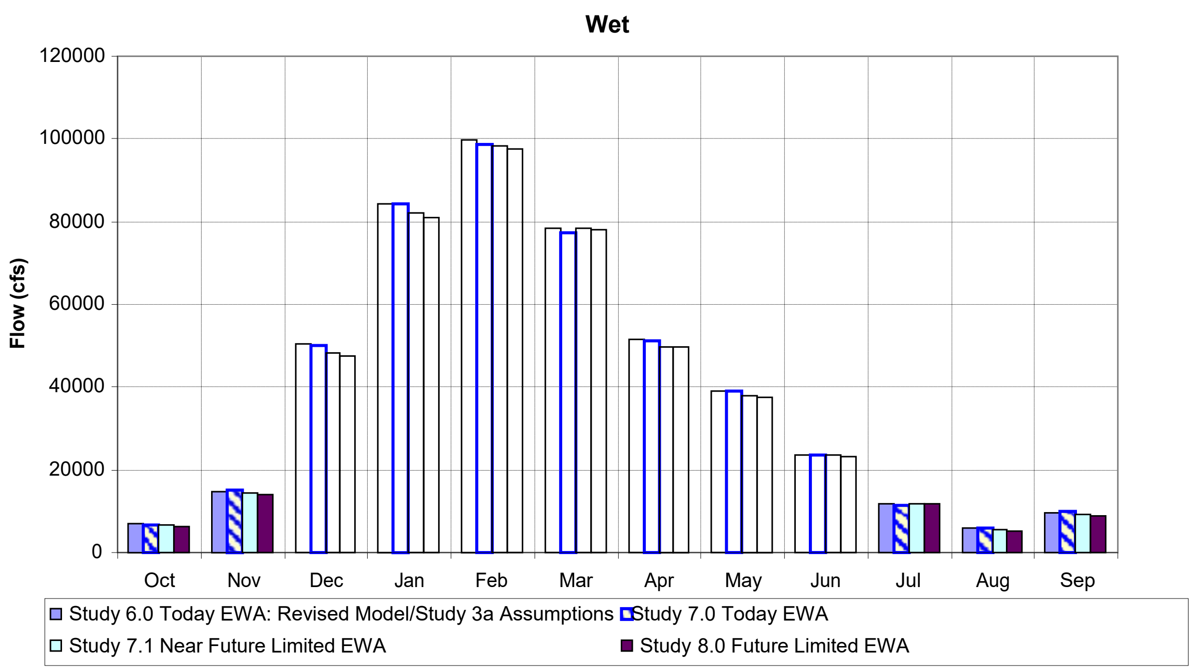


Figure 6-46. Average wet year (40-30-30) monthly delta outflow (CVP/SWP operations BA figure 12-12).

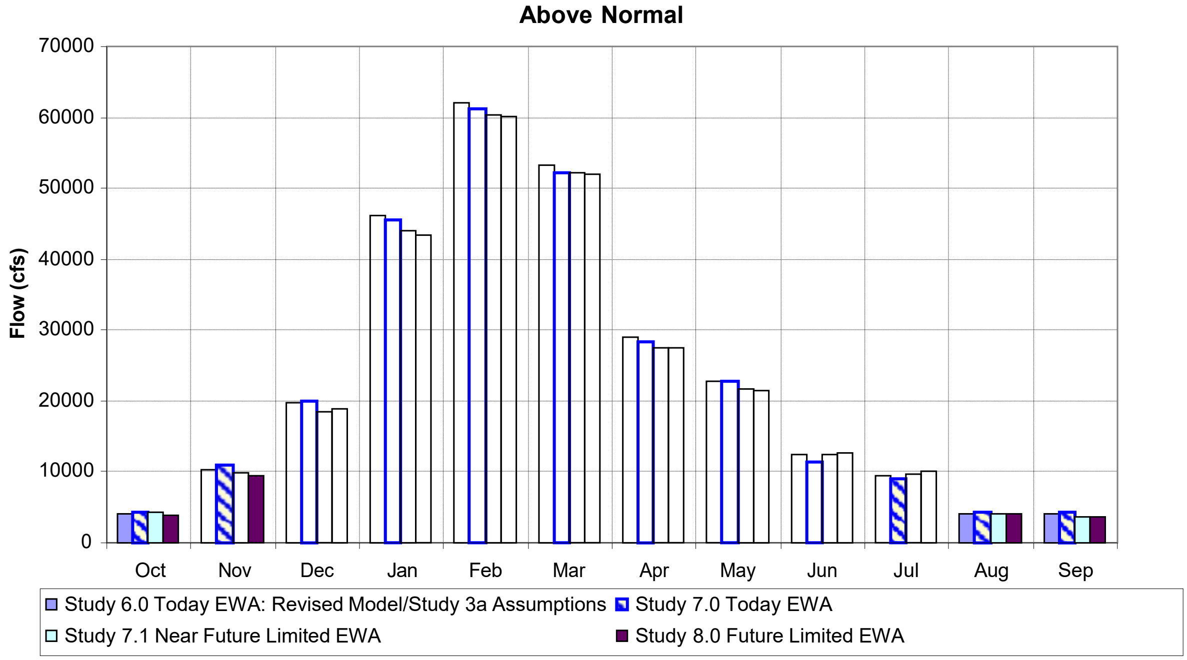


Figure 6-47. Average above normal year (40-30-30) monthly Delta outflow (CVP/SWP operations BA figure 12-13).

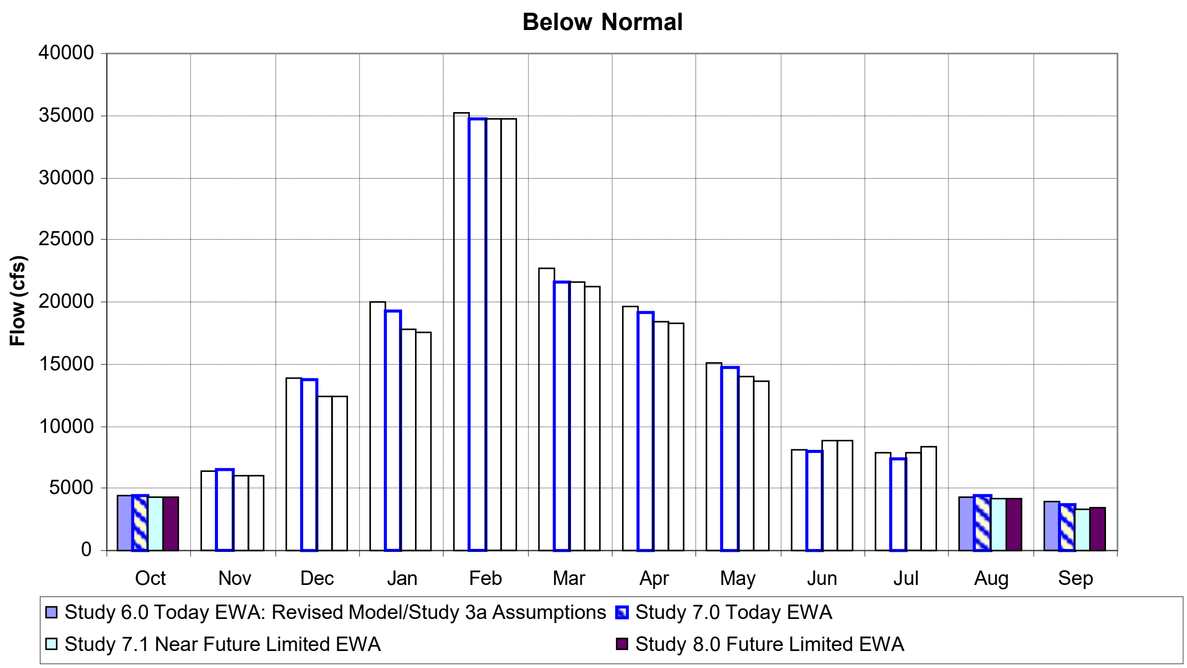


Figure 6-48. Average below normal year (40-30-30) monthly Delta outflow (CVP/SWP operations BA figure 12-14).

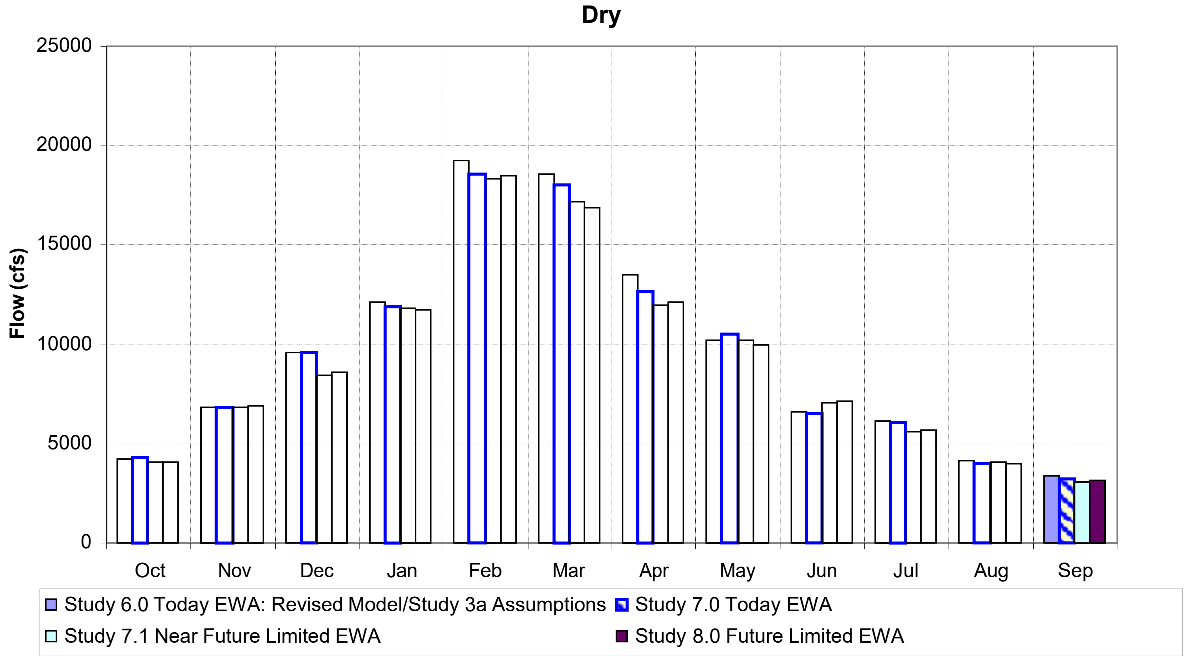


Figure 6-49. Average dry year (40-30-30) monthly Delta outflow (CVP/SWP operations BA figure 12-15).

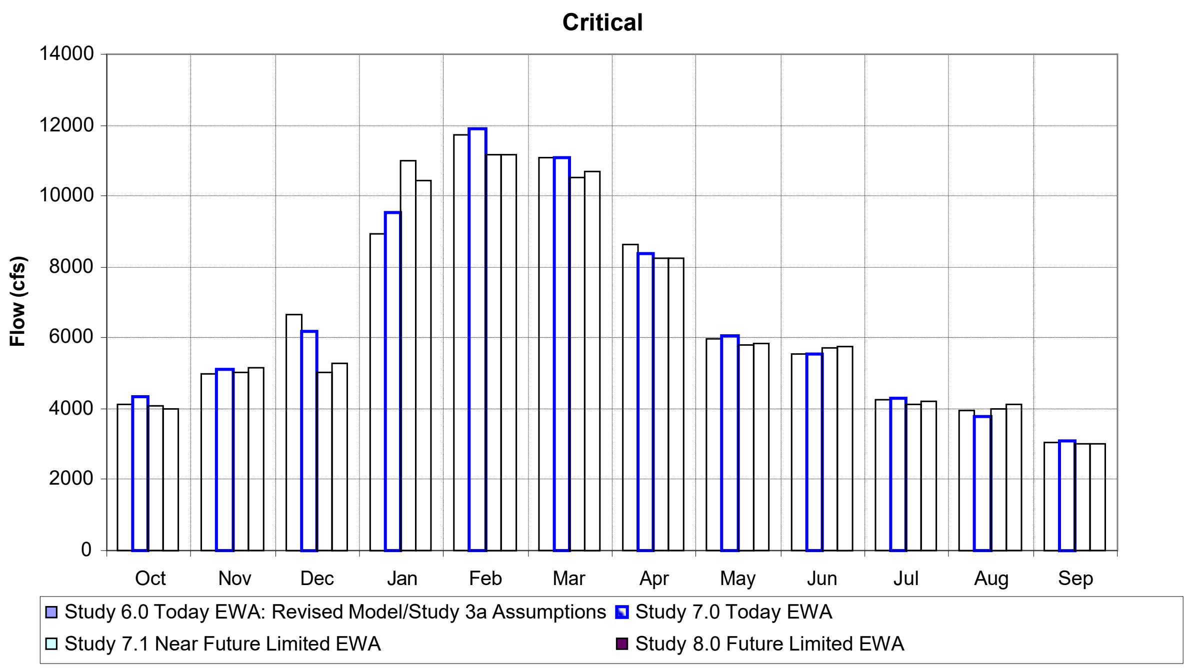


Figure 6-50. Average critically dry (40-30-30) monthly Delta outflow (CVP/SWP operations BA figure 12-16).

6.6.2.2.4 Exports from the Project Facilities

The exports modeled are Reclamation's at the Bill Jones Pumping Plant, the State's pumping at the Harvey O. Banks Pumping Plant, joint point diversions by Reclamation at Banks, and diversions for the Contra Costa Water District and the North Bay Aqueduct on Barker Slough. The future scenario, as modeled by Study 8.0, shows a pumping pattern with increased levels of exports due to the greater future demands south of the Delta, and reduced export curtailments due to EWA actions relative to current practices as modeled in studies 6.0 and 7.0. The near future condition, as represented by study 7.1, also shows an elevated pumping pattern compared to the current operations as represented by studies 6.0 and 7.0.

Reclamation indicates that pumping at the Bill Jones Pumping Plant is limited to 4,200 cubic feet per second (cfs) in studies 6.0 and 7.0, which represent current operations (no intertie). In studies 7.1 and 8.0, pumping rates at Jones are increased to a maximum of 4,600 cfs in anticipation of the Delta-Mendota Canal intertie with the California Aqueduct. The future conditions indicate that Reclamation will maximize its pumping during the months of November through January (*i.e.*, 4,600 cfs) as often as possible. Figure 6-51 (the 50th percentile monthly export rates) indicates that these maximum rates will occur in most months when conditions permit as illustrated by the 95th percentile whisker bars, leaving only April, May, and June below the maximum pumping rate. Wet years tend to present the conditions when Reclamation can take advantage of the intertie and maximal pumping at 4,600 cfs compared to other water year types (figures 6-52 through 6-57). The comparisons between the current studies (6.0 and 7.0) and the future studies (7.1 and 8.0) indicate that only in the months of March and April are pumping rates typically lower in the future operations than in the current operations. The month of May, particularly in drier water years, has higher pumping rates than current operations. In critically dry years, the future conditions have higher pumping rates during the October through May period compared to those seen in the current operations. In the current studies (6.0 and 7.0), pumping is reduced in December, January, and February by the 25 TAF restrictions imposed by the EWA Program. Additional reductions occur in all four studies during the VAMP export reductions, but only the current studies have additional reductions associated with the EWA expenditures to supplement the VAMP shoulders in May for continued export reductions. The future studies (7.1 and 8.0) do not include these additional export reductions, presumably due to the limited EWA assets available. All four studies indicate that pumping will increase during the summer (July through September) for irrigation deliveries. The future studies increase the most during wet and above normal water year types, reaching near maximal pumping rates, while the drier water year types show mixed increases between the different modeling runs.

The modeling studies completed for the CVP/SWP operations BA indicate that total Banks exports increase in December, January and February for studies 7.1 and 8.0 due to the lack of full EWA assets as compared to the full EWA assets modeled for the current conditions (Studies 6.0 and 7.0). The modeling also indicates that the 50th percentile pumping rates approach or exceed 7,000 cfs during wet years and can exceed 8,000 cfs during January and February at the 95th percentile (see figure 6-58). Furthermore, the reductions in pumping during the April and May VAMP export curtailment are less than under the current operational conditions. This is created by the lack of sufficient volumes of water available (including the 48,000 AF available in-Delta from the Yuba River Accord) to offset the export reductions at Banks. During summer months (July to September), the future operations are modeled to include an additional 500 cfs above the 6,880 cfs maximum to offset “fish” related export reductions earlier in the year. The average monthly pumping levels at Banks are shown in figure 6-59 and clearly indicate that on average, the future operational conditions will have higher pumping rates from December through May than under the present conditions. This trend holds through most of the water year types, with future pumping levels being equivalent to or higher than the current operations during the winter and spring months in just about all monthly comparisons (figures 6-60 through 6-64).

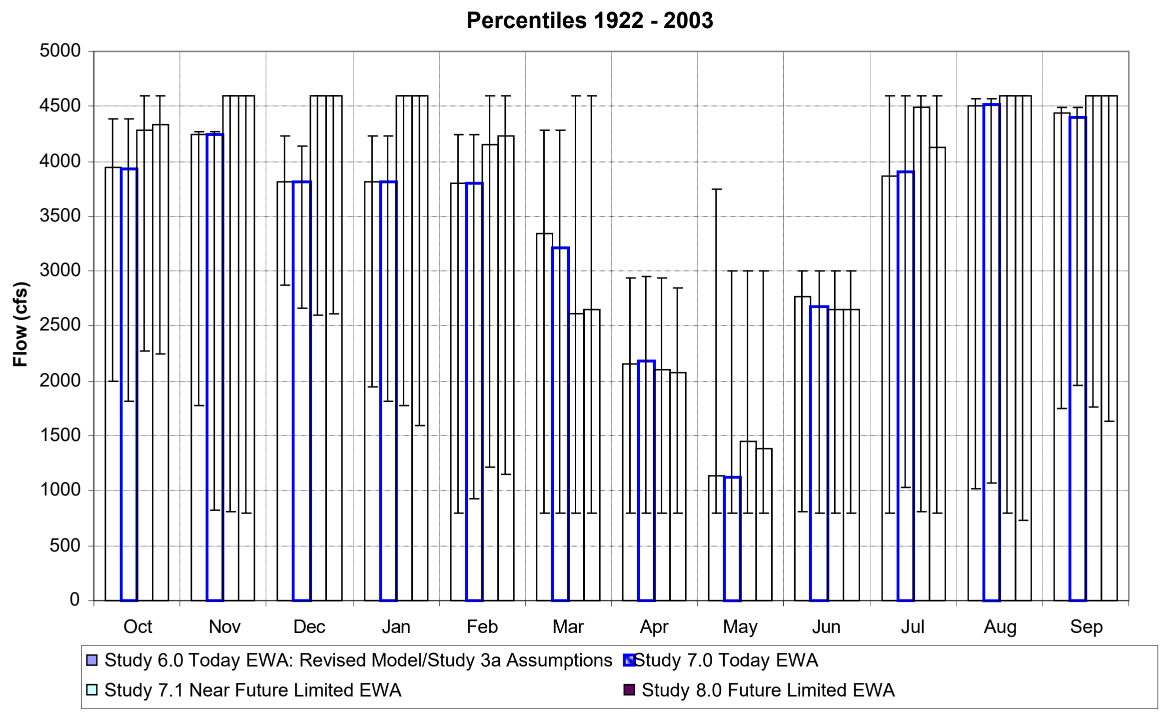


Figure 6-51. Monthly CVP export pumping rate, 50th percentile with 5th and 95th percentile whisker bars (CVP/SWP operations BA figure 12-18).

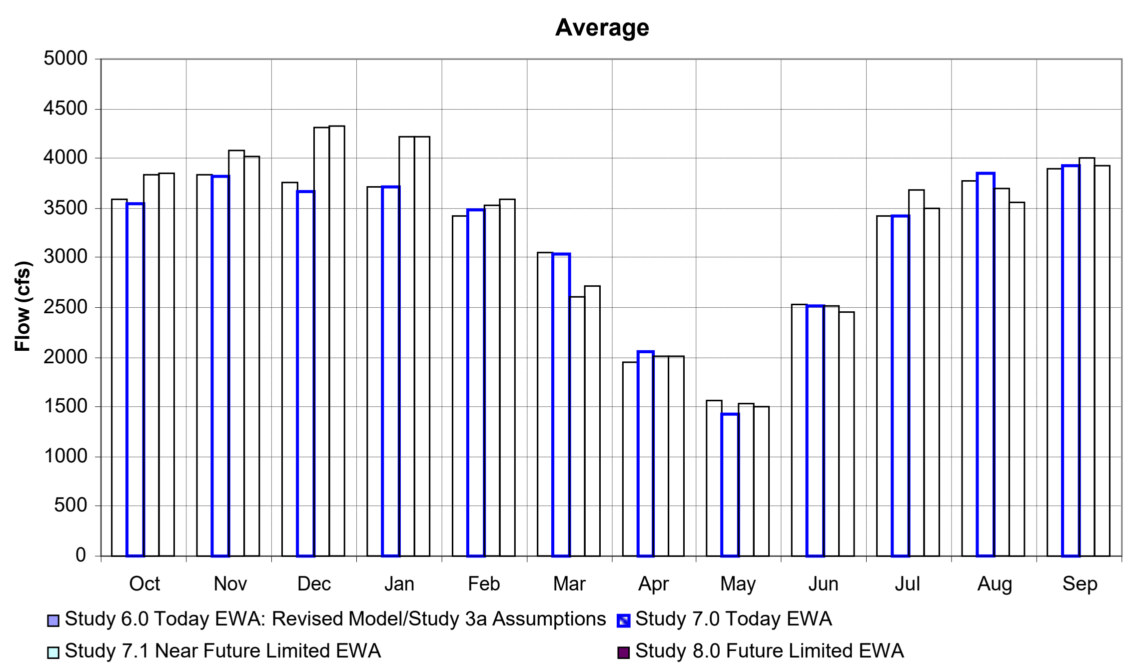


Figure 6-52. CVP monthly average export rate (CVP/SWP operations BA figure 12-19).

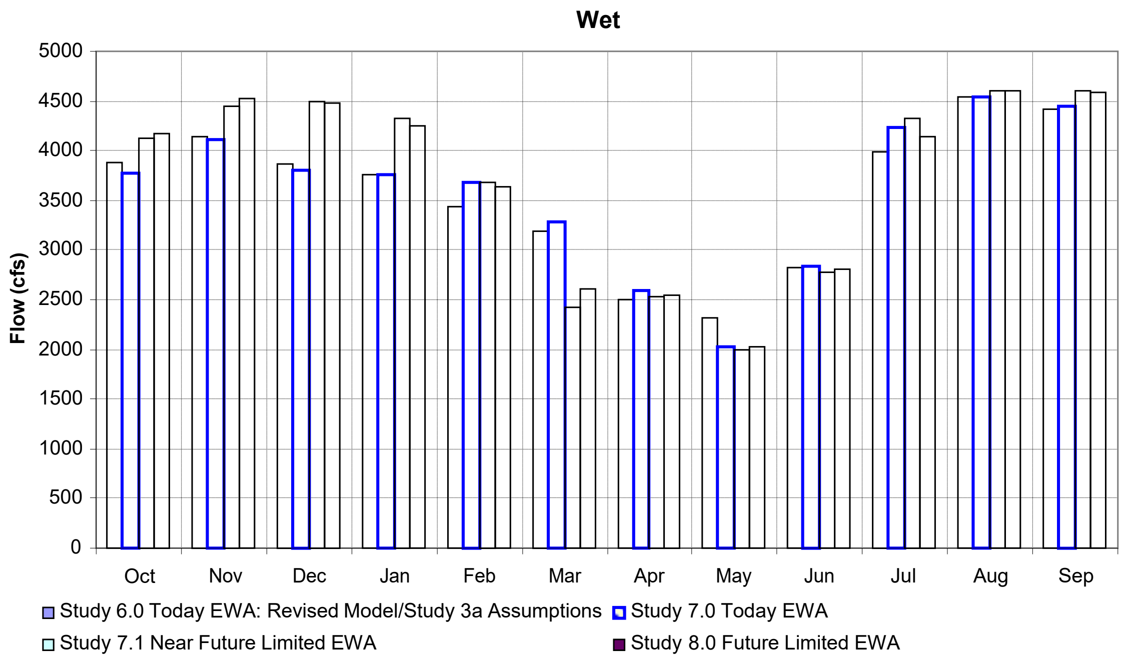


Figure 6-53. Average wet year (40-30-30) monthly CVP export rate (CVP/SWP operations BA figure 12-20).

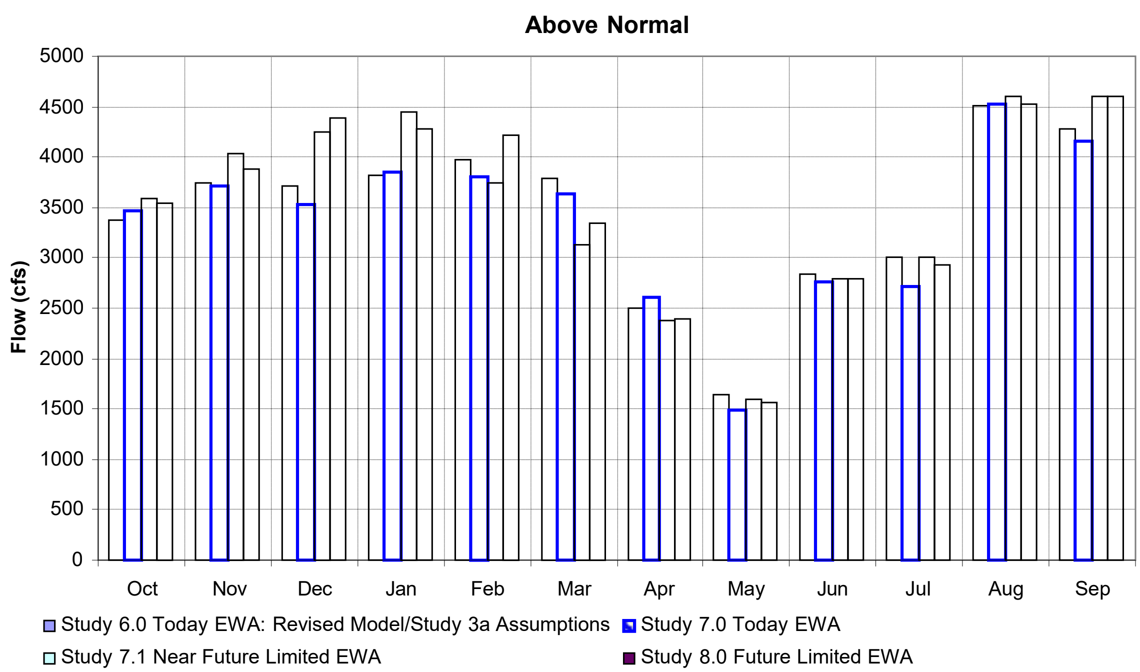


Figure 6-54. Average above normal year (40-30-30) monthly CVP export rate (CVP/SWP operations BA figure 12-21).

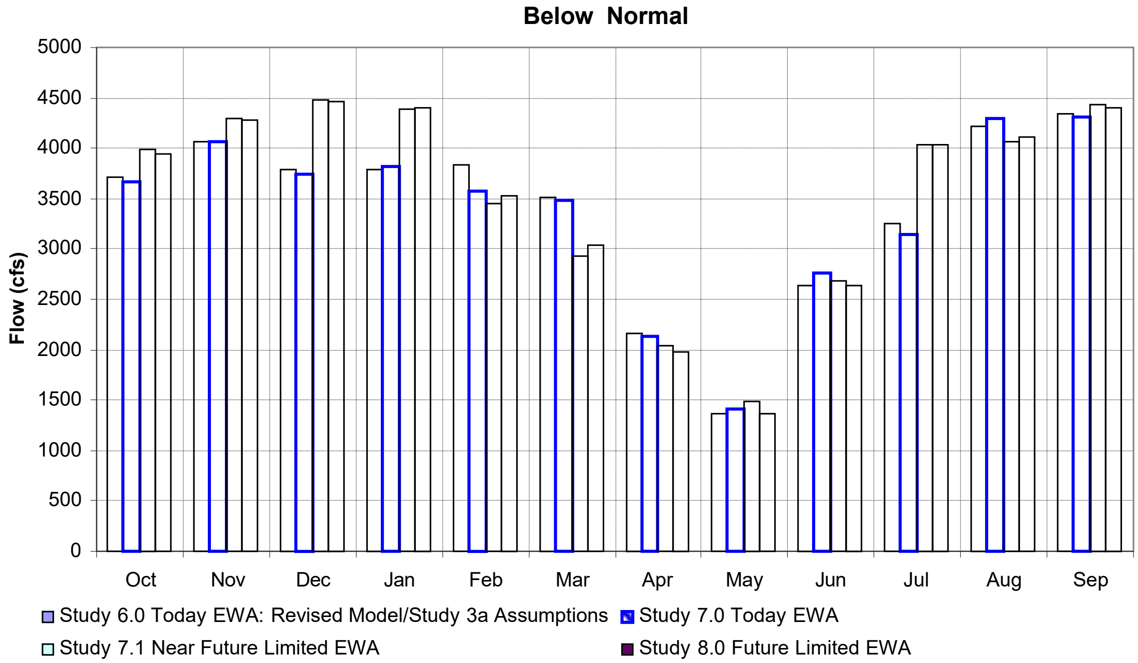


Figure 6-55. Average below normal year (40-30-30) monthly CVP export rate (CVP/SWP operations BA figure 12-22).

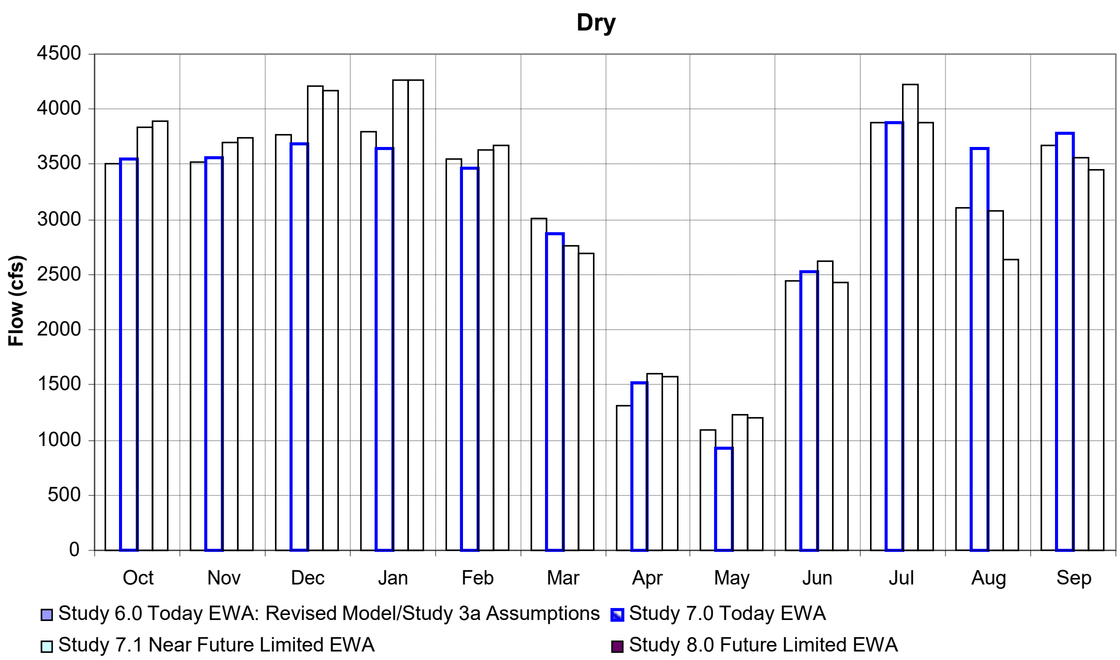


Figure 6-56. Average dry year (40-30-30) monthly CVP export rate (CVP/SWP operations BA figure 12-23).

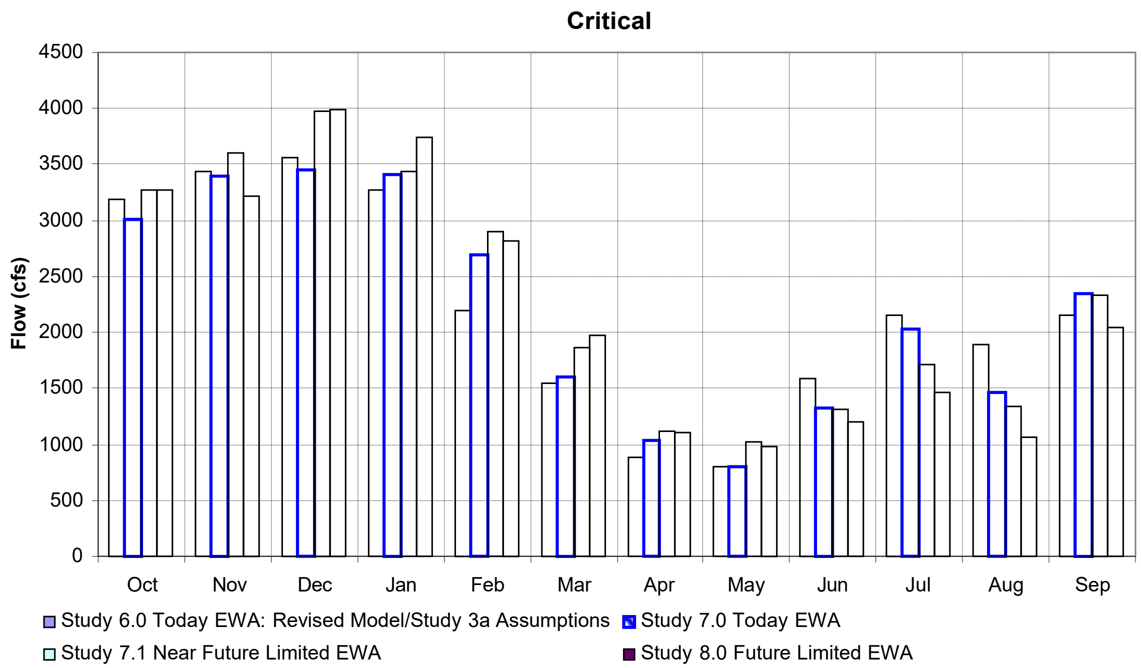


Figure 6-57. Average critically dry year (40-30-30) monthly CVP export rate (CVP/SWP operations BA figure 12-24).

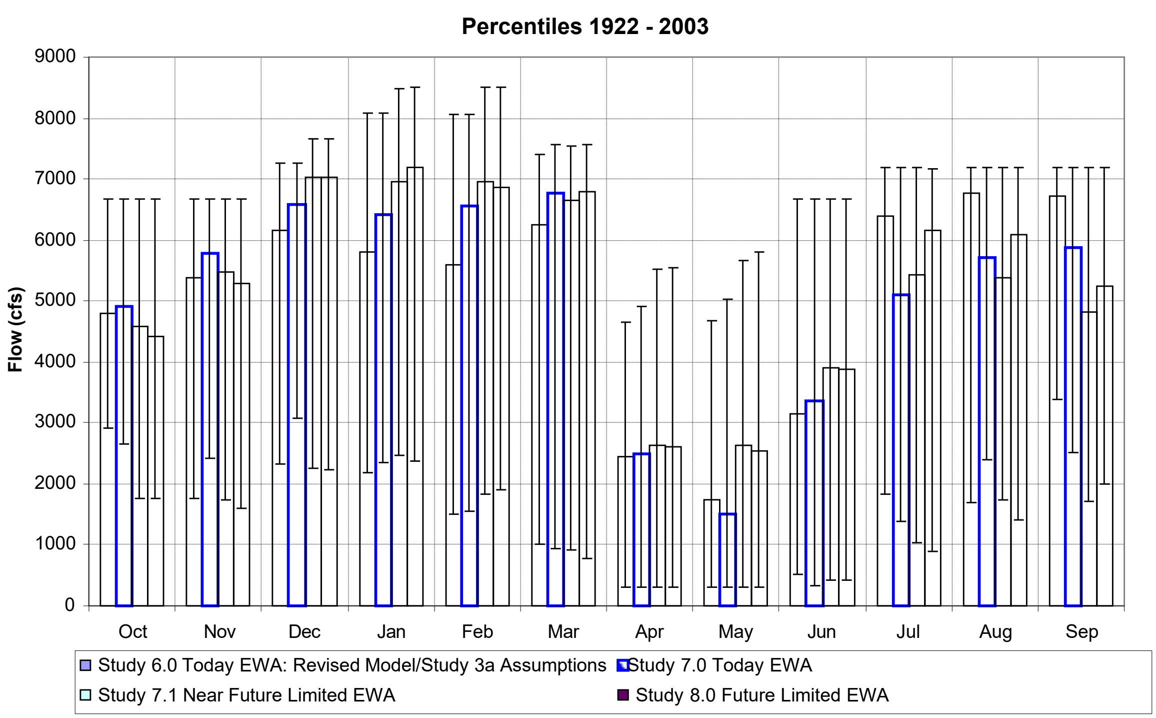


Figure 6-58. Monthly SWP export pumping rate, 50th percentile with 5th and 95th percentile whisker bars (CVP/SWP operations BA figure 6-25).

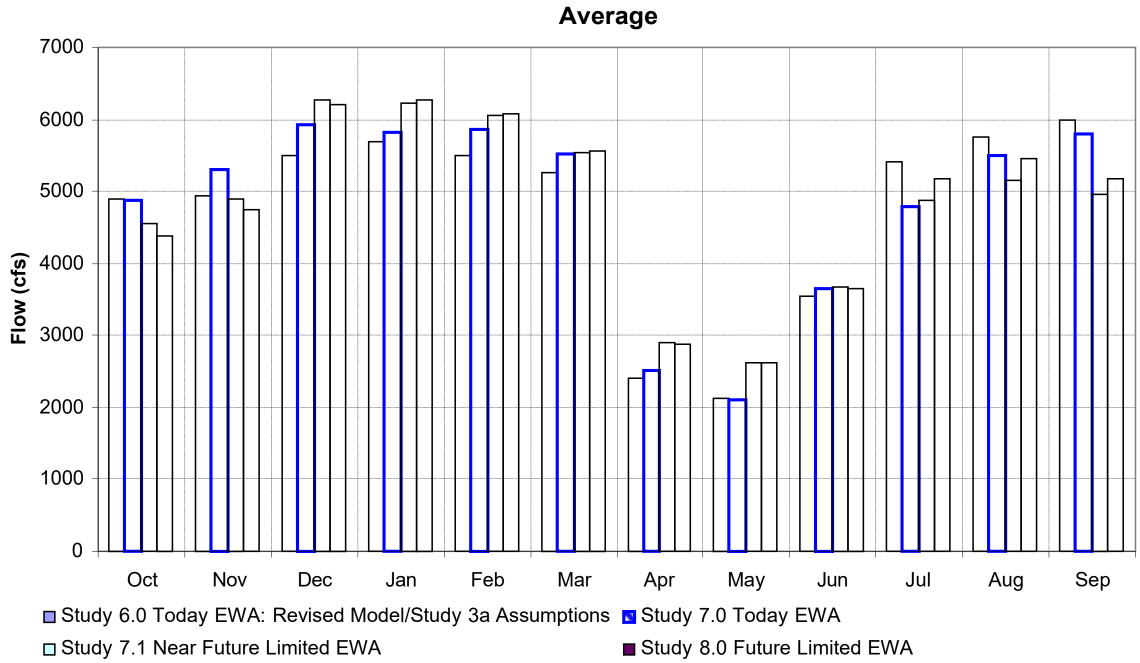


Figure 6-59. SWP monthly average export rate (CVP/SWP operations BA figure 12-26).

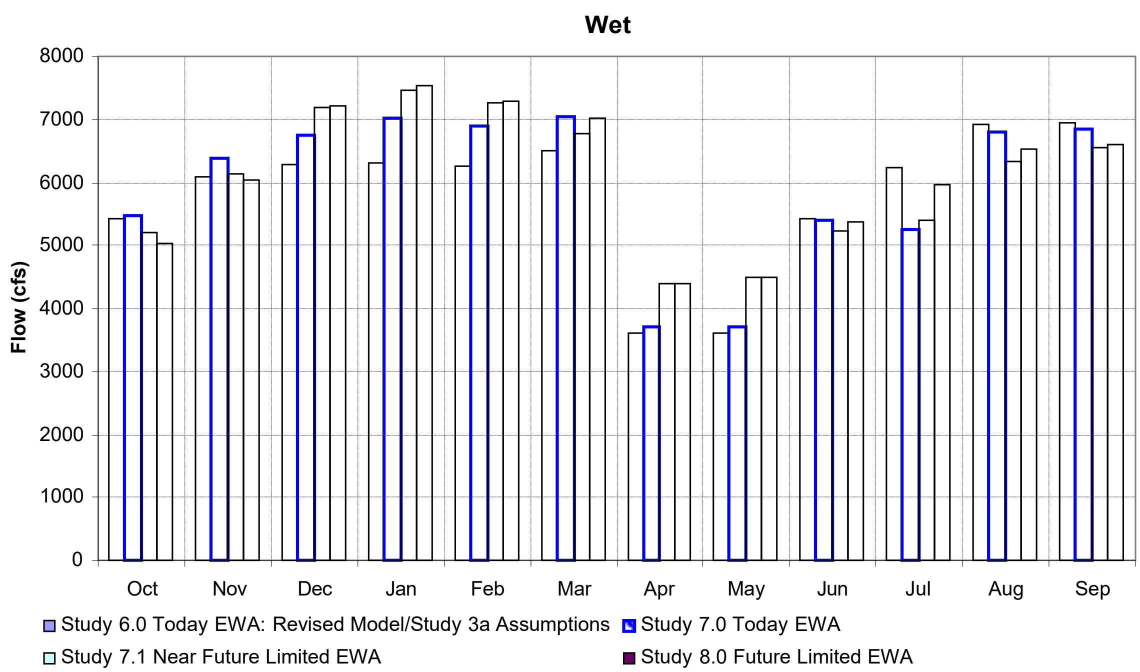


Figure 6-60. Average wet year (40-30-30) monthly SWP export rate (CVP/SWP operations BA figure 12-27).

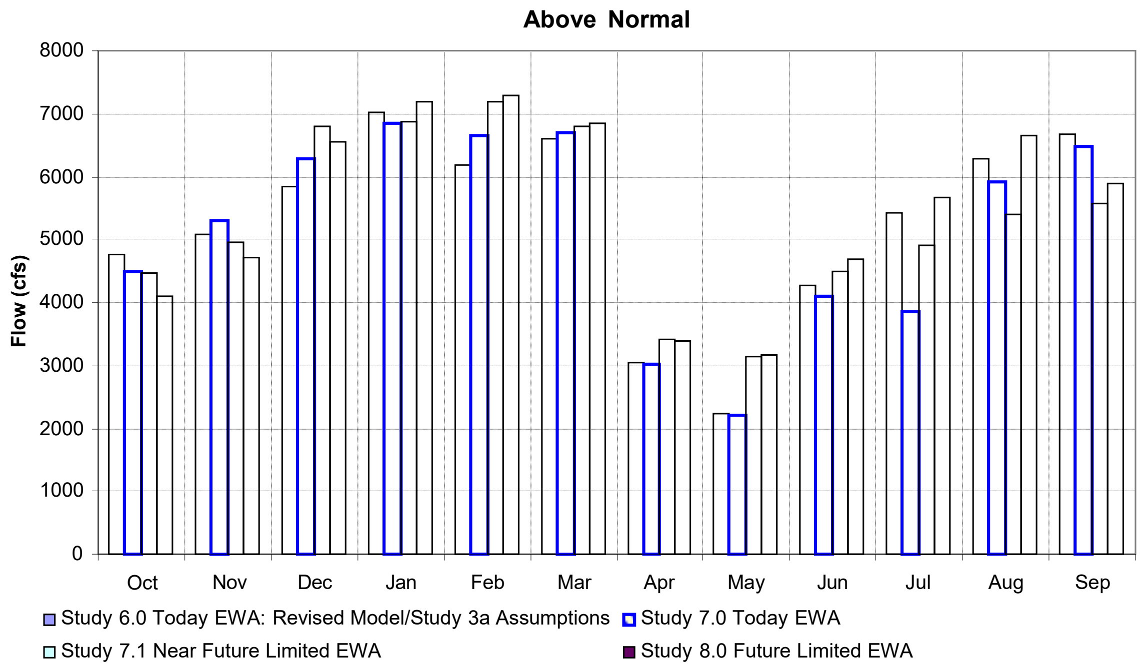


Figure 6-61. Average above normal year (40-30-30) monthly SWP export rate (CVP/SWP operations BA figure 12-28).

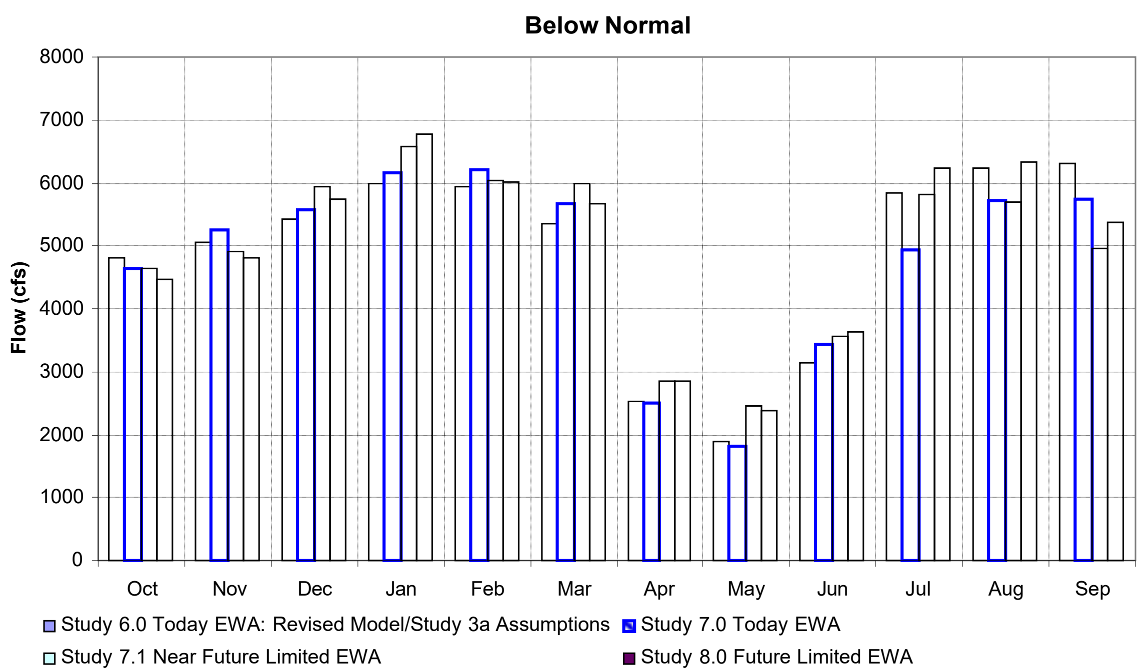


Figure 6-62. Average below normal year (40-30-30) monthly SWP export rate (CVP/SWP operations BA figure 12-29).

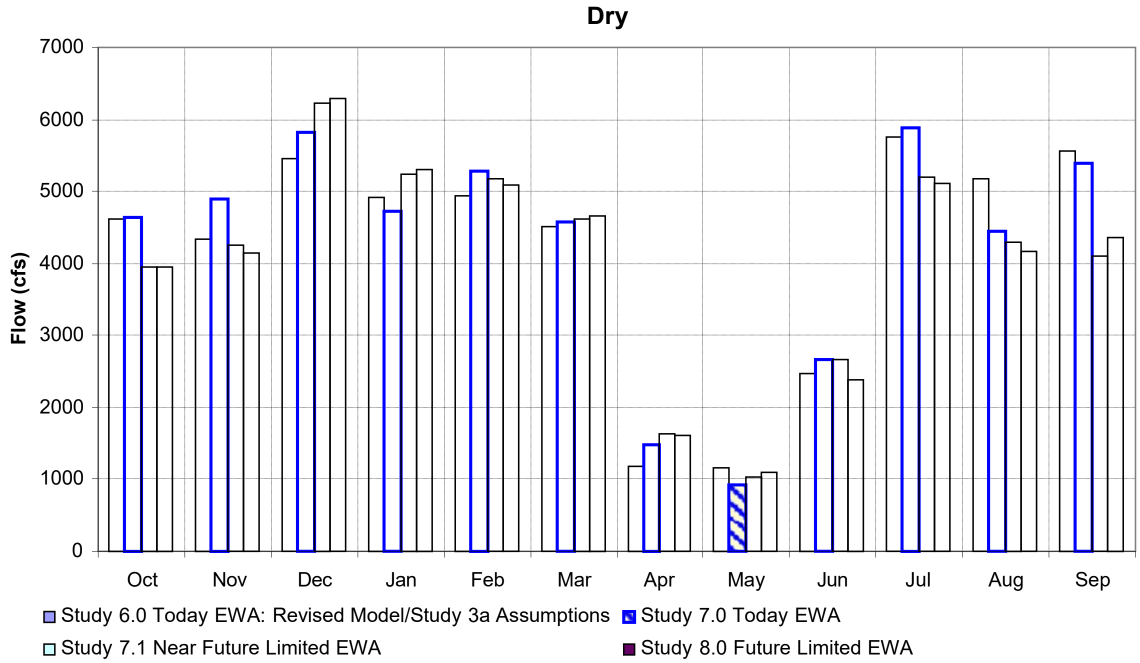


Figure 6-63. Average dry year (40-30-30) monthly SWP export rate (CVP/SWP operations BA figure 12-30).

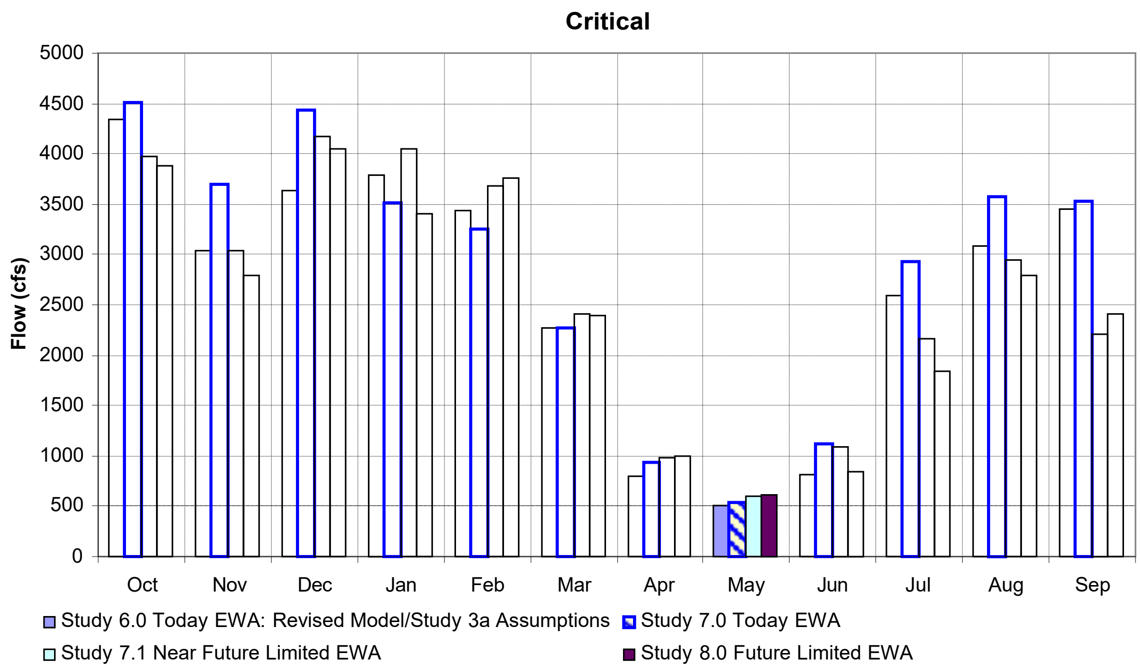


Figure 6-64. Average critically dry year (40-30-30) monthly SWP export rate (CVP/SWP operations BA figure 12-31).

Federal pumping at the Banks facility typically occurs in late summer and extends through October. Additional pumping to supply Cross Valley Contractors may occur during the winter months (November through March). The modeling indicates that the average Federal pumping at the Banks facility is approximately 80 TAF with the future operations having slightly higher pumping needs than the current operations as modeled in Study 7.0. Pumping in Study 7.1 is slightly higher (5 TAF) due to the lack of EWA wheeling relative to Study 7.0. The available capacity at Banks for Federal pumping is reduced in Study 8.0 due to increased SWP demands South of Delta, which reduces the frequency of the pumping availability for Federal use.

The Barker Slough pumping plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery to Napa and Solano Counties. Current pumping capacity is 140 cfs due to limitations in the number of pumps at the facility. An additional pump is required to reach the pipeline design capacity of 175 cfs. During the past several years, daily pumping rates have ranged between 0 and 140 cfs. There has been no discernable trend in monthly pumping levels since 2000 (Dayflow database) although the annual pumping rate for water year 2007 was higher than in previous years (83 cfs). Seasonal pumping rates during the years 2005 to 2007 were 109 cfs in summer (June to August), 94 cfs in fall (September through November), 39 cfs in winter (December through February), and 36 cfs in spring (March through May). The recent historical data indicates that actual pumping levels are substantially less than those predicted in the CALSIM II current conditions scenario (Study 7.0) during the winter and spring months. For instance, the month of December has an average historical export rate of 52 cfs for the years 2005 through 2007. The estimated export rate for December from Study 7.0 is 116 cfs. The historical rate is only 44 percent of the modeled export rate. Similarly, the historical export rate for the month of April (2005 through 2007) is 31 cfs, while the estimate from Study 7.0 is 133 cfs. The historical export rate is only 23 percent of the modeled export rate.

During the summer, seasonal pumping rate for the modeled studies 7.0 and 7.1 are not substantially different from each other (average rates were 115 cfs and 107 cfs, respectively) but both were lower than the future condition modeled in Study 8.0 (135 cfs), a difference of 15 to 20 percent. The historical value for the summer season (2005 to 2007) is 109 cfs, relatively similar to the modeled current conditions. NBA diversions are lowest in fall, averaging 101 cfs in study 7.0, 99 cfs in study 7.1, and 123 cfs in study 8.0. The historical pumping rate during the fall (2005 to 2007) was 94 cfs. Modeled NBA diversions are highest during the winter months. There was very little difference between Studies 7.0 and 7.1 during the winter. However, study 8.0 differed from the other two studies, being greater in December (142 cfs versus 116cfs and 112 cfs) and lower in January (112 cfs versus 157 cfs and 155 cfs) and February (126 cfs versus 155 cfs and 154 cfs). All of the modeled pumping estimates are significantly greater than the historical average of 39 cfs for the period between December and February (2005 to 2007). Modeling estimates for the spring period also were substantially greater than the historical values from 2005 to 2007. The estimates for Study 8.0 export rates were also greater than those for Studies 7.0 and 7.1. For April, Study 8.0 had a diversion rate of 145 cfs while study 7.0 (133 cfs) and Study 7.1 (128 cfs) were lower, a difference of approximately 10 percent. For May, Study 8.0 also had a diversion rate of 145 cfs, which is approximately 25 percent higher than the estimated rates for Studies 7.0 and 7.1 (both 116 cfs). Study 8.0 estimated an export rate of 148 cfs for June, approximately 18 percent higher than the estimates for Study 7.0 (126 cfs), and Study 7.1 (123 cfs). The historical export rate for the spring period between 2005 and 2007 was 36 cfs.

Under the current operating parameters, the projects must comply with California State Water Resources Control Board (SWRCB) D-1641 limitations on the ratio of project exports to the volume of water entering the Delta during the year. This is termed the E/I ratio. The E/I ratio regulates the proportion of water that can be exported by the CVP and SWP in relation to the water that is entering the Delta and is thus available for export. During the summer and fall, E/I ratios are permitted to be higher (a maximum of 65 percent July through December) and therefore pumping rates are increased, allowing the facilities the flexibility to maximize exports (within the constraints of D-1641 and other regulatory limits) during the lower summer and fall Delta inflows. The E/I ratio is restricted to a 35 percent maximum during the February through June period when Delta inflows are typically higher. However, the actual volume of exports can increase significantly when the inflow volumes are high, while still maintaining the same overall E/I ratio. Furthermore, the E/I ratio is essentially determined by the flow volume of the Sacramento River, which comprises approximately 80 percent of the Delta river inflow. This creates a situation where the near field hydraulic conditions in the central and southern Delta waterways are affected to a greater extent than the northern delta waterways due to their proximity to the Project's points of diversion in the South Delta. The modeling for E/I ratios indicate that future operations (Studies 7.1 and 8.0) will have greater E/I ratios during the months of December, January, February, April, May and June compared to Studies 6.0 and 7.0, which typically allocated EWA assets in these months to decrease pumping levels. The limited EWA conditions in the future do not take any actions to reduce exports in the winter and only implement limited actions in the spring (*i.e.*, VAMP). Both current and future operations show increased E/I ratios in the summer months, except during dry and critically dry months, where the future models show decreases in some years. The CVP/SWP operations BA indicates that this is due to low reservoir storage or water quality issues, such as salinity, limiting the ability to pump. The modeling results indicate that due to the increased E/I ratios, the waterways of the South and Central Delta will experience more situations where flows towards the pumps are enhanced than under the current operating conditions.

In summary, historical average annual Delta inflow (1980 – 1991) is approximately 28 MAF (DWR 1995). Current operations divert approximately 6 to 8 MAF of water annually from the Delta (DWR 1995, CALFED 2008, State of California 2008). The modeling completed for the CVP/SWP operations BA indicates that Delta inflows will decrease approximately 200 to 300 TAF annually under the future conditions beyond those already occurring under the current operational scenario. The historical inflow has already been reduced by upstream water diversions to meet current demands in the Central Valley. The additional upstream withdrawals act on top of these withdrawals, thus further diminishing the volume of water reaching the Delta.

Likewise, annual Delta outflow will decrease approximately 300 to 400 TAF under the future operations as compared to the current operations (21 MAF). Most of this decrease will occur in the winter and spring due to limited EWA resources to decrease pumping levels during this time period. This exacerbates an already adverse situation for listed salmonids and green sturgeon created by the current CVP and SWP operations which have elevated winter/spring export levels. This period of elevated exports in winter and spring occurs during the season in which most salmonid runs emigrate through the Delta, as described in the environmental baseline. The lack of data for juvenile and sub-adult green sturgeon makes the effects determination less clear for this species of fish. Under the proposed action, the CVP will increase its pumping limits from 4,200 cfs to 4,600 cfs in response to the proposed intertie between the Delta-Mendota Canal and the California Aqueduct. Reclamation intends to maximize its pumping capacity between November and January by utilizing the 4,600 cfs capacity to its fullest extent. This will result in higher future pumping levels during this time period compared to the current operations, which will increase the exposure of early migrating salmonids to the effects of the exports. Modeling of future conditions also indicates that pumping will decrease, on average, in March and April. Future conditions also indicate that pumping in May will increase over current levels following the VAMP reductions, ultimately resulting in less protection for fish. This action will curtail the extent of post-VAMP shoulders. The future conditions also indicate that pumping will be increased, on average, during the summer in wet years compared to current operations. The modeling for the future SWP operations indicates that it will increase its exports in the months of December, January, and February to the greatest extent possible within the constraints of the regulatory environment. The rationale offered is that since it has limited EWA assets, the SWP will not be able to make any reductions in pumping for fish-related actions, which would normally be offset by EWA assets. The future modeling results also indicate that pumping rates will frequently be over 7,000 cfs during these months and as high as 8,000 cfs when San Joaquin River flows permit the additional capacity. Furthermore, average pumping rates are forecast to be higher during the December through May period than current averages, with less reductions occurring in April and May for VAMP due to less EWA assets available for fish protection measures.

This change in the export regime increases the vulnerability of listed salmonids emigrating through the Delta. The effects on listed green sturgeon are less clear due to the more ambiguous period of juvenile emigration into the Delta. Currently, the CVP and SWP have elevated export schedules during the early winter and late spring period (except for the period encompassing the VAMP experiment) to take advantage of higher flows of water passing through the Delta. The result of this export paradigm is that listed salmonids emigrating through the Delta with these flows are exposed to the increased exports.

The Federal use of the SWP facilities will amount to approximately 80 TAF per year, and will change little between the current and future conditions. Maximal usage of the SWP facilities by Reclamation will occur during the summer months and may result in an increase of up to 1,000 cfs of pumping in years with above normal hydrology, but is more likely to range between 400 and 600 cfs. The E/I ratios are more likely to be higher, on average, in the future compared to current operations, particularly during the critical salmonids migration months of December, January, February, April, May, and June. The explanation offered in the CVP/SWP operations BA is that the limited EWA assets will preclude pumping reductions to benefit fish.

6.6.2.3 Assess Species Exposure

The Sacramento-San Joaquin Delta (figure 5-23) serves as the gateway through which all listed anadromous species in the Central Valley must pass through on their way to spawning grounds as adults or returning to the ocean as juveniles, or post-spawn steelhead and green sturgeon adults. For the purposes of this analysis, “exposure” is defined as the temporal and spatial co-occurrence of adult and juvenile (smolts and fry) life stages of the four listed species and the stressors associated with the proposed action. The temporal and spatial occurrence of each of the runs of Chinook salmon, CV steelhead, and green sturgeon in the Delta is intrinsic to their natural history and the exposure to the proposed action can be anticipated based on their timing and location.

6.6.2.3.1 Temporal Occurance

Table 6-27 provides the temporal distribution of listed anadromous fish species within the Delta.

Table 6-27. Temporal distribution of anadromous fish species within the Delta (KL = Knights Landing, FW = Fremont Weir).

Delta Location																								
	Month																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
a) Adult winter-run Chinook salmon																								
Sac. River	M	M	M	M	M	M	M	M	M	M	M	M									M	M	M	M
b) Juvenile winter-run Chinook salmon																								
Sac. River @ KL	M	M	M	M	M	M	L	L	L	L					L	L	L	L	L	L	M	M	M	M
L Sac. River (seine)	H	H	H	H	M	M	L	L	L	L							L	L	L	L	M	M	H	H
W Sac. River (trawl)	M	M	M	M	H	H	M	M	L	L											L	L	M	M
c) Adult spring-run Chinook salmon																								
Lower Sac River	L	L	L	L	M	M	M	M	M	M	M	L	L	L										
d) Juvenile spring-run Chinook salmon																								
Sac R @ KL	M	M	M	M	H	H	H	H	M	M	L	L									M	M	H	H
e) Adult Central Valley steelhead																								
Sac R @ FW	L	L	L	L											M	M	H	H	M	M	L	L	L	L
San Joaquin River	H	H	M	M	L	L							L	L	L	L	M	M	M	M	M	M	H	H
f) Juvenile Central Valley steelhead																								
Sac R. @ KL	M	M	M	M	H	H	H	H	L	L											L	L	L	L
Sac R @ Hood	L	L	M	M	H	H	H	H	M	M	L										L	L	L	L
Chipps Island (wild)	L	L	L	L	H	H	H	H	M	M	M	M	L	L					L	L	L	L	L	L
Mossdale/SJR					L	L	H	H	H	H	L	L												
Stan R @ Caswell	L	L	M	M	H	H	M	M	M	M	L	L												
Mokelumne R	M	M	M	M	M	M	M	M	M	M	M	M	M	M										
g) Adult Southern DPS green sturgeon (≥ 13 years old for females and ≥ 9 for males)																								
SF Bay and Delta	L	L	L	L	M	M	M	M	M	M	M	M	M	M	M	M	M	M	L	L	L	L	L	L
h) Juvenile Southern DPS green sturgeon (> 10 months and ≤ 3 years old)																								
Delta waterways	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Relative Abundance				H	= High					M	= Medium						L	= Low						

6.6.2.3.1.1 Winter-Run

Adult winter-run first enter the San Francisco Bay Estuary from the Pacific Ocean starting in November. Adults continue to enter the bay throughout the winter months and into late spring

(May/June), passing through the Delta region as they migrate upriver towards their spawning grounds below Keswick Dam (CVP/SWP operations BA; USFWS 2001, 2003).

The main pulse of emigrating juvenile winter-run from the upper Sacramento River enter the Delta in December and January and can extend through April, depending on the water year type. Beach seines and mid-water trawls on the mainstem Sacramento River near the City of Sacramento indicate that some fish enter the Delta as early as mid-November and early December (USFWS 2001, 2003). Monitoring by the USFWS at Chipps Island in the western Delta indicates that winter-run are detected leaving the Delta from September through June, with a peak in emigration occurring in March and April. This peak in emigration timing is supported by the pattern of recoveries of winter-run sized Chinook salmon at the SWP's Skinner Fish Protection Facility and the CVP's Tracy Fish Collection Facility (TFCF) in the South Delta. In addition to the seasonal component of juvenile emigration, distinct increases in recovered fish appear to be correlated with high precipitation events and increases in-river flow and turbidity following rain events (USFWS 2001, 2003). Based on analysis of scales, winter-run smolts enter the ocean environment at an average fork length of 118 mm, indicating a freshwater residence time of approximately 5 to 9 months, most of which is presumed to occur upstream between RBDD and the Delta.

Juvenile winter-run are present in the waterways of the North Delta (*i.e.*, Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, and Cache Slough complex), Central Delta (Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island), South Delta leading to the CVP and SWP pumping facilities including Old and Middle Rivers, and the interconnecting waterways between these main channels such as Victoria Canal, Woodward Canal, and Connection Slough, and the western Delta including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. NMFS does not anticipate seeing adult winter-run upstream of Middle River on the San Joaquin River mainstem or within the waterways of the South Delta in any appreciable numbers. NMFS does not anticipate seeing any significant numbers of juvenile winter-run in the Eastern Delta near Stockton (*i.e.*, White Slough, Disappointment Slough, Fourteenmile Slough), or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts. Presence of winter-run adults and juveniles may occur in other parts of the Delta not described above.

6.6.2.3.1.2 Spring-Run

Adult spring-run enter the San Francisco Bay Estuary from the ocean in January to late February. They move through the Delta prior to entering the Sacramento River system. Spring-run show two distinct juvenile emigration patterns in the Central Valley. Fish may either emigrate to the Delta and ocean during their first year of life as YOY, typically in the following spring after hatching, or hold over in their natal streams and emigrate the following fall as yearlings. Typically, yearlings enter the Delta as early as November and December and continue to enter the Delta through at least March. They are larger and less numerous than the YOY smolts that enter the Delta from January through June. The peak of YOY spring-run presence in the Delta is during the month of April, as indicated by the recoveries of spring-run size fish in the CVP and SWP salvage operations and the Chipps Island trawls. Frequently, it is difficult to distinguish the YOY spring-run outmigration from that of the fall-run due to the similarity in their spawning and emergence times. The overlap of these two runs makes for an extended pulse of Chinook salmon smolts through the Delta each spring, frequently lasting into June.

Juvenile spring-run are present in the same waterways as winter-run in the North Delta, Central Delta, South Delta, and the interconnecting waterways, including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. NMFS does not anticipate seeing any significant numbers of juvenile spring-run in the Eastern Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

6.6.2.3.1.3 CV Steelhead

Adult steelhead have the potential to be found within the Delta during any month of the year. Unlike Chinook salmon, steelhead can spawn more than once, so post-spawn adults (typically females) have the potential to move back downstream through the Delta after completing their spawning in their natal streams. These fish are termed runbacks or kelts. Typically, adult steelhead moving into the Sacramento River basin begin to enter the Delta during mid to late summer, with fish entering the Sacramento River system from July to early September. Kelts are typically seen later in the spring following spawning. Steelhead entering the San Joaquin River basin are believed to have a later spawning run. Adults enter the system starting in late October through December, indicating presence in the Delta a few weeks earlier. Typically water quality in the lower San Joaquin River is marginal during this time, with elevated water temperatures and low DO levels presenting barriers to upstream migration. Early winter rains help to break up these barriers and provide the stimulus to adult steelhead holding in the Delta to move up river towards their spawning reaches in the San Joaquin River tributaries. Fish may continue entering the system through the winter months. Juvenile steelhead are recovered in the USFWS Chipps Island trawls from October through July. There appears to be a difference in the emigration timing between wild and hatchery-reared steelhead smolts. Adipose fin-clipped hatchery fish are typically recovered at Chipps Island from January through March, with the peak in recoveries occurring in February and March. This time period corresponds to the schedule of hatchery releases of steelhead smolts from the different Central Valley hatcheries (Nobriga and Cadrett 2003, CVP/SWP operations BA). The timing of wild steelhead (unclipped) emigration is more spread out. Emigration occurs over approximately 6 months, with peaks in February and March, based on salvage records at the CVP and SWP fish collection facilities. Individual unclipped fish first begin to be collected in fall and early winter, and may extend through early summer (June and July). Wild fish that are collected at the CVP and SWP facilities late in the season may be from the San Joaquin River system, based on the proximity of the basin to the pumps and the timing of the spring pulse flows in the tributaries (April-May). The size of emigrating steelhead smolts typically ranges from 200 to 250 mm in length, with wild fish tending to be at the upper end of this range (Nobriga and Cadrett 2003, CVP/SWP operations BA).

Given the multiple points of entry into the Delta system, CV steelhead are likely to be found in any of the waterways of the Delta, but particularly in the main channels leading to their natal river systems.

6.6.2.3.1.4 Southern DPS of Green Sturgeon

Adult green sturgeon enter the San Francisco Bay estuary in early winter (January/February) before initiating their upstream spawning migration into the Delta. Adults move through the Delta from February through April, arriving in the upper Sacramento River between April and June (Heublein 2006, Kelly *et al.* 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river (*i.e.*, GCID aggregation site; see Vogel 2005, 2008) or immediately migrate back down river to the Delta. Those fish that hold upriver move back downstream later in the fall. Radio-tagged adult green sturgeon have been tracked moving downstream from the GCID aggregation site past Knights Landing during the summer and fall into November and December, following their upstream migrations the previous spring. It appears that pulses of flow in the river "trigger" downstream migration in the late fall, similar to behavior exhibited by adult green sturgeon on the Rogue and Klamath River systems (Erickson *et al.* 2002, Benson *et al.* 2007).

Adults and sub-adults may also reside for extended periods in the western Delta as well as in Suisun and San Pablo bays. Like other estuaries along the west coast of North America, adult and sub-adult green sturgeon (from both Northern and Southern DPSs) frequently congregate in the tidal portions of the San Francisco Bay estuary during the summer and fall. It is not known exactly why these congregations occur, but they do not appear to be related to spawning activities, as most fish do not move upriver out of tidewater. Based on radio and acoustic tag data gathered to date from adult green sturgeon, fish that spawn in one river system do not spawn in other river systems.

Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their life before moving out to the ocean. Green sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. Juveniles are recovered at the SWP and CVP fish collection facilities year round and range in size from 136 mm to 774 mm, with an average size of 330 mm.

6.6.2.3.2 Spatial Distribution

6.6.2.3.2.1 Winter-Run

The main adult winter-run migration route through the Delta region is believed to be the mainstem of the Sacramento River. However, there is the potential for adults to "stray" into the San Joaquin River side of the Delta while on their upstream migration, particularly early in the migratory season (November and December). Significant amounts of Sacramento River water flow into the San Joaquin River side of the Delta through the DCC (when open in November, December, and January), Georgiana Slough, and Three Mile Slough. These sources of Sacramento River water can create false attraction into the lower San Joaquin River. Adult winter-run that choose this path would be delayed in their upstream migration while they mill in the lower San Joaquin River, searching for the distinctive olfactory cues of the Sacramento River. Adults could re-enter the Sacramento River through Georgiana Slough or the Delta reaches of the Mokelumne River system when the DCC is open. The extent of this delay and the proportion of adults moving into the lower San Joaquin River are unknown. Adult winter-run do not typically inhabit the San Joaquin River mainstem upstream of Middle River or within the waterways of the South Delta in any appreciable numbers (Yoshiyama *et al*. 1996, 1998, 2001.

Juvenile winter-run are present in the waterways of the North Delta (*i.e.*, Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, and Cache Slough complex), Central Delta (Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island), South Delta leading to the CVP and SWP pumping facilities including Old and Middle Rivers, and the interconnecting waterways between these main channels such as Victoria Canal, Woodward Canal, and Connection Slough, and the western Delta including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. Juvenile winter-run do not typically inhabit the channels of the Eastern Delta near Stockton (*i.e.*, White Slough, Disappointment Slough, Fourteenmile Slough), or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

6.6.2.3.2.2 Spring-Run

Currently, the only recognized populations of spring-run occur in the Sacramento River basin. Historical populations that occurred in the river basins to the south (*i.e.*, southern Sierra watersheds) have been extirpated. The main migration route for adult spring-run is the Sacramento River channel through the Delta. Similar to winter-run, adults may stray into the San Joaquin River side of the Delta due to the inflow of Sacramento River basin water through one of the interconnecting waterways branching off of the mainstem Sacramento River towards the San Joaquin River. Starting in February, the closure of the DCC radial gates minimizes the influence of this pathway, but flows in the channels of Georgiana and Three Mile Slough provide sufficient flows of water to the San Joaquin River to induce straying from "spurious" olfactory cues present in these waterways.

Juvenile spring-run are present in the same waterways as winter-run in the North Delta, Central Delta, South Delta and the interconnecting waterways, including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. Juvenile spring-run do not typically inhabit the channels of the Eastern Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

6.6.2.3.2.3 CV Steelhead

Populations of CV steelhead occur throughout the watersheds of the Central Valley; however, the primary population source occurs within the watersheds of the Sacramento River basin. Small, apparently self-sustaining populations of steelhead exist in the Mokelumne River system (although influenced by the Mokelumne River Hatchery steelhead program), the Calaveras River (natural) and the Stanislaus River (natural). Furthermore, otilith microchemistry analysis has shown that juvenile *O. mykiss* collected from the Tuolumne and Merced rivers had maternal steelhead origins (Zimmerman *et al*. 2008). Upstream migrating adult steelhead enter both the Sacramento River basin and the San Joaquin River basin through their respective mainstem river channels. Adult steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers. It is also likely that some adult steelhead bound for the San Joaquin River system may detour through the South Delta waterways and enter the San Joaquin River through the Head of Old River near Mossdale. However, due to the number of potential routes, the early entrance of adults into the Delta, and the potential for the DCC to remain open for a substantial portion of the upstream spawning migration, the "actual" route that an adult steelhead follows before committing to its natal watershed could be quite complex. Therefore, adult steelhead could be in any of the larger channels in the Delta region during their spawning migrations. Likewise, steelhead kelts could also be found in any of the channels of the Delta during their return to the ocean. Data for this particular life stage is lacking.

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento River (North Delta region) and from the San Joaquin River (South Delta region). Steelhead smolts from the Mokelumne River system and the Calaveras River system enter the Eastern Delta. The Mokelumne River fish can either follow the north or south forks of the Mokelumne River through the Central Delta before entering the San Joaquin River at RM 22. Some fish may enter the San Joaquin River farther upstream if they diverge from the South Fork of the Mokelumne River into Little Potato Slough. Fish from the Calaveras River enter the San Joaquin River downstream of the Port of Stockton near RM 38. Steelhead smolts from the San Joaquin River basin enter the Delta at Mossdale. Prior to the installation of the Head of Old River Barrier (HORB) on approximately April 15 (start of VAMP), steelhead smolts exiting the San Joaquin River basin can follow either of two routes to the ocean. Fish may either stay in the mainstem of the San Joaquin River and move northwards towards the Port of Stockton and the Central Delta, or they may enter the South Delta through the Head of Old River and move northwards towards the lower San Joaquin River through Old and Middle rivers and their associated network of channels and waterways. When the HORB is not installed, approximately 50 percent of the San Joaquin River flow is directed into Old River. This percentage increases if the CVP and SWP are pumping at elevated levels. In fact, in low flow conditions with high pumping rates, the net flow in the mainstem of the San Joaquin between the Port of Stockton and Old River may reverse direction and flow upstream into the Head of Old River. When the HORB is installed, flow in the San Joaquin River is retained in the mainstem and fish are directed northwards towards the Port of Stockton and eventually through the Central Delta. Given the multiple points of entry into the Delta system, CV steelhead are likely to be found in any of the waterways of the Delta, but particularly in the main channels leading to their natal river systems.

6.6.2.3.2.4 Southern DPS of Green Sturgeon

Adult green sturgeon are presumed to primarily use the mainstem of the Sacramento River through the Delta when making their upstream spawning migrations. During high water conditions that result in the flooding of the Yolo bypass, adult green sturgeon may also utilize the floodplain of the Yolo bypass to move northwards from Cache Slough to the Sacramento River at Fremont Weir. During other times of the year, green sturgeon may be present in any of the waterways of the Delta, based on sturgeon tag returns. The draft report on the 2007 CDFG

Sturgeon Fishing Report Card (CDFG 2008) indicates that 311 green sturgeon were reported caught by sport anglers during 2007. Green sturgeon were caught in both the mainstem of the San Joaquin River between Sherman Island and Stockton (48 fish) and between Rio Vista and Chipps Island (62 fish), with most catches occurring in the fall, although fish were caught throughout the year in both reaches. Additional green sturgeon were caught and released in Suisun (30), Grizzly (14), and San Pablo (20) bays, as well as between Rio Vista and Knights Landing in the Sacramento River (16).

Juvenile and sub-adult green sturgeon are also found throughout the waters of the Delta. They have been recovered at the CVP and SWP fish collection facilities and from areas on the San Joaquin River near San Andreas Shoals.

6.6.2.4 Assess Species Response to the Proposed Action

6.6.2.4.1 Direct Entrainment Due to Exports

6.6.2.4.1.1 Tracy Fish Collection Facility - Current and Future Operations

The TFCF is located in the southwest portion of the Sacramento-San Joaquin Delta near the City of Tracy and Byron. It uses behavioral barriers consisting of primary and secondary louvers to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The original design of the TFCF focused on smaller fish (<200 mm) that would have difficulty fighting the strong pumping plant-induced flows, since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trashrack structure. The secondary louvers are located in the secondary channel just downstream of the traveling debris screen. The primary louvers allow water to pass through into the main Delta-Mendota intake channel and continue towards the Bill Jones Pumping Plant located several miles downstream. However, the openings between the louver slats are tight enough and angled against the flow of water in such a way as to prevent most fish from passing between them and, instead, guide them into one of four bypass entrances positioned along the louver arrays. The efficiency of the louver guidance array is dependent on the ratio of the water velocity flowing into the bypass mouth and the average velocity in the main channel sweeping along the face of the louver panels.

When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated with the D-1485 objectives of achieving water approach velocities for striped bass of approximately 1 foot per second (fps) from May 15 through October 31, and for salmon of approximately 3 fps from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility. Due to changes in south Delta hydrology over the past 50 years, the present-day TFCF is able to meet these conditions approximately 55 percent of the time. This indicates that 45 percent of the time, the appropriate velocities in the primary channel and the corresponding bypass ratio are not being met and fish are presumed to pass through the louvers into the main collection channel behind the fish screen leading to the pumps. The lack of compliance with the bypass ratios during all facility operations alters the true efficiency of louver salvage used in the expansion calculations and therefore under-estimates loss at the TFCF. The salvage estimates provided by the TFCF have not been recalculated to address these periods of noncompliance when the bypass ratios do not meet the specified operating criteria. The efficiency of the louvers is likely to vary in relation to the actual bypass ratio encountered.

Based on the project description, fish passing through the TFCF are required to be sampled for periods of no less than 20 minutes at intervals of every 2 hours when listed fish are present. This sampling protocol is expected to be implemented in the future operations of the TFCF. This is generally from December through June. Currently, sampling intervals are frequently 10 minutes every 2 hours, even though this sampling protocol is supposed to be used when listed fish are not present. Fish observed during sampling intervals are identified to species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the North Delta away from the pumps. Fish may be held for up to 24 hours prior to loading into the tanker trucks. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge.

It has been known for some time that the efficiencies of the TFCF can be compromised by changes in hydrology, debris clogging the louvers, the size of the fish being entrained, and the number of predators present in the collection facilities (Reclamation 1994, 1995). The louvers were originally designed for fish >38 mm in length. Studies by Reclamation in 1993 tested three size ranges of Chinook salmon for primary, secondary, and overall louver efficiency. The test fish ranged in size from 58 mm to 127 mm with the averages of the three test groups being 74.3, 94.0, and 97.5 mm in length. The average efficiency of the primary louvers at the TFCF was found to be 59.3 percent (range: 13 - 82 percent) and the secondary louvers averaged 80 percent (range: 72 - 100 percent) for Chinook salmon. Overall efficiency averaged 46.8 percent (range 12 - 71.8 percent) for Chinook salmon. Recent studies (Reclamation 2008) have indicated that under the low pumping regimen required by the VAMP experiment, primary louver efficiencies (termed capture efficiencies in the report since only one bypass was tested) can drop to less than 35 percent at the TFCF. The reductions in pumping create low velocities in the primary channel, and the necessary primary bypass ratios (>1) cannot be maintained simultaneously with the secondary channel velocities (3.0 to 3.5 fps February 1 through May 31) required under D-1485. These study results indicate that loss of fish can potentially increase throughout the entire louver system if the entire system behaves in a similar way as the test section performed in the experiments. Screening efficiency for juvenile green sturgeon is unknown, although apparently somewhat effective given that green sturgeon, as well as white sturgeon, have been collected during fish salvage operations. Studies by Kynard and Horgan (2001) tested the efficiency of louvers at guiding yearling shortnose sturgeon (*Acipenser brevirostrum*) and pallid sturgeon (*Scaphirhynchus albus*) under laboratory conditions. They found that louvers were 96 to 100 percent efficient at guiding these sturgeon species past the experimental array and to the flume bypass. However, both sturgeon species made frequent contacts with the louver array with their bodies while transiting the louver array. The authors also found that sturgeon would rest at the junction between the louver array and the tank bottom for extended periods. This behavior may degrade the effectiveness of the louver array to guide fish towards the bypass.

In light of the data from the screen efficiency studies, the overall efficiency of the screens for Chinook salmon (46.8 percent) is approximately 62 percent of the "nominal" value of 75 percent efficient, the previously believed efficiency of the louvers. Bates and Jewett (1961 *op. cit.* Reclamation 1995) found the secondary louvers of the TFCF to be approximately 90 percent efficient for young Chinook salmon (> 38 mm in length), while Hallock *et al.* (1968) reported that the primary louvers had an efficiency of approximately 85 percent for similar-sized fish. This gives an overall efficiency of approximately 75 percent (0.90 x 0.85 = 0.765), which has been used in the calculations for determining salvage and loss at the TFCF. During the VAMP experimental period from approximately April 15 to May 15, the potential loss of Chinook salmon may be even greater. The efficiency of the primary louvers may only be 44 percent of the "standard" 80 percent efficiency originally claimed based on the 35 percent "capture" efficiency found in the low flow studies recently completed (Reclamation 2008). This essentially doubles the loss of fish moving through the screens due to the reduction in louver efficiency. It is likely that juvenile green sturgeon are also affected in a similar fashion as lower flows increase the potential for fish to slip through the angled louvers rather than being guided to the bypasses.

Currently, the louvers are cleaned from once to three times a day, depending on the debris load in the water. The salvage efficiency is significantly reduced during the louver cleaning process. During cleaning of the primary louvers, each one of the 36 individual louver panels is lifted by a gantry and cleaned with a stream of high-pressure water. The removal of the louver plate leaves a gap in the face of the louver array approximately 8 feet wide by 20 feet tall. The main pumps at the Bill Jones Pumping Plant continue to run during this process, pulling water through the gap in the louver array at a high velocity. The cleaning process for the primary array can take up to 3 hours to complete, during which time the efficiency of the louver system to screen fish is severely compromised. Similarly, the secondary louvers require that the four bypasses be taken off line to facilitate the cleaning of the louvers in the secondary channel. This process takes approximately 45 minutes to complete. When the bypasses are taken off line, fish are able to pass through the primary louvers due to the high primary channel velocity, which is often greater than the swimming capacity of the fish, pushing them through the louvers. Depending on the frequency of cleaning, screen efficiency is compromised from approximately 4 hours to 12 hours (1 to 3 cleaning cycles) per day, and substantial errors in the number of fish salvaged are likely to occur. Green sturgeon are also likely to be affected in a similar fashion by the removal of the louver screens during cleaning, perhaps even to a greater extent, since any gap along the bottom of the louver array where the louver panel comes in contact with the channel bottom could provide an access point to pass downstream of the louvers. Debris or sediment buildup could provide such a gap.

In response to the 2004 CVP/SWP operations Opinion issued by NMFS, Reclamation is conducting, or has proposed to conduct, studies designed to address the loss of listed fish caused by the louver cleaning operation (*Evaluation of the percent loss of salmonid salvage due to cleaning the primary and secondary louvers at the TFCF.* B. Bridges; principle investigator.

Report was scheduled to be completed by 2008), formulate alternative cleaning operations (*Design and evaluation of louvers and louver cleaners.* B. Mefford, R. Christensen, D. Sisneros, and J. Boutwell, principle investigators. Report was scheduled to be completed by 2008), and investigate the impacts of predators on juvenile Chinook salmon and Delta smelt in the primary channel (*Predator impacts on salvage rates of juvenile Chinook salmon and Delta smelt*. R. Bark, B. Bridges, and M.D. Bowen, principle investigators. This report is due in 2010). However, the project description does not contain any commitment to address these deficiencies and it may be several years before these reports and their proposed remedies transform the operations of the TFCF.

The TFCF will primarily have direct impacts on emigrating salmonids during their juvenile and smolt life history stages, as well as juvenile green sturgeon rearing in the south Delta region. These life history stages are vulnerable to the entrainment effects of the pumping actions of the Bill Jones Pumping Facility, which draws water from the channels of the South Delta to supply the Delta-Mendota Canal and furnish water to the CVP's water contractors south of the Delta. Adult fish are less susceptible to the effects of the screening process. However, some adverse effects have been observed in association with the trash racks in front of the screens. Adult fish cannot fit through the narrow gap between the steel slats on the trash rack. This serves as a physical barrier to their passage. Observations of sea lions "corralling" adult fall-run in front of the TFCF trash rack have been observed by TFCF staff and a NMFS biologist. In addition, adult sturgeon in moribund conditions have been observed impinged upon the trash rack. The causative factor for the sturgeon's initial condition is unknown, but the fish eventually perish against the racks unless rescued and rehabilitated in the aquaculture facility at the TFCF. Predation by sea lions on sturgeon at the TFCF has not been observed to the best of NMFS' knowledge. The anticipated effects of the screening operation upon juvenile salmon and smolts are the direct loss of fish through the louvers. Based upon the information already presented above, this could be more than half of the fish that encounter the screens initially (46.8 percent overall louver efficiency during normal operations, <35 percent overall efficiency during VAMP operations, potential total failure during screen cleaning operations). Fish that pass through the louver array are lost forever to the population. This loss represents not only the loss of individual fish, but a decline in the population abundance as a whole, as these fish represent the survivors of the initial downstream emigration from the spawning areas upstream to the Delta, a journey with its own intrinsically high rate of mortality. The initial loss of fish emigrating downstream in the Sacramento River may be potentially as high as 80 percent based on MacFarlane's (2008) acoustic tagging study. There is additional loss of these fish as they cross the Delta and arrive at the fish collection facilities.

Salmonids and sturgeon that are successfully screened still face adverse factors during the collection phase of the screening process. The physical process of screening exposes the fish to sustained flows along the face of the louver array, to which the fish will typically try to swim against before being entrained into the bypass orifice. Once entrained into the primary bypass, the fish is carried in a dark turbulent flow through the bypass pipeline to the secondary screening channel, where it is again screened by louvers into a second pipeline that finally discharges to the holding tanks for final collection and salvage. During this process, the fish are subjected to turbulent flows, encounters with the walls of the pipeline and screening channels, debris in the flow stream, and predators. This creates stressful conditions for the fish and reduces its physiological condition. These external stressors lead to the release of stress hormones (i.e., catecholamines and corticosteroids) from the fish's endocrine system. Following the release of these stress hormones, a stage of resistance occurs, during which the stress hormones induce changes in the physiological processes in the fish that either help repair any damage (*e.g.*, if the stressor caused a physical injury) or help the animal adapt to the stressors (*e.g.*, if the stressor is a change in environmental conditions like temperature or turbulence) by changing the rate of body functions beyond the "normal" range. If adaptation to the stressors is not possible, because of either the severity or prolongation of the challenge, exhaustion ensues followed by permanent malfunctioning, possibly disease, and ultimately death to the exposed fish (Fagerlund *et. al.* 1995). In other words, delayed responses to the stress of screening are very likely, and could lead to ultimate morbidity or mortality subsequent to the collection procedure. Due to the short period of "observation" of collected fish during the collection, handling, trucking and release (CHTR) process, the ultimate fate of the salvaged fish following release is unknown, particularly in the open Delta/ocean environment following release where additional environmental stressors are present and to which the emigrating fish will be exposed. The CHTR process will be described in more detail in a following section.

Based upon the projected increases in pumping rates modeled in the near future and future conditions (Studies 7.1 and 8.0), the number of fish entrained at the pumps is predicted to increase in proportion to the pumping increases and thus in general be greater than current levels, particularly in the early winter (December through February) and during the VAMP experiment. Furthermore, the proportion of fish salvaged may be overestimated while those lost to the system are likely to be underestimated using the current values for screening efficiencies (75 percent) rather than the 46.8 percent overall efficiency determined in the 1995 studies and the recent VAMP period studies (Reclamation 2008). This would indicate that the TFCF has a greater adverse impact than currently acknowledged. Specific effects to listed salmonid ESUs will be discussed in the salvage section below.

6.6.2.4.1.2 John E. Skinner Fish Protection Facilities – Current and Future Operations

The John E. Skinner Fish Protection Facility was built in the 1960s and designed to prevent fish from being entrained into the water flowing to the Harvey O. Banks Pumping Facility, which lifts water from the inlet canal into the California Aqueduct. The fish screening facility was designed to screen a maximum flow of 10,300 cfs. Water from the Delta is first diverted into Clifton Court Forebay, a large artificially flooded embayment that serves as a storage reservoir for the pumps, prior to flowing through the louver screens at the Fish Protection Facility. After water enters the forebay through the radial gates, it first passes a floating debris boom before reaching the trashrack. The floating debris boom directs large floating material to the conveyor belt that removes the floating material for disposal in an upland area. Water and fish flow under the floating boom and through a trashrack (vertical steel grates with 2-inch spacing) before entering the primary screening bays. There are 7 bays, each equipped with a flow control gate so that the volume of water flowing through the screens can be adjusted to meet hydrodynamic criteria for screening. Each bay is shaped in a "V" with louver panels aligned along both sides of the bay. The louvers are comprised of steel slats that are aligned 90 degrees to the flow of water entering the bay with 1-inch spacing between the slats. The turbulence created by the slats and water flowing through the slats guides fish to the apex of the "V" where bypass orifices are located. Fish entrained into the bypass orifice are carried through underground pipes to a secondary screening array. The older array uses the vertical louver design while the newer array uses a perforated flat plate design. Screened fish are then passed through another set of pipes to the holding tanks. Fish may be held in the holding tanks for up to 8 hours, depending on the density of salvaged fish and the presence of listed species.

Like the TFCF, the louvers are not 100 percent efficient at screening fish from the water flowing past them. Louver efficiency is assumed to be approximately 75 percent (74 percent, DWR 2005b) for calculating the loss through the system, although this value may eventually be shown to be incorrect (see TFCF discussion). Recent studies examining pre-screen predation in Clifton Court Forebay on steelhead smolts (DWR 2008) have tracked a tagged steelhead through the screens into the inlet channel leading to the Banks Pumping plant and then back into the forebay by the trash boom. This passage through the louvers occurred during a period of low pumping rates, indicating that this steelhead was able to negotiate the louvers and the water velocities flowing through it in both directions. Like the TFCF, the individual louver panels are lifted by a gantry crane from their position in the louver array and cleaned with high-pressure water stream to remove debris and vegetation that clog the louver slats. However, flow into each bay can be manipulated or turned off, thereby reducing potential loss through open louver racks. Nevertheless, it should be noted that any fish within the bay following the closure of the bay during cleaning would be vulnerable to loss through the open louver panel slots. This may be of greater concern for sturgeon based on their behavioral response to the louvers as previously described.

The Skinner Fish Protection Facility will primarily have direct impacts on emigrating salmonids during their juvenile and smolt life history stages, although adult salmon, steelhead, and sturgeon (both white and green) are also likely to be entrained into the forebay (adult striped bass move freely into and out of the forebay when hydraulic conditions at the radial gates permit it). Adult and juvenile sturgeon have been observed in the forebay and juveniles appear in the fish salvage collections. These juvenile salmonid life history stages are vulnerable to the entrainment effects of the pumping actions of the Harvey O. Banks Pumping Facility, which draws water from the channels of the South Delta to supply the California Aqueduct and furnish water to the SWP's water contractors. The anticipated effects of the screening operation are the direct loss of fish through the louvers. As discussed for the TFCF, this loss represents not only the loss of individual fish, but a decline in the Chinook salmon population abundance as a whole due to the loss of several hundred to several thousand individual fish annually at the SWP facilities. These fish represent the survivors of the initial downstream emigration from the upstream spawning areas to the Delta. This journey has its own intrinsically high rate of mortality. Overall loss during this portion of the emigration to the ocean may be potentially as high as 80 percent based on MacFarlane's (2008) acoustic tagging study. There is additional loss of these fish as they cross the Delta and arrive at the fish collection facilities, so that only a fraction of the downstream emigrating population survives to encounter the screens.

As previously described for the TFCF operations, salmonids and sturgeon that are successfully screened still face adverse factors during the collection phase of the screening process at the Skinner facility. Like the TFCF, fish are moved through bypass pipelines from the primary louvers to the secondary louver and thence to the collection tanks. Fish are subjected to stressful conditions during this phase of the salvage and collection operations. Following discharge to the collection tanks, fish are processed through the CHTR operation and returned to the western delta. Delayed responses to the stress of screening are very likely, as previously described in the discussion for the TFCF, and could lead to ultimate morbidity or mortality subsequent to the collection procedure (Fagerlund *et al*. 1995). Due to the short period of "observation" of collected fish during the CHTR process, the ultimate fate of the salvaged fish following release is unknown. The CHTR process will be described in more detail in a following section.

Based upon the projected increases in pumping rates modeled in the near future and future conditions (Studies 7.1 and 8.0) for the SWP, the number of fish entrained at the Skinner Fish Protection Facility is predicted to increase in proportion to the pumping increases and, thus, in general, be greater than current levels, particularly in the early winter (December through February) and during the VAMP experiment. The experimental data indicating that "large" fish, such as a steelhead smolt, can pass through the louvers in both directions calls into question the stated efficiency of the louvers in screening out fish in the size range of interest for listed salmonid species (DWR 2008). If the stated efficiencies for the louvers are less than expected, as appears to be the case for the TFCF, then the numbers of fish salvaged and the numbers of fish lost to the system is suspect. Like the TFCF, the impacts to listed salmonids (and potentially green sturgeon) would be greater than anticipated, both currently and in the modeled future. Regardless of the actual efficiencies of the louver screens, the increased pumping predicted by the modeling scenarios will increase the number of fish lost to the system and increase the adverse effects upon listed salmonids in general. Specific effects to listed salmonid ESUs/DPS and green sturgeon will be discussed in the salvage section below.

6.6.2.4.1.3 Clifton Court Forebay Predation Losses

Clifton Court Forebay is operated as a regulating reservoir for the SWP's Harvey O. Banks Pumping Plant in the tidally influenced southern Delta. The forebay allows the SWP to take in water during different portions of the tidal cycle, as permitted by water rights and legal constraints, contain the water by closing radial gates at the inlet of the forebay, and subsequently operating its pumps more efficiently. The forebay was created in 1969 by flooding a 2.6-mile by 2.1-mile tract of agricultural land near Byron, California, creating a 2,200-acre impoundment. The five radial gates at the inlet of the forebay leading to Old River are typically opened following the peak of the high tide and held open for a portion of the ebb tide when the water elevation outside the gates is higher than that inside the gates in the forebay. Water velocities passing through the gates typically approach 14 fps at maximal stage differential, and may for brief periods even surpass this. However, the design criteria for the gates discourage these excursions due to scouring through the mouth of the gates and the surrounding channel area. Currently, a very deep scour hole (approximately 60 feet deep) has formed just inside the forebay, adjacent to the location of the radial gates. When the gates are open, and the flow of water enters the forebay, numerous aquatic species, including many species of fish, are entrained. Included among these species of fish are Chinook salmon (including endangered winter-run and threatened spring-run), threatened CV steelhead, and threatened North American green sturgeon from the Southern DPS (DWR 2005, 2008).

Losses of fish entrained into Clifton Court Forebay occur during passage from the radial gates across the 2.1 miles of open water in the forebay to the salvage facility. This is termed pre-screen loss, and includes predation by fish and birds. Much of this pre-screen loss is thought to be attributable to predation by piscivorous fish, such as striped bass (Gingras 1997, DWR 2008). Gingrass (1997) described a series of survival studies conducted in Clifton Court Forebay using juvenile Chinook salmon and juvenile striped bass. Of the 10 studies cited, 8 evaluated losses of hatchery-reared juvenile Chinook salmon, and 2 evaluated losses of hatchery-reared juvenile striped bass. The calculated loss across Clifton Court Forebay ranged from 63 to 99 percent for juvenile Chinook salmon and 70 to 94 percent for the juvenile striped bass. Gingras (1997), however, opined that naïve hatchery fish introduced directly into Clifton Court Forebay may be more susceptible to predation than wild fish or fish already acclimated to the natural environment, but of hatchery origin (habituated fish). Gingras (1997) states that "introduction of experimental fish directly into Clifton Court Forebay may contribute a large portion of observed pre-screen loss, regardless of other experimental and/ or operational variables (*e.g.*, release group size, experimental fish size, degree of habituation, and export rate). Experimental fish are typically subject to varying degrees of (1) temperature shock (Orsi 1971, Coutant 1973, Kjelson and Brandes 1989), (2) altered salinity, and (3) altered light regime, in addition to turbulent flow and predation at the radial gates. Habituated fish entrained into Clifton Court Forebay would only be subject to turbulent flow and predation near the radial gates. The combined and differential effect of these "acute stressors" on experimental fish should increase vulnerability to predation (Coutant 1969, Orsi 1971, Olla *et al.* 1992, Young and Cech 1994, Mesa 1994, Cech *et al.* 1996)." Gingras (1997) also identified potential biases resulting from the calculation of salvage and pre-screen loss due to expansion of enumerated fish in the salvage counts and estimates of total fish released per experiment based on weight and lengths, effects of introducing large numbers of fish at one time on the efficiency of predators (protective schooling effect), and fish remaining in Clifton Court after the cessation of the experimental period which are not enumerated as surviving the experiment. However, Greene (2008) stated that "In light of Gingras 1997's recognition that introduction of experimental fish would increase the likelihood of predation found in the studies, it is my opinion that a pre-screen mortality rate of 75% at the SWP pumping facilities is a reasonable estimate of pre-screen mortality." Additional predation rates by birds is unknown at this time, but observations by biologist at the forebay have indicated that bird density can be quite high for species that prey on fish as part of their diet, such as Double crested Cormorants (*Phalacrocorax auritus*), Great Egrets (*Ardea albus*), White Pelicans (*Pelacanus erythroryhnchus*), Clark's Grebe (*Aechmophorus clarkia*), Western Grebes (*Aechmophorus occidentalis*), Great Blue Herons (*Ardea nerodias*) and several species of gulls.

A recent study was conducted (DWR 2008) utilizing hatchery steelhead (average size 245 ±5 mm) to examine the pre-screen loss for this species of fish. Results of this study concluded that steelhead of smolt size had a pre-screen loss rate within Clifton Court Forebay that ranged from 78 ± 4 percent to 82 ± 3 percent over the various replicates of the study. These values are similar to smaller Chinook salmon and juvenile striped bass studies conducted previously. The study also found that the screening loss at the Skinner Fish Protection Facility for tagged steelhead was 26 ± 7 percent. This level of screening is equivalent to 67 to 81 percent efficiency, which is comparable with the 75 percent overall efficiency stated for the facility previously. The study also verified that tagged steelhead could exit the forebay under the right hydraulic conditions and enter the channel of Old River. Tagged fish were recorded in Old River outside of the radial gates and one passive integrated transponder (PIT) tagged steelhead was recovered in the TFCF salvage after release in the forebay. In addition, the study also tagged large striped bass with acoustic transmitters and monitored their movements within the forebay. The study found that the striped bass typically moved between the radial gates and the inlet channel/debris boom area of the forebay, apparently congregating in these areas, perhaps to feed, while others moved into the northern area of the forebay. Several of the striped bass (16 of 30 tagged fish) were shown to have left the forebay and reenter Old River and the Delta. Striped bass leaving the forebay were detected as far away as the Golden Gate Bridge and above Colusa on the Sacramento River.

The studies described above (Gingras 1997, DWR 2008) indicate that mortality (*i.e.*, predation) is very high in the forebay for listed salmonids, whether they are smaller-sized Chinook salmon juveniles or larger smolt-sized steelhead. For every one fish salvaged, typically 4 to 5 fish entered the forebay (75 to 80 percent pre-screen loss). Based on the increased frequency of elevated pumping rates described in the near term and future modeling runs for the SWP, NMFS anticipates that substantial numbers of additional Chinook salmon and steelhead will be lost to predation in the forebay. This conclusion is based on the presumption that increased pumping will require the forebay to be operated in such a manner as to supply the additional volumes of water pumped by the Banks Pumping Plant over the current levels. Increased levels of pumping will draw down the forebay water elevation when the gates are closed. With each operation of the radial gates, the difference in hydrostatic head between the outside channel (following the peak of the high tide) and the elevation within the forebay will cause water to flow into the forebay. The greater the elevation differential, the greater the flow (velocity) into the forebay and the greater the volume of water moved in a unit time. This change has the potential to draw additional listed salmonids and green sturgeon into the forebay. The additional increases in the pumping rates seen in the period between December and May corresponds to the time period when listed salmonids are in the system, and thus vulnerable to the effects of the forebay operations. The proposed near term and future operations of the SWP, through the operations of the Clifton Court Forebay, will exert additional adverse effects upon the listed salmonid populations. The loss of these additional individual fish will further reduce the populations of listed salmonids (*i.e.*, the annual loss of hundreds to thousands of wild winter-run, spring-run, and CV steelhead, as enumerated in the annual salvage and loss reports presented by the Interagency Ecological Program for the San Francisco Estuary). These fish, which have survived to reach the South Delta, represent the survivors of the hundreds of thousand to millions of fry that hatched up river in their natal stream reaches. Loss of an appreciable number of these fish represent a loss of abundance in the current population, and perhaps a reduction in future productivity if these fish represent the "hardiest" fish of the current brood year, based on their surviving to the Delta (and through it to the South Delta). These fish represent those fish which have successfully hatched, successfully initiated exogenous feeding, avoided upstream predation during natal rearing, successfully negotiated the migratory corridor from natal rearing areas to the delta, and have shown the ability to avoid predation and successfully forage during their downstream migration through the delta. These fish have the necessary traits, both physiologically and behaviorally, to survive the multiple stressors encountered in the environment and thus, through natural selection, represent the best adapted fish to the current conditions in the Central Valley.

Green sturgeon may be entrained during any month of the year by the operations of the Clifton Court Forebay radial gates. It is unknown what percentage of these fish return to the waters of the Delta through the radial gates, like striped bass, or remain within the forebay for extended periods of time. Based on salvage data, it appears that green sturgeon juveniles are present in the forebay year round, but in varying numbers. NMFS expects that predation on green sturgeon during their stay in the forebay is minimal, given their size and protective scutes, but this has never been experimentally verified.

6.6.2.4.1.4 Collection, Handling, Trucking, and Release Operations

Following the successful screening and redirection of the entrained fish to the holding tanks, both the TFCF and the Skinner Fish Protection Facility engage in a process of CHTR to return the salvaged fish to the waters of the Delta outside the influence of the pumps (DWR 2005a, b). The following general description explains the CHTR procedure for both the TFCF and the Skinner Fish Protection Facility. During the collection phase, the fish are contained within large cylindrical holding tanks, which may collect fish for several hours (up to 24 hours at the TFCF). The holding times are a function of fish density and the presence of listed fish in the collection tanks. High densities or the presence of listed fish require more frequent salvage operations. During the collection phase of salvage, the tanks are dewatered, and the fish are collected in a large conical sample bucket that is lowered into the sump of the holding tank. Fish that are not immediately collected into the sample bucket are washed into the bucket with a stream of water, along with any debris that has accumulated in the holding tank (*i.e.*, plant material such as *Egeria densa* or sticks and branches). Once dewatering and final wash down have been completed, the sample bucket is lifted out of the holding tank by a gantry hoist and moved to either the handling - sorting platform adjacent to the holding tank or directly to the waiting tanker truck. The handling phase requires the collection facilities staff to sort through the collected fish at predetermined intervals (*i.e.*, 20 minute counts every 2 hours at the TFCF when listed fish are present) and identify the captured fish to species, enumerate the species taken, particularly the listed species, and provide data for estimating the salvage numbers for the total operation of the two facilities. These counts also determine the frequency that the other holding tanks must be drained and fish loaded into the trucks and transported to the release sites.

Fish are transferred to tanker trucks following the dewatering procedure in the large conical collecting baskets used in the draining of the holding tanks. Typically fish and the water that remains in the conical basket are released into the waiting truck through the hatch on the top of the truck. Frequently there is a high debris load in the conical collecting basket that is also transferred to the truck along with the fish and water in the basket. Numerous problems associated with fish density, debris load, and loading practices, as well as the physical stress of transport, have been identified as potential stressors to the transported fish, affecting eventual survival.

Fish are driven to one of four sites located in the western Delta. The TFCF releases its fish at a site on Horseshoe Bend on the Sacramento River or adjacent to the State Route 160 highway bridge in Antioch, California. The Skinner Fish Protection Facility releases its salvaged fish at a separate Horseshoe Bend release site, a site on Sherman Island on the north bank of the San Joaquin River, and shares the site at Antioch with the TFCF. Releases are made to the river through pipes that reach from the roadside to the river, and extend 100 or more feet offshore into deeper water. The pipes are typically primed with a flow of river water from onsite pumps to make sure that the walls of the pipe are wetted prior to fish being passed down the pipe to the river. Once the pipe has been primed with the river water, the valve on the tanker truck is opened and the contents of the truck are flushed into the release pipe, using a hose to help wash the tank's contents through the valve orifice with river water. The flow down the lumen of the pipe is turbulent and of fairly high velocity (aided by the injection of flushing flows into the start of the pipeline). Problems associated with the release operations have been identified and include, but are not limited to, high turbulence and shear forces in the pipeline during release; contact with debris during the release, causing injury or death; potential stranding of fish in the tanker truck due to debris clogging the orifice during dewatering; disorientation following release, creating higher potentials for predation; attraction of predators to the pipe outfall structure; delayed mortality due to injuries in the release procedure; and physiological shock due to water quality parameters changing too quickly during the release procedure (DWR 2005a, b).

Current estimates of mortality associated with the CHTR operations indicate that Chinook salmon experience approximately 2 percent mortality after 48 hours following the release of fish through the pipe. Additional mortality associated with predation is likely, but as of yet, experimental data is lacking. A study completed by DWR was expected to be issued by the end of 2008 which addresses the potential for post-release predation at the Delta release points. Estimates of post release predation rates given by DWR range from 10 percent to 30 percent for juvenile salmonids, depending on the density of predators at the release site and the number of fish released per episode (Orsi 1967, Pickard *et al.* 1982*,* Greene 2008). Estimates are crude and several potential biases in the earlier studies are present, including net sampling efficiency, susceptibility of predators to capture, and estimation of predator populations within the study area. Recent evidence obtained using acoustic imaging equipment (DIDSON cameras) has shown that predators are quickly attracted to the discharge pipelines upon the startup of the priming water flow, indicating a learned response to the discharge of salvaged fish at the release sites.

In summary, the CHTR process has inherent risks to salvaged fish, including listed salmonids such as winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon. Fish are exposed to debris and turbulent flow during their movements through pipes, holding tanks, trucks and the discharge pipes. Such activities increase the stress level in the fish and elevate their corticosteroids and catecholamine levels, as previously described. Predation of disoriented and confined fish may occur by predators in the same holding tanks and during transport. There is a high probability that injury and stress will occur during the release phase back into the river and that post release morbidity or mortality will occur in the riverine environment (*e.g.*, infections, reduced swimming ability, or disorientation). Estimates of post release predation range from 10 to 30 percent of the salvaged fish released. Since salvage of listed fish primarily occurs to juveniles or smolt-sized fish, it is this life stage that is most affected by the CHTR process. Loss, including post release mortality, is approximately 12 to 32 percent of the fish salvaged.

NMFS estimates that the direct loss of fish associated with the screening and salvage process is 83.5 percent for the SWP and approximately 65 percent for the CVP for fish from the point they enter Clifton Court Forebay or encounter the trashracks at the CVP (table 6-28).

Table 6-28. Overall survival of fish entrained by the export pumping facilities at the Tracy Fish Collection Facilities and the John E. Skinner Fish Protection Facilities.

Estimate of Survival for Screening Process at the SWP and CVP[1]		
SWP	Percent survival	Running Percent
Pre-screen Survival[2]	25 percent[3] (75 percent loss)	25
Louver Efficiency	75 percent (25 percent loss)	18.75
CHTR Survival	98 percent (2 percent loss)	18.375
Post Release Survival (predation only)	90 percent (10 percent loss)[4]	16.54
CVP[5]	Percent survival	Running Percent
Pre-screen Survival[6]	85 percent (15 percent loss)	85
Louver Efficiency[7]	46.8 (53.2 percent loss)	39.78
CHTR Survival	98 percent (2 percent loss)	38.98
Post Release Survival (predation only)	90 percent (10 percent loss)	35.08

[1]These survival rates are those associated with the direct loss of fish at the State and Federal fish salvage facilities. Please see the text for a more thorough description.

[2]Prescreen loss for the SWP is considered to be those fish that enter Clifton Court Forebay that are lost due to predation or other sources between entering the gates and reaching the primary louvers at the Skinner Fish Protection Facility.

[3]Estimates have ranged from 63 to 99 percent (Gingras 1997). Recent steelhead studies indicate a loss rate of approximately 78 to 82 percent (DWR 2008).

[4]Predation following release of salvage fish ranges from less than 10 percent to 30 percent according to DWR (2009). NMFS uses the lower estimate to give a conservative estimate of loss. Actual loss may be greater, particularly in the winter when the density of salvage fish released is low, and predators can consume a greater fraction of the released fish (DWR 2009).

[5]These values do not incorporate the 45 percent of the operational time that the louvers are in noncompliance with the screening criteria. The actual values of the lover efficiency during this time are not available to NMFS. These values would determine the percentage of survival through the facility under real time circumstances.

[6]Prescreen survival in front of the trashracks and primary louvers at the TFCF have not been verified, but are assumed to be 15 percent.

[7]Overall efficiencies of the louver arrays at the TFCF have been shown to be 46.8 percent (59.3 percent primary, 80 percent secondary). Recent studies indicate overall efficiencies during low flow periods could be less than 35 percent (Reclamation 2008). This value does not include periods when the louvers are being cleaned, where overall efficiency drops towards zero.

6.6.2.4.1.5 Estimates of Direct Loss to Entrainment by the CVP and SWP Export Facilities under the Proposed Action

Individual winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon are entrained by the south Delta export facilities, with most dying or being “lost” to the population in the process. Because all of the different populations are migratory, entrainment is seasonal, based on their presence in the waters of the Delta. Juvenile sized winter-run are vulnerable from approximately December through April, with a peak in February and March. Spring-run juveniles and smolts are vulnerable from approximately November through March (as yearlings) and January through June as YOY. Wild (unclipped) CV steelhead have a longer period of vulnerability, based on their extended periods of emigration as 1 to 2 year old smolts. Wild juvenile steelhead are recovered in the USFWS Chipps Island trawls from October through July. There appears to be a difference in the emigration timing between wild and hatchery reared steelhead smolts, primarily due to the narrow window of hatchery steelhead smolt releases into the system versus the protracted emigration from natal streams by wild fish. Adipose fin-clipped hatchery fish are typically recovered at Chipps Island from January through March, with the peak in recoveries occurring in February and March. The timing of wild steelhead (unclipped) emigration is more spread out. Their emigration occurs over approximately six months, with peaks in February and March, based on salvage records at the CVP and SWP fish collection facilities.

To evaluate the effects of direct entrainment, Reclamation assembled the total CVP + SWP pumping projections (as “Jones” plus “Total Banks”) in the CALSIM II output for the years between 1921 to 2003 and compared the current (Study 7.0), with the near future (Study 7.1), and future (Study 8.0) operations of the project and their anticipated effects on entrainment due to changes in pumping rates. For each comparison presented in table 6-29, the CALSIM II output for the monthly averages of the combined pumping levels of the Jones and Banks facilities are given for the different water year types. Utilization of salvage rates to express the effects of exports on the salmonid populations relies on the fish of interest actually reaching the point of enumeration, where they can be counted. Failure to reach the salvage facilities results in the perception that exports may not have an effect on those populations. Other factors in the Delta, such as predation, and at the salvage facilities (*e.g.*, low louver efficiency, or elevated pre-screen losses), can mask the effects of exports by removing the fish from the system prior to reaching the salvage facilities to be enumerated. Under such circumstances, even though the movement of water southwards towards the pumps due to exports was affecting the movement of fish, it cannot be determined by salvage alone, since the loss of fish prior to the salvage facilities prevents them from being enumerated in the salvage counts and showing any correlation with the exports. An alternative approach to estimating entrainment risk is the magnitude and direction of flows in Old and Middle Rivers under the different future modeling scenarios compared to the current levels. Table 6-30 gives the median net flows in Middle and Old Rivers under Studies 7.0, 7.1, and 8.0, as modeled for the years between 1922 and 2003 by the CALSIM model (CVP/SWP operations BA Appendix E). Both Reclamation and DWR, as well as the USFWS, have used this metric as a tool for evaluating entrainment risk to Delta smelt, and NMFS will incorporate the same tool as an additional ecological surrogate for evaluating the risk of entrainment to salmonids within the same water bodies. Although salmonids and green sturgeon are not water particles, they do use water movement (flow and direction) as cues for their behavioral movements. NMFS will use the movement of particles as a measure of the potential fate of water from the point of the particle injection through the channels of the central and southern Delta based on the eventual disposition of the particle at the end of the model run. In table 6-31, the monthly percentile differences between future CALSIM II Study cases (7.1 and 8.0) with the current Study (7.0) are presented, grouped by water year type and pumping facility.

The modeling runs indicate that export rates will increase over the current operations, as modeled by Study 7.0, through the late fall period and early winter period. Average export rates in November typically increase a modest 2 to 4 percent in most water year types. Under the near future and future operational models, average export rates increase about 10 percent in both December and January (range 5.84 to 15.12 percent increase). These increases can be expected to enhance the potential for fish entrainment (due to higher average export rates) at a time when winter-run juveniles and yearling spring-run are entering the Delta system. These increases in export are seen in all water year types, although the magnitude varies.

Table 6-29. Comparison of predicted monthly total export pumping from the CVP (Jones) and SWP (Banks) facilities for Studies 7.0 (current), 7.1 (near future) and 8.0 (future). The percentage difference is calculated for the percentage change from the near future and future conditions to the current operations. Highlighted cells are where future conditions have less pumping than current conditions.

October	Study 7.0	Study 7.1	% Difference 7.1 - 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	9054	8915	-1.54	9083	0.32
Above Normal	7982	7362	-7.77	7722	-3.26
Below Normal	8100	7717	-4.73	7729	-4.58
Dry	8111	7325	-9.69	7567	-6.71
Critically Dry	6799	6460	-4.99	6468	-4.87

November	Study 7.0	Study 7.1	% Difference 7.1 - 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10503	10743	2.29	10699	1.87
Above Normal	8414	8581	1.98	8422	0.10
Below Normal	8851	8829	-0.25	8922	0.80
Dry	7416	7717	4.06	7748	4.48
Critically Dry	6278	6391	1.80	5801	-7.60

December	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10438	11515	10.32	11585	10.99
Above Normal	8870	10012	12.87	9662	8.93
Below Normal	8770	9829	12.08	9876	12.61
Dry	8924	9816	10.00	9817	10.01
Critically Dry	7107	7855	10.52	7522	5.84

January	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10686	11537	8.15	11425	7.10
Above Normal	10074	11433	13.49	11539	14.54
Below Normal	9908	10815	9.15	10960	10.62
Dry	8410	9584	13.96	9682	15.12
Critically Dry	7224	7646	5.84	7986	10.55

February	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10295	10507	2.06	10617	3.13
Above Normal	10143	10738	5.87	11062	9.06

Below Normal	9759	9625	-1.37	9171	-6.03
Dry	8322	7982	-4.09	8137	-2.22
Critically Dry	5154	6061	17.60	5853	13.56

March	Study 7.0	Study 7.1	% Difference 7.1 – 8.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10099	9138	-9.52	9524	-5.69
Above Normal	10386	9660	-6.99	10138	-2.39
Below Normal	8692	8387	-3.51	8472	-2.53
Dry	7367	7270	-1.32	7188	-2.43
Critically Dry	3798	4316	13.64	4241	11.66

April	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	6226	6944	11.53	6987	12.22
Above Normal	5488	6173	12.48	6226	13.45
Below Normal	4472	4737	5.93	4708	5.28
Dry	2716	3329	22.57	3339	22.94
Critically Dry	1780	2035	14.33	1893	6.35

May	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	6114	6950	13.67	6924	13.25
Above Normal	4174	5193	54.41	5011	20.05
Below Normal	3069	4149	35.19	4051	32.00
Dry	2222	3259	46.67	3073	38.30
Critically Dry	1595	1751	9.78	1644	3.07

June	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	8414	8635	2.63	8616	2.40
Above Normal	7344	7961	8.40	7802	6.24
Below Normal	6480	6988	7.84	6890	6.33
Dry	5621	6212	10.51	6118	8.84
Critically Dry	3540	2754	-22.20	2416	-31.75

July	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	10154	10773	6.10	10875	7.10

Above Normal	8899	10037	12.79	9736	9.41
Below Normal	10476	11111	6.06	10641	1.58
Dry	10593	10539	-0.51	10123	-4.44
Critically Dry	5270	3675	-30.27	3359	-36.26

August	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	11549	11491	-0.50	11627	0.68
Above Normal	11474	11082	-3.42	11168	-2.67
Below Normal	10514	9814	-6.66	9717	-7.58
Dry	7611	5720	-24.85	5277	-30.67
Critically Dry	4224	2020	-52.18	1880	-55.49

September	Study 7.0	Study 7.1	% Difference 7.1 – 7.0	Study 8.0	% Difference 8.0 – 7.0
WY Type	CFS	CFS		CFS	
Wet	11469	11249	-1.92	11315	-1.34
Above Normal	10498	10325	-1.65	10710	2.02
Below Normal	10128	9755	-3.68	9924	-2.01
Dry	8571	7024	-18.05	6838	-20.22
Critically Dry	5828	4922	-15.55	4777	-18.03

Table 6-30. Projected Average Old and Middle River Flows by Water Year Types and Months

Projected Average Old and Middle River Flows (in cfs) in Wet and Above Normal Water Years for the Months of December through March (CVP/SWP operations BA Appendix E CALSIM Output).

Study	December	January	February	March	Average
Study 7.0	-8350	-6391	-7322	-6858	-7230
Study 7.1	-8083	-6511	-7377	-7956	-7482
Study 8.0	-8230	-6276	-7203	-7890	-7400

Projected Average Old and Middle River Net Flows (in cfs) in Wet and Above Normal Water Years for the months of April through July.

Study	April	May	June	July	Average
Study 7.0	-5847	-4381	-4118	-643	-3747
Study 7.1	-6561	-4652	-3450	-1146	-3952
Study 8.0	-6611	-4941	-3792	-1193	-4134

Projected Average Old and Middle River Net Flows (in cfs) in Below Normal and Dry Water Years for the months of December through March.

Study	December	January	February	March	Average
Study 7.0	-7668	-6125	-6767	-7117	-6919
Study 7.1	-6687	-6098	-6504	-8063	-6838
Study 8.0	-6946	-6030	6435	-8004	-6854

Projected Average Old and Middle River Net Flows (in cfs) in Below Normal and Dry Water Years for the months of April through July.

Study	April	May	June	July	Average
Study 7.0	-6889	-6052	-5573	-1064	-4895
Study 7.1	-7889	-5897	-5440	-1442	-5167
Study 8.0	-8038	-5989	-5407	-1428	-5215

Projected Average Old and Middle River Net Flows (in cfs) in Critically Dry Water Years for the months of December through March.

Study	December	January	February	March	Average
Study 7.0	-4576	-5633	-5293	-6158	-5415
Study 7.1	-3375	-5399	-4892	-6389	-5014
Study 8.0	-3312	-5317	-4333	-6315	-4819

Projected Average Old and Middle River Net Flows (in cfs) in Critically Dry Water Years for the months of April through July.

Study	April	May	June	July	Average
Study 7.0	-5368	-4250	-2514	-797	-3232
Study 7.1	-5903	-4744	-2824	-842	-3578
Study 8.0	-5618	-4865	-3024	-870	-3594

February has mixed export patterns. In wet and above normal water years, exports increase modestly, compared to modest decreases in below normal and dry years. Critically dry years see a larger increase in average exports (17.6 percent in Study 7.1 and 13.56 in Study 8.0), which is anticipated to have negative impacts on emigrating fish during this month. The reductions in exports during the below normal and dry water years are expected to benefit outmigrating salmonids, including steelhead, which are entering the system in increasing numbers. Less pumping is believed to reduce the draw of water from the main channel of the San Joaquin River into the South Delta channels leading towards the pumps, and thereby reduce the effects of farfield entrainment of fish into these channels. In particular, fish from the Southern Sierra Diversity groups which include CV steelhead from the San Joaquin River basin, the Calaveras River basin, and wild CV steelhead from the Mokelumne River basin must pass several points of potential entrainment into the South Delta prior to reaching the western Delta. Conversely, increasing exports in the wet, above normal and critically dry water years will adversely affect emigrating salmonids.

Table 6-31. Average change in Banks and Jones pumping grouped by water year type. Highlighted cells indicate conditions where pumping is greater than the Study 7.0 current condition during the primary salmonid migration period (November through June).

Facility	WaterYearType	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Study 7.1 compared to 7.0													
Banks	Critical	7.7%	-8.2%	-6.1%	15.5%	18.2%	8.7%	6.4%	8.8%	25.1%	-7.0%	-11.9%	-13.1%
Banks	Dry	0.2%	-5.3%	7.2%	10.5%	0.0%	4.7%	10.3%	12.4%	3.5%	-8.4%	1.1%	-12.8%
Banks	Bl Normal	11.4%	-4.1%	6.6%	6.1%	-2.4%	7.2%	14.0%	34.3%	6.9%	14.4%	0.9%	-8.3%
Banks	Ab Normal	14.5%	-5.5%	8.3%	-0.3%	7.3%	4.3%	13.1%	42.2%	13.4%	32.5%	-8.5%	-10.2%
Banks	Wet	6.1%	-3.1%	6.6%	5.3%	4.9%	-0.2%	19.2%	20.9%	1.2%	4.2%	-7.8%	-2.9%
Jones	Critical	8.5%	6.2%	15.1%	1.0%	7.9%	16.4%	8.2%	28.6%	-1.0%	-16.6%	-1.7%	-4.3%
Jones	Dry	3.8%	4.5%	11.9%	17.2%	5.1%	-4.2%	6.3%	32.3%	3.9%	7.8%	-13.5%	-7.7%
Jones	Bl Normal	7.5%	6.1%	19.7%	15.0%	-3.4%	-15.7%	-4.3%	5.3%	-2.3%	24.3%	6.6%	-7.5%
Jones	Ab Normal	-0.5%	8.3%	20.6%	15.5%	-1.5%	-13.6%	-9.0%	6.9%	1.2%	9.3%	13.6%	3.3%
Jones	Wet	6.2%	9.0%	18.4%	15.1%	-0.1%	-25.9%	-2.3%	-1.1%	-2.5%	4.5%	5.7%	3.3%
Study 8.0 compared to 7.0													
Banks	Critical	4.8%	-17.5%	-8.7%	-2.9%	20.3%	7.4%	6.7%	13.8%	-11.9%	-22.0%	-17.1%	-2.9%
Banks	Dry	0.3%	-7.8%	8.1%	12.4%	-1.8%	5.3%	8.2%	18.5%	-8.3%	-8.8%	-2.4%	-7.0%
Banks	Bl Normal	7.0%	-5.6%	3.4%	9.9%	-3.1%	1.5%	13.9%	31.3%	9.3%	22.3%	12.9%	-0.2%
Banks	Ab Normal	4.8%	-10.1%	4.4%	4.6%	8.1%	4.8%	12.2%	43.1%	16.9%	51.9%	17.3%	-5.3%
Banks	Wet	2.5%	-4.7%	6.8%	6.1%	5.1%	2.7%	19.2%	20.9%	4.0%	16.1%	-3.8%	-2.7%
Jones	Critical	11.6%	-4.6%	17.5%	9.9%	4.8%	23.4%	5.9%	22.0%	-10.1%	-31.4%	-19.8%	-16.5%
Jones	Dry	8.1%	6.1%	11.9%	17.1%	5.9%	-6.6%	4.2%	29.1%	-3.8%	-0.4%	-29.3%	-8.3%
Jones	Bl Normal	13.8%	7.7%	20.2%	15.6%	-1.6%	-12.9%	-7.2%	-2.6%	-4.2%	19.8%	3.8%	-5.1%
Jones	Ab Normal	-1.6%	4.9%	24.2%	11.2%	11.0%	-7.9%	-8.4%	5.3%	1.2%	7.4%	-0.7%	13.4%
Jones	Wet	8.6%	11.5%	17.9%	13.1%	-1.4%	-20.3%	-1.5%	-0.1%	-1.0%	-8.1%	5.5%	5.1%

The average combined exports for March decrease in all water year types except critically dry years, when the export rate increases approximately 12 percent in the future compared to current operations (13.64 percent increase in Study 7.1 versus Study 7.0 and 11.66 percent increase in Study 8.0 compared to Study 7.0). Therefore, in critically dry years, based on the anticipated export rate increases, risk to winter-run and CV steelhead will increase, particularly since March is typically the peak of their outmigration through the Delta. On the other hand, risk of entrainment, as measured by salvage and export levels, declines during the month of March in the wet, above normal, below normal and dry hydrologic year types.

The months of April and May have significant increases in the export rates under the near future and future modeling runs when compared to the current operations model (Study 7.0). Export rates can increase by as much as 46.67 percent in the month of May during dry water year types, and are only moderately less than this in other water year types. Typically, the increases in exports range from approximately 10 percent to 40 percent during the April and May time period. These increases will likewise negatively affect emigrating salmonids, particularly spring-run and fall-run juveniles that are moving through the Delta during these months. San Joaquin River and Calaveras River basin fish, (*i.e.*, steelhead and fall-run Chinook salmon) are particularly vulnerable due to the proximity of their migration corridor to the location of the CVP and SWP pumping facilities and the multiple pathways leading from their migration corridor to the export facilities (*e.g.*, Head of Old River, Turner and Columbia Cuts, Middle River, and Old River).

The month of June has exports increasing approximately 2.5 percent to 10 percent over current conditions, except for critically dry years when exports are sharply reduced (-22 percent in Study 7.1 and -32 percent in Study 8.0). Overall, actual June export rates are increasing over the April and May levels, so that while the percentage of increases looks smaller than in the previous two months, the total volume of water diverted is actually increasing. This is expected to pull more water southwards through the central and southern Delta waterways towards the pumps. This, in turn, increases the risk of drawing any late emigrating fish present in the central and south Delta towards the pumps as well. This will adversely impact the migration rate of these late emigrating fish during a time when water quality, particularly water temperature, is becoming unfavorable to salmonids.

The month of July has exports that are increasing in the near future and future over the current model levels in wet, above normal, and below normal water year types. Similar to June, the drier water year types see a pattern of decreasing export levels between the future modeling runs and the current modeling run. For the remainder of the summer months, i.e.*,* August and September, the future modeling studies indicate that combined export rates will be equivalent to or lower in than the current conditions as modeled in Study 7.0. Reductions are greatest in the drier water year types. Reductions in summer exports could reduce the vulnerability of green sturgeon juveniles in the central and south Delta from becoming entrained by the pumps.

In the analysis completed for Delta smelt, the CVP/SWP operations BA concluded that upstream flows, *i.e.*, flows that were negative, that were greater than -2000 cfs ± 500 cfs effectively prevented entrainment of Delta smelt that were north of the sampling stations in Old and Middle

River. A linear relationship between Delta smelt entrainment and flow exists at flows greater than -4000 cfs (more seaward flow). At flows less than -4000 cfs (more landward flow) the entrainment rate for Delta smelt begins to take on an exponential characteristic. Based on particle tracking modeling, the Delta smelt work group concluded that net river flows greater than -2000 ± 500 cfs in the Old River and Middle River complex reduced the zone of entrainment so that particles injected into the central Delta at Potato Slough would not be entrained towards the pumps (Kimmerer and Nobriga 2008 *op cit*. CVP/SWP operations BA). NMFS considers this information useful in analyzing the potential "zone of effects" for entraining emigrating juvenile and smolting salmonids. A similar pattern is observed in material (figures 6-65 and 6-66) provided to NMFS by DWR (Greene 2009). Loss of older juveniles at the CVP and SWP fish collection facilities increase sharply at Old and Middle River flows of approximately -5,000 cfs and depart from the initial slope at flows below this. Given the data derived from the CVP/SWP operations BA Appendix E, flows in Old and Middle River are consistently in excess of the -2000 ± 500 cfs threshold for entrainment (*i.e*., more upstream flow). Assuming that in the normal (natural) flow patterns in the Delta, juvenile and smolting Chinook salmon and steelhead will use flow as a cue in their movements and will orient to the ambient flow conditions prevailing in the Delta waterways, then upstream flows will carry fish towards the pumps during current operations. General tendencies of the modeling results indicate that Old River and Middle River net flows trend towards greater upstream flow in the near future and future conditions, resulting in even more fish carried towards the pumps.

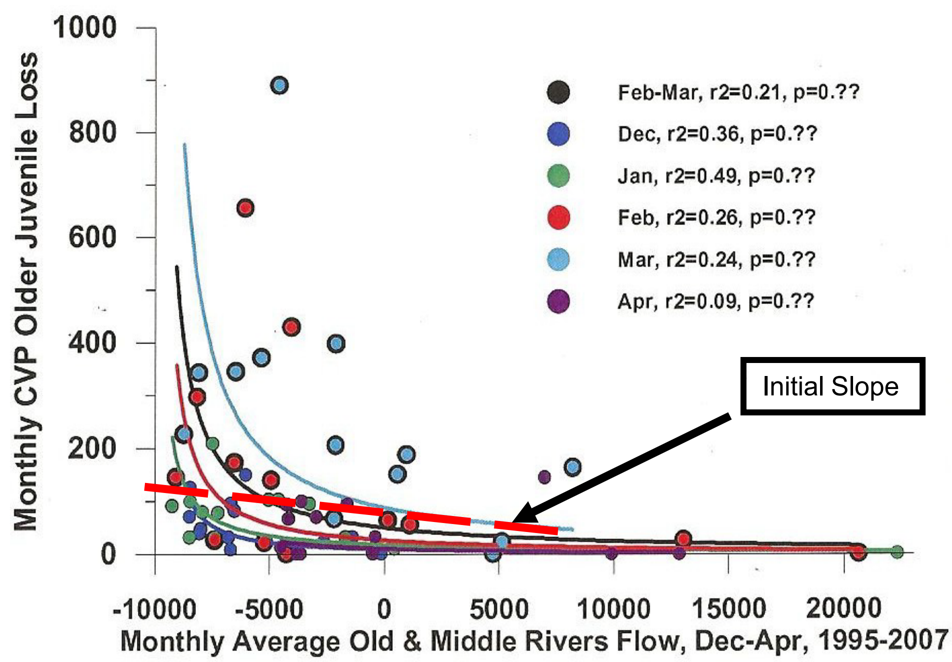


Figure 6-65. Relationship between OMR flows and entrainment at the CVP, 1995-2007 (DWR 2008).

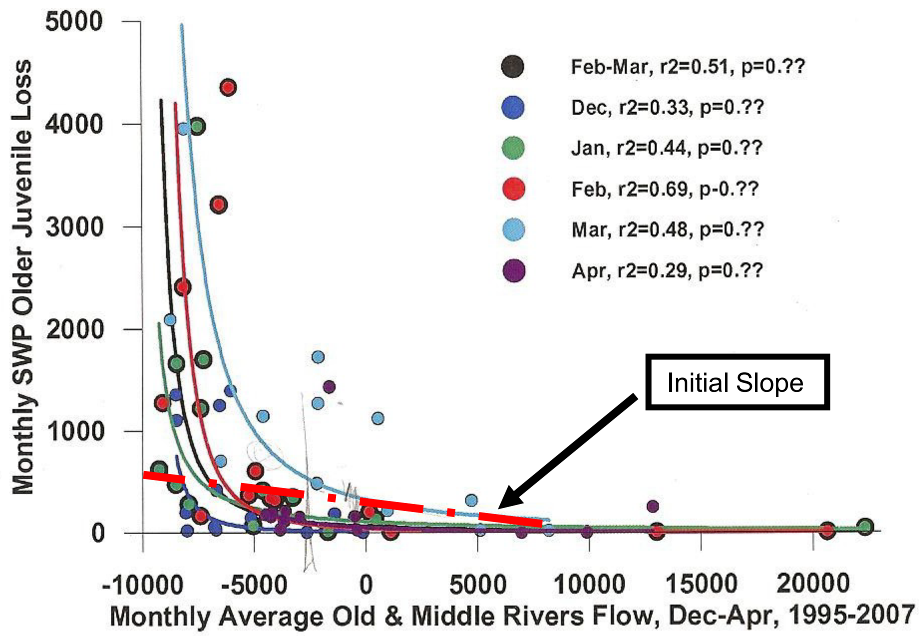


Figure 6-66. Relationship between OMR flows and entrainment at the SWP, 1995-2007 (DWR 2007).

During wet, above normal and critically dry water year types, the greatest level of negative net flows in Old and Middle rivers are seen during the months of December, January, and July. The months of December and January coincide with onset of movement of winter-run and yearling spring–run into the north Delta from the Sacramento River. NMFS believes that these elevated levels of net negative flow present a risk to emigrating fish that have entered the central Delta through Georgiana Slough or, when the DCC is open, the Mokelumne River system. In below normal and dry water year types, the Old and Middle River flows have high levels of net negative flow from December through March and again in June and July. This overlaps with a significant proportion of the salmonid emigration period through the Delta, particularly for winter-run Chinook salmon and Central Valley steelhead. In all water year types, the net negative flows in Old and Middle River are attenuated in April and May in response to the reduced pumping (export levels) required for the VAMP experiments.

The CALSIM II and DSM II modeling also indicates that the magnitude of the net negative flows in Old and Middle rivers generally get "larger" (*i.e.*, more negative, reverse landward flow) with the future conditions in wet, above normal, below normal and dry water year conditions. This corresponds with the trend in increased level of exports described earlier for these water year types. The enhancement of net negative flows in Old and Middle rivers in the near future and future conditions indicate an increasing level of vulnerability to the entrainment for emigrating fish located in the central and southern Delta regions.

Inspection of the salvage and loss records from the CVP and SWP fish collection facilities available through the Central Valley Operations web site (http://www.usbr.gov/mp/cvo/fishrpt.html) indicates that recovery of winter-run sized juvenile Chinook salmon begins in December and continues through approximately the end of March.

Roughly 50 percent of the total annual salvage of juvenile winter-run sized Chinook salmon occurs in March, with the previous 3 months (December, January, and February) accounting for the other 50 percent. Very few winter-run sized Chinook salmon juveniles are captured after the end of March. Likewise, the salvage of steelhead smolts at the fish collection facilities starts as early as November, but is primarily observed in the months of January, February, and March. The salvage of spring-run sized fish is primarily observed in the months of March, April, and May. Nearly two thirds of the spring-run sized Chinook salmon juveniles are collected during the month of April alone. This temporal pattern indicates that listed salmonids are within the waterways of the central and south Delta as early as November and December, but typically are most prevalent from January through May. Southern DPS of green sturgeon are also present during this time frame, as they occupy the waters of the Delta year round.

The presence of listed salmonids and green sturgeon in the salvage collections during the winter and spring months points out their vulnerability to negative flows in Old and Middle River during this time period. Particle tracking model simulations conducted for the Delta smelt consultation indicate that at flows more positive than -2,500 cfs, the probability of a neutrally buoyant particle injected at monitoring Station #815 eventually being entrained at the export facilities is less than 10 percent (see figures 6-67 and 6-68). Station #815 is on the San Joaquin River adjacent to the confluence of the Mokelumne River. This site is a valuable reference point as it is the location at which fish from the Sacramento River are likely to enter the Central Delta and the San Joaquin River system after traveling through Georgiana Slough or the Mokelumne River system. With increasing export pumping under a set of given conditions, the Old and Middle River flows become more negative, and a higher percentage of injected particles from Station #815 are entrained by the export pumps. Similarly, the closer a group of particles is injected to the export facilities, the higher the risk of eventual entrainment at the export facilities. The current profile of listed salmonid entrainment and the estimated Old and Middle River flows from the CALSIM II modeling indicate that fish entering the San Joaquin River from the Sacramento River at the confluence of the Mokelumne River are at an elevated risk of entrainment by the export facilities. Likewise, fish entering the Delta from the San Joaquin River basin, the Calaveras River or the Mokelumne River system are vulnerable to entrainment due to their proximity to the exports (station 912 and Mossdale), and the length of the migration corridor they must travel that is under the influence of the export actions (see figures 6-57c and 6-57d). Pumping rates predicted for the months of December through March create conditions in which the net flows in Old and Middle rivers average less than -4000 cfs (note: more negative values indicate higher export levels and the direction of flow is landwards), with drier years being more negative. The absolute magnitude of Old and Middle River negative flows generally increases (*i.e.*, more flow towards the pumps) under the near term and future modeling studies (see table 6-30).

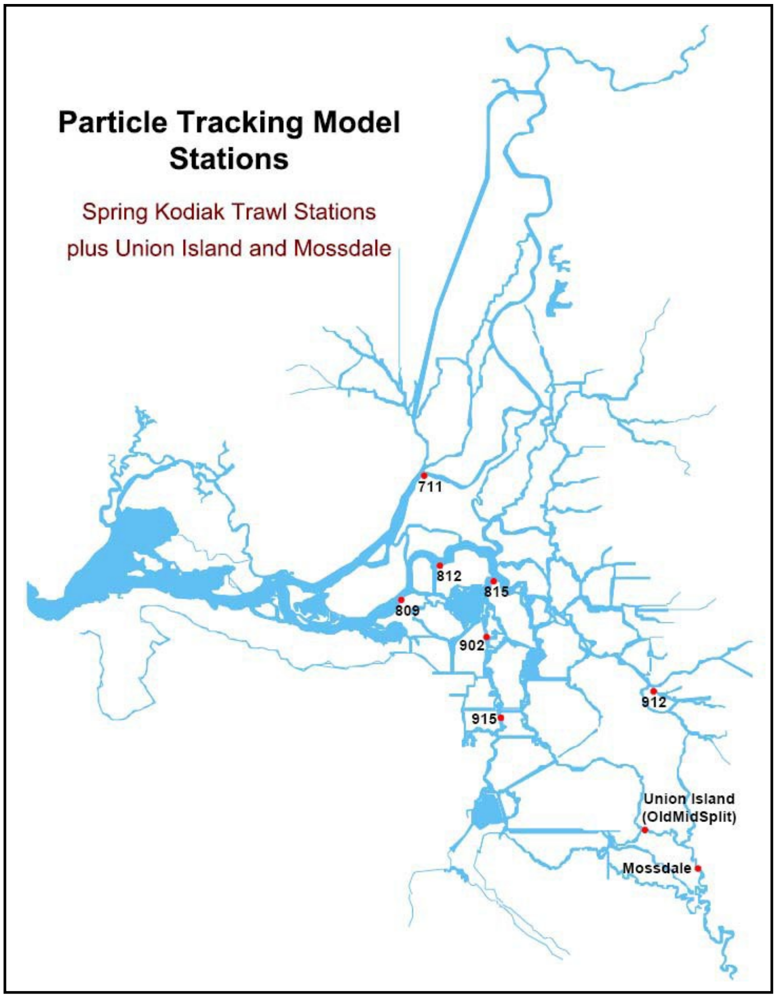
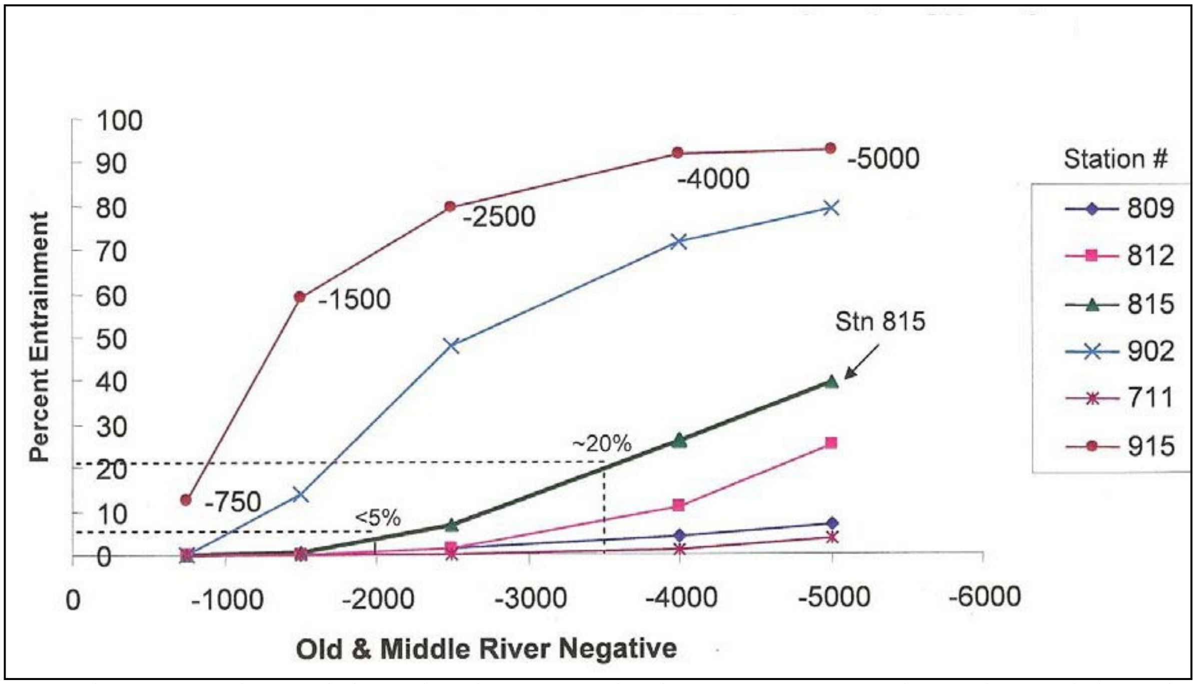


Figure 6-67. Location of particle injection points for the Particle Tracking Model simulations (Hinojosa 2009).



Station Key: Station 809 is located on the San Joaquin River (SJR) at Jersey Point, Station 812 is located on the SJR at Fisherman's Cut, Station 815 is located at the confluence of the Mokelumne River with the SJR, Station 915 is located on Old River at Orwood Tract, Station 902 is on Old River near Rhode Island/ Quimby Island, and Station 711 is on the Sacramento River near Rio Vista and Cache Slough.

Figure 6-68. Calculated percentages of entrainment at the CVP and SWP export facilities for different levels of flow in Old and Middle Rivers. Particles are injected at different locations in the Delta (USFWS 2008a).

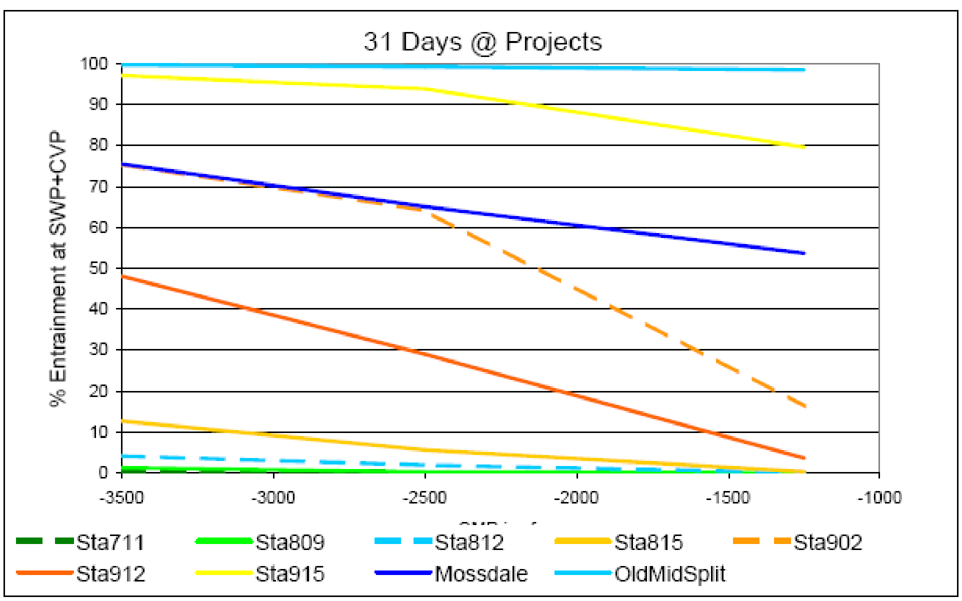


Figure 6-69. Calculated percentage of particles entrained by the CVP and SWP after 31 days at Old and Middle River flows of -3,500 cfs, -2,500 cfs, and -1,250 cfs. Particles were injected at various locations in the Delta. This figure was for March 2005, a "wet" year (Hinojosa 2009).

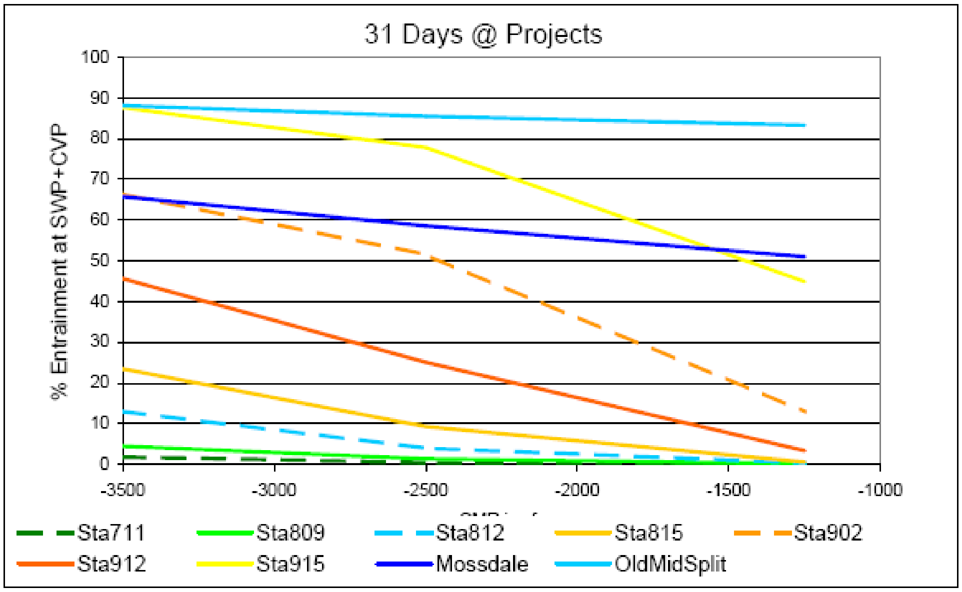


Figure 6-70. Calculated percentage of particles entrained by the CVP and SWP after 31 days at Old and Middle River flows of -3,500 cfs, -2,500 cfs, and -1,250 cfs. Particles were injected at various locations in the Delta. This figure was for March 2008, a "dry" year (Hinojosa 2009).

NMFS uses the findings of the PTM simulations to look at the eventual fate of objects in the river over a defined period of time from a given point of origin in the system. While salmonids and green sturgeon are not "neutrally buoyant particles", they can be represented to some degree by the PTM modeling results. The fish occupy a given body of water in the river and that body of water has eventual fates in the system, as represented by the dispersion of the injected particles. The salmonids have volitional movement within that body of water and react to environmental cues such as tides, water velocity vectors, and net water flow movement within the channel. The eventual fate of that body of water signifies the potential vulnerabilities of fish within that body of water to external physical factors such as export pumping or river inflows. For example, if exports increase, and the eventual fate of the water body indicates that it has a higher probability of entrainment compared to other conditions (*i.e.*, lower export pumping), then NMFS believes that salmonids within that same body of water will also experience a higher probability of entrainment by the export pumping. Conversely, under conditions where the eventual fate of injected particles indicate a high probability of successfully exiting the Delta at Chipps Island, NMFS believes salmonids traveling in the same body of water will have a higher probability of exiting the Delta successfully. Furthermore, conditions which delay movement of particles out of the Delta yet don't result in increased entrainment at the export facilities would indicate conditions that might delay migration through the Delta, which would increase vulnerabilities to predation or contaminant exposure. Finally, flow conditions at river channel splits indicate situations where migrating fish must make a "decision" as to which channel to follow. If water is flowing into a given channel, then fish closer to that channel bifurcation are more likely to be influenced by the flow conditions adjacent to the channel opening than fish located farther away from the channel mouth. Burau *et al.* (2007) describes the complexity of these temporal and spatial conditions and their potential influence on salmonid movement. PTM simulations currently do not give the necessary fine scale resolution both temporally (minutes to fractions of hours) and spatially (three dimensional on the scale of meters) to give clear results at these channel splits. Burau states that spatial distribution of fish across the river channel occurs upstream of the channel splits and is dependent "upon the interaction between local hydrodynamic processes (*e.g.*, secondary currents) and subtle behaviors that play out in a Lagrangian reference frame. These spatial structures evolve over fractions of hours to hours. Junction interactions, on the other hand, happen very rapidly, typically within minutes. Thus, route selection may only minimally depend on behavioral responses that occur in the junction, depending to a greater degree on spatial distributions that are created by subtle behavioral responses/interactions to geometry-mediated current structures that occur up-current of a given junction." This description illustrates the complexity of route selection. Based on Burau's explanation, fish upstream of the split are dispersed by the environmental conditions present in the channel into discrete locations across the channel's cross section. The proximity of these locations to the channel mouth is predictive of the risk of diversion into the channel itself. PTM data can be useful to indicate the magnitude of the net movement of water through the channel after the junction split (and the route selected by the fish), and thus can be used to infer the probable fate of salmonids that are advected into these channels during their migrations.

The comparison of study runs as represented by the percentile differences of monthly pumping rates from both the CVP and SWP facilities are grouped over water year types and compare the future study cases against the current modeled pumping rates (see table 6-29). This table gives better resolution regarding the details of the individual pumping operations of the two pumping plant facilities. The data from the modeling runs for the Banks pumping facility indicates that the comparison between the near term (Study 7.1) and the current pumping levels (Study 7.0) will have a higher rate of pumping increases over the different water year types then decreases during the period when salmonids are emigrating to the ocean (November through June). In particular, the months of April and May will have consistent increases in pumping levels, with rates in wet, above normal and below normal hydrologic years in the month of May showing the greatest relative increases (as high as 42 percent). This is a period of time when YOY spring-run are common in the Delta, as well as fall-run. Therefore increased pumping in April and May has the potential to entrain more individuals from these two runs in the near future and future cases than in the current operational regime. In general, pumping in the near future shows consistent increases at the Banks facility in the period between December and March. These increases place emigrating winter-run, CV steelhead and yearling spring-run at risk of entrainment. As described in the previous section regarding entrainment at the Clifton Court Forebay structure and the operations of the Skinner Fish Protection Facility, loss of entrained salmonids can be quite high for any fish entering this unit.

The pattern of operations for the Jones Pumping Plant facility is slightly different than that of the Banks Facility. In the near future (Study 7.1), pumping is increased over the current levels during the period between November and January. Pumping rates increase modestly in November in all water year types, ranging from 4.5 percent to 9 percent. The following two months, December and January, see pumping increase over 10 percent in almost all cases. This period corresponds to the time when winter-run Chinook salmon juveniles and spring-run Chinook salmon yearlings are entering the Delta from the Sacramento River system. Steelhead smolts are also beginning to enter the Delta waters from their upstream natal streams during this time period. Pumping at the Jones Facility generally decreases during the 3-month period between February and April in below normal, above normal and wet water year types. In dry and critically dry water years, the pumping rates at the Jones Facility tend to increase in the near-term future Study (7.1) over the current modeled conditions (Study 7.0). The reductions in pumping rates are considered to be beneficial to emigrating salmonid populations, particularly since March and April are peak months of movement through the Delta by listed salmonid species.

The modeled pumping rates at the state and Federal pumping plants for the future Study (8.0) are similar to those for the near-future conditions (Study 7.1), therefore the differences between the current operational conditions as modeled by Study 7.0 and the future conditions as modeled by Study 8.0 are not substantially different than those seen in the previous comparisons. The future pumping rates at the Banks pumping plant are still elevated for most of the period between December and May compared to the current operational conditions, and therefore present the same anticipated risk to emigrating salmonid stocks. As seen in the Study 7.1 modeling scenario, pumping rates, as determined by the percentage change from the current level, are substantially increased in the April and May period, which corresponds to the peak of outmigration for YOY spring-run and YOY fall-run. It also overlaps with the VAMP experiment on the San Joaquin River. The modeled pumping rates at the Jones facility under the future conditions in Study 8.0 show a similar pattern to those modeled under Study 7.1.

In summary, the overall pumping rates in the two future modeling scenarios elevate risk to emigrating salmonids in December, January, April, May, and June compared to the current conditions. However, entrainment risks in March are reduced due to pumping reductions taken by the facilities. There are mixed risks in the month of February due to differences in pumping strategy based on the type of water year modeled. In wet, above normal and critically dry water year types, overall pumping is increased. Conversely, pumping is reduced in below normal and dry conditions. The proposed actions also reduce pumping in the summer relative to the current modeling scenario. This benefits green sturgeon that may be rearing in the vicinity of the pumps during the summer, and reduces their risk of entrainment. The most obvious difference in pumping patterns between the current and future scenarios outside of the increases in December and January is the substantial increase in pumping that will occur in April and May at the SWP facilities. This increase in pumping corresponds to the period in which the majority of YOY fall-run and spring-run Chinook salmon are entering the Delta and moving towards the ocean, thus increasing their vulnerability to entrainment. In particular, San Joaquin River basin fish will be exposed to increased entrainment risks due to their migration route's proximity to the pump's entrainment field. This includes the basin's fall-run Chinook salmon population, as well as its severely limited steelhead population.

6.6.2.4.1.6 Discussion of Relationship of Exports to Salvage

There has been considerable debate over the relationship of salvage numbers and the export rate for many years. In addition, the survival rate of salmonid populations passing through the Delta towards the ocean, and the impact of the export facilities on those populations is also an area of controversy. The CVP/SWP operations BA presented data that regressed the loss of older juvenile Chinook salmon against exports (figure 6-71) and found that a significant relationship existed. The relationship was stronger for exports at the SWP ($p = 0.000918$) than for exports at the CVP ($p = 0.0187$). The months of December through April resulted in the most informative relationship based on the historical number of older juvenile Chinook salmon salvaged each month and the relationship of each month to salvage and exports. Conversely, regressions performed for monthly salvage of YOY Chinook salmon against exports did not result in a significant relationship at either the SWP or CVP facilities. Potential problems in this analysis may stem from the reduction of pumping for 30 days during the height of the YOY Chinook salmon emigration for the VAMP experiment, which may skew the data set. Likewise, as previously mentioned, loss of fish in the system prior to reaching the salvage facilities and their enumeration in the salvage will mute the response of the salvage numbers to any increase in exports until an apparent threshold level has been reached. It appears that pre-facility losses reach a saturation point, after which salvage numbers increase in accordance with increases in export rates. The shallow slope of the response curve is an indication of the relative insensitivity of the salvage numbers to the increases in exports. In order to see a large change in salvage numbers, a substantial increase in exports is required. The pattern of data points for larger juveniles indicates that at low export rates, very little increase in salvage is seen with increasing export rates. However, as exports increase further, the scatter in the salvage data points increases with both high and low salvage numbers occurring at the same export level. Interactions with predators may explain this pattern. Increased pumping moves fish past the predators faster within the affected channels, reducing their exposure time to the predators. Thus more fish show up to be counted at the salvage facilities once the threshold for predator success has been surpassed.

Regressions of monthly older Chinook salmon loss against export/inflow ratio between December and April did not result in significant relationships at either the SWP or CVP facilities. There is an inherent problem with using the E/I ratio exclusively in that significantly different pumping rates at the CVP and SWP can have the same E/I ratio when the inflow to the Delta is allowed to vary also. Better resolution of the relationship between the salvage to E/I ratio is achieved when at least one of the variables to the E/I ratio is held constant. In such instances, the relative importance of exports or inflow can be teased out of the relationship. Decisions as to which variable has more influence on the level of salvage can thus be made.

Reclamation also regressed data for steelhead salvage against exports in the CVP/SWP operations BA. The regressions resulted in significant relationships between exports and the salvage of steelhead at the facilities, more so for the SWP than the CVP (figure 6-72). The months of January through May produced the most informative relationships based on the historical number of steelhead salvaged each month and the relationship of each month between salvage and exports. Reclamation found that the months of December and June, due to the low number of salvaged steelhead in those months, had very poor and insignificant relationships to exports. Unlike the regressions performed for juvenile Chinook salmon, Reclamation found significant relationships between steelhead salvage and the E/I ratio for both the SWP and CVP (figure 6-73).

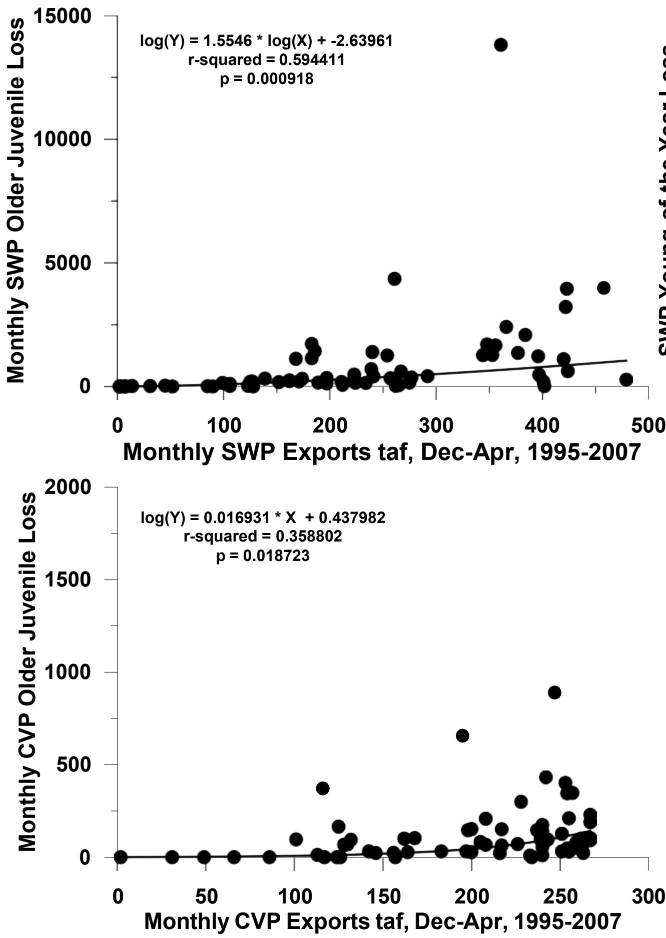


Figure 6-71. Monthly juvenile Chinook salmon loss versus average exports, December through June, 1993 through 2006, at each facility; SWP and CVP (CVP/SWP operations BA figure 13-40).

Recent analyses of the interaction of export rates and the salvage of salmonids at the CVP and SWP have arrived at differing conclusions based on past release and recapture studies conducted in the Delta. Newman (2008) analyzed the results of studies conducted in support of the DCC experiments, the Delta Interior experiments, the Delta Action 8 experiments, and the VAMP experiments. Newman used Bayesian hierarchical models (BHMs) to analyze the data collected from the multiple years of data generated by these four studies. The BHM framework explicitly defines probability models for the release and recovery data gathered and subsequently accounted for the unequal sampling variation and between release pair variation inherent in the raw data pool. Recoveries from multiple locations in the Delta were analyzed in combination rather than separately. According to Newman, the BHM framework is more statistically efficient and coherent than the previous methods of analysis used in these experiments. It is able to address deficiencies in the experimental designs and the high level of variability in the dependent data (*e.g.*, salvage and survival). Several levels of uncertainty can be accounted for using recoveries from multiple locations simultaneously to increase precision. Nevertheless, the original release and recovery data has several significant limitations, such as that fish can be captured only once, the low level of fish salvaged at the CVP and SWP from individual releases and the large variation between such releases under similar conditions, the low probability of capture in the recovery process (trawling), the relatively high level of environmental variation present in the data, and the lack of balance in the release strategy (VAMP experiments) all reduce the accuracy of the estimates of the desired endpoint, *i.e.*, survival of released fish. Newman explains that given the apparently high environmental variation present in these experiments, it could take many more replications of the temporally paired releases to provide a more accurate estimate of the effects of the DCC gate position, the effects of exports and river flow, and the placement of the HORB on the survival of released fish.

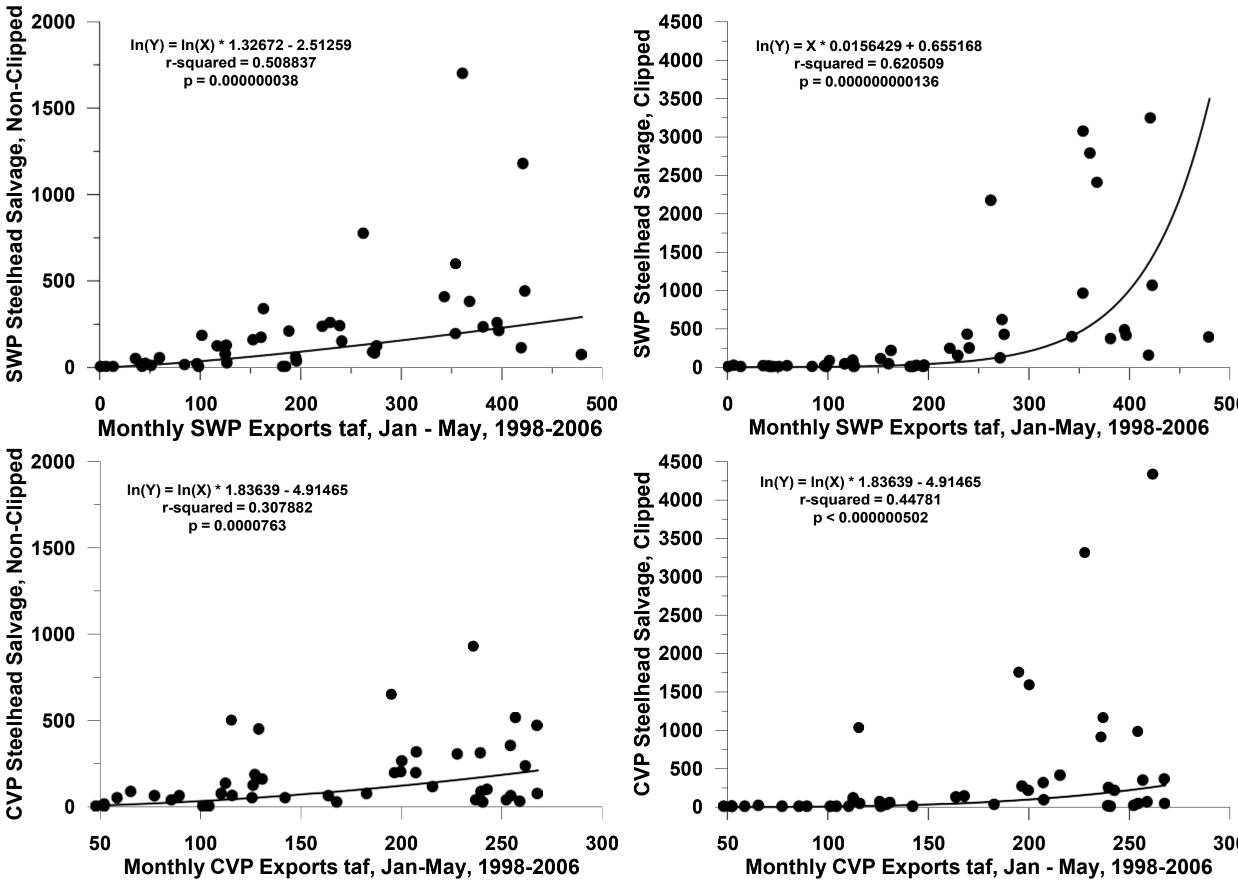


Figure 6-72. Monthly steelhead salvage versus average exports, January through May, 1998 through 2006, at each facility; SWP and CVP (CVP/SWP operations BA figure 13-45).

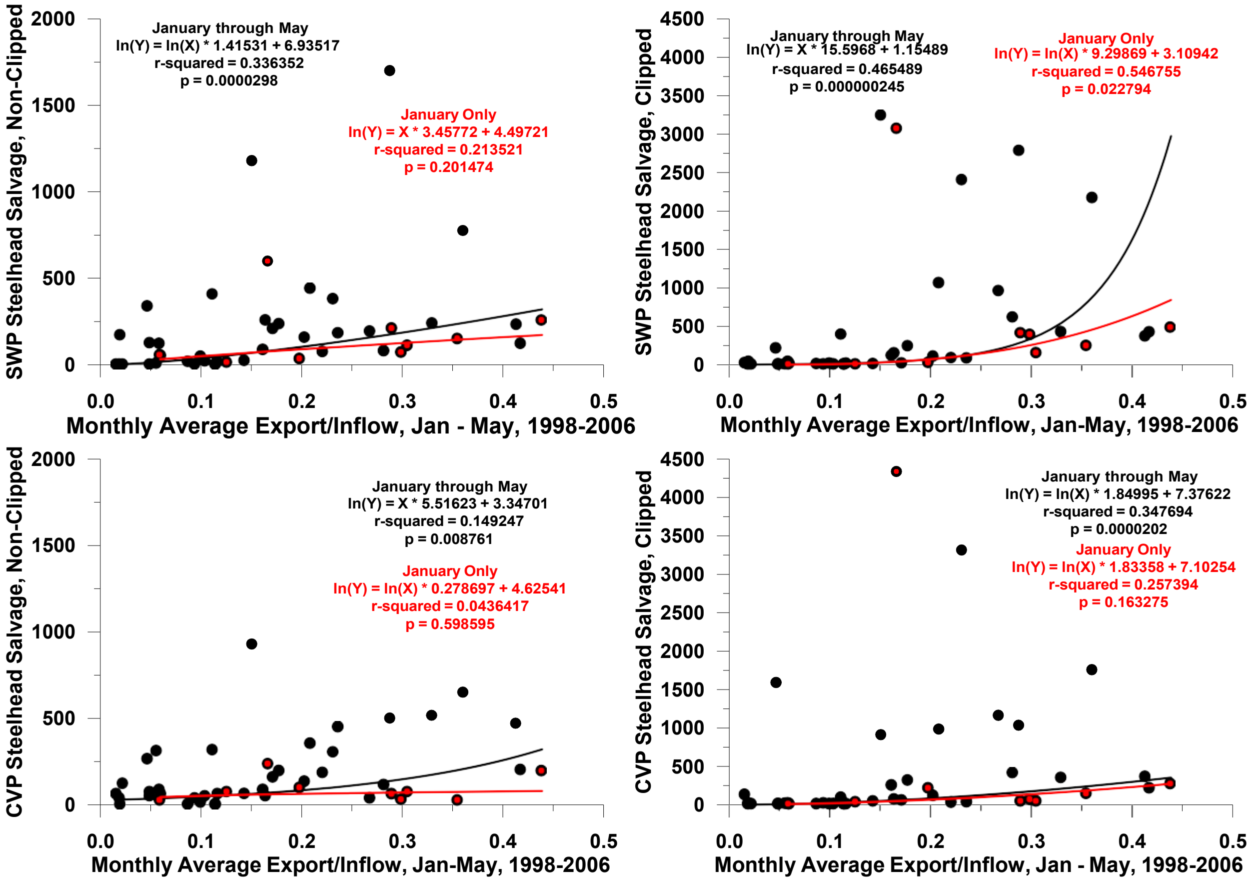


Figure 6-73. Monthly steelhead salvage versus average Export/Inflow ratio in TAF, January through May, and January alone, 1998 through 2006, at each facility; SWP and CVP (CVP/SWP operations BA figure 13-46).

Notwithstanding these limitations, Newman reached the following conclusions:

Delta Cross Channel Experiments: There was modest evidence (64 to 70 percent probability) that survival of fish released at Courtland (upstream of the DCC gates) to Chipps Island relative to the survival of releases made from Ryde (downstream of the DCC) increased when the DCC gates were closed.

Interior Studies: Although there was considerable variation between paired releases, the overall recovery fractions for Ryde releases remained higher than the Georgiana Slough releases in all cases. The means of the ratios for Ryde to Georgiana Slough recoveries were 0.26, 0.43, and 0.39 at Chipps Island, in the ocean, and inland sites, respectively, which is consistent evidence that fish released in Georgiana Slough had a lower probability of surviving than fish released in the Sacramento River at Ryde. Conversely, the relative fraction of fish that were salvaged at the CVP or SWP pumps was approximately 16 times greater for fish released in Georgiana Slough than for fish released in the Sacramento River at Ryde.

Delta Action 8 Experiments: There was a negative association between export volumes and the relative survival of released salmonids (*i.e.*, a 98 percent chance that as exports increased the relative survival of released Chinook salmon juveniles decreased). However, environmental variation in this set of experiments was very large and interfered with the results. There is also a positive association between exports and the fraction of Georgiana Slough releases that are eventually salvaged. With only one exception, (1995 release group), the fraction of fish salvaged from Ryde releases appear to be unrelated to the level of exports (Ryde is downstream of both the DCC and Georgiana Slough channel openings on the Sacramento River)

*VAMP***:** The expected probability of surviving to Jersey Point was consistently greater for fish staying in the San Joaquin River (*i.e.*, passing Dos Reis) than fish entering Old River, but the magnitude of the difference varied between models somewhat. The placement of the HORB effectively keeps fish from entering Old River; therefore the survival of out-migrants should increase. There was a positive association between flow at Dos Reis and subsequent survival from Dos Reis and Jersey Point to Chipps Island. If data from 2003 and later were eliminated from data set, then the strength of the association with flow increased and a positive association between flow in Old River and survival in Old River also appeared. Finally, any associations between water export levels and survival probabilities were weak to negligible. This may have been due to the correlation between flow and export rates during the VAMP experiments. Given the complexity and number of potential models for the VAMP data, Newman recommends a more thorough model selection procedure using Reversible Jump MCM. An alternative analysis by Hanson (2008) did not find any significant relationship between exports and survival. Hanson also analyzed the relationship between exports and entrainment at the CVP and SWP as measured by salvage. Hanson (2008) referred to this fraction as direct losses. In Hanson's analysis, he examined the data from 118 studies involving approximately 14.2 million fish. Hanson found that on average, for fish released into the upper Sacramento River, direct losses due to the CVP and SWP pumps averaged 0.03 percent (sample size n = 118, 95 percent confidence interval (CI) = 0.0145) with a range of 0 to 0.53 percent. Hanson does not elaborate where these fish were released in the Sacramento River, what survival rates where prior to entering the Delta (losses may be as high as 80 percent in the Sacramento River prior to reaching the Delta, MacFarlane *et al*. 2008), whether these releases were paired in both spatial and temporal aspects to minimize environmental variance, the level of variance in pumping rates during his selected time frames of sampling, and how the inefficiency of the trawling recoveries and low recoveries rates at the fish collection facilities may have biased his results (see Newman 2008). Whereas Newman found increasing trends for fish in Georgiana Slough to be entrained with increases in exports (Delta Action 8 Studies), Hanson's analysis did not find this pattern. Likewise, the decrease in survival for fish in Georgiana Slough with increasing export rates found by Newman's analysis were not found in Hanson's analysis of the data. It is not apparent in Hanson's explanation of his analysis how he separated the different experimental studies into subgroups for statistical analysis with the goal of reducing bias and sampling variability, and thereby increasing the precision of his analysis.

Results from the different statistical analyses indicate that the data from the multiple releases-recapture studies are very "noisy" due to high levels of environmental variability. Finding clear cut results is a difficult task in which the various sources of error in the data, whether due to experimental design, sampling efficiency, hydrological conditions, temporal and spatial variability, or inability to maintain constant conditions during the duration of the experiment, all lead to a lack of resolution in determining the final result of interest. Future studies utilizing acoustic tagging are aimed at reducing these confounding factors. In particular, acoustic tagging gives fine scale temporal and spatial resolution to the movements and behavior of fish over an extended period of time. Unlike the release–recapture studies, individual fish can be "sampled" continuously without loss of the test subject (*i.e.*, captured in the trawl or salvage facility). They can be followed after flow splits into different channels and their final disposition determined by reach, if necessary, to calculate their survival without the uncertainty of the current recapture methods employed in studies to date.

6.6.2.5 Indirect Mortality Within the Delta

6.6.2.5.1 Overview of Mortality Sources

Survival of salmonids migrating through the Delta is affected by numerous variables, some related to the proposed action, others independent of the project. As fish move down the mainstem Sacramento River into the North Delta, the intersecting channels splitting off of the main river channel provide alternative routes for migration. For each of these routes, a different probability exists for taking that alternative channel or remaining in the main stem of the river. Within each channel, additional factors come into play that determines the ultimate survival of fish moving through that reach of water. Survival is affected by the degree of predation within each individual channel, which is itself a function of predator types and density. Some predators, such as striped bass, are highly efficient at feeding on various aquatic organisms and quite mobile, thus moving from location to location, opportunistically preying on emigrating salmonids when they encounter them. Others, such as centrarchids (*i.e.*, largemouth bass) are more localized and ambush prey as it moves past their location in a given channel. They are unlikely to follow a migrating school of prey any great distance from their home territory. The suitability of habitat for emigrating salmonids can affect whether sufficient food and cover is available to emigrating fish, which then influences the survival of fish moving through that waterway. For example, a heavily riprapped channel that has essentially a trapezoidal cross section is unlikely to provide suitable foraging habitat or habitat complexity necessary for migrating salmonids. This condition can be further exacerbated if the margins of the channel are vegetated with the non-native *Egeria densa* which provides excellent cover for ambush predators like largemouth bass. Likewise, residence time required for passage of the fish through the alternative channel determines the duration of exposure to the stressors present in that channel. For example, a short residence time in a channel with extreme predation may have the same effect on survival as a prolonged residence time in a channel with low predation.

The exposures to toxicants in these channels are also likely to vary substantially. Passage through a channel with outfalls from a domestic wastewater treatment facility (WWTF) is likely to have a very different profile of chemical exposure compared to a channel dominated by agricultural return water runoff. A further layer of complexity is created by precipitation events that create the "first flush" effects that discharges surface runoff from urbanized and agricultural areas into local streams and waterways through stormwater conveyance systems or irrigation return ditches. Fish swimming through these plumes are exposed to elevated levels of contaminants, as well as reduced water quality parameters (*e.g.*, lowered dissolved oxygen due to high organic matter loading) that have a high potential for compromising the physiological status of the exposed fish, and increasing the level of morbidity or mortality in those fish. In addition, regional effects such as river flows, tides, and export actions are superimposed on top of these localized effects. These large-scale factors can influence the route taken by the fish initially and subsequently determine its eventual disposition due to changes in local hydraulics and flow patterns.

6.6.2.5.2 Applicable Studies

Based on previous studies to date, it is assumed that fish remaining in the main channel of the Sacramento River have a higher survival rate than fish which move into other distributary channels splitting off from the main channel. Survival indices calculated for paired releases on the lower Sacramento River indicated that Chinook salmon smolts released into Georgiana Slough were between 1.5 times to 22 times more likely to be "lost"[15] to the system than fish released in the main stem of the Sacramento River below the head of Georgiana Slough at the town of Ryde, based on the recoveries of marked fish at Chipps Island (Brandes and McLain 2001, table 3). This is equivalent to a mortality rate of 33 to 95 percent. Statistical analysis by Newman (2008) found an average ratio of survival between the Georgiana Slough releases and the Ryde releases of 0.26, 0.43, and 0.39 for recoveries at Chipps Island, in the ocean harvest, and inland sites where adults were subsequently collected following spawning, respectively. Thus, survival in Georgiana Slough is less than one-half of that in the main stem Sacramento River, based on the Ryde releases. In comparison, Vogel (2004) found that approximately 23.5 percent of the radio tagged fish released in the mainstem Sacramento River during his radio telemetry tagging studies in the winter of 2002 were "lost," presumably to predation, leaving 76.5 percent of the fish reaching the Cache Slough Confluence near Rio Vista. Concurrent releases in Georgiana Slough during January and February of 2002 had mortality rates of 82.1 percent. In a similar study conducted in 2000 by Vogel, when ambient flows in the mainstem were higher (22,000 to 50,000 cfs compared to 14,000 to 23,000 cfs), the predicted predation rate on Chinook salmon smolts in the Sacramento River fell to 20 percent, while predicted predation in Georgiana Slough fell to 36 percent of the released fish. Vogel (2008a) conducted another study with acoustically tagged Chinook salmon smolts released on the Sacramento River near Old Town Sacramento in late 2006 and early 2007. While Vogel (2008a) presented preliminary general statistics, the full statistical analysis of this study will be reported by the U.S. Geological Survey (USGS). This study provided preliminary information on the behavior of fish as they passed side channels within the mainstem of the Sacramento River, and reach specific losses of tagged fish (assumed to be due to predation). Two releases were made, one on December 11-12, 2006 (n=96 fish in 4 groups of 24 fish) and one on January 22-23, 2007 (n=150 fish, released 8 groups). Although Vogel (2008a) presented only general summary statistics, he found that losses of fish that remained in the mainstem during the December study were approximately 20 to 22 percent, while those fish that moved into Georgiana Slough and the open DCC channels

[15] For this discussion loss is equivalent to mortality, although the studies to date cannot determine whether loss is the result of mortality from predation or other sources, or the inability to detect and account for all released fish in the Chipps Island trawls or subsequent ocean recoveries.

experienced much higher levels of loss (55 percent in Georgiana Slough, 80 percent in the DCC). The January 2007 loss rates were slightly higher, approximately 35 percent of the mainstem fish were lost, while approximately 73 percent of the fish that entered Georgiana Slough were lost. A fairly large fraction of fish entered the Sutter Slough and Steamboat Slough reaches (37 percent of the fish in the mainstem) with loss rates of approximately 40 percent (see Vogel 2008a for more details). These data indicate that there are reach specific characteristics for loss rates due to intrinsic factors in those channels (*e.g.*, predation). The release of fish in December occurred approximately three days before the DCC was closed due to rising flows in the Sacramento River (DCC was closed on December 15, 2006 at 1000 hours). Sacramento River flows increased to approximately 26,000 cfs during December before receding. Therefore, fish released in West Sacramento had at most 3.5 days to travel downstream and encounter the open DCC gates and enter into the delta interior through this route. Fish traveling downstream during this release encountered a rising hydrograph on the Sacramento River. Conversely, the January 2007 release had closure of the DCC gates during the entire experimental period, with relatively stable flows below 12,000 cfs.

A more detailed report concerning fish releases in mid December 2006 and mid-January 2007 was provided by Burau *et al*. (2007), which statistically analyzed the distribution and survival of tagged salmon released during the same study as Vogel (2008a; December 11-12, 2006 and January 22-23, 2007). Burau *et al*. (2007) estimated that 22 percent (22.2 ±0.065) of released fish entered Sutter Slough and approximately 4 percent (3.7 ± 0.021 percent) entered Steamboat Slough during the December release, the same percentages as Vogel (2008a). Of the fish that reached the vicinity of the second junction point, approximately 18 percent (17.9 ± 0.057) went into the channel of the DCC, and an additional 20 percent (19.6 ± 0.053) went into the channel of Georgiana Slough. Approximately 62 percent (62.5 ± 0.065) continued downstream in the Sacramento River channel below the second junction point. Following the January releases, with the DCC gates closed for the entire experimental period, approximately 30 percent (29.9 ± 0.046) of the fish entered Sutter Slough and 7 percent (7.2 ± 0.026) entered Steamboat Slough. Of the fish that reached the vicinity of the second junction point, approximately 29 percent (28.9 ± 0.063) entered Georgiana Slough (DCC closed) with the remainder moving downstream in the Sacramento River channel (71.1 ±0.063 percent). The first release in December was made on a rising hydrograph with flows of approximately 19,600 cfs and 3 days before the DCC gates closed in response to the increasing flows. The January releases were made under conditions in which the flows in the Sacramento River were much lower, approximately 11,300 cfs at Freeport. The preliminary results from this study indicate that both route selection and reach specific-survival depend on Sacramento River discharge and DCC gate position. Burau *et al*. (2007) states that these data indicate that: (1) when the DCC gates are closed the probability that salmon are entrained in Sutter, Steamboat, and Georgiana sloughs increases, which is consistent with increases in discharge in each of these channels when the gates are closed; (2) survival in every channel was higher at the higher discharge: survival in the Sacramento River increased by approximately 20 percent between the City of Sacramento and Sutter Slough, by approximately 8 percent in the reach between Steamboat Slough and the DCC, and approximately 15 percent between Georgiana Slough and Cache Slough; (3) survival in Georgiana Slough is consistently lower than in any other channel when survivals were estimated (DCC channel and Mokelumne River survival were not estimated); and finally, (4) the precision in the survival estimates are progressively lower (increasing error bars) the farther into the system the measurements are made due to the reduction in fish passing through the lower reaches of these channels. The number of fish passing through the river sections farther from the release sites are reduced due to: (1) the total number of fish is progressively distributed into a greater number of pathways, and (2) mortality occurs as fish traverse the system, leaving fewer viable fish to traverse channels at a greater distance from the release site. The preliminary results from this study suggest that survival increased with increasing flows in the different river channels when comparisons could be made. The interpretation of the DCC gate position with survival was complicated by the very short duration of the "open" gate configuration (3 days) coupled with an increasing hydrograph during this period. Conversely, the "closed" gate condition occurred during lower river flows than the open gate configuration, and thus the comparison of the gate position is confounded by the flow variable between the two studies.

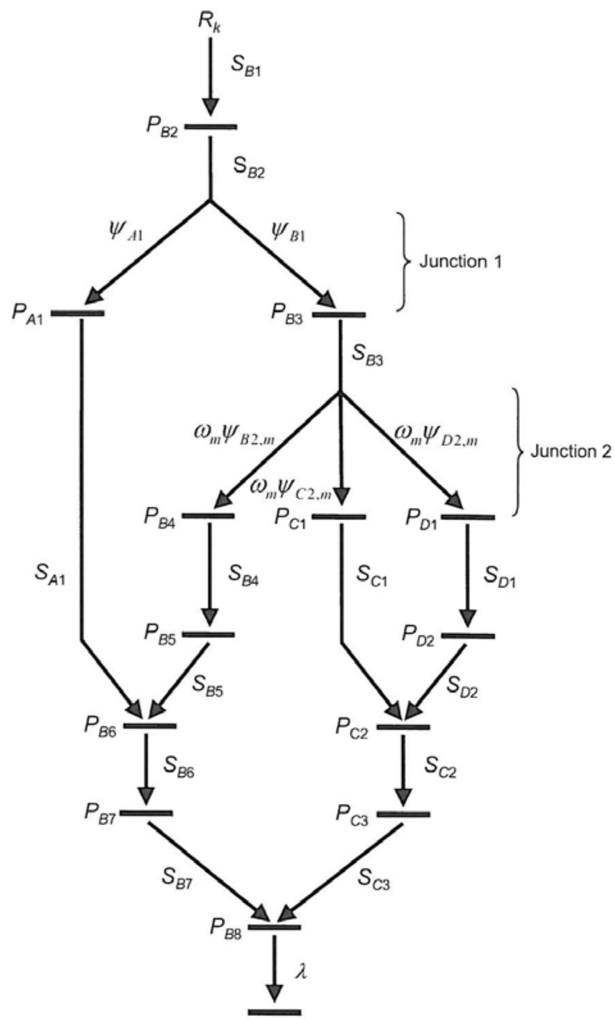
A study run by Perry and Skalski (2008) in the same region and general time frame produced similar results to the Vogel (2008a) and Burau *et al*. (2007) studies in some aspects, but different results in others. They developed a mark-recapture model that explicitly estimated the route-specific components of population-level survival in the Delta. The point estimate of survival through the Delta for the first release made on December 5, 2006 ($\hat{S}_{Delta}$ = 0.351, SE = 0.101, n=66 fish), was lower than the subsequent release made on January 17, 2007 ($\hat{S}_{Delta}$ = 0.543, SE = 0.070, n=80 fish). The authors attributed the observed difference in $\hat{S}_{Delta}$ between releases to (1) changes in the proportion of fish migrating through each distinct route through the Delta, and (2) differences in the survival for each given route traveled. Survival estimates for the routes through the interior of the Delta were lower than for the mainstem Sacramento River during both releases, however only 9 percent of the fish migrated through the interior of the Delta during the January release compared to 35 percent for the December release (table 6-32). The DCC gates closed on December 15, 2006 at 1000 hours, 10 days after the first release of fish on December 5, 2006. Passage data indicated that approximately 95 percent of the fish had passed through the second junction reach by the time the gates were closed. The first release was also made at Sacramento River flows of approximately 11,700 cfs at Freeport. Flows remained below 12,900 cfs until December 9, 2006, giving approximately 4 to 5 days of steady flow before increasing. Approximately 50 percent of the fish were detected arriving at the second junction prior to this date, and 75 percent of the fish had passed by approximately December 12, 2006. In comparison, the release of fish in January corresponded with steady flows of approximately 12,000 cfs for 10 days following the release and the gates in a closed position. Fish passage in January occurred much more quickly than in December, taking only 3 to 4 days to pass through the second junction. Perry and Skalski (2008) concluded that the operation of the DCC gates affected the route selection of fish during the study. The gates were closed on December 15, 2006, approximately half way through the first release study period and remained closed during the entire second study release period. The operation of the DCC affected both route selection and the distribution of flows within the channels of the north Delta. These effects were captured by the mark-recapture modeling of the study (figure 6-74).

Although the Vogel (2008a), Burau *et al*. (2007), and Perry and Skalski (2008) acoustic tagging studies have relatively small sample sizes, each fish provides valuable data concerning route selection, migration speed, and predation (loss) vulnerabilities. The two studies provide information that corresponds to the trends observed in previous CWT studies. These more recent studies verify that survival is lower within the channels of the interior delta and that higher flows benefit survival during fish movement downstream. Although the Vogel (2008a) and Burau *et al*. (2007) studies could not adequately address the effect of DCC gate position on survival due to confounding effects of increasing river flows and the short period between release of study fish and the gate closure, the results from the Perry and Skalski study indicate that population level survival can be increased by closing the gates. This results in reducing the fraction of the fish population entering the inerior of the Delta and increasing the fraction migrating through the northern system of channels, which include the Sacramento River, Sutter Slough and Steamboat Slough channels, where survival was higher relative to the interior Delta. If replications of the acoustic tag studies continue to provide similar outcomes, a more defined and accurate model of routing and predation vulnerabilities can be developed that is statistically robust and could provide a more thorough understanding of the system for ongoing management needs.

Table 6-32. Route-specific survival through the Sacramento-San Joaquin Delta ($\hat{S}_h$) and the probability of migrating through each route (Ψ_h) for acoustically tagged juvenile fall-run released on December 5, 2006, (R_1) and January 17, 2007, (R_2). Also shown is the population survival through the delta (S_{Delta}), which is the average of route specific survival weighted by the probability of migrating through each route (from Perry and Skalski 2008).

Migration Route	Survival $\hat{S}_h$ (SE)	95% Profile Likelihood Interval	Probability of Migratory Route Ψ_h (SE)	95% Profile Likelihood Interval
R_1 ; December 2006 (n=66)				
A) Steamboat & Sutter Sloughs	0.263 (0.112)	0.102, 0.607	0.296 (0.062)	0.186, 0.426
B) Sacramento River	0.443 (0.146)	0.222, 0.910	0.352 (0.066)	0.231, 0.487
C) Georgiana Sloughs	0.332 (0.179)	0.087, 0.848	0.117 (0.045)	0.048, 0.223
D) Delta Cross Channel	0.332 (0.152)	0.116, 0.783	0.235 (0.059)	0.133, 0.361
S_{Delta} (All Routes)	0.351 (0.101)	0.200, 0.692		
R_2: January 2007 (n=80)				
A) Steamboat & Sutter Sloughs	0.561 (0.092)	0.388, 0.747	0.414 (0.059)	0.303, 0.531
B) Sacramento River	0.564 (0.086)	0.403, 0.741	0.498 (0.060)	0.383, 0.614
C) Georgiana Sloughs	0.344 (0.200)	0.067, 0.753	0.088 (0.034)	0.036, 0.170
D) Delta Cross Channel	NA		0.0	NA
S_{Delta} (All Routes)	0.543 (0.070)	0.416, 0.691		

The mainstem Sacramento River channel has generally lower loss rates than the smaller distributary channels that diverge from it and loss rates appear to be affected by river flow levels. The subsequent total survival of fish leaving the Delta at Chipps Island is the sum of survival rates in each route multiplied by the probability of selecting that route multiplied by the "detection" probability for that group from all of the different potential routes that fish may take upon entering the north Delta from the Sacramento River, including the Yolo bypass in flood. This survival number is the fraction of total fish entering the Delta, which have avoided all of the potential sources of mortality to survive to Chipps Island. The number of fish entering the Delta from the Sacramento River is itself approximately 20 percent of the total number of fish that started migrating downstream in the Sacramento River from their natal rearing areas (MacFarlane *et al*. 2008a). This low survival number is due to the intrinsic losses in the migrating population of fish as they encounter the natural and anthropogenic sources of mortality along the migration route.



A1 = Steamboat Slough/Sutter Slough, B1 = West Sacramento, B2 = Freeport, B3 = Courtland, B4 = Walnut Grove/upstream of the DCC, B5 = Ryde, B6 = Rio Vista, B7 = Emmaton, B8 = Chipps Island, B9 = pooled survival from SF Bay stations (λ), C1 = Georgiana Slough, C2 = lower Mokelumne River system, C3 = Antioch/ lower San Joaquin River, D1 = DCC, D2 = Downstream of DCC, upper branches of Mokelumne River. Releases (R_k) are made into the Sacramento River at West Sacramento. Junction 1 is the reach which includes the Steamboat/Sutter Slough junction with the Sacramento River, Junction 2 is the river reach which contains the Sacramento River with the DCC and Georgiana Slough.

Figure 6-74. Schematic of the mark recapture model used by Perry and Skalski (2008) used to estimate survival (S_{hi}), detection (P_{hi}), and route entrainment (ψ_{hi}) probabilities of juvenile late-fall Chinook salmon migrating through the Sacramento-San Joaquin River Delta for releases made on December 5, 2006, and January 17, 2007.

Population level survival through the Delta was estimated from the individual components as:

$$S_{Delta} = \sum_{h=A}^{D} \psi_h S_h$$

where h = the four potential routes, A – D; A = Sutter/Steamboat Slough, B = Sacramento River, C = Georgiana Slough, and D = Delta Cross Channel.

Telemetry tagging also was instrumental in describing movement patterns in the channels of the Central Delta (Vogel 2004, radio telemetry) and the South Delta (SJRGA 2008, acoustic telemetry). Fish released in the mainstem San Joaquin River near Fourteenmile Slough in the spring of 2002 and 2003 showed distinct movement patterns based on the level of export pumping and tides. When the combined exports created negative flows in the channels feeding into the South Delta, (*i.e.*, Turner and Columbia Cuts), a significant proportion of the released fish moved into those channels and were followed in a southerly direction towards the pumps. Conversely, when the VAMP experiment reduced export levels and increased flows in the San Joaquin River, more fish stayed in the main channel of the San Joaquin River and headed downstream with the net flow towards San Francisco Bay. This study also determined that Chinook salmon smolts were not "holding" on the flood tide and then going downstream with the ebb tide (tidal surfing behavior). Fish were observed to move significant distances with the tidal oscillation, and their net movement downstream did not occur at obvious times of the tidal cycle. The data from this study and the North Delta study indicate that fish may be vulnerable to flow split selection several times depending on the magnitude and timing of the tidal oscillation, thus the probability of selecting one route over another is more complex than just a one time exposure to the channel split (see also Horn and Blake 2004). The acoustic tagging studies conducted during the VAMP experiments (SJRGA 2007) indicated that fish responded to flow and presumably export levels when moving downstream in the San Joaquin River past Turner and Columbia Cuts, and the mouths of Middle and Old River. The study also found that fish could pass through the culverts on the HORB and be subsequently detected downstream at the CVP and SWP facilities. Likewise, some fish that passed by the HORB and continued downstream into the Delta proper, were also detected moving southwards towards the pumps, presumably under the influence of the net negative flows in those channels. Preliminary predation hot spots, (*e.g.*, the scour hole in front of the HORB) were also detected, as well as areas with potential water quality concerns (City of Stockton WWTF outfall), which corresponded to increased losses of tagged fish passing through those reaches.

The tagging data and the results of theoretical particle tracking models (see Kimmerer and Nobriga 2008) support the position that movement of fish (or particles), at least in part, are influenced by the inflow of water into the Delta from the surrounding tributaries, and the volume of water being exported from the Delta by the CVP and SWP, thus affecting the flow patterns within the Delta channels. While the correlation of the survival rates of fish released in the Delta Action 8 and the Interior Delta CWT studies with the percentages of particles reaching Chipps Island is poor under most of the runs, Kimmerer and Nobriga (2008) offer potential causes for these differences. They opine that the lack of correlation may be merely due to the differences in the behavior between salmon and neutrally buoyant particles, or, on the other hand, that artifacts of the experiments such as the survival potential of fish traveling through the different waterways (*i.e.*, predation on the CWT fish) or the lack of efficiency in the trawl recapture rates for Chipps

Island biases the results of the CWT studies and results in lower numbers of fish reaching the terminal endpoints than suggested by the PTM results. They conclude that "despite all these differences, the PTM results suggests that river flow may be an important variable in determining which way the salmon go and their probability of survival, and should be included in the design and analysis of future studies" (Kimmerer and Nobriga 2008 page 19). Operations of the CVP and SWP, since they are supplied by the flow of water in the Sacramento and San Joaquin Rivers, set the hydraulic boundary conditions in conjunction with the two main sources of water flowing into the Delta. The boundary conditions, in part, dictate the flow percentage splits into distributary channels, in concert with the overlying tidal signal (see Horn and Blake, 2004). Operations of program infrastructures, such as the DCC radial gates and the South Delta temporary barriers, further influence the probability of entrainment into side channels leading off of the main river channel. The influence of the export pumps becomes more pronounced the closer to the pumps the fish or experimental particle gets, until entrainment is essentially certain.

DWR created a Delta Survival Model as part of their declarations to the court in September, 2008 (Greene 2008). The model provides estimates of survival through the Delta interior for a population of "fish" that enter the Delta from the Sacramento River. The model, using inputs for exports and Delta inflow, calculates percentage splits of the migrating fish population moving downstream in the Sacramento River into the interior of the Delta. The percentage splits are based on PTM simulations with injection points at Hood (upstream of the DCC and Georgiana Slough and indicating movement into the Delta interior) and in the South Mokelumne River (movement towards the export facilities in the South Delta and westwards towards Chipps Island). Interpolation of data provided in the Newman (2008) analysis estimated non-export and export related loss encountered in the Delta based on export levels. From the data output of the model, a final estimate of the survival through the Delta can be derived with losses calculated for export and non-export related mortality. The model is strongly driven by the export/inflow ratio which determines the PTM output and hence the particle fates (*i.e.*, fish) and by the export rate which determines relative survival rate between the Sacramento River and the Delta interior and the export related interior Delta survival rate. NMFS biologists used the summary output from the three studies (7.0, 7.1, and 8.0) simulated with the CALSIM II model over the different water year types for the months between December and June to estimate the different rates of mortality expected under the different CALSIM II scenarios for emigrating salmonids. Loss associated with exports ranged from 0.3 percent of the total population entering the Delta to slightly more than 15 percent of the population entering the Delta over the different simulation runs. The loss associated with non-export factors ranged from 3.3 percent to approximately 31.5 percent of the population. Total survival of the emigrating fish population was estimated to range between 41 and 77 percent. The data indicated that lower survival rates were predicted when E/I ratios were high, and more particles were moved into the Delta interior and thence southwards towards the export facilities. Losses were higher in drier years and during the early season of fish migration (December through February). The data also indicated that the near future and future studies would have higher levels of loss due to higher export levels and thus higher E/I ratios.

6.6.2.5.3 Environmental Factors

In addition to the "direct" effects of the CVP and SWP operations manifested by flows and exports, the modification of the Delta hydraulics for the conveyance of water has altered the suitability of the Delta for native species of fish, such as Chinook salmon, steelhead, and green sturgeon. Since the inception of the CVP and later the SWP, the natural variability in the hydrology of the Delta has been altered. As previously explained, the amount and timing of runoff from the Sacramento and San Joaquin Rivers has been altered and shifted to accommodate human needs. When large-scale exports of water were initiated in the South Delta, it became necessary to "freshen up" the Delta to guarantee high quality fresh water was available to export from the facilities on a reliable basis (*e.g.*, construction of the DCC). This necessitated an increase in the stability of the Delta's hydrology and the formation of a large freshwater "lake" for the reliable conveyance of water from the river sources to the export facilities. The enhanced stability of the freshwater pool in the Delta enabled non-native species, such as centrarchids and catfish, as well as invasive plants, such as *Egeria densa* and water hyacinth, to thrive in this "new" Delta hydrology (Brown and Michniuk 2007). In addition, the altered ecological characteristics of the Delta have been proposed as a contributing factor in the recent Pelagic Organism Decline (POD) observed in the Delta. The combination of these exotic species and altered ecological characteristics of the Delta interact to decrease the suitability of the Delta for native species of fish and have increased the potential for predation and loss (see 2008 CVP/SWP operations BA, Delta smelt sections for a more detailed explanation).

6.6.2.5.4 Summary

Many of the indirect mortality events are interrelated to the operations of the CVP and SWP. As previously discussed, the Delta has been operated as a freshwater conveyance instrument for the past half century. The necessity for the stable and reliable transfer of freshwater from the Sacramento River across this large expanse of waterways has required that natural hydrologies and circulation patterns be altered to maximize the efficiency of the water operations. This change has benefited non-native species to the detriment of native species, which evolved with a more dynamic habitat, which included variable hydrographs and seasonal fluxes of salinity into the western Delta. In light of the POD phenomenon that has become evident in the Delta in recent years, the aspect of a bottom to top reorganization of the ecosystem during the past decade indicates that the Delta is "unhealthy" and even the exotic, introduced species (*i.e.*, striped bass, thread fin shad, *etc*.) are in decline. Continued operations of the CVP and SWP are unlikely to benefit the health of the Delta, and increases of the facility operations are likely to degrade the system beyond their current conditions, rather than return the Delta to a more natural condition, with more functional hydraulics conducive to a healthy ecosystem.

6.6.2.6 Assess Risk to Individuals

This section summarizes the potential risks faced by individual fish of the winter-run population, the spring-run population, the CV steelhead population, and the Southern DPS of green sturgeon in the Delta region. The previous sections have described in detail, the effects of the proposed export operations on these fish.

Increased pumping, as proposed in the project description will increase the vulnerability of individual fish to entrainment at the TFCF and the SFPF in the South Delta. Salmonids entrained at the Federal facility, the TFCF, have a maximal survival estimate of approximately 35 percent under normal operating conditions. However this survival rate may decrease even further depending on louver cleaning frequency, pumping operations, and predation following CHTR releases. The survival rate of salmonids at the state's facility, the SFPF, is estimated to be approximately 16 percent under normal operating conditions. Unlike the Federal facility, where most of the salmonid loss is attributed to the louvers, the state's facility has relatively efficient louvers, but substantially greater predation risks. Predation loss within CCF is the main variable driving survival of entrained fish with little difference evident between the smaller salmon smolts and the larger steelhead smolts. It is estimated that only one out of every four to five fish entering the forebay survive their transit across this water body to be salvaged at the louvers. This predation risk is dependent on predator density and behavior in the forebay. Additional changes to the survival estimate can occur due to changes in export levels at the Banks Pumping Plant and predation risks following release back into the system at the CHTR release stations. It is unknown what percentages of juvenile and sub-adult green sturgeon are lost at the fish collection facilities. Based on the studies by Kynard and Horgan (2001), salvage rates should be almost 100 percent for green sturgeon based on the efficiencies for shortnose and pallid sturgeon. However, cleaning of the louvers where the louvers are lifted out of their guides and reductions in flow along the louver face during export reductions may degrade the louver efficiency for green sturgeon and loss of individual fish becomes greater under such conditions.

Salmonids are also subject to loss as they cross the Delta during their downstream migration towards the ocean. As shown by the Burau *et al*. (2007), Perry and Skalski (2008) and Vogel (2008a) studies, individual fish risk entrainment into the channels of Georgiana Slough under all conditions and into the Mokelumne River system when the DCC gates are open as they migrate downstream in the Sacramento River. Estimated average survival is only 33 percent with a range of approximately 10 percent to 80 percent survival. Most of this loss is believed to be associated with predation, but may also include prolonged exposure to adverse water quality conditions represented by temperature or contaminants. Several years of salmonid survival studies utilizing both CWT and acoustically tagged fish indicate that survival is low in the interior Delta waterways compared to the mainstem Sacramento River. Likewise, survival in the upper San Joaquin River between Durham Ferry and Jersey Point is substantially lower than survival from Jersey Point to Chipps Island (VAMP studies), indicating that transiting the Delta interior is a very risky undertaking for fish exiting from the San Joaquin River basin or the east side tributaries (Mokelumne and Calaveras River basins). The probability of ending up at the Delta export facilities or remaining in the interior delta waterways increases with increased export pumping, particularly for those fish in the San Joaquin River system.

NMFS estimates that loss associated with exports for fish emigrating downstream in the Sacramento River and entering the Delta ranged from 0.3 percent of the total population entering the Delta to slightly more than 15 percent of the population entering the Delta based on the different CALSIM II simulation runs for current (Study 7.0), near future (Study 7.1) and future conditions (Study 8.0) and the Delta Survival Model developed by DWR. The loss associated with non-export factors ranged from 3.3 percent to approximately 31.5 percent of the population.

Total survival of the emigrating fish population from the Sacramento River basin was estimated to range between 41 and 77 percent for fish entering the Delta and subsequently reaching Chipps Island in the western edge of the delta. These values most accurately represent losses to winter-run Chinook salmon and spring-run Chinook salmon since loss rates in the DWR model were constructed from studies of CWT tagged Chinook salmon. NMFS will also use these loss rates for CV steelhead migrating downstream in the Sacramento River for lack of species-specific studies for steelhead predation losses. Loss rates due to predation in the CCF were similar between the smaller Chinook salmon smolts and the larger steelhead smolts, and therefore provide a level of justification in making this assumption. The loss of juvenile and sub-adult green sturgeon in the delta due to exports is unknown. To date, NMFS is not aware of any studies designed to quantify the loss of these fish to export related actions. Only recently have acoustic tagging studies been undertaken to study the movement of fish through the delta and results are still being interpreted by the study investigators. The fact that some individual green sturgeon are collected at the export fish salvage facilities indicates that these fish are vulnerable to the exports and may incur population level effects. Loss rates for CV steelhead emigrating from the San Joaquin River basin and the east side tributaries of the Calaveras River and Mokelumne River systems are expected to be substantially higher than those experienced by the Sacramento River basin fish due to the proximity of the main migration corridor (the San Joaquin River) to the export facilities. Stronger flow effects from the pumps are observed on the San Joaquin River waterways and the nature of the south Delta channels provide multiple access points to the exports when water is being diverted.

Loss rates at the export facilities typically account for several hundred to several thousand individual wild fish per year from the different salmonid populations. As previously discussed, the importance of these wild fish to the population is potentially greater than their actual numbers. These fish represent individuals who have survived the numerous stressors present in the system between their natal streams and the Delta, and therefore represent behavioral and physiological traits that are necessary for survival in the natural environment. Loss of these individuals represents a loss of survival traits that would be beneficial to the population as a whole.

An historical assessment of estimated survival of fall-run smolts through the Delta by water year type at different levels of development in the Central Valley was calculated by Kjelson and Brandes (1989). They found that water development has adversely affected smolt survival over the period spanning 1920 to 1990. The authors reggressed smolt survival estimates on the Sacramento River with river flows at the City of Sacramento and applied this to monthly estimates of smolt migration through the Delta. These parameters were then used to calculate average survival rates using estimated historic flow patterens at Sacramento under four different water development scenarios. The results indicted that reduced inflow to the Delta caused by water development in the Sacramento Valley has reduced smolt survival substantially (table 6-33). The greatest differences in survival occurred in dry and critical years. The estimated maximum decrease in survival associated with the 1990 level of development occurred with the no development scenario. The authors estimated that between 1940 and 1990, survival of fall-run smolts decreased about 30 percent. These are considered minimal estimates of survival decline, since greater survival per unit flow would have occurred prior to the operations of the

DCC in the 1950s than was deduced form the current survival relationships. Survival is more than likely less now than the estimates for the 1990 level of development due to the increased demands in the Central Valley over the intervening 20 years.

Table 6-33. Average estimated Delta survival indices of fall-run Chinook salmon smolts by water year type at different levels of development: unimpaired (no development), and at 1920, 1940, and 1990 levels of development (Table 7 in Kjelson and Brandes 1989).

Water Year Type	Sample Size	Unimpaired No Development	1920 Level of Development	1940 Level of Development	1990 Level of Development
Wet	**19**	**0.97**	**0.92**	**0.91**	**0.83**
Above Normal	**10**	**0.91**	**0.85**	**0.83**	**0.61**
Below Normal	**10**	**0.84**	**0.69**	**0.66**	**0.41**
Dry	**10**	**0.76**	**0.57**	**0.55**	**0.33**
Critical	**8**	**0.33**	**0.17**	**0.21**	**0.12**
Mean		**0.76**	**0.64**	**0.63**	**0.46**

Annual survivals were estimated by weighting monthly survival indices by the average percent from 1978 to 1986 of total outmigrants going to sea (Table 6 in Kjelson and Brandes 1989). Monthly survival indices were estimated from monthly flows using linear relationships between salmon survival and flow at Sacramento where y = 0.00005x – 0.465 when y = survival and x = mean monthly Sacramneto River flow. Data from 1969-71 and 1978-81 were used to derive the equation. Monthly flows for the four different levels of developemnt were obtained from the California Department of Water Resources planning simulation Model studies.

6.6.2.7 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

The proposed export actions represent an adverse impact to the PCEs of the designated and proposed critical habitats in the Delta region. As discussed in the preceding effects section, the exports divert a substantial amount of water (approximately 6 to 8 MAF annually) from the Delta environment. The hydraulic changes created by the export actions have altered the suitability of the delta as a rearing area and migratory corridor for juvenile salmonids, particularly for Central Valley steelhead which has designated critical habitat in the accessible waterways throughout the entire legal Delta. Likewise, the proposed critical habitat for the Southern DPS of green sturgeon encompasses the accessible waterways of the Delta, and overlaps the geographical area of the designated critical habitat for CV steelhead. Designated critical habitat for winter-run and spring-run is primarily confined to the north Delta region and the waterways associated with the main channel of the Sacramento River.

The effects of the CVP/SWP on the rearing qualities of the Delta are related to the removal or reduction of potential forage species from the Delta environment. Juvenile salmonids and green sturgeon rely on both benthic and pelagic microinvertebrates for their forage base. The actions of the exports directly remove the pelagic forms of these microinvertebrates (copepods, diatoms, cladocerans, *etc*.) through water diversion while also indirectly affecting the benthic forms.

These forage species rely on food webs in which phytoplankton and detritus serve as energy sources. Removal of the phytoplankton from the Delta due to water diversions by the CVP/SWP exports disrupts the flow of energy available to these other pelagic and benthic invertebrate communities, as well as reduces the creation of detrital matter from the decomposition of these organisms in the system along with other organic matter.

The actions of the CVP and SWP contribute to the degradation of the waterways in the Delta as migratory corridors. As described in the effects of the export actions above, emigrating juvenile salmonids are adversely affected by the withdrawal of water from the Delta by the export pumps. The flow of water southwards towards the pumps disrupts the natural flow cues used by emigrating salmonids to reach the lower estuary and the ocean beyond. The alteration in the hydrodynamics can entrain fish southwards from the Central Delta towards the pumps, delay migration by disrupting the normal flow cues associated with net downstream flow, and increase the vulnerability of fish to predation by lengthening their migratory route or directing them into new channels not normally used for emigration to the ocean. The effects on San Joaquin River basin steelhead are most pronounced as the conservation value of the migratory corridors in the south and central Delta are the most degraded. Under current conditions, few steelhead are expected to successfully reach the western Delta and the ocean beyond. Impacts to juvenile and sub-adult green sturgeon are less clear as these fish spend 1 to 3 years rearing in the Delta environment before transitioning to their marine life history stage. During this Delta rearing phase, fish are free to migrate throughout the Delta. Entrainment by the net negative export flows in the central and southern delta may cause fish to be pulled into the southern Delta waterways in an unnatural proportion to their normal movements. Ongoing acoustic tracking studies should provide more detailed information on the movements of this life stage in the Delta.

6.6.3 Clifton Court Aquatic Weed Control Program

6.6.3.1 Deconstruct the Action

The SWP has proposed treating the waters of Clifton Court Forebay with copper-based herbicides, including Komeen®, Nautique® and copper sulfate pentahydrate to reduce the standing crop of the invasive aquatic weeds or algal blooms growing in the water body. The dominant species of aquatic weed in the forebay is *Egeria densa*, however other native and invasive aquatic weeds are present. Excessive weeds fragment and clog the trashracks and fish screens of the Skinner Fish Protection Facility reducing operating efficiency and creating conditions in which the screens fail to comply with the appropriate flow and velocity criteria for the safe screening of listed fish. In addition, the weeds create sufficient blockage to the flow of water through the trashracks and louver array, that the pumps at the Banks Pumping Facility begin to reduce the water level downstream of the Skinner Facility and the loss of hydraulic head creates conditions that lead to cavitation of the impeller blades on the pumps if pumping rates are not quickly reduced. The algal blooms do not affect the pumps, but rather reduce the quality of the pumped water by imparting a noxious taste and odor to the water, rendering it unsuitable for drinking water.

DWR has applied herbicides in Clifton Court Forebay since 1995, typically during the spring or early summer when listed salmonids have been present in the forebay. Applications, however, have occurred as early as May 3rd and as late as September 10th during this time. Copper based herbicides present toxicity issues to salmonids and green sturgeon due to their high sensitivity to copper at both sublethal and lethal concentrations.

DWR, in response to NMFS' concern over the use of Komeen® during periods when listed salmonids may be present in the Clifton Court Forebay, has altered its operational procedure for application of copper-based herbicides from previous operations. DWR has proposed to apply copper sulfate or Komeen® between July 1 and August 31 of each year as needed. In addition, DWR will conduct the following actions:

1. Monitor the salvage of listed fish at the Skinner Facility prior to the application of the herbicides in Clifton Court Forebay.
2. Close the radial intake gates at the entrance to Clifton Court Forebay 24 hours prior to the application of herbicides to allow fish to move out of proposed treatment areas and towards the salvage facility.
3. The radial gates will remain closed for 24 hours after treatment to allow for at least 24 hours of contact time between the herbicide and the treated vegetation in the forebay. Gates will be reopened after a minimum of 48 hours.
4. Komeen® will be applied by boat, starting at the shore and moving sequentially farther offshore in its application. Applications will be made be a certified contractor under the supervision of a California Certified Pest Control Advisor.
5. Application of the herbicides will be to the smallest area possible that provides relief to the project.
6. Monitoring of the water column concentrations of copper is proposed during and after herbicide application. No monitoring of the copper concentration in the sediment or detritus is proposed.

6.6.3.2 Assess the Species Exposure

The timing of the application of the aquatic herbicide Komeen® to the waters of the forebay will occur during the summer months of July and August. The probability of exposing salmonids to the copper-based herbicide is very low due to the life history of Chinook salmon and steelhead in the Central Valley's Delta region. Migrations of juvenile winter-run and spring-run fish primarily occur outside of the summer period in the Delta. The presence of juvenile winter-run and spring-run in the Delta is described in *Section 5.5 Status of the Species and Critical Habitat in the Delta Division.* CV steelhead have a very low probability of being in the South Delta during the July through August period proposed for herbicide treatments. Historical salvage data indicates that in wet years, a few steelhead may be salvaged as late as early July, but this is uncommon and the numbers are based on a few individuals in the salvage collections. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the temperatures would be incompatible with salmonid life history preferences, generally exceeding 70ºF by mid-June. In contrast, juvenile and sub-adult green sturgeon are recovered year-round at the CVP/SWP facilities, and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown at present. Therefore, juvenile and sub-adult green sturgeons are likely to be present during the application of the copper-based herbicide Komeen®.

6.6.3.3 Assess Species Response to the Application of Herbicides for the Aquatic Weed Control Program in Clifton Court Forebay

Previous applications of Komeen® have followed the label directions of the product, which limits copper concentration in the water to 1,000 µg/L [1 part per million (ppm) or 1,000 parts per billion (ppb)]. Under the current proposal, DWR intends to apply Komeen® at a working concentration in the water column of 640 ppb as Cu^{2+} from the Komeen® formulation. The copper in Komeen® is chelated, meaning that it is sequestered within the Komeen® molecule and is not fully dissociated into the water upon application. Therefore, not all of the copper measured in the water column is biologically available at the time of application. Toxicity studies conducted by the California Department of Fish and Game (CDFG 2004a, b) measured the concentrations of Komeen® that killed 50 percent of the exposed population over 96 hours (96hr-LC_{50}) and 7 days (7d LC_{50}) as well as determining the maximum acceptable toxicant concentration level (MATC) to exposed organisms. CDFG found that the 96hr-LC_{50} for fathead minnows (*Pimephales promelas*) was 310 ppb (180 – 530 ppb 95 percent confidence limit) and the 7d- LC_{50} was 190 ppb. The MATC was calculated as 110 ppb Komeen® in the water column. Splittail (*Pogonichthys macrolepidotus*), a native cyprinid minnow, was also tested by CDFG. The 96hr-LC_{50} for splittail was 510 ppb.

NMFS did not find toxicity data for exposure of sturgeon to Komeen®, however exposure to other compounds including pesticides and copper were found in the literature (Dwyer *et al*. 2000, Dwyer *et al.* 2005a, b). From these studies, sturgeon species appeared to have sensitivities to contaminants comparable to salmonids and other highly sensitive fish species. Therefore, NMFS will assume that green sturgeon will respond to Komeen® in a fashion similar to that of salmonids and should have similar mortality and morbidity responses.

Pacific salmonids (*Oncorhynchus* spp.) are very susceptible to copper toxicity, having the lowest LC_{50} threshold of any group of freshwater fish species tested by the EPA in their Biotic Ligand Model (BLM; EPA 2003a) with a Genus Mean Acute Value (GMAV) of 29.11 µg/l of copper. In comparison, fathead minnows (*Pimephales promelas*), the standard EPA test fish for aquatic toxicity tests, have a GMAV of 72.07 µg/l of copper. Therefore, salmonids are approximately 3 times more sensitive to copper than fathead minnows, the standard test fish in EPA toxicity testing. NMFS assumes that sturgeon will have a similar level of sensitivity. Hansen *et al.* (2002) exposed rainbow trout to sub-chronic levels of copper in water with nominal water hardness of 100 mg/l (as $CaCO_3$). Growth, whole body copper concentrations, and mortality were measured over an 8-week trial period. Significant mortality occurred in fish exposed to 54.1 µg/l copper (47.8 percent mortality) and 35.7 µg/l copper (11.7 percent mortality). Growth and body burden of copper were also dose dependent with a 50 percent depression of growth occurring at 54.0 µg/l, but with significant depressions in growth still occurring at copper doses as low as 14.5 µg/l after the 8-week exposure.

In a separate series of studies, Hansen *et al.* (1999a, b) examined the effects of low dose copper exposure to the electrophysiological and histological responses of rainbow trout and Chinook salmon olfactory bulbs, and the two fish species behavioral avoidance response to low dose copper. Chinook salmon were shown to be more sensitive to dissolved copper than rainbow trout and avoided copper levels as low as 0.7 µg/l copper (water hardness of 25 mg/l), while the rainbow trout avoided copper at 1.6 µg/l. Diminished olfactory (*i.e.*, taste and smell) sensitivity reduces the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprinting of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen *et al.* 1999b). The olfactory bulb electroencephalogram (EEG) responses to the stimulant odor, L-serine (10^{-3} M), were completely eliminated in Chinook salmon exposed to ∃50 µg/l copper and in rainbow trout exposed to ∃200 µg/l copper within 1 hour of exposure. Following copper exposure, the EEG response recovery to the stimulus odor were slower in fish exposed to higher copper concentrations. Histological examination of Chinook salmon exposed to 25 µg/l copper for 1 and 4 hours indicated a substantial decrease in the number of receptors in the olfactory bulb due to cellular necrosis. Similar receptor declines were seen in rainbow trout at higher copper concentrations during the one-hour exposure, and were nearly identical after four hours of exposure. A more recent olfactory experiment (Baldwin *et al.* 2003) examined the effects of low dose copper exposure on coho salmon (*O. kisutch*) and their neurophysiological response to natural odorants. The inhibitory effects of copper (1.0 to 20.0 µg/l) were dose dependent and were not influenced by water hardness. Declines in sensitivity were apparent within 10 minutes of the initiation of copper exposure and maximal inhibition was reached in 30 minutes. The experimental results from the multiple odorants tested indicated that multiple olfactory pathways are inhibited and that the thresholds of sublethal toxicity were only 2.3 to 3.0 µg/l above the background dissolved copper concentration. The results of these experiments indicate that even when copper concentrations are below lethal levels, substantial adverse effects occur to salmonids exposed to these low levels. Reduction in olfactory response is expected to increase the likelihood of morbidity and mortality in exposed fish by impairing their homing ability and consequently migration success, as well as by impairing their ability to detect food and predators [Also see the technical white paper on copper toxicology issued by NMFS (Hecht *et al.* 2007)]. Given that sturgeon use their sense of smell and tactile stimulus to find food within the bottom substrate, degradation of their olfactory senses could diminish their effectiveness at foraging and compromise their physiological condition through decreases in caloric intake following copper exposure.

In addition to these physiological responses to copper in the water, Sloman *et al.* (2002) found that the adverse effect of copper exposure was also linked to the social interactions of salmonids. Subordinate rainbow trout in experimental systems had elevated accumulations of copper in both their gill and liver tissues, and the level of adverse physiological effects were related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, is presumed to lead to increased copper uptake across the gills due to elevated ion transport rates in chloride cells. Furthermore, excretion rates of copper may also be inhibited, thus increasing the body burden of copper. Sloman *et al.* (2002) concluded that not all individuals within a given population will be affected equally by the presence of waterborne copper, and that the interaction between dominant and subordinate fish will determine, in part, the physiological response to the copper exposure. It is unknown how social interactions affect juvenile and sub-adult green sturgeon in the wild.

Current EPA National Recommended Water Quality Criteria and the California Toxics Rule standards promulgate a chronic maximum concentration (CMC) of 5.9 µg/l and a continuous concentration criteria of 4.3 µg/l for copper in its ionized form. The dissociation rate for the chelated copper molecule in the Komeen® formulation was unavailable at the time of this consultation, so that NMFS staff could not calculate the free ionic concentration of the copper constituent following exposure to water. However, the data from the CDFG toxicity studies indicates that a working concentration of 640 ppb Komeen® will be toxic to salmonids if they are present, either causing death or severe physiological degradation, and therefore green sturgeon would likely be similarly affected based on their similar sensitivities to copper toxicity.

6.6.3.4 Assess Risks to Individuals

The proposed modifications to the herbicide application program's period of application (July 1 through August 31) will substantially avoid the presence of listed salmonids in the Clifton Court Forebay due to the run timing of the juveniles through the Delta. As described earlier, Central Valley steelhead smolts may arrive during any month of the year in the delta, but their likelihood of occurrence is considered very low during the summer months of July and August. It also is highly unlikely that any winter-run or spring-run will be present during this time period in the South Delta. Unlike the salmonids, however, representatives of the Southern DPS of green sturgeon are routinely salvaged during the summer at both the CVP and SWP fish salvage facilities. This is related to their year round residency in the Delta during their first 3 years of life. The numbers salvaged typically increases during the summer (see figure 4-11). It is therefore likely that individuals from the Southern DPS of green sturgeon will be exposed to the copper herbicides, and based on the comparative sensitivities of sturgeon species with salmonids, some of these fish are likely to be killed or otherwise negatively affected. The exact number of fish exposed is impossible to quantify, since the density of green sturgeon residing or present in the forebay at any given time is unknown. The short duration of treatment and rapid flushing of the system will help to ameliorate the adverse conditions created by the herbicide treatment.

The application of Komeen® to Clifton Court Forebay under the Aquatic Weed Control Program will not affect the populations of winter-run or spring-run. These populations of salmonids do not occur in the South Delta during the proposed period of herbicide applications and thus exposure to individuals is very unlikely. Since no individual fish are exposed, population level effects are absent. Exposure of CV steelhead is also very unlikely; however some individual fish may be present during July as indicated by the historical salvage record and thus occurrence of fish in the forebay during the Komeen® treatment is not impossible. The numbers of steelhead that may be potentially exposed to the copper-based herbicide is believed to be very small, and therefore demonstrable effects at the population level resulting from Komeen® exposure are unlikely.

The effects to the green sturgeon population are much more ambiguous due to the lack of information regarding the status of the population in general. Although NMFS estimates that few green sturgeons will be exposed during the 2 to 3 days of herbicide treatment; the relative percentage of the population this represents is unknown. Likewise, the number of green sturgeon that reside in the forebay at any given time and their susceptibility to entrainment is also unknown. This uncertainty complicates the assessment of both population and individual exposure risks. This area of green sturgeon life history needs further resolution to make an accurate assessment of the impacts to the overall status of the population.

6.6.3.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

Clifton Court Forebay is not part of the designated critical habitat for CV steelhead and thus actions taken within the forebay itself do not affect PCEs in the Delta for rearing habitat or migratory corridors. The design of the herbicide application protocol prevents movement of the copper-based herbicide from the forebay into the waters of the Delta outside of the forebay through the closure of the radial gates. After the exposure period, residual herbicide is pulled into the California Aqueduct via the pumps when the radial gates are opened to let in fresh water from the Delta. The flushing of the forebay with external Delta water should reduce any remaining Komeen® to insignificant levels and move the treated water volume into the aqueduct system of the SWP. There should be no discernable effects on designated critical habitat outside of the forebay. The proposed critical habitat for the Southern DPS of green sturgeon also does not include the forebay. As previously discussed above, measures to prevent movement of the copper-based herbicide outside of the forebay treatment area should preclude any discernable effects on proposed critical habitat for green sturgeon.

6.6.4 South Delta Improvement Program – Stage 1

6.6.4.1 Deconstruct the Action

The South Delta Improvement Program (SDIP) Stage 1 involves the placement of four permanent gates in the channels of the South Delta already affected by the temporary rock barriers installed under the TBP action. Three of the location, Old River at Tracy, Middle River near Victoria Canal, and the Head of Old River are essentially the same as the locations for the temporary barriers previously discussed in section 5.6.3. The fourth location, the channel formed by Fabian - Bell and Grant Line Canals will have the permanent structure located several miles to the west of the temporary barrier location. The permanent operable gate will be near the confluence of the Fabian - Bell and Grant Line Canal channel with Old River. This location is between the CVP and SWP facilities on Old River just south of Coney Island. For a short period, during the construction of the permanent gates, the rock barriers will continue to be installed and operated and there will be an overlap between the two actions. NMFS expects that the operation of the permanent gates proposed for the SDIP will have many of the same effects as described for the TBP in regards to changes in the regional hydrodynamics and the increase in predation levels associated with the physical structures and near-field flow aspects of the barriers. The effects of the temporary barriers have been described in NMFS (2009). The CALSIM II and DSM 2 modeling conducted for this consultation incorporated the permanent barriers into the modeling assumptions for Studies 7.1 and 8.0 while including the temporary barriers as part of the current conditions under the assumptions for Study 7.0. Therefore, individual effects of the barriers on the future conditions must be inferred from the modeling output, or derived from other sources of information. The future baseline conditions include the ongoing natural and anthropogenic activities in the Delta not associated with the project (levees, dredging, contaminants, urban development, non-native species, predation, *etc*.). NMFS considers the 4-month winter "no barrier" situation to be the most conservative future baseline condition with regard to the TBP. It represents a "no action" condition for the barrier operations. In winter, the HORB is completely removed while the majority of the three agricultural rock barriers are removed, leaving only portions of the the side abutments containing the culverts remaining in the river channel. The channels are open to river flow and tidal circulation with a minimum of channel obstruction. The projects would be operated to Study 7.0, the purported baseline condition present under current operations in the simulation modeling. Addition of the barriers in spring is in response to the ongoing export actions of the project and the requirement to provide suitable water surface elevations in the south Delta for agricultural diversions.

As described in previous sections, future pumping rates are expected to increase during the April and May time frame over the current conditions due to the reduction in "environmental" water available to make export curtailments. Although the reduction in "environmental water" is not related to the proposed SDIP action, it does coincide with the proposed operations of the permanent gates in April and May, and therefore has bearing on the effects of the gates on fish drawn into the South Delta by the export actions. Based on the description and analysis for the SDIP in the draft EIR/EIS (DWR 2005) and the SDIP Action Specific Implementation Plan (DWR 2006), the stated purposes for the permanent gates, includes maintaining surface water elevations for South Delta agricultural diverters and enhancing the flexibility to operate the CVP and SWP exports without impacting the South Delta diverters. Operations of the inflatable gates from June through November likewise enable the projects to more frequently sustain higher levels of pumping within regulatory and operational parameters by avoiding impacting South Delta water elevations and reducing the electrical conductivity levels in the South Delta waterways. It does this by "trapping" high quality Sacramento River water upstream of the permanent operable gates and redirecting its flow within the channels to improve water quality and circulation between the three agricultural gates. During the flood tide, higher quality water with Sacramento River origins flows upstream past the position of the gates and provides the desired water quality conditions within the South Delta channels. Without the gates, this higher quality water would flow back downstream on the ebb tide and not provide the desired water quality improvements upstream of the gate positions during all phases of the tidal cycle.

6.6.4.2 Assess Species Exposure

The permanent operable gates proposed under the SDIP action will be present year round in the four locations in the South Delta identified for the operable gates. Winter-run juveniles will be exposed to the effects of the gates from December through June when they have been documented to occur in the channels of the South Delta based on the salvage records of the projects. Predation associated with the physical structures of the operable gates will occur year round and effect juvenile winter-run when they are present in the vicinity of the gates. Operations of the gates will occur from April through November and affect juvenile winter-run when they are present during this time period (April through June). In addition to predation, delays in migration and hydraulic effects linked to the operation of the inflatable gates will affect winter-run juveniles during this period. No adult winter-run are expected to be present at any time in the channels influenced by the operable gates.

Juvenile spring-run are expected to be present from January through June based on historical salvage records. Predation associated with the physical structures of the operable gates will occur year round and effect juvenile spring-run when they are present in the vicinity of the gates. Operations of the gates will occur from April through November and affect juvenile spring-run from approximately April through June. In addition to predation, delays in migration and hydraulic effects linked to the operation of the inflatable gates will affect juvenile spring-run during this period. No adult spring-run are expected to be present at any time in the channels influenced by the operable gates.

CV steelhead smolts may be present from approximately November through the end of June based on historical salvage records. Predation associated with the physical structures of the operable gates will occur year round and affect steelhead smolts when they are present in the vicinity of the gates. Operations of the gates will occur from April through November and affect juvenile spring-run from approximately April through June and late fall (November). In addition to predation, delays in migration and hydraulic effects linked to the operation of the inflatable gates will affect steelhead smolts during this period. Adult steelhead from the San Joaquin River basin are expected to be present in the channels influenced by the operable gates during their upstream spawning run. This is typically the fall through the winter period (September through approximately March) with the highest numbers occurring in December.

Green sturgeon have the potential to be present year round in the areas affected by the operable gates. Historical salvage records indicate that juveniles (≈130 mm to 750 mm) have been salvaged in every month of the year at the CVP and SWP fish collection facilities. Fishing records (CDFG 2008) provided by the new sturgeon report card for sport fishermen indicate that adults and sub-adults are caught by fisherman year round in the San Joaquin River.

6.6.4.3 Assess Species Response to the Proposed Action

The operation of the permanent agricultural gates allows the manipulation of water circulation in the channels of the South Delta by redirecting flows "upstream" in Old and Middle rivers and downstream through Grant Line and Fabian/Bell canals. This redirection of flows in the channels of the South Delta is accomplished through the operation of the inflatable gates ("Obermeyer" style dams). Gates are fully deflated when the downstream tidal elevations match the upstream water elevations. At this time, flooding tides are allowed to flow over the fully lowered dam and into the channels upstream of the gate structures. Estimates of the volume of flood tide allowed to pass over the gates are approximately 80 percent of the unimpeded flow without the barriers (or their operations). The current temporary rock barriers allow significantly less, water to flow over them, passing approximately 50 percent of the unimpeded tidal flow upstream of the barriers. The current temporary barriers present a greater physical barrier to tidal upstream flows, allowing water to pass through the culverts or over the top of the weir when tidal elevations are sufficient, while blocking a large fraction of the tidal volume with the rock weir structure.

After the flood tide has reached its peak, the gates are inflated and their crest elevations manipulated to retain the water pushed upstream by the flood tides before it starts to recede on the ebbing tide. By manipulating the elevations of the three agricultural dams (Old River at Tracy, Grant Line/ Fabian–Bell, and Middle River), water circulation can be "forced" to move through the channels in whichever direction deemed necessary for circulation needs. Under proposed operations, the crests of the Obermeyer dams at Old River at Tracy and Middle River will be retained at slightly higher elevations than the dam crest on Grant Line/ Fabian-Bell Canal. Typically, flow will not be allowed to move back over these two dam crests on the falling tide, since the crests of the two dams will be maintained above the high tide elevation (Appendix 1 to this Opinion, pages 133-134). The remaining dam on Grant Line/ Fabian–Bell Canal will be operated to maintain a minimum water surface elevation of 0.00 feet msl in the channels of the South Delta. This method of gate operations results in a larger volume of water past the locations of the inflatable gates on each flood tide (80 percent of normal tidal volume). This "cell" of water will then essentially become trapped behind the inflated gates and forced to flow progressively "upstream" in the direction of the lowest dam crest elevation between the three agricultural barriers. Frequently this means the net flow is negative to the normal flow of water in the channel, such as in Old River and Middle River. The larger volume of water will carry any fish within that body of water with it above the barrier. It is expected that these fish will then be exposed to predation pressures above the barriers, changes in water quality conditions that may occur, and irrigation diversions associated with South Delta agriculture.

Under the current temporary barriers operational conditions, fish (*i.e.*, juvenile salmon, steelhead) that have not been entrained by the SWP at Clifton Court Forebay, or the CVP pumps have the potential to move upstream on the incoming flood tide into the channels of Old River or Grant Line/Fabian-Bell Canal. These fish are currently blocked by the rock barriers upstream of the project facilities. Fish are also likely to enter Middle River before encountering the project facilities farther south in the Delta and likewise encounter the rock weir on Middle River upstream of its confluence with Victoria Canal. These conditions are also encountered on the rising tide in future operations by the upright Obermeyer dams located on these channels. In the current conditions, some fish pass upstream through the tied open culverts (typical spring operations for Delta smelt protection), prior to the tide overtopping the crest of the rock weir. Under future conditions, no fish will pass upstream until the dam is deflated. Once the dam is deflated however, a greater proportion of the fish congregating below the barrier will be entrained upstream of the gate, and thus more will be "trapped" by the raised gate on the falling tide due to the greater volume of water passed through the position of the gate. The differences in the level of predation associated with the alternative operations protocols between barriers and gates are difficult to determine without empirical data. Both scenarios are likely to have high levels of predation associated with their implementation. In both cases, fish are blocked, at least initially, in their movement upstream on the flooding tide by the structures. In the current operations, some fish are passed through culverts, and predation is expected to be high following their discharge from the culverts on the down current side of the culvert where predators are expected to be waiting to prey on the disoriented fish [detailed analysis provided in NMFS

(2009)]. In both the current and future operations, fish are expected to be carried past the main portion of the barriers when tidal levels reach their peak. In the current operations, fish would be carried over the top of the weir through a turbulent flow field. It is expected that predators will be located on either side of the weir and that some of those predators down current of the barrier will follow the prey fish upstream over the weir. Some prey fish may remain below the barrier and attempt to flee to the margins of the channel or into the deeper water at the foot of the barrier. In the future operational conditions, the Obermeyer dam will drop to its fully open position on the channel floor once downstream water elevations are equal to the upstream water elevations. This creates an essentially unimpeded channel cross section at the barrier location which allows for almost total unobstructed flow upstream. This design is intended to have flows always moving upstream with the flooding tide, thus fish will move with the current upstream. Predators will likely follow the prey species upstream above the barrier location, and will be "trapped" with them following the inflation of the dam on the ebbing tide. Predation rates will be dependent on predator density and occurrence of prey species in the channels, as well as length of exposure to the predators in these channels.

The physical structures of the permanent barriers also create predator habitat within the channels of the South Delta. The designs of the four barriers include substantial amounts of riprapped levee facing coupled with sheet pile walls. The sheet pile walls have large indentations created by the corrugated nature of the metal sections, with each section having an approximately 36-inch long by 18-inch deep depression associated with it (DWR 2006). At each barrier location, the foundation for the multiple Obermeyer dam sections comprising the barrier will span the entire width of the channel (several hundred feet). The width of the foundation for each Obermeyer dam section is approximately 10 to 15 meters and is not completely flat to the channel bottom, but rises slightly due to the curved hydrofoil shape of the dam structure itself. Preliminary design drawings indicate that at low tide, water elevations over the dam will only be a few feet (approximately 1 to 1.5 meters at the Middle River and Old River at Tracy sites, slightly deeper, approximately 2 meters, at the Head of Old River) except for the Grant Line/ Fabian–Bell location which will be installed in deep water (6 m deep). This condition is expected to create localized turbulent flow over the structure on a fine spatial scale. Fine scale flow disruption creates microhabitats by increasing the complexity of the boundary layer along the channel bottom or margins. Predators can utilize these microhabitats to hold station in while waiting for prey to pass by. This disruption of the flow field is on the order of a few meters or less and would not be captured by the hydraulic modeling previously done for the project. An example of such microhabitat would be a boulder or ledge in a stream, which provides relief from the stream flow to a fish, such as a trout, holding below it. The placement of the four gates will ensure that any fish entering the channels of the South Delta, whether from the San Joaquin River side via the Head of Old River or from the western side via one of the three channels with gates, will have to negotiate at least two gates to move through the system. The argument that the gates only occupy a small footprint in the South Delta and therefore do not create an additional risk of predation is false. The physical structures of the gates create a point where predation pressure is increased and which migrating fish must negotiate to complete their downstream journey if they enter the South Delta channels. The environmental stressors created by the implementation of the SDIP will add to the already existing stressors present in the San Joaquin River basin.

The analysis of the SDIP presented in the draft EIR/EIS (DWR 2005 Appendix J) also included numerous PTM runs which analyzed various combinations of flow, export pumping levels, and gate operations (and by reference SDIP gate operations at the Head of Old River). The particle tracking simulations conducted for the SDIP proposal indicated that entrainment in the lower San Joaquin River watershed is of great concern to fisheries management. In the simulations without the HORB installed, nearly 100 percent of the particles injected above the Head of Old River split at Mossdale are entrained by the CVP and SWP pumps after 30 days, regardless of the level of pumping at the two facilities. This situation is greatly exacerbated when flows on the San Joaquin River flow are less than or equal to the level of exports. Entrainment of particles injected at other points in the South Delta, along the San Joaquin River as far west as Jersey Point, and in the Mokelumne River/ Georgiana Slough system are also subject to entrainment. The PTM results indicate that the rates of entrainment increase in concert with increasing pumping rates when the flows on the San Joaquin River are low. The conclusions drawn from these findings are that even with a 30-day reduction in pumping (*i.e.*, a VAMP-like scenario or an EWA style export curtailment) significant levels of particle entrainment still occurs in the channels of the South Delta and Central Delta and that 30 days of pumping reduction may not be sufficient to reduce overall entrainment. This situation is exacerbated by low inflows from the San Joaquin River basin, even if delta outflow is increasing due to higher Sacramento River flows occurring simultaneously.

Entrainment of particles from the North Delta region and the Sacramento River also can be significant under the baseline operational conditions tested in the SDIP proposal. Particle injections made at Freeport with the DCC open, exports at the CVP equal to 4,600 cfs and the SWP equal to 6,680 cfs, had project entrainment levels of 50 to 60 percent depending on the Delta outflow level (5,000; 7,000; and 12,000 cfs). Even with the higher Delta outflow levels, approximately 15 percent of the particles “lingered” within the Delta after the 30-day period of the simulation run. This scenario represents the type of conditions expected in the late fall and early winter before the DCC is closed (October through January) and represented by the CALSIM II modeling for the CVP/SWP operations consultation.

Therefore, the simulations completed for the SDIP (DWR 2005) indicate that under typical conditions found in the South Delta with low San Joaquin River inflows, nearly all the particles entering the South Delta from the San Joaquin River basin will be entrained by the project exports. The “zone of entrainment” extends into the central and northern regions of the Delta, with particles either being entrained directly by the project exports or “lingering” in the south Delta after 30-days of simulation. This “baseline” operational condition is further degraded by the future export increases modeled in Studies 7.1 and 8.0 as modeled in the CVP/SWP operations BA, which have extended periods of elevated pumping levels over the current conditions.

The PTM simulations for the SDIP proposal also addressed the gate operations at the Head of Old River during VAMP conditions. Results indicated that when the gate was in, the level of entrainment for the Mossdale injections was still exceptionally high and nearly all of the particles were either captured by the project exports at the CVP and SWP or other diversions in the South

Delta (approximately 30 to 50 percent) or otherwise retained within the waterways of the South and Central Delta. With the Head of Old River gate closed, particles travelled downstream in the San Joaquin River past Stockton, but were subsequently entrained into the channels of Turner and Columbia Cuts, Middle River, and Old River. The radio and acoustic telemetry work done by Vogel (2004) and SJRGA (2007) support this aspect of the modeling results. Another characteristic of the closed Head of Old River gate condition is the increase in entrainment of particles released farther downstream in the San Joaquin River system at Prisoners Point and Jersey Point as well as in the Mokelumne River system. Since exports could not divert water from the San Joaquin River entering through the Head of Old River, the additional water was pulled from the lower San Joaquin River reaches, thus increasing the risk of entrainment in these lower segments. This characteristic of the hydraulic environment created by the Head of Old River gate places fish entering the Central Delta from the Sacramento River at greater risk of entrainment. The simulated fraction of particles escaping the Delta and reaching Chipps Island was consistently low under all of the tested parameters for passive particles, never exceeding 15 percent of the Mossdale injections. The highest San Joaquin River flow to export pumping ratio tested was 2:1 with 3,000 cfs combined pumping coupled with 7,000 cfs San Joaquin River outflow (reduced pumping scenario). This resulted in 14.9 percent of the particles reaching Chipps Island after 30 days. In simulations where the Head of Old River gate was not installed, a lower percentage of the particles reached Chipps Island then under the gate installed situation, having been quickly entrained into Old River and subsequently captured at the CVP.

Based on the PTM simulations and the initial results of radio and acoustic telemetry studies, the proposed SDIP still has significant effects on San Joaquin River basin fish. The eventual entrainment of San Joaquin River fish by the SWP and CVP after they have passed the head of Old River through the channels lower down on the San Joaquin River (*e.g.*, Turner and Columbia Cuts) is contradictory to the stated purpose of the fish barrier portion of the SDIP proposal. The agricultural gates component of the proposal benefits agricultural interests without apparent detriment to those interests and allows the CVP and SWP to enhance their water diversion opportunities by providing greater flexibility to their operations within the constraints of existing regulatory criteria. As described previously, the agricultural gates and the enhanced pumping regimen under studies 7.1 and 8.0 are detrimental to listed fish occurring in the South Delta, regardless of their origins (*i.e.*, spring-run from the Sacramento River or CV steelhead from the San Joaquin River basin) and the proposed action (which include the enhanced pumping schedule under studies 7.1 and 8.0) will increase the loss of fish over the current conditions. The purported benefit of the SDIP proposal to fisheries management was the Head of Old River gate, which was supposed to reduce the entrainment of fall-run originating from the San Joaquin River basin during their spring out migration period. CV steelhead migrating from the San Joaquin Basin during the Head of Old River gate operations were also believed to have been protected by the gate. Based on the PTM simulation results and the telemetry findings, this protective aspect of the Head of Old River operable gate appears to be overstated, and in fact the operation of the gate may place fish entering the system from other tributaries such as the Calaveras River, Mokelumne River, and Sacramento River at greater risk of entrainment when it is in operation. In order to achieve the proposed benefits of the operable gate at the Head of Old River, reductions in exports, coupled with increases in San Joaquin River flows to move fish through the system are needed. Without these concurrent actions, the full benefit of the operable gate cannot be realized. The proposed SDIP action did not make this linkage part of the operations.

6.6.4.4 Assess Risks to Individuals

Many of the effects described in NMFS (2009) for the TBP apply to the proposed SDIP action. The significant difference is the additional predation impacts that can occur during the December through March period. Under the SDIP action, physical structure remains in the channel year round and thus provides habitat and hydraulic conditions that are beneficial to predators in the area. NMFS expects that this will increase the predation potential for listed salmonids present in the South Delta channels during this period. Migratory delays are not anticipated to occur during this period due to the gates lowered condition. Passage past the locations of the gates during the winter period should not be affected except for the previously mentioned predation issues.

NMFS does not anticipate that the permanent gates will increase predation on green sturgeon during the winter period. As described in NMFS (2009), any green sturgeon present in the South Delta channels are typically large enough to be at low risk of predation by predators such as largemouth bass or striped bass. The operations of the gates in the period between April and November may impede passage during the gates up condition, but passage should be available when the gates are lowered during the flood tide.

Spring-run Chinook salmon - The affects to the spring-run population under the SDIP actions are expected to be comparable to the effects already described for the temporary barriers discussion in NMFS (2009). Since approximately 80 percent of the spring-run population presence occurred during the April through June period, the predation effects and migrational delays should be similar in magnitude between the two projects. The difference between the two actions is the additional predation risk to early migrating spring-run prior to April. These fish would encounter the permanent physical structures of the SDIP gates and the predator issues associated with them. NMFS does not expect more than approximately 3 percent of the total annual spring-run population in the Central Valley to be present in the South Delta waters within the vicinity of the permanent gates.

Winter-run Chinook salmon – Since the permanent gates are in place year round, the entire population of winter-run that enter the waters of the South Delta has the potential to encounter the predation effects associated with the SDIP gates. This is in contrast to the temporary barriers, in which only 3 percent of the winter-run population in the South Delta was exposed to the rock barriers during the April through June period of their operations. Migrational delays should be similar to those described for the temporary barriers in NMFS (2009). The period of gate operations during winter-run presence is the same as previously described for the operations of the rock barriers. NMFS anticipates that approximately 3 percent of the winter-run population is present in the waters of the South Delta within the vicinity of the permanent gates and the export facilities when the permanent gates will be operated for water surface elevation control.

Central Valley steelhead – The permanent gates have the potential to affect all of the CV steelhead that move through the South Delta. Previously, only about 9 percent of the annual presence of steelhead in the South Delta was affected by the temporary barriers and their operations. Due to the year round presence of the physical structures in the channels of the South Delta related to the permanent gates, steelhead smolts are exposed to the predation issues whenever they are present in the waters adjacent to the gate locations. Delays in migration should remain comparable to the temporary barriers, affecting only 9 percent of the annual steelhead presence in the South Delta, since the operations of the permanent gates occur during the same months as the temporary barriers' operations. However, San Joaquin River basin steelhead are disproportionately affected due to their close proximity to the project and the overlap of their migratory corridor with the action's location. Adult effects should also be comparable between the two actions. This should primarily be delays in migration due to gate operations, rather than blockage of migration since the gates are operated in concert with the tidal stages in the south Delta.

Green Sturgeon – The proposed SDIP permanent barriers will be operated during the same seasonal periods as has been done previously for the TBP (April through November). Therefore, effects to the green sturgeon population are expected to generally be comparable between the two programs. The operations of the permanent gates may expose more fish during the operational season to migrational delays due to the tidal operation of the gates allowing passage upstream of the gates; however, the length of delay should be considerably shorter than the temporary barriers due to the same tidal operations which allow the gates to be opened on each tidal cycle, thereby allowing the opportunity for sturgeon to pass downstream of the gates. Nevertheless, the permanent gates do represent a barrier to free movement of fish in the waterways of the South Delta even if it is only for a short time.

Little is known about the population size or the movements of green sturgeon within the Delta, therefore assessments of population effects are difficult at best to make. In order to make any reasonable assessment, the number of green sturgeon present in the population, as well as the frequency of occurrence in the South Delta would need to be known. NMFS does not have this information. Monitoring studies using acoustic tags aimed at assessing the behavior of green sturgeon in relation to the barriers and the movements of green sturgeon within the channels of the South Delta are planned for the near future but have not been implemented to date.

6.6.4.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

The conservation value of CV steelhead designated critical habitat in the South Delta will be degraded as a result of the SDIP impacts. Part of the intrinsic values of the PCEs listed for critical habitat in the South Delta is unobstructed passage of emigrating fish through the region. This characteristic of the PCE's will be permanently modified by the construction and operation of the proposed barriers as well as additional risks of entrainment and predation presented by the modified pumping environment fostered by the SDIP proposal. As described above, listed steelhead will be prevented from using portions of the Delta by the Head of Old River permanent gate. Migration will be restricted to one channel initially until the fish pass the Port of Stockton. The risk of entrainment by the export facilities appears to have been delayed until the fish pass into the lower sections of the river, rather than prevented as proposed. Furthermore, delays in migration appear to be a distinct possibility following the movement of steelhead into the lower San Joaquin River below the Port of Stockton. The functioning of the lower San Joaquin River as a migratory corridor has not been improved by the action; rather migration has been redirected into only one possible route to avoid adverse impacts in another migratory route. Although the selected mainstem San Joaquin River route apparently has better overall survival than the southern Delta waterways, it does place the San Joaquin River basin at increased risk for catastrophic events that could impact the one selected migratory route, particularly since the selected route passes a major waste water treatment plant in the City of Stockton and the industrialized Port of Stockton. Accidental chemical spills are potential catastrophes that could severely impact a given year class or more depending on its severity.

In addition to the installation of the gates, the SDIP proposes to dredge certain channels of the South Delta to enhance conveyance of water for agricultural diversion and circulation flow patterns (portions of Old and Middle River), reduce scouring (West Canal), and increase water depth for private water diversions located upstream of the proposed agricultural gates. This will, at the minimum, reduce the benthic communities in the affected channels for a short period of time until the substrate is recolonized. It is also likely that the profile of the new benthic community will be different than surrounding areas for a considerable period of time (climax community versus disturbed community effect) as well as whether native or exotic species are better situated to take advantage of the newly disturbed substrate. These newly created channels with greater depth will also alter the community complexity and species profiles of organisms that will inhabit them. For instance, greater depth may alter the species profiles of predatory fish inhabiting these channels by providing additional cover in the form of deeper waters in the dredged channels thus allowing larger predatory fish or greater numbers of fish to inhabit them. Listed fish will more than likely pass through these channels when the Head of Old River permanent gate is not in operation, and the altered habitat will become part of their migrational corridor. It is likely that the value of the future aquatic habitat within the boundaries of the proposed SDIP project will reflect a more degraded value to migrating San Joaquin River basin CV steelhead compared to the current situation. The proposed action does not incorporate any actions to enhance the aquatic environment beyond its current standing nor does it reverse any of the anticipated adverse alterations to the aquatic habitat considered above. Therefore, NMFS believes that the future habitat condition will be adversely modified and provide a less suitable suite of PCEs to listed steelhead that will diminish their likelihood of survival through the South Delta. Likewise, the value of the aquatic habitat to fall-run will be diminished by the SDIP proposal. Although fall-run are unlisted, they share similar habitat requirements with CV steelhead for migration and rearing and their future use of the habitat will be adversely modified by the proposed actions. Therefore the value of the South Delta waterways as essential fish habitat also will be diminished.

The waterways of the South Delta have also been proposed as critical habitat for the Southern DPS of green sturgeon (September 8, 2008, 73 FR 52084). Like the CV steelhead, green sturgeon critical habitat in the South Delta requires unobstructed passage through the channels of the South Delta during their rearing and migratory life stages. The operation of the barriers as proposed will create obstructions to their free passage when the gates are in their upright positions. It is unknown whether sturgeon will volitionally move against the current of an incoming tide to pass back downstream over the barriers when they are lowered on the incoming flood tide. Furthermore, the duration of time in which the gates are lowered compared to the periods in which they are raised is unequal. The gates are predominately in the raised position throughout the tidal cycle, except for the few hours they are lowered on the incoming tides. DWR and Reclamation believe that theoretically sturgeon may pass through the boat locks associated with the barriers during their operations and thus not be obstructed in their passage. This theory has not been proven satisfactorily by the information provided in their analysis. It is based on the belief that the boat locks will be used frequently enough to allow fish to move through the structures without undue delays. Unlike the Suisun Marsh Salinity Control Gates, the boat locks will not be left open the majority of the time, but will remain closed to retain stage elevations until needed for boat passage.

6.6.5 Delta Cross Channel

6.6.5.1 Deconstruct the Action

The DCC was constructed by Reclamation in the early 1950s to redirect high quality Sacramento River water southwards through the channels of the Mokelumne River system towards the South Delta and the CVP pumps at Tracy. This modification of the Delta's hydraulics prevented the mixing of the Sacramento River water with water in the western Delta, with its higher salinity load, prior to diverting it to the CVP pumps. Originally the gates remained open except during periods of high Sacramento River flow (> 20,000 to 25,000 cfs) when scouring of the channel or flooding risks downstream of the gates warranted closure. Currently, Reclamation operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce saltwater intrusion rates in the western Delta.

The conditions for closing the DCC gates to protect fishery resources were first instituted in the State Water Resource Control Board's D-1485 decision in 1978. In 1995, the Water Quality Control Plan (WQCP) for the Bay Delta (95-1) instituted additional operations of the DCC for fisheries protection (SWRCB 1995). These criteria were reaffirmed in the SWRCB's D-1641 decision. The DCC gates may be closed for up to 45 days between November 1 and January 31 for fishery protection purposes. From February 1 through May 20, the gates are to remain closed for the protection of migrating fish in the Sacramento River. From May 21 through June 15, the gates may be closed for up to 14 days for fishery protection purposes. Reclamation determines the timing and duration of the closures after discussion with USFWS, CDFG, and NMFS. These discussions will occur through the water operations management team (WOMT) as part of the weekly review of CVP/SWP operations. WOMT uses input from the Salmon Decision Process to make its gate closure recommendations to Reclamation.

The Salmon Decision Process (CVP/SWP operations BA Appendix B) includes "Indicators of Sensitive Periods for Salmon" such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the Salmon Decision Process. The Salmon Decision Process is used by the fishery agencies and project operators to facilitate the complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions.

The primary avenue for juvenile salmonids emigrating down the Sacramento River to enter the interior Delta, and hence becoming vulnerable to entrainment by the export facilities, is by diversion into the DCC and Georgiana Slough. Therefore, the operation of the DCC gates may significantly affect the survival of juvenile salmonids emigrating from the Sacramento River basin towards the ocean. Survival in the Delta interior is considerably lower than the mainstem Sacramento River. This has previously been discussed in section 6.6.2.5 *Indirect Mortality Within the Delta*.

6.6.5.2 Assess the Species Exposure

The proportion of juvenile Chinook salmon that enter the Delta from the Sacramento River is given in table 6-34. Salvage and loss across months (http://www.usbr.gov/mp/cvo/fishrpt.html) represents fish presence in the South Delta (table 6-27). The closure of the DCC gate under the current schedule protects 100 percent of the migrating fish from February 1 through May 20 from entering the DCC channel and entering the Mokelumne River system through Snodgrass Slough. Prior to February 1, the gates can be closed for up to 45 days between November 1 and January 31 (maximum 50 percent). After May 20, the gates can be closed for up to 14 days through June 15.

Table 6-34. The proportion of juvenile Chinook salmon and steelhead production entering the Delta from the Sacramento River by month.

Month	Sacramento River Total[1,2]	Fall-Run[3]	Spring-Run[3]	Winter-Run[3]	Sacramento Steelhead[4]
January	12	14	3	17	5
February	9	13	0	19	32
March	26	23	53	37	60
April	9	6	43	1	0
May	12	26	1	0	0
June	0	0	0	0	0
July	0	0	0	0	0
August	4	1	0	0	0
September	4	0	0	0	1
October	6	9	0	0	0
November	9	8	0	03	1
December	11	0	0	24	1
Total	100	100	100	100	100

Notes:
[1] Mid Water trawl data
[2] All runs combined

[3] Runs from Sacramento River basin only
[4] Rotary screw trap data from Knights Landing
Source: DWR and Reclamation (2005 Tables J-23 and J-24, Appendix J).

Winter-run Chinook salmon - Prior to the DCC gate closures in February, approximately 44 percent of the annual winter-run juvenile population is vulnerable to entrainment into the DCC. Emigration of winter-run juveniles during December and January accounts for nearly all of this entrainment. Loss records from the CVP and SWP fish collection facilities (http://www.usbr.gov/mp/cvo/fishrpt.html) have a slightly lower fraction of the winter-run juvenile population present in the Delta during December and January (≈21 percent of the annual total), which may represent the lag in movement across the delta or potentially holding and rearing behavior. The majority of adult winter-run will migrate upstream through the Delta during the period when the DCC gates are closed.

Spring-run Chinook salmon – Only 3 percent of the annual juvenile spring-run emigration occurs prior to February in the Sacramento River basin. However, this fraction represents the yearling spring-run life history stage, an important alternative to the more common YOY life history stage where fish emigrate during their first spring after hatching. Spring-run juveniles are not represented in the salvage and loss records at the CVP/SWP facilities until March and April. Adult spring-run migrating through the Delta will encounter the DCC gates in both the closed position prior to May 15 and the open gate configuration after May 15.

Central Valley steelhead – Approximately 7 percent of the steelhead form the Sacramento River basin emigrate prior to February in any given year and thus would be vulnerable to open DCC gates and diversion into the Delta interior. Steelhead begin showing up in the salvage at the CVP and SWP fish collection facilities in January and February and most likely represent the steelhead moving out of the Mokelumne system during December and January. Adult steelhead are likely to encounter the DCC gates in both an open and closed configuration through out their extended spawning migration. Most steelhead have entered the Sacramento system prior to February and therefore would have been exposed to open gates.

Green sturgeon – Little is known about the migratory behavior of juvenile green sturgeon in the Sacramento River basin. It is likely that juvenile green sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. It is likely that these fish will enter the Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta. More information is required to accurately assess the migratory movements of juvenile sturgeon in the river system, as well as their movements within the Delta during their rearing phase in estuarine/Delta waters. Adult green sturgeon are likely to encounter closed DCC gates during their upstream spawning migration in winter and early spring, but encounter open gates during their downstream migration in summer and fall following spawning.

6.6.5.3 Assess Species Response to the Proposed Action

The DCC can divert a significant proportion of the Sacramento River's water into the interior of the Delta. The DCC is a controlled diversion channel with two operable radial gates. When fully open, the DCC can allow up to 6,000 cfs of water to pass down the channel into the North and South Forks of the Mokelumne River in the central Delta (Low *et al*. 2006, CVP/SWP operations BA Appendix E). During the periods of winter-run emigration (*i.e*., September to June) through the lower Sacramento River, approximately 45 percent of the Sacramento River flow (as measured at Freeport) can be diverted into the interior of the Delta through the DCC and Georgiana Slough when both gates are open. When the gates are closed, approximately 15 to 20 percent (as measured at Freeport) of the Sacramento River flow is diverted down the Georgiana Slough channel[16] (CVP/SWP operations BA Appendix E). Peak flows through Georgiana Slough can be almost 30 percent of the Sacramento River flows. Together, the DCC and Georgiana Slough can divert nearly half of the Sacramento River's flow into the Delta interior.

In most years, the peak of winter-run emigration past the DCC occurs from late November through February, based on USFWS trawl and seining data (USFWS 2001, 2003, 2006; Low *et al.* 2006, DWR 2005); when 10 to 25 percent of the Sacramento River flow can be diverted through the DCC and an additional 17 to 20 percent is diverted down Georgiana Slough. There is little change between the current and future conditions (Study 7.0 compared to Studies 7.1 and 8.0). Kjelson and Brandes (1989) found that survival of tagged Chinook salmon smolts was negatively correlated (r= -0.63) with the percentage of water diverted through the DCC from the Sacramento River. When diversion rates were high (> 60 percent) with the DCC gates open, the survival of smolts released above the DCC was about 50 percent less than those releases which occurred below the DCC. When the gates were closed, there was no difference between the two release points under high flow conditions, however, under low flow conditions, the survival of the upper release point was about 25 percent less than the downstream release point. Kjelson and Brandes (1989) attributed this lower survival rate to the effect of the fish being diverted into Georgiana Slough. Low *et al.* (2006) found significant linear relationships between the proportion of Sacramento River flow diverted into the interior of the Delta in December and January and the proportion of the juvenile winter-run lost at the CVP/SWP export facilities. Analysis of 2-week intervals found highly significant relationships between these proportions in late December (December 15 to 31) and early January (January 1 to 15) periods before the DCC gates are closed. A series of studies conducted by Reclamation and USGS (Horn and Blake 2004) supports the previous report's conclusion of the importance of the DCC as an avenue for entraining juvenile salmonids into the central Delta. These studies used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the river during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night to entrainment into the DCC than during the day, due to their higher position in the water column and the depth of the lip to the DCC channel mouth (-2.4 meters). The study concluded that juvenile Chinook salmon entrainment at a channel branch will not always be proportional to the average amount of flow

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[16] Instantaneous percentages can be much higher depending on the interaction of river flow and tidal flow as describe in Horn and Blake (2004).

entering that branch, and can vary considerably throughout the tidal cycle. Furthermore, secondary circulation patterns can skew juveniles into the entrainment zones surrounding a given branch, thus resulting in a disproportionately high entrainment rates. This characteristic was observed in the recent acoustic tagging studies (Burau *et al*. 2007, Perry and Skalski 2008, Vogel 2008a) experiments at the mouth of Sutter and Steamboat sloughs. The percentage of fish selecting the alternative routes from the mainstem Sacramento River was different than the percentage of water entering the channel, indicating spatial distribution in the channel may play an important role in entrainment rates.

Fish that are diverted into the Delta interior and survive the high loss rates migrating through Georgiana Slough and the lower Mokelumne River system are eventually discharged into the San Joaquin River system near RM 22. As presented previously in the Delta Division discussion, changes in Delta hydrodynamic conditions associated with CVP and SWP export pumping inhibit the function of Delta waterways as migration corridors. When pumping is elevated, the flows in the river reaches surrounding this confluence are directed towards the export facilities, indicated by negative flows in Old and Middle River. Additional loss is experienced during this movement of fish towards the CVP/SWP facilities and throughout the salvage process. With mandatory closure of the DCC gates from February 1 through May 20 (pursuant to current criteria in SWRCB D-1641), approximately 50 percent of juvenile winter-run outmigration and 70 to 90 percent of the steelhead and spring-run juveniles migrating downstream in the Sacramento River are not exposed to the open DCC gate configuration and are therefore expected to have a greater likelihood of remaining in the Sacramento River (including Sutter and Steamboat sloughs) and surviving to Chipps Island. These fish will be less vulnerable to decreased survival rates through the Delta interior and any subsequent losses related to the effects of CVP and SWP Delta export pumping from the San Joaquin River confluence southwards. That segment of the respective salmonid populations which migrates earlier than the mandatory closures will be exposed to the effects of the DCC gates when they are in the open configuration. All fish will be exposed to entrainment into Georgiana Slough, which has the potential to capture approximately 15 to 20 percent of the downstream migrants moving past it.

Several years of USFWS fisheries data indicate that the survival of salmon smolts in Georgiana Slough and the central Delta is significantly reduced when compared to the survival rate for fish that remain in the Sacramento River (Kjelson and Brandes 1989, Brandes and McLain 2001). Data from investigations conducted since 1993 with late fall-run during December and January are probably the most applicable to emigrating steelhead and spring-run yearlings due to their comparable sizes. These survival studies were conducted by releasing one group of marked (*i.e.*, CWT and adipose fin clipped) hatchery-produced salmon juveniles into Georgiana Slough, while a second group was released into the lower Sacramento River. Results have repeatedly shown that survival of juvenile salmon released directly into the Sacramento River while the DCC gates are closed are, on average, two to eight times greater than survival of those released into the central Delta via Georgiana Slough (CDFG 1998, Newman 2008). More recent acoustic tagging studies support these earlier findings (Perry and Skalski 2008) indicating that when the DCC is closed, survival through the delta can increase approximately 50 percent compared to open DCC conditions (35.1 percent survival with the DCC open versus 54.3 percent survival with the DCC closed; data from Perry and Skalski 2008). In comparison, Burau *et al*. (2007) found that increasing flows influenced survival in the Sacramento River, *e.g.*, higher flows correlated to higher survival in the different channels. These results were described previously in the Delta Division section assessing indirect mortality within the Delta.

The results of these studies demonstrate that the likelihood of survival of juvenile salmon, and probably steelhead, is reduced by deleterious factors encountered in the central Delta. In addition to predation, water quality parameters such as temperature can have significant effects on survival. Baker *et al.* (1995) showed that the direct effects of high water temperatures are sufficient to explain a large part (*i.e.*, 50 percent) of the smolt mortality actually observed in the Delta. The CVP and SWP export operations are expected to contribute to these deleterious factors through altered flow patterns in the Central and South Delta channels. In dry years, flow patterns are altered to a greater degree than in the wet years and are expected to result in a higher level of impact to emigrating steelhead and winter-run and spring-run smolts (Kjelson and Brandes 1989). If the DCC gates are opened for water quality improvements or other purposes, a significantly greater proportion of Sacramento River flow and juvenile fish will be diverted into the central Delta.

False Attraction and Delayed Migration - From November through May, adult winter-run and spring-run and steelhead migrate through the Delta for access to upstream spawning areas in the Sacramento and San Joaquin basins. Changes in Delta hydrodynamics from CVP and SWP export pumping in the South Delta may affect the ability of adult salmon and steelhead to successfully home in on their natal streams. Radio tagging studies on adult fall-run indicate that these fish frequently mill about in the Delta, often initially choosing the wrong channel for migration (CALFED 2001). CVP and SWP export pumping alters Delta hydrodynamics by reducing total Delta outflows by as much as 14,000 cfs and reversing net flows in several central and south Delta channels. Adults destined for the Sacramento Basin may experience some minor delays during passage through the Delta by straying temporarily off-course in northern and central Delta waterways. Closure of the DCC gates from November 1 through May 20 may block or delay adult salmonids that enter the Mokelumne River system and enter through the downstream side of the DCC. However, it is anticipated that closure of the DCC gates during this period will reduce diversion of Sacramento River water into the Central Delta, thereby improving attraction flows for adults in the mainstem Sacramento River. Intermittent openings to meet water quality standards or tidal operations are not expected to cause significant delays to adults because of their temporary nature and the ability of adults to drop back and swim around the DCC gates. Acoustic tracking studies by Odenweller of CDFG (CALFED 2001) indicated that adult fall-run may make extensive circuitous migrations through the Delta before finally ascending either the Sacramento or San Joaquin Rivers to spawn. These movements included “false” runs up the mainstems with subsequent returns downstream into the Delta before their final upriver ascent.

Within the south Delta, several studies have indicated that adult fall-run may be negatively impacted by the operations of the export facilities during their upstream spawning migration (Hallock *et al.* 1970, Mesick 2001). The reduced fall flows within the San Joaquin system, coupled with the elevated pumping actions by the SWP and CVP during the fall to “make up” for reductions in pumping the previous spring, curtails the amount of San Joaquin River basin water that eventually reaches the San Francisco Bay estuary. It is necessary for the scent of the San Joaquin basin watershed to enter the Bay in order for adult salmonids to find their way back to their natal river. Reductions, or even the elimination, of this scent trail has been postulated by Mesick (2001) to increase the propensity for fall-run to stray from their natal San Joaquin River basin and into the adjacent Mokelumne River or Sacramento River basins. This problem may exist for CV steelhead that utilize the San Joaquin River basin or the Calaveras River for their olfactory cues during their upstream spawning migrations back to their natal stream. The increased time spent by adults searching for the correct olfactory cues in the Delta could lead to a decrease in the fish's overall health, as well as a reduction in the viability of its gametes. Increased exposure to elevated water temperatures, chemical compounds and bacterial or viral infections present in the Delta increases the likelihood that adult Chinook salmon and their eggs may experience negative effects on the behavior, health, or reproductive success of the fish (Meehan and Bjornn 1991, Rand *et. al.* 1995).

In addition, the existence of the chronic DO sag in the San Joaquin River between the Port of Stockton and Turner Cut can delay the upstream migration of adult salmonids. The ambient DO levels in this portion of the San Joaquin can drop below 4 mg/L during the fall and early winter periods. Hallock *et al.* (1970) found that most adult fall-run would not migrate through water with less than 5 mg/L DO. Laboratory data for juvenile Chinook salmon (Whitmore *et al.* 1960) supports this finding as the juvenile Chinook salmon avoided water with less than 4.5 mg/L under controlled laboratory conditions. Flow levels in the mainstem San Joaquin below the head of Old River are inherently dependent on the status of the HORB, reservoir releases, and the operation of the CVP pumps. When flow rates are high, the DO sag does not set up. Conversely, when flows drop below approximately 1,500 cfs, the conditions in the deep-water ship channel become conducive to creating the low DO situation.

6.6.5.4 Assess Risks to Individuals

As previously described earlier in the Delta division analysis, individual juvenile fish that move into the Delta interior through the DCC or Georgiana Slough are at a much higher risk of mortality from predation or other stressors in the environment. These other stressors can take the form of delayed migration; water quality issues such as temperature and low DO, and prolonged exposure to contaminants in the system. Individual winter-run juveniles and spring-run juveniles are at an increased risk of entrainment if they move downstream earlier in the season than later, or respond to increases in river flows upstream of the Delta in the Sacramento River or reductions in river temperature. These environmental cues typically induce winter-run juveniles and yearling spring-run to initiate downstream movement towards the Delta and the ocean. Individuals that display this sensitivity to early triggers are at a higher risk of mortality due to the open configuration of the DCC gates. Fish that are successful in surviving the Delta interior by passing through Georgiana Slough or the Mokelumne River system still must negotiate the effects of the export pumps and the altered hydraulics in the San Joaquin River main stem. If exports are high, individual fish face a greater probability of being entrained towards the export facilities. Such increased exports are modeled for the current, near future, and future conditions of the CVP/SWP operations action. Survival from the San Joaquin River southwards towards the pumps is considered to be low for salmonids. It is thought that this is primarily a result of intense predation pressure within the waterways leading to the facilities. Fish that ultimately reach the salvage facilities still face a high probability of mortality from that encounter. Calculated losses (mortalities) at the CVP are approximately 2 out of every 3 fish that enter the salvage operation. Fish survival is far worse at the SWP facility where 1 out of 6 fish survive the salvage operation, primarily due to high predation losses in the forebay. Steelhead smolts, although larger than spring-run or winter-run emigrants, are also likely to have low survival rates if they are diverted into the Delta interior. Recent studies in Clifton Court Forebay verified that 200- to 250-mm long steelhead smolts were just as likely to be eaten by predators as the smaller Chinook salmon smolts.

Little information is available regarding juvenile green sturgeon movements in the lower Sacramento River and Delta waterways. It is unknown how vulnerable these juvenile sturgeons are to diversion into the DCC or Georgiana Slough or their risk to predation by the larger predators such as striped bass and largemouth bass that inhabit the Delta system. Additional research is required to answer these questions before a thorough assessment can be made.

Winter-run Chinook salmon – Nearly half of the annual winter-run population emigrates during the gates open period in late fall and early winter. These early emigrating winter-run are vulnerable to the effects of the open DCC gates as previously explained. The loss of individuals from this segment of the winter-run population may decrease the population’s future expression of varied life history strategies, such as early migrational behavior. Having a broad representation of different life history strategies enables the population to spread its survival risk over time, rather than having one monotypic life history. By varying the time that individuals emigrate to the Delta and the ocean, the population can take advantage of potentially better environmental conditions outside of the normal migration period. In the case where environmental conditions may be poor for most of the run during the “normal” migration period due to stochastic variation in the environment (*e.g.*, poor upwelling conditions in the coastal ocean), those segments of the population that migrated at different times may find more suitable conditions and thus perpetuate the population. Maintaining those segments of the winter-run population that exhibit different life history behavioral traits is central to the long-term viability of the population. Based on the data generated from the acoustic tracking studies of Perry and Skalski (2008) and Burau *et al.* (2007), NMFS has estimated that losses to the winter-run population associated with the operations of the DCC range from 6 to 20 percent of the winter-run population entering the Delta. These estimates used the percentage of fish entering the Delta interior through either the DCC or Georgiana Slough channels (based on acoustic tracking data of Chinook salmon smolts: 28 percent when DCC open, 18 percent when closed), the survival estimates within those channels (35 percent survival base case, 10 percent survival when high losses occur, 75 percent survival when losses are low), the monthly position of the DCC gates, and the percentage of the winter-run population entering the Delta from the Sacramento River each month from table 6-26.

Spring-run Chinook salmon – The DCC gates are open during the period when yearling spring-run are emigrating into the Delta from their upstream natal tributaries. Like the early migrating winter-run juveniles, the yearling spring-run life history strategy represents an important component of the overall spring-run life history. Yearling fish are larger than young of the year emigrants, having spent additional time growing in their natal streams over the summer before emigrating downstream. They have a higher success rate at transitioning to the ocean environment than the smaller YOY. They also represent a mechanism to spread out the risk to an individual brood year's population by going out later than the more common first spring emigration life history strategy expressed by the young of the year emigrants. By having more opportunities to enter the ocean at different times, the probability of finding suitable conditions increases. This in turn increases the likelihood that the population will endure. Maintaining those segments of the spring-run population that exhibit different life history behavioral traits is central to the long-term viability of the population. Based on the data generated from the acoustic tracking studies of Perry and Skalski (2008) and Burau *et al.* (2007), NMFS has estimated that losses to the spring-run population associated with the operations of the DCC and fish entering the Delta interior range from approximately 5 to 17 percent of the spring-run population entering the Delta. These estimates used the percentage of fish entering the Delta interior through either the DCC or Georgiana Slough channels (based on acoustic tracking data of Chinook salmon smolts: 28 percent when DCC open, 18 percent when closed), the survival estimates within those channels (35 percent survival base case, 10 percent survival when high losses occur, 75 percent survival when losses are low), the monthly position of the DCC gates, and the percentage of the spring-run population entering the Delta from the Sacramento River each month from table 6-26.

Central Valley steelhead – As discussed for the winter-run and spring-run populations, diversity of life history strategies represents a mechanism by which the population can take advantage of variability in the natural environment and spread its risks across a larger temporal period. By encountering many different environmental conditions, the probability of finding an environment with suitable conditions increases. Although only a small proportion of the Sacramento Valley steelhead are emigrating during the period when the gates are open in late fall and early winter, they represent an important component of the life history strategy of the CV steelhead. These early migrants are vulnerable to the open gates and the expected high loss rate in the Delta interior would remove an important component of the steelhead life history strategy from the population. Based on the data generated from the acoustic tracking studies of Perry and Skalski (2008) and Burau *et al.* (2007), NMFS has estimated that losses to the CV steelhead population associated with the operations of the DCC ranage from approximately 5 to 17 percent of the CV steelhead population entering the Delta from the Sacramento River basin. These estimates used the percentage of fish entering the Delta interior through either the DCC or Georgiana Slough channels (based on acoustic tracking data of Chinook salmon smolts: 28 percent when DCC open, 18 percent when closed), the survival estimates within those channels (35 percent survival base case, 10 percent survival when high losses occur, 75 percent survival when losses are low), the monthly position of the DCC gates, and the percentage of the winter-run population entering the Delta from the Sacramento River each month from table 6-26.

Green sturgeon – It is unknown what population effects the DCC gate operations will have on the green sturgeon population in the Delta. The behavior of green sturgeon juveniles in relation to the gate operations is unknown. The situation is further complicated by the lack of knowledge of migrational timing for juvenile green sturgeon entering the Delta from the Sacramento River and thus the timing of their exposure to the gate operations. Adult green sturgeon may be impacted by the potential for delay behind the closed gates during their upstream migration. However, acoustic tagging efforts to date indicate that tagged fish move upriver through the mainstem of the Sacramento River in the Delta and not within the interior delta waters adjacent to the downstream channel of the DCC. Only those fish that entered the downstream sections of the Mokelumne River system and continued upstream in this system would be subject to migrational delays below the DCC gates during their spawning runs. This may change as more fish are tagged and a greater knowledge of adult fish movement is gained.

6.6.5.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

For both the winter-run and spring-run, designated critical habitat lies adjacent to the location of the DCC gates. In the case of designated critical habitat for the winter-run (58 FR 33212) the DCC is specifically not included because the biological opinions issued by NMFS in 1992 and 1993 concerning winter-run included measures on the operations of the gates that were designed to exclude winter-run from the channel and the waters of the Central Delta. For the spring-run, designated critical habitat (70 FR 52488) includes the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough, including the location of the gates. Designated critical habitat for CV steelhead includes most of the Delta and its waterways; however, the DCC waterway was not included in the text or maps of the Federal Register notice as being part of the Delta waters designated as critical habitat. Nevertheless, actions of the DCC gates affect the critical habitat PCEs designated for the spring-run and CV steelhead populations as well as the essential fish habitat functions for winter-run Chinook salmon. Primarily, DCC gate operations interfere with the performance of the Sacramento River as a migratory corridor for spring-run and CV steelhead and as essential habitat for winter-run by preventing access downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean. Fish entrained into the DCC and the Mokelumne River systems are at a greater risk of mortality than their counterparts who have remained in the mainstem of the Sacramento River. The operations of the gates permit fish to enter habitat and waterways they would not normally have access to with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Operations of the gates have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor.

6.6.6 Contra Costa Water District Diversions

6.6.6.1 Deconstruct the Action

CCWD currently operates three facilities to divert water from the Delta for irrigation and Municipal and Industrial (M&I) uses. These are the facilities at Mallard Slough on the lower San Joaquin River near Chipps Island, on Rock Slough near Oakley, and on Old River near the Highway 4 Bridge. The fourth diversion to be added to those facilities operated by CCWD is the "Alternative Intake Project" on Victoria Slough in the South Delta. Reclamation owns the Contra Costa Canal and shortcut pipeline, as well as the Rock Slough Intake and pumps. The CCWD operates and maintains these facilities under contract to Reclamation. CCWD owns

Mallard Intake, Old River Intake and Los Vaqueros Reservoir, and the proposed Alternative Intake on Victoria Canal. Separate Opinions have been issued for these structures.

The Rock Slough Intake is an unscreened diversion owned by Reclamation and one of three operated in the Delta by CCWD. Pumping Plant 1, located several miles downstream from the canal's headworks on Rock Slough, has the capacity to pump 350 cfs into the concrete lined portion of the Contra Costa Canal. The Rock Slough intake currently accounts for approximately 17 percent of the total water diverted by the CCWD in the Delta. Pursuant to the USFWS' (1993) Opinion for the Los Vaqueros Project, the positively screened Old River Facility is now the primary diversion point for CCWD, accounting for approximately 80 percent of the annual water supply diverted by CCWD. In the future, when the positively screened Alternative Intake comes on line, the share of CCWD water diverted from the Old River and Victoria Canal intakes will account for approximately 88 percent of the annual water diversions for the CCWD, while the Rock Slough intake will be reduced to approximately 10 percent of the annual diversions. All three current intakes are operated as an integrated system to minimize impacts to listed fish species. CCWD diverts approximately 127 TAF per year in total, of which approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), demand is supplied by direct diversion from the Delta. In addition, when salinity is low enough, Los Vaqueros Reservoir is filled at a rate of up to 200 cfs from the Old River Intake. However, the biological opinions for the Los Vaqueros Project and the Alternative Intake Project, CCWD's memorandum of understanding with the CDFG, and SWRCB D-1629 of the State Water Resources Control Board, include fisheries protection measures consisting of a 75-day period during which CCWD does not fill Los Vaqueros Reservoir and a concurrent 30-day period during which CCWD halts all diversions from the Delta, provided that Los Vaqueros Reservoir storage is above emergency levels. The default dates for the no-fill and no-diversion periods are March 15 through May 31 and April 1 through April 30, respectively.

6.6.6.2 Assess Species Exposure

At least one of the listed species are present in the south Delta waterways adjacent to the CCWD diversion intakes in all months of the year. Winter-run are present from approximately December through June based on salvage records from the CVP/SWP fish collection facilities. The peak occurrence of winter-run in the south Delta is from January through March. Juvenile spring-run are present in the South Delta in the vicinity of the CCWD diversions from January through June with peak occurrence from March through May. Central Valley steelhead may be present in the waters of the South Delta from October through July, but have peak occurrence from January through March. Both juvenile and sub-adult green sturgeon are expected to be present year round in the South Delta as indicated by the salvage record. Adult green sturgeon have been caught by sport fisherman in the mainstem of the San Joaquin River from Sherman Island to the Port of Stockton in most months of the year based on the draft 2007 sturgeon report card (CDFG 2008). Presence in the South Delta is assumed for the same period. During the 75 day pumping reduction from March 15 to May 31 and the 30 day no pumping period (April 1 to April 30), the effects of the CCWD action is significantly reduced or eliminated.

6.6.6.3 Assess Species Response to the Proposed Action

In the 1993 winter-run Opinion, NMFS required monitoring for winter-run. Based on the CDFG sampling during the period from 1994 through 1996, mortality from entrainment in the Rock Slough Intake occurred from January to June. Annual numbers captured in a sieve-net downstream of the pump plant for the years 1994-1996 were 2 to 6 winter-run, 25 to 54 spring-run, and 10 to 14 steelhead (Morinaka 2003). Additional losses (8 to 30 percent) due to predation in the canal and fish being killed passing through the intake also were determined to occur. Extrapolated numbers of juvenile Chinook salmon (all races) entrained at Rock Slough between 1994 and 1996 ranged from 262 to 646 fish per year.

Since that time, most of CCWD water diversions have shifted to newer, screened facilities on Old River near Highway 4. These screens are designed to exceed NMFS' juvenile salmon screening criteria since they also must be protective of juvenile and larval delta smelt which co-occur in the same waters. In addition, the current pumping rates at Rock Slough have been reduced in the winter months compared to the historical conditions (CVP/SWP operations BA Appendix E). Before 1998, the Rock Slough Intake was CCWD's primary diversion point. It has been used less since 1998 when Los Vaqueros Reservoir and the Old River Pumping Plant began operating. The diversion at the headworks structure is currently sampled with a sieve net three times per week from January through June and twice per week from July through December. A plankton net is fished at the headworks structure twice per week during times larval delta smelt could be present in the area (generally March through June). A sieve net is fished at Pumping Plant #1 two times per week from the time the first winter-run is collected at the CVP and SWP (generally January or February) through June. Since 1998, the expanded fish monitoring has only recovered 1 winter-run sized Chinook salmon, 14 spring-run sized Chinook salmon, 6 unclipped steelhead, 8 clipped steelhead, and one steelhead of indeterminate origin. During the same period of time, 19 wild fall-run and 2 clipped fall-run have been recovered (table 6-35) at the Rock Slough Headworks and Pumping Plant 1. NMFS previously estimated that annual take of listed fish at the Rock Slough Intake will be 50 spring-run, 50 winter-run, and 20 steelhead. In all of the years of fish monitoring, no green sturgeon has ever been recovered in the seines or plankton nets.

Table 6-35. Summary of listed fish captured at the Rock Slough Headworks and Pumping Plant 1 and amount of water diverted each year, 1998 – 2008.

Summary of Sieve Net and Plankton Net Monitoring Conducted at the Rock Slough Headworks and Pumping Plant 1 (PP1) from August 1998 through March 2008.

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Totals
Months Monitoring Occurred	Aug-Dec	Mar-Dec	Mar-Dec	Jan-Aug	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Mar	
Amount of Water Diverted at Rock Slough Acre Feet	68,683	43,037	51,421	26,749	35,904	27,302	31,283	35,686	43,273	39,366	5,848	408,552
Number of Headworks &PP1 Sieve Net Surveys	Unknown	Unknown	Unknown	Unknown	Unknown	35	102	131	133	107	54	**562**
Number of Headworks Plankton Net Surveys	Unknown	Unknown	Unknown	Unknown	10	0	34	26	15	23	10	**118**
Winter-run Chinook	Dec=1	0	0	0	0	0	0	0	0	0	0	**1**
Spring-run Chinook	0	0	0	0	0	0	Mar=1 Apr=5	May=4	May=4	0	0	**14**
Central Valley steelhead (unclipped)	0	0	0	0	0	0	0	Mar=2 Apr=1	Jan=1 Mar=1	May=1	0	**6**
Central Valley steelhead (clipped)	0	0	0	0	0	0	0	0	0	0	Feb=6 Mar=2	**8**
Central Valley steelhead (unknown)	0	0	0	0	0	0	0	Feb=1	0	0	0	**1**
Fall run/late fall run Chinook (unclipped)	0	0	May=3	0	0	0	Mar=2 Apr=3 May=1	Apr=2 May=6 Jun=1	May=1	0	0	**19**
Fall run/late fall run Chinook (clipped)	0	0	0	0	0	0	May=1	May=1	0	0	0	**2**
Green sturgeon	0	0	0	0	0	0	0	0	0	0	0	**0**
Delta smelt	0	0	0	0	0	0	0	Feb=1*	0	0	0	**1**
Longfin smelt	0	0	0	0	0	0	0	0	0	0	Mar=1**	**1**

Future entrainment is expected to be reduced with the addition of CCWD's Alternative Intake Project. As previously stated, the percentage of water diverted from the Delta via the Rock Slough Intake will fall from 17 percent to approximately 10 percent of the annual CCWD diversions when the Alternative Intake Project comes on line. Furthermore, the use of the Rock Slough Intake will move into the summer months, when listed salmonids will be less likely to be present in the waters adjacent to the intake. The two other intakes on Old River and Victoria Canal will both be positively screened. Approach velocities and sweeping velocities for these two facilities will exceed NMFS' criteria for screening since they are designed to also meet Delta smelt criteria (see NMFS 2007). Estimates of future losses of spring-run and winter-run at the Rock Slough Intake with the Alternative Intake Project in service have been made assuming future CCWD demands of 188,000 af/year. Based on average densities of the salmon in channels (from monitoring programs over the past 10 years), losses were estimated at about 5 winter-run and 16 spring-run juveniles per year.

6.6.6.4 Assess Risk to Individuals

Individual salmonids are likely to be present in the waters of the South Delta near the Old River Intake and the future Alternative Intake site on Victoria Canal during the winter and spring periods. Since the fish screens of the Old River Intake and the future Alternative Intake have been designed to meet Delta smelt standards, NMFS does not expect any salmonids to be entrained by these facilities, as the Delta smelt screening criteria are more stringent than those required for the protection of salmon fry or juveniles. The past several years of monitoring at the Old River Intake Facility has not recovered any listed fish from behind the screens, indicating that they are effective for salmonids. Individual fish may become impinged on the outside of the screens and incur some level of injury from the contact with the screens or become susceptible to localized predation adjacent to the screens while holding position in front of the screens. Experiments by Swanson *et al.* (2004) exposed juvenile Chinook salmon to a simulated fish screen in a large annular flume. Juvenile Chinook salmon tended to exhibit positive rheotaxis, swimming against the resultant current at all times. The incidence of impingement was very low (< 1 percent) in experimental fish. However, juvenile Chinook salmon experienced frequent temporary contacts with the screen surface, particularly with their tails (80 percent of contacts). The rate of morbidity was very low following the incidental contacts with the screen in these experiments. However, this could be a reflection of the benign environmental conditions under which the experiments took place. There were no predators, and the post-experiment observation period only lasted 48 hours. In the field, screens may have debris and other anomalies on their surface, which could produce abrasions to the skin of the fish. These wounds to the skin of the juvenile salmonid would create an opening for pathogens to colonize, and possibly cause morbidity or mortality in the affected fish later on. In addition, predators may seize the opportunity to mount attacks on juvenile salmonids that are dazed by the contact with the screen, or otherwise concentrated around the surface of the screen while holding position against the current. NMFS assumes a 5 percent loss for fish exposed to the screens (95 percent effective) due to these various effects.

NMFS does not anticipate that the screens will have any demonstrable effect on green sturgeon juvenile and sub-adults. The size of the sturgeon present in the south Delta would preclude them from being entrained through the small perforations in the screen. Green sturgeon rearing in the south Delta are considerably larger than the small perforations in the screen. Salvaged green sturgeons are bigger than 125 mm and average 330 mm. Studies with pallid and shortnose sturgeon (Kynard and Horgan 2001) previously mentioned had nearly 100 percent efficiency with louver arrays with considerably larger gaps in the screen than present at the CCWD's intake facilities. NMFS does not anticipate that there will be any significant loss of green sturgeon related to the operation of the positive barrier screens.

Entrainment at the Rock Slough diversion is expected to be minimal based on the past several years of monitoring data at this facility. Although the diversion is not screened, current operations which minimize water diversions from this facility have substantially reduced the number of listed salmonids entrained. Future plans to further reduce exports to only the summer months will have additional benefits as listed salmonids will be less likely to be present in the regional waters. Risk to individual fish will remain, but overall risk will be reduced since pumping is minimized during periods when fish are present in the system, and the likelihood of entrainment within the flow to the Rock Slough intake is reduced due to its lower volume. No green sturgeon have ever been recovered during the 10 years of monitoring the Rock Slough canal and NMFS does not expect this to change. Risk to individual sturgeon is considered to be very low to nonexistent.

Increased flows in the future could affect OMR flows in the region. This could lead to increased impacts on individual fish moving in the region's waterways by increasing their vulnerability to the CVP/SWP export facilities.

Based on the efficiency of the positive barrier screens in the Old River and Alternative Intake facilities, the risks to the populations of winter-run and spring-run, CV steelhead, and green sturgeon present in the South Delta during the year are believed to be minimal. As mentioned in the above section, NMFS assumes that the screens are 95 percent efficient and are likely much better than this in reality. Although individual fish my suffer mortality or morbidity, it is not anticipated that this will occur at a scale that would have population level ramifications. Likewise, given the very low numbers of listed salmonids and the complete absence of green sturgeon from the monitoring records over the past 10 years at the Rock Slough facility, its operation is believed to have negligible effects on the populations of listed salmonids or green sturgeon present in the South Delta. The combined diversions from all three intakes however, may affect the OMR flows in the region and could make them more negative. This would create additional stresses on the hydrodynamics in the South Delta, which can translate into greater impacts on fish movements in the region and a greater likelihood of encountering the flow fields around the CVP/SWP export facilities.

6.6.6.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

The effects of the CCWD on the designated critical habitat of CV steelhead and proposed critical habitat for Southern DPS green sturgeon in the South Delta is anticipated to be minimal by themselves. The current and future levels of exports are substantially below those envisioned for the CVP and SWP facilities. Nevertheless, the exports from the CCWD intakes do contribute to the additive net negative flow in Old and Middle Rivers and thus, in combination with the much larger CVP and SWP exports, negatively impact the hydrodynamics of the South Delta. This affects the value of the South Delta waterways as migratory corridors for steelhead and green sturgeon.

6.6.7 North Bay Aqueduct at Barker Slough Intake

6.6.7.1 Deconstruct the Action

DWR operates the North Bay Aqueduct (NBA) intake in the North Delta through the operation of the Barker Slough Pumping Plant. The NBA delivers water to Solano and Napa Counties. The plant's exports currently range from 30 to 140 cfs. Current pumping capacity is limited to 140 cfs due to capacity of the existing pumps at the facility. An additional pump is required to reach the pipeline design capacity of 175 cfs. The Barker Slough Pumping Plant facility is equipped with a positive barrier fish screen designed and constructed to meet NMFS' fish screening criteria. The Barker Slough Pumping facility entrains water from Barker Slough and surrounding waterbodies including Campbell Lake, Calhoun Cut, and Lindsey Slough. It is approximately 7 to 10 miles upstream of the confluence of Lindsey Slough with Cache Slough. Due to the entrainment of water from the surrounding sloughs, the intake has the potential to entrain migrating salmonids and green sturgeon that may be present in the Cache Slough complex of channels, including waters from the Yolo Bypass and Miners Slough.

6.6.7.2 Assess Species Exposure

Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant, however several years of monitoring have failed to consistently capture any salmonids during the winter Delta smelt surveys (1996 to 2004) in Lindsey Slough or Barker Slough. Captures of Chinook salmon have usually occurred in the months of February and March and typically are only a single fish per net haul (http://www.delta.dfg.ca.goc/data/nba). Most Chinook salmon captured have come from Miners Slough, which is a direct distributary from the Sacramento River via Steamboat and Sutter Sloughs. No steelhead have been captured in the monitoring surveys between 1996 to 2004, the dates available on the DFG website. Green sturgeon are assumed to occur in the waters of Cache Slough and the Sacramento ship channel as green sturgeon have been caught in these waters by sport fisherman.

6.6.7.3 Assess Species Response to the Proposed Action

Seasonal pumping rates during the years 2005 to 2007 were 109 cfs in summer (June to August), 94 cfs in fall (September through November), 39 cfs in winter (December through February), and 36 cfs in spring (March through May). The recent historical data indicates that actual pumping levels are substantially less than those predicted in the CALSIM II current conditions scenario (Study 7.0) during the winter and spring months. For instance, the month of December has an average historical export rate of 52 cfs for the years 2005 through 2007. The estimated export rate for December from Study 7.0 is 116 cfs. The historical rate is only 44 percent of the modeled export rate. Similarly, the historical export rate for the month of April (2005 through 2007) is 31 cfs, while the estimate from Study 7.0 is 133 cfs. The historical export rate is only 23 percent of the modeled export rate. Therefore under the current historical conditions, relatively little exports are diverted from the Barker Slough Pumping Plant. In the modeled export scenario representing current conditions (Study 7.0), pumping is increased nearly two fold over historical conditions and increases even more during the near future and future conditions modeled for the action. This would increase the potential for entrainment over the current historical conditions observed at the pumping plant.

During the summer, seasonal pumping rates for the modeled studies 7.0 and 7.1 are not substantially different from each other (average rates were 115 cfs and 107 cfs, respectively) but both were lower than the future condition modeled in Study 8.0 (135 cfs), a difference of 15 to 20 percent. The historical value for the summer season (2005 to 2007) is 109 cfs, relatively similar to the modeled current conditions. NBA diversions are lower in fall, averaging 101 cfs in study 7.0, 99 cfs in study 7.1, and 123 cfs in study 8.0. The historical pumping rate during the fall (2005 to 2007) was 94 cfs, which is similar to Study 7.0 which modeled the current conditions. Modeled NBA diversions are highest during the winter months. There was very little difference between Studies 7.0 and 7.1 during the winter. However, study 8.0 differed from the other two studies, being greater in December (142 cfs versus 116cfs and 112 cfs) and lower in January (112 cfs versus 157 cfs and 155 cfs) and February (126 cfs versus 155 cfs and 154 cfs). All of the modeled pumping estimates are significantly greater than the historical average of 39 cfs for the period between December and February (2005 to 2007). This represents a substantial increase between historical conditions and the modeled conditions. Modeling estimates for the spring period also were substantially greater than the historical values from 2005 to 2007. The estimates for Study 8.0 export rates also were also greater than those for Studies 7.0 and 7.1. For April, Study 8.0 had a diversion rate of 145 cfs while study 7.0 (133 cfs) and Study 7.1 (128 cfs), a difference of approximately 10 percent. For May, Study 8.0 also had a diversion rate of 145 cfs, which is approximately 25 percent higher than the estimated rates for Studies 7.0 and 7.1 (both 116 cfs). Study 8.0 estimated an export rate of 148 cfs for June, approximately 18 percent higher than the estimates for Study 7.0 (126 cfs), and Study 7.1 (123 cfs). The historical export rate for the spring period between 2005 and 2007 was 36 cfs. Again the modeled rates are substantially greater than the historical pumping rates.

Overall, the modeled exports represent a significant increase in export levels and thus a greater risk to salmonids and green sturgeon in the waters adjacent to the pumping facility compared to their historical vulnerability. The increased export rates increase the potential exposure of fish to the fish screen over the historical conditions. However, the screens, which were designed to protect juvenile salmonids per NMFS criteria, should prevent entrainment and greatly minimize any impingement of fish against the screen itself. Furthermore, the location of the pumping plant on Barker Slough is substantially removed from the expected migrational corridors utilized by emigrating Chinook salmon and steelhead smolts in the North Delta system. Green sturgeon may be present in the waters of Lindsey and Barker sloughs since they are present in Cache Slough and the Sacramento Ship Channel. Green sturgeon are expected to be fully screened by the positive barrier fish screen in place at the pumping facility.

6.6.7.4 Assess Risks to Individuals

Based on the increases in modeled pumping rates over the historical export rates between 2005 and 2007, individual fish would be at a greater risk of exposure to the screens in response to the proposed action’s greater export rates. However, the presence of salmonids in the waters of Barker Slough does not appear to be likely based on the monitoring data available. If the fish are not present in the vicinity of the export pumps, then there is no increase in the encounter rates with the screens. NMFS does not expect to see a demonstrable increase in the take of salmonids from the increased exports of the Barker Slough pumps for this reason.

The presence of green sturgeon is possible at the Barker Slough Pumping facility, but the entrainment risks presented by the pumps are minimized by the design of the screens. NMFS does not expect that individual green sturgeon will be harmed by the screens.

There is no discernable effect to the populations of winter-run or spring-run due to the operations of the Barker Slough Pumping Facility. The infrequent presence of Chinook salmon in the monitoring surveys indicates that Chinook salmon are at low risk of entrainment. Density appears to be quite low, and those Chinook salmon that have been captured in the monitoring surveys have tended to be in Miners Slough, a waterway to the east of Barker Slough. If Chinook salmon were to be pulled into the vicinity of the screened pumps by the increased exports, the screens are designed to effectively prevent the entrainment of these fish.

No steelhead have been recovered during the monitoring surveys conducted for the NBA at any of the monitoring sites sampled in the region. Therefore, it would appear that steelhead are rare in these waters and very few would have the potential to be affected by the screened export pumps. The take of very few fish would not be sufficient to have a population effect on Central Valley steelhead.

6.6.7.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

The location of the Barker Slough Pumping Plant lies within the regional waterways designated as critical habitat for both spring-run and CV steelhead. The Federal Register (September 2, 2005, 70 FR 52488) identifies the upstream tidal limits of Cache Slough and Prospect Slough, as well as Miners Slough and the Yolo Bypass within the Sacramento Delta Hydrologic Unit 5510 as critical habitat. Barker Slough and Lindsey Slough are interconnected with the Cache Slough complex of waterways and were not specifically excluded as critical habitat as was the Sacramento DWSC. The proposed critical habitat for Southern DPS of green sturgeon includes the Yolo bypass as well as waters of the legal Delta. Designated critical habitat for winter-run is more ambiguous, as only the Sacramento River was named as critical habitat (58 FR 33212) and not any of the tributaries or side channels and sloughs associated with the north Delta system.

The footprint of the Barker Slough Pumping Plant is relatively small and located approximately 7 to 10 miles upstream from Cache Slough on Barker Slough. Barker Slough is a dead-end Slough without any significant sources of inflow. It does not physically block a migratory corridor, nor does it occur in habitat that appears to be utilized extensively by Chinook salmon, steelhead, or green sturgeon based on the monitoring surveys mentioned previously. The primary effects of the NBA and the Barker Slough Pumping Plant are related to the entrainment of water from the Cache Slough complex of waterways. The entrainment of water from these waterways can redirect or delay listed salmonids present in those waterways. This can affect the PCE concerned with the preservation of the functionality of the migratory corridors for listed salmonids or green sturgeon. However the effect the Barker Slough Pumping on this PCE is believed to be negligible due to the relatively small magnitude of the diversion, even with the predicted increases in exports in the near future and future conditions.

6.6.8 Vernalis Adaptive Management Plan

6.6.8.1 Deconstruct the Action

The VAMP is an experimental study that provides for a steady 31-day pulse flow of water (target flow) at the Vernalis gage on the San Joaquin River during the months of April and May. The target flow is calculated from a formula which takes into account the existing flows in the San Joaquin River and the current and past 2 year's hydrology, based on the San Joaquin River Basin 60-20-20[17] water year classification scheme. In addition to the target flow, there are corresponding restrictions in the export levels of the CVP and SWP pumping facilities as well as the installation of the fish barrier at the Head of Old River. Both Reclamation and DWR are signatories to the SJRA and have agreed to pay 4 million dollars per year ($4,000,000) to the SJRGA to cover the authorities' contribution of water to the plan from their respective water supplies. Reclamation's share of this payment is $3,000,000 per year, and DWR, as part of its CVPIA cost share obligations, will furnish the remaining $1,000,000. This funding agreement is set to terminate on December 31, 2009, while the SJRA sunsets in 2012 unless it is extended.

During the early discussions regarding modeling assumptions, Reclamation and DWR committed to providing a VAMP-like river flow in the San Joaquin River and export reductions during the VAMP operational period, should the agreement not be extended into the future (project description, pages 76-77). The VAMP target flows and export rates are contained in table 6-36, below. For the purposes of the combined CVP/SWP operations forecasts, the VAMP target flows are simply assumed to exist at the Vernalis gage compliance point. Currently, supplemental volumes of water needed to reach the annual target flow are released on each of the three east side tributaries, *i.e.* the Stanislaus River, the Tuolumne River, and the Merced River, in a coordinated fashion to provide pulse flows down each river channel while maintaining the target flow at the Vernalis gage. These pulse flows are believed to stimulate outmigration of fall-run (the target species for the VAMP experiments) downstream towards the Delta. However, it also is acknowledged that other species of fish, including the CV steelhead, benefit from these pulses. NMFS believes that these pulse flows are critical cues for the listed steelhead in these tributaries to initiate their downstream emigration to the ocean (see SJRGA annual reports 2001-2008).

[17]60-20-20, also known as the San Joaquin Valley's water year type index, equals 0.6 * Current Apr-Jul Runoff + 0.2 * Current Oct-Mar Runoff + 0.2 * Previous Year's Index, where runoff is the sum of unimpaired flow in MAF at: Stanislaus River below Goodwin Reservoir (aka inflow to New Melones Res.), Tuolumne River below La Grange (aka inflow to New Don Pedro Reservoir), Merced River below Merced Falls (aka inflow to Lake McClure), and San Joaquin River inflow to Millerton Lake, and the previous year's index is a maximum of 4.5 (http://cdec.water.ca.gov/cgi-progs/iodir/wsi).

Table 6-36. Scheduled VAMP target flows and export reductions required under the San Joaquin River Agreement.

VAMP Vernalis Flow and Delta Export Targets		
Forecasted Existing Flow (cfs)	Vamp Target Flow (cfs)	Delta Export Target Rates (cfs)
0 to 1,999	2,000	
2,00 to 3,199	3,200	1,500
3,200 to 4,449	4,450	1,500
4,450 to 5,699	5,700	2,250
5,700 to 7,000	7,000	1,500 or 3,000
Greater than 7,000	Provide stable flow to extent possible	1,500, 2,250, or 3,000

Reclamation and DWR did not provide further resolution of their future operations other than to provide VAMP-like flows at Vernalis. NMFS has considerable interest in how the flows in the two other tributaries, besides the Stanislaus River, will be affected by the future CVP/SWP operations. As mentioned above, the Tuolumne River and Merced River release a portion of the total supplemental water required to meet the targeted flows required under the VAMP experiment each year. These flows are integral to stimulating outmigration of both the threatened CV steelhead, and fall-run, a species of concern under the ESA, from the Tuolumne River and Merced River. Furthermore, decreases in the pulse flows on these rivers would be an adverse modification of critical habitat designated for CV steelhead in regards to flow related decreases in rearing area suitability and physical and flow related obstructions in the migration corridors from the rearing areas below the dams, downstream to Vernalis on the San Joaquin River where the Stanislaus River enters.

6.6.8.2 Assess Species Exposure

VAMP actions will primarily affect CV steelhead originating in the San Joaquin River basin. Under historical and current conditions, pulse flows in the tributaries will affect steelhead originating in the Stanislaus, Tuolumne, and Merced rivers. These pulse flows are typically staggered among the tributaries to maintain the desired target flows at Vernalis, with the Stanislaus River generally contributing the greatest volume. San Joaquin River basin steelhead within the mainstem San Joaquin River from the Merced River confluence through the Delta benefit from the VAMP pulse flows.

Within the Delta proper, other runs of listed salmonids and the Southern DPS of green sturgeon may benefit from the additional water flowing downstream and the export reductions taken as part of the experiment. During the 31 day pulse flow (typically April 15 through May 16), spring-run from the Sacramento River basin, steelhead from several watersheds outside of the San Joaquin River basin (*i.e.*, the Sacramento River basin, Feather River, American River, Mokelumne River and Calaveras River), the tail end of the winter-run outmigration, and rearing green sturgeon in the Delta all may benefit from the VAMP operations due to their potential presence in the Delta during this time period.

6.6.8.3 Assess Species Response to the Proposed Action

The VAMP experiments were designed to examine the relationships between upstream flows as measured at Vernalis, the role of exports, and the eventual survival of fall-run migrating through the Delta. The experiments provided sufficient in-river flows to provide migratory cues in the three San Joaquin River tributaries to fall-run and subsequently to test the relationship of flows with survival through the lower river reaches of the mainstem San Joaquin River and subsequently through the Delta. CV steelhead co-occurring with fall-run in these tributaries were also expected to benefit from these flow manipulations.

Under the future proposed VAMP-like operations, spring pulse flows are only linked to the Vernalis standard. Reclamation and DWR have not elaborated the details of this plan, particularly if pulse flows will continue on the Merced and Tuolumne rivers as has occurred historically in the VAMP experiment. Decreased flows on these rivers would create a situation in which the downstream water temperatures on the valley floor would become warmer with the progressively increasing air temperatures experienced during a typical spring in the Central Valley. As spring progressed, the increasing air temperature would continue to warm the river water and create thermal barriers within the downstream reaches of the river channel. Without a suitable pulse of cooler water moving downstream from increased dam releases to breakdown this thermal barrier, juvenile salmonids would be unlikely to survive their migration downstream to the Delta, dying from excessive thermal exposure en route. The only recourse is to remain within the reaches immediately below the terminal dams and reside in the cool tailwater reaches of the river over the summer and emigrate the following fall or winter when air temperatures decrease with the onset of winter. Unfortunately, due to the restricted habitat available below the dams with sufficient cool water to maintain suitable habitat requirements for either steelhead or fall-run Chinook salmon, density dependent mortality is anticipated to occur. There is currently insufficient space in the tailwater sections of these tributaries to support a large population of over summering salmonids under current summertime releases, and this is itself identified by NMFS as a limiting factor in steelhead recovery in the San Joaquin River basin. Forcing increased numbers of Chinook salmon and steelhead to compete for the limited over summering habitat and their resources (food, holding areas, cover, *etc*.) due to lack of sufficient outmigration spring pulse flows, would place additional stressors on the remaining populations of CV steelhead that would "normally" be present in these areas over the summer.

NMFS reviewed several reports in assessing the effects of flow in the San Joaquin River basin on the salmonid populations residing in the basin. Skinner (1958) reported that Central Valley populations of Chinook salmon exhibited wide fluctuations in abundance from 1870 onward by examining landings of Chinook salmon in California. The overall trend in abundance was negative, but every 30 years or so, particularly large landings occurred. Skinner (1958) opined that the declines in the Chinook salmon fisheries appear to be chronologically associated with water development projects in California, and the increase in the ocean troll fishery. Skinner (1958) describes the effects of the construction of Friant Dam on the upper San Joaquin River on the extirpated the spring-run population that formerly inhabited that watershed. Skinner (1958) stated:

> "Friant Dam on the San Joaquin River has had multiple effects on the spring fishery. In the first place the dam has cut off a third or more of the spawning area. Secondly, flows below the dam were inadequate during normal migration periods to assure passage of the fish either up or down the river. Only enough water is permitted to flow down the river to fulfill irrigation commitments. The released water flows to the delta Mendota Pool and a small amount reaches the 'Sack Dam' at Temple Slough where it is diverted for agricultural purposes. Below this point, the river goes dry except for small amounts of water received from its downstream tributaries. Because of these conditions, salmon obviously cannot ascend to the spawning area in the vicinity of Friant Dam."

Skinner (1958) also makes the observation that with the extirpation of the San Joaquin River spring run population that the commercial catches of spring run plummeted from 2,290,000 pounds in the 1946 season to 14,900 pounds in 1953. Functional extirpation of the San Joaquin River spring-run population occurred following the completion of the Madera Canal in 1944, and the completion of the Friant-Kern canal in 1949, allowing full use of the distributional system under Reclamation's operational plan. Skinner (1958) concluded that the last successful spawn of spring run in the San Joaquin River has not occurred "since the spring of 1946." This is an example of the direct consequences resulting from the alteration and loss of necessary in-stream flows to support salmonid populations below dams in the San Joaquin River basin.

Kjelson *et al.* (1981) described the effects of freshwater inflow on survival, abundance, migration, and rearing of Chinook salmon in the upstream (Delta) portions of the Sacramento-San Joaquin Estuary. Kjelson *et al*. (1981) pointed out that additional inflows of freshwater at the appropriate time during the winter and spring will increase the numbers of fry and juvenile salmon utilizing the estuary and the survival of juveniles in the estuary. Flow-related concerns for salmon in the estuary stem from water development activities in the Central Valley that have altered the distribution of flow resulting in impacts on juvenile and adult salmon migrations, as well as the lack of comprehensive flow standards on the tributaries and mainstem river reaches that are protective of salmon. The authors further explain that water development projects have caused major changes in the flow patterns within the estuary and the amount of flow entering the ocean from upstream sources. The San Joaquin River system has been particularly altered as most of the upstream inflow to the basin has been captured and utilized in regions upstream of the Delta. Typical export rates substantially exceed the flow of the San Joaquin River; hence most of the San Joaquin River flow goes to the export pumps rather than to the ocean. The authors concluded that the distribution and flow of water through the Delta waterways are heavily influenced by the design and operation of the state and federal water projects. Kjelson *et al.* (1981) report that analysis of data gathered between 1957 and 1973 indicates that the numbers of adult Chinook salmon spawners returning to the San Joaquin River system are influenced by flows 2.5 years earlier during their rearing and downstream emigration life history phases. In general, higher flows resulted in greater numbers of adults returning to spawn. Kjelson *et al.* (1981) also implicate the potential adverse effects of the pumps in the reduced survival of fish emigrating through the Delta, indicating that as export rates are increased, more downstream migrating salmon are drawn to the fish screens. Kjelson *et al.* (1981) estimate that the number of fish observed at the fish screens is probably only 5 percent of the total downstream migration in the system, but that a "much larger fraction probably is drawn out of their normal migration path" by the effects of the pumps on water flow in the Delta's channels. Kjelson *et al*. (1981)

state that the "alteration in flow distribution caused by drafting increased volumes of water across the Delta to the pumps apparently increases the mortality of salmon that do not ever reach the fish screens." In support of this statement, Kjelson *et al*. (1981) point out those mark-recapture studies in which fish that migrate downstream in waterways that are far removed from the effects of the pumps had higher relative survival rates than those released in waterways under the influence of the pumps.

Kjelson *et al.* (1982) reiterate the reduced survival of salmon in the delta due to influences of natural and anthropogenic sources. They found that Chinook salmon smolt survival decreased as flow rates decreased and water temperatures increased, particularly in the later portions of the outmigration period. Furthermore, they restated their belief that the influence of the state and federal exports negatively impacted the survival of emigrating smolts through the Delta.

In a study assessing the influence of San Joaquin River inflows, state and Federal exports, and migration routes, Kjelson *et al.* (1990) released experimental fish (coded wire tagged hatchery Chinook salmon) during the spring of 1989 at Dos Reis on the San Joaquin River below the head of Old River, and in Old River itself downstream of the head under conditions with low San Joaquin River flow (≈ 2,000 cfs) and high/low export conditions (10,000 cfs and 1,800 cfs). The results of the study were unexpected as the rate of survival was not greater for the low export conditions compared to the higher export conditions. Upon further examination of the data, Kjelson *et al*. (1990) found that survival was comparatively lower for all upstream release groups that year compared to other studies conducted in previous years. In addition, Kjelson *et al.* (1990) surmised that the short period of reduced exports (7 days) was not long enough to allow fish to exit the system and move beyond the influence of the exports when higher pumping resumed. Based on the times to recovery at Chipps Island, it was concluded that a sizeable proportion of the released fish were still in the Delta when the higher export levels resumed. This conclusion is further reinforced by the salvage of fish released at Jersey Point, indicating that fish were drawn upstream into the interior of the Delta and towards the pumps from their release points in the western Delta. The study, although having several significant flaws, did conclude that survival was higher in the mainstem San Joaquin River compared to Old River and that survival in the Delta interior was lower compared to the western Delta (*i.e.,* Jersey Point releases). Kjelson *et al*. (1990) cautioned about drawing conclusions about export rates and survival from the data due to its obvious flaws.

Kjelson and Brandes (1989) reports on the results of ongoing mark-recapture studies conducted in the Sacramento-San Joaquin Delta and the effects of river flows, percent diversion of Sacramento River water through the DCC, and river temperatures. The findings of that paper also conclude that elevated flows, as measured at Rio Vista on the Sacramento River, increase survival of Chinook salmon smolts from the Sacramento River basin through the Delta as measured by both ocean recoveries of adults and recaptures of tagged smolts at Chipps Island in the mid-water trawls. Similarly, adult escapement in the San Joaquin River basin also increases with spring time flows at Vernalis 2.5 years earlier. Increasing water temperature was also shown to decrease smolt survival through the Delta during the critical April through June outmigration period of fall-run.

In a more recent report, Mesick *et al.* (2007) assessed the limiting factors affecting populations of fall run and steelhead in the Tuolumne River. The paper describes potential limiting factors which may affect the abundance of fall-run and both resident and anadromous (steelhead) forms of rainbow trout in the Tuolumne River. This information was then synthesized into conceptual models to help guide management decisions in regards to steelhead and fall-run. In general, Mesick *et al.* (2007) found that river flows were the limiting factor with the greatest influence on the salmonid populations in the Tuolumne River. As found in previous studies, there is a strong relationship between adult escapement and spring-time river flows during the juvenile/smolt outmigration stage. Flows measured over the period between March 1 and June 15 explained over 90 percent of the variation in the escapement data. However, Mesick *et al*. (2007) identified two critical flow periods for salmon smolts on the Tuolumne River: winter flows which affect fry survival to smolt stage, and spring flows which affect the survival of smolts migrating from the river through the delta. Based on results from ongoing VAMP studies, Mesick *et al*. (1990) also noted that increased flows at Vernalis also increased survival of smolts emigrating through the Delta. Water temperature in the river was also identified as a potential limiting factor for salmonid survival within the emigration time period. Flows have a substantial role in maintaining suitable water temperatures within the river system, with higher flows prolonging and extending the cool water migratory corridor downstream than low flow conditions. Mesick *et al.* (1990) found that for Tuolumne River fall-run escapement data, that exports had little effect on adult production compared to winter and spring flows. Flows were the primary factor, beyond all other factors, in determining adult production from smolts.

NMFS also reviewed the restoration reports for the CVPIA, including the three volumes of "Working Paper on Restoration Needs" for the AFRP (USFWS 1995) and the Final Restoration Plan for the AFRP (USFWS 2001). The plan identified the Delta as the highest priority for restoration actions (USFWS 2001 page 17), given that it was highly degraded, due in part to CVP (and SWP) operations, and that all anadromous fish must pass through the delta as juveniles and adults. In addition, the San Joaquin River mainstem and its tributaries below Mendota Pool were assigned a high priority (but lower than the Delta) due to its highly degraded habitat and substantially reduced production of fall-run. Specific actions in each watershed and the Delta were identified to address the limiting factors present in those areas and were prioritized as to their ability to implement the "doubling goal" for affected fish populations. In general, actions scored a high priority if they promote natural channel and riparian habitat values and natural processes, such as those affecting stream flow, water temperature, water quality, and riparian areas. Actions are assigned medium priority if the affect emigration or access to streams, such as sites of entrainment into diversions and migration barriers. Like the previous reports, the AFRP Restoration Plan recommended increasing flows within the tributaries and mainstem San Joaquin River as a high priority action to increase salmonid production. Within the Delta, actions which would provide protection to juvenile salmonids migrating through the Delta from November 1 through June 30, equivalent to the protection provided by restricting exports to minimal levels, were given high priority. The specific increases in flow were developed to achieve the targeted doubling of fish populations as required under the CVPIA, and are not necessarily the flows needed to sustain or protect populations from further decline or achieve population stability. Targeted flows are typically much greater than the average or median flows observed in the rivers under current conditions. In addition to flows, maintaining appropriate water temperatures in the tributaries for salmonid life history stages were also given a high priority. The AFRP restoration plan recommended that actions be implemented "to maintain suitable water temperatures or minimize length of exposure to unsuitable water temperatures for all life stages of Chinook salmon in the San Joaquin River and Delta." Targeted water temperatures are 56ºF between October 15 and February 15 and 65ºF between April 1 and May 31 for Chinook salmon in the mainstem San Joaquin River. Furthermore, the construction and operation of a barrier at the head of Old River to improve conditions for Chinook salmon migration and survival was given a high priority so long as its operation had minimal adverse effects on other delta fish species.

An additional reference used by NMFS during the evaluation of flow impacts in the San Joaquin River Basin is CDFG's "Final Draft 11-28-05 San Joaquin River Fall-run Chinook salmon Population Model," which evaluated various parameters that have been identified as influencing abundance of escapement of fall-run into the San Joaquin River. These parameters included such variables as ocean harvest, Delta exports and survival, abundance of spawners, and spring flow magnitude, duration, and frequency. The model was developed in response to the SWRCB call for comments and recommendations to the 1995 WQCP San Joaquin River spring Vernalis flow objectives in 2005. CDFG determined that the Vernalis spring flow objectives were not adequate for the long-term protection of fall-run beneficial uses in the San Joaquin River basin because: (1) the San Joaquin River salmon population trend continues to be below the 1967 - 1991 historic average upon which the narrative Doubling Goal was established (CVPIA Restoration Plan goals); (2) salmon smolts are not afforded the level of protection as envisioned by the 1995 WQCP; (3) the VAMP experiment is not working because it has not been implemented as designed; and (4) spring outflow is the primary factor controlling fall-run population in the San Joaquin River basin. CDFG summarized the shortfalls of the 1995 WQCP Vernalis flow objectives as being due to: (1) the diminished magnitude of the Vernalis flow objective; (2) the narrowness of the pulse flow protection window; (3) the infrequent occurrence of elevated flow objective levels; and (4) the frequent occurrence of reduced flow objective levels. CDFG found in the development of their spreadsheet model that non-flow parameters had little or no relationship to fall-run population abundance and that spring-time flow magnitude, duration, and frequency were the dominant factors influencing Chinook salmon abundance in the basin. In their analysis of the influence of exports and flow on salmon production, CDFG could not find a statistically significant role for exports compared to the influence of the spring time flows. The role of flow always dominated the interaction of exports and flow on salmon abundance. However, it should be noted that exports typically increase when San Joaquin River flows increase, thereby making exact relationships difficult to determine and that only a narrow range of river flows and exports were tested in the VAMP experiments to date. CDFG summarized the relationship between export, flow, and salmon production to be that when the ratio of exports to Vernalis flow decreases both escapement and cohort production increases. The relationships that suggest flow is the dominant factor influencing salmon production, rather than exports, are: (1) when the ratio of spring exports to spring Vernalis flows decreases, Vernalis flow greatly increases and San Joaquin River basin production greatly increases; (2) when the ratio of spring exports to spring Vernalis flows increases, Vernalis flow greatly decreases and San Joaquin River basin salmon production substantially decreases; (3) juvenile salmon survival increases when spring Vernalis flows increase; (4) spring export to spring Vernalis flow ratio has little influence upon juvenile salmon survival; and (5) as the difference between spring Vernalis flow level and spring export flow level increases, escapement increases. Nevertheless, CDFG recognized that the influence of delta exports upon San Joaquin River salmon production was not totally clear but that its influence was not as negative, at least compared to flows, as it had previously been thought to be. Its analysis indicated that comparatively, flows were the much more influential variable in determining production levels in the basin compared to exports.

The model results indicated that in all scenarios tested, increasing the magnitude of spring outflow resulted in increased salmon production for all water year types. Likewise, in all scenarios tested, expanding the window of protection resulted in increased salmon production. The greatest increment in salmon production associated with increasing the window of protection was from 30 days to 60 days. Further increases in the window of protection beyond 60 days produced smaller incremental gains in salmon production. The 60-day period roughly encompasses the majority of the salmon outmigration window. When both flow magnitude and the window of protection are increased together, the salmon production in the basin increases substantially. Based on the model results, CDFG concluded that the optimal mix of flows and window of protection was: (1) wet years=20,000 cfs for 90 days; (2) above normal years=15,000 cfs and a 75-day window; (3) below normal years = 10,000 cfs for 60 days; (4) dry years = 7,000 cfs for 45 days; and (5) critical years = 5,000 cfs for 30 days. The model suggests that these flow objectives at Vernalis would accomplish the Doubling Goals of the CVPIA-AFRP, improve the fall-run replacement ratio, and would, as compared to other possible flow objective windows simulated with the model which met the Doubling Goals; result in the lowest water demand. This mixture of flows and protective windows, however, still used approximately 1 million additional acre feet of water from the reservoirs, on average, to meet its needs.

Recent papers examining the effects of exports on salmon survival have been unable to prove a statistically significant reduction in survival related to exports (Newman 2008). However Newman also caveats these findings by indicating that the data used in his analysis had a very low signal to noise ratio and that substantially greater numbers of observations were needed to more precisely estimate the effects of exports on salmon survival (Newman and Brandes in review). The final resolution of the impacts of exports on survival is still being assessed and the inability of the statistical analysis to detect true impacts is not surprising given the high level of environmental variation in the data sets analyzed. The inability to find a significant relationship between exports and salmon survival in a data set with a high noise to signal ratio does not mean that a relationship does not exist, but that further work is warranted to reduce the level of noise and clarify the relationship between these two factors.

6.6.8.4 Assess Risk to Individuals

The alterations of flow in the future VAMP-like action will affect individual steelhead residing in the Tuolumne and Merced rivers, based on the assumption that Reclamation and DWR will provide the water necessary for the Vernalis flow standards solely from the Stanislaus River. Reduced flows on the Tuolumne and Merced rivers will lead to declines in the suitability of the riverine habitats for steelhead, increased intra- and interspecies competition for resources and space in the remaining cold water reaches below the terminal dams, and a diminishment in the opportunity to emigrate successfully from these basins in the spring. This may cause individual steelhead to residualize in the tailwater sections of the rivers and forego their steelhead life history expression. Steelhead that are successful in leaving the Tuolumne and Merced River basins will encounter conditions similar to the current VAMP operations once they pass Vernalis, as the flows are required to be comparable to the historical VAMP conditions at this point. Conditions through the Delta should also be comparable to current conditions, as a commitment to continue export reductions has been made by Reclamation and DWR as part of the project description. In light of the results from the recent years of the VAMP experiment, steelhead survival through the Delta is expected to be low. The loss of individually marked Chinook salmon between the upstream release points and downstream recapture locations remains high, and the survival of steelhead smolts is expected to be similar to these experimental fish since they travel through the same migratory corridor at the same time.

The expected changes in the VAMP water releases among the three tributaries is expected to decrease the viability of the San Joaquin River basin steelhead population. The diminishment of the steelhead habitat in the Tuolumne and Merced River tailwaters essentially reduces the available functioning habitat to only the Stanislaus River. This increases the risk to the population as only the Stanislaus River can be operated to support the basin's remaining population with any certainty. Risks associated with catastrophic events increase dramatically when the population is reduced to only one stream for its survival in the basin and the viability of the Southern Sierra steelhead diversity group becomes more tenuous as a result. This decreases the overall viability of the CV steelhead DPS by reducing the survival capacity of one of its original diversity groups.

6.6.8.5 Effects of the Action on Designated and Proposed Critical Habitat in the Delta Division

The potential changes in the VAMP springtime pulses have the potential to substantially reduce the function of the designated critical habitat on the Tuolumne and Merced River for steelhead. The reductions in springtime pulses on these tributaries reduce the values of PCEs associated with freshwater rearing and freshwater migratory corridors. As previously explained in the effects section for this action, reductions in springtime pulses reduce the cues for steelhead to initiate their downstream emigration at an appropriate time. The pulses help to connect the upper tailwater sections of the rivers with the lower valley floor reaches. Temperatures during spring increase on the valley floor and the altered hydrology of the tributaries due to dams prevents runoff from spring snowmelt from providing a continuous corridor of appropriately cool water between the rearing areas (now below the dams) with the lower valley floor reaches running down the middle of the San Joaquin Valley. This connection must now be made from controlled releases from the terminal dams. Without the releases, the downstream sections of the tributaries and valley floor sections of the San Joaquin River are too warm to provide appropriate thermal conditions for emigrating steelhead. Warmer temperatures may prove to be fatal in their own right, but are also expected to reduce the condition of the emigrating steelhead and make them more susceptible to predators and disease. Reduced flows are also likely to increase the population density of steelhead in the shrinking habitat below the dams as the weather warms. The outcomes of this truncated rearing habitat were previously explained in the effects section for this action. Overall survival is expected to decrease with the reduction in the value of the freshwater rearing habitat available to the steelhead.

6.6.9 Climate Change

The results from Reclamation's climate modeling show that climate change typically had more effect on Delta flows during wetter years than during drier years. This result seems related to how CVP and SWP operations occur with more flexibility during wet years, within the constraints of flood control requirements, compared to drier years when the CVP and SWP operations may be more frequently constrained to maintain in-stream flows and other environmental objectives.

- Head of Old River Flows
  - Remained positive (oceanward) for all scenarios
  - Decreased in winter and spring of wetter years for the drier climate change scenarios (studies 9.4 and 9.5)
  - Increased in winter of wetter years for the wetter climate change scenarios (studies 9.2 and 9.3)
  - Changes were minor during drier years for all climate change scenarios
- Old and Middle River Flows
  - Flows were typically negative (landward) except for a flow reversal in winter of wetter years for the wetter, less warming scenario (study 9.2)
  - Fall and winter flows are the most sensitive to climate change
  - Negative winter flows decreased for the wetter scenarios and increased for the drier scenarios
  - Negative fall flows increased for the wetter scenarios and decreased for the drier scenarios
- QWEST Flows (westward flows from the Delta towards the ocean)
  - Magnitude and direction of QWEST is affected by climate change scenario and season.
  - Flow direction is
    - typically positive during wetter water years except for summer for the drier climate change scenarios
    - always positive in the spring
    - typically negative in the summer of drier years except for the drier, more warming scenario
    - positive in the fall of drier years for the drier climate change scenarios and negative in fall of drier years for the wetter climate change scenarios
  - Winter flows are the most sensitive to climate change and response varies by scenario
- Cross Delta Flows
  - Winter flows were the most sensitive to climate change, flows decreased for the drier climate scenarios and increased for the wetter climate scenarios

Results show that climate change typically had more effect on Delta velocities during wetter years than during drier years. This result is consistent with the Delta flow results

- Head of Old River Velocities

  - Are positive (oceanward) for all scenarios
  - Increased in winter and spring of wet years for the wetter climate change scenarios
  - Decreased in winter and spring of wet years for the drier climate change scenarios
  - Changes were typically less than 0.05ft/s during drier years for all climate change scenarios

- Middle River at Middle River Velocities
  - Are negative (landward) for all scenarios except for a slight reverse flow in winter of the wetter, less warming scenario
  - During wetter years, negative winter velocities decreased for the wetter climate change scenarios and increased for the drier climate change scenarios
  - Changes were typically less than 0.05ft/s for drier climate change scenarios

- San Joaquin River at Blind Point Velocities
  - Are positive (oceanward) for all scenarios
  - Changes were typically less than 0.05ft/s

- Cross Delta Velocities (Georgiana Slough)
  - Are positive (oceanward) for all sceanarios
  - Increased in winter for the wetter climate change scenarios and decreased in winter for the drier climate change scenarios

The fall and winter periods appear to have the most sensitivity to climate changes. In general, the pattern of study results suggests that OMR flow during January through June becomes more negative during dry years in the drier/less warming and drier/more warming scenarios, but with some substantial changes that are mostly either increases in negative flow or decreases in positive flow compared to the other scenarios. In other words, in the drier climate change scenarios it is expected that fish in the channels surrounding the CVP and SWP projects will be exposed to higher entrainment risks during the January through June time frame than under projected future conditions without climate change. Wetter climate patterns appear to present less entrainment risk during the January through June period in wet and above normal water year types, but elevated risks during the below normal, dry and critically dry water year types. The late fall period (October through December) also had consistently higher risks of entrainment in the wetter climate scenarios than the base case modeled in Study 9.0 for the future climate change models (see tables 6-37 and 6-38).

Table 6-37. Trends for Average Changes in Flow for Climate Change Scenarios Relative to the Base Case.

Trends and flow directions are based on 50 percent values. Trends are rounded to nearest 250 cfs. No shading (white) indicates locations with positive (oceanward) flows. Dark shading (blue) indicates locations with negative (landward) flows. Light shading (yellow) indicates locations with mixed flow regimes (sometimes positive and sometimes negative). Seasons are defined as winter is Jan-Mar, spring is Apr-Jun, summer is Jul-Sep, and fall is Oct-Dec. Wetter year types are those classified as wet or above normal. Drier year types are those classified as below normal, dry or critically dry.

Name	Year Type	Wetter, Less Warming Flow	Wetter, More Warming Flow	Drier, Less Warming Flow	Drier, More Warming Flow
Head of Old River	Wetter	Increased by 1750cfs in spring, 1000cfs in summer, 250cfs in fall, and 750cfs in winter	Increased by 500cfs in winter, decreased by 1500cfs in spring, decreases were less than 250cfs in summer and fall	Decreased by 3500cfs in winter and spring, and decreased by 250cfs in summer and fall	Decreased by 2750cfs in winter and 3000cfs in spring, decreases were less than 250cfs in summer and fall
	Drier	Changes were less than 250cfs	Changes were less than 250cfs	Changes were less than 250cfs	Changes were less than 250cfs
Old and Middle River	Wetter	In winter flows changed from negative 3200cfs (landward) to positive 100cfs (oceanward). The rest of the year, negative (landward) flows decreased by 750cfs in spring, 250cfs in summer, and increased by 500cfs in fall	Negative (landward) flows decreased by 2500cfs in winter, 750cfs in spring, and 250cfs in summer. Negative flows increased by 750cfs in fall.	Negative (landward) flows increased by 3250cfs in winter, 500cfs in spring and 1000cfs in summer. Negative flows decreased by 500cfs in fall.	Negative (landward) flows increased by 1250cfs in winter. Negative flows decreased by 250cfs in spring and by 1750cfs in fall. Summer flow changes were less than 250cfs.
	Drier	Negative (landward) flows increased by less than 250cfs in winter, 750cfs in spring, 1000cfs in summer and 1750cfs in fall.	Negative (landward) flows increased by 500cfs in winter, spring, fall, and 750cfs in summer.	Changes were less than 250cfs in spring and fall. Negative (landward) flows decreased by 750cfs in summer and increased by 500cfs in winter.	Negative (landward) flows decreased by 250cfs in winter, 500cfs in spring, 1000cfs in summer and 750cfs in fall
QWEST	Wetter	Increased by 4000cfs in winter, 3000cfs in spring, 1500cfs in summer and 500cfs in fall	Increased by 3750cfs in winter, changes were less than 250cfs in spring, increased by 250cfs in summer, and decreased by 500cfs in fall	Positive (oceanward) flows decreased by 6500cfs in winter, 1750cfs in spring, 750cfs in summer, and 250cfs in winter.	Positive (oceanward) flows decreased by 4250cfs in winter and 1250cfs in spring, 250cfs in summer. Positive fall flows increased by 250cfs.
	Drier	Negative (landward) winter flows of 0cfs changed to positive (oceanward) flows of 400cfs. Positive spring flows increased by 250cfs. Summer flow changes were less than 250cfs. Positive flows of 200 fall flows changed to negative flow of 300cfs.	Changes were less than 250cfs	Flow changes were less than 250cfs in winter. Positive flows increased by 250cfs in spring and fall, 750cfs in summer.	Flow changes were less than 250cfs in winter. Positive (oceanward) flows increased by 750cfs in spring, summer, and fall.
Cross Delta	Wetter	Increased by 1000cfs in winter, decreased by 250cfs in spring and summer, changes were less than 250cfs in fall	Increased by 2000cfs in winter, 750cfs in spring, and decreased by 750cfs in summer and 500cfs in fall	Decreased by 1250cfs in winter, 500cfs spring and fall, increased by 250cfs in summer	Decreased by 2250cfs in winter, 500cfs in spring, 250cfs in summer and 1000cfs in fall
	Drier	Increased by 250cfs in winter and summer, 750cfs in fall, changes were less than 250cfs in spring	Increased by 500cfs in winter, 250cfs in fall, changes were less than 250cfs in spring and summer	Decreased by 250cfs in winter, summer and fall, decreased by 500cf in spring	Decreased by less than 500cfs in winter, spring and fall, decreased by 750cfs in summer

Table 6-38. Trends for Average Changes in Delta Velocities for Climate Change Scenarios Relative to the Base Case.
Trends and velocity directions are based on 50 percent values. Trends are rounded to nearest 0.05ft/s. No shading (white) indicates locations with positive (oceanward) velocities. Solid shading (blue) indicates locations with negative (landward) velocities. Lighter shading (yellow) indicates locations with mixed velocity regimes (sometimes positive and sometimes negative). Seasons are defined as winter is Jan-Mar, spring is Apr-Jun, summer is Jul-Sep, and fall is Oct-Dec. Wetter year types are those classified as wet or above normal. Drier year types are those classified as below normal, dry or critically dry.

Name	Year Type	Wetter, Less Warming Velocity	Wetter, More Warming Velocity	Drier, Less Warming Velocity	Drier, More Warming Velocity
Head of Old River	Wetter	Increased by 0.05ft/s in winter, 0.25-0.50ft/s in spring and summer, and 0.15ft/s in fall	Increased by 0.05ft/f in winter, increased by 0.35ft/s in spring, and changes were less than 0.05ft/s in summer and fall	Decreased by 0.70ft/s in winter, 0.9ft/s in spring, 0.1ft/s in summer and less than 0.15ft/s in fall	Decreased by 0.5ft/s in winter, 0.75ft/s in spring, 0.05ft/s in summer and fall
	Drier	Increased by 0.05ft/s in spring, changes were less than 0.05ft/s in summer, fall and winter	Changes were less than 0.05ft/s	Decreased by 0.05ft/s in winter, spring and summer, decreased by less than 0.05ft/s in fall	Decreased by 0.05ft/s in winter and changes were less than 0.05ft/s in spring, summer and fall
Middle River at Middle River	Wetter	Winter velocities changed negative (landward) 0.1ft/s to nearly 0ft/s. Negative velocity changes were less than 0.05ft/s in spring and summer. Changes were less than 0.05ft/s in fall	Negative (landward) velocities decreased by 0.05ft/s in winter, changes were less than 0.05ft/s in spring, summer and fall	Negative (landward) velocities increased by by 0.1ft/s in winter. Velocity changes were less than 0.05ft/s in spring, summer and fall.	Negative (landward) velocities increased by 0.05ft/s in winter and decreased by 0.05ft/s in fall. Velocity changes were less than 0.05ft/s in spring and summer.
	Drier	Negative (landward) velocities decreased by 0.05ft/s in fall, changes were less than 0.05ft/s in winter, spring and summer	Changes were less than 0.05ft/s	Changes were less than 0.05ft/s	Changes were less than 0.05ft/s
San Joaquin River at Blind Pt.	Wetter	Increased by 0.05ft/s in winter and spring, changes were less than 0.05ft/s in summer and fall	Increased by 0.05ft/s in winter, changes were less than 0.05ft/s in spring, summer and fall	Decreased by 0.05ft/s in winter, changes were less than 0.05ft/s in spring, summer and fall	Decreased by 0.05ft/s in winter, changes were less than 0.05ft/s in spring, summer and fall
	Drier	Changes were less than 0.05ft/s	Changes were less than 0.05ft/s	Changes were less than 0.05ft/s	Changes were less than 0.05ft/s
Georgiana Slough	Wetter	Increased by 0.10ft/s in winter, 0.05ft/s in spring, 0.25ft/s in fall, and changes were less than 0.05ft/s in summer	Increased by 0.15ft/s in winter, changes were less than 0.05ft/s in spring, summer and fall	Decreased by 0.1ft/s in winter and fall, increased by 0.05ft/s in summer and changed less than 0.05ft/s in spring	Decreased by 0.15ft/s in winter, 0.10ft/s in spring, 0.05ft/s in summer and fall
	Drier	Changes were less than 0.05ft/s	Increased by 0.05ft/s in winter, spring and fall, and changes were less than 0.05ft/s in summer	Decreased by 0.05ft/s in winter, spring and summer, changes were less than 0.05ft/s in fall	Decreased by 0.05ft/s in winter, summer and fall, and 0.1 ft/s in spring

6.6.10 Summary of the Delta Effects

The quality of the Delta has been diminished over the past hundred years. Human activities in the surrounding watershed during this period have led to the removal of vast stands of riparian forests and severe reductions in the fringing marshland habitat surrounding the Delta waterways, creation of armored levees throughout the valley floor watershed, channelization of waterways and construction of new channels to aid water conveyance in the interior of the delta (*e.g.*, Victoria Canal, Grant Line Canal) and commercial shipping traffic (The Bay Institute 1998, Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Over the past half century, substantial increases in the volume and frequency of water diversions by the CVP and SWP have occurred. The value of the Delta as a rearing habitat for juvenile salmonids has been incrementally diminished with each modification to the system. Current data indicating that survival is substantially better for those fish that remain in the main channel of the Sacramento River rather than dispersing into the side channels and interconnected waterways (Brandes and McLain 2001; Vogel 2004, 2008a) indicate that the Delta has lost its ecological function for these fish and that human induced conditions, such as exotic introduced predators, pollution, and water diversion operations have negated the benefits of these habitats for rearing fish during their outmigration to the ocean. Likewise, fish emigrating from the San Joaquin River basin are very unlikely to survive their passage through the Delta to enter the San Francisco Bay estuary at Chipps Islands (SJRGA 2001-2008) for many of the same reasons. As described above, substantial reductions in the basin's salmonid population have occurred as a direct result of these anthropogenic actions as well as those occurring upstream in the tributaries. Population impacts can be so severe that they may lead to the extirpation of a population as seen in the loss of the sizeable spring-run population that once inhabited the San Joaquin River Basin (Skinner 1958). Currently, the San Joaquin River basin's population of fall-run is decline, and the CV steelhead population is comprised of very limited number of fish.

The current suite of projects under consultation for the CVP/SWP operations in the Delta includes continued water diversions at the CVP and SWP facilities in the South Delta, which will increase under the near term and future conditions over the already substantial level of diversions. Increased water diversions during the periods of listed salmonid outmigrations will unquestionably lead to increased loss of listed salmonids from both the Sacramento River and San Joaquin River basins at the water diversion facilities, either through direct or indirect means. The magnitude of these increases remains uncertain. For example, the estimates of loss and salvage at the fish collection facilities have inherent assumptions that can lead to errors in the final calculation of these values. For instance, the assumption that fish are passed through the facility at a consistent level; thereby allowing subsamples to be taken at timed intervals to determine overall salvage and loss estimates is likely an inaccurate assumption. Fish are more than likely to come through the facilities in an episodic pattern, with pulses of high numbers of fish followed by periods of low to no fish in the samples. This would be particularly relevant for fish that are rare or low in numbers to begin with. The assumption that a 10 minute or 20 minute count every 2 hours would always capture these events needs to be more thoroughly evaluated. Furthermore, the variations in louver efficiencies related to bypass flows and the impacts of operations such as louver cleaning need to be more adequately addressed in calculating the loss and salvage numbers. Likewise, the uncertainty of the extent of the contribution of indirect or interrelated losses related to fish moving across the Delta towards the pumps under the influence of the water withdrawals (*i.e.*, net negative flows) to the overall loss estimate continues to remain a significant area of concern. As described earlier in the Delta effects analysis, many of the sources of loss associated with moving fish through the Delta, such as predator populations and the increased prevalence of non-native aquatic weeds such as *Egeria densa*, have their own interconnections with the operations of the CVP and SWP, and their continued presence is linked to maintaining an artificially stable Delta environment conducive to moving freshwater towards the pumps.

Given the current fragility of the winter-run, spring-run, and CV steelhead populations, additional levels of take will create a disproportionate level of adverse effects upon these groups of fish[18]. The low numbers of individuals in these populations and the current and future disability of their habitats to support spawning and rearing reduce the ability of the fish populations to recover from chronic take issues as current reproductive success likely cannot compensate for additional losses of individuals. Historical data indicate that entrainment of fish at the CVP and SWP is likely to occur in a more episodic fashion, when pulses of fish move through the system under the influence of environmental factors that are not easily captured in averaged data. The proposed Delta operations of the CVP and SWP under CVP/SWP operations not only maintain the current trajectory of loss seen today, but increase that trajectory through increased pumping rates and greater amounts of water diverted annually. Therefore, it is unlikely that the listed fish populations will experience any form of recovery and/or reduced vulnerability to loss resulting from these operations as described.

In addition to these core environmental conditions in the Delta, the future project actions will continue to expose fish to the salvage facilities as a consequence of the pumping operations resulting in continued losses into the future. Furthermore, operation of the permanent gates will lead to losses associated with predation at the physical structures and the local and farfield hydraulic conditions created by the barriers. Due to the geometry and hydraulic conditions in the South Delta, the interactions of the CVP and SWP with populations of salmonids in the San Joaquin River basin are exceptionally adverse. Under current operating conditions, significant reductions in the abundance of CV steelhead and fall-run originating in the San Joaquin River basin, (as well as the Calaveras River and Mokelumne River basins) are likely to continue to occur. This not only decreases the abundance of the San Joaquin River basin populations as they emigrate to the sea, but also reduces the genetic diversity and spatial distribution of the Central Valley salmonid populations by placing an inordinate amount of risk in this region of the ESU. This violates the "representation and redundancy rule" of having viable populations represented in each of the historic geographical regions in which the different populations originally occurred.

6.7 Suisun Marsh Facilities

DWR operates several facilities within Suisun Marsh that may affect listed anadromous salmonids and threatened green sturgeon. The SMSCG are operated seasonally to improve water quality in Suisun Marsh. At Roaring River and Morrow Island, DWR operates water distribution

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[18] The resilience of the Southern DPS of green sturgeon is unknown. Currently, there are no accurate estimates of the standing population of green sturgeon (*i.e.*, abundance) comprising the Southern DPS and therefore estimates of the different population parameters are unavailable.

systems that serve both public and privately managed wetlands in the marsh. DWR also operates the Goodyear Slough Outfall to provide lower salinity water to wetland managers along Goodyear Slough.

6.7.1 Suisun Marsh Salinity Control Gates

Located in the southeastern corner of Suisun Marsh, the SMSCG span the 465-foot width of Montezuma Slough. The facility consists of three radial gates, a boat lock structure, and a maintenance channel that is equipped with removable flashboards. When the SMSCG are in operation, the flashboards are installed at the maintenance channel and the gates are operated tidally. Fish migrating through Montezuma Slough must pass through this structure, which extends across the full width of Montezuma Slough. DWR proposes to operate the SMSCG periodically for approximately 10 to 20 days per year between October and May; however, the facility may operate more frequently in critically dry years and less in wet years. During the period between October and May, listed anadromous salmonids and green sturgeon migrating in Montezuma Slough will periodically encounter the SMSCG in operation and fish passage may be affected.

Operation of the SMSCG from October through May coincides with the upstream migration of adult Central Valley anadromous salmonids and green sturgeon. The late winter and spring downstream migration of Central Valley salmonids also overlaps with the operational period of the SMSCG. As adult Central Valley anadromous salmonids travel between the ocean and their natal Central Valley streams, Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. Fisheries sampling conducted by CDFG indicates many adult Central Valley salmon migrate upstream through Montezuma Slough (Edwards *et al*. 1996, Tillman *et al*. 1996), but the proportion of the total run utilizing this route is unknown. Sub-adult green sturgeon can be found in Suisun Marsh year-round (Matern *et al*. 2002), and adult green sturgeon may also use Montezuma Slough as a migration route between the ocean and their natal spawning areas in the upper Sacramento River.

To evaluate the potential effects of the SMSCG operations on adult salmonid passage, telemetry studies were initiated in 1993 on adult Chinook salmon. In seven different years (1993, 1994, 1998, 2001, 2002, 2003, and 2004), migrating adult fall-run were tagged and tracked by telemetry in the vicinity of the SMSCG. These studies showed that the operation of the SMSCG delays passage of some adult Chinook salmon. While other adult salmon never pass through the SMSCG and instead swim downstream for approximately 30 miles to Suisun Bay and then access their natal Central Valley streams via Honker Bay. Based on the results of studies conducted during the early 1990s, the CDFG recommended modifications to the structure to improve passage (Edwards *et al.* 1996, Tillman *et al*. 1996).

Telemetry studies conducted in 1998, 1999, 2001, 2002, 2003, and 2004, were designed to evaluate adult salmonid passage rates under various SMSCG configurations and operational conditions. In 1998, modifications were made to the flashboards at the SMSCG maintenance channel to include two horizontal openings, but telemetry monitoring indicated that the modified flashboards did not improve salmon passage (Vincik *et al*. 2003). Telemetry studies conducted in 2001, 2002, 2003, and 2004, evaluated the use of the existing boat lock as a fish passageway.

These results indicated that fish passage improved when the boat lock was opened. Successful passage rates improved by 9, 16, and 20 percent in 2001, 2003, and 2004, respectively, when compared to full SMSCG operation with the boat lock closed. In addition, opening of the boat lock reduced mean passage time by 19 hours, 3 hours, and 33 hours in 2001, 2003, and 2004, respectively. The 2002 results did not confirm these findings, but equipment problems at the structure during the 2002 season likely confounded the 2002 fish passage studies (Vincik 2004).

DWR proposes to operate the SMSCG as needed from October through May to meet salinity standards set by the State Water Resources Control Board and Suisun Marsh Preservation Agreement. In 2006 and 2007, the gates were operated periodically for 10-20 days annually. DWR anticipates this level of operational frequency (10-20 days per year) can generally be expected to continue in the future except during the most critical hydrological conditions. When the SMSCG are not operated, the gates remain in the open position and fish passage at the facility is not impeded.

Full operation of the SMSCG includes the flashboards installed and the gates tidally operated. Based on the results of fish passage studies, DWR proposes to hold the boat lock portion of the structure in an open position at all times during SMSCG operation to allow opportunities for fish passage during all phases of the tidal cycle. Under this operational plan, NMFS expects that between 55 and 70 percent of the adult salmonids arriving at the SMSCG during its 10-20 days of annual operation will successfully pass upstream at the structure. This rate of passage is virtually identical to the passage rate when the SMSCG is not operational (DWR and CDFG 2004). CDFG telemetry studies indicate 30 to 45 percent of the adult salmonids do not pass the structure even when the gates are not operating. Adult salmonids that do not continue upstream past the SMSCG are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker Bays.

Little is known about adult green sturgeon upstream passage at the SMSCG. Acoustic tagging results from 2007 indicate adult green sturgeon migrate to the upper Sacramento River via Suisun and Honker Bays, not Montezuma Slough (Woodbury 2008); although the NMFS study's sample size was small (six adult sturgeon) and limited to 1 year of results. The results of the 2007 acoustic tagging study also suggest that green sturgeon require 4 to 6 weeks to pass upstream from San Francisco Bay to the upper Sacramento River, and it was not uncommon for sturgeon to interrupt their migration and linger in the vicinity of Rio Vista for up to 2 weeks (NMFS unpublished data).

When the gates of the SMSCG are operating, green sturgeon will have an opportunity to pass upstream through the boat locks as salmon do or through the open gates during ebb tide. Based on the results of salmon telemetry studies, the operation of the SMSCG may also delay the upstream passage of an actively migrating adult green sturgeon by 3 to 4 days. Fish are likely impeded by the flashboards of the SMSCG along the northern shoreline and the tidally-operated gates reduce the hydrodynamic effect of flood tides downstream of the structure. Many species of fish are known to synchronize their movements through estuaries with the ebb and flow of the tides (Gibson 1992). Kelly *et al*. (2007) report sub-adult sturgeon in San Francisco and San Pablo Bays typically move in the same direction as the prevailing current. The results of the

2007 acoustic tagging study indicate adult green sturgeon in the upper Delta and lower Sacramento River typically move against the prevailing tidal current (NMFS, unpublished data). Thus, adult green sturgeon are likely capable of continuing their upstream migration by navigating through the SMSCG on an ebb tide or through the continuously open boat lock when the SMSCG are being operated.

During the majority of the period between October and May, the SMSCG will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 10-20 days of periodic operation, individual adult salmonids and green sturgeon may be delayed in their spawning migration from a few hours to several days. The effect of this delay is not well understood. Winter-run are typically several weeks or months away from spawning and, thus, they may be less affected by a migration delay in the estuary. Steelhead migrate upstream as their gonads are sexually maturing and a delay in migration may negatively impact their reproductive viability. Spring-run are typically migrating through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. Spring-run generally utilize high stream flow conditions during the spring snowmelt to assist their upstream migration. Rapid upstream movement may be needed to take advantage of a short duration high stream flow event, particular in dry years when high flow events may be uncommon. If the destination of a pre-spawning adult salmon or steelhead is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows. Green sturgeon spawn in the deep turbulent sections of the upper reaches of the Sacramento River, and spring stream flows in the mainstem Sacramento River are generally not limiting their upstream migration. It is also common for green sturgeon to linger for several days in the Delta prior to initiating their active direction migration to the upper Sacramento River (NMFS unpublished data). However, delays at the SMSCG may affect the time of arrival at the RBDD and exacerbate the fish passage problems at RBDD, as discussed above.

Downstream migrating juvenile salmonids and green sturgeon may also be affected by the operation of the SMSCG. The operational season of the SMSCG overlaps with the outmigration period of Central Valley salmonid smolts. As juvenile salmon and steelhead emigrate downstream, some fish will pass through Montezuma Slough as they travel towards the ocean. If the SMSCG are in operation, the gates will open and close twice each day with the tides. On the ebb tide, the gates are open and fish will pass downstream into Montezuma Slough without restriction. On the flood tide, the gates are closed and freshwater flow and the passage of juvenile fish will be restricted. Most juvenile listed salmonids in the western Delta entering San Francisco Bay are expected to be actively emigrating smolts. Smolts are likely taking advantage of the ebb tide to pass downstream (Vogel 2004), and, thus, the operation of the SMSCG is not expected to significantly impede their downstream movement in the estuary. Juvenile green sturgeon are thought to remain in the estuary for several years, feeding and growing before beginning their oceanic phase. These juvenile green sturgeon typically display lengthy periods of localized, non-directional movement interspersed with occasional long distance movements (Kelly *et al*. 2007). This behavior and movement by green sturgeon is not likely to be negatively affected by periodic delays of a few hours to several days at the SMSCG.

Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the SMSCG. These predatory fish are known to congregate in areas where prey species can be easily ambushed. Pikeminnow are not typically major predators of juvenile salmonids (Brown and Moyle 1981), but both pikeminnow and striped bass are opportunistic predators that will take advantage of localized, unnatural circumstances. The SMSCG provides an enhanced opportunity for predation because fish passage is blocked or restricted when the structure is operating. However, DWR proposes to limit the operation of the SMSCG to only periods required for compliance with salinity control standards, and this operational frequency is expected to be 10-20 days per year. Therefore, the SMSCG will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow. In addition, most listed Central Valley salmonid smolts reach the Delta as yearlings or older fish. Since the size and type of prey taken by pikeminnow varies with the size and age of the fish (Brown and Moyle 1981), the relatively large body size and strong swimming ability of listed salmon and steelhead smolts reduce the likelihood of being preyed upon. Juvenile green sturgeon in the estuary are also relatively large and unlikely prey for striped bass and pikeminnow.

Montezuma Slough is designated critical habitat for endangered winter-run and proposed for designation as critical habitat for the Southern DPS of green sturgeon. PCEs of designated critical habitat for salmon in the action area include water quality and quantity, foraging habitat, natural cover including large substrate and aquatic vegetation, and migratory corridors free of obstructions. The specific PCEs of proposed critical habitat for the Southern DPS of green sturgeon in estuarine areas include: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. As discussed above, fish passage will be affected by the operation of the SMSCG. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 10-20 days of annual operation. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Overall, the short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or suitability for rearing of listed anadromous salmonids and green sturgeon.

6.7.2 Roaring River Distribution System

The water intake for the Roaring River Distribution System (RRDS) on Montezuma Slough is located immediately downstream of the SMSCG. The eight 60-inch diameter culverts of the Roaring River intake are equipped with fish screens and operated to maintain a screen approach velocity of 0.2 feet per second. During high tide, water is diverted through the RRDS intakes to raise the water surface elevation within the RRDS. The low screen velocity at the intake culverts combined with a small screen mesh size are expected to successfully prevent listed salmonids and green sturgeon from being entrained into the RRDS.

As discussed above, Montezuma Slough is designated critical habitat for endangered winter-run and proposed for designation as critical habitat for green sturgeon. The operation of the RRDS may affect some PCEs of designated and proposed critical habitat. Fish passage and the migration corridor will not be affected, because the RRDS intakes are properly screened. However, water withdrawals at RRDS could influence flow, water quality, and food resources. The water surface elevation and water circulation at this location on Montezuma Slough is dominated by tides. The diversion is also tidally-operated by filling the intake pond at the RRDS during high tide. Since high tide conditions raise the water surface elevation throughout Montezuma Slough, water withdrawals at the RRDS intake do not reduce the quantity of available habitat and are not expected to negatively affect the condition of estuarine habitat for listed salmonids or green sturgeon in Montezuma Slough

6.7.3 Morrow Island Distribution System

The Morrow Island Distribution System (MIDS) diverts water from Goodyear Slough through three 48-inch diameter culverts during high tide. Although the MIDS intakes do not currently have fish screens, it is unlikely a listed salmonid or green sturgeon will be entrained into the water distribution system. Fisheries monitoring performed in 2004-05 and 2005-06 identified entrainment of 20 fish species. However, no listed salmonids or green sturgeon were observed in the MIDS entrainment studies. Two non-listed fall-run fry (39-44 mm) were captured, but this was likely due to their small size and poor swimming ability. Fall-run fry commonly arrive in the Delta and estuary at a very small size and they outmigrate as smolts at a very early age compared to Central Valley listed anadromous salmonids. The large size and better swimming ability of juvenile listed salmonids in the Delta allow these fish to avoid entrainment at MIDS. In addition, the location of the MIDS intake on Goodyear Slough further reduces the risk of entrainment. Goodyear Slough is not a migratory corridor for listed salmonids or green sturgeon.

Goodyear Slough is not designated critical habitat for anadromous salmonids, but is proposed for designation as critical habitat for green sturgeon. The slough is subject to tidal influence and the MIDS intake is also tidally-operated. High tide conditions raise the water surface elevation throughout the area and, thus, the withdrawal of water at MIDS during high tide does not reduce the volume of aquatic habitat in the marsh. Low water intake velocities minimize the loss of aquatic organisms to entrainment. Overall, the quality of habitat, foraging of prey organisms by juvenile sturgeon, and the other specific PCEs for proposed green sturgeon critical habitat are not likely to be negatively affected by the operation of MIDS.

6.7.4 Goodyear Slough Outfall

DWR operates the Goodyear Slough Outfall to improve water circulation in the marsh. This structure consists of four 48-inch diameter culverts with flap gates designed to drain water from the southern end of Goodyear Slough into Suisun Bay. On flood tides, the gates reduce the amount of tidal inflow into Goodyear Slough. Due to its location and design, listed salmonids and green sturgeon are not likely to encounter this structure or be negatively affected by its operation. Improved water circulation by the operation of the Goodyear Slough Outfall likely benefits juvenile salmonids and sturgeon in Suisun Marsh by improving water quality and increasing foraging opportunities. PCEs of proposed critical habitat for green sturgeon are not likely to be negatively affected by the operation of the Goodyear Slough Outfall.

6.8 Effects of the Action on Southern Resident Killer Whales

The proposed action has the potential to affect Southern Residents indirectly by reducing availability of their preferred prey, Chinook salmon. Central Valley Chinook salmon stocks are available to Southern Residents across their coastal range (based on coded wire tag recoveries, Weitkamp 2007); and available in greater magnitude south of Cape Falcon (O'Farrell *et al.* 2008). Any proposed action-related effects that decrease the availability of salmon, and Chinook salmon in particular, could adversely affect Southern Residents in their coastal range.

Section 3 of this Opinion defines the proposed action as the continued operation of the CVP and SWP, effective through December 31, 2030. In addition to current day operations, several other actions are included in this consultation. These actions are: (1) an intertie between the CA and the DMC; (2) FRWP; (3) the operation of permanent gates, which will replace the temporary barriers in the South Delta; (4) changes in the operation of the RBDD; and (5) Alternative Intake Project for the Contra Costa Water District. Additionally, the operation of Nimbus Fish Hatchery and production from Trinity River Fish Hatchery are interrelated and interdependent to the proposed action (section 1.5.2). Any changes to these hatchery programs that may be required, either as a result of HGMP development and implementation or other long-term planning processes will be subject to separate section 7 consultation. The time lines to implement hatchery reform at Nimbus and Trinity are currently unknown. Therefore, the effects of current hatchery practices at Nimbus and Trinity are considered for the term of this Opinion.

Most of the direct effects of the proposed action occur within freshwater and estuarine systems of the Sacramento and San Joaquin rivers, the Sacramento-San Joaquin Delta, and San Francisco Bay (Section 3.2, Action Area); effects experienced by Southern Residents in their coastal range are indirect. That is, the proposed action affects the abundance of prey for Southern Residents in the ocean. Changes in prey abundance would affect the entire DPS of Southern Resident killer whales. The best available information indicates that salmon are the preferred prey of Southern Residents year round (Krahn *et al.* 2002, 2007), including in coastal waters, and that Southern Residents require regular supplies of adult Chinook salmon prey coast-wide, likely including stocks from the Sacramento and San Joaquin rivers of California's Central Valley (*Status of the Species* section).

In this analysis, NMFS considers effects of the proposed action on the Southern Residents by evaluating prey reduction caused by the action. Where appropriate, NMFS also considers prey production contributed by hatchery mitigation programs that are interrelated and interdependent to the action.

6.8.1 Effects on the Southern Residents' Prey Base

Our analysis of effects on Southern Residents follows from the salmon analysis on listed Chinook salmon in this Opinion, as well as additional information on non-listed Chinook salmon. We evaluate effects on the Southern Residents considering: (1) NMFS' effects analysis for listed winter-run and spring-run, and (2) effects on non-listed Chinook salmon, also part of Southern Residents' prey base.

6.8.1.1 Prey Reduction of ESA-listed Chinook Salmon ESUs

The effects analysis of this Opinion for winter-run and spring-run finds that the proposed action is likely to appreciably reduce the likelihood of their survival and recovery. In other words, thr proposed action appreciably increases the risk of extinction of these listed entities of salmon. Additionally, NMFS has concluded that the proposed action is likely to reduce the conesrvaton value of designated critical habitats of winter-run and spring-run.

NMFS evaluated effects on the Southern Residents qualitatively. We assessed the likelihood for localized depletions, and long-term implications for Southern Residents' survival and recovery, resulting from extirpations of winter-run and spring-run ESUs. In this way, NMFS can determine whether the increased likelihood of extinction of prey species is also likely to appreciably reduce the likelihood of survival and recovery of Southern Residents.

A reduction in prey would occur over time as winter-run and spring-run abundance declines. Hatchery programs, which account for a portion of the winter- run and spring-run ESUs, may provide a short-term buffer, but it is uncertain whether hatchery-only stocks could be sustained indefinitely. Although not currently large in numbers (20-year average adult escapements from 1986-2007 were 4,066 and 12,889, respectively; CDFG 2008), the loss of these ESUs would also preclude the potential for their future recovery to healthy, more substantial numbers.

Differences in adult salmon life histories and locations of their natal streams likely affect the distribution of salmon across the Southern Residents' coastal range. The continued decline and potential extinction of winter-run and spring-run populations, and consequent interruption in the geographic continuity of salmon-bearing watersheds in the Southern Residents' coastal range, is likely to alter the distribution of migrating salmon and increase the likelihood of localized depletions in prey, with adverse effects on the Southern Residents' ability to meet their energy needs. A fundamental change in the prey base originating from California's Central Valley is likely to result in Southern Residents abandoning areas in search of more abundant prey or expending substantial effort to find depleted prey resources.

6.8.1.2 Other Effects on Southern Residents' Prey Base

In addition to effects on winter-run and spring-run, the proposed action will affect non-listed fall-run and late fall-run in California's Central Valley, and non-listed spring-run and fall-run in the Trinity River watershed. We quantify the effects of hatchery production and project operations on non-listed Chinook salmon prey available to Southern Residents. The analysis considers effects of the proposed action and interrelated and interdependent actions over the effective term of this Opinion (through December 31, 2030).

6.8.1.2.1 Effects of Artificial Production

Effects from artificial propagation of non-listed fall-run from the Central Valley (Nimbus Fish Hatchery) and for non-listed spring- and fall-run from the Trinity River watershed (Trinity River Fish Hatchery) are included in the analysis because Nimbus Fish Hatchery production, and Chinook salmon production from Trinity River Fish Hatchery, are interrelated and interdependent to the proposed action. These hatcheries produce Chinook salmon that is available to Southern Residents as prey. This analysis uses the current levels of funding and production, which are proposed to continue over the term of the proposed action (as discussed above, any changes to current funding and production as a result of a HGMP or other long-term planning processes are beyond the scope of this action, and will be subject to separate section 7 consultation).

Nimbus Hatchery is one of the five hatchery programs that produce Central Valley fall-run. In total, approximately 90 percent of fall-run returning to the Central Valley are hatchery-origin fish, and the remaining 10 percent are natural-origin (± 6 percent; based on Barnett-Johnson *et al*. 2007). Only a portion of hatchery-origin fall-run available to Southern Residents are produced by interrelated or interdependent actions, those of Nimbus Fish Hatchery in the Central Valley and the Trinity River Fish Hatchery. The Nimbus Fish Hatchery program produces an average of 13.3 percent of the Central Valley fall-run available to Southern Residents in the near-term (current and 5- to 10-year horizon) and projected for the long-term (30-year horizon, range: 12.9 to 15.1 percent; table 6-39).

The Trinity River Fish Hatchery is the sole producer of hatchery-origin spring- and fall-run that return to the Trinity River watershed. The Trinity River Fish Hatchery program produces 57 percent of the Trinity spring- and fall-run available to Southern Residents (based on the average hatchery proportion of Chinook salmon escapements to the watershed from 1991-2006; Appendix 3). Currently, the Trinity River Fish Hatchery's mitigation goal is to produce 45 percent of escapement (Hannon 2009a).

Table 6-39. Percent of Central Valley fall- and late fall-fun annually available to killer whales that are produced by the Nimbus Fish Hatchery program over the duration of the proposed action (Appendix 3).

Time Horizon	Average (percent)	Range[a] (percent)
Current[b]	13.3	12.9 to 14.8
5- to 10-year projection[c]	13.3	12.9 to 15.1
30-year projection[d]	13.3	12.9 to 15.0

[a] Range incorporates variability in adult escapement over the past 20 years.
[b] Study 7.0
[c] Study 7.1
[d] Study 8.0

The potential harmful effects of artificial propagation on the long-term fitness of salmon populations are discussed previously in this Opinion (section 4.2.4.8, Hatchery Operations and Practices). Specifically, hatcheries can adversely affect population viability by reducing abundance, productivity, spatial distribution and/or diversity of natural-origin fish (McElhany *et al*. 2000). The immediate cause of the recent fall-run decline is most likely a result of ocean conditions (Lindley *et al*. 2009). However, freshwater impacts, including hatchery programs, most likely contributed to the collapse (Lindley *et al.* 2009). Continued hatchery funding is not likely to change over the term of this Opinion, and time lines for implementing hatchery reform at Nimbus and Trinity River fish hatcheries are currently uncertain. We evaluate potential long-term effects of current practices at Nimbus and Trinity River fish hatcheries by considering practices that may be detrimental to natural fish and any best management practices in place to avoid harmful effects on natural fish (CDFG and NMFS 2001).

Both hatchery programs include current practices that negatively affect natural fish and could diminish the productivity, distribution, and diversity of non-listed stocks over the long-term. Such effects could make these stocks less resilient to the effects of disease, climate change, and stochastic events. These hatchery programs also include some practices that are designed to maintain stock integrity.

At Nimbus Fish Hatchery, fall-run smolts are trucked to San Pablo Bay for release in the western Delta. Trucking smolts before release increases the straying of Nimbus Fish Hatchery fall-run escapement to rivers throughout the Central Valley, and causes demographic and genetic risks to natural fall-run populations. Additionally, Nimbus Fish Hatchery transfers Chinook salmon eggs to other hatcheries in the Central Valley, which reinforces homogenization of fall-run. At Trinity River Fish Hatchery, current practices for brood stock collection are based on observed phenotypic differences between spring and fall races, which is potentially unreliable and may contribute to genetic introgression between spring and fall hatchery runs. Nimbus and Trinity River fish hatcheries also employ practices that protect the natural fish and genetic diversity, including broodstock collection across run-timing for full representation of runs in hatchery programs, and marking hatchery smolts at a constant 25 percent rate of all releases (since spring of 2007 at Nimbus Fish Hatchery and for at least 10 years at Trinity River Fish Hatchery). These marking practices are parallel to methods under development to standardize data collection and increase monitoring programs in the Central Valley (CDFG and NMFS 2001).

6.8.1.2.2 Effects of Project Operations

6.8.1.2.2.1 Central Valley

Project operations in the Central Valley reduce reproductive success of adult and increase mortality of early life-stage (egg through smolt) fall- and late fall-run (Appendix 3). If considered alone, project operations would reduce the abundance of adult Chinook salmon in the ocean and reduce prey available to Southern Residents. To determine whether the Chinook salmon prey base for Southern Residents is reduced by the proposed action, we compare the decrease in the prey base for Southern Residents resulting from project-caused mortality on Central Valley fall- and late fall-run to the increase in the prey base resulting from the Nimbus Fish Hatchery program production of fall- and late fall-run. As described above, the Nimbus Fish Hatchery program produces an average of 13.3 percent of the Central Valley fall- and late fall-run available to Southern Residents. In the short-term, the proposed action would have to cause a greater percent reduction in the Central Valley fall- and late fall-run than this production from hatcheries to result in an overall reduction in prey for Southern Residents. Although we consider these net effects of project operations and hatchery production in the short-term, we also separately considered the long-term effects of hatchery production on prey available to Southern Residents above (section 6.8.1.2.1), and identified that hatchery practices could diminish the productivity, distribution and diversity of non-listed stocks over the long term.

NMFS quantified freshwater mortality sources for Central Valley fall- and late fall-run to evaluate an overall change in freshwater mortality attributed to project operations. Overall mortality from early life-stages was used to estimate the effective reduction in ocean abundance of fall and late fall-run and quantify effects on Southern Residents' prey base (methods described in Appendix 3). Mortality sources quantified include high water temperature and low flow upstream, and direct entrainment in the Delta. Although not quantified, project operations also cause mortality from fish stranding, redd dewatering and predation (Appendix 3).

Project operations in the Central Valley reduce the total hatchery and natural fall- and late fall-run available to Southern Residents by between 1.9 and 2.3 percent annually (average) over the project duration (range: 1.1 to -13.5 percent; table 6-40). Hatchery production interrelated and interdependent to the proposed action more than offsets the overall losses of Central Valley fall- and late fall-run (compare tables 6-39 and 6-40). Although fall- and late fall-run mortality does not result in a net reduction in the Southern Residents' prey base, project operations disproportionately affect natural-origin fish with potential long-term effects on fall- and late fall-run stocks, discussed further below.

Table 6-40. Percent annual reduction in hatchery and natural Central Valley fall- and late fall-run available to Southern Residents from project-caused mortality over the duration of the proposed action (Appendix 3).

Time Horizon	Average (percent)	Range[a] (percent)
Current[b]	-1.9	1.1 to -11.8
5- to 10-year projection[c]	-2.3	1.1 to -13.9
30-year projection[d]	-2.3	1.1 to -13.5

[a] Range incorporates variability in adult escapement over the past 20 years.
[b] Study 7.0
[c] Study 7.1
[d] Study 8.0

The project operations disproportionately affect nautral-origin fish because all of the natural-origin fish are exposed to in-river mortality sources, while the majority of the hatchery smolts, post-smolts and yearlings (20,660,000 out of a total Central Valley Chinook salmon hatchery release of 34,660,000) are released in San Francisco Bay and are not exposed to in-river mortality sources. As discussed above, natural-origin returns contribute approximately 10 percent of the available Central Valley fall- and late fall-run, and the remainder is hatchery-origin fish. Natural-origin salmon are important to the long-term maintenance of population distribution and diversity, both important factors for retaining population viability (McElhany *et al*. 2000) and buffering environmental variation (Lindley *et al*. 2009). Therefore, we also quantified the prey reduction specific to natural-origin fall and late fall-run.

Project operations in the Central Valley reduce natural-origin fall- and late fall-run by between 9.8 and 10.7 percent annually (average) over the project duration (range: -0.7 to -41.9 percent, table 6-41). Currently, and in the future, there is a potential for an annual reduction of as much as 40 percent from project operations, depending in part on environmental variability. Up to 40 percent annual reductions in the natural-origin component of Central Valley fall- and late fall-run could further diminish the 10 percent contribution of natural adults, and potentially compromise the retention of diversity in the Central Valley fall- and late fall- run stocks over the long term.

Table 6-41. Percent annual reduction in natural Central Valley fall- and late fall-run Chinook salmon available to Southern Residents from project-caused mortality over the duration of the proposed action (Appendix 3).

Time Horizon	Average (percent)	Range[a] (percent)
Current[b]	-9.8	-0.9 to -39.0
5- to 10-year projection[c]	-10.7	-0.7 to -41.9
30-year projection[d]	-10.7	-0.7 to -40.6

[a] Range incorporates variability in adult escapement over the past 20 years.
[b] Study 7.0
[c] Study 7.1
[d] Study 8.0

6.8.1.2.2.2 Trinity River Watershed

Project operations in the Trinity River affect Chinook salmon populations in the Klamath/Trinity River watershed. The implementation of the Trinity River Restoration Program has provided increased flows from the Trinity River and stream habitat improvements. These actions should positively affect Chinook salmon production in the Klamath/Trinity River watershed (CVP/SWP operations BA, DOI 2000). Therefore, project operations in the Trinity River will have no adverse effects on ocean abundance of Chinook salmon and Southern Residents' prey base. As stated above, production from the Trinity River Fish Hatchery program is interrelated and interdependent to the proposed action. The Trinity River Fish Hatchery produces between 45 and 57 percent of the Trinity River spring- and fall-run available to Southern Residents (based on hatchery returns in the recent past and current mitigation goals). In the short-term, these components of the interrelated and interdependent action increase prey available to Southern Residents from the Trinity River watershed. Long-term concerns about the effects of hatchery practices on availability of Southern Resident prey resources were addressed above.

6.8.1.2.3 Effects of Climate Change

We also considered the sensitivity of project operations and system conditions with future climate change over the term of the Opinion, using a worst case scenario represented by drier, warmer conditions (Appendix 3). The scenario was based on changes in system hydrology and upstream survival of early life-stage Chinook salmon under drier, warmer climate conditions. We cannot directly compare the climate change scenario to previous analysis of project operations projected for the term of the Opinion, because the climate scenario evaluated includes different assumptions about system hydrology that complicates our ability to separate out project vs. non-project related effects. The climate scenario does indicate that drier, warmer conditions would cause greater reductions in natural Central Valley fall- and late-fall run (compare table 6-41 with table 6-42), even though overall returns and hatchery returns are affected similarly with or without the change in climate regime (compare tables 6-39 and 6-40 with table 6-42).

Table 6-42. Percent annual change in Central Valley fall- and late fall-run Chinook available to Southern Residents under a drier, warmer climate scenario (based on Study 9.5, Appendix 3).

Change in Adult Returns	Average (percent)	Range[a] (percent)
Overall returns	-3.0	0.6 to -14.9
Hatchery-origin returns	13.4	13.0 to 15.3
Natural-origin returns	-16.7	-4.4 to -51.7

[a] Range incorporates variability in adult escapement over the past 20 years.

7.0 Interrelated or Interdependent Actions

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. 1536; 50 CFR 402.02).

7.1 Nimbus Fish Hatchery

Nimbus Fish Hatchery is interrelated to the operations of the CVP and SWP, as it was designed to mitigate for the loss of fish habitat above Folsom Dam. The effects of steelhead produced at Nimbus Fish Hatchery is a major stressor to the survival and recovery of CV steelhead in the lower American River. Therefore, the effects of Nimbus Fish Hatchery steelhead on American River steelhead are addressed in section 6.4.3.4.

8.0 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

8.1 Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

8.2 Agricultural Practices

Agricultural practices may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River and Delta. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation, as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

8.3 Increased Urbanization

The Delta, East Bay, and Sacramento regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial, and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. City of Manteca (2007) anticipates 21 percent annual growth through 2010 reaching a population of approximately 70,000 people. City of Lathrop (2007) expects to double its population by 2012, from 14,600 to approximately 30,000 residents. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the section 7 consultation process with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This, in turn, would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the Delta.

8.4 Activities within the Nearshore Pacific Ocean

Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities are primarily those conducted under state, tribal or Federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

A Final Recovery Plan for Southern Resident killer whales was published in 2008 (NMFS 2008a). Although state, tribal and local governments have developed plans and initiatives to benefit marine fish species, ESA-listed salmonids, green sturgeon, and Southern Residents, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably certain to occur" in its analysis of cumulative effects.

Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects, above whether future non-Federal actions will lead to an increase or decrease in prey available to Southern Resident, or have other effects on their survival and recovery.

9.0 INTEGRATION AND SYNTHESIS OF THE EFFECTS

The *Integration and Synthesis* section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementation of the proposed action through year 2030. In this section, we integrate effects within a year and across the 21 years of operations, and then add these effects to the baseline (section 5.0) and cumulative effects (section 8.0) to assess whether it is reasonable to expect that the proposed action is not likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution, or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (section 4.0). The *Analytical Approach* (section 2) described the analyses and tools we have used to complete our assessments.

This section is organized by species such that we integrate and synthesize the effects to the species survival and recovery first, and the effects to that species' critical habitat second. For species with multiple populations, such as spring-run and steelhead, populations are organized by diversity groups. The information for the survival and recovery analysis is presented in the following stepwise order: (1) Status of the Species; (2) Future Environmental Baseline to which we will add the effects of the action; (3) Summary of Effects to Individuals; (4) Risk to the Population; and (5) Risk to the ESU. This same general order was used to present the critical habitat analysis, with the exceptions that steps (1) and (2) are combined into one step titled, the

Status of Critical Habitat; and steps (3) and (4) are accomplished in one step titled, Project Effects on Critical Habitat. The last step was used to assess the risk to critical habitat as designated or proposed.

Anderson *et al*. (2009) stated the following:

- NMFS addressed a long list of stressors, but it is not evident which ones NMFS has determined are most important;
- The jeopardy decision tables need to be filled out with key lines of evidence;
- There needs to be a connection between the most important stressors, the determination of jeopardy, and the RPA actions that address those key stressors; and
- Risk needs to be consistently conveyed through examining the range of information regarding a particular stressor or response, and whether the effect is high, medim, or low.

For each CVP-controlled stream, NMFS compiled a table that summarized the stressors and their responses for each population of fish, by species, while following their life cycle in the freshwater environment. For each response, NMFS assigned a relative magnitude of effect (high, medium, or low), which was a qualitative assessment of the likelihood of a fitness consequence occurring. The categories to assign magnitude of risk of stressors that were analyzed were defined as follows:

- High – lethal effect due to stressor that had a broad effect on population at significant frequency
- Medium – between high and low
- Low – generally, sublethal effect, or lethal effect on a very small percentage of one population at a very infrequent interval

NMFS then determined the weight of evidence (high, medium, or low) that it had for the effect. The weight of evidence was based on the best available scientific information, and categorized as follows:

- High certainty – multiple scientific and technical publications, especially if conducted on the species within the area of effect, quantitative data, and/or modeled results; generally from the BA.
- Medium certainty – between high and low
- Low – one study, or unpublished data, or scientific hypotheses that had been articulated but not tested.

High magnitude of effect coupled with high weight of evidence for that effect indicated a greater likelihood of a fitness consequence, whereas a high magnitude of effect with a low weight of evidence provided little certainty of a fitness consequence. The fitness consequences, by life history stage, were considered in context of the status of the species and future environmental baseline, in order to evaluate the effect of the action at the population scale. The summary tables were used to evaluate the effects of the action in the context of the viability parameters of abundance, growth rate, spatial structure, and diversity.

9.1 Sacramento River Winter-Run Chinook Salmon

9.1.1 Status of Sacramento River Winter-Run Chinook Salmon

Historically, independent winter-run populations existed in Battle Creek, and in the Pit, McCloud, and Little Sacramento rivers in the Upper Sacramento River. One-hundred percent of historic winter-run spawning habitat in the upper Sacramento River has been blocked by Shasta and Keswick Dams, resulting in one remaining population, limited to the mainstem Sacramento River. Winter-run no longer inhabit Battle Creek as a self-sustaining population, probably because hydropower operations make conditions for eggs and fry unsuitable (NMFS 1997).

Historical winter-run population estimates, which included males and females, were as high as near 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). In recent years, the carcass survey population estimates of winter-run included a high of 17,205 (table 4-2) in 2006, followed by a precipitous decline to about 2,500 cfs in 2007 and about 2,800 fish in 2008.

We used the cohort replacement rate, and also a 5-year running average of the cohort replacement rate, as a representation of population growth rate. When the cohort replacement rate is 1.0, the population is stable and replacing itself. Table 4-2 provides cohort replacement rates since 1986. As shown, the cohort replacement rates from 1995 through 2006 were stable or increasing, indicating a positive growth rate trend. However, in the last 2 spawning seasons, the cohort replacement rate was less than one, which means a short-term decline in population growth rate.

In the most recent status assessment of winter-run, Lindley *et al.* (2007) determined that the winter-run population is at a moderate extinction risk according to PVA, and at a low risk according to other criteria (*i.e.*, population size, population decline, the risk of wide ranging catastrophe, hatchery influence). However, hatchery-origin winter-run from LSNFH have made up more than 5 percent of the natural spawning run in recent years and in 2005, their contribution exceeded 18 percent of the in-river escapement. Lindley *et al*. (2007) recommended that if hatchery-origin fish continued to contribute more than 15 percent of the returning spawners, then the population would be reclassified from low to moderate extinction risk. In addition, data used for Lindley *et al*. (2007) did not include the significant decline in escapement numbers in 2007 and 2008, which are reflected in the population size and population decline, nor the current drought conditions.

Lindley *et al.* (2007) also states that the winter-run ESU fails the “representation and redundancy rule” because it has only one population, and that population spawns outside of the ecoregion in which it evolved. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction (Lindley *et al*. 2007). A single catastrophe could extirpate the entire Sacramento River winter-run Chinook salmon ESU, if its effects persisted for four or more years. The entire stretch of the Sacramento River used by winter-run is within the zone of influence of Mt. Lassen, an active volcano, which last erupted in 1915. Some other possible catastrophes include a prolonged drought that depletes the cold water storage of Shasta Reservoir or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak (Lindley *et al*. 2007).

NMFS concludes that the winter-run ESU remains at a high risk of extinction. Key factors upon which this conclusion is based include: (1) the ESU is composed of only one population, which has been blocked from all of its historic spawning habitat; (2) the ESU has a risk associated with catastrophes, especially considering the remaining population's proximity to Mt. Lassen and its dependency on the coldwater management of Shasta Reservoir; and (3) the population has a "high" hatchery influence (Lindley *et al*. 2007).

9.1.2 Future Baseline of Winter-Run Chinook Salmon Excluding CVP/SWP Effects

This section describes the environmental baseline upon which we will add the effects of the proposed action in order to help assess the response and risk to the species. The general baseline stress regime for Chinook salmon in the freshwater, estuarine, and marine environment is depicted in figure 9-1.

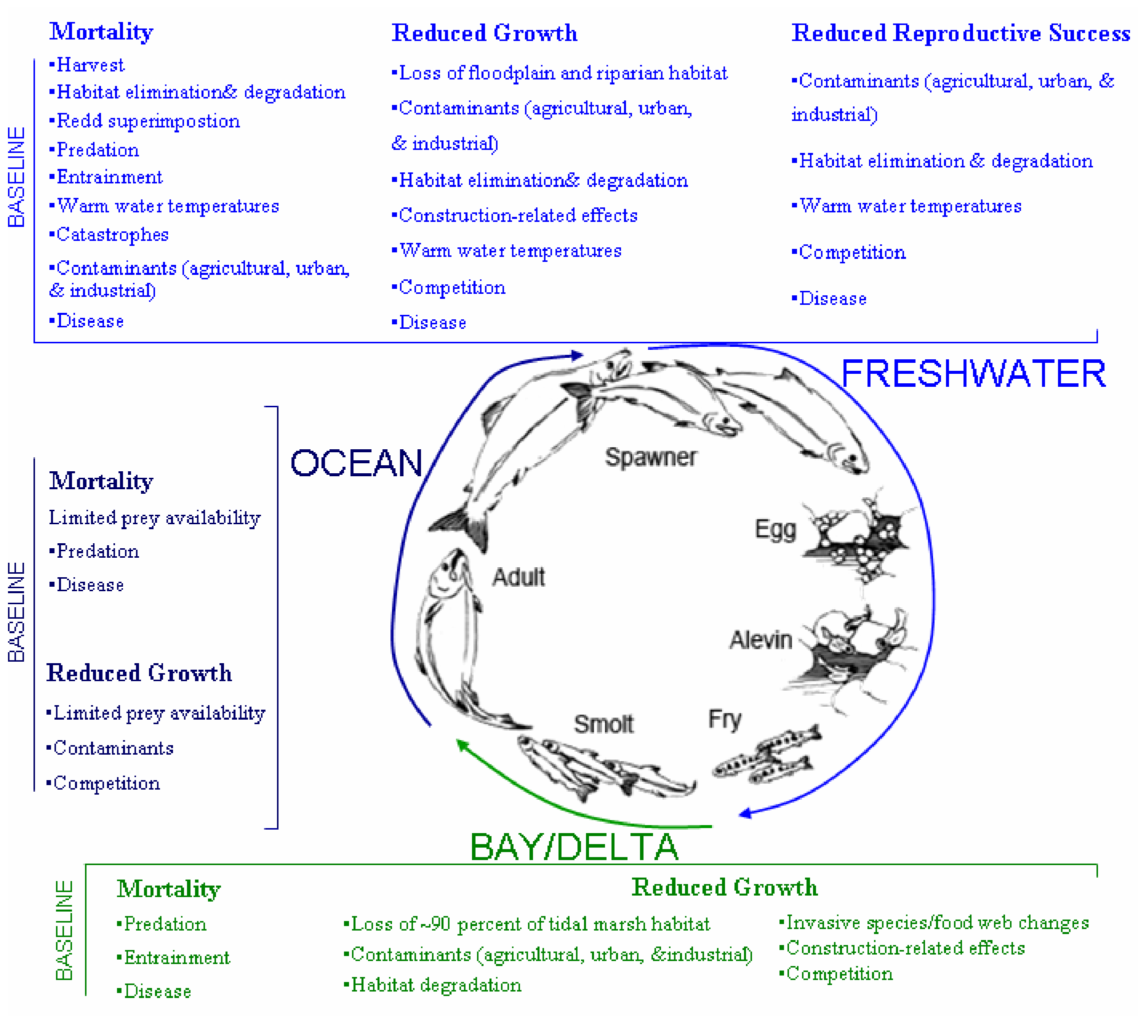

Figure 9-1. Chinook salmon stressors excluding CVP/SWP-related effects (*i.e.*, the figure represents the general baseline stress regime). Chinook salmon are in freshwater during their adult immigration and holding, spawning, egg incubation, alevin, fry, and fingerling life stages. They are in the Bay/Delta as smolts and in the ocean as sub-adults and adults. Although not depicted in the figure, climate change is a baseline stressor expected to exacerbate many of the depicted conditions for anadromous salmonids throughout their

life cycle, particularly with respect to water temperature in all environments, inland hydrology, and ocean productivity (*e.g*., upwelling).

A key aspect of the baseline stress regime that warrants discussion here is climate change. Lindley *et al*. (2007) summarized several studies (Hayhoe *et al*. 2004, Dettinger *et al*. 2004, Dettinger 2005, VanRheenen *et al*. 2004, Knowles and Cayan 2002) on how anthropogenic climate change is expected to alter the Central Valley, and based on these studies, described the possible effects to anadromous salmonids. Climate models for the Central Valley are broadly consistent in that temperatures in the future will warm significantly, total precipitation may decline, the variation in precipitation may substantially increase (*i.e.*, more frequent flood flows and critically dry years), and snowfall will decline significantly (Lindley *et al*. 2007). Not surprisingly, temperature increases are expected to further limit the amount of suitable habitat available to anadromous salmonids. The potential for more frequent flood flows might be expected to reduce the abundance of populations, as egg scour becomes a more common occurrence. The increase in the occurrence of critically dry years also would be expected to reduce abundance, as, in the Central Valley, low flows during juvenile rearing and outmigration are associated with poor survival (Kjelson and Brandes 1989, Baker and Morhardt 2001, Newman and Rice 2002). In addition to habitat effects, climate change may also impact Central Valley salmonids through community effects. For example, warmer water temperatures would likely increase the metabolism of predators, reducing the survival of juvenile salmonids (Vigg and Burley 1991). Peterson and Kitchell (2001) showed that on the Columbia River, pikeminnow predation on juvenile salmon during the warmest year was 96 percent higher than during the coldest. In summary, climate change is expected to exacerbate existing stressors and pose new threats to Central Valley salmonids by reducing the quantity and quality of inland habitat (Lindley *et al*. 2007).

9.1.3 Summary of Proposed Action Effects on Winter-Run Chinook Salmon

Proposed action-related effects to winter-run are summarized in table 9-1. Detailed descriptions regarding the exposure, response, and risk of winter-run to these stressors are presented in section 6.

As shown in table 9-1, proposed action-related stressors reduce the fitness of individuals in all inland life stages. The cumulative effect of these stressors throughout the life cycle likely has important consequences for the viability of the population, as Naiman and Turner (2000) demonstrated that it is possible to drive a Pacific salmon population to extinction (or to increase population size), by only slight changes in survivorship at each life history stage (see figure 2-3). It is important to recognize that the proposed action directly or indirectly affects the survivorship of each life stage, including fish that do not survive in the ocean because they do not enter the ocean in “top form.” In addition, as discussed below, other factors beyond abundance govern the viability of a species and its extinction risk.

Table 9-1. Summary of proposed action-related effects on winter-run.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult Immigration Delta	Dec.-Apr.	DCC gate closures	Winter-run could be delayed in the Delta resulting in greater exposure to both the in-river sport fishery and contaminants (reduced egg fertility or reduced viability and motility of spermatocytes during spawning).	Low	Low - based on limited supporting data	Reduced survival and reduced reproductive success
2	Adult Immigration RBDD	May – Jul.	RBDD gate closures from May 15 - Sept 15 every year until 2019	~15 % of adults delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity; continues every year until 2019	High	High - based on TCCA (2008) and CVP/SWP operations BA, including many historical cited studies	Reduced survival and reduced reproductive success
3	Adult Immigration RBDD	May – Jul.	RBDD emergency 10 day gate closures prior to May 15	Greater proportion of run blocked or delayed; sub lethal effects on eggs in fish and energy loss. These emergency gate closures have occurred twice in the past 10 years and the frequency of occurrence may increase with climate change.	High	High - based on TCCA (2008) and CVP/SWP operations BA	Reduced survival and reduced reproductive success
4	Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year from April 15 to Sept 30	Introgression or hybridization with spring/fall run/late-fall Chinook salmon; loss of genetic integrity and expression of life history	High	Low	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
4	Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year from April 15 to Sept 30	Density dependency - aggressive behavior among spawning fish could cause higher prespawn mortality, increased fighting for suitable spawning sites, adults forced downstream into unsuitable areas	Medium - may increase as abundance increases	Medium	Reduced survival and reduced reproductive success
4	Spawning Primarily upstream of RBDD	Apr. – Aug.	Reduced spawning area from moving TCP upstream in almost every year from April 15 to Sept 30	Redd superimposition - spawning on top of other redds, destroys eggs	Medium - may increase as abundance increases	Low	Reduced egg survival and reduced reproductive success
5	Spawning Primarily upstream of RBDD	Apr. – Aug.	Water temperatures warmer than life history stage requirements below TCP, every year April 15 -Sept 30)	Prespawn mortality; reduced fecundity	High	High - based on CVP/SWP operations BA models and laboratory and hatchery evidence of temperature tolerances	Reduced survival and reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
6	Embryo Incubation Primarily upstream of RBDD	Apr. – Oct.	Water temperatures warmer than life history stage requirements, every year from April 15 - Sept 30. (No carry-over storage target designed for fish protection is included in the proposed action. Without such a target, the risk of running out of coldwater in Shasta Reservoir increases.)	Egg mortality - 16% in critically dry years and increases to 65% in critically dry years with climate change. On average, for all water year types, mortality is 5-12% with climate change and 2-3% without. 56ºF is exceeded at Balls Ferry in 30% of the years in August and 55% of the years in September Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of winter-run to survive during subsequent life stages (Campbell *et al*. 1998). Campbell *et al.* (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	High	High - based on water temperature and salmon mortality modeling presented in the CVP/SWP operations BA and on scientific literature. Significance of sub-lethal effects cited in Deas *et al*. (2008)	Reduced survival
7	Embryo Incubation Primarily upstream of RBDD	Apr. – Oct.	Flow fluctuations caused by ACID dam installation, 2 x /year, every year in April - November	Redd dewatering and stranding; loss of a portion, or all eggs in redd	Low	High - based on hydrology, but low based on redd surveys and low rate of redd dewatering historically observed	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
8	Juvenile rearing Upstream of and including RBDD	Jul. – Mar.	Water temperatures warmer than life stage requirements	Increased susceptibility to predation and disease	Medium	High - based on modeled water temps presented in CVP/SWP operations BA and scientific literature regarding temperature tolerances (EPA 2001; Myrick and Cech 2001, 2004)	Reduced survival
9	Juvenile rearing Upstream of and including RBDD	Jul. – Mar.	RBDD passage downstream through dam gates May15 - Sept 15	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 10% of winter-run would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	High	High - based on mortality studies at RBDD and timing of emigration (Vogel *et al*. 1988; Tucker 1998; TCCA 2008)	Reduced survival
10	Juvenile rearing Upstream of and including RBDD	Jul. – Mar.	Lake Red Bluff, river impounded May15 - Sept 15	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967.	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11	Juvenile rearing Upstream of and including RBDD	Jul. – Mar.	Flow fluctuations caused by ACID dam removal in November	Fry standing and juvenile isolation; juveniles killed or subjected to predation and higher temps in side channels. Flow fluctuations from the dam removal occur over a short time period, limiting the exposure to potential fry stranding and juvenile isolation.	Low	High - based on real-time management of dam removal	Reduced reproductive success
12	Juvenile rearing Upstream of and including RBDD	Jul. – Mar.	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency)	Low	High - based on annual monitoring of fish screens	Reduced survival
13	Juvenile rearing/smolt emigration RBDD to Colusa	Sep. – Nov.	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High - based on CVP/SWP operations BA	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
14	Juveniles and smolts RBDD to Colusa	Sep. – Nov.	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on Co-manager review draft of Central Valley Salmon Recovery Plan and CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
15	Juveniles and smolts Colusa to Sacramento	Sep. – Nov.	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few winter-run are expected to be in this area during the fall.	Low	Low - based on lack of monitoring	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
16a-e	Juvenile/ Smolt emigration Delta	Nov. - May	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	During dry and critical years in December and January, modeling estimates of monthly mortality of up to approximately 15% of the total winter-run population entering the Delta at Freeport is associated with exports (Greene 2008). Of those winter-run entering the *interior* of the Delta (through DCC or Georgiana Slough), mortality is estimated to be approximately 66% (range of 35-90% mortality). This equates to approximately 5-20% of the total population entering the Delta at Freeport. Anticipated delays in migration due to export operations.	High	Low to High (see below) 15% mortality estimates are from DWR PTM modeling (Greene 2008) Delta interior mortality estimated from acoustic tagging studies (Vogel 2003; Horn and Blake 2004; Perry and Skalski 2008; Vogel 2008a)	Reduced survival
16a	Juvenile/ Smolt emigration Delta	Nov. - May	DCC operations - open gate configurations from November through January	Increased vulnerability of entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Open gate configuration in December and January exposes approximately 45% of the winter-run population estimated at Knights Landing to risk of diversion into the interior Delta	High	High – Numerous studies *i.e.*, Delta Action 8, DCC, and Delta Interior experiments confirm low survival of fish entrained into the delta interior. Acoustic tagging studies provide similar conclusions for survival within the Delta interior	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
16b	Juvenile/ Smolt emigration Delta	Nov. - May	Loss in Delta interior	Diversion of emigrating fish into the delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Island) are observed for fish migrating through the Delta interior. Loss of up to 15% of winter-run population entering the Delta	High	High – numerous studies find similar high loss rates for fish relased in the Delta interior.	Reduced survival
16c	Juvenile/ Smolt emigration Delta	Nov. - May	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately two thirds of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85% of the exposed fish. The percentage of the population exposed is variable, typically less than 2-3%, and frequently is much lower (0.5%) based on salvage recovery estimates. Percentage of population actually arriving at the export facilities and entering the salvage process is low.	Low	High- numerous studies have evaluated screening efficiency, predation, and overall salvage operations survival	Reduced survival
16d	Juvenile/ Smolt emigration Delta	Nov. - May	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on salmon as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta	High	Low to Medium. Invasion of non-native species into delta is well documented, interaction with salmonid populations less well documented	Reducted survival, Reduced growth

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
16e	Juvenile/ Smolt emigration Delta	Nov. - May	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, *etc*.). Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics well studied. Effects of Delta hydrodynamics on organisms relatively unstudied	Reduced survival, reduced growth

9.1.4 Assess Risk to the Population

Population viability is determined by four parameters: spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning conditions (habitats) and the connections between such habitats (McElhany *et al*. (2000). Properly functioning condition defines the inland habitat conditions necessary for the long-term survival of Pacific salmon populations (McElhany *et al*. (2000). As described in section 6, habitat conditions in the Sacramento River and Delta are adversely affected by the proposed action in a number of ways, including, but not limited to: (1) delaying adult immigration through RBDD operations; (2) moving the TCP upstream during spawning and embryo incubation; (3) creating conditions favorable for predators as juveniles migrate downstream of RBDD during the gates in period; (4) pulling more water and juvenile salmon into the Central and South Delta; and (5) changing the Delta from a variable salinity system to one that is predominantly freshwater. In these ways, the proposed action reduces the population's current spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the winter-run population, and consequently the ESU.

The diversity of winter-run continues to be limited as a result of the proposed action. The release of cold water to accommodate adult winter-run migration, holding, spawning, and egg incubation is predictable, beginning and ending on specific dates, leaving little room for variability in both the run and spawn timing within the species, both of which have been identified as key diversity traits (McElhany *et al*. 2000).

In addition, the diversity of winter-run is reduced by proposed operations due to effects which truncate the timing of particular life stages. RBDD (gates down) delays up to approximately 15 percent of the adults, some of which suffer pre-spawn mortality or have reduced spawning success. This delay at RBDD effectively reduces the numbers of potentially fit spawners from the tail end of the spawning population, thereby reducing genetic and life history diversity. In addition, while the gates are still down, RBDD results in the increased mortality of the first 10 percent of the juveniles outmigrating, thereby truncating the first part of the outmigration period. Furthermore, a portion of winter-run smolts are expected to be entrained into the Central and South Delta through the DCC when the gates are open during the November 1 through January 31[19] time frame. Our analysis in section 6.6, above, shows that the survival of winter-run juveniles is considerably lower through the Central and South Delta than if the juveniles stayed within the mainstem Sacramento River. The lower survival rates of the juveniles through the Central and South Delta are attributable to the direct and indirect effects of the Federal and State pumps. Because the DCC is open during the beginning of the winter-run smolt outmigration period, entrainment of juveniles through the DCC again truncates the first part of the outmigration period of smolts. The near term and future operations would likely result in more of the Sacramento River being diverted to the Central and South Delta through the DCC, thereby resulting in increased entrainment (and subsequent mortality) of winter-run smolts during the early part of their outmigration period. Thus, the combined effects of RBDD gates down and

[19] D-1641 provides for a 45-day discretionary closure of the DCC gates from November 1 though January 31.

DCC gates open result in constricting the period of survival of winter-run during their inland residency (figure 9-2).

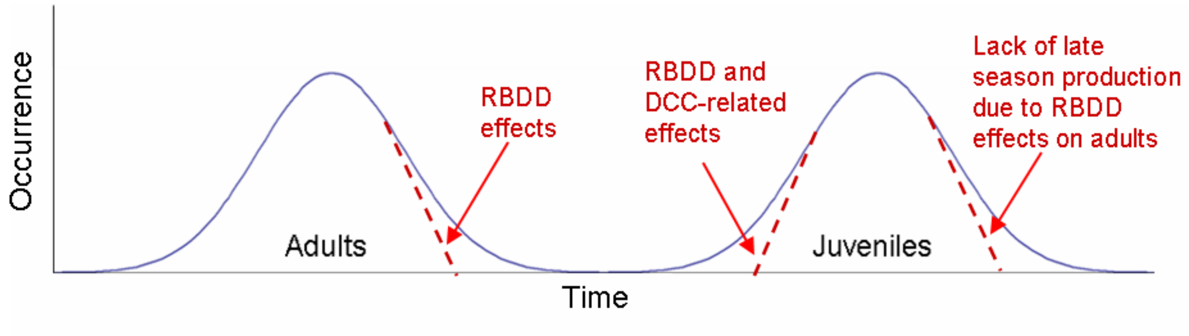

Figure 9-2. General depiction of proposed action-related effects on the temporal distribution of adult and juvenile winter-run during their inland residency. Winter-run adults delayed or blocked by RBDD during the late portion of their spawning run effectively reduces their occurrence on the spawning grounds, which reduces overall production during this time period. This has a negative impact on the spawning success of winter-run that have not migrated upstream of RBDD after the gates are down, which consequently limits the potential for juvenile production during the late part of this life stage period. Juvenile production also is limited during the early part of this life stage period by RBDD- and DCC-related effects.

The timing of winter-run smolt ocean entry, coupled with the timing, location, and magnitude of ocean upwelling and related prey availability, is critical to the growth and survival of these fish. Research suggests that juvenile Chinook salmon that migrate from natal rearing areas during the early part of this life stage period enter the ocean earlier than juveniles that leave during the later part of the life stage period (MacFarlane and Norton 2002, MacFarlane *et al*. 2008). Put another way, Chinook salmon that are spawned first, are generally the ones that hatch, emerge, rear, and migrate to the ocean first. As the timing of winter-run ocean entry is constricted by the proposed action, the probability that smolts will enter an ocean environment with favorable conditions for growth and survival decreases because ocean productivity often varies considerably within one season (Lenarz *et al*. 1995). A wider temporal distribution of ocean entry increases the chance that at least some smolts will enter a productive ocean. As described in Lindley *et al*. (2009), the proximate cause of a recent collapse in fall-run was that the 2004 and 2005 brood years entered the ocean during a period of low ocean productivity[20]. One recommendation by those authors to improve the resiliency of fall-run is to increase the stock's diversity by evaluating hatchery practices that increase the variation in timing of ocean entry.

In addition to impacts to the spatial structure and diversity, the proposed action is expected to result in substantial mortality to winter-run as a combined result of: (1) delays at RBDD during adult immigration resulting in prespawn mortality; (2) moving the TCP upstream during embryo incubation, thereby exposing eggs that were incubating downstream of the adjusted TCP at water temperatures at or below the upper limit for optimal survival (*i.e*., 56° F) to water temperatures associated with higher egg mortality; (3) increasing predation of juveniles when the RBDD gates are down; (4) entraining juveniles into the Central and South Delta (figure 9-3); (5) entraining

[20] Lindley *et al*. (2009) state that the rapid and likely temporary deterioration in ocean conditions is acting on top of a long-term, steady degradation of the freshwater and estuarine environment.

and impinging juveniles at the pumps (both direct and indirect loss); and (6) loss associated with the CHTR program.

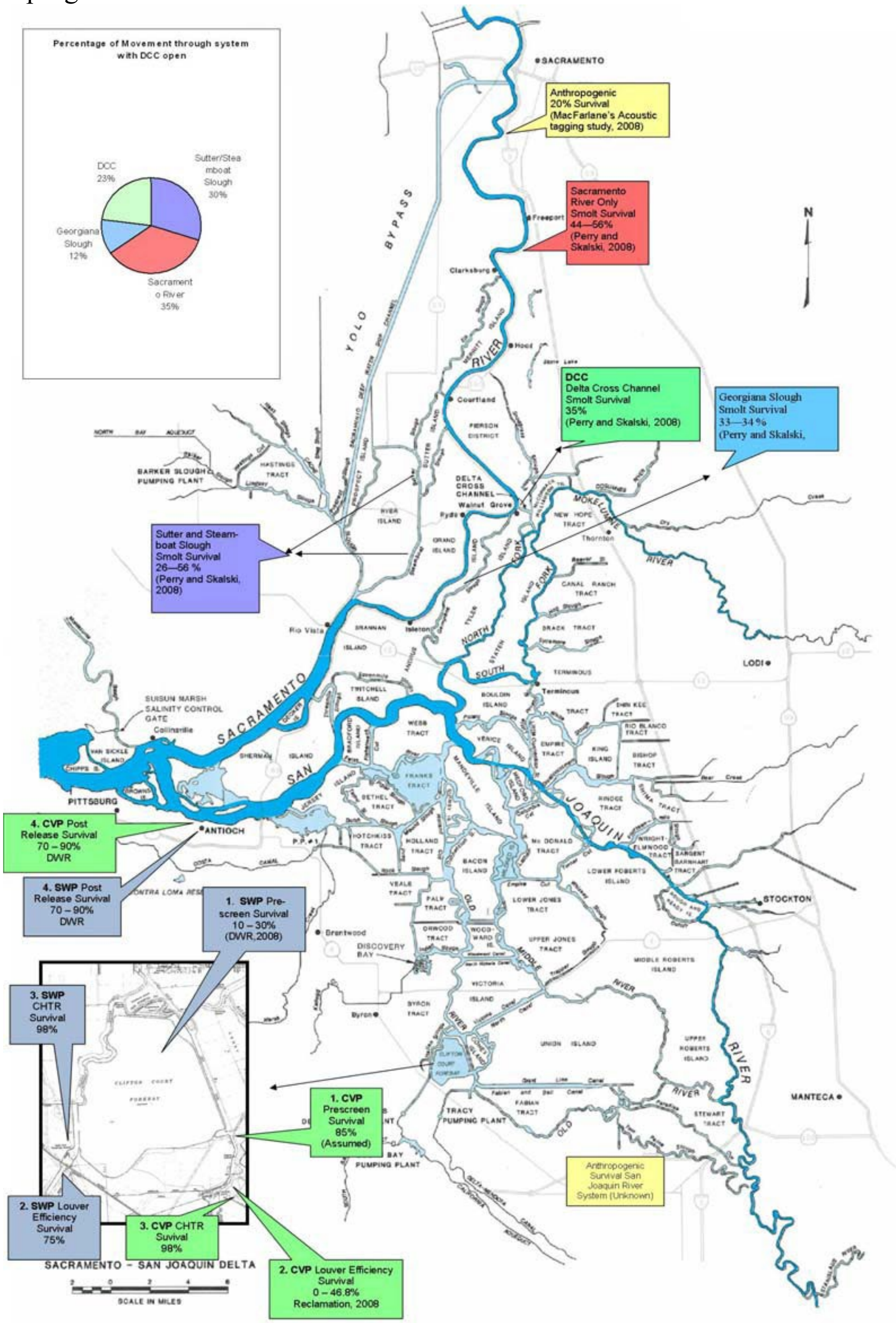

Figure 9-3. Relative magnitude and location of juvenile salmonid survival throughout the Delta.

The cumulative effect of proposed action-related mortality at multiple life stages every year, continues to increase the extinction risk of the winter-run population. Furthermore, most of this mortality is expected to occur during the juvenile and smolt life stages prior to ocean entry – a key transition in the life cycle that has been shown to be most limiting to salmon production in the Central Valley (Bartholow 2003) and in other systems (Wilson 2003). Results from a recent study indicate that about 80 to 90 percent of Chinook salmon juveniles die when migrating from the mainstem Sacramento River near Battle Creek through the San Francisco Estuary (Delta, Suisun, San Pablo, and San Francisco bays; MacFarlane *et al*. 2008). This range was derived from an acoustic tagging study of hatchery-produced late fall-run released as smolts. Mortality of naturally-produced winter-run, which must avoid predators immediately upon emerging from spawning gravels as fry, is most likely higher than that reported for the late fall-run smolts because of size-related differences in vulnerability to predation (*i.e*., fry are more vulnerable to predation than smolts).

All of the above factors which reduce the spatial structure, diversity, and abundance of winter-run, further compromise the capacity of this population to respond and adapt to environmental changes. Future projections over the duration of the proposed action (*i.e*., through 2030), considering both increasing water demands and climate change, exacerbate risks associated with the proposed action, further increasing the risk to the population.

In the Sacramento River, comparing climate change scenarios (Study 9.0 base vs Study 9.5 drier, more warming) shows that average winter-run mortality increases from 15 percent to 25 percent. EOS carryover storage at Shasta is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming (CVP/SWP operations BA table 9-23). Under these conditions, winter-run would experience a loss of spawning habitat, as water temperatures below dams becomes harder to control and the cold water pool in Shasta diminishes.

At the population level, the added impacts of the proposed action with climate change in the future baseline decreases adult abundance for all listed fish species. Crozier *et al*. (2008) predicted the probability of quasi-extinction in 4 populations of Snake River spring/summer Chinook salmon using a life-cycle model for the 2040 timeframe. They found that mean Chinook salmon population size decreased from 20-37 percent in the more moderate climate scenarios (1.77ºC rise in average temperature) to 37-50 percent in the hottest and driest scenarios (2.6ºC warming). Lower flows in October and higher temperatures caused parr-to-smolt survival to decline from 18-19 percent in the more moderate scenario to 34-35 percent in the drier scenario. Although density-dependent processes compensated for declines in par-to-smolt survival, the probability of extinction still fell below the critical thresholds. Population growth rate (lamda) declined under all climate change scenarios. The risk of dropping below the lowest historical level of abundance shifted from a range of 6-36 percent in the current climate to 54-86 percent in the drier hotter climate. Maintaining habitat diversity could potentially help buffer against the impacts of climate change (Lindley *et al*. 2009).

9.1.5 Assess Risk to the Sacramento River Winter-Run Chinook Salmon ESU

Because winter-run is solely composed of one population, the risks to this population described in the previous section represent the risks to the ESU. As previously stated, the winter-run ESU is currently at a high risk of extinction in large part because: (1) the ESU is composed of only one population, which has been blocked from all of its historic spawning habitat; (2) the ESU has a risk associated with catastrophes, especially considering the remaining population's proximity to Mt. Lassen and its dependency on the coldwater management of Shasta Reservoir; and (3) the population has a "high" hatchery influence (Lindley *et al*. 2007). The proposed action does not improve any of these factors; it increases the population's extinction risk by adding numerous stressors on top of to the species' baseline stress regime, as is generally depicted in figure 9-4. With implementation of the proposed action, winter-run will have to cope with these additional stressors, which will adversely affect each life stage throughout the species' life cycle every year for the next 21 years. NMFS expects that the adverse affects will increase as the proposed action advances to full build out. Most winter-run exhibit a 3-year life cycle, indicating that seven generations of winter-run will be affected by the proposed action.

Given the evidence of the reduction in numbers, reproduction and/or distribution of the species, NMFS concludes that Reclamation has not ensured that the proposed action is not likely to appreciably reduce the likelihood of viability, and therefore the likelihood of both the survival and recovery of the Sacramento River winter-run Chinook salmon ESU (table 9-2).

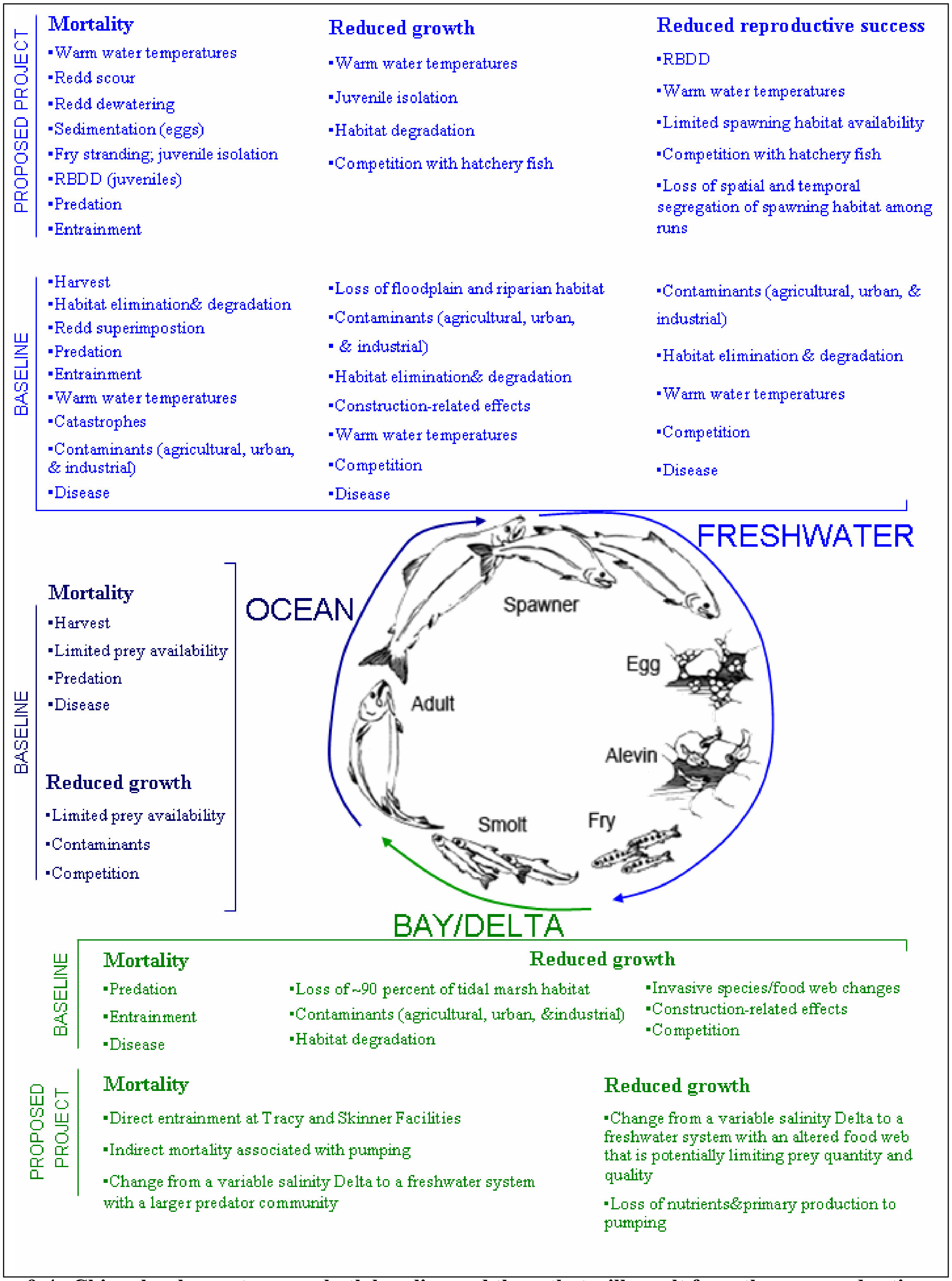

Figure 9-4. Chinook salmon stressors, both baseline and those that will result from the proposed action. Chinook salmon are in freshwater during their adult immigration and holding, spawning, egg incubation, alevin, fry, and fingerling life stages. They are in the Bay/Delta as smolts and in the ocean as sub-adults and adults. Although not depicted in the figure, climate change is a baseline stressor expected to exacerbate the depicted conditions for anadromous salmonids throughout their life cycle, particularly with respect to water temperature in all environments, inland hydrology, and ocean productivity (*e.g.*, upwelling).

Table 9-2. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the Sacramento River Winter-Run Chinook Salmon ESU. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Not Likely/Likely to Jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River;; and (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).*	True	End
		False	Go to B
B	**Winter-run are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to delay ~15% of winter-run adults migrating upstream; ~10% of winter-run juveniles emigrating past RBDD would be exposed to greater predation. (2) All freshwater life stages of winter-run will be exposed to regulated Sacramento River flows and their effects on river processes and morphology every year through 2030. (3) Each year through 2030, winter-run are expected to be exposed to water temperatures warmer than life stage requirements during spawning, egg incubation, and juvenile rearing and outmigration. (4) As water is moved from the north Delta to the export facilities in the south Delta, each year through 2030, winter-run juveniles will have increased exposure to an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and direct entrainment at the Federal and State pumping plants.*	True	NLAA
		False	Go to C
C	**Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Delayed upstream migration at RBDD causes individual adults to consume more energy, which limits the amount of energy available for reproduction, resulting in the deposition of fewer and/or less viable eggs. Mortality of juvenile salmon migrating downstream past RBDD reportedly ranges from 5 to 50%. (2) Loss of natural river function resulting from flow regulation has reduced the quality and quantity of rearing and migratory habitats, thereby reducing the growth and survival of individual winter-run juveniles. (3) Egg mortality resulting from exposure to warm water temperatures is expected to range up to 65% in critically dry years with climate change. Individuals are expected to experience sub-lethal effects due to warm water temperatures during the spawning, embryo incubation, and juvenile rearing life stages. (4) Mortality of winter-run juveniles that enter the Delta interior is expected to range from 35 to 90 %, resulting in the loss of approximately 5-20 percent of the entire ESU.*	True	NLAA
		False	Go to D
D	**Any responses are not likely to constitute "take" or reduce the fitness of the individuals that have been exposed.** *Key Evidence: (1) The reduction in energy available for egg production associated*	True	NLAA

	with delayed upstream migration at RBDD reduces the fitness of individuals by reducing their reproductive capacity. (2)"Take" of winter-run individuals in the form of reduced growth and survival is expected due to the loss of natural river function associated with flow regulation. (3) and (4) As described in step C, "take" of winter-run individuals, in the form of mortality, is expected particularly during the egg incubation (water temperature effects) and juvenile rearing/smolt emigration (predation and entrainment in the Delta) life stages.	False	Go to E
E	**Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent.** *Key Evidence: The cumulative effects of RBDD operations, flow regulation, warm water temperatures, project-related impacts in the Delta, and other project-related stressors (see table 9-1) are expected to sufficiently reduce the survival and/or reproductive success of winter-run individuals at multiple life stages every year through 2030 such that key population parameters (i.e., spatial structure, diversity, and abundance) will be appreciably reduced (see section 9.1.4 Assess Risk to the Population). Reductions in these parameters over the next 21 years will likely reduce the viability of the population.*	True	NLJ
		False	Go to F
F	**Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species.** *Key evidence: The winter-run ESU is solely composed of the Sacramento River population. Therefore, because the viability of this population is expected to be reduced by stressors related to the proposed Action, the viability of the species also is expected to be reduced.*	True	NLJ
		False	LJ

9.2 Sacramento River Winter-Run Chinook Salmon Critical Habitat

9.2.1 Status of Sacramento River Winter-Run Chinook Salmon Critical Habitat

As described in section 4.2.1.2.4.3, winter-run critical habitat is composed of seven physical and biological features that are essential for the conservation of winter-run. All of those physical and biological features can be characterized as suitable and necessary habitat features that provide for successful spawning, rearing, and migration. Therefore, we will be evaluating the effect of the proposed action in terms of its effect on spawning and rearing habitat and migratory corridors.

Currently, many of the physical and biological features that are essential for the conservation of winter-run are impaired, and provide limited conservation value. For example, when the gates are in, RBDD reduced the value of the migratory corridor for upstream and downstream migration. Unscreened diversions throughout the mainstem Sacramento River, and the DCC when the gates are open during winter-run outmigration, do not provide a safe migratory corridor to San Francisco Bay and the Pacific Ocean.

In addition, the annual change in TCP has annually degraded the conservation value of spawning habitat by reducing the amount of spawning habitat based on preferred spawning water temperature (56°F). The current condition of riparian habitat for winter-run rearing is degraded by the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system. However, some complex, productive habitats with floodplains remain in the system (*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and flood bypasses (*i.e.*, Yolo and Sutter bypasses).

Based on the impediments caused by RBDD (gates in), unscreened diversions, DCC (gates open during the winter-run outmigration period), and the degraded condition of spawning habitat and riparian habitat, the current condition of winter-run critical habitat is degraded, and does not provide the conservation value necessary for the recovery of the species.

9.2.2 Project Effects on Sacramento River Winter-Run Chinook Salmon Critical Habitat

Critical habitat for winter-run is comprised of physical and biological features that are essential for the conservation of winter-run, including freshwater spawning sites, rearing sites, and migration corridors to support one or more life stages of winter-run. As summarized below, the conservation value of critical habitat throughout the Sacramento River from Keswick Dam to the Delta (302 miles) will be degraded by the proposed action.

9.2.2.1 Spawning Habitat

As future water demands increase, and in consideration of climate change scenarios, potential spawning habitat will be consistently reduced by temperature control to smaller and smaller areas below Keswick Dam as Reclamation's ability to provide spawning habitat necessary for the conservation of the species will be reduced. The value of spawning habitat is also reduced by flow fluctuations twice a year every year to install and remove the ACID diversion dam. These sudden drops in flow degrade successful spawning, incubation, and larval development by reducing and dewatering some of the available habitat.

9.2.2.2 Rearing Habitat

The value of rearing habitat will continue to be degraded as hydrologic conditions resulting from operations favor the proliferation of introduced non-native warm water predators of juvenile salmonids.

Reclamation will continue to operate RBDD (modification of 6 miles of free-flowing riverine habitat to lake-like habitat) and the ACID diversion dam (modification of 3 miles of free-flowing riverine habitat to lake-like habitat) for 4 to 6 months of every year. Food supply, shelter, and cover will continue to be reduced during the 4 months that the gates are in. In the future full build out scenario, the value of rearing habitat will improve when the gates are out for up to 10 months of each year. However, stranding and isolation in sloughs adjacent to the lake would still occur, and riparian habitat will not likely establish.

9.2.2.3 Migratory Corridors

The value of upstream and downstream migratory corridors will continue to be degraded as a result of the continued operation of RBDD and the ACID diversion dam, which preclude unobstructed passage. The creation of Lake Red Bluff results in the reduction in value of rearing habitat and degradation of 15 miles of shoreline that slows down flows, inundates riparian areas, and increases habitat for warm water predators. The value of the migratory corridor will also continue to be degraded when the RBDD gates come out in September and cause stranding and isolation in sloughs adjacent to the lake. In the future full build out scenario (2030, which we assume the effects will be realized starting in year 2019), the 10-month gates out and 2-month (which is really 2½ months) gates in scenario will improve the value of the migratory corridor by providing unobstructed passage.

During outmigration, the DCC, when the gates are open, continues to degrade the value of the mainstem Sacramento River as a migratory corridor by entraining a portion of the outmigrating juveniles into the Central Delta, where survival and successful outmigration to the Pacific Ocean is lower than if the juveniles remained in the main migratory corridor of the Sacramento River. The proposed action exacerbates this problem by altering water movement through the Sacramento River and Delta such that water in the north part of the Delta (*e.g.*, immediately upstream of the DCC) is pulled southward towards the Federal and State pumping plants through the DCC and/or Georgiana Slough.

9.2.3 Assess Risk to the Winter-Run Chinook Salmon Critical Habitat

Many of the physical and biological features that are essential for the conservation of winter-run are currently degraded. As a result of implementing the proposed action, some of those physical and biological features will likely remain the same, which will keep their conservation value low. However, the conservation value of many of the physical and biological features will likely be further degraded. For example, the proposed action will further degrade the value of spawning, rearing, and migratory habitat. Reoperation of RBDD in the future full build out scenario, so that the gates are down for 2½ months instead of the 4-month near-future (*i.e.*, 2009-2019) scenario, will slightly improve the value of rearing and migratory habitat. However, the conservation value of these habitats will remain degraded by other stressors related to both the proposed action and the baseline (see figure 9-4).

The effects of the proposed action under climate change scenarios would likely further degrade the value of spawning and rearing habitat by increasing water temperatures. Cold water in Shasta Reservoir will run out sooner in the summer, degrading winter-run spawning habitat, and the value of rearing habitat would likely be further degraded by juveniles emigrating earlier, encountering thermal barriers sooner, and be subjected to predators for longer periods of time. Juveniles that do not emigrate earlier will likely congregate in areas of cold water refugia, like in the few miles below dams where competition for food, space, and cover would be intense.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to reduce the conservation value of the critical habitat, as designated, for the conservation of Sacramento River winter-run Chinook salmon (table 9-3).

Table 9-3. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Sacramento River Winter-Run Chinook Salmon Designated Critical Habitat. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Adverse Modification of Critical Habitat (AD MOD).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct of indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the*	True	End

	environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River; and (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).	False	Go to B
B	**Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, the migratory corridor for winter-run adult immigration and juvenile emigration is expected to be affected by RBDD operations; rearing habitat will be affected by the formation of Lake Red Bluff. (2) Holding, spawning, rearing, and migratory habitats in the Sacramento River will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (3) Each year through 2030, winter-run spawning, egg incubation, and juvenile rearing habitats are expected to be affected by water temperatures warmer than life stage-specific requirements. (4) Each year through 2030, as water is moved from the north Delta through the DCC towards the pumping plants in the south Delta, a portion of outmigrating winter-run juveniles will be entrained into the central Delta, where survival and successful outmigration to the Pacific Ocean is expected to be lower than if the juveniles remained in the main migratory corridor of the Sacramento River.*	True	NLAA
		False	Go to C
C	**The quantity, quality, or availability of all constituent elements of critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations will reduce the quality of habitat for winter-run adult immigration and juvenile emigration, as well as the quality and quantity of rearing habitat through the formation of Lake Red Bluff. (2) Loss of natural river function resulting from flow regulation has reduced the quality and quantity of rearing and migratory habitats. (3) Each year through 2030, the provision of water temperatures warmer than life stage-specific requirements will reduce the quantity and quality of winter-run spawning, egg incubation, and juvenile rearing habitats. (4) Each year through 2030, the quality of migratory habitats is reduced by entraining juvenile winter-run into low quality rearing/migratory habitat in the central Delta.*	True	NLAA
		False	Go to D
D	**Any reductions in the quantity, quality, or availability of one or more constituent elements of critical habitat are not likely to reduce the conservation value of the exposed area.** *Key Evidence: Reductions in the conservation value of migratory, spawning, and rearing habitats are expected due to reductions in the quantity, quality, or availability of critical habitat constituent elements resulting from RBDD operations, flow regulation, the provision of water temperatures in the Sacramento River warmer than life stage-specific requirements, and the movement of water towards the Federal and State pumping plants.*	True	NLAA
		False	Go to E
E	**Any reductions in the conservation value of the exposed area of critical habitat are not likely to reduce the conservation value of the critical habitat designation.** *Key Evidence: Because the conservation value of all inland habitat types (migratory, spawning, and rearing) necessary to complete the salmon life cycle are expected to be reduced with implementation of the proposed Action, it is likely that the conservation value of the critical habitat designation will also be reduced.*	True	No AD MOD
		False	AD MOD

9.3 Central Valley Spring-Run Chinook Salmon ESU

In this section, we describe how the proposed action is expected to affect the likelihood of survival and recovery of the Central Valley spring-run Chinook salmon ESU by summarizing how project operations will affect each extant spring-run population. We will first summarize the status of the Central Valley spring-run Chinook salmon ESU. Next, within each diversity group, the risk to each population will be assessed by considering its status, baseline stress regime, and how the proposed action is expected to affect individuals of the population throughout their life cycle.

The risk to the species will be assessed by considering the risk of the various diversity groups and populations. As stated in the Analytical Approach, if appreciable reductions in any population's viability are expected to result from implementation of the proposed action, then this would be expected to appreciably reduce the likelihood of both the survival and recovery of the diversity group the population belongs to, as well as the listed ESU/DPS. This assumption is based on the recommendation from the TRT that every extant population is necessary for the recovery of the species (Lindley *et al.* 2007). NMFS interprets this assumption to indicate that an increase in the extinction risk of one or more of the populations increases the extinction risk of the species.

9.3.1 Status of Central Valley Spring-Run Chinook Salmon ESU

Lindley *et al*. (2007) stated that perhaps 15 of the 19 historical (independent) populations of spring-run are extinct, with their entire historical spawning habitats behind various impassable dams. Those authors only considered Butte, Deer, and Mill creeks as watersheds with persistent populations of Chinook salmon confirmed to be spring-run, although they recognized that Chinook salmon exhibiting spring-run characteristics persist within the Feather River Hatchery population spawning in the Feather River[21] below Oroville Dam and in the Yuba River below Englebright Dam. The populations in butte, Deer, and Mill creeks and in the Feather and Yuba rivers fall within the Northern Sierra Nevada diversity group. Butte and Deer creek spring-run populations are at low risk of extinction, and the Mill Creek population is at either a moderate of low risk (Lindley *et al*. 2007). Other spring-run populations seem to persist in this diversity group in Antelope and Big Chico creeks, albeit at an annual population size in the tens or hundreds of fish, with no returning spawners in some years.

In addition, populations of spring-run may occur in the Basalt and Porous lava diversity group in the mainstem Sacramento River[22] and in Battle Creek, although, similar to the Antelope and Big Chico Creek population, these populations are made up of only tens or hundreds of fish. These populations are presumably dependent on strays from other populations, although the extent of

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[21] An analysis of the proposed action effects on Feather River spring-run will be covered in a separate Opinion related to the relicensing of Oroville Dam.

[22] The presence of Keswick and Shasta dams has resulted in a spatial and temporal overlap of spring-run and fall-run spawning. Considerable hybridization between these runs has occurred. Genetic analyses of early-returning Chinook salmon in the mainstem Sacramento River have not been conducted. Without specific genetic information to consider, for the purposes of this Opinion, NMFS assumes that the Chinook salmon exhibiting spring-run behavior (*e.g*., upstream migration during spring and spawning during early fall) in the mainstem Sacramento River represent a distinct spring-run population. This assumption is supported by a recent study of Central Valley steelhead genetics, which generally indicated that run timing remains an important factor in describing genetic structure in the Central Valley (Garza and Pearse 2008).

this dependency is not known. Lindley *et al.* (2007) concluded that these populations are entirely composed of strays, as those authors stated that the spring-run have been extirpated from the entire diversity group.

Ephemeral populations are found in the Northwestern California Diversity Group in Beegum and Clear creeks, and salmon have been observed in Thomes Creek during the spring, although monitoring in that creek has not been conducted consistently due to poor access and difficult terrain. Returning adult spring-run population sizes in Beegum and Clear creeks have generally ranged from tens up to a few hundred fish. Habitat restoration in Clear Creek has improved conditions for spring-run and the population has been responding positively to these improvements.

With the exception of Clear Creek, the Sacramento River, and the Feather River, the proposed action does not affect spring-run within the above listed tributaries. However, spring-run produced in all of these tributaries are affected by the proposed action as they migrate, hold, or rear within the Sacramento River and Delta.

Historically, the majority of spring-run in the Central Valley were produced in the Southern Sierra Nevada Diversity Group, which contains the San Joaquin River and its tributaries. All spring-run populations in this diversity group have been extirpated (Lindley *et al*. 2007).

With demonstrably viable populations in only one of four diversity groups that historically contained them, spring-run fail the representation and redundancy rule for ESU viability (Lindley *et al*. 2007). The current distribution of viable populations makes spring-run vulnerable to catastrophic disturbance. All three extant independent populations are in basins whose headwaters occur within the debris and pyroclastic flow radii of Mt. Lassen, an active volcano that the USGS views as highly dangerous (Hoblitt *et al*. 1987). The current ESU structure is, not surprisingly, also vulnerable to drought. Even wildfires, which are of much smaller scale than droughts or large volcanic eruptions, pose a significant threat to the ESU in its current configuration. A fire with a maximum diameter of 30 km, big enough to burn the headwaters of Mill, Deer and Butte creeks simultaneously, has roughly a 10 percent chance of occurring somewhere in the Central Valley each year (Lindley *et al*. 2007).

9.3.2 Future Baseline of Central Valley Spring-Run Chinook Salmon Excluding CVP/SWP Effects

This section describes the environmental baseline upon which we will add the effects of the proposed action in order to help assess the response and risk to the species. Habitat elimination and degradation has been a primary factor causing the threatened status of spring-run in the Central Valley. Physical habitat modifications (*e.g*., dam construction and river straightening and associated riprap applications) and other anthropogenic and natural effects in freshwater, estuarine, and marine environments have greatly diminished the viability of the ESU, and continue to do so. These baseline stressors are similar to those that affect winter-run (see figure 9-1) and include harvest, predation, water management, agricultural, urban, and industrial land use, competition, and invasive species and associated food web changes.

9.3.3 Northwestern California Diversity Group

9.3.3.1 Clear Creek Spring-Run Chinook Salmon

9.3.3.1.1 Status of Clear Creek Spring-Run Chinook Salmon

Spring-run are increasing in abundance in Clear Creek due to habitat restoration funded by CALFED and the CVPIA, including the removal of McCormick-Saeltzer Dam, habitat restoration, gravel augmentation, temperature control and increased flows. The spring-run population in Clear Creek has gone from zero to about a few hundred adults annually in the last 12 years. Most of the spring-run are descendents from introduced Feather River Hatchery stock in the 1990s.

Although the abundance of Clear Creek spring-run has been increasing over the last decade, it is still at an abundance level that makes the population vulnerable to extirpation from demographic stochasticity - seemingly random effects of variation in individual survival or fecundity with little or no environmental pressure (Shaffer 1981, Allendorf *et al*. 1997, McElhany *et al*. 2000). As such, the population would fall into the high risk of extinction category based on abundance, as described in Lindley *et al*. (2007, see table 4-3).

9.3.3.1.2 Future Baseline of Clear Creek Spring-Run Chinook Salmon Excluding CVP/SWP Effects

The general baseline stress regime for Clear Creek spring-run in freshwater, estuarine, and the marine environment is depicted in figure 9-1. More specifically, baseline stressors within Clear Creek include Whiskeytown Dam blocking access to historic habitat (Yoshiyama *et al*. 1996), a lack of natural recruitment of spawning gravels and a lack of suitable habitat during the summer for juvenile rearing and adult holding. The dam forces spring-run to hold and spawn at a relatively low elevation in habitats that were not historically used for those life stages. The dam also limits the availability of spawning gravels, and as such, the availability of spawning habitat.

9.3.3.1.3 Summary of Proposed Action Effects on Clear Creek Spring-Run Chinook Salmon

Proposed action-related effects to spring-run within Clear Creek are summarized in table 9-4. Detailed descriptions regarding the exposure, response, and risk of spring-run to these stressors are presented in section 6.2.

Table 9-4. Summary of proposed action-related effects on Clear Creek spring-run.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult immigration Delta	Mar. – Sep.	DCC gate closures	Spring-run could be delayed in the Delta resulting in greater exposure to both the in-river sport fishery and contaminants (reduced egg fertility or reduced viability and motility of spermatocytes during spawning).	Low	Low - based on limited supporting data	Reduced survival and reduced reproductive success
2	Adult immigration RBDD	Mar. – Sep.	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) force fish to use inefficient ladders	~72 % of the spring-run that spawn upstream of RBDD are delayed by approximately 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	High	High - based on TCCA EIS/EIR on RBDD and CVP/SWP operations BA, including many historical cited studies	Reduced reproductive success
3	Adult immigration Clear Creek	Mar. – Sep.	Water temperatures warmer than life history stage requirements during summer holding period	Water temp control to Igo; possibly some pre-spawn mortality in critically dry years when not enough cold water in Whiskeytown Lake	High	High - based on temperature data, USFWS reports, and CVP/SWP operations BA	Reduced reproductive success
4	Adult immigration Clear Creek	Mar. – Sep.	Lack of variable flows in spring and low summer flows (50 cfs), when b2 is unavailable	Limited cues for upstream migration resulting from spring flows with little variation. With low summer flows, adults are impeded from accessing upstream holding areas.	High	High - based on CVP/SWP operations BA (chpt 4) and CALSIM modeling runs	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
5	Spawning Clear Creek	Sep. - early Oct.	Spawning area limited due to temperature management and limited spawning habitat availability down to Igo Gage	Density dependency effects & redd superimposition; limited carrying capacity of stream will dictate population size; possible loss of some individuals that spawn below Igo	Low currently - with potential to increase if gravel augmentation creates more spawnable habitat below the Igo gage.	High - based on water temperature data and the CVP/SWP operations BA	Reduced reproductive success and reduce survival
6	Spawning Clear Creek	Sep. - early Oct.	Low summer flows (50 cfs), when b(2) is unavailable	Adults spawn further downstream in less suitable conditions (*i.e.*, in areas with relatively warm water temps.)	High	High - based on CVP/SWP operations BA (chpt 4)	Reduced survival, Reduced reproductive success
7	Embryo incubation	Sep. – Dec.	Water temperatures warmer than life history stage requirements in September only for fish that spawn below TCP (Igo)	Mortality varies with exceedance rate and number of redds; loss of some portion of those eggs; reduced chance of survival for fry	High	High - based on CVP/SWP operations BA models and laboratory evidence of temperature tolerances	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
8	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 5 % of the spring-run ESU spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	High	High - based on mortality studies at RBDD and timing of emigration from Clear Creek (Vogel *et al.* 1988, Tucker 1998, TCCA 2008)	Reduced survival
9	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth
10	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency).	Low	High - based on annual monitoring of fish screens	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High - based on CVP/SWP operations BA	Reduced survival
12	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on Co-manager review draft of Central Salmon Recovery Plan and CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
13	Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few spring-run are expected to be in this area during the fall.	Low	Low - based on lack of monitoring	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
14a-e	Juvenile rearing/smolt emigration Delta	Nov-June	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Project-related mortality is significant (figure 9-3). Of the spring-run entering the *interior* of the Delta (through DCC or Georgiana Slough), mortality is estimated to be approximately 66% (range of 35-90% mortality) (Brandes and McClain 2001, Newman 2008, Perry and Skalski 2008).	High for yearlings Low for YOY	Low to High (see below)	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
14a	Juvenile rearing/smolt emigration Delta	Nov. - Jun.	DCC operations - open gate configurations from November through January	Increased vulnerability of entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Yearling spring-run more vulnerable to effects of open DCC gates than YOY spring-run. Open gate configuration in December and January exposes approximately 3 % of the total spring-run ESU to entrainment into the DCC, but exposes a high proportion of yearling emigrants during this period (DWR 2005). Yearlings have a higher likelihood of survival to adults and are more important to the population. Hence a small loss can have a greater magnitude of effect.	High for yearlings Low for YOY	High – Numerous studies *i.e.*, Delta Action 8, Delta Cross channel, and Delta Interior experiments confirm low survival of fish entrained into the delta interior. Acoustic tagging studies provide similar conclusions for survival within the delta interior.	Reduced survival Reduced life history diversity
14b	Juvenile rearing/smolt emigration Delta	Nov. - Jun.	Loss in interior Delta	Diversion of emigrating fish into the Delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Isalnd) are observed for fish migrating through the Delta interior. Loss of up to 15 % of spring-run ESU entering the Delta based on modeling	Medium	High – numerous studies find similar high loss rates for fish relased in the Delta interior.	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
14c	Juvenile rearing/smolt emigration Delta	Nov. - Jun.	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately 66 % of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85 % of the exposed fish. The percentage of the ESU exposed is variable, typically less than 2-3 %, and frequently is much lower (0.5 %) based on salvage recovery estimates. Percentage of ESU actually arriving at the export facilities and entering the salvage process is low.	Low	High - numerous studies have evaluated screening efficiency, predation, and overall salvage operations survival	Reduced survival
14e	Juvenile rearing/smolt emigration Delta	Nov. - Jun.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on salmon as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta.	High	Low to medium. Invasion of non-native species into delta is well documented, interaction with salmonid populations is not as well documented	Reducted survival, Reduced growth

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
14f	Juvenile rearing/smolt emigration Delta	Nov. - Jun.	Altered Delta hydrodynamics	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, *etc.*). Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics well studied. Effects of Delta hydrodynamics on organisms is not as well understood.	Reduced survival, reduced growth

9.3.3.1.4 Assess Risk to Clear Creek Spring-Run Chinook Salmon

The risk to Clear Creek spring-run is determined by effects to the population's spatial structure (habitat), diversity, and abundance, and productivity. As described in section 6, habitat conditions in Clear Creek, the Sacramento River, and the Delta are adversely affected by the proposed action in a number of ways, including, but not limited to: (1) delaying adult immigration resulting from DCC and RBDD operations; (2) providing flows and water temperatures within Clear Creek under dry hydrologic conditions that are stressful to spring-run; (3) entraining juveniles into the Central and South Delta; and (4) entraining and impinging juveniles at the Jones and Banks pumping plants. In these ways, the proposed action reduces the population's current spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the spring-run population.

The spring-run population in Clear Creek (200 adults in 2008) represents a small, but important, part of the west side diversity group of the ESU. However, of all the west side tributaries, Clear Creek has the highest abundance. A loss of this population would significantly reduce the diversity of the entire spring-run population. Under the proposed operations, the spring-run population is near the maximum capacity that can be maintained on Clear Creek, since spawning locations are limited in the upper reaches (*i.e.*, 8 of 18 miles are confined to a narrow canyon). Therefore, even if flows were to be increased the amount of spawning habitat available to spring-run would not increase significantly, unless gravel can be added. The behavioral and genetic diversity of the spring-run population is expected to be negatively affected by the proposed action. Spring-run that spawn further downstream where the channel is mostly alluvial are exposed to unsuitable over summer holding and spawning temperatures. They are also more likely to hybridize with early returning fall-run.

The population is likely to persist in most years, but experience higher mortality as it expands downstream due to the limited amount of suitable spawning and rearing habitat, thus reducing the likelihood of recovery. High water temperatures in the lower reaches and continuation of a static flow pattern (*i.e.*, 200 cfs throughout most the year) as proposed action will substantially limit the quantity and quality of habitat, thereby limiting the spatial structure of the spring-run population in Clear Creek. Uncertainty in how b(2) water is applied and how Trinity River diversions will impact flows on Clear Creek increase the risk of extinction to this population. An extended drought period lasting more than 3 years would compromise the spring-run population's ability to persist, unless hatchery strays recolonizing the area below the dam. Based on CALSIM modeling, there are 2 periods when drought conditions persist for up to 6 years. In the future, due to climate change, drought conditions will likely occur more often and of greater severity

Operation of the CVP/SWP negatively affects the diversity of Clear Creek spring-run and the proposed action is expected to continue these effects. The operation of RBDD affects the temporal distribution of adult spring-run on their spawning migration to Clear Creek holding and spawning grounds. Spawning run timing is considered a key diversity trait for salmon species (McElhany *et al*. 2000). Based on recent population estimates (CVP/SWP operations BA page 6-22), the abundance of spring-run spawners attempting to migrate upstream of RBDD accounts for about 10 percent of the entire run in the Sacramento River basin. Of this 10 percent, approximately 70 percent attempt to migrate past RBDD after the gates are down, and therefore are delayed for an average of 21 days until they locate and navigate the fish ladders. During low flow conditions, spring-run passage to upstream holding and spawning habitats in the tributaries may be impeded at falls, critical riffles and man-made segregation weirs intended to separate spring-run from fall-run, presumably forcing these fish to either back track and hold and spawn within the mainstem Sacramento River or remain in unsuitable lower tributary habitats. Spring-run that are delayed at RBDD and cannot access Clear Creek holding and spawning habitats as a result of low flows or the erection of a segregation weir may end up spawning with spring-run and fall-run originating from the mainstem Sacramento River.

In addition to impacts to the spatial structure and diversity, the proposed action is expected to result in substantial mortality to spring-run juveniles, including those from Clear Creek. Results from a recent study indicate that about 80 to 90 percent of Chinook salmon smolts die when migrating from the mainstem Sacramento River near Battle Creek through the San Francisco Estuary (Delta, Suisun, San Pablo, and San Francisco bays; MacFarlane *et al*. 2008). This range was derived from an acoustic tagging study of hatchery-produced late fall-run released in the Sacramento River as smolts. Mortality of Clear Creek spring-run migrating downstream through the system is most likely even higher than that which is reported for the late fall-run smolts because: (1) spring-run emigrate from Clear Creek as post-emergent fry and are generally less robust and more vulnerable to predation smolts; and (2) studies suggest that there is a positive relationship between juvenile salmon mortality and emigration distance (Anderson *et al*. 2005, MacFarlane *et al*. 2008). Fish leaving Clear Creek must travel about 18 miles further in the Sacramento River, than the fish in the MacFarlane *et al*. (2008) study, which were released near the mouth of Battle Creek (and at 2 other downstream locations).

Although the survival data presented in MacFarlane *et al*. (2008) includes natural and anthropogenic sources of mortality, much of this mortality is believed to be attributed to proposed action-related effects. For example, as described in section 6.6, project-related entrainment into the Central and South Delta greatly increases the risk of mortality from direct (entrainment and impingement at the pumps) and indirect (predation) effects (figure 9-3).

In addition, proposed action-related loss of juveniles passing RBDD may be an important source of mortality to Clear Creek spring-run. Spring-run emigrate from Clear Creek primarily as post emergent fry during December and January and if those emigrants continued moving downstream without rearing in the mainstem Sacramento River for an extended period of time they would encounter RBDD when the gates are out, and thus would not be subject to higher mortality. However, if the post-emergent fry leaving Clear Creek rear over the winter and spring in the mainstem Sacramento River above RBDD and emigrate from May through September, they would encounter RBDD when the gates are in, in which case, they would be more susceptible to predation.

In the year 2019, modifications to RBDD operations will be implemented such that the gates will be in for about 2½ months per year, instead of the current practice of about 4 months per year. Although this modification will lessen the adverse effects of RBDD on spring-run populations which occur above the dam, such as Clear Creek, the dam will likely remain to function as a stressor to these fish on their upstream and/or downstream migrations.

Due to habitat restoration efforts in Clear Creek, the spring-run population has been growing over the past 15 years from essentially zero fish in the early 1990s up to nearly 200 in 2007. It is uncertain how long this population will continue on its current positive trajectory. However, the proposed Project's effects on the habitat conditions, diversity, and abundance of Clear Creek spring-run are expected to reduce or limit the population's growth rate over the next 21 years. NMFS expects that the adverse affects will increase as the proposed action advances to full build out.

All of the above factors which reduce the spatial structure, diversity, abundance, and productivity of Clear Creek spring-run, compromise the capacity for this population to respond and adapt to environmental changes. Future projections over the duration of the proposed action (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the proposed action, further increasing the risk to the population.

9.3.3.2 Cottonwood/Beegum and Thomes Creek Spring-Run Chinook Salmon

Returning adult spring-run population size in Beegum Creek has generally ranged from tens up to a few hundred fish and even fewer spring-run return to Thomes Creek. Clearly, both of these populations fall into the high risk of extinction category based on abundance (see table 4-3).

The general baseline stress regime for Chinook salmon in the freshwater, estuarine, and marine environment is depicted in figure 9-1. More specifically, baseline stressors to spring-run in Thomes Creek include high water temperatures, low flows, water diversions and associated seasonal diversion dams, gravel mining, and other habitat alterations such as levee construction and bank protection actions (*i.e.*, rip rapping). In the Cottonwood/Beegum watershed, baseline stressors include high water temperatures, low flows, diversions, and gravel mining.

The proposed action will affect Beegum Creek and Thomes Creek spring-run every year through 2030 when these fish are migrating upstream through the Delta and Sacramento River as adults and as juveniles migrating downstream through these areas. The proposed action stressors for these life stages and locations for spring-run from Beegum and Thomes creeks are similar to the stressors described for Clear Creek spring-run in table 9-4 (except spring-run in Thomes Creek are not exposed to the stressors of RBDD, as Thomes Creek enters the Sacramento River downstream of the Sacramento River). Specifically, the DCC affects the adult immigration life stage and RBDD delays adult spring-run for an average of 21 days during the middle portion of their upstream migration. These delays decrease the probability that spring-run returning to tributaries above RBDD will encounter potentially critical riffles when spring run-off flows are high enough for salmon to successfully pass them. Also, the survival of juvenile spring-run migrating downstream from Beegum and Thomes creeks is expected to be reduced by proposed action-related factors in the Delta, as well as by RBDD, depending on whether outmigrants encounter the dam while the gates are in. Considering the extremely small spring-run population sizes in these creeks, and the 21 year duration of the proposed Project, proposed project actions (*i.e*., DCC, RBDD, and direct and indirect loss in the Delta) will likely have population-level consequences for both of these populations.

9.3.4 Basalt and Porous Lava Diversity Group

9.3.4.1 Mainstem Sacramento River Spring-Run Chinook Salmon

9.3.4.1.1 Status of Mainstem Sacramento River Spring-Run Chinook Salmon

There are few data available to describe the population size of spring-run spawning in the mainstem of the Sacramento River. Counts of spring-run passing upstream of RBDD have been made since 1969, but these fish may have spawned in one of several systems which support spring-run populations, including Clear Creek, Cottonwood/Beegum Creek, Battle Creek, or the mainstem Sacramento River. As such, the abundance of adults returning to spawn in the mainstem Sacramento River cannot be estimated from monitoring at RBDD.

General information on the abundance of adult spring-run spawning in the mainstem Sacramento River may be inferred from redd survey monitoring. Since 1995, Chinook salmon redd survey data from the mainstem Sacramento River have been collected by CDFG. These data, although not collected with consistent sampling methods from year to year, do provide some indication of the number of spring-run redds constructed in the mainstem Sacramento River. In general, newly constructed salmon redds observed in September have been classified as spring-run, whereas August redds are classified as winter-run and October redds are classified as fall-run. Redd-based spawning population estimates generally require information on the number of redds counted, the number of redds per female, and the ratio of males per female in the river. The number of putative spring-run redds has ranged from 11 to 105 since 1995, with a median value of about 30 redds (unpublished data from CDFG). Chinook salmon females reportedly utilize one redd, increasing the size of the redd in an upstream direction as the spawning season progresses (Healey 1991). McReynolds *et al*. (2007) reported a female-to-male sex ratio of about 3 to 1 for spring-run spawning in Butte Creek. Similarly, the sex ratio of winter-run spawners is generally 3 females for every male. Applying these redd per female and sex ratio observations to the range of mainstem Sacramento River spring-run redds that have been observed, results in a rough approximation of abundance ranging from 15 to 140 fish. Spawner abundance estimates at these levels places the mainstem Sacramento River spring-run population at high risk of extinction based on the population size criteria described in Lindley *et al*. (2007).

9.3.4.1.2 Future Baseline of Mainstem Sacramento River Spring-Run Chinook Salmon Excluding CVP/SWP Effects

The general baseline stress regime for mainstem Sacramento River spring-run in the freshwater, estuarine, and marine environment is depicted in figure 9-1. More specifically, baseline stressors to spring-run within the mainstem Sacramento River include a loss of spatial separation from fall-run resulting from the presence of Keswick and Shasta dams. Historically, spring-run spawned at higher elevations than fall-run. This inability to migrate to higher elevation holding and spawning habitat, coupled with an overlap in the temporal distribution of spring-run and fall-run spawning, has led to introgression between these runs. In addition, because spring-run and fall-run now must use the same spawning habitat, spring-run likely have suffered greater mortality at the embryo incubation life stage. The spring-run spawning period begins earlier than that of fall-run. Thus, embryos incubating in spring-run redds are vulnerable to disturbance when the fall-run returns to the spawning grounds and begins moving gravels around for redd construction. Incubating embryos are sensitive to physical disturbance, particularly during the early part of incubation.

9.3.4.2 Summary of Proposed Action Effects on Mainstem Sacramento River Spring-Run Chinook Salmon

Proposed action-related effects to spring-run within the mainstem Sacramento River are summarized in table 9-5. Detailed descriptions regarding the exposure, response, and risk of spring-run to these stressors are presented in section 6.

9.3.4.1.4 Assess Risk to Mainstem Sacramento River Spring-Run Chinook Salmon

Population viability is determined by four parameters: spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning conditions (habitats) and the connections between such habitats. Properly functioning condition defines the inland habitat conditions necessary for the long-term survival of Pacific salmon populations. As described in section 6, habitat conditions in the Sacramento River and the Delta are negatively affected by the proposed action in a number of ways, including, but not limited to: (1) delaying adult immigration through the DCC and RBDD operations; (2) providing water temperatures that are stressful to spring-run; (3) entraining juveniles into the Central and South Delta; and (4) changing the Delta from a natural, variabale salinity system to an unnatural freshwater system with a more abundant predator community. In these ways, the proposed action reduces the population’s current spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the mainstem Sacramento River spring-run population.

Table 9-5. Summary of proposed action-related effects on mainstem Sacramento River spring-run.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult immigration Delta	Mar. – Sep.	DCC gate closures	Spring-run could be delayed in the Delta resulting in greater exposure to both the in-river sport fishery and contaminants (reduced egg fertility or reduced viability and motility of spermatocytes during spawning).	Low	Low based on limited supporting data	Reduced survival and reduced reproductive success
2	Adult immigration RBDD	Mar. – Sep.	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) force fish to use inefficient ladders	~72% of the spring-run that spawn upstream of RBDD are delayed by approximately 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	High	High based on TCCA EIS/EIR on RBDD and CVP/SWP operations BA, including many historical cited studies	Reduced reproductive success
3	Spawning Sacramento River	Sep. – Oct.	No temporal separation between spring-run and fall-run spawning due to delays at RBDD (no spatial separation due to Keswick and Shasta dams)	Introgression -Hybridization with fall run and competition for habitat	High	High based on RBDD genetics report (USFWS 2008b)	loss of genetic integrity and expression of life history

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
4	Embryo incubation	Sep. – Dec.	Water temperatures warmer than life history stage requirements, during September and October	Under near-term operations (Study 7.1) mortality is expected to range from approximately 9% in wet years up to approximately 66 % in critically dry years, with an average of approximately 21 % over all water year types; under modeled climate change projections, average egg mortality over all water year types is expected to be 50 % and during the driest 15 % of years is expected to be 95 %. Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of spring-run to survive during subsequent life stages (Campbell *et al*. 1998). Campbell *et al*. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	High	High based on past exceedances of temp. criteria (see figure 6-14 in CVP/SWP operations BO)	Reduced survival
5	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 5 percent of the spring-run ESU that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	High	High - based on mortality studies at RBDD and timing of emigration from Clear Creek (Vogel *et al*. 1988; Tucker 1998; TCCA 2008)	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
6	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth
7	Juvenile rearing and downstream movement Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency).	Low	High - based on annual monitoring of fish screens	Reduced survival
8	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High - based on CVP/SWP operations BA	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
9	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on Co-manager review draft of Central Valley Salmon Recovery Plan and CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
10	Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few spring-run are expected to be in this area during the fall.	Low	Low - based on lack of monitoring	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11a-e	Juvenile rearing/smolt emigration Delta	Nov - Jun.	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Project-related mortality is significant. Of the spring-run entering the *interior* of the Delta (through DCC or Georgiana Slough), mortality is estimated to be approximately 66 % (range of 35-90 % mortality) (Brandes and McClain 2001; Newman 2008; Perry and Skalski 2008).	High	Low to High (see below)	

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11a	Juvenile rearing/smolt emigration Delta	Nov - Jun.	DCC operations - open gate configurations from November through January	Increased vulnerability of entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Yearling spring-run are more vulnerable to the effects of open DCC gate than YOY spring-run. Open gate configuration in December and January exposes approximately 3 % of spring-run ESU to entrainment into the DCC, but exposes a high proportion of yearling emigrants during this period.	Low	High – Numerous studies *i.e.*, Delta Action 8, Delta Cross channel, and Delta Interior experiments confirm low survival of fish entrained into the delta interior. Acoustic tagging studies provide similar conclusions for survival within the delta interior	Reduced survival Reduced life history diversity
11b	Juvenile rearing/smolt emigration Delta	Nov - Jun.	Loss in interior Delta	Diversion of emigrating fish into the delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Isalnd) are observed for fish migrating through the Delta interior. Loss of up to 15 % of spring-run ESU entering the Delta based on modeling	Medium	High – numerous studies find similar high loss rates for fish relased in the Delta interior.	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11c	Juvenile rearing/smolt emigration Delta	Nov - Jun.	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately two thirds of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85 % of the exposed fish. The percentage of the population exposed is variable, typically less than 2-3 %, and frequently is much lower (0.5 %) based on salvage recovery estimates. Percentage of population actually arriving at the export facilities and entering the salvage process is low.	Low	High- numerous studies have evaluated screening efficiency, predation, and overall salvage operations survival	Reduced survival
11d	Juvenile rearing/smolt emigration Delta	Nov - Jun.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on salmon as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta.	High	Low to medium. Invasion of non-native species into delta is well documented, interaction with salmonid populations is not as well understood	Reducted survival, Reduced growth

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11e	Juvenile rearing/smolt emigration Delta	Nov - Jun.	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, etc.). Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics well studied. Effects of Delta hydrodynamics on organisms not as well studied.	Reduced survival, reduced growth
12	All stages	Not applica ble	Nimbus Hatchery fall-run production straying to mainstem Sacramento River	Competition for habitat and hybridization with hatchery fall-run	Low	Low because Nimbus fall-run have historically not been marked, so the degree of straying to spring-run habitats is not well understood	Reduced fitness of wild fish

Operation of the CVP and SWP negatively affects the diversity of spring-run in the mainstem Sacramento River, and the proposed action is expected to continue these effects. The operation of the DCC and RBDD affects the temporal distribution of adult spring-run on their spawning migration to mainstem Sacramento River spawning grounds. Spawning run timing is considered a key diversity trait for salmon species (McElhany *et al*. 2000). Based on recent population estimates (CVP/SWP operations BA page 6-22), the abundance of spring-run spawners attempting to migrate to the mainstem Sacramento River spawning grounds and to tributaries (*e.g*., Cottonwood/Beegum, Clear, and Battle creeks) upstream of RBDD accounts for about 10 percent of the entire run in the Sacramento River. Of this 10 percent, approximately 70 percent attempt to migrate past RBDD after the gates are down, and therefore are likely delayed until they locate and navigate the fish ladders. During low flow conditions, spring-run passage to upstream holding and spawning habitats in the tributaries may be impeded at falls or critical riffles, presumably forcing these fish to either back track and hold and spawn within the mainstem Sacramento River or remain in highly unsuitable habitats in the tributaries. Spring-run that are delayed at RBDD and cannot access tributary spawning habitats as a result of low flows may end up spawning with spring-run and fall-run originating from the mainstem Sacramento River, which continues the pattern of genetic introgression and hybridization that has occurred since RBDD was built in the late 1960s (CDFG 1988, NMFS 2004b, TCCA 2008).

In addition to impacts to the spatial structure and diversity, the proposed action is expected to result in substantial mortality to spring-run juveniles, including those produced in the mainstem Sacramento River. Results from a recent study indicate that about 80 to 90 percent of Chinook salmon smolts die when migrating from the mainstem Sacramento River near Battle Creek through the San Francisco Estuary (Delta, Suisun, San Pablo, and San Francisco bays; MacFarlane *et al*. 2008). Mortality of spring-run that are naturally-produced within the Sacramento River, which must avoid predators immediately upon emerging from spawning gravels as fry, is most likely higher than the mortality reported for the late fall-run smolts based on size-related differences in vulnerability to predation (*i.e*., fry are more vulnerable to predation than smolts). Although the survival data presented in MacFarlane *et al*. (2008) includes natural and anthropogenic sources of mortality, much of this mortality is believed to be attributed to proposed action-related effects. For example, Project-related entrainment into the Central and South Delta greatly increase the risk of mortality from direct (entrainment and impingement at the pumps) and indirect (predation) effects (figure 9-3).

All of the above factors which reduce the spatial structure, diversity, and abundance of mainstem Sacramento River spring-run, compromise the capacity for this population to respond and adapt to environmental changes. Future projections over the duration of the proposed action (*i.e*., through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the proposed action, further increasing the risk of the population.

In the Sacramento River, comparing climate change scenarios (Study 9.0 base vs Study 9.5 drier, more warming) shows that average spring-run mortality increases from 20 percent to 55 percent (figure 6-20). EOS carryover storage at Shasta is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming (CVP/SWP operations BA table 9-23). Under these conditions, spring-run would experience a loss of spawning habitat, as water temperatures below dams becomes harder to control and the cold water pool in Shasta diminishes.

9.3.4.3 Battle Creek Spring-Run Chinook Salmon

Returning adult spring-run population size in Battle Creek has generally ranged from tens up to a few hundred fish, placing the population at a high risk of extinction based on abundance (see table 4-3).

The general baseline stress regime for Chinook salmon in the freshwater, estuarine, and marine environment is depicted in figure 9-1.

The proposed action affects Battle Creek spring-run when these fish are migrating upstream through the Delta and Sacramento River as adults and as juveniles migrating downstream through these areas. The proposed action stressors for these life stages and locations for spring-run from Battle Creek are the same stressors described above for mainstem Sacramento River spring-run in table 9-5. That is, the DCC and RBDD adversely affect adult immigration and proposed action-related factors in the Delta decrease juvenile/smolt survival. RBDD delays adult spring-run during the middle portion of their upstream migration for about 21 days. This delay exposes spring-run to thermally stressful conditions, which may result in prespawn mortality, reduce overall fecundity, or reduce egg viability (EPA 2001). Considering the extremely small spring-run population sizes in Battle Creek, along with the effect of the DCC and RBDD on upstream migration and the magnitude of proposed action-related loss of juvenile Chinook salmon migrating through the Delta (figure 9-3), it is likely that the proposed action also has population-level effects for this population.

9.3.5 Northern Sierra Nevada Diversity Group

9.3.5.1 Antelope, Mill, Deer, Big Chico, and Butte Creeks and Yuba River Spring-Run Chinook Salmon

Antelope, Mill, Deer, Big Chico, and Butte creeks and the Yuba River enter the Sacramento River below RBDD and thus, spring-run returning to those watersheds are not affected by the dam. The baseline stress regime for these spring-run populations includes all non-CVP/SWP stressors that were previously described (see figure 9-1) as well as stressors within each watershed, such as high water temperatures and agricultural diversions that diminish instream flows, act as passage impediments for adult immigration, and entrain juveniles as they rear and migrate downstream. The spring-run produced in these watersheds are also expected to be adversely affected by the effects of the proposed action in the Delta, as they are migrating upstream as adults or downstream as juveniles. Given that these watersheds do not contain any CVP or SWP facilities, hatcheries, or other direct effects from the proposed action, it is less likely that the proposed action will have population-level effects as compared to watersheds above RBDD (*e.g.*, Battle, Beegum and Clear Creeks). Nevertheless, the abundance of every spring-run population within the Northern Sierra Nevada diversity group is expected to be reduced by proposed action-related factors in the Delta.

9.3.6 Assess Risk to the Central Valley Spring-Run Chinook Salmon ESU

As previously stated, the spring-run ESU is currently likely to become endangered within the foreseeable future in large part because: (1) the ESU is currently composed of only one diversity group containing extant independent populations; (2) habitat elimination and modification throughout the Central Valley have drastically altered the ESU's spatial structure and diversity; and (3) the ESU has a risk associated with catastrophes, especially considering the remaining independent populations' proximity to Mt. Lassen and the probability of a large scale wild fire occurring in those watersheds (Lindley *et al*. 2007). In addition, population growth rate (lamda) declined under all climate change scenarios considered by Crozier *et al*. (2008). The risk of dropping below the lowest historical level of abundance shifted from a range of 6-36 percent in the current climate to 54-86 percent in the drier hotter climate (Crozier *et al*. 2008). Maintaining habitat diversity could potentially help buffer against the impacts of climate change (Lindley *et al*. 2009). The proposed action does not improve any of these factors. Our VSP analysis at the population and diversity group scales show that the proposed action reduces the viability of every extant spring-run population and diversity group. Thereefore, the viability of the ESU is expected to be significantly reduced with implementation of the proposed action.

Given the evidence of the reduction in numbers, reproduction and/or distribution of the species, NMFS concludes that Reclamation has not ensured that the proposed action is not likely to appreciably reduce the likelihood of viability, and therefore the likelihood of both the survival and recovery of the Central Valley spring-run Chinook salmon ESU (table 9-6).

Table 9-6. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the Central Valley Spring-Run Chinook Salmon ESU. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Not Likely/Likely to Jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River and Clear Creek flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River and Clear Creek; and (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).*	True	End
		False	Go to B
B	**CV spring-run are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to delay ~70% of the spring-run adults that spawn upstream of RBDD (i.e., approximately 10% of the total run size returning to the Sacramento River) and ~5% of spring-run juveniles emigrating past RBDD would be exposed to greater predation. (2) All*	True	NLAA

	freshwater life stages of Sacramento River and Clear Creek spring-run will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (3) Each year through 2030, Clear Creek and mainstem Sacramento River spring-run are expected to be exposed to water temperatures warmer than life stage requirements during egg incubation. (4) As water is moved from the north Delta to the export facilities in the south Delta, each year through 2030, spring-run juveniles will have increased exposure to an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and direct entrainment at the Federal and State pumping plants.	False	Go to C
C	**CV spring-run are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Delayed upstream migration at RBDD causes individual adults to consume more energy, which limits the amount of energy available for reproduction, resulting in the deposition of fewer and/or less viable eggs. Mortality of juvenile salmon migrating downstream past RBDD reportedly ranges from 5 to 50 %. (2) Loss of natural river function resulting from flow regulation in the Sacramento River and in Clear Creek has reduced the quality and quantity of rearing and migratory habitats, thereby reducing the growth and survival of individual spring-run juveniles in those systems. (3) .Under near-term operations (Study 7.1) spring-run egg mortality from exposure to warm water temperatures in the mainstem Sacramento River is expected to range from approximately 9% in wet years up to approximately 66% in critically dry years, with an average of approximately 21% over all water year types; under modeled climate change projections, average egg mortality over all water year types is expected to be approximately 50 % and during the driest 15 % of years is expected to be approximately 95%. In addition to mortality, individual spring-run from the mainstem Sacramento River are expected to experience sub-lethal effects during the egg incubation life stage resulting from exposure to warm water temperatures. Individual Clear Creek spring-run are expected to experience lethal and sub-lethal effects due to warm water temperatures during the adult immigration and holding, and egg incubation life stages. (4) Mortality of spring-run juveniles that enter the Delta interior is expected to range from 35 to 90%, resulting in the loss of approximately 5-16 percent of the entire ESU.*	True	NLAA
		False	Go to D
D	**Any responses are not likely to constitute "take" or reduce the fitness of CV spring-run that have been exposed.** *Key Evidence: (1) The reduction in energy available for egg production associated with delayed upstream migration at RBDD reduces the fitness of individuals by reducing their reproductive capacity; RBDD operations are expected to increase "take" of spring-run juveniles migrating downstream. (2) "Take"of spring-run individuals in the form of reduced growth and survival is expected due to the loss of natural river function associated with flow regulation in the Sacramento River and in Clear Creek. (3) and (4) As described in step C, "take" of spring-run individuals, in the form of mortality and sub-lethal effects, is expected particularly during the egg incubation (water temperature effects) and juvenile rearing/smolt emigration (predation and entrainment in the Delta) life stages.*	True	NLAA
		False	Go to E
E	**Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent.** *Key Evidence: The cumulative effects of RBDD operations, flow regulation, warm water temperatures, project-related impacts in the Delta, and other project-related stressors (see tablse 9-4 and 9-5) are expected to sufficiently reduce the survival and/or reproductive success of spring-run individuals at multiple life stages every year through 2030 such that key population parameters (i.e. spatial structure, diversity, and abundance) are appreciably reduced for all extant spring-run populations. Reductions in these parameters over the next 21 years will likely reduce the viability of every extant spring-run population.*	True	NLJ
		False	Go to F

F	**Any reductions in the viability of the exposed populations are not likely to reduce the viability of CV spring-run.** *Key Evidence: Considering the greatly diminished status of the CV spring-run ESU, NMFS assumes that if a population-level effect on any of the populations within the ESU is expected from implementation of the proposed action, then a species-level effect will be expected as well. The proposed action reduces the viability of every extant spring-run diversity group and population. Therefore, the viability of the ESU is expected to be significantly reduced with implementation of the proposed action.*	True	NLJ
		False	LJ

9.4 Central Valley Spring-Run Chinook Salmon Critical Habitat

9.4.1 Status of Central Valley Spring-Run Chinook Salmon Critical Habitat

Critical habitat for spring-run is composed of primary constituent elements that are essential for the conservation of the species including, but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Most of the historic spawning and rearing habitat for spring-run is above impassable dams[23] as is the case for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin rivers. Due to this habitat elimination, current spring-run spawning habitat largely occurs in areas that historically functioned as either rearing habitat or migratory corridors for spring-run, or spawning habitat for fall-run. The quality of spawning habitat used by spring-run in the Central Valley is diminished when fall-run, which spawn later than but still during spring-run spawning, arrive at the spawning grounds and physically disturb spring-run redds during their redd construction. This competition for spawning habitat between spring-run and fall-run, which was created by dam construction, occurs on several Central Valley rivers, including the mainstem Sacramento River. Spawning habitat for spring-run in the mainstem Sacramento River is often negatively affected by operation of the CVP through warm water releases from Shasta Reservoir. Additionally, the status of spring-run critical habitat is degraded by CVP operations and infrastructure such as the DCC and RBDD.

Substantial habitat degradation and alteration also has affected the rearing, migratory, and estuarine areas used by spring-run. Some general examples of how spring-run critical habitat has been degraded include the loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use. One specific example of degradation to estuarine habitats used by spring-run is that human activities in the San Francisco Bay-Delta Estuary have caused the loss or conversion of more than 500,000 acres of tidal wetlands and thousands of acres of shoreline and stream habitat (http://sfep.abag.ca.gov/pdfs/fact_sheets/SF_Bay_Delta_Estuary.pdf). Perhaps the most striking indication that the status of estuarine habitats used by spring-run has been degraded is the collapse of the pelagic community in the Delta that has been observed in recent years (Sommer *et al*. 2007). It is not immediately clear how the changes in the Delta ecosystem affect spring-run, but it is certain that substantial changes to spring-run estuarine habitat are occurring. It should be noted that the area in which the pelagic organism collapse is occurring does overlap

[23] All critical habitat for spring-run occurs below impassable barriers.

with spring-run critical habitat in the Delta, but the area of collapse also occurs in areas of the Delta that are not designated as spring-run critical habitat.

Due to past and present day effects to spring-run habitat, the current condition of spring-run critical habitat is considered to be highly degraded, and does not provide the conservation value necessary for the survival and recovery of the species.

9.4.2 Northwestern California Diversity Group

9.4.2.1 Spring-Run Chinook Salmon Critical Habitat in Clear Creek

9.4.2.1.1 Status of Spring-Run Chinook Salmon Critical Habitat in Clear Creek

Whiskeytown Dam at RM 18.1 is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential spring-run habitat. Prior to 2000, the McCormick-Saeltzer Dam presented a barrier to upstream migration for anadromous salmonids. Following removal of the Dam in 2000, access to approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam was restored. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Gravel injection projects are conducted to make up for this loss of spawning gravel recruitment, but limited spawning habitat availability is a problem in Clear Creek.

Currently the release schedule from Whiskeytown Dam calls for flows of 200 cfs from October 1 to June 1 and 150 cfs, or less, from July through September in order to maintain water temperatures below 60°F. Under dry and warm climate conditions, water temperatures above 60° F occur in Clear Creek. Lindley *et al*. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to spring-run, having limited area at higher elevations and being highly dependent on rainfall.

9.4.2.1.2 Project Effects on Spring-Run Chinook Salmon Critical Habitat in Clear Creek

The proposed action adversely affects Clear Creek spring-run critical habitat in a few ways. As shown in table 9-4 above, the proposed action is expected to produce stressors to habitats within Clear Creek used for spring-run adult immigration and holding, spawning, and egg incubation. Those stressors include warm water temperatures, and low summer flows. Under dry and warm climate conditions, the proposed action is expected to provide water temperatures warmer than is required for successful holding, spawning and egg incubation.

9.4.2.1.3 Assess Risk to Spring-Run Chinook Salmon Critical Habitat in Clear Creek

At least six factors, when considered concurrently, suggest that implementation of the proposed action is expected to place critical habitat for Clear Creek spring-run at considerable risk. First, Clear Creek habitat below Whiskeytown Dam is believed to be of marginal suitability for spring-run (Lindley *et al*. 2004). Records reviewed by Yoshiyama *et al*. (1996) do not suggest that spring-run were historically abundant in Clear Creek indicating limitations to the quantity and/or quality of habitat even before the construction of Whiskeytown Dam (Lindley *et al*. 2004). Third, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Fifth, under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will decrease the conservation value of these habitats (see table 9-4).

9.4.2.2 Spring-Run Chinook Salmon Critical Habitat in Cottonwood/Beegum and Thomes Creeks

Like Clear Creek, Cottonwood/Beegum and Thomes creeks appear to offer habitat of marginal suitability to spring-run Chinook salmon, having limited area at higher elevations and being highly dependent on rainfall, instead of snowmelt like the Sierra watersheds (Lindley *et al.* 2004). It is also worth noting that Cottonwood/Beegum, Thomes, and Clear creeks are on the east side of the coast range and, thus, lie in that mountain range's rain shadow (Lindley *et al*. 2004). Unlike Clear Creek, Cottonwood/Beegum and Thomes creeks do not have a large reservoir constructed on them, and thus are characterized by a more natural hydrograph. Water temperatures are generally warmer and flows are generally lower on these creeks than on Clear Creek. Spring-run critical habitat in Thomes Creek is degraded by high water temperatures, low flows, water diversions and associated seasonal diversion dams, gravel mining, and other habitat alterations such as levee construction and bank protection actions (*i.e*., rip rapping). In the Cottonwood/Beegum watershed, critical habitat is degraded by high water temperatures, low flows, diversions, and gravel mining.

9.4.3 Basalt and Porous Lava Diversity Group

9.4.3.1 Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

9.4.3.1.1 Status of Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

Within the range of the spring-run ESU, biological features of the designated critical habitat that are considered vital for spring-run include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. As generally described above in section 9.4.1, the status of critical habitat in each of these biological features is considered to be highly degraded, particularly with respect to habitats within the mainstem Sacramento River. The quality of spawning habitat used by spring-run in the mainstem Sacramento River is diminished when fall-run, which commence spawning slightly later in the season than spring-run, arrive at the spawning grounds, move gravels around for redd construction, and physically disturb spring-run redds during that process. Spawning and egg incubation habitat for spring-run in the mainstem Sacramento River is often adversely affected by operation of the CVP through warm water releases from Shasta Reservoir. Freshwater rearing and migration habitats have been degraded by RBDD operations which delay upstream migration, reduce the availability of quality rearing habitat through the related seasonal creation of Lake Red Bluff, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional adverse effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through flow regulation,levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

9.4.3.1.2 Project Effects on Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

The proposed action negatively affects mainstem Sacramento River critical habitat in several ways. As shown in table 9-5 above, the proposed action produces stressors to spawning, rearing, and migratory habitats in the mainstem Sacramento River. Those stressors include operation of RBDD, limited spawning habitat availability resulting from water temperature management, exposure to warm water temperatures during egg incubation and juvenile rearing, and loss of natural river function and morphology, affecting all habitat types and rearing habitat quanity and quality in particular.

9.4.3.1.3 Assess Risk to Spring-Run Chinook Salmon Critical Habitat in the Mainstem Sacramento River

At least four factors, when considered together, suggest that implementation of the proposed action is expected to place spring-run critical habitat in the mainstem Sacramento River at considerable risk. First, spawning, rearing, and migratory habitats within the mainstem Sacramento River are believed to be substantially degraded and generally would be considered as not properly functioning (McElhany *et al*. 2000, NMFS 1996b). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Third, under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially exacerbating adverse effects to spawning, rearing, and migratory habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will further compromise the conservation value of each of these habitats (see table 9-5).

9.4.3.2 Spring-Run Chinook Salmon Critical Habitat in Battle Creek

Spring-run habitat on Battle Creek is generally considered to be suitable largely due to many cold springs which feed the creek and the fact that the watershed receives a considerable amount of snowmelt during the spring and early summer. However, Battle Creek habitat is affected by several PG&E owned and operated diversion facilities on the North and South Forks. These facilities allow PG&E to control the majority of the flows in the anadromous fish reaches of the Battle Creek watershed. Because these facilities limit the availability of suitable anadromous salmonid habitat within the watershed, a cooperative partnership among Federal, State, and local entities was formed to develop and implement the Battle Creek Salmon and Steelhead Restoration Project. Specific restoration components, include improved instream flow releases, selected decommissioning of dams at key locations in the watershed, dedication of water diversion rights for instream purposes at decommissioned sites, construction of tailrace connectors, and installation of Fail-Safe Fish Screens and Fish Ladders (http://www.usbr.gov/mp/battlecreek/pdf/main/MOU.pdf). This restoration project has not yet been implemented, but is expected to be in the near future.

9.4.4 Northern Sierra Nevada Diversity Group

The proposed action does not affect spring-run critical habitat within any of the watersheds in the Northern Sierra Nevada Diversity Group with the exception of the Feather River. The effects to Feather River spring-run critical habitat are being evaluated in a separate Opinion related to the FERC relicensing of Oroville Dam.

9.4.5 Assess Risk to Central Valley Spring-Run Chinook Salmon Critical Habitat

At least five factors, when considered concurrently, suggest that implementation of the proposed action is expected to place spring-run critical habitat at considerable risk. First, the status of spring-run critical habitat is one characterized by severe degradation, including factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through flow regulation and levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use. In general, much of the spawning, rearing, migratory, and estuarine habitat would be considered as not properly functioning (NMFS 1996b). For example, NMFS (1996b) suggests that floodplain connectivity would be considered not properly functioning if the following description applied: "*severe reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent drastically reduced and riparian vegetation/succession altered significantly*." That descriptor certainly fits the Central Valley situation where only about 5 percent of Delta wetlands remain available due to levee construction and conversion to agricultural land (Williams 2006). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, overall drier conditions (Lindley *et al*. 2007), and altered estuarine habitats through changes in hydrology and sea level rise. Third, under current practices, human population growth will place an increasing demand for limited water supplies, potentially exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will continue to compromise the conservation value of spring-run spawning and rearing habitats in Clear Creek and the mainstem Sacramento River, and compromise the conservation value of migratory and estuarine habitats for all extant spring-run populations.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to reduce the conservation value of the critical habitat, as designated, for the conservation of Central Valley spring-run Chinook salmon (table 9-7).

Table 9-7. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Central Valley Spring-Run Chinook Salmon Designated Critical Habitat. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Adverse Modification of Critical Habitat (AD MOD).

Step	Apply the Available Evidence to Determine if…	True/False	Action

A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River and Clear Creek flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River and Clear Creek; and (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).*	True	End
		False	Go to B
B	**Areas of designated critical habitat for CV spring-run are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, the migratory corridor for spring-run adult immigration and juvenile emigration is expected to be affected by RBDD operations; rearing habitat will be affected by the formation of Lake Red Bluff. (2) Holding, spawning, rearing, and migratory habitats in the Sacramento River and Clear Creek will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (3)Each year through 2030, spring-run egg incubation habitats are expected to be affected by water temperatures warmer than life stage-specific requirements. (4) Each year through 2030, as water is moved from the north Delta through the DCC towards the pumping plants in the south Delta, a portion of outmigrating spring-run juveniles will be entrained into the central Delta, where survival and successful outmigration to the Pacific Ocean is expected to be lower than if the juveniles remained in the main migratory corridor of the Sacramento River.*	True	NLAA
		False	Go to C
C	**The quantity, quality, or availability of all constituent elements of CV spring-run critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations will reduce the quality of habitat for spring-run adult immigration and juvenile emigration, as well as the quality and quantity of rearing habitat through the formation of Lake Red Bluff. (2) Loss of natural river function resulting from flow regulation has reduced the quality and quantity of rearing and migratory habitats in the Sacramento River and in Clear Creek. (3)Each year through 2030, the provision of water temperatures warmer than life stage-specific requirements will reduce the quantity and quality of spring-run egg incubation habitats in the mainstem Sacramento River; and adult immigration and holding and egg incubation habitats in Clear Creek. (4) Each year through 2030, the quality of migratory habitats is reduced by entraining juvenile spring-run into low quality rearing/migratory habitat in the central Delta.*	True	NLAA
		False	Go to D
D	**Any reductions in the quantity, quality, or availability of one or more constituent elements of spring-run critical habitat are not likely to reduce the conservation value of the exposed area.** *Key Evidence: Reductions in the conservation value of migratory, egg incubation, and rearing habitats are expected due to reductions in the quantity, quality, or availability of critical habitat constituent elements resulting from RBDD operations, flow regulation in the Sacramento River and Clear Creek, the provision of water temperatures in the Sacramento River and Clear Creek warmer than life stage-specific requirements, and the movement of water towards the Federal and State pumping plants.*	True	-
		False	Go to E
E	**Any reductions in the conservation value of the exposed area of spring-run critical habitat are not likely to reduce the conservation value of the critical habitat designation.** *Key Evidence: Because the conservation value of all inland habitat types*	True	No AD MOD

	(migratory, spawning/egg incubation, and rearing) necessary to complete the salmon life cycle are expected to be reduced with implementation of the proposed action, it is likely that the conservation value of the critical habitat designation will also be reduced.	False	AD MOD

9.5 Central Valley Steelhead

In this section, we describe how the proposed action is expected to affect the likelihood of survival and recovery of the CV steelhead DPS by summarizing how Project operations will affect steelhead from Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River. We will focus on these four populations for a few reasons. First, they are the only populations that are affected by the proposed action within their respective watersheds as well as in the migratory corridors (*i.e.*, mainstem Sacramento River, mainstem San Joaquin River, and Delta). Second, these four populations are from each of the four diversity groups (biogeographical regions) that are composed of extant steelhead populations, and thus proposed action effects that are common to every extant steelhead population in the migratory corridors (including the Delta) will be described as these four populations are described in turn. To illustrate this, consider the Calaveras and Stanislaus rivers, both from the Southern Sierra Nevada Diversity Group. Steelhead from the Calaveras River are only affected by the proposed action when they occur in the Delta, and although the effects will not be discussed as they relate to the Calaveras River steelhead population, Delta effects to steelhead from the southern Sierra Nevada Diversity Group are described in the Stanislaus River analysis. Lastly, as described in Lindley *et al*. (2007), there are almost no data with which to assess the status of any of the extant steelhead populations in the Central Valley. As such, it did not make sense to attempt to assess whether stressors to individuals from populations that are only affected in the migratory corridors would constitute population-level effects. However, it does seem reasonable to assess whether effects to individual steelhead from Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River add up to population-level consequences, as some status information for each of these steelhead populations is available and the individuals from these four populations are affected by the proposed action throughout their inland life cycle.

This section will first summarize the status of CV steelhead. Next, within each diversity group, the risk to one of the four populations identified above will be assessed by considering its status, baseline stress regime, and how the proposed action is expected to affect individuals from that population throughout their life cycle. These effects and associated risk to individuals are considered concurrently with the population status and baseline, to reason whether or not the proposed action is expected to have a population-level effect. Finally, the risk to the species will be assessed by considering the risk to the various populations associated with implementation of the 21-year long proposed action. As stated in the Analytical Approach, if a population-level effect on any of the populations within the ESU is expected from implementation of the proposed action, then a species-level effect will be expected as well, based on the recommendation from the TRT that every extant population is necessary for the recovery of the species. NMFS interprets this to indicate that an increase in the extinction risk of one or more of the populations increases the extinction risk of the species.

9.5.1 Status of the Central Valley Steelhead DPS

CV steelhead were listed as threatened on March 19, 1998. Their classification was retained following a status review on January 5, 2006 (71 FR 834). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. Steelhead historically were well distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al*. 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessible due to Shasta and Keswick dams), south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alteration from water diversion projects), and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al*. 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996), with nearly all historic spawning habitat blocked behind impassable dams in many major tributaries, including in the Northwestern California (Clear Creek), the Basalt and Porous Lava (Sacramento, Pit, and McCloud rivers), the northern Sierra Nevada (Feather, Yuba, American Rivers, and Mokelumne rivers), and the southern Sierra Nevada (Stanislaus, Tuolumne, Merced, Calaveras, and San Joaquin rivers) diversity groups (Lindley *et al*. 2007).

Historic CV steelhead run size is difficult to estimate given limited data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead in the Sacramento River, upstream of the Feather River, through the 1960s. Steelhead counts at RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996; McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2004, a total of 12 steelhead smolts were collected at Mossdale (CDFG unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks. A few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Snorkel surveys from 1999 to 2002 indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, *op. cit*. Good *et al*. 2006). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated. Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be void of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (Demko and Cramer 2000). It is possible that naturally spawning populations exist in many other streams. However, these populations are undetected due to lack of monitoring programs (IEPSPWT 1999).

The majority (66 percent) of BRT votes was for "in danger of extinction," and the remainder was for "likely to become endangered." Abundance, productivity, and spatial structure were of highest concern. Diversity considerations were of significant concern. The BRT was concerned with what little new information was available and indicated that the monotonic decline in total abundance and in the proportion of wild fish in the CV steelhead DPS was continuing.

9.5.2 Baseline Stress Regime for the Central Valley Steelhead DPS

Extensive habitat elimination and degradation has been a primary factor causing the threatened status of CV steelhead. Physical habitat modifications (*e.g*., dam construction and river straightening and associated riprap applications) and many other anthropogenic effects on habitat have greatly diminished the viability of the DPS. The general future baseline for steelhead in the freshwater, estuarine, and marine environment is similar to that of winter-run (figure 9-1), with an exception that there is no targeted ocean fishery for steelhead. Detailed descriptions of baseline stressors to CV steelhead are provided in section 4.2.4, *Factors Responsible for the Current Status of Winter-Run, Spring-Run, CV Steelhead, and the Southern DPS of Green Sturgeon.* Future baseline stressors on CV steelhead are similar to those that affect winter-run, spring-run, and the Southern DPS of green sturgeon.

9.5.3 Northwestern California Diversity Group

9.5.3.1 Clear Creek Steelhead

9.5.3.1.1 Status of Clear Creek Steelhead

An abundant resident *O. mykiss* population in Clear Creek has prohibited obtaining estimates of steelhead abundance. However, snorkel surveys conducted from 1999 to 2002 suggest that anadromous steelhead are present in Clear Creek (Newton 2002 *op. cit*. Good *et al*. 2005). Although the overall status of this population is largely unknown, the observation that steelhead are present in Clear Creek is important to the spatial structure and overall viability of the DPS.

9.5.3.1.2 Future Baseline of Clear Creek Steelhead Excluding CVP/SWP Effects

The general baseline stress regime for steelhead in the freshwater, estuarine, and marine environment is depicted in figure 9-1[24]. Within Clear Creek, specific stressors include warm water temperatures in the lower reaches and a lack of natural gravel recruitment resulting in limited spawning habitat availability. Lindley *et al*. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to steelhead, having limited area at higher elevations and being highly dependent on rainfall.

[24] The stressor identified in figure 9-1 generally apply to all Central Valley anadromous salmonids with the exception that ocean harvest would not be considered an important stressor for steelhead as there is no targeted ocean fishery for that species.

9.5.3.1.3 Proposed Action Effects on Clear Creek Steelhead

Proposed action-related effects to steelhead within Clear Creek are summarized in table 9-8. Detailed descriptions regarding the exposure, response, and risk of steelhead to these stressors are presented in section 6.

9.5.3.1.4 Assess Risk to Clear Creek Steelhead

As described in section 6, habitat conditions in Clear Creek, the Sacramento River, and the Delta are adversely affected by the proposed action in a number of ways, including, but not limited to: (1)regulating flows in a way that impairs natural river processed; (2) providing flows and water temperatures in the lower reaches of Clear Creek that are stressful to steelhead; (3) delaying the upstream migration of adult steelhead through RBDD operations; (4) reducing the availability of quality rearing habitat through the seasonal creation of Lake Red Bluff; (5) creating improved feeding opportunities at RBDD for predators such as pikeminnow and striped bass; and (6) entraining juveniles into poor quality habitats in the Central and South Delta. In these ways, the proposed action reduces the population's current spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the Clear Creek steelhead population.

Table 9-8. Summary of proposed action-related effects on Clear Creek steelhead.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult immigration and holding Clear Creek	Aug. – Mar.	Water temperatures warmer than life history stage requirement for migration possible in lower reach near confluence with Sacramento River during August and September	Some adults may not enter mouth of Clear Creek, (1) delayed run timing, (2) seek other tributaries, (3) spawn in mainstem Sac. R.; reduced in vivo egg viability	Low- except for critically dry years	Medium - based on modeled water temps.	Reduced reproductive success
2	Adult immigration RBDD	Aug. – Mar.	RBDD gate closures from May15 – Sept. 15 force adults to use inefficient fish ladders	17% of those that spawn above RBDD, delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity	High	Medium - based on run timing and ability to hold until spawning	Reduced reproductive success
3	Spawning Clear Creek	Dec. – Mar.	Reduction in frequency and magnitude of peak flows due to the operation of Whiskeytown Dam	Less habitat diversity, limited spawning habitat availability; reduced production of eggs and fry, possible crowding and competition from late-fall Chinook salmon	Medium to High	High - based on spawning surveys	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
4	Egg incubation Clear Creek	Dec. - May	Water temperatures warmer than life history stage requirements	In critically dry years, higher egg mortality and sub-lethal effects for eggs spawned in March	Low	High - based on temperature modeling, scientific literature on life stage requirements (*e.g.*, EPA 2001, Myrick and Cech 2001), and observed spawning surveys	Reduced survival
5	Juvenile rearing Clear Creek	May – Sep.	Low summer flows (50 cfs), when b(2) is unavailable	Limited rearing habitat availability; less food, reduced growth, increased predation risk	High	High - based on modeled flows (CVP/SWP operations BA), uncertain availability of b(2), and historical data (http://cdec.water.ca.gov/)	Reduced survival
6	Juvenile rearing Clear Creek	May – Sep.	Water temperatures warmer than life history stage requirements	Limited over-summering habitat, reduced growth, increased susceptibility to disease and predation	High	High - based on modeled water temperature (CVP/SWP operations BA), uncertain availability of b(2), and historical data (http://cdec.water.ca.gov/)	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
7	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 1% of the steelhead DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	Low	High - based on tagging studies for juveniles passing RBDD (Vogel *et al*. 1988; Tucker 1998) and timing of steelhead emigration (TCCA 2008)	Reduced survival
8	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Reduction in rearing habitat quality and quantity; delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth
9	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g*., 95% efficiency).	Low	High - based on annual monitoring of fish screens	Reduced survival
10	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High - based on CVP/SWP operations BA	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on Co-manager review draft of Central Salmon Recovery Plan and CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
12	Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. Few steelhead are expected to be in this area during the fall.	Low	Low - based on lack of monitoring	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
13a-e	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Substantial mortality related to the proposed action (figure 9-2).	High	Low to High (see below)	Reduced survival
13a	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	DCC operations	Open gate configurations from late May through January increases vulnerability of steelhead entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Open gate configuration exposes less than 10 % of steelhead smolt population to entrainment into the DCC.	Low	Medium– numerous studies with Chinook salmon indicate poor survival in Delta interior. Steelhead predation studies in CCF indicate steelhead and Chinook vulnerabilities are similar to predation	Reduced survival Reduced life history diversity

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
13b	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Loss in interior Delta	Diversion of emigrating fish into the delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Island) are observed for fish migrating through the Delta interior. Most Clear Creek steelhead should remain in the Sacramento River past the DCC because it is closed from Feb. – June, but there is risk of diversion through Georgiana Slough. Mortality of juvenile steelhead entering CCF ranging from approximately 74 to 85% (DWR 2008).	Medium	Medium– numerous studies find high loss rates for Chinook salmon relased in the Delta interior. CCF predation reports indicate that steelhead and Chinook salmon have similar predation vulnerabilities	Reduced survival
13c	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately two thirds of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85 % of the exposed fish. Plus an additional loss of approximately 10 % of all species released in the CHTR program. In January – March, when steelhead are present, loss ranges up to 100 % (DWR 2009). Percentage of steelhead produced in the Sacramento River and its tributaries actually arriving at the export facilities and entering the salvage process is expected to be low.	Low	Medium to High- numerous studies have evaluated screening efficiency, predation, and overall salvage operations for Chinook salmon survival. Recent steelhead predation studies completed	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
13d	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on steelhead as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta.	High	Low to medium. Invasion of non-native species into delta is well documented, interaction with steelhead populations is not well documented	Reducted survival, Reduced growth
13e	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, etc.). Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics well studied. Effects of Delta hydrodynamics on organisms is not as well understood.	Reduced survival, reduced growth

Recent redd surveys indicate a small, self-sustaining population (~300 adults) is increasing in abundance. This is most likely a result of intensive restoration efforts combined with increased flows, dam removal, and water temperature control. As CV steelhead expand throughout the 18 miles of stream they are likely to be impacted more often by low flows and high temperatures during the summer rearing period. Recent surveys (USFWS 2008) show a shift in spawning distribution downstream to between 4 and 6 miles above the confluence where over summer temperatures exceed the 60°F temperature compliance location set at Igo (RM 14.1). This shift in spawning is most likely a result of gravel augmentation and restoration efforts in key areas downstream. In 2008, 94 of 148 steelhead redds (63 percent) were observed downstream of the TCP. Since most juveniles stay within close proximity to where they are born during the first year this shift would expose a majority of the Clear Creek steelhead population to unsuitable habitat conditions. Exposure to stressful water temperatures during spawning, embryo incubation, juvenile rearing, and smolt emigration is likely to reduce the spatial structure and growth rate, thus adding to the risk of extinction.

The diversity of Clear Creek steelhead also may be affected by the proposed action. Water releases from Whiskeytown Dam has changed the thermal regime and likely the food web structure of Clear Creek (Lieberman *et al*. 2001) such that a resident life history strategy may have fitness advantages over anadromous forms (Lindley *et al*. 2006). Little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the role that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on Clear Creek, which may favor residency, are detrimental to the anadromous population in Clear Creek or not (Lindley *et al*. 2007). Zimmerman *et al*. (2008) did demonstrate that resident rainbow trout can produce anadromous smolts and anadromous steelhead can produce resident rainbow trout in the Central Valley. However, the study indicated that the proportion of resident rainbow trout to anadromous steelhead in the Central Valley is largely in favor of the resident form with 740 of 964 *O. mykiss* examined being the progeny of resident rainbow trout.

In addition to impacts to the spatial structure and possibly life history diversity, the proposed action is expected to result in direct mortality to steelhead. Proposed action-related sources of steelhead mortality include: (1) increasing predation of juveniles when the RBDD gates are down; (2) entraining juveniles into the Central and South Delta (figure 9-3); (3) entraining and impinging juveniles at the pumps (both direct and indirect loss); and (4) loss associated with the CHTR program.

In the driest 4 percent of years, steelhead abundance and productivity will be reduced due to less habitat available and sublethal water temperatures. With climate change, warmer conditions would reduce the rearing habitat in all water years, therefore fewer steelhead would likely be produced.

All of the above factors, which reduce the spatial structure, diversity, and abundance of Clear Creek steelhead, compromise the capacity for this population to respond and adapt to environmental changes. Future projections over the duration of the proposed action (*i.e.*, through

2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the proposed action, further increasing the risk of the population.

9.5.4 Basalt and Porous Lava Diversity Group

9.5.4.1 Mainstem Sacramento River Steelhead

9.5.4.1.1 Status of Mainstem Sacramento River Steelhead

The status of the CV steelhead on the mainstem Sacramento River is mainly unknown since there is no direct monitoring. However, we know that historically the population that spawns above RBDD is decreasing based on dam counts at RBDD and 3 of the major tributaries (*i.e*., Battle Creek, Clear Creek, and Cottonwood Creek). Since the RBDD gates started operation in 1967, the CV steelhead abundance in the upper Sacramento River has declined from 20,000 to less than 1,200 adults. The current abundance is less than 10 percent of the CVPIA doubling goal of 13,000 adults in the upper Sacramento River. Redd surveys for winter-run indicate that resident *O. mykiss* do spawn in the mainstem in May. A significant tailwater trout population supports a thriving recreational fishery due to the cold water releases for winter-run. This resident trout population can cross with anadromous forms of *O. mykiss* (common in some San Joaquin River tributaries). Rotary screw trap data at RBDD indicate that most juvenile steelhead observed there are resident forms based on timing and size. Zimmerman *et al*. (2008), found that the vast majority of *O. mykiss* collected from the Sacramento River exhibited a resident life history strategy.

9.5.4.1.2 Future Baseline of Mainstem Sacramento River Steelhead Excluding CVP/SWP Effects

The stressors that CV steelhead experience in the mainstem are the same as previously mentioned for winter-run with the addition of the following; no access to high elevation spawning and over summer habitat, lack of LWD and Shaded Riparian Habitat, increase in warm water predator populations, exposure to pesticides and herbicides in agricultural return water, urbanization, fragmentation-loss of core populations, loss of anadromous life history, competition from resident forms of *O. mykiss*, competition from introduced fish species more suited to regulated rivers, lack of small stream habitat, lack of smaller size gravel for spawning, fishing pressure, climate change, and the lack of policies aimed at changing the current regime (*i.e*., water for fish second).

9.5.4.1.3 Proposed Action Effects on Mainstem Sacramento River Steelhead

Proposed action-related effects to steelhead within the Sacramento River are summarized in table 9-9. Detailed descriptions regarding the exposure, response, and risk of steelhead to these stressors are presented in section 6.

9.5.4.1.4 Assess Risk to Mainstem Sacramento River Steelhead

As described in section 6 and summarized in table 9-9, habitat conditions in the mainstem Sacramento River and the Delta are adversely affected by the proposed action in a number of ways, including, but not limited to: (1) delaying the upstream migration of adult steelhead through RBDD operations; (2) reducing the availability of quality rearing habitat through the seasonal creation of Lake Red Bluff; (3) creating improved feeding opportunities at RBDD for predators such as pikeminnow and striped bass; and (4) entraining juveniles into poor quality habitats in the Central and South Delta. In these ways, the proposed action reduces the population's current spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the mainstem Sacramento River steelhead population.

The diversity of mainstem Sacramento River steelhead also may be affected by the proposed action. Water releases from Shasta Dam has changed the thermal regime and the food web structure of the Sacramento River (Lieberman *et al*. 2001) such that a resident life history strategy may have fitness advantages over anadromous forms (Lindley *et al*. 2006, McEwan 2001). Little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the role that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on the Sacramento River, which may favor residency, are detrimental to the anadromous population in the Sacramento River or not (Lindley *et al*. 2007). Zimmerman *et al*. (2008) did demonstrate that resident rainbow trout can produce anadromous smolts and anadromous steelhead can produce resident rainbow trout in the Central Valley. However, the study indicated that the proportion of resident rainbow trout to anadromous steelhead in the Central Valley is largely in favor of the resident form with 740 of 964 *O. mykiss* examined being the progeny of resident rainbow trout. This proportional imbalance is even more prominent in the Sacramento River River where about 92 percent (142 out of 154) of *O. mykiss* sampled were offspring of resident adults (Zimmerman *et al*. 2008). Only 1 out of the 154 *O. mykiss* sampled showed an anadromous migratory history, although the sampling was not intended to be selective for adults, so some fish sampled may not yet have made their downstream migration to the ocean.

In addition to impacts to the spatial structure and possibly life history diversity, the proposed action is expected to result in direct mortality to steelhead. Proposed action-related sources of steelhead mortality include: (1) increasing predation of juveniles when the RBDD gates are down; (2) entraining juveniles into the Central and South Delta (figure 9-3); (3) entraining and impinging juveniles at the pumps (both direct and indirect loss); and (4) loss associated with the CHTR program.

All of the above factors, which reduce the spatial structure, diversity, and abundance of mainstem Sacramento River steelhead, compromise the capacity for this population to respond and adapt to environmental changes. Future projections over the duration of the proposed action (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the proposed action, further increasing the risk of the population.

Table 9-9. Summary of proposed action-related effects on mainstem Sacramento River steelhead.

#	Life Stage/ Location	Life Stage Timin g	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult immigration RBDD	Aug. – Mar.	RBDD gate closures from May15 – Sept. 15 force adults to use inefficient fish ladders	17% of those that spawn above RBDD, delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity	High	Medium - based on run timing and ability to hold until spawning	Reduced reproductive success
2	Spawning Sacramento River	Dec. – Mar.	Straying of Nimbus Hatchery steelhead to mainstem Sacramento River spawning habitats	Reduced genetic fitness of Sacramento River steelhead through the spread of Eel River genes and potentially hatchery rainbow trout genes to many below-barrier sites in the Central Valley (Garza and Pearse 2008).	High	High – based on the genetic structure of CV steelhead described in Garza and Pearse (2008)	Reduced genetic fitness
3	Egg incubation Sacramento River	Dec. - May	Water temperatures warmer than life history stage requirements	Sub-lethal effects - reduced early life stage viability; direct mortality in critically dry years; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar.).	Medium	High - based on temperature modeling, scientific literature on life stage requirements (e.g., EPA 2001, Myrick and Cech 2001), and observed spawning surveys	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
4	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Reduction in rearing habitat quality and quantity; delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth
5	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 1 % of the steelhead DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	Low	High - based on tagging studies for juveniles passing RBDD (Vogel et al. 1988; Tucker 1998) and timing of steelhead emigration (TCCA 2008)	Reduced survival
6	Juvenile rearing/smolt emigration Upstream of and including RBDD	Year-round	Screened CVP diversions including continuing operation of the RBDD Research Pumping Plant	Mortality from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation. All screens were designed to meet NMFS fish screen criteria (*e.g.*, 95% efficiency).	Low	High - based on annual monitoring of fish screens	Reduced survival

#	Life Stage/ Location	Life Stage Timin g	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
7	Juvenile rearing/smol t emigration Upstream of and including RBDD	Year-round	Provision of higher flows and cooler water temps during the summer than occurred prior to the construction of Shasta Dam	Potential fitness advantage for resident *O.mykiss* over the anadromous form, which would drive an evolutionary (*i.e.*, genetic) change if life history strategy is heritable (Lindley *et al*. 2007).	High	Medium to High Medium because the degree to which life history strategy is controlled by genetics is not clear. High because resident *O. mykiss* are the dominant form in the Sacramento River, as indicated in a recent study which reported that approximately 92 % (142 out of 154) of *O. mykiss* sampled from the Sacramento River were offspring of resident adults (Zimmerman *et al*. 2008).	Reduced reproductive success

#	Life Stage/ Location	Life Stage Timin g	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
8	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High - based on CVP/SWP operations BA	Reduced survival
9	Juvenile rearing/smolt emigration RBDD to Colusa	Year-round	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on Co-manager review draft of Central Valley Salmon Recovery Plan and CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
10	Juvenile rearing/smolt emigration Colusa to Sacramento	Year-round	Low fall flows	Yearling emigration delayed, higher predation; fewer smolts survive to the Delta. However, few steelhead are expected to be in this area during the fall.	Low	Low - based on lack of monitoring	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11a-e	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Substantial mortality related to the proposed action (figure 9-2)	High	Low to High (see below)	Reduced survival
11a	Juvenile rearing/smolt emigration Delta	Oct. - Jul.	DCC operations	Open gate configurations from late May through January increases vulnerability of steelhead entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Open gate configuration exposes less than 10 % of the steelhead that are produced in the Sacramento River and its tributaries to entrainment into the DCC.	Low	Medium– Numerous studies with Chinook salmon indicate poor survival in Delta interior. Steelhead predation studies in CCF indicate steelhead and Chinook vulnerabilities are similar to predation	Reduced survival Reduced life history diversity

#	Life Stage/ Location	Life Stage Timin g	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11b	Juvenile rearing/smol t emigration Delta	Oct. - Jul.	Loss in interior Delta	Diversion of emigrating fish into the delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Isalnd) are observed for fish migrating through the Delta interior. Most Sacramento steelhead should remain in the Sacramento River as the open gate configuration of DCC exposes less than 10 % of the steelhead that are produced in the Sacramento River and its tributaries.	Medium	Medium– numerous studies find high loss rates for Chinook salmon relased in the Delta interior. CCF predation reports indicate that steelhead and Chinook salmon have similar predation vulnerabilities	Reduced survival
11c	Juvenile rearing/smol t emigration Delta	Oct. - Jul.	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately two thirds of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85 % of the exposed fish. Percentage of Sacramento River steelhead population actually arriving at the export facilities and entering the salvage proccess is expected to be low.	Low	Medium to High- numerous studies have evaluated screening efficiency, predation, and overall salvage operations for Chinook salmon survival. Recent steelhead predation studies completed	Reduced survival

#	Life Stage/ Location	Life Stage Timin g	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
11d	Juvenile rearing/smol t emigration Delta	Oct. - Jul.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on steelhead as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta.	High	Low to medium. Invasion of non-native species into delta is well documented, interaction with steelhead populations is not as well documented	Reducted survival, Reduced growth
11e	Juvenile rearing/smol t emigration Delta	Oct. - Jul.	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, etc.) Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics well studied. Effects of Delta hydrodynamics on organisms is not as well studied.	Reduced survival, reduced growth

Reclamation's mortality model was not run for CV steelhead to determine the effects of different climate change scenarios because steelhead have a shorter incubation period than salmon, and the model would have to be changed. However, late-fall salmon can be used as a surrogate for CV steelhead since they spawn at similar times in the winter. Late fall-run mortality increases in Study 9.5 (drier, more warming) and Study 9.3 (wetter, more warming) under all water year types on average 4 percent over the future full build out scenario (Study 9.0). EOS carryover storage at Shasta is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming (CVP/SWP operations BA table 9-23).

9.5.5 Northern Sierra Nevada Diversity Group

9.5.5.1 American River Steelhead

9.5.5.1 Status of American River Steelhead

Historically, the American River supported three separate runs of steelhead corresponding to the summer, fall, and winter seasons. Mining activities and dam construction during the late 1800s and early 1900s drastically degraded and eliminated anadromous salmonid habitat. By 1955, summer-run steelhead (and spring-run Chinook salmon) were completely extirpated and only remnant runs of fall- and winter-run steelhead persisted in the American River (Gerstung 1971). Stressors, including the construction of the American River Division facilities of the CVP, contributed to the subsequent extirpation of fall-run steelhead. The current population size of about a few hundred in-river spawning steelhead (Hannon and Deason 2008) is much lower than estimates from the 1970s (Staley 1975), and is primarily composed of fish originating from Nimbus Hatchery. This means that the listed population (*i.e*., naturally-produced fish) in the lower American River is at an abundance level lower than the estimates provided by Hannon and Deason (2008) and is likely on the order of tens.

In addition to small population size, other major factors influencing the status of naturally spawning steelhead in the American River include: (1) a 100 percent loss of historic spawning habitat resulting from the construction of Nimbus and Folsom Dams (Lindley *et al*. 2007), which has obvious and extreme implications for the spatial structure of the population; and (2) the operation of Nimbus Fish Hatchery, which has completely altered the diversity of the population.

Lindley *et al*. (2007) classifies the natural population of American River steelhead at a high risk of extinction because this population is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. The small population size and complete loss of historic spawning habitat and genetic composition further support this classification.

9.5.5.1.2 Future Baseline of American River Steelhead Excluding CVP/SWP Effects

Excluding stressors resulting from American River Division operations, baseline stressors to American River steelhead include the presence of Folsom and Nimbus dam, loss of natural riverine function and morphology, predation, and water quality. A detailed description of how these stressors affect steelhead in the American River is provided in section 5.4.3.

9.5.5.1.3 Proposed Action Effects on American River Steelhead

Proposed action-related effects to steelhead within the American River are summarized in table 9-10. Detailed descriptions regarding the exposure, response, and risk of steelhead to these stressors are presented in section 6. Additionally, an analysis related to potential climate change effects on American River steelhead is presented in that section.

Table 9-10. Summary of proposed action-related effects on American River steelhead.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Spawning Primarily upstream of Watt Ave. area	Late-Dec. - early Apr.	Folsom/Nimbus releases – flow fluctuations	Redd dewatering and isolation prohibiting successful completion of spawning	Medium	Medium	Reduced reproductive success
2	Spawning Primarily upstream of Watt Ave. area	Late-Dec. - early Apr.	Nimbus Fish Hatchery – hatchery *O. mykiss* spawning with natural-origin steelhead	Reduced genetic diversity. Garza and Pearse (2008) showed that genetic samples from the population spawning in the river and the hatchery population were “extremely similar”.	High	High – based on Garza and Pearse (2008)	Reduced reproductive success
3	Embryo incubation Primarily upstream of Watt Ave. area	Late-Dec. - May	Water temperatures warmer than life stage requirements	Sub-lethal effects - reduced early life stage viability; direct mortality; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar. and Apr.)	Medium	High – based on past water temperature data, CVP/SWP operations BA water temp. modeling, published literature regarding the thermal tolerance of steelhead eggs	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
4	Embryo incubation Primarily upstream of Watt Ave. area	Late-Dec. - May	Folsom/Nimbus releases – high instream flows resulting in redd scour	Egg and alevin mortality. Spawning substrate mobilization in the American River reportedly begins to occur at flows of 30,000 -50,000 cfs (Ayres Associates 2001). Flood frequency analysis for the American River at the Fair Oaks gauge shows that, on average, flows will reach 30,000 cfs approximately once every 4 years and 50,000 cfs approximately once every 5 years (CVP/SWP operations BA).	Medium	High – based on evidence of the flow magnitude required to mobilize spawning substrate (Ayres Associates 2001) and the frequency of such flows (CVP/SWP operations BA, USFWS 2003)	Reduced survival
5	Embryo incubation Primarily upstream of Watt Ave. area	Late-Dec. - May	Folsom/Nimbus releases – flow fluctuations	Redd dewatering and isolation. Hannon *et al.* (2003) reported that 5 steelhead redds were dewatered and 10 steelhead redds were isolated at the lower Sunrise side channel when Nimbus Dam releases were decreased on February 27, 2003. When releases were decreased on March 17, 2003, seven steelhead redds were dewatered and five additional redds were isolated from flowing water at the lower Sunrise side channel. In April 2004 at the lower Sunrise side channel, five steelhead redds were dewatered and "many" redds were isolated (Water Forum 2005a). Redd dewatering at Sailor Bar and Nimbus Basin occurred in 2006 (Hannon and Deason 2008).	High	High – based on Hannon et al. (2003), Water Forum (2005a), and Hannon and Deason (2008).	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
6	Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Folsom/Nimbus releases – flow fluctuations; low flows	Fry stranding and juvenile isolation - observations of juvenile steelhead isolation in the American River were made in both 2003 and 2004 (Water Forum 2005a). Low flows limiting the availability of quality rearing habitat including predator refuge habitat	High	High – based on past studies (CDFG 2001; Water Forum 2005a)	Reduced survival
7	Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Water temperatures warmer than life stage requirements	Physiological effects - increased susceptibility to disease (*e.g.*, anal vent inflammation) and predation. Visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F (Water Forum 2005a). With the exception of 2005, from 1999 through 2007, daily mean water temperatures at Watt Avenue from August through September were warmer than 65°F for approximately 81 percent of the days, and during 2001, 2002, 2004, 2006, and 2007, water temperatures were often over 68°F (figure 30a). Under a drier and warmer climate change scenario (Study 9.5), modeled water temperatures at Watt Avenue from June through September under full build out of the proposed Project range from 65°F to 82°F (Reclamation 2009). Even if no regional climate change is assumed (Study 9.1), water temperatures at this location during this time period are expected to range from 63°F to 79°F.	High	High – based on actual (cdec data) and modeled water temps, published literature regarding the thermal tolerance of steelhead juveniles (e.g., EPA 2001; Myrick and Cech 2001), and past studies (Water Forum 2005a).	Reduced growth; Reduced survival
8	Smolt emigration Throughout entire river	Jan. – Jun.	Water temperatures warmer than life stage requirements	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Medium	Medium	Reduced growth; Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
9a-e	Smolt emigration Delta	Jan. – Jun.	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamic s)	Substantial mortality related to the proposed action (figure 9-3)	High	Low to High (see below)	Reduced survival
9a	Smolt emigration Delta	Oct. - Jul.	DCC operations	Open gate configurations from late May through January increases vulnerability of steelhead entrainment into the Delta interior where survival is considerably lower than within the Sacramento River mainstem. Mandatory gate closure from Feb 1 through end of May prevents entrainment into the DCC. Open gate configuration exposes less than 10 % of the steelhead that are produced in the Sacramento River and its tributaries to entrainment into the DCC.	Low	Medium– Numerous studies with Chinook salmon indicate poor survival in Delta interior. Steelhead predation studies in CCF indicate steelhead and Chinook vulnerabilities are similar to predation	Reduced survival Reduced life history diversity

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
9b	Smolt emigration Delta	Oct. - Jul.	Loss in interior Delta	Diversion of emigrating fish into the delta interior exposes fish to increased loss. Lower survival rates to the western Delta (Chipps Isalnd) are observed for fish migrating through the Delta interior. Most American River steelhead should remain in the Sacramento River as the open gate configuration of DCC exposes less than 10 % of the steelhead that are produced in the Sacramento River and its tributaries.	Medium	Medium– numerous studies find high loss rates for Chinook salmon relased in the Delta interior. CCF predation reports indicate that steelhead and Chinook salmon have similar predation vulnerabilities	Reduced survival
9c	Smolt emigration Delta	Oct. - Jul.	Loss at export facilities	Entrainment of fish at the CVP results in loss of approximately two thirds of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85% of the exposed fish. Percentage of American River steelhead population actually arriving at the export facilities is expected to be low.	Low	Medium to High- numerous studies have evaluated screening efficiency, predation, and overall salvage operations for Chinook salmon survival. Recent steelhead predation studies completed	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
9d	Smolt emigration Delta	Oct. - Jul.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Direct predation on steelhead as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta	High	Low to medium. Invasion of non-native species into delta is well documented, interaction with steelhead populations is not as well documented	Reducted survival, Reduced growth
9e	Smolt emigration Delta	Oct. - Jul.	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (predation, poor water quality, contaminants, etc.). Affects a large fraction of the Central and Southern Delta.	High	Low to High. Delta hydrodynamics is well studied. Effects of Delta hydrodynamics on organisms are not as well understood.	Reduced survival, reduced growth

9.5.5.1.4 Assess Risk to American River Steelhead

Population viability is determined by four parameters: spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning conditions (habitats), as defined in McElhany *et al*. (2000), and the connections between such habitats. NMFS defines properly functioning condition as the freshwater habitat conditions necessary for the long-term survival of Pacific salmon populations (McElhany *et al*. 2000). As described above, habitat conditions in the lower American River are adversely affected by the proposed action to such a degree that the survival, growth, and reproductive success of multiple steelhead life stages is reduced. For example, American River steelhead are exposed to stressful water temperatures during spawning, embryo incubation, juvenile rearing, and smolt emigration. Based on the entire effects analysis, it is apparent that the water temperatures and flows expected with implementation of the proposed action will continue to substantially limit the quantity and quality of habitat, thereby limiting the spatial structure of American River steelhead. These limitations to the spatial structure of a population which have already been blocked off from all of its historic spawning habitat certainly adds to its risk of extinction.

The behavioral and genetic diversity of American River steelhead also is expected to be negatively affected by the proposed action. Warm water temperatures in the American River under the proposed action are expected to result in higher fitness for steelhead spawned early (*e.g.,* January) in the spawning season, as eggs spawned later (*e.g*., March) would be exposed to water temperatures above their thermal requirements (see *Assess Species Response*, section 6.4.3, above). This selective pressure towards earlier spawning and incubation would truncate the temporal distribution of spawning, resulting in a decrease in population diversity. Additionally, the genetic diversity of steelhead in the river has been completely altered by Nimbus Fish Hatchery operations, relative to the historic diversity.

In addition to the negative effects on the spatial structure and diversity, the proposed action is expected to reduce the abundance of American River steelhead. Direct mortality (*e.g*., redd scour, redd dewatering, and potential water temperature-related egg mortality) associated with proposed operations has been documented at both the egg and juvenile life stages. The fitness consequences from water temperature-related anal vent inflammation of the juveniles (*e.g*., compromised immune system, resulting in increased predation, reduced energy for growth) also would be expected to negatively affect the population growth rate.

The combined effects of the proposed action on the spawning, embryo incubation, juvenile rearing, and smolt emigration life stages of steelhead in the American River, reduces the viability of the population and places the population, which was already at high risk of extinction (see section 9.5.5.1.,1 *Status of American River Steelhead*), at even greater risk. This notion is especially supported considering that Naiman and Turner (2000) demonstrated how even slight reductions in survival from one life stage to the next at each and every life stage can have serious consequences for the persistence of a population, and the proposed action reduces the survival of each and every steelhead life stage, including the life stage transition from smolt to adult-sized fish in the ocean. Although the proposed action does not directly affect steelhead in the ocean, it indirectly lowers their ocean survival because they are entering it in a weakened state.

Future projections over the duration of the proposed action (*i.e*., through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of current American River Division operations, further increasing the risk of extinction of naturally-spawned American River steelhead. For example, comparing annual water deliveries from the American River Division in recent years (*e.g*., about 300 TAF in 2006) to annual demands that were modeled in the CVP/SWP operations BA for full build out of the proposed action (*i.e*., 800 TAF in 2030), suggests that annual demands by 2030 are expected to be about three to four times higher than current levels. This increased water demand is expected to result in considerable challenges to flow and water temperature management for American River aquatic resources below Nimbus Dam, and will likely exacerbate the adverse habitat conditions already occurring in the river under present day water demands. In addition to increasing water demands, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007).

9.5.6 Southern Sierra Nevada Diversity Group

9.5.6.1 Stanislaus River Steelhead

9.5.6.1.1 Status of Stanislaus River Steelhead

Studies have documented the occurrence of CV steelhead in the Stanislaus River based on incidental observations obtained from fall-run sampling (Anderson *et al*. 2007; S.P. Crammer and Associates Inc. 2000, 2001) as well as from otolith microchemistry analyses (Zimmerman *et al.* 2008). However, information regarding the abundance of Stanislaus River steelhead is very limited. In the 2006-7 season, 12 steelhead were observed passing through a Stanislaus River counting weir (Anderson *et al*. 2007). One of the steelhead observed at the weir had an adipose fin clip, indicating some opportunity for genetic introgression from hatchery operations on other Central Valley rivers. Steelhead smolts also have been captured in the Stanislaus River in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001), but the numbers are very low, ranging from 10 to 30 annually. Most of the steelhead smolts are captured from January to mid-April, are 175 to 300 mm fork length, and display morphological characteristics associated with smoltification, indicating these fish are exhibiting an anadromous life form. These fish are physiologically prepared to leave the river at a time well after the scheduled VAMP pulse flows, but not later than when historical unimpaired rain-on-snow events would have provided out migration flows.

9.5.6.1.2 Future Baseline of Stanislaus River Steelhead Excluding CVP/SWP Effects

Excluding stressors resulting from proposed action operations, baseline stressors to Stanislaus River steelhead include the presence of Goodwin, Tulloch and New Melones dams, loss of natural riverine function and morphology, agricultural and urban land uses, gravel mining, predation, and water quality, particularly temperature, contaminants and suspended sediment. A detailed description of how these stressors affect steelhead in the Stanislaus River is provided in section 5.5.3.

9.5.6.1.3 Proposed Action Effects on Stanislaus River Steelhead

Proposed action-related effects to Stanislaus River steelhead are summarized in table 9-11. Detailed descriptions regarding the exposure, response, and risk of steelhead to these stressors are presented in section 6. Additionally, an analysis related to potential climate change effects on Stanislaus River steelhead is presented in that section.

9.5.6.1.4 Assess Risk to Stanislaus River Steelhead

Population viability is determined by Spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning conditions (habitats), as defined in McElhany *et al*. (2000). Thus, reductions in the quantity or quality of available habitat are assumed to reduce a population's spatial structure.

Habitat conditions in the Stanislaus River and Delta are negatively affected by the proposed action to such a degree that the survival, growth, and/or reproductive success of all inland life stages of steelhead is reduced (see table 9-11). For example, Stanislaus River steelhead are exposed to stressful water temperatures during adult immigration, embryo incubation, juvenile rearing, and smolt emigration. In addition, flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt emigration life stages. Based on the effects analysis throughout the steelhead life cycle, it is apparent that the proposed action has substantial negative effects on the habitat, and therefore spatial structure, in the Stanislaus River and Delta. A further reduction to the spatial structure of a population which has already been blocked off from its historic spawning habitat certainly adds to its risk of extinction.

Table 9-11. Summary of proposed action-related effects on Stanislaus River steelhead.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult Immigration Delta to Riverbank	Oct-Dec	Water temperatures warmer than life history stage requirements	Delayed entry into river (CDFG 2007a); pre-spawn mortality; reduced condition factor.	Medium	Medium – based on CDFG (2007a)	Reduced reproductive success; Reduced survival to spawn
2	Spawning Stanislaus River	Dec-Feb	Unsuitable flows restrict spawnable habitat and dewater redds	Limited spawning habitat availability according to Aceituno (1993). Instream flows typically drop in January from higher December levels when San Joaquin River water quality objectives are met. This increases the risk for redd dewatering and direct egg mortality.	High	Low- populations so low that direct observation is difficult	Reduced reproductive success
3	Spawning Stanislaus River	Dec-Feb	Excessive fines in spawning gravel resulting from lack of overbank flow	Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site Fine material deposited in gravel beds because of lack of overbank flow to inundate floodplain and deposit fine material on floodplain, instead of in river (Kondolf *et al*. 2001).	High	Medium-deposition documented by Kondolf *et al*. (2001) and reduced permeability in spawning beds measured by Mesick (2001); energetic effects not documented for steelhead.	Reduced reproductive success

4	Egg incubation and emergence Stanislaus River	Dec-May	Excessive fines in spawning gravel resulting from lack of overbank flow	Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other steelhead or fall-run; suppressed growth rates.	High	High – based on reduced permeability in spawning beds measured by Mesick (2001); and geomorphic assessment (Kondolf *et al*. (2001)	Reduced survival
5	Egg incubation and emergence Stanislaus River	Dec-May	Water temperatures warmer than life history stage requirements	Egg mortality, especially for eggs spawned in or after March; Embryonic deformities (Deas *et al*. 2008) Temperatures may be operationally managed, depending on year type	Medium	High – based on actual (CDEC) data and modeled (CVP/SWP operations BA) water temperatures, published literature regarding the thermal tolerance of steelhead juveniles (*e.g*., EPA 2003a; Myrick and Cech 2001)	Reduced survival
6	Juvenile rearing Stanislaus River	Year round	Contaminants (particularly dormant sprays)	Reduced food supply; suppressed growth rates; smaller size at time of emigration, starvation; indirect: loss to predation; poor energetics; indirect stress effects.	Low	Low – limited information for Stanislaus River fish	Reduced growth rates; Reduced survival

7	Juvenile rearing Stanislaus River	Year round	Operations can create usable habitat conditions below dam equivalent to 50% of historic linear stream access and only in reaches that were historically seasonably unsuitable for rearing.	Reduced food supply; suppressed growth rates; smaller size at time of emigration, starvation.	High	Medium to High – based on Lindley *et al.* (2007)	Reduced growth rates; Reduced survival
8	Juvenile rearing Stanislaus River	Year round	Lack of overbank flow to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration.	High	High – based on geomorphic studies (Kondolf *et al*. 2001), and floodplain habitat literature (Sommer *et al.* 2001a, 2001b, 2005; Jeffres *et al.* 2008; Heady and Merz 2007)	Reduced growth rates; Reduced survival

9	Juvenile rearing Stanislaus River	Year round	Reduction in rearing habitat complexity due to reduction in channel forming flows	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration.	High	High – based on geomorphic studies (Kondolf *et al*. 2001), and floodplain habitat literature (Sommer *et al.* 2001a, 2001b, 2005; Jeffres *et al.* 2008; Heady and Merz 2007)	Reduced growth rates; Reduced survival
10	Juvenile rearing Stanislaus River	Year round	Unsuitable flows for maintaining juvenile habitat	Crowding and density dependent effects relating to reduced habitat availability. Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth.	High	High – based on IFIM analysis (Aceituno 1993)	Reduced growth rates; Reduced survival
11	Juvenile rearing and out-migration Stanislaus River	All year with increase Feb-May during out-migration	Predation by non-native fish predators because rearing habitat is lacking	Juvenile mortality; Reduced juvenile production.	High	High – based on geomorphic studies (Kondolf *et al*. 2001), and predation analyses on Stanislaus and Tuolumne Rivers (Demko *et al*.1999, Stillwater Sciences 2000)	Reduced survival
12	Juvenile rearing Stanislaus River	Year round Jan-April (14 months)	End of summer water temperatures warmer than life history stage	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth.	High	High – based on actual (CDEC) data and modeled (CVP/SWP operations BA) water temperatures.	Reduced growth rates; Reduced survival

13	Smoltification and emigration Stanislaus River at mouth	Jan. - Jun.	Water temperatures warmer than life history stage (Mar - June)	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress.	High	High – based on actual (CDEC) data and modeled (CVP/SWP operations BA) water temperatures	Reduced diversity.
14	Smolt emigration Stanislaus River	Jan. – Jun.	Suboptimal flow (March – June)	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation.	High	High – based on actual (CDEC-temperature, smolted steelhead occurrence at Oakdale/Caswell rotary screw-traps) data and modeled (CVP/SWP operations BA) water temperatures	Reduced survival; Reduced diversity
15a-d	Smolt emigration Delta	Jan. – Jun.	Cumulative direct and indirect loss associated with export operations (Loss in Southern Delta, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Substantial mortality to steelhead from the southern Sierra Nevada diversity group. Based on VAMP studies of fall-run, mortality ranges from 90 – 99 % from San Joaquin River release points to Chipps Island (SJRGA 2006). Similar results are assumed for steelhead, as shown through the CCF studies showing similar loss rates between steelhead and Chinook salmon (DWR 2008).	High	Low – based on lack of steelhead-specific data High – based on studies of Chinook salmon mortality using acoustic tags, PTM modeling (CVP/SWP operations BA), and supplemental PTM model runs.	Reduced survival

15a	Smolt emigration Delta	Jan-Jun.	Loss in Southern Delta	Exports increase residence time of emigrating fish by diverting juveniles into the channels of the South Delta. This exposes steelhead to increased losses to predation and contaminants. Vulnerability to entrainment into the channels of the South Delta is elevated during high export operations. Lack of HORB increases entrainment into Old River (SJRGA 2006). Lower survival rates to the western Delta (Chipps Island) are observed for fish migrating through the South Delta interior (USFWS 2006).	High–	Medium–numerous studies find high loss rates for Chinook salmon released in the Delta interior. CCF predation reports indicate that steelhead and Chinook salmon have similar predation vulnerabilities. Supplemental PTM model runs indicate a high rate of entrainment of particles to the pumps.	Reduced survival
15b	Smolt emigration Delta	Jan-Jun.	Loss at export facilities	Percentage of the southern Sierra Nevada steelhead diversity group exposed to salvage process is considered high due to high rate of diversion of flows and particles to the export facilities. Entrainment of fish at the CVP results in loss of approximately 66 % of the exposed fish. Entrainment of fish at the SWP results in the loss of approximately 85 % of the exposed fish (see table 6-28).	High	Medium to High-numerous studies have evaluated screening efficiency, predation, and overall salvage operations for Chinook salmon survival. Recent steelhead predation studies completed (DWR 2008).	Reduced survival

15c	Smolt emigration Delta	Jan-Jun.	Project operations create a stabilized freshwater ecosystem in Delta all year, every year, instead of allowing for salinity variability.	Stabilized freshwater environment is conducive to the propagation of non-native species such as large mouth bass and other centrarchids, water hyacinth, *Egeria densa*, and asian clams. Predation on steelhead as well as shifts in useable habitat and food resources occur due to non-native species presence. Non-native species have altered the balance of the ecosystem and have increased the level of loss for fish emigrating through the Delta.	High	Low to medium. Invasion of non-native species into Delta is well documented (Cohen and Moyle 2004; Brown and Michniuk 2007; Ford and Brown 2001) interaction with steelhead populations is not as well documented	Reduced survival, Reduced growth
15d	Smolt emigration Delta	Jan-Jun.	Altered Delta hydrodynamic s	Creation of reverse flows within Central and Southern Delta waterways, reduced primary and secondary productivity due to export of food web base, delay in migration through Delta due to altered hydrodynamics and loss of migratory cues. Delays increase exposure to sources of mortality and morbidity (poor water quality, contaminants, *etc*.). Affects a large fraction of the Central and Southern Delta which encompasses the migratory route of southern Sierra Nevada diversity group steelhead.	High	Low to High. Delta hydrodynamics is well studied (IEP 2008; Herbold and Moyle 1989) Effects of Delta hydrodynamics on organisms are not as well understood.	Reduced survival, reduced growth

Of equal importance to spatial structure in determining population viability is the presence of sufficient behavioral and genetic diversity within the population to allow it to be flexible and adapt to changing environmental conditions through utilization of a wide range of habitats. Some evidence indicates that the life history diversity of steelhead may be affected by CVP operations. For example, water releases from Shasta Dam have changed the thermal regime and the food web structure of the Sacramento River (Lieberman *et al*. 2001) such that a resident life history strategy may have fitness advantages over anadromous forms (Lindley *et al*. 2006). A similar situation likely applies to the Stanislaus River, which also has a hydrograph and thermal regime much different than what steelhead in that river evolved with. Little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the role that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on the Stanislaus River, which may favor residency, are detrimental to the anadromous population or not (Lindley *et al*. 2007). Zimmerman *et al*. (2008) demonstrated that resident rainbow trout can produce anadromous smolts and anadromous steelhead can produce resident rainbow trout in the Central Valley. However, the study indicated that the proportion of resident rainbow trout to anadromous steelhead in the Central Valley is largely in favor of the resident form with 740 of 964 *O. mykiss* examined being the progeny of resident rainbow trout. This proportional imbalance is even more prominent in the Stanislaus River where nearly 90 percent (139 out of 157) of *O. mykiss* sampled were offspring of resident adults (Zimmerman *et al*. 2008). In addition, the lack of specificity in how decisions will be made under real-time operations and by whom can have unpredictable effects on steelhead. The uncertain participation of Merced and Tuolumne River water operations in spring pulse flows in the future can affect the diversity and continued existence of the Stanislaus River population and of the Southern Sierra diversity group.

In addition to the negative effects on the spatial structure and life history diversity, the proposed action is expected to reduce the abundance of Stanislaus River steelhead. Mortality associated with the proposed action is expected through such sources as potential water temperature-related pre-spawn adult mortality, redd dewatering, egg suffocation from deposition of fines, and direct and indirect losses in the Delta.

The combined effects of the proposed action on the adult immigration, spawning, embryo incubation, juvenile rearing, and smolt emigration life stages of steelhead in the Stanislaus River, reduces the viability of the population and places the population, which was already at high risk of extinction due to extremely low abundance, at even greater risk. As previously described, Naiman and Turner (2000) demonstrated how even slight reductions in survival from one life stage to the next at each and every life stage can have serious consequences for the persistence of a populations. Considering that the proposed action reduces the survival of each and every steelhead life stage, including the life stage transition from smolt to adult-sized fish in the ocean, Stanislaus River steelhead may not persist with implementation of the proposed action.

Future projections over the duration of the proposed action (*i.e*., through 2030), considering both increasing water demands and climate change, exacerbate risks to Stanislaus River steelhead. For example, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007).

9.5.7 Assess Risk to the Central Valley Steelhead DPS

The proposed action is expected to expose individual steelhead from Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River to stressors that have fitness consequences for each inland life stage. Cumulatively, these fitness reductions throughout the inland steelhead life cycle, are expected to result in population level consequences for each of the four populations, reducing their viability. For Central Valley ESUs and DPSs, reductions in population viability are assumed to also reduce the viability of the diversity group the population belongs to as well as the species. Because the four diversity groups with extant steelhead populations are represented by these four populations[25], the viability of all four extant steelhead diversity groups is expected to be decreased with implementation of the proposed action. In consideration of the status and baseline stress regime of the species, these diversity group- and population-level consequences identified above greatly increase the extinction risk of the species. Given the evidence of the reduction in numbers, reproduction and/or distribution of the species, NMFS concludes that Reclamation has not ensured that the proposed action is not likely to appreciably reduce the likelihood of viability, and therefore the likelihood of both the survival and recovery of the CV steelhead DPS (table 9-12).

Table 9-12. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the CV steelhead DPS. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Not Likely/Likely to Jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River, Clear Creek, and Stanislaus River flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River, Clear Creek, the American River, and the Stanislaus River; (4) low late-summer flows in Clear Creek and in the American and Stanislaus rivers; and (5) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).*	True	End
		False	Go to B
B	**CV steelhead individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to delay ~17% of the steelhead adults that spawn upstream of RBDD and all of the progeny from those adults are faced with reduced rearing habitat quantity and quality resulting from the formation of Lake Red Bluff. (2) All freshwater life stages of*	True	NLAA

[25] Clear Creek belongs to the Northwestern California diversity group; the mainstem Sacramento River population belongs to the Basalt and Porous Lava diversity group; the American River belongs to the Northern Sierra Nevada diversity group; and the Stanislaus River belongs to the Southern Sierra Nevada diversity group.

	Sacramento River, Clear Creek, and Stanislaus River steelhead will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (3) Each year through 2030, steelhead in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River are expected to be exposed to water temperatures warmer than life stage-specific requirements during multiple life stages, including egg incubation and juvenile rearing. (4) Steelhead rear in their natal stream year-round for 1 to 2 years, and thus are expected to be exposed to low late-summer flows in Clear Creek and in the American and Stanislaus rivers. (5) As water is moved from the north Delta and from the San Joaquin River to the Federal and State export facilities, each year through 2030, CV steelhead juveniles will have increased exposure to an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and entrainment at the facilities.	False	Go to C
C	**CV steelhead individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Delayed upstream migration at RBDD causes individual adults to consume more energy, which limits the amount of energy available for reproduction, resulting in the deposition of fewer and/or less viable eggs. (2) Loss of natural river function resulting from flow regulation in the Sacramento River, Clear Creek, and the Stanislaus River has reduced the quality and quantity of rearing and migratory habitats, thereby reducing the growth and survival of individual steelhead juveniles in those systems. (3) Exposure to warm water temperatures in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River is expected to cause eggs deposited later (i.e., March) in the spawning season to suffer increased mortality and structural deformities during incubation, particularly during critically dry years. Thermal stress responses (e.g., reduced immune system function) are also expected to occur in individual juvenile steelhead rearing over the summer in Clear Creek and the American River. (4) Low late-summer flows limit the availability of quality rearing habitat, including predator refuge areas. Under these low flow conditions, juvenile steelhead have an increased susceptibility to predation and density dependent related factors (e.g., disease and competition for prey and habitat). (5) Mortality of juvenile steelhead migrating from the San Joaquin River to Chipps Island is expected to range from 90 to 99 %, with most of the mortality coming from project-related sources. Mortality of steelhead that enter the Delta interior from the Sacramento River is expected to range from 35 to 90 %, resulting in the loss of approximately 5-17 percent of the Sacramento River basin population of the Central Valley DPS.*	True	NLAA
		False	Go to D
D	**Any responses are not likely to constitute "take" or reduce the fitness of the CV steelhead individuals that have been exposed.** *Key Evidence: (1) The reduction in energy available for egg production associated with delayed upstream migration at RBDD reduces the fitness of individuals by reducing their reproductive capacity. (2) "Take" of steelhead individuals in the form of reduced growth and survival is expected due to the loss of natural river function associated with flow regulation in the Sacramento River, Clear Creek, and the Stanislaus river. (3) and (4) As described in step C, "take" of steelhead individuals, in the form of mortality and sub-lethal effects, is expected with exposure to warm water temperatures particularly during the egg incubation and juvenile rearing life stages, and with exposure to low flows during juvenile rearing. (5) As described in step C, "take" of steelhead individuals, in the form of mortality, is expected in the Delta during juvenile rearing/smolt emigration.*	True	NLAA
		False	Go to E
E	**Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent.** *Key Evidence: The cumulative effects of RBDD operations, flow regulation, warm water temperatures, low flows, project-related impacts in the Delta, and other project-related stressors (see tables 9-8 through 9-11) are expected to sufficiently*	True	NLJ

	reduce the survival, growth, and/or reproductive success of steelhead individuals at multiple life stages every year through 2030 such that key population parameters (i.e. spatial structure, diversity, and abundance) are appreciably reduced for steelhead populations in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River. Reductions in these parameters are of sufficient magnitude for one to reasonably expect a reduction in the viability of each of the four populations.	False	Go to F
F	**Any reductions in the viability of the exposed populations are not likely to reduce the viability of CV steelhead the species.** *Key Evidence: Considering the greatly diminished status of the CV steelhead DPS, NMFS assumes that if a population-level effect on any of the populations within the DPS is expected from implementation of the proposed action, then a species-level effect will be expected as well. The proposed action is expected to reduce the viability of at least four steelhead populations. Therefore, the viability of the DPS is expected to be significantly reduced with implementation of the proposed action.*	True	NLJ
		False	LJ

9.6 Central Valley Steelhead Critical Habitat

Following much of the same logic introducing the integration and synthesis of the CV steelhead species analysis presented in section 9.5, the following discussion will not address effects to critical habitat for every extant population affected by the proposed action, but will focus on how critical habitat for steelhead in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River is expected to be affected by the proposed action. By focusing on these four areas, all steelhead critical habitat that is affected by the proposed action is evaluated.

9.6.1 Status of Central Valley Steelhead Critical Habitat

It is estimated that 80 percent of the historic spawning and rearing habitat for CV steelhead is above impassable dams as is the case for the Sacramento, Feather, Yuba, American, Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin rivers. All critical habitat for Central Valley steelhead occurs below impassable barriers. As such, steelhead critical habitat largely occurs in areas that historically functioned as either rearing or migratory habitats.

Critical habitat for CV steelhead is composed of PCEs that are essential for the conservation of the species including, but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Stressors to CV steelhead PCEs are similar to the stressors described for spring-run critical habitat and include water diversions and water management, dams and other structures, loss of floodplain connectivity, loss of natural riverine function, bank protection; dredging, sediment disposal, gravel mining, invasive aquatic organisms, and agricultural, urban, and industrial land use (McEwan 2001). In addition, unlike spring-run critical habitat which excludes much of the Delta, steelhead critical habitat includes the Delta – an ecosystem that has had dramatic habitat changes in recent years related to water quality, toxic algae blooms (*e.g.*, Microcystis), and invasive species (*e.g.*, the aquatic macrophyte *Egeria densa*). Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of CV steelhead critical habitat is degraded, and does not provide the conservation value necessary for the survival and recovery of the species.

9.6.2 Northwestern California Diversity Group

9.6.2.1 Steelhead Critical Habitat in Clear Creek

9.6.2.1.1 Status of Steelhead Critical Habitat in Clear Creek

Whiskeytown Dam at RM 18.1 is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential steelhead habitat. Prior to 2000, the McCormick-Saeltzer Dam presented a barrier to upstream migration for anadromous salmonids. Following removal of the Dam in 2000, access to approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam was restored. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Gravel injection projects are conducted to make up for this loss of spawning gravel recruitment, but limited spawning habitat availability is a problem in Clear Creek.

Currently the release schedule from Whiskeytown Dam calls for flows of 200 cfs from October 1 to June 1 and 150 cfs, or less, from July through September in order to maintain water temperatures below 60°F. Under dry and warm climate conditions, water temperatures above 60°F occur in Clear Creek. Lindley *et al*. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to steelhead, having limited area at higher elevations and being highly dependent on rainfall.

9.6.2.1.2 Project Effects on Steelhead Critical Habitat in Clear Creek

The proposed action adversely affects Clear Creek critical habitat for steelhead in a few ways. The proposed action produces stressors to steelhead critical habitat in Clear Creek that primarily affect rearing habitat. Flow regulation impairs natural river processes and decreases habitat complexity and variability, which limits the quality and quantity of rearing habitat. Additionally, low flows and warm water temperatures during the summer limit the availability of quality rearing habitat.

9.6.2.1.3 Assess Risk to Steelhead Critical Habitat in Clear Creek

At least six factors, when considered together, suggest that implementation of the proposed action is expected to place critical habitat for Clear Creek steelhead at considerable risk. First, the habitat within Clear Creek is believed to be of marginal suitability for steelhead (Lindley *et al*. 2004). Second, rearing and migratory habitats within the Sacramento River are believed to be substantially degraded and generally would be considered as not properly functioning (NMFS 1996b). Third, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Fourth, estuarine habitats have been substantially degraded (*e.g*., Sommer *et al*. 2007) and climate change is expected to further alter estuarine habitats through sea level rise and hydrological changes. Fifth, under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will decrease the conservation value of these habitats (table 9-8).

9.6.3 Basalt and Porous Lava Diversity Group

9.6.3.1 Steelhead Critical Habitat in the Mainstem Sacramento River

9.6.3.1.1 Status of Steelhead Critical Habitat in the Mainstem Sacramento River

Within the range of CV steelhead, biological features of the designated critical habitat that are considered vital for steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. As generally described above in section 9.6.1, the status of critical habitat in each of these biological features is considered to be degraded. Freshwater rearing and migration habitats have been degraded by RBDD operations which delay upstream migration, reduce the availability of quality rearing habitat through the related seasonal creation of Lake Red Bluff, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional adverse effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use. The status of estuarine habitats for steelhead also is considered to be highly degraded as is evident by the collapse of pelagic organisms in the Delta (Sommer *et al*. 2007, IEP 2008). It is not immediately clear how the changes in the Delta ecosystem affect steelhead, but it is certain that substantial changes to steelhead estuarine habitat are occurring.

9.6.3.1.2 Project Effects on Steelhead Critical Habitat in the Mainstem Sacramento River

The proposed action negatively affects critical habitat for steelhead from the mainstem Sacramento River in several ways. As shown in table 9-9 above, the proposed action produces stressors to rearing (RBDD, Lake Red Bluff), migratory (RBDD), and estuarine (entrainment of juveniles into central and south Delta) habitats for mainstem Sacramento River steelhead.

9.6.3.1.3 Assess Risk to Steelhead Critical Habitat in the Mainstem Sacramento River

At least five factors, when considered together, suggest that implementation of the proposed action is expected to place critical habitat for mainstem Sacramento River steelhead at considerable risk. First, spawning, rearing, and migratory habitats within the mainstem Sacramento River are believed to be substantially degraded and generally would be considered as not properly functioning (NMFS 1996b). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Third, estuarine habitats also have been substantially degraded (*e.g*., Sommer *et al*. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes. Fourth, under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially creating or exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will further compromise the conservation value of rearing, migratory, and estuarine habitats (see table 9-9).

9.6.4 Northern Sierra Nevada Diversity Group

9.6.4.1 Steelhead Critical Habitat in the American River

9.6.4.1.1 Status of Steelhead Critical Habitat in the American River

The PCEs of critical habitat for lower American River steelhead include freshwater spawning, freshwater rearing, freshwater migration, and estuarine habitats. There is a general consensus in the available literature suggesting that habitat for steelhead in the American River is impaired (CVP/SWP operations BA; Water Forum 2005a,b; SWRI 2001; McEwan and Nelson 1991; CDFG 2001). Of particular concern are warm water temperatures during embryo incubation, rearing, and migration, flow fluctuations during embryo incubation and rearing, and limited flow-dependent habitat availability during rearing. All of these concerns are related to water management operations of the CVP.

In addition, the status of estuarine habitats for steelhead also is considered to be highly degraded as is evident by the collapse of pelagic organisms in the Delta (Sommer *et al*. 2007, IEP 2008). It is not immediately clear how the changes in the Delta ecosystem affect steelhead, but it is certain that substantial changes to steelhead estuarine habitat are occurring.

9.6.4.1.2 Project Effects on Steelhead Critical Habitat in the American River

Steelhead spawning (embryo incubation) and rearing PCEs in the American River are expected to be negatively affected by flow and water temperature conditions associated with the proposed action. For example, steelhead spawning, egg incubation, and rearing habitat in the lower American River is adversely affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation. Additionally, steelhead egg incubation, juvenile rearing, and migratory habitat quality is expected to be reduced by the occurrence of warm water temperatures.

9.6.4.1.3 Assess Risk to Steelhead Critical Habitat in the American River

At least five factors, when considered together, suggest that implementation of the proposed action is expected to place critical habitat for American River steelhead at considerable risk. First, spawning, rearing, and migratory habitats within the American River are believed to be substantially degraded and generally would be considered as not properly functioning (NMFS 1996b). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Third, estuarine habitats also have been substantially degraded (*e.g*., Sommer *et al*. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes. Fourth, annual water demands by 2030 are expected to be about three to four times higher than current levels. This increased water demand is expected to result in considerable challenges to flow and water temperature management for American River aquatic resources below Nimbus Dam, and will likely exacerbate the adverse habitat conditions already occurring in the river under present day water demands. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will further compromise the conservation value of spawning (*i.e*., embryo incubation), rearing, migratory, and estuarine habitats (see table 9-10).

9.6.5 Southern Sierra Nevada Diversity Group

9.6.5.1 Steelhead Critical Habitat in the Stanislaus River

9.6.5.1.1 Status of Steelhead Critical Habitat in the Stanislaus River

Steelhead critical habitat on the Stanislaus River has been designated up to Goodwin Dam. The PCEs of critical habitat for Stanislaus River steelhead include freshwater spawning, freshwater rearing, freshwater migration, and estuarine habitats. Although Stanislaus River water temperatures are generally suitable for spawning and rearing, during the smolt emigration life stage (January through June), steelhead are exposed to water temperatures that would prohibit successfully completing transformation to the smolt stage. In addition, steelhead spawning and rearing habitat on the Stanislaus River is affected by the limited occurrence of flows that are sufficient to carry out natural geomorphic processes. As such, sediment deposition on spawning habitats has decreased the availability of suitable spawning areas. Without strategic releases for geomorphic processes to manage fine sediment deposition in spawning gravels, spawning beds will be increasingly choked with sediment and unsuitable for spawning. The relatively low and uniform releases in the Stanislaus River adversely affect rearing habitat by reducing habitat complexity and decreasing connectivity with flood plains, areas proven to be high quality rearing habitats (Sommer *et al*. 2005). In addition, the status of estuarine habitats for steelhead also is considered to be highly degraded as is evident by the collapse of the pelagic community in the Delta. This collapse is, in part, related to dramatic habitat changes in recent years related to water quality, toxic algae blooms (*e.g*., Microcystis), and invasive species (*e.g*., the aquatic macrophyte *Egeria densa*). It is not immediately clear how the changes in the Delta ecosystem affect steelhead, but it is certain that substantial alterations to steelhead estuarine habitat are occurring.

9.6.5.1.2 Project Effects on Steelhead Critical Habitat in the Stanislaus River

Aside from the effect to estuarine habitats, the factors affecting the current status of critical habitat for Stanislaus River steelhead are all related to operations of the East Side Division of the CVP. Because the proposed action is the continued operation of the East Side Division in a manner that is presumably[26] generally consistent with past operations, it is expected that the proposed action will continue to compromise the conservation value of the spawning, freshwater rearing, and freshwater migration corridors PCEs of critical habitat within the Stanislaus River. In addition, Delta division operations are expected to compromise estuarine habitat for steelhead by effects to outflow and water quality.

[26] Many details of East Side Division operations were not clearly described in the project description.

9.6.5.1.3 Assess Risk to Steelhead Critical Habitat in the Stanislaus River

At least five factors, when considered together, suggest that implementation of the proposed action is expected to place critical habitat for Stanislaus River steelhead at considerable risk. First, spawning, rearing, and migratory habitats within the Stanislaus River are believed to be degraded and generally would be considered as not properly functioning (NMFS 1996b). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007). Third, estuarine habitats also have been substantially degraded (*e.g*., Sommer *et al*. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes. Fourth, under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially creating or exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats for steelhead from the Stanislaus River. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will further compromise the conservation value of spawning, rearing, migratory, and estuarine habitats (see table 9-11).

9.6.6 Assess Risk to Central Valley Steelhead Critical Habitat

At least five factors, when considered concurrently, suggest that implementation of the proposed action is expected to place CV steelhead critical habitat at considerable risk. First, the status of steelhead critical habitat is one characterized by severe degradation including factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use. In general, much of the spawning, rearing, migratory, and estuarine habitat for steelhead would be considered as not properly functioning (NMFS 1996b). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, overall drier conditions (Lindley *et al*. 2007), and altered estuarine habitats through changes in hydrology and sea level rise. Third, under current practices, human population growth will place an increasing demand for limited water supplies, potentially exacerbating adverse effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the proposed action is expected to produce stressors every year for the next 21 years that will further compromise the conservation value of steelhead spawning and rearing habitats in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River, and further compromise the conservation value of migratory and estuarine habitats for all extant steelhead populations.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to reduce the conservation value of the critical habitat, as designated, for the conservation of CV steelhead (table 9-13).

Table 9-13. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Central Valley Steelhead Designated Critical Habitat. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Adverse Modification of Critical Habitat (AD MOD).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, and creating favorable conditions for predators); (2) Sacramento River, Clear Creek, and Stanislaus River flow regulation disrupting natural river function and morphology; (3) warm water temperatures in the mainstem Sacramento River, Clear Creek, the American River, and the Stanislaus River; (4) low late-summer flows in Clear Creek and in the American and Stanislaus rivers; (5) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants) and (5) construction of the South Delta Permanent Gates.*	True	End
		False	Go to B
B	**Areas of designated critical habitat for CV steelhead are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to delay ~17% of the steelhead adults that spawn upstream of RBDD and all of the progeny from those adults are faced with reduced rearing habitat quantity and quality resulting from the formation of Lake Red Bluff. (2) Holding, spawning, rearing, and migratory habitats in the Sacramento River, Clear Creek, and the Stanislaus River will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (3) Each year through 2030, multiple habitat types including those supporting egg incubation and juvenile rearing in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River are expected to be exposed to water temperatures warmer than life stage-specific requirements. (4) Each year through 2030, rearing habitats in Clear Creek and in the American and Stanislaus rivers will be exposed to low flows particularly during the late-summer. (5) As water is moved from the north Delta and from the San Joaquin River to the Federal and State export facilities, each year through 2030, a large portion of emigrating steelhead will be entrained in low quality habitats characterized by an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and increased risk of direct entrainment at the facilities. (5) Constructio of South Delta Permanent Gates will alter approximately 25 miles of waterways resulting in additional predator structure, altered hydrodynamics, and impacted migratory corridors for CV steelhead originating in the San Joaquin River basin.*	True	NLAA
		False	Go to C
C	**The quantity, quality, or availability of all constituent elements of CV steelhead critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action.** *Key Evidence: (1) Each year through 2019, RBDD operations will reduce the quality of migratory habitat for steelhead adult immigration, as well as the quality and quantity of juvenile rearing habitat through the formation of Lake Red Bluff. (2) Loss of natural river function resulting from flow regulation has reduced the*	True	NLAA

	quality and quantity of rearing and migratory habitats in the Sacramento River, Clear Creek, and the Stanislaus River. (2) Each year through 2030, the provision of water temperatures warmer than life stage-specific requirements will reduce the quantity and quality of steelhead egg incubation habitats in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River; the quality of rearing habitats in Clear Creek and the American River also will be reduced. (3) Low late-summer flows limit the availability of quality rearing habitat, including predator refuge areas. (4) Each year through 2030, the quality of rearing and migratory habitats is reduced by entraining juvenile steelhead into low quality habitats in the central and south Delta. (5) Construction of South Delta Permanent Gates will increase structure for predators and diminish migratory corridor value of the South Delta waterways to CV steelhead originating in the San Joaquin River basin.	False	Go to D
D	**Any reductions in the quantity, quality, or availability of one or more constituent elements of CV steelhead critical habitat are not likely to reduce the conservation value of the exposed area.** *Key Evidence: Reductions in the conservation value of migratory, egg incubation, and rearing habitats are expected due to reductions in the quantity, quality, or availability of critical habitat constituent elements resulting from (1) RBDD operations; (2) flow regulation in the Sacramento River, Clear Creek, and Stanislaus River; (3) the provision of water temperatures warmer than life stage-specific requirements in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River; (4) low late-summer flows in Clear Creek, and the American and Stanislaus rivers; (5) the movement of water towards the Federal and State pumping plants; and (6) Construction of South Delta Permanent Gates creates impediments to migration and increased predator habitat.*	True	-
		False	Go to E
E	**Any reductions in the conservation value of the exposed area of CV steelhead critical habitat are not likely to reduce the conservation value of the critical habitat designation.** *Key Evidence: Because the conservation value of all inland habitat types (migratory, spawning/egg incubation, and rearing) necessary to complete the steelhead life cycle are expected to be reduced with implementation of the proposed Action, it is likely that the conservation value of the critical habitat designation will also be reduced.*	True	No AD MOD
		False	AD MOD

9.7 Southern DPS of North American Green Sturgeon

9.7.1 Status of Southern DPS of Green Sturgeon

Information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has recently emerged. Lindley (2006) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River. This information also agrees with the results of green sturgeon tagging studies completed by CDFG in which a total of 233 green sturgeon were tagged in the San Pablo Bay estuary between 1954 and 2001 (CDFG 2002), and tagged fish were recovered in the Sacramento-San Joaquin Estuary, in the Pacific Ocean off of California, from commercial fisheries off of the Oregon and Washington coasts, and in the Columbia River estuary (CDFG 2002).

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004). Currently, upstream migrations of sturgeon are permanently blocked by Keswick and Shasta Dams on the mainstem of the Sacramento River. Although no historical accounts exist for identified green sturgeon spawning occuring above the current dam sites, suitable spawning habitat existed based on habitat assessments done for Chinook salmon, and the geographic extent of spawning has been reduced due to the impassable barriers constructed on the river. Seasonal operations of the RBDD have blocked various proportions of the adult spawning population from the river segments upstream of the RBDD location. The initial operations of the RBDD with gates in all year long precluded any spawning above the dams location for green sturgeon. Subsequent modifications in the RBDD gate closures have allowed greater fractions of the population to ascend the Sacramento River and utilize the spawning habitat in the upper 53 mile between the RBDD and the ACID Dam. Today, with gates in from May 15 to September 15, approximately half of the adult spawning run of green sturgeon can move upriver to spawn prior to the closure of the gates.

Green sturgeon spawning on the Feather River (part of the Southern DPS) is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate to upstream spawning areas now blocked by the dam which was constructed in 1968.

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the european settlement of the region. During the latter half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). In the past two years, captures of juvenile and larval green sturgeon have been very low at the monitoring sites at RBDD and GCID, indicating poor spawning success in those years. Information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon entrained per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the proportion of the Southern DPS of green sturgeon in the catch is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006) indicates a maximum spawning population of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71). Based on the length and estimated age of post-larvae captured at RBDD (approximately 2 weeks of age) and GCID (downstream; approximately 3 weeks of age), it appears the majority of Southern DPS of green sturgeon are spawning above RBDD. Note, there are many assumptions with this interpretation (*i.e.*, equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

Since green stugeon are iteroparous, each adult is capable of making several spawning runs during its lifestime. Individual year class failures may occur, but do not necessarily indicate an eminent decline in the viability of the DPS. Sustained year class failures over multiple years however are cause for concern. In addtion, rapid declines in the abundance of any one of the life history stages would also indicate potential population declines, particularly in the sub-adult or adult life stages. Population modeling by Heppell (2007) indicates that there is a high sensitivity to population growth rate to changes in the survival rate of sub-adult and adult fish. Significant increases in the survival of YOY green sturgeon or annual egg production is required to compensate for even low levels of mortality in the sub-adult or adult life stages (*i.e.*, mortalities associated with RBDD gate operations), since a single female produces between 60,000 and 140,000 eggs (Moyle *et al*. 1992, Moyle 2002), and therefore, contributes significantly to the population. In response to these vulnerabilities, sportfishing for green sturgeon has been eliminated in the west coast waters of the United States where members of the Southern DPS would be vulnerable to harvest. However, hooking mortality of green stugeon incidently caught while fishing for other species (*i.e.*, white stugeon) still remains and significant numbers of green sturgeon remain vulnerable to sportfishing in the Delta and Sacramento River regions. Even low levels of hooking mortality can be detrimental to a long-lived species such as green sturgeon. Long-lived species like sturgeon can experience several encounters with sportfisherman, and each encounter carries a risk of mortal injury from the hooking experience. As the number of encounters increases, the risk of a fatal encounter increases. Southern DPS of green sturgeon become vulnerable to sportfishing when in the Sacramento River and the San Francisco Bay estuary during spawning migrations as well as during summer "congregations" in estuaries along the west coast of the United States. This vulnerability is somewhat mitigated by the dominant marine orientation of these fish which, distances them from sportfishing exposure for most of their life history. Another factor that influences green sturgeon adult and sub-adult life stages is the bycatch of green sturgeon during the commercial white sturgeon fisheries activities in the northwest. During commercial fishing activities, some green sturgeon are retained as bycatch. This represents a source of mortality to the Southern DPS of green sturgeon due to the high percentage of Southern DPS of green sturgeon in the Columbia River estuary population.

Southern DPS of green sturgeon remain vulnerable to extirpation due to the one extant population in the Sacramento River and the limited region in which they can potentially spawn in the river. No identified spawning activities, let alone separate independent populations, have been identified in the large tributaries to the Sacramento River to date and thus the one spawning population is vulnerable to catastrophes in the spawning reach surrounding the RBDD (*i.e.*, contaminant spills, increasing water temperatures, flow alterations, *etc*.). To further complicate the determination of the status of the Southern DPS of green sturgeon, no empirical estimates of abundance or recruitment exist for this population.

NMFS concludes that the Southern DPS of North American green sturgeon remains vulnerable to becoming endangered in the future. Key factors upon which this conclusion is based include: (1) the DPS is comprised of only one spawning population, which has been blocked from a considerable portion of its potenital spawning range by dams; (2) the DPS has a risk associated with catastrophies and environmental perturbations (*i.e.*, water temperatures from Shasta Dam) affecting current spawning areas; (3) mortality rates have significant effects on the adult and sub-adult life history phases of this long-lived species. There are both advantages and disadvantages to being long lived. Longevity enables the species to engage in multiple spawning behaviors over a long period of time, thus increasing the probability that at least one brood year will be successful to carry on the population, among many less successful brood years. However, long-lived species tend to be slower in reaching maturity (12 to 20+ years for green sturgeon) and fish may be lost to the population before being able to spawn for the first time. In addition, long-lived species are at agreater risk of mortality due to exposure to fishing presure and contaminants.

9.7.2 Baseline Stress Regime on Southern DPS of Green Sturgeon Excluding CVP/SWP Effects

Adult green sturgeon in the Delta would likely experience sublethal effects through their exposure to a wide spectrum of contaminants, including originating in urban stormwater runoff (which contains petroleum products, heavy metals, and various organic solvents), agricultural derived runoff (*i.e.*, pesticides, herbicides, fertilizers, and animal wastes), and wastewater treatment plants (metals, pharmaceuticals, personal care products, organic compounds). The duration and level of exposure, as well as the toxicity of the contaminant, will determine the physiological response of the exposed organism. Sublethal effects include a diminishment of their reproductive capacity, and incremental increases in the contaminant burden in their body tissues. Reductions in productivity are possible due to the effects of contaminants on the different organ systems and metabolic pathways of the exposed organism, which may lead to reduced egg fertility or reduced viability and motility of spermatocytes during spawning. Furthermore, since sturgeon are long lived (60 to 70+ years) they may make repeated spawning migrations through the Delta and continually ingest contaminated forage prey or be exposed to contaminants in the water column that would add to their total body burdens during these spawning migrations.

Adult green sturgeon will be exposed to fishing pressure and may experience hooking mortalities due to incidental catches by fisherman targeting other species. Reductions in productivity may occur if gravid females abort their spawning runs following capture and returning downstream without spawning due to excessive stress from the capture and release process. The proportion of the population that will exhibit this behavior is unknown.

9.7.3 Summary of Proposed Action Effects on Southern DPS of Green Sturgeon

Delays in migration of adult green sturgeon due to the installation and operation of the SDIP phase 1 facilities are possible. Adult green sturgeon that are trapped behind the permanent gates could have a reduction in fitness, or eventual mortality of the exposed fish over the course of the irrigation season, if this impedance in movement is prolonged due to lower water quality and limitations in food resources.

Adult green sturgeon encounter major passage impediments due to the installation of dams in the upper Sacramento River. The ACID dam is installed in early April approximately 5 miles below Keswick Dam, effectively blocking utilization of this stretch of river by spawning green sturgeon. Those green sturgeon that pass through the location of the ACID dam prior to its closure in April, are trapped behind it until it is removed in October. The percentage of the green sturgeon spawning run that would be able to access the uppermost 5 miles of the Sacramento River below Keswick Dam is unknown precisely, but is estimated to represent at a maximum only 15 to 20 percent of the spawning run based on fish passage estimates at RBDD 53 miles downstream. It is highly likely that only a small proportion of those fish passing the location of the RBDD prior to April would move all the way up to the location of the ACID dam.

The RBDD is currently installed in the Sacramento River on May 15 and effectively blocks adult green sturgeon movement upstream of its location until it is removed in mid-September. This schedule also will be implemented during the near future operations as described in the CVP/SWP operations BA. Future operations (beginning in 2019) will modify gate closures to 10 days in May, open in June, and closed again during the months of July and August. RBDD blocks access to 53 miles of spawning and rearing habitat between the RBDD location and the ACID dam. Under current operations, an estimated 35 to 40 percent of the potential spawning population moving upstream on the Sacramento River may be blocked by the closure of the RBDD based on run timing. Fish that have successfully passed upstream of the dam before its closure are faced with injury or mortality when they move back downstream following their spawning activities. Such an occurrence was observed in 2007, following the reopening of the RBDD gates with only a 6-inch clearance below the gates, when approximately 10 to 12 adult green sturgeon were killed due to impingement or physical trauma related to the gates. Current and future gate closures will maintain a minimum of 12 inches of clearance below the gates to allow passage of adult sturgeon beneath the gates without impingement. Closure of the RBDD gates also forces green sturgeon to hold below the dam. These fish may not spawn at all before moving back downstream to the Delta and ocean, or are forced to spawn in areas downstream of the RBDD. Spawning activity has recently been confirmed near the confluence of Antelope Creek with the Sacramento River based on observations of spawning behavior and recovery of eggs downstream of the site. However, relative success of these downstream spawning events compared to the success of spawning events occurring upstream of RBDD are unknown. Conditions may be less favorable downstream of the RBDD location for spawning, however ambient water temperature appears to be generally satisfactory (≤17ºC or 62ºF) in the Sacramento River downstream to Hamilton City during the critical egg fertilization and incubation period following spawning activities. Water temperatures in excess of 17ºC (62ºF) cause substantial increases in egg mortality or deformities in the hatching embryos if they survive to hatching. The suitability of spawning areas below the location of the RBDD may be further restricted in the future due to increased water temperatures resulting from climate warming as modeled under the different climate change scenarios. NMFS anticipates that the closures of the ACID dam and the RBDD will increase the loss of individual fish and reduce the abundance of adult fish in the green sturgeon population.

Additional potential adult migration barriers to green sturgeon on the Sacramento River include the Sacramento Deep Water Ship Channel Locks, Freemont Weir, Sutter bypass, and the DCC gates. Table 9-14 provides a summary of of proposed action-related effects on the Southern DPS of green sturgeon.

9.7.4 Assess Risk to the Population

Events such as the 2007 loss of fish from the gate closures potentially impact a large segment of the spawning adult population that may take years to replace (*i.e*., large mature females with correspondingly large egg production and spawning success). Blocking access to upstream spawning areas will likely decrease the productivity and spatial structure of the green sturgeon population. Fish forced to spawn below RBDD are believed to have a lower rate of spawning success compared to those fish that spawn above the RBDD. Furthermore, reductions in genetic diversity may occur due to the separation of upstream and downstream populations created anthropogenically by the closure of the RBDD on May 15. The dam closure artificially prevents the interchange of genetic material between early arriving fish that move above the dam prior to closure and those blocked by the dam after May 15. It is unknown whether early migratory behavior is genetically controlled or is a result of random events in the life history of the fish as it migrates from the ocean to the spawning grounds and whether this characteristic is expressed each time the individual fish makes a spawning run during its lifetime. In addition, the population level effects will take several years to manifest themselves due to the longevity of the species. Failure to spawn successfully in one particular year can be mitigated for in a following spawning cycle, giving rise to strong year classes and weaker year classes. The trend over several generations will dictate the trajectory of the population viability over time.

Table 9-14. Summary of proposed action-related effects on green sturgeon.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
1	Adult Immigration Delta	Feb. – Sep. (peak in Apr.)	DCC gate closures & Suisun Marsh Salinity Control gates	Sturgeon adults could encounter gates closed from March to May and may be delayed in the Delta resulting in greater exposure to both the in-river sport fishery and contaminants (reduced egg fertility or reduced viability and motility of spermatocytes during spawning).	Low	Low - based on limited supporting data	Unknown
2	Adult Immigration Delta	Feb. – Sep. (peak in Apr.)	Low flows during March - June	Adults need large spring flows to trigger movement upstream to spawn, low flows may delay migration enough that they encounter RBDD closed gates and are forced to spawn downstream in less suitable habitat	Medium	Low – based on new data from acoustic tagging studies	Reduced survival and reduced reproductive success
3	Adult Immigration & emigration RBDD	Mar. - Dec.	RBDD gate closures from May 15 - Sept 15 (every year until 2019).	Passage blocked, 55 miles of spawning habitat made inaccessible upstream of RBDD after May 15. Large aggregations (25-30) of spawning adults observed below RBDD gates. Estimate 35% of run blocked based on run timing. Also, mortalities associated with downstream passage under gates post-spawn, or after fish move above gates. Mortality greater on larger, more fecund females that can not fit through 18" opening.	High	High - based on run timing and recent tagging studies.	Reduced survival and reduced reproductive success.
4	Adult Immigration RBDD	Apr. – May 15.	Emergency 10 day gate closures prior to May 15	Greater proportion of run blocked or delayed (40 -50%) based on run timing; Greater mortalities associated with downstream passage under gates post spawn, or after moving above gates, sub lethal effects on eggs in fish and energy loss. Occurred twice in the past 10 years, but the frequency of occurrence may increase with climate change.	High	High - based on TCCA EIS/EIR on RBDD and CVP/SWP operations BA	Reduced survival and reduced reproductive success. (note: 12 adults were observed killed by gates in 2006)
5	Adult Immigration ACID	Apr. – May 15.	ACID gate closure April to November	Passage blocked to 5 miles of spawning habitat below Keswick Dam.	Unknown	Low – based on unknown use of this area and how much spawning area is needed.	Reduced habitat and reduced spawning success.

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
6	Adult Holding	Jun. – Dec.	Water temperature and low flows	Some adults may hold for up to 9 months in the upper Sacramento River post-spawn waiting for an increase in flows to move downstream. Water temperatures in September and October may stress individuals after the cold water pool is depleted. Dam controlled releases reduce the first pulse flow in the fall that may trigger adults to move out, so they stay longer in upstream areas. Delayed emigration, reduced fitness, longer periods between spawning runs.	Unknown	Low – no studies to support	Reduced probability of repeat spawning
7	Spawning	Apr. – Jul.	RBDD	Unnatural spawning site created below RBDD, portion of run (only one in CV) spawning in water 2 feet deep, channel aggradation below hydraulics from gates, eggs suffocate, physiological effects, delayed hatch, greater predation on eggs due to accumulation of predators below RBDD.	High	High – based on one year's data on egg and larval spawning habitat (FWS 2009), visual observations, & underwater photography	Reduced reproductive success
8	Spawning	Apr. – Jul.	Blocked access to individuals above RBDD	Spawners that migrate upstream after the RBDD gates go in are prevented from spawning with the portion of the run already above RBDD. Reduced genetic variability, may reduce fecundity, or size of fish if smaller adults arrive first.	Unknown	Low, based on theory	Reduced survival and reduced reproductive success
9	Embryo Incubation	Apr. – Aug.	Water temperatures warmer than life history stage requirements below Hamilton City.	For eggs and fry that are spawned in areas from RBDD to Hamilton water quality is less suitable than above RBDD where temperatures are controlled for winter-run Chinook. Eggs suffocate from less flow, physiological effects, delayed hatch, greater predation on eggs due to presence of non-native introduced warm-water species.	Medium	Low – spawning distribution based on only one year of data.	Reduced egg survival and reduced reproductive success

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
10	Juvenile rearing to Hamilton City	Jun. – Nov.	Water temperatures warmer than life history stage requirements.	Juveniles move downstream immediately after hatching and encounter sub-optimum temperatures below Hamilton City due to truncated spawning distribution. May reduce growth, feeding, delay emigration, and increase predation from warm water species.	Unknown	Low – no studies to support this.	Reduced survival
11	Juvenile rearing Upstream of and including RBDD	Jun. – Nov.	Lake Red Bluff, river impounded May15 - Sept 15	Reduction in rearing habitat quality and quantity; increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967.	High	High - based on number of river miles affected by the formation of Lake Red Bluff	Reduced survival and reduced growth
12	Juvenile rearing Upstream of and including RBDD	Jun. – Nov.	RBDD passage downstream through dam gates May15 - Sept 15	Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 100 % of the green sturgeon DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008). Approximately 70 % of the entire green sturgeon DPS spawns above RBDD. Mortality of juvenile salmon emigrating past RBDD when the gates are in ranges from 5 -50 % (Vogel *et al*. 1988; Tucker 1998); mortality of juvenile green sturgeon emigrating past RBDD has not been estimated, but is expected to increase when the gates are in.	High	High - based on knowledge of predator congregations forming below RBDD when the gates are in (Vogel *et al*. 1988; Tucker 1998) and timing of sturgeon emigration (TCCA 2008).	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
13	Juvenile rearing RBDD to Colusa	Jul. - Nov.	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in fall), modifies critical habitat, including impaired geomorphic process	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	High - based on CALFED funded Ecological Flow Tool model (Sac EFT)	Reduced survival and reduced growth
14	Juvenile rearing	Jul. – Nov.	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	High based on the abundance of unscreened diversions and on Mefford and Sutphin (2009)	Reduced survival
15	Juveniles Colusa to Sacramento and enter Delta	Jun. – Nov.	Low fall flows	Emigration delayed, higher predation; fewer juveniles survive to the Delta	Unknown	Low – no studies to support this.	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
16	Juvenile and subadult Clifton Court Forebay	July and August	Contaminant exposure	Application of copper based herbicides for control of aquatic nuisance weeds and algae in Clifton court Forebay. Copper is a toxicant that affects among other things, olfactory response, animal behavior, and cellular membrane functions at low concentrations. Expected treatment concentrations of dissolved copper, as formulated in the herbicide, exceed lethal levels for salmonids. Presence of green sturgeon during July and August is confirmed by the salvage records of the CVP and SWP facilities	Unkown - Percentage of juvenile Southern DPS population within CCF is unknown during treatment period	High Copper is a known toxicant to sturgeon based on studies with other sturgeon species. Sensitivities are similar to salmonids based on previous studies. Exposure studies of copper herbicide Komeen have indicated potential adverse effects on exposed salmonids	Reduced survival, reduced growth, impaired olfactory response. Alterations to cellular membrane functions.
17	Juvenile and subadult Delta	Year round	Loss at export facilitiest	Entrainment of fish at the CVP and SWP in every month of the year. Louvers function well for larger fish but are inefficient for smaller fish. Fish behavior may make them susceptible to the cleaning practices of louvers. In louver studies, fish position themselves in front of the bottom edge of the louver along the channel bottom, where they held position for prolonged periods of time.	Unknown Percentage of juvenile and subadult population entrained is unknown due to lack of information on the abundance of these life stages.	Medium Studies with other species of sturgeon have assessed louver efficiency. No studies with green sturgeon	Reduced survival

#	Life Stage/ Location	Life Stage Timing	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect (High, Medium, Low)	Weight of Evidence (High, Medium, Low)	Probable Fitness Reduction
18	Juvenile and subadult Delta	Year round	Impaired movements through South Delta waterways due to temporary barriers or permanent gates	Presence of green sturgeon juveniles and subadults in the South Delta as confirmed by salvage records. Presence occurs during operational season of barriers (April through November). Closure of waterways by temporary barriers or permanent gates inhibits movement of green sturgeon through these waterways. Fish located upstream of barriers are potentially trapped or delayed in their movements downstream by structures.	Unknown The percentage of the population present in South Delta waterways is unknown. Movement patterns of green sturgeon in the Delta is unknown.	Low Lack of abundance data for juvenile and subadult green sturgeon limits assessment. Increased collection of green sturgeon movements within Delta waterways from acoustic tagging is in early phases, data is preliminary	Reduced survival, reduced growth

9.7.5 Assess Risk to the Southern DPS of Green Sturgeon

The proposed action is expected to have population level consequences for the single extant population in the mainstem Sacramento River. In consideration of the status and future baseline of the species, these population-level consequences greatly increase the extinction risk of the species. Given the evidence of the reduction in numbers, reproduction and/or distribution of the species, NMFS concludes that Reclamation has not ensured that the proposed action is not likely to appreciably reduce the likelihood of the viability, and therefore the likelihood of both the survival and recovery of the Southern DPS of North American green sturgeon (table 9-15).

Table 9-15. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the Southern DPS of North American Green Sturgeon. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Not Likely/Likely to Jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream, degrading rearing and migratory habitat through the formation of Lake Red Bluff, creating favorable conditions for predators below the RBBDD structure, and creating lethal conditions for passage under the lowered gates); (2) warm water temperatures in the mainstem Sacramento River below RBDD that exceed green sturgeon egg development criteria; (3) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants); and (4) impediments to free movement in the channels of the South Delta due to construction of the South Delta Permanent Gates.*	True	End
		False	Go to B
B	**Southern DPS of green sturgeon individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to block ~35 to 40 % Southern DPS green sturgeon adults migrating upstream; 100 percent of green sturgeon juveniles spawned above the RBDD would be exposed to greater predation and potential injury due to high turbulence when passing through the RBDD gates from May 15 to September15 while emigrating downstream; adult mortalities have recently been recorded due to "emergency gate operations;" (2) Each year through 2030, green sturgeon are expected to be exposed to water temperatures warmer than life stage requirements during spawning, and egg incubation; (3) As water is moved from the north Delta to the export facilities in the south Delta, each year through 2030, green sturgeon juveniles will have increased exposure to an abundant predator community, an aquatic environment degraded by pesticides and contaminants from domestic and agricultural sources, and direct entrainment at the Federal and State pumping plants; and (4) Operations of the Permanent Gates in the South Delta will impede or block free movement of green sturgeon within the affected channels of the South Delta.*	True	NLAA
		False	Go to C

C	**Southern DPS of green sturgeon individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action** *Key evidence. (1) Operation of the RBDD will block upstream migration of spawning green sturgeon adults, preventing them from accessing spawning habitat above the location of RBDD and separating the spawning population into two subgroups – an early migrating group and a late migrating group based on the gate closure timing. Juvenile green sturgeon are expected to fall prey to predators below the RBDD structure during downstream migrations, adult sturgeon will be vulnerable to impingement or injury by the lowered gates as has occurred in the past; (2) Water temperatures below RBDD become progressively warmer, limiting the success of egg development following spawning for those fish not ascending above the RBDD location. Water temperatures above approximately 17°C increase the rate of mortality or deformities in the developing embryos and larval sturgeon; (3) Operations of the export facilities draw fish into the South Delta and increase their vulnerability to export entrainment resulting in increased levels of death or injury; and (4) Operations of South Delta Permanent gates result in loss of free movement through the channels of the South Delta and increased exposure to water quality issues such as contaminants and high temperatures.*	True	NLAA
		False	Go to D
D	**Any responses are not likely to constitute "take" or reduce the fitness of the Southern DPS of green sturgeon individuals that have been exposed.** *Key evidence. (1) Separation of spawning adult population into two potential subgroups limits the free flow of genetic materials within the spawning population. Increased susceptibility of juveniles to predation or injury occurs during passage through the RBDD structure. Adults passing under the lowered gates are expected to have an increased risk of injury or mortality; (2) Reduced viability of eggs and increases in larval deformities due to elevated water temperatures reduces the overall success of the spawning events; (3) Loss of green sturgeon juveniles occurs through "take" of the fish at the export fish collection facilities, leading to death, injury, or loss to the system by passing through the louvers and into the diversion channels during operational activities such as cleaning; and (4) Operation of the Permanent Gates delays or hinders free movement of fish within the South Delta channels and increases the duration of their exposure to stressors such as contaminants from agricultural drain water discharges, wastewater discharges and .low dissolved oxygen.*	True	NLAA
		False	Go to E
E	**Any reductions in individual fitness are not likely to reduce the viability of the populations those Southern DPS of green sturgeon individuals represent.** *Key Evidence: The cumulative effects of RBDD operations, warm water temperatures (particularly below the RBDD site), project-related impacts in the Delta, and other project-related stressors (see table 9-2) are expected to sufficiently reduce the survival and/or reproductive success Southern DPS green sturgeon individuals at multiple life stages every year through 2030 such that key population parameters (i.e. spatial structure, diversity, and abundance) will be appreciably reduced (see section 9.1.4 Assess Risk to the Population). Reductions in these parameters over the next 21 years will likely reduce the viability of the population.*	True	NLJ
		False	Go to F
F	**Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species.** *Key evidence: The Southern DPS of green sturgeon is solely composed of the Sacramento River population. Therefore, because the viability of this population is expected to be reduced by stressors related to the proposed Action, the viability of the species also is expected to be reduced.*	True	NLJ
		False	LJ

9.8 Southern DPS of Green Sturgeon Proposed Critical Habitat

9.8.1 Status of Proposed Southern DPS of Green Sturgeon Critical Habitat

As described in section 4.2.3.4, proposed critical habitat for the Southern DPS of green sturgeon consists of several physical and biological features occurring in riverine, estuarine, and marine habitats that are essential for the conservation of the species. However, all of those physical and biological features can be characterized as suitable and necessary habitat features that provide for successful spawning, rearing, and migration. Therefore, we will be evaluating the effect of the proposed action in terms of its effect on spawning and rearing habitat and migratory corridors.

9.8.1.1 For Freshwater Riverine Systems

9.8.1.1.1 Water Quality

Currently, the installation and operation of the RBDD gates blocks access to 53 miles of upper river with suitable water quality conditions for green sturgeon spawning and rearing. Water temperature for spawning and egg incubation is near optimal (15ºC) from RBDD upriver during the spawning season. Below the RBDD, the water temperature begins to become warmer and exceeds the thermal tolerance level for egg incubation at Hamilton City. The spawning area left for green sturgeon between RBDD and Hamilton City after the gates are lowered has the thermal regime gradually increase from optimal (15ºC/ 59ºF) to sub optimal where egg hatching success decreases and malformations in embryos increase above 17 ºC/62 ºF.

9.8.1.1.2 Migratory Corridor

The installation of the RBDD impairs the function of the Sacramento River as a migratory corridor for both green sturgeon adults and larvae/juveniles. With the RBDD gates closed, the river no longer has unobstructed access to river habitat above the RBDD and changes the function of the river to such an extent that fish survival and viability are compromised. The closed gates block green sturgeon access to approximately 53 river miles above the dam for approximately 35 to 40 percent of the spawning population that arrive after May 15. The closed gates also decrease the conservation value of water flow by: (1) increasing the potential for predation on downstream emigrating larvae in the slow moving water upstream of the RBDD (Lake Red Bluff), (2) increasing predation below the location of the RBDD due to the turbulent boil created below the structure and the concentration of predators located, and (3) creating increased potential for adults to be injured which try to pass beneath the gates during the closed operations. The closed gate configuration also has the potential to alter the genetic diversity of the population by separating the population into upstream and downstream spawning groups based on run timing.

9.8.1.1.3 Water Depth

The installation of the RBDD blocks green sturgeon from known holding pools above the structure. Although known holding areas exist below the RBDD, such as the hole just above the GCID diversion, the RBDD decreases the number of deep holding pools the adult fish can access through its operation. This affect is a result of blockage of the migratory corridor.

9.8.1.2 For Estuarine Habitats

9.8.1.2.1 Migratory Corridor

The effects of combined exports present an entrainment issue that could delay migration or decrease survival or population viability through entrainment into the facilities itself. These effects increase in magnitude the closer to the export facilities the fish are located. Likewise, the installation of the barriers under the TBP enhance the potential to delay movement and migratory behavior in the channels of the South Delta. Juvenile and adult green sturgeon may be trapped behind the barriers after installation/ operation for varying periods of time. The rock barriers of the TBP present the greatest obstacle to movement during their installation and operation, but are removed from the channels each winter.

9.8.2 Project Effects on Proposed Critical Habitat for Southern DPS of Green Sturgeon

Project effects on proposed critical habitat are very similar to those described above in section 9.8.1, except that:

1. Reclamation proposes to reoperate RBDD in the future full build out scenario (beginning in 2019) so the RBDD gates would be in for approximately 2½ months each year rather than the current 4 months. Beginning in 2019, the conservation value of the migratory corridor PCE would improve, however, it will still be degraded, compared to a migratory corridor with unimpeded passage opportunities throughout the spawning migration season, and

2. The operation of the permanent barriers present differing levels of obstruction, depending on the usage of the inflatable barrier gates. When the gates are up, movement past the gates is precluded, and migrational movement is impeded (migratory corridor PCE). The value of the water quality and food resources PCEs would also be reduced.

9.8.3 Assess Risk to the Proposed Southern DPS of Green Sturgeon Critical Habitat

The value of the upstream migration corridor is currently degraded, mainly by the installation of the ACID Dam and RBDD. When the gates are down, RBDD precludes access to 53 miles of spawning habitat for 35-40 percent of the spawning population of green sturgeon. In the near term (through 2019), Reclamation proposes to continue to operate RBDD with gates in 4 months out of each year, thereby continuing to degrade the value of the migration corridor in two ways. First, RBDD has the potential to directly kill adult green sturgeon, thereby not meeting the essential feature of safe passage. Once the RBDD gates are down, it completely blocks upstream migration, thereby not meeting the essential feature of unobstructed passage. Although reoperation of RBDD in the future full build out scenario will improve/increase unobstructed passage for adults, they will still experience obstructed passage over half the time.

The conservation value of water quality (in terms of temperature) for successful spawning and egg incubation will likely be compromised downstream of RBDD, so that the progeny of green sturgeon that spawn downstream of RBDD will likely experience sublethal effects.

The effects of the proposed action under climate change scenarios would likely further degrade the water quality PCE. As climate change scenarios model water temperature increases by 1-3°F, cold water in Shasta Reservoir will run out sooner in the summer, especially for those green sturgeon that do not successfully migrate upstream before the RBDD gates down period.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to reduce the conservation value of the critical habitat, as designated, for the conservation of the Southern DPS of green sturgeon (table 9-16).

Table 9-16. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Southern DPS of Green Sturgeon Proposed Critical Habitat. Acronyms and Abbreviations in the Action Column Refer to Not Likely to Adversely Affect (NLAA) and Adverse Modification of Critical Habitat (AD MOD).

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	**The proposed action is not likely to produce stressors that have direct of indirect adverse consequences on the environment** *Key Evidence: Proposed action-related stressors adversely affecting the environment include: (1) RBDD operations (i.e., impeding fish passage upstream to spawning areas, degrading rearing and migratory habitat through the formation of Lake Red Bluff, creating favorable conditions for predators below the RBDD location, creating downstream passage impediments to adult green sturgeon); (2) warm water temperatures in the mainstem Sacramento River, particularly below the RBDD location,; (3) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants); and (4) migratory corridor and rearing habitat modification due to the South Delta Permanent Gates construction and operation.*	True	End
		False	Go to B
B	**Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action** *Key Evidence: (1) Each year through 2019, RBDD operations are expected to diminish the availability of spawning areas by blocking ~35 to 40 % of the Southern DPS of green sturgeon adults migrating upstream and accessing the spawning areas above RBDD; altering the hydraulics of the river for approximately 6 miles upstream of RBDD by the creation of Lake Red Bluff affecting flow and potentially diminish the quality of substrate for spawning in this reach due to sedimentation, increase the risk for 100 percent of green sturgeon juveniles spawned above the*	True	NLAA

	RBDD passing downstream in their migratory corridor through the RBDD gates from May 15 to September15 due to elevated predator densities and extreme turbulence associated with the reach immediately below the RBDD structure; Degrades the quality of emigration corridors for adult green sturgeon that must pass under the closed RBDD gates exposing these fish to potential injury or death; (2) Each year through 2030, diminish the functionality of spawning areas, particularly those that may occur downstream of the RBDD location, by increasing water temperatures above physiological limits for developing eggs; (3) Each year through 2030, migratory corridors in the Sacramento-San Joaquin Delta will be affected year round by the conveyance of water by the export facilities through the waterways of the Delta. Redirection and delay of fish movement and entrainment of fish by the export facilities are anticipated; (4) migratory corridors and water quality in the South Delta will be affected by the operations of the South Delta Permanent Gates following their construction.	False	Go to C
C	**The quantity, quality, or availability of all constituent elements of critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action** *Key Evidence: (1) Each year through 2019, RBDD operations will reduce the quantity and quality of spawning habitat for adult Southern DPS green sturgeon by blocking access to Sacramento River reaches above RBDD from May 15 to September 15. The quality of the migration corridor for downstream emigration of adult green sturgeon spawning above the RBDD is diminished by the closure of the RBDD. The quality of the migration corridor for juvenile green sturgeon is negatively affected by the operation of the RBDD. The quantity and quality of water quality and flow which influences rearing habitat is diminished by the formation of Lake Red Bluff behind the closed RBDD; (2) Each year through 2030, water temperatures warmer than life stage-specific requirements will reduce the quantity and quality of habitat necessary for Southern DPS green sturgeon spawning and egg incubation; (3) Each year through 2030, the quality of migratory corridor habitats is reduced by entraining juvenile green sturgeon into the South Delta under the influence of export actions; and (4) Each year following the construction of the Permanent Operable Gates in the South Delta, gate operations will impede free movement of green sturgeon in the channels of the South Delta affected by the gates.*	True	NLAA
		False	Go to D
D	**Any reductions in the quantity, quality, or availability of one or more constituent elements of critical habitat are not likely to reduce the conservation value of the exposed area** *Key Evidence: Reductions in the conservation value of migratory, spawning, and rearing habitats for Southern DPS of green sturgeon are expected due to reductions in the quantity, quality, or availability of critical habitat constituent elements resulting from RBDD operations, the provision of water temperatures in the Sacramento River warmer than life stage-specific requirements for Southern DPS of green sturgeon, and the movement of water towards the Federal and State pumping plants.*	True	-
		False	Go to E
E	**Any reductions in the conservation value of the exposed area of critical habitat are not likely to reduce the conservation value of the critical habitat designation** *Key Evidence: Because the conservation value of several of the inland habitat types (migratory corridor ,water quality suitable for spawning and rearing and water flow) necessary to complete the green sturgeon life cycle are expected to be reduced with implementation of the proposed Action, it is likely that the conservation value of the critical habitat designation will also be reduced.*	True	No AD MOD
		False	AD MOD

9.9 Southern Resident Killer Whales

This section discusses the effects of the action in the context of the status of the species, the environmental baseline, and cumulative effects, and offers our opinion as to whether the effects of the proposed action are likely to jeopardize the continued existence of the Southern Residents.

The Southern Resident killer whale DPS has fewer than 90 members and a variable productivity rate. In NMFS' opinion, the loss of a single individual, or the decrease in reproductive capacity of a single individual, is likely to reduce the likelihood of survival and recovery of the DPS. Thus the section 7 analysis must scrutinize even small effects on the fitness of individuals that increase the risk of mortality or decrease the chances of successful reproduction.

A reduction in prey or a requirement of increased foraging efficiency may have physiological effects on Southern Residents. In response to fewer or less dense prey patches, Southern Residents would need to expend additional energy to locate and capture available prey. Increased energy expenditure or insufficient prey may result in poor nutrition, which could lead to reproductive or immune effects or, if severe enough, death. A reduction in prey is also likely to work in concert with other threats to produce an adverse effect. For example, insufficient prey could cause whales to rely upon their fat stores, which contain high contaminant levels, impairing reproductive success or compromising immune function.

Based on persuasive scientific information that Southern Residents prefer Chinook salmon in inland waters of Washington State and British Columbia, they are likely to also prefer Chinook salmon when available in coastal waters of their range, which extends south to Central California. Southern Residents overlap with the occurrence of Central Valley Chinook salmon, which are available to Southern Residents across their coastal range, and in greater magnitude south of Cape Falcon. Some of the numerous sightings of Southern Residents in California waters have coincided with large runs of salmon, with feeding witnessed in Monterey Bay. Additionally, there is genetic and chemical evidence that Chinook salmon from the Central Valley are consumed by Southern Residents (*i.e.*, genetic identity confirmed from prey remains, and DDT-signature in the whales).

In the long-term, the proposed action increases the risk of extinction of winter-run and spring-run ESUs. Their extinction would reduce prey availability and increase the likelihood for local depletions of prey in particular locations and times. In response, the Southern Residents would increase foraging effort or abandon areas in search of more abundant prey. Fewer populations contributing to Southern Residents' prey base reduces the representation of diversity in life histories, resiliency in withstanding stochastic events, and redundancy to ensure there is a margin of safety for the salmon and Southern Residents to withstand catastrophic events. These reductions increase the extinction risk of salmon and Southern Residents.

Additionally, the proposed action reduces the abundance of naturally produced CV fall-run, while increasing the abundance of hatchery produced fall-run. Although the proposed hatchery production may replace the lost natural production in the short term, over the long term it is uncertain whether the lost natural production can be replaced. There is also no evidence that a population that is predominantly produced in hatcheries can persist over the long term. Moreover, some of the current hatchery practices are likely to diminish the productivity, distribution and diversity of CV fall-run over the long term. We have similar concerns regarding the effects of current hatchery practices on retention of diversity in Trinity River non-listed spring- and fall-runs. Without retention of natural diversity, these stocks likely will be less resilient to the effects of disease, climate change and stochastic events. The long-term potential for these stocks to sustain the same magnitude of ocean abundance currently available to Southern Residents is likely to be compromised by a loss of diversity in CV fall- and late fall-runs and non-listed spring- and fall-runs from the Trinity River watershed.

An increase in the risk of extinction of winter-run and spring-run ESUs, along with loss of diversity in fall-run will likely reduce available prey for Southern Residents. As described above, reductions in prey or a resulting requirement of increased foraging efficiency increase the likelihood of physiological effects. The Southern Residents would likely experience nutritional, reproductive, or other health effects from reduced prey as a result of the proposed action. Because of the small population size, a decrease in reproductive capacity of a single individual from prey reductions, is likely to reduce the likelihood of survival and recovery of the DPS.

In summary:

- Increased risk of extinction of winter-run and spring-run as a long-term consequence of the proposed action increases the risk of a permanent reduction in prey available to Southern Residents, and increases the likelihood for local depletions of prey in particular locations and times.
- Losing the potential for future recovery of winter-run and spring-run diminishes the potential for Southern Residents to recover.
- Over the long term, project operations disproportionately kill naturally spawning Central Valley fall-run. Although the killed naturally produced fish are replaced by hatchery adults in the whales' forage grounds, over the long term, there is no evidence that replacement can be maintained. Moreover, current hatchery practices funded by the proposed action are likely to diminish the productivity, distribution, and diversity of Central Valley fall-run. Current hatchery practices may similarly affect diversity in non-listed Chinook salmon stocks from the Trinity River watershed. This loss of natural diversity will compromise the ability of these stocks to withstand stochastic events or climate effects, and ultimately compromise the availability of fall-run stocks that contribute to Southern Residents' prey base.

10.0 CONCLUSIONS

After reviewing the best scientific and commercial information available, the current status of the species, the environmental baseline for the action area, the effects of the proposed action, and cumulative effects, it is NMFS' Opinion that the long-term operations of the CVP and SWP, as proposed, is not likely adversely affect Central California Coast steelhead and their designated critical habitat.

However, the long-term operations of the CVP and SWP are likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, Southern DPS of North American green sturgeon, and Southern Resident killer whales. The long-term operations of the CVP and SWP are likely to destroy or adversely modify critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead.

After reviewing the best scientific and commercial data available, including the current status of proposed Southern DPS of North American green sturgeon critical habitat, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' conference opinion that the long-term operations of the CVP and SWP are likely to destroy or adversely modify proposed critical habitat for the Southern DPS of North American green sturgeon.

11.0 REASONABLE AND PRUDENT ALTERNATIVE

11.1 OVERVIEW

11.1.1 Approach to the RPA

If NMFS finds that a proposed action is likely to jeopardize a listed species or adversely modify its critical habitat, the ESA requires NMFS to suggest those reasonable and prudent alternatives that it believes would enable the project to go forward in compliance with the ESA. By regulation, a RPA is defined as "alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the [NMFS] Director believes would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat" (50 CFR 402.02).

Regulations also require that NMFS discuss its findings and any RPAs with the action agency and utilize the action agency's expertise in formulating the RPA, if requested (50 CFR 402.14(g)(5)). This RPA was developed through a thoughtful and reasoned analysis of the key causes of the jeopardy and adverse modification findings, and a consideration of alternative actions within the legal authority of Reclamation and DWR to alleviate those stressors. NMFS has worked closely with Reclamation and DWR staff and greatly appreciates the expertise contributed by these agencies.

Because this complex action takes place in a highly altered landscape subject to many environmental stresses, it has been difficult to formulate an RPA that is likely to avoid jeopardy to all listed species and meets all regulatory requirements. As detailed in this Opinion, the current status of the affected species is precarious, and future activities and conditions not within the control of Reclamation or DWR are likely to place substantial stress on the species. NMFS initially attempted to devise an RPA for each species and its critical habitat solely by modifying project operations (*e.g*., timing/magnitude of releases from dams, closure of operable gates and barriers, and reductions in negative flows). In some cases, however, simply altering project operations was not sufficient to ensure that the projects were likely to avoid jeopardizing the species or adversely modifying critical habitat.

Consequently, NMFS developed focused actions designed to compensate for a particular stressor, considering the full range of authorities that Reclamation and DWR may use to implement these actions. These authorities are substantial. The CVPIA, in particular, provides Reclamation with ample authority to provide benefits for fish and wildlife through measures such as purchasing water to augment in-stream flow, implementing habitat restoration projects, and taking other beneficial actions (Cummins *et al.,* 2008). Some RPA actions, therefore, call for restoring habitat or providing fish passage above dams, even though the water projects are not directly responsible for the impaired habitat or the blocked passage.

NMFS concentrated on actions that have the highest likelihood of alleviating the stressors with the most significant effects on the species, rather than attempting to address every project stressor for each species or every PCE for critical habitat. For example, water temperatures lethal to incubating eggs often occur when the air is warm and flows are low. Fish cannot reach spawning habitat with colder water at higher elevations if it is above currently impassable dams. Accordingly, NMFS' near-term measures provide suitable water temperatures below dams in a higher percentage of years, and long-term measures provide passage to cooler habitat above dams as soon as practicable. Reducing egg mortality from high water temperatures is a critical step in slowing or halting the decline of Central Valley salmonids.

The effects analysis in this Opinion explains that the adverse effects of the proposed action on listed anadromous fish and their critical habitats are both direct and indirect. The USFWS stated in its biological opinion on effects of the projects on Delta smelt that in addition to direct adverse effects such as entrainment at the pumps, the water projects have affected smelt "by creating an altered environment in the Delta that has fostered both the establishment of non-indigenous species and habitat conditions that exacerbate their adverse influence on delta smelt population dynamics." (USFWS 2008a, p. 189) Similarly, NMFS concludes that the water projects have both directly altered the hydrodynamics of the Sacramento-San Joaquin River basins and have interacted with other activities affecting the Delta to create an altered environment that adversely influences salmonid and green sturgeon population dynamics. The altered environment includes changes in habitat formation, species composition, and water quality, among others. Consequently, NMFS must take a broad view of the ways in which the project agencies can improve the ecosystem to ameliorate the effects of their actions.

There are several ways in which water operations adversely affect listed species that are addressed in this RPA. We summarize the most significant here:

1) Water operations result in elevated water temperatures that have lethal and sub-lethal effects on egg incubation and juvenile rearing in the upper Sacramento River. The immediate operational cause is lack of sufficient cold water in storage to allow for cold

water releases to reduce downstream temperatures at critical times and meet other project demands. This elevated temperature effect is particularly pronounced in the Upper Sacramento for winter-run and mainstem spring-run, and in the American River for steelhead. The RPA includes a new year-round storage and temperature management program for Shasta Reservoir and the Upper Sacramento River, as well as long-term passage prescriptions at Shasta Dam and re-introduction of winter-run into its native habitat in the McCloud and/or Upper Sacramento rivers.

2) In Clear Creek, recent project operations have led to increased abundance of Clear Creek spring-run, which is an essential population for the short-term and long-term survival of the species. Nonetheless, in the proposed action, continuation of these operations is uncertain. The RPA ensures that essential flows and temperatures for holding, egg incubation and juvenile survival will be maintained.

3) Red Bluff Diversion Dam (RBDD) on the Sacramento River impedes both upstream migration of adult fish to spawning habitat and downstream migration of juveniles. Effects are significant for winter-run and spring-run, but are particularly pronounced for green sturgeon and its proposed critical habitat in that a significant portion of the population is blocked from its spawning and holding habitat. The RPA mandates gate openings at critical times in the short term while an alternative pumping plant is built, and, by 2012, opening of the gates all year.

4) Both project and non-project effects have led to a significant reduction in necessary juvenile rearing habitat in the Sacramento River Basin and Delta. The project's flood control operations result in adverse effects through reduced frequency and magnitude of inundation of rearing habitat. To minimize these effects, the RPA contains both short-term and long-term actions for improving juvenile rearing habitat in the Lower Sacramento River and northern Delta.

5) Another major effect of water operations is diversion of out-migrating juveniles from the north Delta tributaries into the interior Delta through the open DCC gates. Instead of migrating directly to the outer estuary and then to sea, these juveniles are caught in the interior Delta and subjected to pollution, predators, and altered food webs that cause either direct mortality or impaired growth. The RPA mandates additional gate closures to minimize these adverse effects to winter-run, spring-run, and steelhead.

6) Similarly, water pumping causes reverse flows, leading to loss of juveniles migrating out from the Sacramento River system in the interior Delta and more juveniles being exposed to the State and Federal pumps, where they are salvaged at the facilities. The RPA prescribes Old and Middle River flow levels to reduce the number of juveniles exposed to the export facilities and prescribes additional measures at the facilities themselves to increase survival of fish.

7) The effects analysis shows that juvenile steelhead migrating out from the San Joaquin River Basin have a particularly high rate of loss due to both project and non-project

related stressors. The RPA mandates additional measures to improve survival of San Joaquin steelhead smolts, including both increased San Joaquin River flows and export curtailments. Given the uncertainty of the relationship between flow and exports, the RPA also prescribes a significant new study of acoustic tagged fish in the San Joaquin Basin to evaluate the effectiveness of the RPA and refine it over the lifetime of the project.

8) On the American River, project-related effects on steelhead are pronounced due to the inability to consistently provide suitable temperatures for various life stages and flow-related effects caused by operations. The RPA prescribes a flow management standard, a temperature management plan, additional technological fixes to temperature control structures, and, in the long term, a passage at Nimbus and Folsom Dams to restore steelhead to native habitat.

9) On the Stanislaus River, project operations have led to significant degradation of floodplain and rearing habitat for steelhead. Low flows also distort cues associated with out-migration. The RPA proposes a year-round flow regime necessary to minimize project effects to each life-stage of steelhead, including new spring flows that will support rearing habitat formation and inundation, and will create pulses that cue out-migration.

10) Nimbus Fish Hatchery steelhead program contribute to both loss of genetic diversity and mixing of wild and hatchery stocks of steelhead, which reduces the viability of wild stocks. The Nimbus and Trinity River Hatchery programs for non-listed fall-run also contribute to a loss of genetic diversity, and therefore, viability, for fall-run. The RPA requires development of Hatchery Genetics Management Plans to improve genetic diversity of both steelhead and fall-run, an essential prey base of Southern Resident.

This RPA is composed of numerous elements for each of the various project divisions and associated stressors and must be implemented in its entirety in order to avoid jeopardy and adverse modification. There are several actions that allow the project agencies options for alleviating a particular stressor. Reclamation and DWR may select the option they deem most practical — NMFS cares only that the stressor be sufficiently reduced. There are several actions in which NMFS expressly solicits additional research and suggestions from the project agencies for alternative actions to achieve needed results.

NMFS recognizes that the RPA must be an alternative that is likely to avoid jeopardizing listed species or adversely modifying their critical habitats, rather than a plan that will achieve recovery. Both the jeopardy and adverse modification standards, however, include consideration of effects on an action on listed species' chances of recovery. NMFS believes that the RPA does not reduce the likelihood of recovery for any of the listed species. The RPA cannot and does not, however, include all steps that would be necessary to achieve recovery. NMFS is mindful of potential social and economic consequences of reducing water deliveries and has carefully avoided prescribing measures that are not necessary to meet section 7 requirements.

An RPA must avoid jeopardy to listed species in the short term, as well as the long term. Essential short-term actions are presented for each division and are summarized for each species to ensure that the likelihood of survival and recovery is not appreciably reduced in the short term (*i.e.*, one to five years). In addition, because the proposed action is operation of the CVP/SWP until 2030, this consultation also includes long-term actions that are necessary to address project-related adverse effects on the likelihood of survival and recovery of the species over the next two decades.

Some of these long-term actions will require evaluation, planning, permitting, and funding. These include:

1) Providing fish passage at Shasta, Nimbus, and Folsom Dams, which ultimately is the only means of counteracting the loss of habitat needed for egg incubation and emergence, and steelhead over-summering habitat at lower elevations. This habitat loss has already occurred and will be exacerbated by climate change and increased water demands.

2) Providing adequate rearing habitat on the lower Sacramento River and Yolo Bypass through alteration of operations, weirs, and restoration projects.

3) Engineering projects to further reduce hydrologic effects and indirect loss of juveniles in the interior Delta.

4) Technological modifications to improve temperature management in Folsom Reservoir.

NMFS considered economic and technological feasibility in several ways when developing initial actions in this RPA. The RPA also allows for tailored implementation of many actions in consideration of economic and technological feasibility without compromising the RPA's effectiveness in avoiding jeopardy and adverse modification of critical habitat. Examples include:

1) Providing reasonable time to develop technologically feasible alternatives where none are "ready to go" – *e.g.*, the Delta engineering action (Action IV.1.3), and lower Sacramento River rearing habitat action (Action I.6.1).

2) Calling for a stepped approach to fish passage at dams, including studies and pilot projects, prior to a significant commitment of resources to build a ladder or invest in a permanent trap and haul program.

3) Providing a health and safety exception for export curtailments.

4) Using monitoring for species presence to initiate actions when most needed.

NMFS examined water supply costs of the RPA as one aspect of considering economic feasibility. While only costs to the action agency are considered in determining whether a RPA meets the regulatory requirement of economic feasibility, NMFS is mindful of potential social and economic costs to the people and communities that historically have depended on the Delta for their water supply. Any water supply impact is undesirable. NMFS made many attempts through the iterative consultation process to avoid developing RPA actions that would result in high water costs, while still providing for the survival and recovery of listed species.

NMFS estimates the water costs associated with the RPA to be 5-7% of average annual combined exports: 5% for CVP, or 130 TAF/year, and 7% for SWP, or 200 TAF/year[27]. The combined estimated annual average export curtailment is 330 TAF/year. These estimates are over and above export curtailments associated with the USFWS smelt Opinion. The OMR restrictions inn both Opinions tend to result in export curtailments of similar quantities at similar times of year. Therefore, in general, these 330 TAF export curtailments are associated with the NMFS San Joaquin River Ratio actions in the RPA. These water costs can be offset by application of b(2) water resources, water conservation, groundwater use, water recycling and toher processes currently underway.

The RPA includes collaborative research to enhance scientific understanding of the species and ecosystems, and to adapt actions to new scientific knowledge. This adaptive structure is important, given the long-term nature of the consultation and the scientific uncertainty inherent in a highly variable system. Monitoring and adaptive management are both built into many of the individual actions and are the subject of an annual program review. NMFS views both the CALFED Science Program and the NMFS Southwest Fisheries Science Center as essential partners in ensuring that the best scientific experts are brought together to assess the implementation and effectiveness of actions in this RPA. We will continue to pursue many of the long-term recommendations for improving science as recommended by the CALFED and CIE peer reviews, and we will seek to incorporate this new science as it becomes available through the adaptive management processes embedded in the RPA.

Finally, we note that the project agencies are currently developing and evaluating a plan to construct a diversion on the Sacramento River and a canal around the Delta, in the BDCP planning effort. Such a reconfiguration of the water conveyance system would take careful planning to avoid jeopardizing Sacramento River and north Delta species, as well as several years of environmental review and permitting, and would trigger a re-initiation of this Opinion. We expect that the collaborative research that is part of this RPA will inform this planning effort as it proceeds.

11.1.2 Organization of the RPA

The specific actions in the RPA are detailed in Section 11.2. That section begins with overarching actions that apply to operations in all geographic divisions of the project, including procedures for orderly functioning of the many technical teams that assist with decision making, research and adaptive management, and monitoring. These are followed by actions specific to each geographic division of the proposed action: Sacramento River, American River, East Side

[27] The proportion share between the CVP and SWP is attributable to CalLite programming and may not represent the true share of export reductions that would be allocated to each facility under actual conditions.

(Stanislaus River), and the Delta. There is a suite of actions for each geographic area. Section 11.2 concludes with subsections regarding fish passage at dams and modification of hatchery practices.

Section 11.3 is a species-by-species explanation of: (1) how each measure contributes to avoiding jeopardy or adverse modification for that species; and (2) the basis for NMFS' conclusion that the RPA measures as a whole are likely to avoid jeopardizing the species or adversely modifying its critical habitat. The information is presented in both narrative and table form. The narrative provides an overview, while the tables add detail. This section also address the other regulatory criteria necessary for a Reasonable and Prudent Criteria.

11.2 Reasonable and Prudent Alternative – Specific Actions

11.2.1. Decision-Making Procedures, Monitoring and Adaptive Management Protocols

11.2.1.1 Responsibilities and Procedures of Technical Teams

There are currently four Fisheries and Operations Technical Teams whose function is to make recommendations for adjusting operations to meet contractual obligations for water delivery and minimize adverse effects on listed anadromous fish species:

- Sacramento River Temperature Task Group (SRTTG)
- Clear Creek Technical Working Group (CCTWG)
- American River Group (ARG)
- San Joaquin River Technical Committee (SJRTC)

This RPA requires the creation of three additional technical teams:

- Delta Operations for Salmon and Sturgeon (DOSS) Group
- Stanislaus Operations Group (SOG)
- Interagency Fish Passage Steering Committee

Each group has responsibility to gather and analyze information, and make recommendations, regarding adjustments to water operations within the range of flexibility prescribed in the implementation procedures for a specific action in their particular geographic area. Under previous operations plans, recommendations for adjustments were made to the Water Operations Management Team (WOMT), a management-level group of representatives of Reclamation, DWR, CDFG, NMFS, and USFWS. The WOMT then made recommendations to state and regional directors for final action.

The Project Description for the proposed action (Appendix 1 to this Opinion), as revised by this RPA, establishes the responsibilities of each technical team. The RPA establishes the operations parameters that are necessary to avoid jeopardizing listed species or adversely modifying their critical habitat. Within those parameters, there is flexibility to adjust actions within a specified range based on current conditions. The allowed range of flexibility is prescribed in the "implementation procedures" portion of the RPA action. The technical teams and the WOMT will work within those implementation procedures to meet discretionary water contract obligations to the greatest extent consistent with survival and recovery of listed species. The teams also may recommend changes to the measures in this RPA, as detailed in the Research and Adaptive Management section of the RPA. Recommended changes outside the range of flexibility specified in the implementation procedures must receive written review and concurrence by NMFS and may trigger re-initiation.

This action prescribes standard operating procedures for decision-making that will apply to all teams.

1) Within 90 days of issuance of this Opinion, Reclamation shall send to the WOMT members a list of current members of each technical team. The WOMT representatives shall review the membership and make changes, if necessary. All groups shall include members with expertise in fish biology and hydrology. Each group shall designate a group leader to convene meetings and assure that necessary administrative steps are taken, such as recording and distributing meeting notes and recommendations.

2) Each group shall establish a regular meeting schedule at the beginning of each year, based on the anticipated need for adjustments to operations, and distribute the schedule to the members of the group. The group leader may reschedule a meeting, or call a special meeting, with three days notice at his or her discretion, or on request of NMFS or any two or more group members.

3) Brief notes of each meeting shall be recorded, including issues considered, recommendations made, and key information on which recommendations were based. Meeting notes shall be distributed to members within two days of the meeting.

4) Within one day after a technical team advises that an operational action should be initiated, changed, suspended, or terminated, consistent with the implementation procedures specified for actions in this RPA, the group leader shall provide to NMFS and Reclamation written advice and a biological rationale. The technical teams shall use the process described in the applicable RPA implementation procedures to provide a framework for their analysis. NMFS shall determine whether the proposed action is consistent with the implementation procedures in this RPA. If NMFS determines that the proposed action is consistent with the implementation procedures, then it avoids jeopardy to listed species or adverse modification of critical habitat. Both the technical team's advice and NMFS' recommendation shall be presented to the WOMT for discussion and concurrence. In the event that there is not consensus at the workgroup level, the workgroup leader shall convey the options and summary of the technical discussion to NMFS for consideration. NMFS will make a recommendation for action within the procedural guidelines of this RPA. NMFS will present its recommendations to the WOMT for discussion and concurrence (see #6 below).

5) If the recommended action will affect species within the jurisdiction of USFWS as well as NMFS, the technical team making the recommendation shall, to the extent that time allows, first coordinate with the Smelt Working Group (SWG). The technical team and the SWG, to the extent feasible, shall jointly make a recommendation to USFWS and NMFS (the Services), who will jointly determine whether the recommended action is consistent with the actions and implementation procedures of this RPA and is, therefore, necessary to avoid jeopardy to listed species and adverse modification of critical habitat. The Services shall then present their findings and recommendations to the WOMT.

6) The WOMT shall either concur with NMFS' (or the Services', as appropriate) recommendation or provide a written alternative to the recommendation, with biological justification, to NMFS (or the Services) within one calendar day. NMFS (or the Services) shall then make a determination as to whether the action proposed by the WOMT is consistent with this Opinion and ESA obligations.

7) Once NMFS (or the Services) makes a final determination that a proposed operational action is consistent with ESA obligations, Reclamation and DWR shall implement the operational action within two calendar days. Reclamation and DWR shall submit to NMFS (or the Services) data demonstrating the implementation of the action on a weekly basis, or post their operations on their website.

8) The action shall remain in effect until NMFS (or the Services), with advice from the appropriate technical team(s), determines that it should be modified or terminated as inconsistent with the implementation procedures for the RPA. The action shall be modified or terminated within two calendar days of such a determination.

9) These procedures may be modified for a particular team or working group by mutual agreement of NMFS and Reclamation. Modifications to the procedures shall be in writing, dated, and promptly distributed to all members of the group.

11.2.1.2. Research and Adaptive Management

Not later than November 30 of every year, in conjunction with the CALFED Science Program or other Science Peer Review process, Reclamation and NMFS shall host a workshop to review the prior water years' operations and to determine whether any measures prescribed in this RPA should be altered in light of information learned from prior years' operations or research. After completion of the annual review, NMFS may initiate a process to amend specific measures in this RPA to reflect new information, provided that the amendment is consistent with the Opinion's underlying analysis and conclusions and does not limit the effectiveness of the RPA in avoiding jeopardy to listed species or adverse modification of critical habitat. NMFS will ask the appropriate informational and technical teams to assess the need for a particular amendment and make recommendations to NMFS, according to the group processes for decision-making set forth in this RPA in action 11.2.1.1 above.

NMFS and Reclamation will establish a research program in coordination with the CALFED Science Program and other agencies to address key research and management questions arising from this Opinion. Prior to the beginning of a new calendar year, Reclamation shall submit to NMFS a research plan for the following year, developed in coordination with the above programs and agencies. Reclamation also shall provide NMFS access to all draft and final reports associated with this research. Specific research projects that have been identified as important to begin in the first year and complete as soon as possible are:

1) Cooperative development of a salmonid lifecycle model acceptable to NMFS, Reclamation, CDFG, and DWR

2) Temperature monitoring and modeling identified in RPA Action I.5

3) Green sturgeon research described in the RBDD actions

4) Rearing habitat evaluation metrics to guide rearing habitat Action 1.6

5) A 6-year acoustic-tagged study of juvenile salmonids out-migration in the San Joaquin River and through the southern Delta identified in Action IV.2.2.

11.2.1.3. Monitoring and Reporting

1) Reclamation and DWR shall participate in the design, implementation, and funding of the comprehensive CV steelhead monitoring program, under development through ERP, that includes adult and juvenile direct counts, redd surveys, and escapement estimates on CVP- and SWP-controlled streams. This program is necessary to develop better juvenile production estimates that form the basis of incidental take limits and will also provide necessary information to calculate triggers for operational actions.

2) Reclamation and DWR shall ensure that all monitoring programs regarding the effects of CVP and SWP operations and which result in the direct take of winter-run, spring-run, CV steelhead, or Southern DPS of green sturgeon, are conducted by a person or entity that has been authorized by NMFS. Reclamation and DWR shall establish a contact person to coordinate these activities with NMFS.

3) Reclamation and DWR shall submit weekly reports to the interagency Data Assessment Team (DAT) regarding the results of monitoring and incidental take of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon associated with operations of project facilities.

4) Reclamation and DWR shall provide an annual written report to NMFS no later than October 1, following the salvage season of approximately October to May. This report shall provide the data gathered and summarize the results of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon monitoring and incidental take associated with the operation of the Delta pumping plants (including the Rock Slough Pumping

Plant). All juvenile mortality must be minimized and reported, including those from special studies conducted during salvage operations. This report should be sent to NMFS (Southwest Region, Protected Resources Division, Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95814-4706).

5) Reclamation and DWR shall continue the real-time monitoring of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the lower Sacramento River, the lower San Joaquin River, and the Delta to establish presence and timing to serve as a basis for the management of DCC gate operations and CVP and SWP Delta pumping operations consistent with actions in this RPA. Reclamation and DWR shall conduct continuous real-time monitoring between October 1 and June 30 of each year, commencing in 2009.

6) Reclamation and DWR shall submit weekly DAT reports and an annual written report to NMFS describing the results of real-time monitoring of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon associated with operations of the DCC and CVP and SWP Delta pumping facilities, and other Division level operations authorized through this RPA.

7) Reclamation shall coordinate with NMFS, the USFWS, and CDFG to continue implementation and funding of fisheries monitoring of spring-run and CV steelhead (including adult snorkel surveys, population estimates for steelhead, and rotary screw trapping) in Clear Creek to aide in determining the benefits and effects of flow and temperature management.

8) Monitoring Requirements: The following (A-E) are necessary to adaptively manage project operations and are either directly related to management of releases (*e.g*., temperature and flow), or are a necessary component the Salmon Decision Process used to manage Delta operations (*e.g*., DCC gates and export pumping). Reclamation and DWR shall jointly fund these monitoring locations for the duration of the Opinion (through 2030) to ensure compliance with the RPA and assess the performance of the RPA actions. Most of these monitoring stations already exist and are currently being funded through a variety of sources (*i.e*., CDFG, USFWS, Reclamation, DWR, CALFED, and Interagency Ecological Program), however, CALFED funding for monitoring ends in 2009 and CDFG funding has been reduced due to budget cuts.

   a) Upstream: Adult escapement and juvenile monitoring for spring-run, winter-run, and steelhead on the Sacramento River, American River, Feather River, Clear Creek, Mill Creek, Deer Creek and Battle Creek. These may be performed through carcass surveys, redd surveys, weir counts, and rotary screw trapping.
   b) RBDD: Adult counts using the three current fish ladders until the new pumping plant is operational. Rotary screw trapping to determine juvenile Chinook salmon passage or abundance year-round before and after pumping plant is operational. Green sturgeon monitoring, to include adult and juvenile estimates of passage, relative

abundance, and run timing, in order to determine habitat use and population size with respect to management of Shasta Reservoir resources.

c) Sacramento River new juvenile monitoring station: The exact location to be determined, between RBDD and Knights Landing, in order to give early warning of fish movement and determine survival of listed fish species leaving spawning habitat in the upper Sacramento River.
d) Delta: Continuation of the following monitoring stations that are part of the IEP: Chipps Island Trawl, Sacramento Trawl, Knights Landings RST, and beach seining program. Additionally, assist in funding new studies to determine green sturgeon relative abundance and habitat use in the Delta.
e) San Joaquin River monitoring shall include: Adult escapement and juvenile monitoring for steelhead on the Stanislaus River; Mossdale Kodiak Trawling to determine steelhead smolt passage; steelhead survival studies associated with VAMP; monitoring at HORB to determine steelhead movement in and around the barrier; predation studies in front of HORB and at the three agricultural barriers in the South Delta; and new studies to include the use of non-lethal fish guidance devices (*e.g.*, sound, light, or air bubbles) instead of rock barriers to keep juveniles out of the area influenced by export pumping.

11.2.2 Actions Listed by Division

I. SACRAMENTO RIVER DIVISION

Introduction to the Sacramento River Division: Project operations of the Sacramento River Division affect winter-run, spring-run, CV steelhead, the Southern DPS of green sturgeon. In addition, project operations affect fall-run, which are not listed. Fall-run salmon are considered in developing the actions as a prey base for Southern Residents. This Division section of the RPA includes actions related to minimizing adverse effects to spring-run and steelhead spawning and rearing in Clear Creek and all species in the main stem Sacramento River. Actions include those necessary to reduce the risk to temperature effects to egg incubation in the upper river, especially to winter-run and spring-run spawning below Shasta Dam. Also, the RPA contains actions for operation of RBDD – a major impediment to salmonid and green sturgeon migration. In addition, the RPA includes an action related to adjusting the antiquated Wilkins Slough navigation requirement, mandates the continuation of the fish screening program, and calls for restoration of essential rearing habitat in the lower river/northern Delta.

Operations of the Sacramento River Division are interconnected with those of the Trinity River Division. NMFS is in the process of conducting a separate consultation on the effects of the Trinity River Division operations on listed coho salmon in the Trinity River. NMFS is committed to ensuring appropriate coordination between the analysis and results of this Opinion and the forthcoming coho opinion. The Sacramento River Division RPA will be analyzed in that Opinion, and may be adjusted as necessary to avoid jeopardy to coho salmon and adverse modification of critical habitat.

Action Suite I.1. Clear Creek

Suite Objective: The proposed action includes a static flow regime (no greater than 200 cfs all year) and uncertainty as to the availability of b(2) water in the future pose significant risk to these species. The RPA actions described below were developed based on a careful review of past flow studies, current operations, and future climate change scenarios. Although not all of the flow studies have been completed, NMFS believes these actions are necessary to address adverse project effects on flow and water temperature that reduce the viability of spring-run and CV steelhead in Clear Creek.

Action I.1.1. Spring Attraction Flows

Objective: Encourage spring-run movement to upstream Clear Creek habitat for spawning.

Action: Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem. This may be done in conjunction with channel-maintenance flows (Action I.1.2).

Rationale: In order to prevent spring-run from hybridizing with fall-run in the Sacramento River, it is important to attract early spring-run adults as far upstream in Clear Creek as possible, where cooler water temperatures can be maintained over the summer holding period through releases from Whiskeytown Dam. This action will also prevent spring-run adults from spawning in the lower reaches of Clear Creek, where water temperatures are inadequate to support eggs and pre-emergent fry during September and October.

Action I.1.2. Channel Maintenance Flows

Objective: Minimize project effects by enhancing and maintain previously degraded spawning habitat for spring-run and CV steelhead

Action: Reclamation shall re-operate Whiskeytown Glory Hole spills during the winter and spring to produce channel maintenance flows of a minimum of 3,250 cfs mean daily spill from Whiskeytown for one day, to occur seven times in a ten-year period, unless flood control operations provide similar releases. Re-operation of Whiskeytown Dam should be implemented with other project facilities as described in the EWP Pilot Program (Reclamation 2008d).

Rationale: Channel maintenance flows are a necessary element of critical habitat (see PCEs) in order to restore proper functioning rivers. This modified operation allows higher flows necessary to move spawning gravels downstream from injection sites, which will increase the amount of spawning habitat available to spring-run and steelhead. Previous studies (McBain and Trush 1999) have shown that Clear Creek lacks sufficient gravel for spawning habitat. Both spring-run and steelhead need higher flows to provide the spawning and rearing habitat elements essential for survival and recovery.

Action I.1.3. Spawning Gravel Augmentation

Objective: Enhance and maintain previously degraded spawning habitat for spring-run and CV steelhead.

Action: Reclamation, in coordination with the Clear Creek Technical team, shall continue spawning gravel augmentation efforts. By December 31 each year, Reclamation shall provide a report to NMFS on implementation and effectiveness of the gravel augmentation program.

Rationale: Similar to above for Action I.1.2. Recent studies (USFWS 2007, 2008) have shown steelhead and spring-run utilize gravel injection sites for spawning. Gravel augmentation has increased the steelhead spawning habitat available in the lower reaches of Clear Creek and directly relates to higher abundance in recent years. The gravel augmentation program also benefits fall-run and late fall-run spawning. Including the gravel augmentation program in the RPA ensures that it is reasonably certain to occur in the future.

<u>Action I.1.4. Spring Creek Temperature Control Curtain *(Note: This action benefits Sacramento River conditions, but is part of Clear Creek operations)*</u>

Objective: Reduce adverse impacts of project operations on water temperature for listed salmonids in the Sacramento River.

Action: Reclamation shall replace the Spring Creek Temperature Control Curtain in Whiskeytown Lake by June 2011 .

Rationale: The Spring Creek Tunnel releases provide cold water to Keswick Reservoir, which improves the ability to lower water temperatures during the summer for winter-run spawning and incubation. Recent underwater surveys concluded that the Whiskeytown Curtain is in poor condition and needs a major overhaul (Reclamation 2008b). Six rips in the fabric run the full depth of the curtain to 55 feet.

<u>Action I.1.5. Thermal Stress Reduction</u>

Objective: To reduce thermal stress to over-summering steelhead and spring-run during holding, spawning, and embryo incubation.

Action: Reclamation shall manage Whiskeytown releases to meet a daily water temperature of:

1) 60ºF at the Igo gage from June 1 through September 15; and

2) 56ºF at the Igo gage from September 15 to October 31.

Reclamation, in coordination with NMFS, will assess improvements to modeling water temperatures in Clear Creek and identify a schedule for making improvements.

Rationale: The water temperature criteria address the critical need for colder water that historically was available to salmonids above Whiskeytown Dam. If the criteria are not met, juvenile steelhead rearing habitat is limited, predation is higher, and disease is more prevalent. Spring-run adults need colder water to hold over during the summer until September. If water temperature is too warm, spring-run experience pre-spawn mortality and reduced production. The lower water temperature in September is necessary to reduce mortality of spring-run eggs and pre-emergent fry.

<u>Action I.1.6. Adaptively Manage to Habitat Suitability/IFIM Study Results</u>

Objective: Decrease risk to Clear Creek spring-run and CV steelhead population through improved flow management designed to implement state-of-the-art scientific analysis on habitat suitability.

Action: Reclamation shall operate Whiskeytown Reservoir as described in the Project Description with the modifications described in Action I.1 until September 30, 2012, or until 6 months after current Clear Creek salmonids habitat suitability (*e.g*., IFIM) studies are completed, whichever occurs later.

When the salmonid habitat suitability studies are completed, Reclamation will, in conjunction with the CCTWG, assess whether Clear Creek flows shall be further adapted to reduce adverse impacts on spring-run and CV steelhead, and report their findings and proposed operational flows to NMFS within 6 months of completion of the studies. NMFS will review this report and determine whether the proposed operational flows are sufficient to avoid jeopardizing spring-run and CV steelhead or adversely modifying their critical habitat.

Reclamation shall implement the flows on receipt of NMFS' written concurrence. If NMFS does not concur, NMFS will provide notice of the insufficiencies and alternative flow recommendations. Within 30 days of receipt of non-concurrence by NMFS, Reclamation shall convene the CCTWG to address NMFS' concerns. Reclamation shall implement flows deemed sufficient by NMFS in the next calendar year.

Rationale: Past project operations have reduced spring-run and CV steelhead abundance in Clear Creek by creating passage barriers, raising water temperature, and reducing spawning gravels in key areas of critical habitat. Abundance has increased in recent years as a result of passage improvements, habitat restoration, and operational changes to improve temperature control. Persistence of the population and maintenance of its critical habitat will require continuation of flows adequate for migration and maintenance of spawning gravels and suitable water temperatures.

Action Suite I.2. Shasta Operations

Introduction to Shasta Operations: Maintaining suitable temperatures for egg incubation, fry emergence, and juvenile rearing in the Sacramento River is critically important for survival and recovery of the winter-run ESU. The winter-run ESU has been reduced to a single population, which has been blocked from its historical range above Shasta Dam. Consequently, suitable temperatures and habitat for this population must be maintained downstream of Shasta Dam through management of the cold water pool behind the dam in the summer. Maintaining optimum conditions for this species below Shasta is crucial until additional populations are established in other habitats or this population is restored to its historical range. Spring-run are also affected by temperature management actions from Shasta Reservoir.

The effects analysis in this Opinion highlights the very challenging nature of maintaining an adequate cold water pool in critically dry years, extended dry periods, and under future conditions, which will be affected by increased downstream water demands and climate change. This suite of actions is designed to ensure that Reclamation uses maximum discretion to reduce adverse impacts of the projects to winter-run and spring-run in the Sacramento River by maintaining sufficient carryover storage and optimizing use of the cold water pool. In most years, reservoir releases through the use of the TCD are a necessity in order to maintain the bare minimum population levels necessary for survival (Yates *et al.* 2008, Angilletta *et al.* 2008).

The effects analysis in this Opinion, and supplemental information provided by Reclamation, make it clear that despite Reclamation's best efforts, severe temperature-related effects cannot be avoided in some years. The RPA includes exception procedures to deal with this reality. Due to these unavoidable adverse effects, the RPA also specifies other actions that Reclamation must take, within its existing authority and discretion, to compensate for these periods of unavoidably high temperatures. These actions include restoration of habitat at Battle Creek that may be support a second population of winter-run, and a fish passage program at Keswick and Shasta dams to partially restore winter-run to their historical cold water habitat.

Objectives: The following objectives must be achieved to address the avoidable and unavoidable adverse effects of Shasta operations on winter-run and spring-run:

1) Ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning between Balls Ferry and Bend Bridge in most years, without sacrificing the potential for cold water management in a subsequent year. Additional actions to those in the 2004 CVP/SWP operations Opinion are needed, due to increased vulnerability of the population to temperature effects attributable to changes in Trinity River ROD operations, projected climate change hydrology, and increased water demands in the Sacramento River system.

2) Ensure suitable spring-run temperature regimes, especially in September and October. Suitable spring-run temperatures will also partially minimize temperature effects to naturally-spawning, non-listed Sacramento River fall-run, an important prey base for endangered Southern Residents.

3) Establish a second population of winter-run in Battle Creek as soon as possible, to partially compensate for unavoidable project-related effects on the one remaining population.

4) Restore passage at Shasta Reservoir with experimental reintroductions of winter-run to the upper Sacramento and/or McCloud rivers, to partially compensate for unavoidable project-related effects on the remaining population.

<u>Action 1.2.1 Performance Measures.</u>

Objective: To establish and operate to a set of performance measures for temperature compliance points and End-of-September (EOS) carryover storage, enabling Reclamation and NMFS to assess the effectiveness of this suite of actions over time. Performance measures will help to ensure that the beneficial variability of the system from changes in hydrology will be measured and maintained.

Action: The following long-term performance measures shall be attained. Reclamation shall track performance and report to NMFS at least every 5 years. If there is significant deviation from these performance measures over a 10-year period, measured as a running average, which is not explained by hydrological cycle factors (*e.g.,* extended drought), then Reclamation shall reinitiate consultation with NMFS.

Performance measures for EOS carryover storage at Shasta Reservoir:

- 87 percent of years: Minimum EOS storage of 2.2 MAF
- 82 percent of years: Minimum EOS storage of 2.2 MAF and end-of-April storage of 3.8 MAF in following year (to maintain potential to meet Balls Ferry compliance point)
- 40 percent of years: Minimum EOS storage 3.2 MAF (to maintain potential to meet Jelly's Ferry compliance point in following year)

Measured as a 10-year running average, performance measures for temperature compliance points during summer season shall be:

- Meet Clear Creek Compliance point 95 percent of time
- Meet Balls Ferry Compliance point 85 percent of time
- Meet Jelly's Ferry Compliance point 40 percent of time
- Meet Bend Bridge Compliance point 15 percent of time

Rationale: Evaluating long-term operations against a set of performance measures is the only way to determine the effectiveness of operations in preserving key aspects of life history and run time diversity. For example, maintaining suitable spawning temperatures down to Bend Bridge in years when this is feasible will help to preserve the part of winter-run distribution and run timing that relies on this habitat and spawning strategy. This will help to ensure that diversity is preserved when feasible. The percentages are taken from those presented in the CVP/SWP operations BA, effects analysis in the Opinion, and NMFS technical memo on historic Shasta operations.

<u>Action I.2.2. November through February Keswick Release Schedule (Fall Actions)</u>

Objective: Minimize impacts to listed species and naturally spawning non-listed fall-run from high water temperatures by implementing standard procedures for release of cold water from Shasta Reservoir.

Action: Depending on EOS carryover storage and hydrology, Reclamation shall develop and implement a Keswick release schedule, and reduce deliveries and exports as detailed below.

Action I.2.2.A Implementation Procedures for EOS Storage at 2.4 MAF and Above

If the EOS storage is at 2.4 MAF or above, by October 15, Reclamation shall convene a group including NMFS, USFWS, and CDFG, through B2IT or other comparable process, to consider a range of fall actions. A written monthly average Keswick release schedule shall be developed and submitted to NMFS by November 1 of each year, based on the criteria below. The monthly release schedule shall be tracked through the work group. If there is any disagreement in the group, including NMFS technical staff, the issue/action shall be elevated to the WOMT for resolution per standard procedures.

The workgroup shall consider and the following criteria in developing a Keswick release schedule:

1) Need for flood control space: A maximum 3.25 MAF end-of-November storage is necessary to maintain space in Shasta Reservoir for flood control.

2) Need for stable Sacramento River level/stage to increase habitat for optimal spring-run and fall-run redds/egg incubation and minimization of redd dewatering and juvenile stranding.

3) Need/recommendation to implement USFWS' Delta smelt Fall X2 action as determined by the Habitat Study Group formed in accordance with the 2008 Delta smelt Opinion. NMFS will continue to participate in the Habitat Study Group (HSG) chartered through the 2008 Delta smelt biological opinion. If, through the HSG, a fall flow action is recommended that draws down fall storage significantly from historical patterns, then NMFS and USFWS will confer and recommend to Reclamation an optimal storage and fall flow pattern to address multiple species' needs.

If there is a disagreement at the workgroup level, actions may be elevated to NMFS Sacramento Area Office Supervisor and resolved through the WOMT's standard operating procedures.

Rationale: 2.2 MAF EOS storage is linked to the potential to provide sufficient cold water to meet the minimum Balls Ferry Compliance point in the following year, and it is achievable approximately 85 percent of the time. Based on historical patterns, EOS storage will be above 2.4 MAF 70 percent of the time. The 2.4 MAF storage value provides a reasonable margin above the 2.2 level to increase the likelihood that the Balls Ferry Compliance Point will be reached while also implementing fall releases to benefit other species and life stages.

Therefore, in these circumstances, actions should target the fall life history stages of the species covered by this Opinion *(i.e.*, spring-run spawning, winter-run emigration). The development of a Keswick release schedule is a direct method for controlling storage maintained in Shasta Reservoir. It allows Reclamation to operate in a predictable way, while meeting the biological requirements of the species. The B2IT workgroup has been used in the past to target actions to benefit fall-run during this time of year using b(2) resources, and, because of its expertise, may also be used by Reclamation to develop this flow schedule. In the past, the B2IT group has used the CVPIA AFRP guidelines to target reservoir releases. Over time, it may be possible to develop a generic release schedule for these months, based on the experience of the work group.

Action I.2.2.B Implementation Procedures for EOS Storage Above 1.9 MAF and Below 2.4 MAF

If EOS storage is between 1.9 and 2.4 MAF, then Reclamation shall convene a group including NMFS, USFWS, and CDFG, through B2IT or other comparable workgroup, to consider a range of fall actions. Reclamation shall provide NMFS and the work group with storage projections based on 50 percent, 70 percent, and 90 percent hydrology through February, and develop a monthly average Keswick release schedule based on the criteria below. The monthly release schedule shall be submitted to NMFS by November 1.

Criteria for the release schedule shall include:

1) Maintain Keswick releases between 7000 cfs and 3250 cfs to reduce adverse effects on mainstem spring-run and conserve storage for next year's cold water pool.

2) Consider fall-run needs per CVPIA AFRP guidelines, through January, including stabilizing flows to keep redds from de-watering.

3) Be more conservative in Keswick releases throughout fall and early winter if hydrology is dry, and release more water for other purposes if hydrology becomes wet. For example, release no more than 4,000 cfs if hydrology remains dry.

The Keswick release schedule shall follow this or a similar format, to be refined by the workgroup:

	October forecast based on EOS storage	50% hydrology		70% hydrology		90% hydrology	
		Projected storage MAF	Planned release CFS	Projected storage MAF	Planned release CFS	Projected storage MAF	Planned release CFS
Monthly average Keswick	November						
	December						
	January						

release	February						

Reclamation, in coordination with the work group, shall review updated hydrology and choose a monthly average release for every month (November, December, January, February), based on the release schedule. In the event that the updated hydrology indicates a very dry pattern and consequent likely reduction in storage, the work group may advise Reclamation to take additional actions, including export curtailments, if necessary to conserve storage

If there is a disagreement at the work group level, actions may be elevated to NMFS and resolved through the WOMT's standard operating procedures.

Rationale: It is necessary to be reasonably conservative with fall releases to increase the likelihood of adequate storage in the following year to provide cold water releases for winter-run. This action is intended to reduce adverse effects on each species without compromising the ability to reduce adverse effects on another species. A work group with biologists from multiple agencies will refine the flow schedule, providing operational certainty while allowing for real-time operational changes based on updated hydrology. Over time, it may be possible to develop a generic release schedule for these months, based on the experience of the work group.

Action I.2.2.C. Implementation and Exception Procedures for EOS Storage of 1.9 MAF or Below

If the EOS storage is at or below 1.9 MAF, then Reclamation shall:

1) In early October, reduce Keswick releases to 3,250 cfs as soon as possible, unless higher releases are necessary to meet temperature compliance points (see action I.2.3).

2) Starting in early October, if cool weather prevails and temperature control does not mandate higher flows, curtail discretionary water deliveries (including, but not limited to agricultural rice decomposition deliveries) to the extent that these do not coincide with temperature management for the species. It is important to maintain suitable temperatures targeted to each life stage. Depending on air and water temperatures, delivery of water for rice decomposition, and any other discretionary purposes at this time of year, may coincide with the temperature management regime for spring-run and fall-run. This action shall be closely coordinated with NMFS, USFWS, and CDFG.

3) By November 1, submit to NMFS storage projections based on 50 percent, 70 percent, and 90 percent hydrology through February. In coordination with NMFS, Reclamation shall: (1) develop a monthly average Keswick release schedule similar in format to that in Action I.2.2.B, based on the criteria below and including actions specified below; and (2) review updated hydrology and choose a monthly average release for every month, based on the release schedule. November releases shall be based on a 90 percent hydrology estimate.

Criteria and actions:

1) Keswick releases shall be managed to improve storage and maintained at 3,250 cfs unless hydrology improves.

2) November monthly releases will be based on 90 percent hydrology.

3) Consider fall-run needs through January as per CVPIA AFRP guidelines, including stabilizing flows to keep redds from dewatering.

4) Continue to curtail discretionary agricultural rice decomposition deliveries to the extent that these do not coincide with temperature management for the species, or impact other ESA-listed species. It is important to maintain suitable temperatures targeted to each life stage. Depending on air and water temperatures, delivery of water for rice decomposition may coincide with the temperature management regime for spring-run and fall-run. This action shall be closely coordinated with NMFS. USFWS, and CDFG.

5) If operational changes are necessary to meet Delta outflow, X2, or other legal requirements during this time, then:

   a) CVP/SWP Delta combined exports shall be curtailed to 2,000 cfs if necessary to meet legal requirements while maintaining a 3,250 cfs Keswick release (or other planned release based on biological needs of species); and
   b) if it is necessary to curtail combined exports to values more restrictive than 2000 cfs in order to meet Delta outflow, X2, or other legal requirements, then Reclamation and DWR shall, as an overall strategy, first, increase releases from Oroville or Folsom; and
   c) in general, Reclamation shall increase releases from Keswick as a last resort.
   d) Based on updated monthly hydrology, this restriction may be relaxed, with NMFS' concurrence.

6) If the hydrology and storage have not improved by January, additional restrictions apply – see Action I.2.4.

Rationale: Per actions I.2.3 and I.2.4 below, Reclamation is required to meet 1.9 MAF EOS. The BA's CALSIM modeling shows that during a severe or extended drought, 1.9 EOS storage may not be achievable. In this circumstance, Reclamation should take additional steps in the fall and winter months to conserve Shasta storage to the maximum extent possible, in order to increase the probability of maintaining cold water supplies necessary for egg incubation for the following summer's cohort of winter-run.

Assessment of the hydrologic record and CALSIM modeling shows that operational actions taken during the first year of a drought sequence are very important to providing adequate storage and operations in subsequent drought years. The biological effects of an extended drought are particularly severe for winter-run. Extended drought conditions are predicted to increase in the future in response to climate change. While it is not possible to predict the onset of a drought sequence, in order to ensure that project operations avoid jeopardizing listed species, Reclamation should operate in any year in which storage falls below 1.9 MAF EOS as potentially the first year of a drought sequence. The CVP storage system is likely to recover more quickly in the winter and spring months if additional storage conservation measures are taken in the fall and winter.

The curtailments to discretionary rice decomposition deliveries and combined export curtailment of 2,000 cfs are necessary to conserve storage when EOS storage is low. These actions were developed through an exchange of information and expertise with Reclamation operators.

This action is consistent with comments from the Calfed Science Peer Review panel. That panel recommended that Shasta be operated on a two-year (as opposed to single year) hydrologic planning cycle and that Reclamation take additional steps to incorporate planning for potential drought and extended drought into its operations.

Action I.2.3. February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)

Objective: To conserve water in Shasta Reservoir in the spring in order to provide sufficient water to reduce adverse effects of high water temperature in the summer months for winter-run, without sacrificing carryover storage in the fall.

Actions:

1) Reclamation shall make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin at least as conservative as the 90 percent probability of exceedence. Subsequent updates of water delivery commitments must be based on monthly forecasts at least as conservative as the 90 percent probability of exceedence.

    a) Reclamation shall provide the draft February forecast, and a projection of temperature management operations for the summer months, to NMFS no later than seven business days after receipt of the official DWR runoff forecast.
    b) NMFS shall be provided at 3 three business days to review the draft forecast.
    c) NMFS shall review the draft February forecast to determine whether the predicted delivery schedule is likely to leave sufficient water for temperature management to meet ESA requirements.
    d) NMFS shall provide a written evaluation to Reclamation prior to Reclamation making the first allocation announcements and for each subsequent month for discretionary contract deliveries.
    e) Reclamation shall manage releases from Keswick consistent with the February forecast and subsequent monthly hydrology updates.

2) Reclamation shall make releases to maintain a temperature compliance point not in excess of 56 degrees between Balls Ferry and Bend Bridge from April 15 through May 15.

Action I.2.3.A Implementation Procedures if February Forecast, Based on 90 Percent Hydrology, Shows that Balls Ferry Temperature Compliance Point and 2.2 MAF EOS are Both Achievable

NMFS will review the draft February forecast to determine whether both a temperature compliance point at Balls Ferry during the temperature control season (May – October), and EOS storage of at least 2.2 MAF, is likely to be achieved. If both are likely, then Reclamation shall announce allocations and operate Keswick releases in March, April, and May consistent with its standard plan of operation. Preparation of a separate Keswick release schedule is not necessary in these circumstances.

Rationale: The 90 percent forecast is a conservative approach for assessing the potential to meet both the Balls Ferry TCP and 2.2 MAF EOS performance goals. If both of these performance goals are projected to be met at the time of the February forecast, then no restrictions on allocations due to this suite of actions are necessary.

Action I.2.3.B Implementation Procedures if February Forecast, Based on 90 Percent Hydrology, Shows that Only Balls Ferry Compliance or 2.2 MAF EOS, but Not Both, Is Achievable

1) On or before February 15, Reclamation shall reduce Keswick releases to 3,250 cfs, unless NMFS concurs on an alternative release schedule. This reduction shall be maintained until a flow schedule is developed per procedures below.

2) In coordination with NMFS, by March 1, Reclamation shall develop an initial monthly Keswick release schedule, based on varying hydrology of 50 percent, 70 percent, and 90 percent (similar in format to the fall and winter action implementation procedures – see table above). These schedules shall be used as guidance for monthly updates and consultations.

3) Based on this guidance, Reclamation shall consult with NMFS monthly on Keswick releases. Reclamation shall submit a projected forecast, including monthly average release schedules and temperature compliance point to NMFS every month, within 7 business days of receiving the DWR runoff projections for that month. Within 3 business days of receiving this information from Reclamation, NMFS will review the draft schedule for consistency with the criteria below and provide written recommendations to Reclamation.

4) The initial monthly Keswick release schedule, and subsequent monthly updates, shall be developed based on the following criteria and including the following actions:

a) Maintain minimum monthly average flows necessary to meet nondiscretionary delivery obligations and legal requirements.
b) Provide for flow-related biological needs of spring life stages of all species covered by this Opinion in the Sacramento River and Delta, to the greatest extent possible.
c) If operational changes are necessary to meet Delta outflow, X2, or other legal requirements during this time, then:

- CVP/SWP Delta combined exports shall be curtailed to 2,000 cfs if necessary to meet legal requirements while maintaining a 3,250 cfs Keswick Dam release (or other planned release based on biological needs of species); and
- if it is necessary to curtail combined exports to values more restrictive than 2000 cfs in order to meet Delta outflow, X2, or other legal requirements, then Reclamation and DWR shall, as an overall strategy, first, increase releases from Oroville or Folsom Dam; and
- in general, Reclamation shall increase releases from Keswick Dam as a last resort.
- Based on improvements in updated monthly hydrology, this restriction may be relaxed, with NMFS' concurrence.

Rationale: It is necessary to manage storage for potential dry years, to reduce adverse effects on winter-run egg incubation in summer months, and on spring-run in fall months. According to information provided by Reclamation, the hydrology is too variable this time of year to provide for a meaningful 3-month release schedule. Instead, monthly consultations between NMFS and Reclamation are needed to ensure that operations are based on biological criteria.

Action I. 2.3. C. Drought Exception Procedures if February Forecast, Based on 90 Percent Hydrology, Shows that Clear Creek Temperature Compliance Point or 1.9 MAF EOS Storage is Not Achievable

Reclamation shall follow all procedures immediately above (Action I.2.3.B) and, in addition, shall:

1) By March 1, provide a contingency plan with a written justification that all actions within Reclamation's authorities and discretion are being taken to preserve cold water at Shasta Reservoir for the protection of winter-run.

2) The contingency plan shall also, at a minimum, include the following assessments and actions:

   a) Relaxation of Wilkins Slough navigation criteria to at most 4,000 cfs.
   b) An assessment of any additional technological or operational measures that may be feasible and may increase the ability to manage the cold water pool.
   c) Notification to State Water Resources Control Board that meeting the biological needs of winter-run and the needs of resident species in the Delta, delivery of water to nondiscretionary Sacramento Settlement Contractors, and Delta outflow requirements per D-1641, may be in conflict in the coming season and requesting the Board's assistance in determining appropriate contingency measures, and exercising their authorities to put these measures in place.

3) If, during the temperature control season, a Clear Creek TCP on the Sacramento River cannot be achieved, then Reclamation shall bypass power at Shasta Dam if NMFS determines a bypass is necessary for preserving the cold water pool. This power by-pass may be necessary to maintain temperature controls for winter-run, or later in the temperature season, for spring-run.

Rationale: In these circumstances, there is a one-in-ten likelihood that minimal requirements for winter-run egg survival will not be achieved due to depletion of the cold water pool, resulting in temperature-related mortality of winter-run and, in addition, most likely contributing to temperature-related mortality of spring-run spawning in the fall. This is a conservative forecast, since there is a 90 percent probability that conditions will improve. However, the effects analysis in this Opinion concludes that these poor conditions could be catastrophic to the species, potentially leading to a significant reduction in the viability of winter-run. Delta objectives (salinity, X2, E/I ratio, OMR flow restrictions for both smelt and salmon) are also controlling at this time of year. There is potential for conflict between the need to maintain storage at Shasta and other legal and ecological requirements. Consequently, it is necessary to immediately limit releases from Shasta and develop a contingency plan.

Notification to the State Water Resources Control Board (SWRCB) is essential. Sacramento Settlement Contract withdrawal volumes from the Sacramento River can be quite substantial during these months. The court has recently concluded that Reclamation does not have discretion to curtail the Sacramento Settlement contractors to meet Federal ESA requirements. Therefore, NMFS is limited in developing an RPA that minimizes take to acceptable levels in these circumstances. Consequently, other actions are necessary to avoid jeopardy to the species, including fish passage at Shasta Dam in the long term.

Separate from this consultation, NMFS will work with the SWRCB to determine whether contingency plans within the Board's authority are warranted, and to assist in developing such plans that will allow Reclamation to meet ESA requirements. The incidental take statement for this Opinion also provides limitations of ESA incidental take coverage for Settlement Contractors under the terms of this Opinion.

Action 1.2.4 May 15 Through October Keswick Release Schedule (Summer Action)

Objective: To manage the cold water storage within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat temperatures for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the Sacramento River between Keswick Dam and Bend Bridge, while retaining sufficient carryover storage to manage for next year's cohorts. To the extent feasible, manage for suitable temperatures for naturally spawning fall-run.

Action: Reclamation shall develop and implement an annual Temperature Management Plan by May 15 to manage the cold water supply within Shasta Reservoir and make cold water releases from Shasta Reservoir and Spring Creek to provide suitable temperatures for listed species, and, when feasible, fall-run.

Reclamation shall manage operations to achieve daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows:

1) Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and not in excess of 56°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31 for protection of mainstem spring run, whenever possible.

2) Reclamation shall operate to a final Temperature Management Plan starting May 15 and ending October 31.

3) As part of the adaptive management process, and in coordination with NMFS, by March 2010, Reclamation shall fund an independent modeler to review these procedures and the recommendations of the Calfed Science Panel report on temperature management and recommend specific refinements to these procedures to achieve optimal temperature management, with due consideration of the Calfed Science panel's recommendations (Deas *et al*., 2009) regarding temperature management. Upon written concurrence of

NMFS, refinements to the implementation procedures for this action suite, based on the independent contractor's report, may be adopted and implemented.

Implementation Procedures: Reclamation shall take the following steps to develop an annual Temperature Management plan:

1) By April 15, Reclamation shall develop and submit to NMFS both 50 percent and 90 percent forecasts, consistent with its draft plan of summer operations. Reclamation shall model two complete runs for each forecast, one with an upstream TCP and one with a downstream TCP. Together, Reclamation will present four risk-management options to NMFS for review. EOS Storage will be projected for each of the four runs. If it is very wet or very dry, there will be fewer options to present to NMFS.
2) NMFS will provide comments within five business days to Reclamation, recommending that Reclamation either: (1) operate to one of the options; or (2) develop an alternative operations plan necessary to meet reasonably attainable preferred TCP and EOS storage.
3) Within five business days of receiving NMFS' recommendations, and based on NMFS' comments, Reclamation will develop an operations plan with specific monthly average Keswick releases to attain both TCP from May 15 through the EOS and EOS storage, and submit the plan to NMFS for concurrence.
4) By May 15, Reclamation and NMFS shall jointly submit a final Temperature Management Plan to meet the SWRCB 90-5 requirements using the SRTTG. From May 15 through October 31, the SRTTG shall track implementation of this plan, and shall refine it based real-time information, including run timing, location of redds, air and surface water temperature modeling, and projected versus actual extent of the cold water pool. Any disagreement at the work group level regarding how to implement or modify the plan will be elevated to NMFS and resolved through WOMT standard operating procedures.

Rationale: Depending on hydrology and air temperature, from May through October, it is necessary to use the cold water pool in Shasta Reservoir to provide cold water releases to maintain suitable water temperatures for listed anadromous fish below Shasta. Without access to the cold water pool, suitable temperatures for egg incubation are not attainable. Preparation of an annual Temperature Management Plan allows Reclamation, in consultation with NMFS, to achieve optimal cold water management in a given year. Temperature management requires tradeoffs between extending the range of suitable habitat by moving the compliance point downstream from Balls Ferry, and conserving EOS storage. The storage level at the EOS is important to manage the risk of unsuitably warm water temperatures for winter-run in the following summer. Maintaining suitable temperatures in September and October is also important to minimize adverse effects of project operations to main stem Sacramento River spring-run. Fall-run, a non-listed species that is important as a prey base for Southern Resident Killer Whale, also benefits from suitable temperatures in the Fall.

Development of 2 to 4 options for temperature management, prior to finalizing a plan allows for meaningful discussion of appropriate risk management strategies in a given year, based on timely hydrologic and biological considerations. Important factors differ from year to year, and need to be considered in operations planning. They include the projected size of the winter-run year class (and thus the extent of habitat needed); timing and location of spawning and redds based on aerial surveys; the extent of the cold water pool, given air temperatures; and operation of the Temperature Control Device to provide optimal use of the cold water pool. Preparation of a draft plan also allows for iterative planning and feedback. Operations can be tailored each year to achieve the optimal approach to temperature management to maintain viable populations of anadromous fish, based on the best available information.

The Calfed Science Program peer review report on temperature management emphasized the importance of refining temperature management practices in the long term and included recommendations for doing so. The requirement to hire an independent contractor to recommend specific refinements to the procedures in this RPA responds to these recommendations.

Action I.2.5. Winter-Run Passage and Re-Introduction Program at Shasta Dam

See Fish Passage Program, Action V

Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead

Objective: To partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run to the Battle Creek watershed. A second population of winter-run would reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.

Description of Action: Reclamation shall direct discretionary funds to implement the Battle Creek Salmon and Steelhead Restoration Project. Phase 1A funding is currently allocated through various partners and scheduled to commence in Summer 2009 (Reclamation 2008c). DWR shall direct discretionary funds for Phase 1B and Phase 2, consistent with the proposed amended Delta Fish Agreement by December 31 of each year, Reclamation and DWR will submit a written report to NMFS on the status of the project, including phases completed, funds expended, effectiveness of project actions, additional actions planned (including a schedule for further actions), and additional funds needed. The Battle Creek Salmon and Steelhead Restoration Project shall be completed no later than 2019.

Rationale: Modeling projections in the BA show that adverse effects of ongoing project operations cannot be fully minimized. Severe temperature-related effects due to project operations will occur in some years. This RPA includes an exception procedure in anticipation of these occurrences (see Action I.2.2). Establishing additional populations of winter-run is critical to stabilize the high risk of extinction resulting from the proposed action on the only existing population of this species. $26 million has been identified for this project in the American Recovery and Reinvestment Act of 2009.

Action Suite I.3. Red Bluff Diversion Dam (RBDD) Operations

Objectives: Reduce mortality and delay of adult and juvenile migration of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon caused by the presence of the diversion dam and the configuration of the operable gates. Reduce adverse modification of the passage element of critical habitat for these species. Provide unimpeded upstream and downstream fish passage in the long term by raising the gates year-round, and minimize adverse effects of continuing dam operations, while pumps are constructed replace the loss of the diversion structure.

Action I.3.1. Operations after May 14, 2012: Operate RBDD with Gates Out

Action: No later than May 15, 2012, Reclamation shall operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish. If the Red Bluff Alternative Intake Structure is not anticipated to be operational by May 15, 2012, Reclamation may submit a request to NMFS, no later than January 31, 2012, to close the gates from June 15 to September 1, 2012. This request must document that all milestones for construction of the alternative pumping plant have been met and that all other conservation measures (see below) have been implemented.

Rationale: RBDD impedes and delays upstream migration of adult winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon. It also impedes and delays downstream passage of juveniles of the same species. It adversely modifies critical habitat for these species by impairing important mainstem passage. Pumps can be used to deliver water currently made available by placing gates in the river, and $109 million has been identified in the recent American Recovery and Reinvestment Act of 2009 for the Red Bluff Pumping Plant.

Action I.3.2. Interim Operations

Action: Until May 14, 2012, Reclamation shall operate RBDD according to the following schedule:

- September 1 - June 14: Gates open. No emergency closures of gates are allowed.
- June 15 - August 31: Gates may be closed at Reclamation's discretion, if necessary to deliver water to TCCA.

Rationale: Having gates out until June 15 is necessary for winter-run, spring-run and green sturgeon adult passage to spawning habitat. TCCA can withdraw 465 cfs without the gates in the river. Their water demand typically reaches 800 cfs by June 15, therefore, TCCA will need supplemental pumping capacity to meet water demand until June 15. NMFS has consulted with Reclamation separately on the effects of an interim pumping operation. Implementation of these improvements to passage conditions at RBDD, in conjunction with several other conservation and research measures proposed by TCCA (Appendix 2-B), is expected to reduce the effects of continuing (for the next three years) the (modified) operations of RBDD to a level that will not reduce the likelihood of survival and recovery of these ESUs and DPSs.

Action I.3.3. Interim Operation for Green Sturgeon

Objective: Allow passage of green sturgeon during interim operations.

Action: When gates are in, Reclamation shall retain a minimum 18-inch opening under the gates that are open, to allow safe downstream passage of adult green sturgeon. The 18-inch opening may be modified to 12 inches by the RBDD technical team if necessary to maintain the structural integrity of the dam and/or adequate attraction flows for salmonids at the fish ladders, or in consideration of other real-time fish migratory issues.

Rationale: Twelve to 18 inches is the estimated minimum gate opening that would allow adult green sturgeon to pass downstream underneath the RBDD gates uninjured.

Action I.3.4: Measures to Compensate for Adverse Effects of Interim Operations on Green Sturgeon

Objective: Offset short-term effects to green sturgeon due to interim gate operations by investing in geographically specific research needed to determine green sturgeon life history and recovery needs.

Action: Reclamation shall continue ongoing funded research to characterize green sturgeon populations in the upper Sacramento River Basin, their movements, and habitat usage, as planned through fiscal year 2009. In addition, Reclamation (or TCCA) shall convene a technical team, including representatives from NMFS, CDFG, USFWS, Corps, the University of California at Davis (UCD), and other cooperators, to review studies and results and coordinate research needs for green sturgeon. Reclamation and/or TCCA shall provide the necessary funding to insure that research will continue to be conducted in a coordinated and cooperative manner with the express intent of fully implementing the research projects described in the UCD proposal in Appendix 2-B to this Opinion.

Rationale: The exact timing of spawning migration for green sturgeon is not known, and during interim operations the potential remains for late arriving green sturgeon to be blocked by the dam after June 14. There is also a potential for post-spawn adult migrants and post-hatch juvenile migrants to be adversely affected, since they must pass downstream through the narrow clearance and high turbulence caused by the closed dam gates between June 14 and August 31.

Although the proposed studies will not directly benefit the green sturgeon that will be impacted by the dam during the interim period before the gates are permanently lifted, these studies will greatly benefit the Southern DPS of green sturgeon as a whole by revealing important information that will improve their likelihood of survival and recovery over the long term. The studies will provide vital information on the life history and biological requirements of green sturgeon, which will allow NMFS to develop and implement a comprehensive and effective recovery plan for the DPS. By combining these long-term benefits to the survival and recovery of the Southern DPS of green sturgeon with the other significant improvements to habitat conditions required within this RPA (reduced gates-in periods, increased minimum gate openings, improved water temperature conditions for spawning and rearing, improved migration and rearing conditions in the lower river and Delta), the full implementation of this RPA is expected to offset the effects of continuing (for the next three years) the (modified) operations of RBDD to a level that will not reduce the likelihood of survival and recovery of the green sturgeon DPSs.

Action I.3.5. Measures to Compensate for Adverse Effects of Interim Operations on Spring-Run

Objective: Offset unavoidable short-term effects to spring-run from passage impediments of RBDD by restoring spring-run passage elsewhere in the Sacramento River system.

Action: Reclamation shall provide $500,000 for implementation of spring- run passage improvement projects in the Sacramento River. Appendix 2-B describes specific projects that may be implemented. By December 15, 2009, Reclamation shall provide NMFS with a prioritized list of projects from Appendix 2-B and an implementation schedule. Reclamation shall provide an annual report to NMFS on implementation and effectiveness of projects. Reclamation shall monitor and maintain these projects for five years.

Rationale: During interim operations, late arriving spring-run may be adversely affected by the dam after June 14. Construction and maintenance of the interim pumping facility also may have short-term adverse effects on spring-run.

The proposed passage restoration projects are likely to benefit the spring-run ESU as a whole by improving access to spawning habitat for some of the key populations within the ESU. Although the proposed improvements will not provide passage benefits to the small dependent populations that spawn upstream of RBDD, they will benefit the large independent populations that spawn in downstream tributaries. Passage improvements for the large independent population, in turn, will benefit the smaller populations throughout the Central Valley that depend on these larger populations to supplement their numbers and genetic diversity.

Action I.4. Wilkins Slough Operations

Objective: Enhance the ability to manage temperatures for anadromous fish below Shasta Dam by operating Wilkins Slough in the manner that best conserves the dam's cold water pool for summer releases.

Action: Reclamation shall convene the SRTTG to review past operational data, hydrology, and fisheries needs for Wilkins Slough. The SRTTG shall recommend Wilkins Slough minimum flows for anadromous fish in critically dry years, in lieu of the current 5,000 cfs navigation criterion. Recommendations shall be made to NMFS by December 1, 2009. The recommendations will be implemented upon NMFS' concurrence.

In years other than critically dry years**,** the need for a variance from the 5,000 cfs navigation criterion will be considered during the process of developing the Keswick release schedules (Action I.2.2-4).

Rationale: In some circumstances, maintaining the Wilkins Slough navigation channel at 5,000 cfs may be a significant draw on Shasta reservoir levels and affect the summer cold water pool necessary to maintain suitable temperatures for winter-run egg incubation and emergence. Reclamation has stated that it is no longer necessary to maintain 5,000 cfs for navigation (CVP/SWP operations BA, page 2-39). Operating to a minimal flow level based on fish needs, rather than on outdated navigational requirements, will enhance the ability to use cold-water releases to maintain cooler summer temperatures in the Sacramento River.

Action I.5. Funding for CVPIA Anadromous Fish Screen Program (AFSP)

Objective: To reduce entrainment of juvenile anadromous fish from unscreened diversions.

Action: Reclamation shall screen priority diversions as identified in the CVPIA AFSP, consistent with previous funding levels for this program. In addition, Reclamation/CVPIA Program shall evaluate the potential to develop alternative screened intakes that allow diverters to withdraw water below surface levels required by the antiquated Wilkins Slough navigation requirement criterion of 5,000 cfs.

Rationale: Approximately ten percent of 129 CVP diversions listed in Appendix D-1 of the CVP/SWP operations BA are currently screened. Of these, most of the largest diversions (greater than 250 cfs) have already been screened; however, a large number of smaller diversions (less than 250 cfs) remain unscreened or do not meet NMFS fish screening criteria (NMFS 1997; *e.g.,* CVP and SWP Delta diversions, Rock Slough diversion). The AFSP has identified priorities for screening that is consistent with the needs of listed fish species. Screening will reduce the loss of listed fish in water diversion channels. In addition, if new fish screens can be extended to allow diversions below 5,000 cfs at Wilkins Slough, then cold water can be conserved during critically dry years at Shasta Reservoir for winter-run and spring-run life history needs.

Action Suite I.6: Sacramento River Basin Salmonid Rearing Habitat Improvements

Objective: To restore floodplain rearing habitat for juvenile winter-run, spring-run, and CV steelhead in the lower Sacramento River basin, to compensate for unavoidable adverse effects of project operations. This objective may be achieved at the Yolo Bypass, and/or through actions in other suitable areas of the lower Sacramento River.

The suite of actions includes near term and long-term actions. The near-term action (Action I.6.2) is ready to be implemented and can provide rearing benefits within two years of issuing this Opinion. The long-term actions (Actions I.6.1, I.6.3, and I.6.4) require additional planning and coordination over a five- to ten-year time frame.

These actions are consistent with Reclamation's broad authorities in CVPIA to develop and implement these types of restoration projects. When necessary to achieve the overall objectives of this action, Reclamation and DWR, in cooperation with other agencies and funding sources, including the Delta Fish Agreement and any amendments, shall: (1) apply for necessary permits; (2) seek to purchase land, easements, and/or water rights from willing sellers; (3) seek additional authority and/or funding from Congress or the California State Legislature, respectively; and (4) pursue a Memorandum of Agreement with the Corps.

Similar actions addressing rearing and fish passage are under consideration in the BDCP development process and may ultimately satisfy the requirements in Actions I.6 and I.7. BDCP is scheduled to be completed by December 31, 2010.

Action I.6.1. Restoration of Floodplain Rearing Habitat

Objective: To restore floodplain rearing habitat for juvenile winter-run, spring-run, and CV steelhead in the lower Sacramento River basin. This objective may be achieved at the Yolo Bypass, and/or through actions in other suitable areas of the lower Sacramento River.

Action: In cooperation with CDFG, USFWS, NMFS, and the Corps, Reclamation and DWR shall, to the maximum extent of their authorities (excluding condemnation authority), provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type. In the event that this action conflicts with Shasta Operations Actions I.2.1 to I.2.3, the Shasta Operations Actions shall prevail.

Implementation procedures: By December 31, 2011, Reclamation and DWR shall submit to NMFS a plan to implement this action. This plan should include an evaluation of options to: (1) restore juvenile rearing areas that provide seasonal inundation at appropriate intervals, such as areas identified in Appendix 2-C or by using the Sacramento River Ecological Flow Tool (ESSA/The Nature Conservancy 2009) or other habitat modeling tools; (2) increase inundation of publicly and privately owned suitable acreage within the Yolo Bypass; (3) modify operations of the Sacramento Weir (which is owned and operated by the Department of Water Resources) or Fremont Weir to increase rearing habitat; and (4) achieve the restoration objective through other operational or engineering solutions. An initial performance measure shall be 17,000-20,000 acres (excluding tidally-influenced areas), with appropriate frequency and duration. This measure is based on the work by Sommer *et al*. (2001, 2004) at Yolo Bypass and on recent analyses conducted for the BDCP process of inundation levels at various river stages. (BDCP Integration Team 2009).[28] The plan may include a proposal to modify this performance measure, based on best available science or on a scientifically based adaptive management process patterned after Walters (1997).

This plan also shall include: (1) specific biological objectives, restoration actions, and locations; (2) specific operational criteria; (3) a timeline with key milestones, including restoration of significant acreage by December 31, 2013; (4) performance goals and associated monitoring, including habitat attributes, juvenile and adult metrics, and inundation depth and duration criteria; (5) specific actions to minimize stranding or migration barriers for juvenile salmon; and (6) identification of regulatory and legal constraints that may delay implementation, and a strategy to address those constraints. Reclamation and DWR shall, to the maximum extent of their authorities and in cooperation with other agencies and funding sources, implement the plan upon completion, and shall provide annual progress reports to NMFS. In the event that less than one half of the total acreage identified in the plan's performance goal is implemented by 2016, then Reclamation and DWR shall re-initiate consultation.

The USFWS' Delta smelt biological opinion includes an action to restore 8,000 acres of tidal habitat for the benefit of Delta smelt. If these 8,000 acres also provide suitable rearing habitat for salmonids, they may be used in partial satisfaction of the objective of this action.

This action is not intended to conflict with or replace habitat restoration planning in the BDCP process.

Rationale: Rearing and migration habitats for all anadromous fish species in the Sacramento basin are in short supply. Project operations limit the availability of such habitats by reducing the frequency and duration of seasonal over-bank flows as a result of flood management and storage operational criteria. Recent evaluations on the Yolo Bypass and Cosumnes River have shown that juvenile Chinook salmon grow faster when seasonal floodplain habitats are available (Sommer *et al*. 2001, 2005; Jeffres *et al.* 2008). Sommer *et al.* (2005) suggest these floodplain benefits are reflected in adult return rates. This action is intended to offset unavoidable adverse effects to rearing habitat and juvenile productivity of winter-run, spring-run, and CV steelhead in the Sacramento River basin, by increasing available habitat that is inundated with the frequency and duration of suitable floodplain rearing habitats during December through April.

In high flow years (*e.g.*, similar to 1998), this action can be achieved solely by inundation of the Yolo Bypass. In other years, this action may be accomplished by a combination of actions such as increasing the year-to-year inundation frequency of existing floodplains such as portions of the Yolo Bypass, by restoring rearing habitat attributes to suitable areas, through restoration or enhancement of intertidal areas such as Liberty Island, creation or re-establishment of side channels, and re-created floodplain terrace areas.

[28] The analyses assumed a notch in the Fremont Weir.

Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass

Description of Action: By September 30, 2010, Reclamation and/or DWR shall take all necessary steps to ensure that an enhancement plan is completed and implemented for Liberty Island/Lower Cache Slough, as described in Appendix 2-C. This action shall be monitored for the subsequent five years, at a minimum, to evaluate the use of the area by juvenile salmonids and to measure changes in growth rates. Interim monitoring reports shall be submitted to NMFS annually, by September 30 each year, and a final monitoring report shall be submitted on September 30, 2015, or in the fifth year following implementation of enhancement actions. NMFS will determine at that time whether modification of the action or additional monitoring is necessary to achieve or confirm the desired results. This action shall be designed to avoid stranding or migration barriers for juvenile salmon.

Action I.6.3. Lower Putah Creek Enhancements

Description of Action: By December 31, 2015, Reclamation and/or DWR shall develop and implement Lower Putah Creek enhancements as described in Appendix 2-C, including stream realignment and floodplain restoration for fish passage improvement and multi-species habitat development on existing public lands. By September 1 of each year, Reclamation and/or DWR shall submit to NMFS a progress report towards the successful implementation of this action. This action shall not result in stranding or migration barriers for juvenile salmon.

Action I.6.4. Improvements to Lisbon Weir

Action: By December 31, 2015, Reclamation and/or DWR shall, to the maximum extent of their authorities, assure that improvements to the Lisbon Weir are made that are likely to achieve the fish and wildlife benefits described in Appendix 2-C. Improvements will include modification or replacement of Lisbon Weir, if necessary to achieve the desired benefits for fish. If neither Reclamation nor DWR has authority to make structural or operational modifications to the weir, they shall work with the owners and operators of the weir to make the desired improvements, including providing funding and technical assistance. By September 1 of each year, Reclamation and/or DWR shall submit to NMFS a report on progress toward the successful implementation of this action. Reclamation and DWR must assure that this action does not result in migration barriers or stranding of juvenile salmon.

Rationale for Actions I.6.2 to I.6.4: These actions have been fully vetted by CDFG and found to be necessary initial steps in improving rearing habitat for listed species in the lower Sacramento River basin. These improvements are necessary to off-set ongoing adverse effects of project operations, primary due to flood control operations. Additional descriptions of these actions are contained in the draft amendment to the Delta Fish Agreement (CVP/SWP operations BA appendix Y).

Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass

Objective: Reduce migratory delays and loss of adult and juvenile winter-run, spring-run, CV steelhead and Southern DPS of green sturgeon at Fremont Weir and other structures in the Yolo Bypass.

Description of Action: By December 31, 2011, as part of the plan described in Action I.6.1, Reclamation and/or DWR shall submit a plan to NMFS to provide for high quality, reliable migratory passage for Sacramento Basin adult and juvenile anadromous fishes through the Yolo Bypass. By June 30, 2011, Reclamation and/or DWR shall obtain NMFS concurrence and, to the maximum extent of their authorities, and in cooperation with other agencies and funding sources, begin implementation of the plan, including any physical modifications. By September 30, 2009, Reclamation shall request in writing that the Corps take necessary steps to alter Fremont Weir and/or any other facilities or operations requirements of the Sacramento River Flood Control Project or Yolo Bypass facility in order to provide fish passage and shall offer to enter into a Memorandum of Understanding, interagency agreement, or other similar mechanism, to provide technical assistance and funding for the necessary work. By June 30, 2010, Reclamation shall provide a written report to NMFS on the status of its efforts to complete this action, in cooperation with the Corps, including milestones and timelines to complete passage improvements.

Reclamation and/or DWR shall assess the performance of improved passage and flows through the bypass, to include an adult component for salmonids and sturgeon (*i.e.,* at a minimum, acoustic receivers placed at the head and tail of the bypass to detect use by adults).

Rationale: The Yolo Bypass and Fremont Weir has been a documented source of migratory delay to, and loss of, adult winter-run, spring-run, CV steelhead and Southern DPS of green sturgeon. The existing fish passage structure is inadequate to allow normal passage at most operational levels of the Sacramento River. The project agencies must work with the Corps, which owns and operates Fremont Weir, to achieve improvements for fish. Other structures within the Yolo Bypass, such as the toe drain, Lisbon Weir, and irrigation dams in the northern end of the Tule Canal, also can impede migration of adult anadromous fish. Additionally, stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas. This action offsets unavoidable project effects on adult migration and minimizes the direct losses from flood management activities associated with operations.

II. AMERICAN RIVER DIVISION

Introduction to American River Actions: The CV steelhead DPS is the only species addressed in this Opinion with a spawning population in the American River. The DPS includes naturally spawned steelhead in the American River (and other Central Valley stocks) and excludes steelhead spawned and reared at Nimbus Fish Hatchery. The in-river population is small, with observations of a few hundred adults returning to spawn in the American River each year. Limited observations made in 2003, 2004, 2005, and 2007 of whether in-river spawners were adipose fin-clipped or not indicate that some in-river spawners are of wild origin (Hannon and Deason 2008). This suggests that the listed stock has some ability to survive habitat conditions in the American River, Delta, and Ocean, even in their degraded state as described in preceding sections of this Opinion.

The in-river population is likely entirely made up of Nimbus Fish Hatchery steelhead or their descendents. Early Nimbus Fish Hatchery broodstock included naturally produced fish from the American River and stocks from the Washougal (Washington), Siletz (Oregon), Mad, Eel, Sacramento and Russian rivers, with the Eel River stock being the most heavily used (Staley 1976, McEwan and Jackson 1996).

Even though the American River steelhead population is small and is entirely influenced by hatchery fish with out-of-basin genetics, NMFS views the population as being important to the survival and recovery of the species. CV TRT shares this view by recommending that, "*every extant population be viewed as necessary for the recovery of the ESU"* (Lindley *et al.,* 2007). In addition, the steelhead population has presumably become somewhat locally adapted to the American River, and it has potential to substantially contribute to the viability of the DPS if water, habitat, and hatchery management efforts are coordinated and directed at achieving such a goal.

Key proposed project-related stressors include: (1) the provision of water temperatures warmer than steelhead life stage-specific requirements; (2) flow fluctuations that dewater redds, strand fry, and isolate fry and juveniles in off-channel pools where they are vulnerable to both predation and exposure to lethal and sub-lethal water temperatures; and (3) low flows limiting the availability of quality rearing habitat including predator refuge habitat.

The most influential baseline stressor to steelhead within the American River Division is the presence of Nimbus and Folsom dams, which block steelhead from all of their historic spawning and rearing habitat. This Opinion concludes that both increased water demands and effects of climate change will lead to further deterioration of suitable habitat conditions, including increased temperatures and decreased flows. Therefore, a passage program to expand the range of the American River steelhead population above Folsom Dam is necessary. If feasible, American River steelhead should be provided access to their full historic range. Given the long-term duration associated with the fish passage actions (see Fish Passage Program below, in Action V), it is necessary to plan and implement actions targeted at improving steelhead habitat below Nimbus Dam. NMFS concludes that coordinated management in four realms - water operations and associated structures, American River habitat, Nimbus Fish Hatchery operations, and in-river harvest – will substantially lower the extinction risk of American River steelhead

Action II.1. Lower American River Flow Management

Objective: To provide minimum flows for all steelhead life stages.

Action: Implement the flow schedule specified in the Water Forum's[29] Flow Management Standard (FMS), which is summarized in Appendix 2-D of this Opinion. The FMS flow schedule has been developed by the Water Forum, Reclamation, USFWS, NMFS, and CDFG in order to establish required minimum flows for anadromous salmonids in the lower American River. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam.

Reclamation shall ensure that flow, water temperature, steelhead spawning, and steelhead rearing monitoring is conducted annually in order to help inform the ARG process and to evaluate take associated with flow fluctuations and warm water temperatures. Steelhead monitoring surveys should follow the objectives and protocols specified in the FMS Monitoring and Evaluation Program relating to steelhead spawning and rearing.

Implementation procedures: Reclamation shall convene the American River Group (ARG), comprised of representatives from Reclamation, NMFS, USFWS, CDFG and the Water Forum, to make recommendations for management within the constraints of the FMS. If there is a lack of consensus, ARG shall advise NMFS, and NMFS will make a recommendation to the WOMT for a decision.

Rationale: Reclamation operates Folsom Dam and Reservoir to provide water for irrigation, municipal and industrial uses, hydroelectric power, recreation, water quality, flood control, and fish protection. Reclamation operates Folsom Dam and Reservoir under a state water right permit and fish protection requirements that were adopted in 1958 as SWRCB Decision 893 (D-893). This decision allows flows at the mouth of the American River to fall as low as 250 cfs from January through mid-September, with a minimum of 500 cfs required between September 15 and December 31.

Biological, socioeconomic, legal, and institutional conditions have changed substantially since the SWRCB adopted D-893 in 1958. For example, D-893 does not address requirements of the CVPIA, the 1995 Bay Delta Plan, or previous Opinions to protect Central Valley anadromous salmonids. The SWRCB, Reclamation and many diverse stakeholders (*e.g.*, Water Forum) involved in various American River actions have agreed that the conditions specified in D-893 are not sufficiently protective of the fishery resources within the lower American River.

The flow schedule specified in Appendix 2-D was developed to require more protective minimum flows in the lower American River in consideration of the river's aquatic resources, particularly steelhead and fall-run.

The monitoring called for in this RPA action including flow, water temperature, steelhead spawning, and steelhead rearing monitoring is necessary for the ARG to responsibly carry

[29] In September 1993, the Water Forum, a diverse group of business and agricultural leaders, citizens groups, environmentalists, water managers, and local governments in the Sacramento Region, was formed to evaluate water resources and future water supply needs of the Sacramento metropolitan region.

out this mission. In addition, this monitoring is necessary to evaluate take associated with American River Division operations.

Action II.2. Lower American River Temperature Management

Objective: Maintain suitable temperatures to support over-summer rearing of juvenile steelhead in the lower American River.

Action: Each year, Reclamation shall prepare a draft Operations Forecast and Temperature Management Plan based on forecasted conditions and submit the draft Plan to NMFS for review by May 1 of each year. The information provided in the Operations Forecast will be used in the development of the Temperature Plan. The draft plan shall contain: (1) forecasts of hydrology and storage; (2) a modeling run or runs, using these forecasts, demonstrating that the temperature compliance point can be attained (see Coldwater Management Pool Model approach in Appendix 2-D); (3) a plan of operation based on this modeling run that demonstrates that all other non-discretionary requirements are met; and (4) allocations for discretionary deliveries that conform to the plan of operation. Reclamation shall use an iterative approach, varying proposed operations, with the objective to attain the temperature compliance point at Watt Avenue Bridge. Within ten calendar days of receiving the draft Temperature Plan, NMFS will provide a written review of this plan for the purpose of determining whether requirements in this Opinion are likely to be met. Reclamation shall produce a final plan prior to May 15 deliveries and implement the plan upon finalization. Reclamation may update the plan every month based on hydrology and must seek NMFS' concurrence on proposed deviations from the plan that may reduce the likelihood that the temperature objective will be met.

Temperature Requirement: Reclamation shall manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower American River. If this temperature is exceeded for three consecutive days, or is exceeded by more than 3°F for a single day, Reclamation shall notify NMFS in writing and will convene the ARG to make recommendations regarding potential cold water management alternatives to improve water temperature conditions for fish, including potential power bypasses. If there is a lack of consensus on actions to be taken, the ARG shall advise NMFS and be elevated through the WOMT standard operating procedures.

Exception: When preparing the Operations Forecast and Temperature Management Plan, Reclamation may submit to NMFS a written determination that, after taking all actions within its authorities, it is unlikely to meet the above temperature requirement. This determination must be supported by specific iterative modeling techniques that vary allocations and delivery schedules such as application of the Coldwater Management Pool model (see Appendix 2-D). In the event that Reclamation determines that other nondiscretionary requirements (*e.g.*, D-1641 or requirements of the USFWS' Delta smelt biological opinion) conflict with attainment of the temperature requirement, Reclamation will convene the ARG to obtain recommendations. If consensus cannot be achieved within the ARG, the ARG shall advise NMFS, and NMFS will make a recommendation to the WOMT, per standard operating procedures.

During the May 15 to October 31 period, when the 65°F temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (*i.e.*, no more than one degree Fahrenheit every 12 hours) to as high as 68°F.

The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for steelhead, and thereafter may also be used to provide cold water for fall-run spawning.

Rationale: As demonstrated in section 6.4 of this Opinion, steelhead are frequently exposed to water temperatures warmer than required for juvenile rearing, resulting in reduced fitness as is evident through the expression of visible thermal stress symptoms (*i.e.*, bacterial inflammations). This thermal stress decreases steelhead immune system function and increases steelhead vulnerability to other sources of sub-lethal and lethal effects such as disease and predation. Monitoring of juvenile steelhead conducted by CDFG showed that bacterial inflammation was prevalent in steelhead throughout the river and the frequency of its occurrence increased as the duration of exposure to water temperatures over 65°F increased. The 65°F or lower daily average water temperature target was identified based on CDFG's monitoring as well as published scientific literature. Based on past convention of the ARG, the temperature compliance point is maintained at Watt Avenue Bridge, even though suitable rearing habitat is between Watt Avenue and Nimbus Dam.

Action II.3. Structural Improvements

Objective: Improve the ability to manage the cold water pool to provide suitable temperatures for listed fish through physical and structural improvements at the dams.

Action: Reclamation shall evaluate physical and structural modifications that may improve temperature management capability, as detailed below. Upon completion of the evaluation, Reclamation shall select the most promising projects and shall submit, by June 30^{th} 2010, a proposed plan to NMFS to implement selected projects. Reclamation shall seek NMFS' concurrence that the proposed projects are likely to be effective in reducing adverse effects of warm water temperatures on listed fish. With NMFS' concurrence, Reclamation shall implement selected projects by December 15, 2012.

Modifying the following structures may substantially improve the ability to manage temperature in the Lower American River to reduce adverse effects of unsuitably warm water on listed species. The comparative benefits and costs of alternative modifications that will achieve objectives have not been fully analyzed. Reclamation shall analyze alternatives for each of the objectives listed below and shall implement the most effective alternative(s) for each objective:

1) **Folsom Dam temperature control device.** The objective of this action is to improve access to and management of Folsom Reservoir's cold water pool. Alternatives include enhancement of the existing shutters, replacement of the shutter system, and construction of a device to access cold water below the penstocks. If neither Reclamation nor DWR has authority to make structural or operational modifications to the control device, they shall seek to enter into an MOU with the Army Corps of Engineers to utilize their existing authorities.

2) **Cold water transport through Lake Natoma.** The objective of this action is to transfer cold water from Folsom Dam to Nimbus Dam with minimal increase in temperature. Alternatives include dredging, construction of temperature curtains or pipelines, and changes in Lake Natoma water surface elevation.

3) **El Dorado Irrigation District Temperature Control Device (EID TCD).** The objective of this action is to conserve cold water in Folsom Lake. Alternative intake structures have been analyzed by EID. The most effective device for conserving cold water should be constructed. If neither Reclamation nor DWR has authority to make structural or operational modifications to the EID TCD, they shall work with the owners and operators of the TCD to make the desired improvements, including providing funding and technical assistance

4) **Temperature Management Decision-Support Tools.** The objective of this action is to provide effective tools to make transparent temperature management decisions. Alternatives include decision impact analyses, regular analysis of a broad array of operational scenarios, improved operations group processes, and monitoring.

Rationale: Maintaining suitable water temperatures for all life history stages of steelhead in the American River is a chronic issue because of operational (*e.g.*, Folsom Reservoir operations to meet Delta water quality objectives and demands and deliveries to M&I users in Sacramento County) and structural (*e.g.*, limited reservoir water storage and coldwater pool) factors. Increased water demand and climate change will lead to further deterioration of suitable habitat conditions, including increased temperatures. Action II.2 provides for a temperature management plan to minimize operational effects to steelhead using current technology. However, the current technology is out-dated resulting in less than optimal ability to access and fully utilize cold water in any given hydrology or ambient temperature regime. Alternative technologies have been studied previously, but not funded or implemented. Because of the significant temperature related effects that will persist despite implementation of Action II.2, all feasible technological options should be pursued. These technological actions will increase the likelihood that temperate control points will be attained, as prescribed in Action II-2, and therefore American River water temperatures will be suitable for steelhead more frequently.

Action II.4. Minimize Flow Fluctuation Effects

Objective: Reduce stranding and isolation of juvenile steelhead through ramping protocols.

Action: The following flow fluctuation objectives shall be followed:

1) From January 1 through May 30, at flow levels <5,000 cfs, flow reductions shall not exceed more than 500 cfs/day and not more than 100 cfs per hour.

2) From January 1 through May 30, Reclamation shall coordinate with NMFS, CDFG, and USFWS to fund and implement monitoring in order to estimate the incidental take of salmonids associated with reductions in Nimbus Dam releases.

3) Minimize the occurrence of flows exceeding 4,000 cfs throughout the year, except as may be necessary for flood control or in response to natural high precipitation events.

Rationale: Flow fluctuations in the lower American River have been documented to result in steelhead redd dewatering and isolation (Hannon *et al.,* 2003, Hannon and Deason 2008), fry stranding, and fry and juvenile isolation (Water Forum 2005a). By limiting the rate of flow reductions, the risk of stranding and isolating steelhead is reduced. Two lower American River habitat evaluations indicate that releases above 4,000 cfs inundate several pools along the river that are isolated at flows below this threshold (CDFG 2001, Hall and Healey 2006). Thus, by maintaining releases below 4,000 cfs the risk of isolating juvenile steelhead is reduced.

Action II.5. Fish Passage at Nimbus and Folsom Dams

Objective: Provide access for steelhead to historic cold water habitat above Nimbus and Folsom dams.

Action: See Fish Passage Program, Action V.

Rationale: The effects analysis in this Opinion leads to the conclusion that steelhead will continue to be vulnerable to serious effects of elevated temperatures in most years and particularly in dry and critically dry years, even if actions are taken to improve temperature management. The frequency of these occurrences is expected to increase with climate change and increased water demands. Therefore, it is essential to evaluate options for providing steelhead to access their historic cold water habitat above Nimbus and Folsom dams and to provide access if feasible.

Action Suite II.6. Implement the Following Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations

Objective of Actions II.6.1-3: The following actions are identified to offset project effects related to Nimbus Fish Hatchery by reducing introgression of out-of-basin hatchery stock with wild steelhead populations in the Central Valley, including the American River population and other populations in the Sacramento River system (Garza and Pearse 2008). In addition, actions are necessary at both Nimbus and Trinity River fish hatcheries to increase diversity of fall-run production, in order to increase the likelihood of prey availability for Southern Residents and reduce adverse effects of hatchery fall-run straying on genetic diversity of natural fall-run and spring-run.

Action II.6.1. Preparation of Hatchery Genetic Management Plan (HGMP) for Steelhead

Action: Reclamation shall fund CDFG to prepare a complete draft HGMP for steelhead production at Nimbus Fish Hatchery, in accordance with current NMFS guidelines, and submit that draft for NMFS review by June 2011. Specific actions shall include:

1) Reclamation shall fund genetic screening at Nimbus Fish Hatchery for steelhead to determine most appropriate brood stock source. This action shall be completed by March 31, 2012.

2) Reclamation shall fund a study examining the potential to replace the Nimbus Fish Hatchery steelhead broodstock, with genetically more appropriate sources. This action shall be completed by March 31, 2012.

Action II.6.2. Interim Actions Prior to Submittal of Draft HGMP for Steelhead

Action: Reclamation shall use its authorities to ensure that, prior to completion of the draft HGMP, the hatchery is operated according to the following protocols:

1) Release all hatchery-produced steelhead juveniles in the American River at Nimbus Fish Hatchery or at a location in the American River as close to Nimbus Fish Hatchery as is feasible to reduce straying. This action shall be implemented within 30 days of issuance of this Opinion.

2) Release all unclipped steelhead adults returning to Nimbus Fish Hatchery back into the lower American River so they can spawn naturally. This action shall be implemented within 30 days of issuance of this Opinion.

3) Stop inter-basin transfers of steelhead eggs or juveniles to other hatcheries, except upon specific written concurrence of NMFS. This action shall be implemented within 30 days of issuance of this Opinion.

Action II.6.3: Develop and Implement Fall-run Chinook Salmon Hatchery Management Plans for Nimbus and Trinity River Fish Hatcheries

Action: By June 2014, develop and begin implementation of Hatchery Management Plans for fall-run production at Nimbus Fish Hatchery and spring-run and fall-run at Trinity River Fish Hatchery. Reclamation shall fund CDFG to develop and submit draft plans for NMFS review by June 2013. The goal of the plans shall be to reduce impacts of hatchery Chinook salmon on natural fall-run and spring-run, and increase the genetic diversity and diversity of run-timing for these stocks.

Rationale for actions II.6.1-3: Hatcheries have been established on CVP and SWP rivers to offset effects of dams and project operations. Since these hatcheries were initially put into operation, additional knowledge has been developed that has advanced NMFS understanding of how hatchery operations can affect listed and non-listed salmonids. The operations of Nimbus Fish Hatchery and the spring- and fall-run operations of Trinity River Fish Hatchery are inter-related and interdependent to the proposed action.

Nimbus Fish Hatchery steelhead broodstock is predominantly Eel River stock. Maintaining this genetic broodstock has adverse effects on listed steelhead in the CV steelhead DPS (Garza and Pearse 2008). Based on genetics information presented in Garza and Pearse (2008), *O. mykiss* from the American River above Folsom Dam retain ancestral CV steelhead genetics and potentially could provide a broodstock source to replace the current Nimbus Fish Hatchery steelhead broodstock. This would eliminate the spread of Eel River genetics to CV steelhead. An HGMP is necessary to minimize effects of ongoing steelhead hatchery program on steelhead contained within the DPS.

Southern Residents depend on Chinook salmon as prey. Preparation of hatchery management plans for fall-run at Nimbus Fish Hatchery and spring-run and fall-run at Trinity River Fish Hatchery is necessary to reduce operational effects on Southern Residents prey over the long term. Improving the genetic diversity and diversity of run timing of Central Valley fall-run will decrease the potential for localized prey depletions and increase the likelihood that fall-run can withstand stochastic events, such as poor ocean conditions (Lindley *et al.,* 2009), and thereby provide a consistent food source in years with overall poor productivity. .

III. EAST SIDE DIVISION

Introduction to Stanislaus River/Eastside Division Actions: The steelhead population on the Stanislaus River is precariously small and limited to habitat areas below the dams that historically were unsuitable owing to high summer temperatures. All of the four steelhead populations in the Southern Sierra Nevada Diversity Group of the CV steelhead DPS are in similar condition and are not presently considered viable. Using the framework in this Opinion for jeopardy analysis, the DPS is not viable if one of the Diversity Groups is not viable. The overall poor status of the Diversity Group increases the importance of minimizing the effects of project operations on the Stanislaus River population.

Modeled operations suggest that it is possible to operate dams of the Eastside Division in a manner that avoids jeopardy to steelhead; however, if future climate conditions are warmer, drier, or both, summertime temperatures will restrict the extent of suitable habitat for steelhead.

The fundamental operational criteria are sufficiently ill-defined in the CVP/SWP operations BA as to provide limited guidance to the Action Agency on how to operate. This suite of actions provides sufficiently specific operational criteria so that operations will avoid jeopardizing steelhead and will not adversely modify their critical habitat. Operational actions to remove adverse modification of critical habitat include a new flow schedule to minimize effects of flood control operations on functionality of geomorphic flows and access of juvenile steelhead to important rearing areas.

Overall Objectives: (1) Provide sufficient definition of operational criteria for Eastside Division to ensure viability of the steelhead population on the Stanislaus River, including freshwater migration routes to and from the Delta; and (2) halt or reverse adverse modification of steelhead critical habitat.

Overall Rationale: Sufficient uncertainty exists as to whether VAMP pulse flows and b(2) allocations are reasonably likely to occur in the future. VAMP, as defined by the SJRA, is due to expire in 2011. The BA commits to subsequent flows similar to VAMP ("Vamp-like flows"), but this is a very vague commitment. The project description does not define the particular contribution, timing, duration, or magnitude of these flows from the tributaries that contribute to VAMP, including the Stanislaus River. In addition, the BA specifies the amount of water designated to offset VAMP export curtailments as 48 TAF; but the need, based on past performance, has varied from approximately 45 to 150 TAF. Additional demands for smelt protection and future drainage settlement terms are being placed on b(2) water, and it is uncertain that b(2) water will be available consistently in each year in the quantity, duration, and timing needed for CV steelhead in the Stanislaus River. The annual water contract allocation process from New Melones is inadequately defined in the project description to assure the proposed action will not prevent the establishment of a viable population of steelhead.

Action III.1.1. Establish Stanislaus Operations Group for Real-Time Operational Decision-Making as Described in These Actions and Implementation Procedures

> **Action:** Reclamation shall create a SOG to provide a forum for real-time operational flexibility implementation of the alternative actions defined in this RPA and for clarification of decision-making processes regarding other allocations of the NMTP. This group shall include Reclamation, NMFS, USFWS, DWR, CDFG, SWRCB, and outside expertise at the discretion of NMFS and Reclamation. This group shall provide direction and oversight to ensure that the East Side Division actions are implemented, monitored for effectiveness and evaluated. Reclamation, in coordination with SOG, shall submit an annual summary of the status of these actions. See introduction to RPA for further information on group procedures.

Action III.1.2. Provide Cold Water Releases to Maintain Suitable Steelhead Temperatures

> **Action**: Reclamation shall manage the cold water supply within New Melones Reservoir and make cold water releases from New Melones Reservoir to provide suitable temperatures for CV steelhead rearing, spawning, egg incubation smoltification, and adult migration in the

Stanislaus River downstream of Goodwin Dam in order to maintain the following temperature compliance schedule:

Criterion and Temperature Compliance Location	Duration	Steelhead Life Stage Benefit
Temperature below 56°F at Orange Blossom Bridge (OBB)	Oct 1*-Dec 31	Adult migration
Temperature below 52 °F at Knights Ferry and 57°F at OBB	Jan 1-May 31	Smoltification
Temperature Below 55°F at OBB	Jan 1-May 31	Spawning and incubation
Temperature below 65°F at OBB	June 1-Sept 30	Juvenile rearing

***This criterion shall apply as of October 1 or as of initiation date of fall pulse flow as agreed to by NMFS**.

Temperature compliance shall be measured based on a seven-day average daily maximum temperature.

Exception: If any of these criteria is or is expected to be exceeded based on a three-day average daily maximum temperature, Reclamation shall immediately notify NMFS of this condition and shall submit to NMFS a written determination that, after taking all actions within its authorities, it is unlikely to meet the above temperature requirement and the extent and duration of the expected exceedance. This determination must be supported by specific iterative modeling techniques that vary allocations and delivery schedules. In the event that Reclamation determines that other nondiscretionary requirements (*e.g*., D-1641 or requirements of the USFWS' Delta smelt biological opinion) conflict with attainment of the temperature requirement, Reclamation will convene SOG to obtain recommendations. If consensus cannot be achieved within SOG, then SOG shall advise NMFS, and NMFS will make a recommendation to WOMT per standard operating procedures.

Rationale: CV steelhead are dependent on East Side Division operations to maintain suitable in-stream temperatures. Operational criteria are not clearly described in the CVP/SWP Operations BA to ensure that appropriate temperatures are met for CV steelhead adult migration, spawning, egg incubation, juvenile rearing, and smoltification. The temperature compliance schedule above provides an operational framework to minimize temperature-related effects of proposed operations in the reaches of the river most used by CV steelhead on a year-round basis. Temperature criteria for adult CV steelhead migration in the lower Stanislaus River are included, as we expect that fall attraction flows will improve downstream temperature conditions for adult migration.

Observations at the fish counting weir on the Stanislaus River indicate that apparent CV steelhead enter the river in October, usually coincident with the release of fall attraction flows that provide cooler water and flow cues for fall-run.

The literature regarding appropriate criteria for smoltification suggests optimal temperatures of less than 52°F (Adams *et al*., 1975, Myrick and Cech 2001) or 57°F (EPA 2001). In order to provide optimal temperatures for smoltification within a feasible operational scenario, the smoltification temperature criteria are lower for Knights Ferry at 52°F and 57°F for Orange Blossom Bridge.

No steelhead spawning surveys have been conducted on the Stanislaus River, but fall-run surveys indicate that spawning may occur from Goodwin Dam (RM 59) almost to the City of Oakdale (RM 40), with the highest use occurring above Knights Ferry (RM 55). Based on observations of trout fry, most spawning occurs upstream of OBB (Kennedy and Cannon 2002). Consequently, specific temperature criteria of 55ºF or less at Riverbank should be met from December through May to ensure that temperatures are suitable for all available spawning habitat, however, modeled results and CDEC data (figure 6-35) indicates that temperatures at Riverbank are likely to exceed this level. Based on observations of trout fry, most spawning occurs upstream of OBB (Kennedy and Cannon 2002). Suitable spawning temperatures are likely to be met at OBB, except in May in critically dry years, and exception procedures will be implemented.

Action III.1.3. Operate the East Side Division Dams to Meet the Minimum Flows, as Measured at Goodwin Dam, Characterized in Figure 11-1, and as Specified in Appendix 2-E

Objective: To maintain minimum base flows to optimize CV steelhead habitat for all life history stages and to incorporate habitat maintaining geomorphic flows in a flow pattern that will provide migratory cues to smolts and facilitate out-migrant smolt movement on declining limb of pulse.

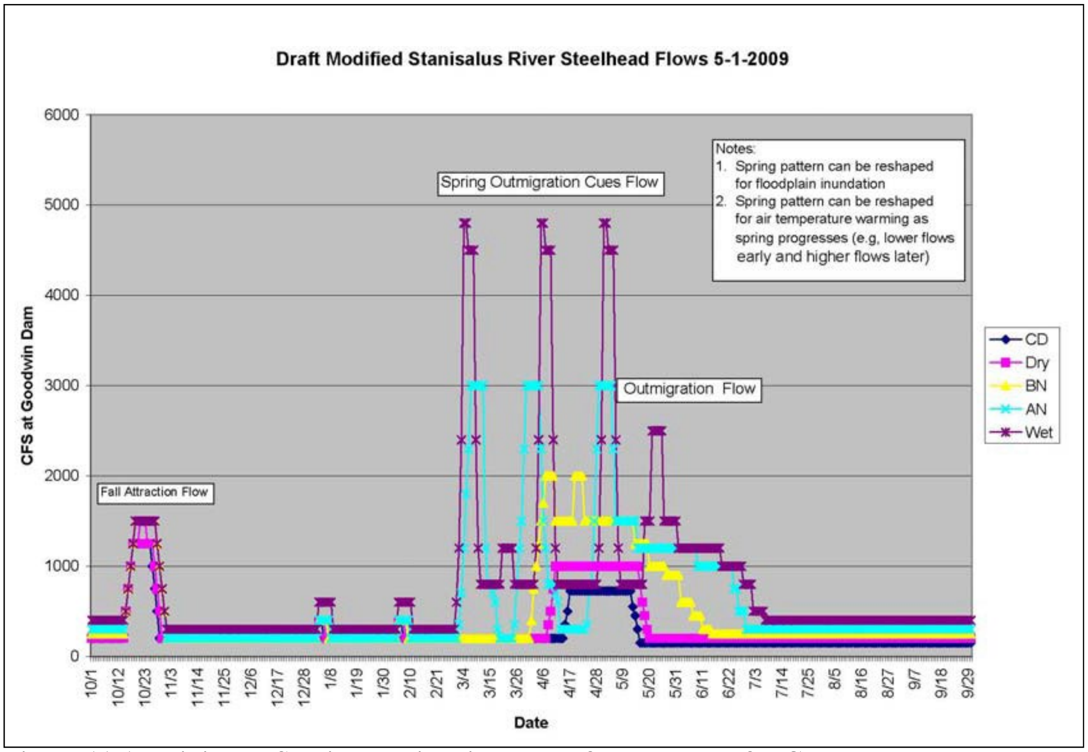


Figure 11-1. Minimum Stanislaus River in-stream flow schedule for CV steelhead as measured at Goodwin Dam

Action: Reclamation shall operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed in Appendix 2-E and generally described in figure 11-1 above. This flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases for other operational criteria. When operating at higher flows than specified, Reclamation shall implement ramping rates for flow changes that will avoid stranding and other adverse effects on CV steelhead. In particular, flows that exceed 800 cfs will inundate known side channels that provide habitat, but that also pose stranding risks. When spring pulses greater than 800 cfs are identified in figure 11-1, the declining limb is not reduced below 800 cfs until the late spring flows occur.

Implementation procedures: Reclamation shall convene the SOG to adaptively manage flows according to this schedule. Specifically, upon the recommendations of the team, Reclamation may execute shorter duration pulses more frequently (*e.g.*, 2 – 4 times) during the longer pulse period. Implementation of this action should be coordinated with allocation of water resources dedicated for fish, such as the 98.3 TAF to CDFG and b(2) or b(3), if applied. The SOG shall follow standard operating procedures resolving any conflict through the WOMT process. The team shall also advise Reclamation on operations needed to minimize the adverse effects of flow fluctuations associated with New Melones Reservoir and Goodwin Dam operations on CV steelhead spawning, egg incubation, and fry and juvenile rearing within the Stanislaus River. If new information is developed, such as an update of Stanislaus River CV steelhead in-stream flow needs, more specific geomorphic analyses regarding channel forming flows, or real-time recommendations from the SOG, Reclamation may submit to NMFS a revised annual minimum flow schedule that may be implemented if NMFS concurs that it is consistent with ESA obligations. These revisions may trigger re-initiation and re-consultation.

Rationale: This flow schedule includes the following components:

1) Minimum base flows based on IFIM (Aceituno 1993) to optimize available CV steelhead habitat for adult migration, spawning, and juvenile rearing. These base flows are scaled to water year type as defined by the Interim Operations Plan (IOP) water supply parameter[30], with lowest flows in critically dry years and highest flows in wet years.

2) Fall pulse flow to improve in-stream conditions sufficiently to attract CV steelhead to the Stanislaus River.

3) Winter instability flows to simulate natural variability in the winter hydrograph and to enhance access to varied rearing habitats.

4) Channel forming and maintenance flows in the 3,000 to 5,000 cfs range in above normal and wet years to maintain spawning and rearing habitat quality. These flows are scheduled to occur after March 1 to protect incubating eggs and are intended to work synergistically with providing outmigration flow cues and late spring flows, described next. These flows are high intensity, but limited duration to avoid potential seepage issues that have been alleged under extended periods of flow greater than 1,500 cfs.

5) Outmigration flow cues to enhance likelihood of anadromy.

6) Late spring flows for conveyance and maintenance of downstream migratory habitat quality in the lowest reaches and into the Delta.

An analysis of Stanislaus River rotary screw trap captures of smolted CV steelhead conducted by Reclamation in April 2009 (Hannon 2009b) identified that the median date for smolt CV steelhead out migration is March 1 (Figure RR- Julian Day 60), ranging from January through June. Juveniles are generally captured in trawls at Mossdale in smolted condition in late May (Julian Day 151 and Figure 4-4). CV steelhead are larger than fall-run smolts and may be less dependent on pulse flows to convey them out of the Stanislaus River, but the variability of pulses provides migratory cues to smolted CV steelhead. Capture information suggests that it is important to maintain suitable migratory conditions from the Stanislaus River to the Delta into the month of June. This action will allow more smolted fish to migrate out of system by extending the declining limb of the outmigration pulse and increasing migratory cues.

[30] The IOP water supply parameter is a function of end of February New Melones Reservoir storage and forecasted inflow from March through September.

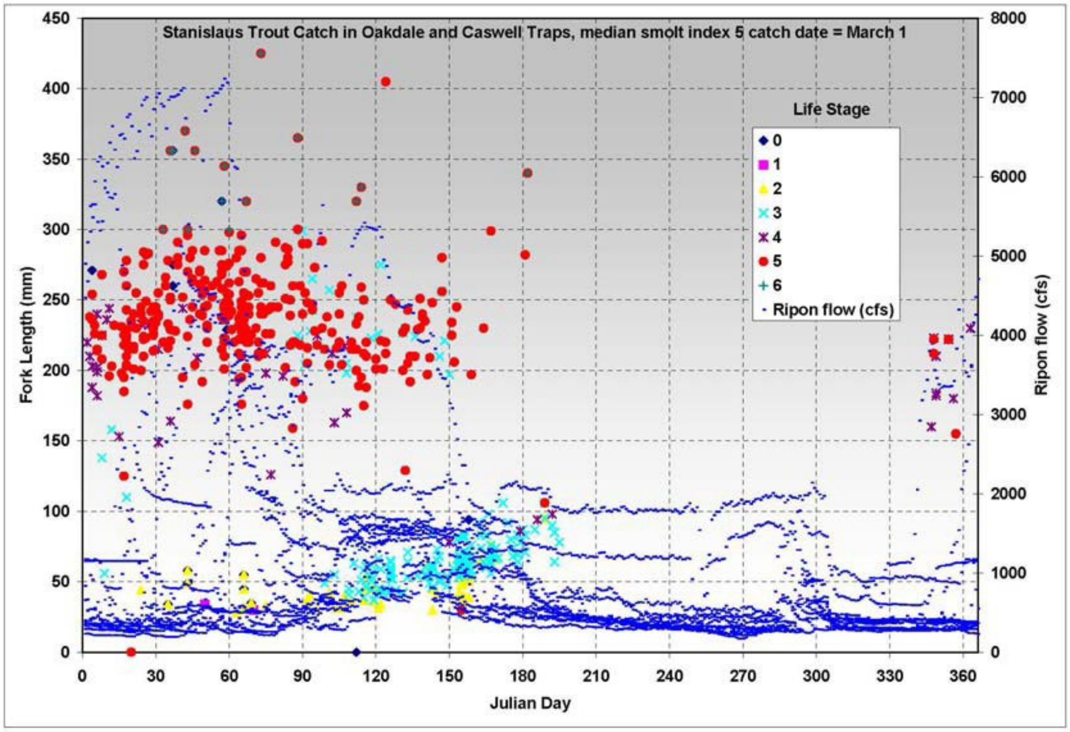


Figure 11-2. Smolt stage *O.mykiss* captured in Stanislaus River Rotary Screw Traps

The fall pulse flow was originally instituted to provide attraction flows for fall-run. Monitoring of adult salmonids at the Stanislaus River counting weir indicates that the fall pulse flow attracts both fall-run and CV steelhead into the Stanislaus River, making freshwater riverine habitat available. These riverine conditions have better temperature and water quality than conditions in the Delta during this period. The purpose of the fall pulse flow is to provide flow cues downstream for incoming adults, as well as providing some remedial effect on the low dissolved oxygen conditions that develop in the Stockton Deep Water Ship Channel. In addition to steelhead, this action also produces ancillary benefits to fall-run EFH.

Modeling conducted in the preparation of this action indicate that the temperature criteria of Action III.1.2 can generally be met under this alternative minimum flow schedule and are often improved, but that exceedances may occur in certain months (*e.g.*, May and early fall) during dry year types. Based on SALMOD analyses, temperature related mortality may be about 2 percent higher in critically dry years, but is reduced by about 1 percent in all other year types under the proposed alternative (Figure 11-3).

Salmon Mortality:

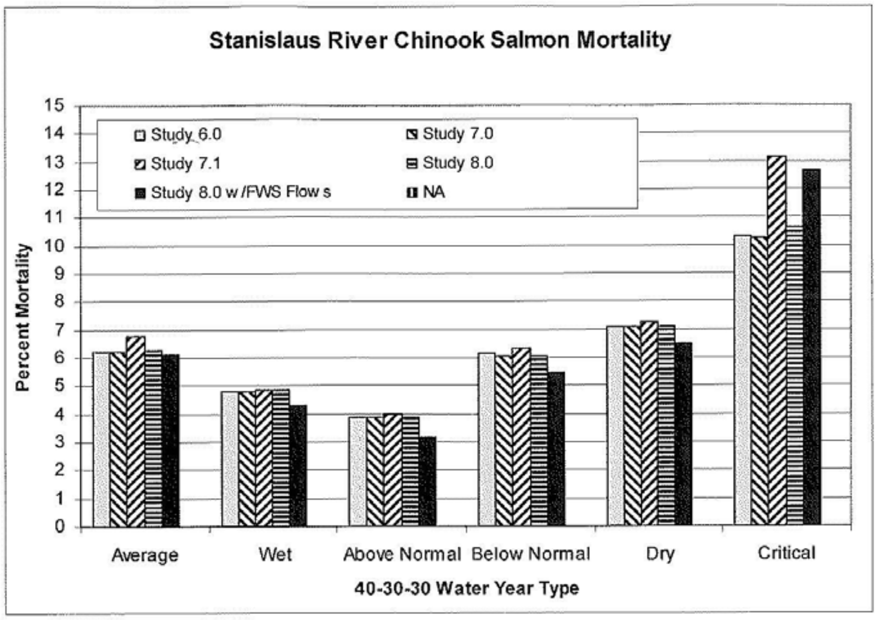


Figure 11-3. Modeled temperature effects of alternative Stanislaus River flows, draft provided by Reclamation on May 5, 2009.

Action Suite III.2. Stanislaus River CV Steelhead Habitat Restoration

Overall objective: Dam operations have and will continue to suppress channel-forming flows that replenish spawning beds. The physical presence of the dams impedes normal sediment transportation processes. This action is necessary to partially alleviate adverse modification of steelhead critical habitat from operations.

Action III.2.1. Increase and Improve Quality of Spawning Habitat with Addition of 50,000 Cubic Yards of Gravel by 2014 and with a Minimum Addition of 8,000 Cubic Yards per Year for the Duration of the Project Actions

Action: Reclamation shall minimize effects of their operations through improving spawning habitat with addition of 50,000 tons of gravel by 2014. Reclamation shall submit a plan, including monitoring, and schedule to NMFS for gravel augmentation by June 2010. Reclamation shall begin gravel augmentations no later than summer 2011. Reclamation shall submit to NMFS a report on implementation and effectiveness of action by 2015. Spawning gravel replenishment sites shall be monitored for geomorphic processes, material movement, and salmonid spawning use for a minimum of three years following each addition of sediment at any given site.

Rationale: Kondolf (*et al.,*) 2001 identified levels of sediment depletion at 20,000 cubic yards per year owing to a variety of factors including mining and geomorphic processes associated with dam operations, past and ongoing. Kondolf (*et al*.,) 2001 and other reports cited in that work, identify a loss of over 60 percent of spawning area for salmonids since 1966. This level of replenishment will restore adversely affected spawning habitat to relieve adverse habitat conditions and provide sediment to partially offset ongoing loss rates. Sediment addition may also be conducted in a manner to remediate sediment related loss of geomorphic function, such as channel incision, to and allow for inundation of floodplain rearing habitat.

Action III.2.2. Conduct Floodplain Restoration and Inundation Flows in Winter or Spring to Inundate Steelhead Juvenile Rearing Habitat on One- to Three-Year Schedule.

Action: Reclamation shall seek advice from SOG to develop an operational strategy to achieve floodplain inundation flows that inundate CV steelhead juvenile rearing habitat on a one- to three-year return schedule. Reclamation shall submit a proposed plan of operations to achieve this flow regime by June 2011. This plan shall include the minimum flow schedule identified in Action III.1.2, or shall provide justification for any proposed modification of the minimum flow schedule. NMFS will review and, if satisfactory, approve the operational strategy. Reclamation will implement strategy starting in 2012.

Rationale: Kondolf *et al*., (2001) identified that floodplain terraces and point bars inundated before operation of New Melones Dan have become fossilized with fine material and thick riparian vegetation that is never rejuvenated by scouring. Channel forming flows in the 8,000 cfs range have occurred only twice since New Melones Dam began operation 28 years ago. Lack of channel forming flows and lack of sediment input blocked by the dams has resulted in channel incision of one to three feet over 13 years. Floodplain juvenile rearing habitat and connectivity will continue to be degraded by New Melones operations, as proposed.

Action III.2.3. Restore Freshwater Migratory Habitat for Juvenile Steelhead by Implementing Projects to Increase Floodplain Connectivity and to Reduce Predation Risk During Migration

Objective: This action is necessary to compensate for continued operational effects on rearing and freshwater migratory habitat due to flood control operations. The goal of this action is to improve habitat quality of freshwater migratory habitat for juvenile steelhead.

Action: By June 2010, in cooperation with the SOG, Reclamation shall develop a list of projects to improve the habitat values of freshwater migratory habitat in the Stanislaus River, and associated monitoring, for implementation and submit the list to NMFS for review. Reclamation shall begin implementation of NMFS-approved projects by June 2011. Reclamation shall submit a report of project implementation and effectiveness by June 2016.

These projects may include actions that reduce exposure to predation directly, or projects that may offset predation effects by improving rearing habitat values to allow juveniles to grow larger before outmigration. These projects may include both flow- and non-flow-related actions. Flow-related actions shall be coordinated with operational flows as defined in

Action III.2.2 and Action III.1.2. These projects may also include, but shall not be limited to, evaluations to identify locations or sources of higher juvenile mortality in order to identify and implement projects with the highest likelihood to prevent CV steelhead mortality.

Rationale: Predation studies on the Tuolumne River have shown losses of up to 60 percent of outmigrating salmon smolts in run-of-river gravel mining ponds and dredged areas. Losses on the Stanislaus River have not been similarly quantified, but predation on fall run smolts and *O. mykiss* by striped bass and large mouth bass have been documented. These run-of-river ponds also reduce flow velocities as compared to incoming river channels, requiring outmigrating salmonids to expend more energy to traverse these sections. Operational releases provide flows lower than typical unimpaired flows, which exacerbates the effect of this stressor on outmigrating juveniles and degrades the habitat value of necessary freshwater migratory corridors. Additional flows or flow pulses could alleviate this added energy demand and improve survival through these problem areas. Channel modifications in these problem areas can improve migration success. Improvements in floodplain habitat quality can improve juvenile growth and larger juveniles are more likely to avoid predation mortality.

Action III.2.4. Evaluate Fish Passage at New Melones, Tulloch, and Goodwin Dams

Objective: Evaluate access for steelhead to historic cold water habitat above New Melones, Tulloch, and Goodwin dams.

Action: See Fish Passage Program, Action V.

Rationale: The effects analysis in this Opinion leads to the conclusion that steelhead will continue to be vulnerable to serious effects of elevated temperatures in dry and critically dry years, even if actions are taken to improve temperature management. The frequency of these occurrences is expected to increase with climate change and increased water demands. Therefore, it is essential to evaluate options for providing steelhead to access their historic cold water habitat above New Melones, Tulloch, and Goodwin dams and to provide access if feasible..

IV. DELTA DIVISION

Introduction: An important life history phase for all anadromous fish is their movement through an estuary as adults moving upstream to spawning grounds, and as juveniles moving downstream to the ocean. For some fish, the estuary also serves as a staging area and, for some juveniles, a rearing area prior to their entering the ocean. Within the Central Valley, all anadromous fish, including listed winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon, depend on the Sacramento-San Joaquin Delta environment during these life phases. This dependence was an important factor in designation of critical habitat in the Delta for these species. A properly functioning Delta is critical to migration pathways and rearing habitat, both of which are primary constituent elements of critical habitat for these fish.

Currently, the fish are exposed to a multitude of stressors in the Delta during passage and rearing. The Delta has been severely degraded over the past 150 years, primarily due to anthropogenic actions within its boundaries and in its surrounding watersheds. Nearly 90 percent of its fringing marshes have been lost and replaced with raised levees armored with rock riprap. The channelization of the Delta waterways through the construction of raised levees for flood control has isolated the Delta from its surrounding floodplains. These seasonally inundated floodplains served as important rearing habitats for many of the native fish species occurring in the Delta, including salmonids, and juvenile green sturgeon.

The structure of the Delta, particularly in the central and southern Delta, has been significantly altered by construction of manmade channels and dredging, for shipping traffic and water conveyance. Intentional and unintentional introductions of non-native plant and animal species have greatly altered the Delta ecosystem. Large predatory fish such as striped bass and largemouth bass have increased the vulnerability of emigrating juveniles and smolts to predation, while infestations of aquatic weeds such as *Egeria densa* have diminished the useable near-shore, shallow water habitat needed by emigrating salmonids for rearing.

The use of Delta islands for intensive agriculture has increased demand for irrigation water from the Delta, as well as increased the discharge of agricultural runoff into Delta waterways surrounding these farmed islands. These discharges carry chemicals such as fertilizers, pesticides, herbicides, and excessive nutrients, leading to degradation of water quality parameters such as DO content and suspended sediment, and increasing exposure to toxic compounds. Likewise, increasing urbanization in the areas surrounding the Delta increases the load of contaminants associated with stormwater runoff, discharges from wastewater sanitation plants, and industrial activities. Overall, conditions in the Delta make emigrating anadromous fish highly vulnerable to any added stressors and substantially reduce their chances for survival.

The proposed actions for the CVP and SWP include continued diversion of water from the Delta at the project's export facilities, with increased export levels. These actions will increase the level of stressors in the Delta beyond those previously described and exacerbate many of those already present. NMFS has identified several factors associated with operation of the CVP and SWP that affect the long-term viability and resiliency of winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon in the Central Valley. In addition to these specific factors, the operations of the CVP and SWP alter Delta hydrodynamics and interact with other stressors to enhance the vulnerability of listed fish to morbidity and mortality during their time in the Delta.

The adverse effects of the proposed action identified in this Opinion include:

1) Diversion from the North Delta into the Delta interior of early emigrating winter-run juveniles, yearling spring-run, and CV steelhead, through the operation of the DCC gates in late fall and early winter.

2) Enhanced vulnerability of juvenile salmonids to entrainment and indirect mortality, through alteration of the hydrodynamics of the interior and south Delta waterways, due to the influence of export pumping actions in winter and spring.

3) Enhanced vulnerability of CV steelhead from the San Joaquin River basin to exports and export-related changes in hydrodynamics.

4) Direct mortality from entrainment of juvenile salmonids and green sturgeon at the CVP and SWP export facilities.

The actions prescribed below will minimize or avoid the proposed action's adverse effects on hydraulic patterns in the Delta that affect listed salmonids and green sturgeon. They will modify the interactions that listed fish have with other stressors in the Delta and thereby avoid appreciably reducing the likelihood of survival and recovery of listed fish.

The current metric for monitoring direct take and mortality of listed fish by the CVP and SWP actions is the level of salvage and calculated loss at fish collection facilities. This metric is a reflection of export levels and the diversion of large volumes of water through the facilities. Counting fish at the salvage facilities alone, however, does not account for fish that have been lost prior to the point of collection, and thus is an inaccurate measure of adverse export influence. It does not account for fish that have been drawn into the waters of the central Delta through the DCC gates or Georgiana Slough and lost to predation, toxics, or other factors before reaching the south Delta, nor does it account for fish that make it to the south Delta, where they are further influenced by the reverse flows moving toward the pumps and are delayed in their migration; which increases their vulnerability to predation, toxics, or other forms of loss, such as stranding in agricultural diversions.

Overall Objectives: The juveniles of all four listed species migrating downstream in the Sacramento River have a much greater chance of survival when they migrate directly to the estuary within the Sacramento River than when they are diverted by water operations into the southern or central Delta, where they are exposed to increased risks of predation, exposure to toxic pollutants, and entrainment into water diversions. The Delta Division measures will reduce the likelihood of diversion of emigrating juveniles into the southern or central Delta, and will reduce mortality of emigrating juveniles that have been entrained at the fish collection facilities and entered the salvage process.

There are six actions to be taken in the Delta:

- Action IV.1: Modify DCC gate operations and evaluate methods to control access to Georgiana Slough and the Interior Delta to reduce diversion of listed fish from the Sacramento River into the southern or central Delta.
- Action IV.2: Control the net negative flows toward the export pumps in Old and Middle rivers to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento River into the southern or central Delta.

- Action IV.3: Curtail exports when protected fish are observed near the export facilities to reduce mortality from entrainment and salvage.
- Action IV.4: Improve fish screening and salvage operations to reduce mortality from entrainment and salvage.
- Action IV.5: Establish a technical group to assist in determining real-time operational measures, evaluating the effectiveness of the actions, and modifying them if necessary.
- Action IV.6: Do not implement the South Delta Barriers Improvement Program.

A summary of Actions IV.1 and IV.2 and their timeframes is provided below in Figure 11-4.

Action Suite IV.1 Delta Cross Channel (DCC) Gate Operation, and Engineering Studies of Methods to Reduce Loss of Salmonids in Georgiana Slough and Interior Delta

Objective: Reduce the proportion of emigrating listed salmonids and green sturgeon that enter the interior delta through either the open DCC gates or Georgiana Slough.

Rationale: Salmon migration studies show losses of approximately 65 percent of groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Diversion into the internal Delta also increases the likelihood of entrainment and mortality associated with the pumping facilities. These effects are inferred from both particle tracking models, which derive the fate of particles over time, and direct study of acoustically tagged and CWT salmonids (Vogel 2004, SJRGA 2007).

On average, up to 25 percent of Sacramento River flows are diverted into the channels of the DCC when the gates are open, with a maximum of 35 to 40 percent. Approximately 20 percent, on average, of the Sacramento River flow is diverted into Georgiana Slough. During November and December, approximately 25 percent of the Sacramento River flow is diverted into the interior Delta through these two channels. Recent studies by Perry and Skalski (2008) indicate that by closing the DCC gates when fish are present, total through-Delta survival of marked fish to Chipps Island increases by nearly 50 percent for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of emigrating fish into Sutter and Steamboat Sloughs and away from Georgiana Slough, resulting in higher survival rates. Similar benefits have been described in previous studies (Newman 2008, Brandes and McLain 2001) with CWT fish.

Based on data from monitoring studies in the lower Sacramento River, approximately 45 percent of the annual winter-run emigration from the Sacramento River enters the Delta between November and January. During the same period, about eight percent of the annual CV steelhead emigration from the Sacramento River Basin occurs. Yearling spring-run pass into the Delta in January, but these fish account for only three percent of the total annual population of spring-run emigrants entering the Delta.

	Action IV. 1.2 - Operation of DCC to enhance protection of emigrating salmonids/green sturgeon	**Action IV. 2.1** - Maintain San Joaquin River Inflow/Export ratio		**Action IV. 2.2** - Acoustic Tag Experiment	**Action IV. 2.3** - Reduced exports to limit negative flows in OMR depending on presence of salmonids
		2009 - 2011 Interim Operations	**2012 + Long term Operations**		
Oct.	**Oct. 1 - Nov. 30** - Gates closed if fish are present				
Nov.					
Dec.	**Dec. 1 -14** - Gates closed except for experiments/water quality				
Jan.	**Dec. 15 -Jan. 31** Gates Closed				**Jan 1 - June 15** - OMR (-5000 to -2500 cfs) until after June 1 water temperature at Mossdale ≥72° F for 7 days
Feb.	**Feb. 1 - May 15 - Gates Closed per D1641**				
Mar.				**March 1 - June 15**	
Apr.		**April 1 - May 31** - Maintain Vernalis Inflow/Export ratio dependingon IOP water supply parameters	**April 1 - May 31** - Maintain Vernalis Inflow/Export Ratios depending on water year type		
May	**May 15 - June 15** - up to 14 days closed per D-1641				
Jun.					

Figure 11-4. A summary of Actions IV.1 and IV.2 and their timeframes.

Percent of Juvenile Chinook salmon and steelhead production entering the Delta from the Sacramento River by month.

Month	Sacramento River Total[1,2]	Fall-Run[3]	Spring-Run[3]	Winter-Run[3]	Sacramento Steelhead[4]
January	12	14	3	17	5
February	9	13	0	19	32
March	26	23	53	37	60
April	9	6	43	1	0
May	12	26	1	0	0
June	0	0	0	0	0
July	0	0	0	0	0
August	4	1	0	0	0
September	4	0	0	0	1
October	6	9	0	0	0
November	9	8	0	03	1
December	11	0	0	24	1
Total	100	100	100	100	100

Notes:
[1]Mid Water trawl data
[2]All runs combined
[3]Runs from Sacramento River basin only
[4]Rotary screw trap data from Knights Landing
Source: SDIP Draft EIR/EIS 2005 Tables J-23 and J-24, Appendix J.

Actions taken during the early emigration period (November through January) to reduce diversion of listed salmonids can affect a significant proportion of the populations of listed fish. As discussed earlier in the effects section, these early migrants represent life history strategies that spread the risk of mortality over a greater temporal span, increasing diversity and resiliency of the populations.

Action IV.1.1 Monitoring and Alerts to Trigger Changes in DCC Operations

Objective: To provide timely information for DCC gate operation that will reduce loss of emigrating winter-run, spring-run, CV steelhead, and green sturgeon.

Action: Monitoring of Chinook salmon migration in the Sacramento River Basin and the Delta currently occurs at the RBDD, in spring-run tributaries to the Sacramento River, on the Sacramento River at Knights Landing and Sacramento, and sites within the Delta. Reclamation and DWR shall continue to fund these ongoing monitoring programs, as well as the monitoring of salvage and loss of Chinook salmon juveniles at the Delta fish collection facilities operated by the CVP and SWP. Funding shall continue for the duration of the proposed action (2030). Reclamation and DWR may use their own fishery biologists to conduct these monitoring programs, or they may provide funds to other agencies to do the required monitoring.

Monitoring protocols shall follow established procedures utilized by the USFWS, CDFG, Reclamation, and DWR. Information collected from the monitoring programs will be used to make real-time decisions regarding DCC gate operation and export pumping.

The DOSS group (Action IV.5) and WOMT will use information from monitoring to make decisions regarding DCC closures consistent with procedures below.

The DCC gate operations in the fall are initiated through a series of alerts. These alerts are signals that gate operations may need to be altered in the near future to avoid diversion of juvenile Chinook salmon migrating down the Sacramento River.

There are two initial alerts to warn of salmon presence in the system:

First Alert: There are two components to the first alert. Either condition, when met or identified, can trigger the alert. Capture of yearling-sized (> 70 mm) spring-run at the mouths of natal tributaries between October and April indicates that emigration from the tributaries has started or is occurring. As an environmental surrogate to the capture of the yearling-sized spring-run, which are difficult to capture in the rotary screw traps at the mouths of the natal tributary creeks, tributary flow increases are used to signal conditions conducive to emigration. Starting in October, an increase in tributary flow of more than 50 percent over levels immediately preceding the flow spike is used to indicate the appropriate cues for the initiation of salmon emigration[31].

Second Alert: The second alert is based on two physical hydrologic criteria. When both criteria are met the second alert is triggered. The monitoring station used for these environmental measurements is Wilkins Slough, located near Knights Landing approximately 35 miles upstream of the Delta. When flows are greater than 7,500 cfs as measured at Wilkins Slough, and water temperatures are less than 13.5°C (56.3°F) as measured at Knights Landing, the second alert is triggered. Recoveries of emigrating Chinook salmon at the Knights Landing monitoring location have been associated with these two hydrologic conditions.

Rationale: Monitoring programs are necessary to track the movement of salmon within the Central Valley watersheds so that timely changes can be made when project actions are in conflict with the needs of listed fish. Evidence of initiation of juvenile Chinook salmon migration in the upper tributaries, or environmental conditions that would trigger such migration, is the basis for the alerts. The alerts are important to effective gate operation because the collection and dissemination of field data to the resource agencies, and coordination of responsive actions, may take several days to occur. The first two alerts warn NMFS and Reclamation that changes in DCC gate operations are likely to be necessary within a short time period.

[31] The first significant flow in October is associated with the beginning of spring-run yearling emigration from natal tributaries - an indication that those fish are on their seaward migration and will soon be entering the Delta where they are susceptible to mortality factors associated with the Delta Cross Channel (DCC) and SWP/CVP export operations. This first tributary flow event, or "First Alert", is the early warning criteria for closing the DCC.

Action IV.1.2 DCC Gate Operation

Objective: Modify DCC gate operation to reduce direct and indirect mortality of emigrating juvenile salmonids and green sturgeon in November, December, and January.

Action: During the period between November 1 and June 15, DCC gate operations will be modified from the proposed action to reduce loss of emigrating salmonids and green sturgeon. The operating criteria provide for longer periods of gate closures during the emigration season to reduce direct and indirect mortality of yearling spring-run, winter-run, and CV steelhead. From December 1 to January 31, the gates will remain closed, except as operations are allowed using the implementation procedures/modified Salmon Decision Tree (below).

Implementation procedures: Monitoring data related to triggers in the decision tree will be reported on DAT calls and evaluated by DOSS (for formation of DOSS – see Action KK). Reclamation/DWR shall take actions within 24 hours of a triggered condition occurring. If the decision tree requires an evaluation of data or provides options, then DOSS shall convene within one day of the trigger being met. DOSS shall provide advice to NMFS, and the action shall be vetted through WOMT standard operating procedures.

October 1-November 30:

Date	VI. Action Triggers	Action Responses
October 1-November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) are greater than 3 fish per day but less than or equal to 5 fish per day.	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.

Rationale: Depending on the catch magnitude, there are several options for closing the DCC gates, ranging from not closing them and monitoring catch at Knights Landing and the Sacramento monitoring sites, to closing the DCC gates until the catch index decreases to fewer than three fish per day at the Knights Landing and Sacramento monitoring sites. Fish and water quality needs (*i.e.,* salinity levels) are frequently mutually exclusive, with respect to the DCC position, from November through January.

December 1-14:

Date	Action Triggers	Action Responses
December 1 - December 14	Water quality criteria are met per D-1641.	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (*e.g.,* Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS' prior approval of the study.
	Water quality criteria are not met but both the KLCI and SCI are less than 3 fish per day.	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
	Water quality criteria are not met but either of the KLCI or SCI is greater than 3 fish per day.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5

Rationale: The Spring-run Protection Plan (1998 *op. cit*. CVP/SWP operations BA Appendix B) provides that Reclamation will close the DCC gates on December 1 for the protection of spring-run yearlings unless there is a water quality issue. The DOSS can recommend opening the DCC gates for water quality purposes during this period. In addition, CDFG analysis indicates that there is a significant relationship between DCC gate operations and subsequent loss of winter-run at the Delta Fish Facilities. Closing the DCC gates between December 15 and January 15 reduces the total loss of winter-run at the Delta Fish Facilities. The report is posted at: http://www.science.calwater.ca.gov/pdf/ewa/EWA_delta_cross_channel_closures_06_111406.pdf.

The USFWS conducts a juvenile Chinook salmon Delta survival experiment each year in December and January. This is usually conducted in the first two weeks of December and may include experimental openings of the DCC gates. http://www.delta.dfg.ca.gov/jfmp/PatFiles/Delta_Action_8_Workshop.doc. These studies may be implemented if NMFS concurs that the study plan has been adapted to sufficiently reduce loss of salmonids..

December 15 – January 31:

Date	Action Triggers	Action Responses
December 15 – January 31	December 15-January 31	DCC Gates Closed.
	NMFS-approved experiments are being conducted.	Agency sponsoring the experiment may request gate opening for up to five days; NMFS will determine whether opening is consistent with ESA obligations.
	One-time event between December 15 to January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions.	Upon concurrence of NMFS, DCC Gates may be opened one hour after sunrise to one hour before sunset, for up to 3 days, then return to full closure. Reclamation and DWR will also reduce Delta exports down to a health and safety level during the period of this action.

Rationale: CDFG analysis indicates that there is a significant relationship between DCC gate operations and subsequent loss of winter-run at the Delta Fish Facilities. Closing the DCC gates between December 15 and January 15 reduces the total loss of winter-run at the Delta Fish Facilities. The report is posted at: http://www.science.calwater.ca.gov/pdf/ewa/EWA_delta_cross_channel_closures_06_111406.pdf

If the KLCI or SCI is less than three, and the water temperature and flow criteria are indicative of low risk to listed salmonids, then experiments on fall- and late-fall-run may be permissible; however, in a low production year, trap efficiencies and detection rates may result in under-representation of the number of fish passing these locations. Under such conditions the DOSS group shall act conservatively in this decision process even when no fish have been detected at Knights Landing or Sacramento rotary screw traps. If conditions change, indicating that risks to listed salmonids are elevated, experiments will be suspended and the DCC gates closed if NMFS determines that closure is necessary to reduce the risk to emigrating salmonids.

February 1 – June 15:

Date	Action Trigger	Action Response
February 1 – May 15	D-1641 mandatory gate closure.[9]	Gates closed, per WQCP criteria

Date	Action Trigger	Action Response
May 16 – June 15	D-1641 gate operations criteria	DCC gates may be closed for up to 14 days during this period, per 2006 WQCP, if NMFS determines it is necessary.

Overall Rationale for Action IV.1.2: Emigrating salmonids are vulnerable to diversion into the DCC when the gates are open. Fish traveling downstream in the Sacramento River move past the mouth of the DCC on the outside bend of the river. A series of studies conducted by Reclamation and USGS (Horn and Blake 2004) used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the river during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night to entrainment into the DCC than during the day, due to their higher position in the water column and the depth of the lip to the DCC channel mouth (-2.4 meters). Additional studies have shown that the mortality rate of the fish diverted into the DCC and subsequently into the Mokelumne river system is quite high (Perry and Skalski 2008; Vogel 2004, 2008). Closure of the DCC gates during periods of salmon emigration eliminates the potential for entrainment into the DCC and the Mokelumne River system with its high loss rates. In addition, closure of the gates appears to redirect the migratory paths of emigrating fish into channels with relatively less mortality (*e.g.,* Sutter and Steamboat Sloughs), due to a redistribution of river flows among the channels. The overall effect is an increase in the apparent survival rate of these salmon populations as they move through the Delta.

The closure of the DCC gates will increase the survival of salmonid emigrants through the Delta, and the early closures reduce loss of fish with unique and valuable life history strategies in the spring-run and CV steelhead populations. Spring-run emigrating through the Delta during November and December are yearling fish. These fish are larger and have a higher rate of success in surviving their entrance into the ocean environment. In addition, variation in the timing of ocean entry distributes the risk of survival over a broader temporal period. This alternative life history strategy reduces the probability that poor ocean conditions in spring and summer will affect the entire population of spring-run. Since yearling fish enter the marine environment in late fall and winter, they avoid the conditions that young-of-the-year fish encounter in spring and summer, thus increasing the likelihood that at least a portion of the population will benefit from suitable ocean conditions during their recruitment to the ocean phase of their life cycle. For the same reasons, CV steelhead benefit from having their ocean entry spread out over several months.

Action IV.1.3 Consider Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to CVP and SWP Export Facilities

Objectives: Prevent emigrating salmonids from entering the Georgiana Slough channel from the Sacramento River during their downstream migration through the Delta. Prevent emigrating salmonids from entering channels in the south Delta (*e.g.*, Old River, Turner Cut) that increase entrainment risk to CV steelhead migrating from the San Joaquin River through the Delta.

Action: Reclamation and/or DWR shall convene a working group to consider engineering solutions to further reduce diversion of emigrating juvenile salmonids to the interior Delta and consequent exposure to CVP and SWP export facilities. The working group, comprised of representatives from Reclamation, DWR, NMFS, USFWS, and CDFG, shall develop and evaluate proposed designs for their effectiveness. in reducing adverse impacts on listed fish and their critical habitat. Reclamation or DWR shall subject any proposed engineering solutions to external independent peer review and report the initial findings to NMFS by March 30, 2012. Reclamation or DWR shall provide a final report on recommended approaches by March 30, 2015. If NMFS approves an approach in the report, Reclamation or DWR shall implement it. To avoid duplication of efforts or conflicting solutions, this action should be coordinated with USFWS' Delta smelt biological opinion and BDCP's consideration of conveyance alternatives..

Rationale: One of the recommendations from the CALFED Science Panel peer review was to study engineering solutions to "separate water from fish." This action is intended to address that recommendation. Years of studies have shown that the loss of migrating salmonids within Georgiana Slough and the Delta interior is approximately twice that of fish remaining in the Sacramento River main stem (Kjelson and Brandes 1989; Brandes and McLain 2001; Vogel 2004, 2008; and Newman 2008). Based on the estimated survival rate of 35 percent in Georgiana Slough (Perry and Skalski 2008), the fraction of emigrating salmonids that would be lost to the population is 6 to 15 percent of the number entering the Delta from the Sacramento River basin. Keeping emigrating fish in the Sacramento River would increase their survival rate. This action is also intended to allow for engineering experiments and possible solutions to be explored on the San Joaquin river/Southern Delta corridor to benefit out-migrating steelhead. For example, non-physical barrier (i.e., "bubble curtain") technology can be further vetted through this action.

Action Suite IV.2 Delta Flow Management

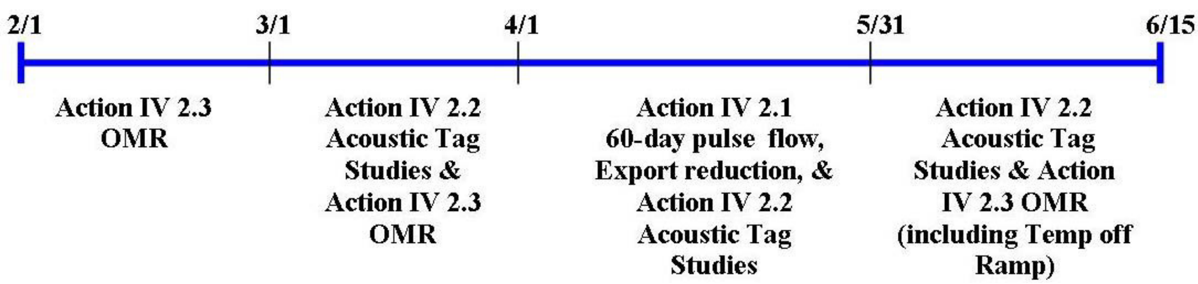
Objective: Maintain adequate flows in both the Sacramento River and San Joaquin River basins to increase survival of steelhead emigrating to the estuary from the San Joaquin River, and of winter-run, spring-run, CV steelhead, and green sturgeon emigrating from the Sacramento River through the Delta to Chipps Island.

Rationale for the Suite of Actions: Numerous studies have found positive associations between increased river flows and increased survival of salmon smolts through the Delta and the adult escapement of that cohort several years later when they return to spawn. Increased flows and greater smolt survival have been positively associated in other river systems as well Increased flows reduce the travel time of smolts moving through the river and Delta system, thus reducing the duration of their exposure to adverse effects from predators, water diversions, and exposure to contaminants.

Action IV.2.1 San Joaquin River Inflow to Export Ratio

Objectives: To reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta, by increasing the inflow to export ratio. To enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: The following timeline indicates the annual schedule for implementing related San Joaquin actions that will occur concurrent with this action.



Phase I: Interim Operations in 2010-2011.

From April 1 through May 31:

1. Flows at Vernalis (7-day running average shall not be less than 7 percent of the target requirement) shall be based on the New Melones Index[32]. In addition to the Goodwin flow schedule for the Stanislaus River prescribed in Action III.1.3 and Appendix 2-E, Reclamation shall increase its releases at Goodwin Reservoir, if necessary, in order to meet the flows required at Vernalis, as provided in the following table. NMFS expects that tributary contributions of water from the Tuolumne and Merced rivers, through the SJRA, will continue through 2011 and that the installation of a fish barrier at the Head of Old River will continue to occur during this period as permitted.

New Melones Index (TAF)	Minimum flow required at Vernalis (cfs)
0-999	No new requirements
1000-1399	D1641 requirements or 1500, whichever is greater
1400-1999	D1641 requirements or 3000, whichever is greater
2000-2499	4500
2500 or greater	6000

2. Combined CVP and SWP exports shall be restricted through the following:

Flows at Vernalis (cfs)	Combined CVP and SWP Export
0-6,000	1,500 cfs
6,000-21,750[33]	4:1 (Vernalis flow:export ratio)
21,750 or greater	Unrestricted until flood recedes below 21,750

In addition:

1) Reclamation/DWR shall seek supplemental agreement with the SJRGA as soon as possible to achieve minimum long term flows at Vernalis (see following table) through all existing authorities.

San Joaquin River Index (60-20-20)	Minimum long-term flow at Vernalis (cfs)
Critically dry	1,500

[32] The New Melones Index is a summation of end of February New Melones Reservoir storage and forecasted inflow using 50% exceedance from March through September.

[33] Flood warning stage at Vernalis is 24.5 feet, flow is 21,750 cfs at this point. Flood stage is 29 feet with a corresponding flow of 34,500 cfs. Data from CDEC looking at April 8-9, 2006 period. As such, recognizing that the flows associated with these stages do vary, the trigger allowing unrestricted exports will be a Vernalis stage of 24.5 feet.

Dry	3,000
Below normal	4,500
Above normal	6,000
Wet	6,000

Rationale:

1) Flows at Vernalis: Reclamation has limited discretion to require additional flows from the Tuolumne and Merced rivers that are necessary in the long run to meet the needs of outmigrating juvenile steelhead. Modeling for our analysis of the East Side Division show that relying on New Melones Reservoir to provide the flows at Vernalis cannot be sustained, and attempting to do so would likely have additional adverse effects on CV steelhead. Reclamation and DWR have obtained additional flows in the Tuolumne and Merced rivers through CVPIA authorities, including options to purchase water from willing sellers, and entered into the SJRA which expires on December 31, 2009. Reclamation is in negotiations to extend the current agreement to 2011. The flows required in Phase I at Vernalis were developed through iterative modeling and will provide an important increment of additional flow to provide for outmigration of steelhead smolts, while not unduly depleting New Melones Reservoir storage. Using CVPIA authorities, it is important that Reclamation seek to immediately change the terms of the existing SJRA to achieve the long-term flows.

2) The rationale for the export curtailments is provided in the rationale for Phase II.

3) The SWRCB has initiated proceedings to establish minimum flows in the San Joaquin River basin. The proceedings are scheduled to conclude in 2011. Flow requirements for fish will be provided by this action in the interim.

Phase II: Beginning in 2012:

From April 1 through May 31:

1. Reclamation shall continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action III.1.3 and Appendix 2-E.

2. Reclamation and DWR shall implement the Vernalis flow-to-combined export ratios in the following table, based on a 14-day running average.

San Joaquin Valley Classification	Vernalis flow (cfs):CVP/SWP combined export ratio[34]
Critically dry	1:1[35]

[34] Exception to the ratio is provided for floods, where exports are not restricted until the flood recedes. See footnote 2 above.
[35] Minimum combined CVP and SWP exports is for health and safety.

Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750.

Exception procedure for multiple dry years: If the previous 2 years plus current year of San Joaquin Valley "60-20-20" Water Year Hydrologic Classification and Indicator as defined in D-1641 and provided in following table, is 6 or less, AND the New Melones Index is less than 1 MAF, exports shall be limited to a 1:1 ratio with San Joaquin River inflow, as measured at Vernalis.

San Joaquin Valley Classification	Indicator
Critically dry	1
Dry	2
Below normal	3
Above normal	4
Wet	5

Exception procedure for Health and Safety: If, by February 28 of a given year, Reclamation and DWR predict that they will not be able to achieve these ratios and make deliveries required for human health and safety, even after pursuing all options to augment inflow while preserving the ability to meet fish flow needs in all seasons, the agencies may submit a plan to NMFS to maximize anadromous fish benefits while meeting health and safety needs. The project agencies' current estimate of health and safety needs is a combined CVP/SWP export rate of 1,500 cfs. The plan must demonstrate that all opportunities for purchasing water in the San Joaquin Basin have been or will be exhausted, using b(3) or other water purchasing authority.

Meeting the long-term biological requirements of listed species and providing adequate water deliveries for these needs under the current system configuration may not be compatible, particularly considering anticipated hydrologic patterns associated with climate change. For this reason, Reclamation and DWR may propose a reconfiguration of the water conveyance system to allow diversion from the Sacramento River. Such an alteration of the conveyance system is being considered in the BDCP planning process. The operation of a conveyance structure that diverts water directly from the Sacramento River carries additional risk for listed species that migrate, spawn, or rear in the Sacramento River or North Delta. As detailed in this Opinion, the status of those species is precarious. Any new conveyance will be subject to section 7 consultation, and issues of injury or mortality of juvenile fish associated with all diversion facilities, reduction of flow variability for fish life history functions, reduction of Shasta Reservoir storage necessary for mainstem temperature control, and other potential adverse effects must be adequately addressed in any conveyance proposal.

Rationale: VAMP studies of CWT Chinook salmon smolts indicate that in general, fish released downstream of the zone of entrainment created by the export pumps (*e.g.*, Jersey Point) have higher survival indices to Chipps Island than fish released higher up in the system (*e.g.*, Durham Ferry, Mossdale, or Dos Reis). Studies identify increased flows as a factor that increases survival of tagged Chinook salmon smolts. To date, most VAMP experiments have utilized San Joaquin River flows to export pumping ratios of approximately 2:1. Survival to Chipps Island of smolts released upstream has been relatively low under these conditions. (Kjelson *et al*. 1981, Kjelson and Brandes 1989, SJRGA 2007). Historical data indicates that high San Joaquin River flows in the spring result in higher survival of outmigrating Chinook salmon smolts and greater adult returns 2.5 years later (Kjelson *et al.* 1981, Kjelson and Brandes 1989, USFWS 1995) and that when the ratio between spring flows and exports increase, Chinook salmon production increases (CDFG 2005, SJRGA 2007). NMFS, therefore, concludes that San Joaquin River Basin and Calaveras River steelhead would likewise benefit under higher spring flows in the San Joaquin River in much the same way as fall-run do. For a full explanation of data and analysis supporting this action, see appendix 5.

Increased flows within the San Joaquin River portion of the Delta will also enhance the survival of Sacramento River salmonids. Those fish from the Sacramento River which have been diverted through the interior Delta to the San Joaquin River will benefit by the increased net flow towards the ocean caused by the higher flows in the San Joaquin River from upstream and the reduced influence of the export pumps. Such flows will reduce the proportion of Sacramento River fish that continue southwards toward the pumps and increase the percentage that move westwards toward Chipps Island and the ocean. Although the real environment is much more complex than this generality, in theory, increasing the speed of migration through a particular reach of river, or shortening the length of the migratory route decrease the extent of exposure to factors causing loss (Anderson *et al.* 2005)

Action IV.2.2 Six-Year Acoustic Tag Experiment

Objective: To confirm proportional causes of mortality due to flows, exports and other project and non-project adverse effects on steelhead smolts out-migrating from the San Joaquin basin and through the southern Delta.

Action: Reclamation and DWR shall fund a 6-year research-oriented action concurrent with Action IV.2.1.

The research shall be composed of studies utilizing acoustically-tagged salmonids, and will be implemented to assess the behavior and movement of the outmigrating fish in the lower San Joaquin River. The studies will include three releases of acoustic tagged fish, timed to coincide with different periods and operations: March 1 through March 31, April 1 through May 31, and June 1 through June 15. NMFS anticipates that studies will utilize clipped hatchery steelhead and hatchery fall-run as test fish.

During the period from March 1 through March 30, the exports will be operated in accordance with the requirements dictated by action IV.2.3. During the 60-day period between April 1 and May 30, exports will be dictated by the requirements of action IV.2.1. Reclamation shall operate to a minimum 1:1 inflow to export ratio during the period between

June 1 and June 15, allowing exports to vary in relation to inflows from the San Joaquin to test varying flow to export ratios during this period. If daily water temperatures at Mossdale exceed 72ºF for seven consecutive days during the period between June 1 and June 15, then the inflow to export ratio may be relaxed. NMFS anticipates that warm water conditions in the lower San Joaquin River will not be suitable for steelhead under these conditions.

Implementation procedures:

1) By September 1, 2009, Reclamation/DWR shall convene DOSS for the purpose of refining the study design for this experiment. The experiments shall be developed to ensure that results are statistically robust and uncertainties due to experimental design have been minimized to the fullest extent possible. Additional expertise may be included in the workgroup, at the discretion of the agencies.

2) Issues relevant to listed anadromous fish species that shall be addressed include, but are not limited to:
   a) Increasing survival of emigrating smolts from the tributaries into the main stem of the San Joaquin River.
   b) Increasing survival of emigrating smolts through the main stem of the San Joaquin River downstream into the Delta.
   c) Increasing survival of emigrating smolts through the Delta to Chipps Island.
   d) The role and influence of flow and exports on survival in these migratory reaches.
   e) Selection of routes under the influence of flows and exports.
   f) Identifying reach-specific mortality and or loss.
   g) The effectiveness of experimental technologies, if any, *e.g.,* non-physical barrier ("bubble curtain**.")**

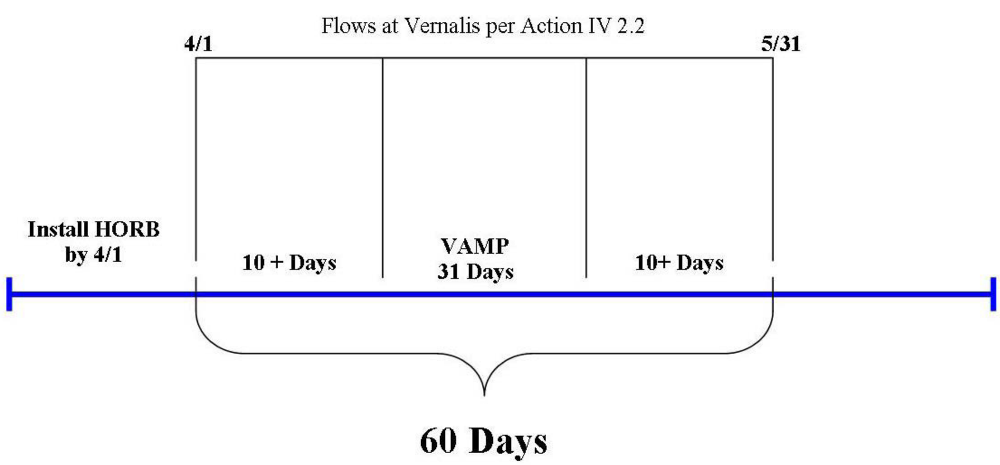
3) Annual reviews of the study results shall be conducted by the DOSS group. At the end of the 6-year period, a status review of Action IV.2.1 shall be prepared by the DOSS group. The status review shall be used to assess the success of Action IV.2.1 in increasing survival through the Delta for San Joaquin River basin salmonids, but in particular, steelhead. Based on the findings of the status review, the DOSS group will make recommendations to NMFS, Reclamation, CDFG, DWR, and USFWS on future actions to be undertaken in the San Joaquin River basin as part of an adaptive management approach to the basin's salmonid stocks.

4) Complementary studies to achieve performance goals**:** At its discretion, Reclamation and DWR also may develop and propose complementary studies to examine alternative actions that would accomplish the targeted survival performance goals. A primary effort of these studies will be to establish an appropriate survival goal for out-migrating steelhead smolts from Vernalis to Chipps Island in all water year types. Reclamation and DWR may propose studies which test actions that incorporate non-flow or non-export related actions. The studies shall contain specific actions within the authority and discretion of Reclamation and/or DWR, an evaluation of the projected benefits of each action with respect to increasing survival to the performance goal, evidence used to

support this evaluation including literature citations, particle tracking modeling and other predictive tools, to demonstrate that the survival will be achieved, and a demonstration that the actions are reasonably certain to occur within the term of the study period. Any complementary study proposal shall be peer reviewed by the Calfed Science Program (or other comparable science group) and by the DOSS workgroup prior to being submitted to NMFS.

Upon receipt of the complementary study proposal, NMFS will review the draft proposal for sufficiency of information, experimental design, and likelihood to meet performance goals and provide comments back to Reclamation and DWR within 30 days of receipt. If NMFS concurs with the complementary study proposal, and finds the studies do not conflict with the actions implemented under the RPA, then the study may be conducted concurrently with the actions set forth above (Action IV.2.1 and IV.2.2). Throughout the six years of study, all new data will be annually evaluated by the proposed DOSS group, which will then provide recommendations through a written report to the management of NMFS and Reclamation for continuing actions in the San Joaquin River basin in support of CV steelhead.

Exception: If, despite Reclamation and DWR's best efforts, the new experiment is not ready for implementation in 2010, then VAMP study design may continue for 1 year, upon written concurrence of NMFS. A generalized representation of the design is provided, as follows:



Rationale: This experiment will provide important information about the response of fish migration to flows, exports, and other stressors in the San Joaquin River corridor. Flows and exports will be varied according to time period. From March 1 through March 31, the studies will assess the relationship of the Vernalis flow-to-export ratio under the OMR flow restriction (see Action IV.2.3) to route selection at channel bifurcations in the South Delta and mainstem San Joaquin River, survival in the different channels reaches of the South Delta, and ultimately through the Delta to Chipps Island as a whole.

From April 1 through May 30, the studies will assess the effectiveness of varying ratios by water year type (see Action IV.2.1) by comparing channel selection, route survival, and overall through-Delta survival during this period of stabilized conditions to the other two periods.

From June 1 to June 15, the studies will focus on the relative importance of exports, as compared to flows, by deliberately varying exports under similar flow conditions. Acoustic tagging studies have the potential to provide this level of resolution. Results from these studies may be able to indicate, at a fine temporal and spatial scale, how exports and flow influence route selection of migrating fish and their survival probabilities in the different channel reaches. Knowledge of these factors should aid in the management decision process and reduce project impacts to listed salmonids based on findings with strong scientific foundations.

Action IV.2.3 Old and Middle River Flow Management

Objective: Reduce the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. Enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range shall be determine based on the following decision tree:

Date	Action Triggers	Action Responses
January 1 – June 15	January 1 – June 15	Exports are managed to a level that produces a 14-day running average of the tidally filtered flow of (minus) -5,000 cfs in Old and Middle River (OMR). A five-day running average flow shall be calculated from the daily tidally filtered values and be no more than 25 percent more negative than the targeted requirement flow for the 14-day average flow.[36]

[36] Daily OMR flows used to compute the 14-day and 5-day averages shall be tidally filtered values reported by the USGS for the Old River at Bacon Island and Middle River at Middle River monitoring stations. The 14-day running average shall be no more negative than the targeted flow requirement. The 5-day running average shall be no more than 25 percent more negative than the targeted flow requirement. (Transition explanations below are based on personal communication Ryan Olah, USFWS, to ensure consistency of OMR measurements and averaging periods with implementation of OMR in Smelt Biological Opinion).

January 1 – June 15 First Stage Trigger (increasing level of concern)	Daily SWP/CVP older juvenile loss density (fish per taf) 1) is greater than incidental take limit divided by 2000 (2 percent WR JPE ÷ 2000), with a minimum value of 2.5 fish per taf, or 2) daily loss is greater than daily measured fish density divided by 12 taf (daily measured fish density ÷ 12 taf) or 3) CNFH CWT LFR or LSNFH CWT WR cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 taf (daily measured fish density ÷ 12 taf)[37]	Reduce exports to achieve an average net OMR flow of (minus) -3,500 cfs for a minimum of 5 consecutive days. The five day running average OMR flows shall be no more than 25 percent more negative than the targeted flow level at any time during the 5-day running average period (*e.g.*, -4,375 cfs average over five days). Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for 3 consecutive days following the 5 consecutive days of export reduction[38]. Reductions are required when any one criterion is

Transition to more restrictive (less negative) OMR limit

When a more restrictive Old and Middle River flow (OMR) limit is decided upon, the water projects may continue to operate to the old limit for up to two additional days, with both 5-day and 14-day averaging periods in effect. On the third day, the moving daily OMR will be no more negative than the new limit, and no moving averages will apply. New moving averages will be calculated from the third day forward. On the fourth day, OMR can be no more than 25% more negative than the daily OMR on the third day; On the fifth day, OMR can be no more than 25% more negative than the midpoint between the daily OMRs on the third day and the fourth day; on the sixth day, OMR can be no more than 25% more negative than the average of the OMRs on the third, fourth, and fifth day; and so on. From the 8th day forward, if OMR restrictions due to triggers are still be implemented, a full 5-day moving average will exist, and daily OMR on any day cannot be more than 25% more negative than the 5-day moving average. On the 17th day, a 14-day moving average will be available. Consequently, from the 17th day forward, the 14-day moving average cannot be more negative than the OMR limit.

Transition to less restrictive (more negative) OMR limit

When a less restrictive OMR limit is decided upon, the water projects may begin to operate to that limit on the same day. The 5-day and 14-day averaging periods will continue to be computed through the transition. However, the 5-day averaging period will not provide 25% flexibility from the day the new OMR is imposed through the 7th day after the new limit is adopted. Through the 7th day after imposition, daily OMR may not be more negative than the new limit.

[37] NMFS assumes that the loss of winter-run Chinook salmon and steelhead are similar in nature based on annual loss estimates. As an initial trigger, the density of steelhead, which includes smolts and adults, will be used in the same equation as the older juvenile salmon trigger to change OMR flows. This will be reviewed by the DOSS group annually and recommendations to the trigger criteria made based on an assessment of the results.

[38] Three consecutive days in which the loss numbers are below the action triggers are required before the OMR flow reductions can be relaxed to -5,000 cfs. A minimum of 5 consecutive days of export reduction are required for the protection of listed salmonids under the action. Starting on day three of the export curtailment, the level of fish loss must be below the action triggers for the remainder of the 5-day export reduction to relax the OMR requirements on day 6. Any exceedances of the triggers restarts the 5-day OMR actions with the three day loss monitoring criteria.

		met.
January 1 - June 15 Second Stage Trigger (analogous to high concern level)	Daily SWP/CVP older juvenile loss density (fish per taf) is 1) greater than incidental take limit (2 percent of WR JPE) divided by 1000 (2 percent of WR JPE ÷ 1000), with a minimum value of 2.5 fish per taf, or 2) daily loss is greater than daily fish density divided by 8 taf (daily fish density ÷8 taf), or 3) CNFH CWT LFR or LSNFH CWT WR cumulative loss greater than 0.5%, or 4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 taf (daily measured fish density ÷ 8 taf)	Reduce exports to achieve an average net OMR flow of (minus) -2,500 cfs for a minimum 5 consecutive days. Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for 3 consecutive days following the 5 consecutive days of export reduction. Reductions are required when any one criterion is met.
End of Triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72ºF (22ºC) for 7 consecutive days (1 week), whichever is earlier.	If trigger for end of OMR regulation is met, then the restrictions on OMR are lifted.

Implementation procedures: Combined exports will be managed to provide for an OMR flow of -5,000 cfs, tidally filtered over 14-days during the period between January 1 and June 15. The 5-day running average shall be no more than 25 percent more negative than the targeted flow requirement. Further reductions in exports will occur in a tiered fashion depending on the magnitude of Chinook salmon and steelhead salvage at the CVP and SWP fish salvage facilities. There are two export reductions triggered by increases in fish salvage rates at the fish collection. The first reduction decreases exports to achieve a net average

OMR flow of -3,500 cfs over a minimum of 5 consecutive days. The second reduction, based on higher salvage numbers, further reduces exports to achieve a net average OMR flow of -2,500 cfs over a minimum of 5 days.

These actions will be taken in coordination with USFWS RPA for Delta smelt and State-listed longfin smelt 2081 incidental take permit. During the January 1 through June 15 period, the most restrictive export reduction shall be implemented. If the USFWS Delta smelt RPA requires greater reductions in exports than those required by NMFS for salmonids, to achieve a more positive OMR flow, then the smelt action will be implemented, since it also will increase survival of listed salmonids. Likewise, if the NMFS RPA criteria are more restrictive than those called for under the Delta smelt RPA, then NMFS RPA criteria will prevail and will increase survival of Delta smelt as well as salmonids.

Rationale: Juvenile listed salmonids emigrate downstream in the main channel of the San Joaquin River during the winter and spring period. Juvenile listed steelhead from the San Joaquin River basin, the Calaveras River basin, and the Mokelumne River basin also utilize the lower reaches of the San Joaquin River as a migration corridor to the ocean. The river reach between the Port of Stockton and Jersey Point has many side channels leading south toward the export facilities. High export levels draw water through these channels toward the pumps, as these channels are the conduits that supply water to the pumps from the north. Outputs from PTM simulations, as well as data from acoustic tagging studies (Vogel 2004, SJRGA 2006, 2007), show that migrating fish are vulnerable to diversion into these channels and respond to flow within the channels, including the net migration speed downstream (SJRGA 2008).

The acoustic tagging studies also indicate that fish behavior is complex, with fish exhibiting behavior that is not captured by the "tidal surfing' model utilized as one of the options in the PTM simulations. Fish made their way downstream in a way that was more complicated than simply riding the tide, and no discernable phase of the tide had greater net downstream movement than another. Furthermore, tagged fish chose channels leading south more frequently when exports were elevated, than when exports were lower (Vogel 2004). Fish that moved into channels leading south may eventually find their way back to the main channel of the San Joaquin, but this roundabout migratory path exposes fish to higher predation risks as well as the potential to become lost within the Delta interior, increasing migration route length and duration of the outmigration. Increased time in the channels of the Central and South Delta exposes fish to unscreened agricultural diversions, discharges of agricultural irrigation return water to the Delta, increased water temperature later in the season, and the risk of predation from pelagic predators such as striped bass and localized ambush predators such as largemouth bass. In order to increase the likelihood of survival, emigrating steelhead from the San Joaquin Basin and the east-side tributaries should remain in the mainstem of the San Joaquin River to the greatest extent possible and reduce their exposure to the adverse effects that are present in the channels leading south toward the export facilities.

Reducing the risk of diversion into the central and southern Delta waterways also will increase survival of listed salmonids and green sturgeon entering the San Joaquin River via Georgiana Slough and the lower Mokelumne River. As described in the effects section of the Opinion, these fish also are vulnerable to entrainment by the far-field effects of the exports. The data output for the PTM simulation of particles injected at the confluence of the Mokelumne River and the San Joaquin River (Station 815) indicate that as net OMR flow increases southwards from -2,500 to -3,500 cfs, the risk of particle entrainment nearly doubles from 10 percent to 20 percent, and quadruples to 40 percent at -5,000 cfs. At flows more negative than -5,000 cfs, the risk of entrainment increases at an even greater rate, reaching approximately 90 percent at -7,000 cfs. Even if salmonids do not behave exactly as neutrally buoyant particles, the risk of entrainment escalates considerably with increasing exports, as represented by the net OMR flows. The logical conclusion is that as OMR reverse flows increase, risk of entrainment into the channels of the South Delta is increased. Conversely, the risk of entrainment into the channels of the South delta is reduced when exports are lower and the net flow in the OMR channels is more positive -- that is, in the direction of the natural flow toward the ocean.

Action IV.3 Reduce Likelihood of Entrainment or Salvage at the Export Facilities

Objective: Reduce losses of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon by reducing exports when large numbers of juvenile Chinook salmon are migrating into the upper Delta region, at risk of entrainment into the central and south Delta and then to the export pumps in the following weeks.

Action: From November 1 through April 30, operations of the Tracy and Skinner Fish Collection Facilities shall be modified according to monitoring data from upstream of the Delta. In conjunction with the two alerts for closure of the DCC (Action IV.1.1), the Third Alert shall be used to signal that export operations may need to be altered in the near future due to large numbers of juvenile Chinook salmon migrating into the upper Delta region, increasing their risk of entrainment into the central and south Delta and then to the export pumps.

Third Alert: The catch index is greater than 10 fish captured per day from November 1 to February 28, or greater than 15 fish captured per day from March 1 to April 30, from either the Knights Landing catch index or the Sacramento catch index.

Response: From November 1 through December 31, when salvage numbers reach the action triggers, exports shall be reduced as follows:

Date	Action Triggers	**Action Responses**

November 1 – December 31	Daily SWP/CVP older juvenile loss density greater than 8 fish/thousand acre feet (taf), or daily loss is greater than 95 fish per day, or Coleman National Fish Hatchery coded wire tagged late fall-run Chinook salmon (CNFH CWT LFR) or Livingston Stone National Fish Hatchery coded wire tagged winter-run (LSNFH CWT WNT) cumulative loss is greater than 0.5%.	Reduce exports to a combined 6,000 cfs for 3 days or until CVP/SWP daily density is less than 8 fish/taf. Export reductions are required when any one of the four criteria is met.
	Daily SWP/CVP older juvenile loss density greater than 15 fish/taf, or daily loss is greater 120 fish per day, or CNFH CWT LFR or LSNFH CWT WNT cumulative loss greater than 0.5%.	Reduce exports to a combined 4,000 cfs for 3 days or until CVP/SWP daily density is less than 8 fish/taf. Export reductions are required when any one of the four criteria is met.

From January 1 through April 30, implement Action IV.2.3 which include restrictions on OMR flows rather than set levels of combined export pumping. Alert triggers will remain in effect to notify the operators of the CVP and SWP that large numbers of juvenile Chinook salmon are entering the Delta system.

Rationale: As explained previously, juvenile salmonids and green sturgeon have a lower chance of survival to the ocean if they are diverted from their migratory routes on the main Sacramento and San Joaquin Rivers into the central and south Delta. Export pumping changes flow patterns and increases residence time of these diverted fish in the central Delta, which increases the risk of mortality from predation, water diversions, poor water quality, and contaminant exposure, as well as the likelihood of entrainment at the pumps. When more fish are present, more fish are at risk of diversion and losses will be higher. The Third Alert is important for real-time operation of the export facilities because the collection and dissemination of field data to the resource agencies and coordination of response actions may take several days. This action is designed to work in concert with the OMR action in IV.2.3.

Action Suite IV.4 Modifications of the Operations and Infrastructure of the CVP and SWP Fish Collection Facilities

Objective: Achieve 75 percent performance goal for whole facility salvage at both state and Federal facilities. Increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of winter-run, spring-run, CV steelhead, and green sturgeon.

Action: Reclamation and DWR shall each achieve a whole facility salvage efficiency of 75 percent at their respective fish collection facilities. Reclamation and DWR shall implement the following actions to reduce losses associated with the salvage process, including: (1) conduct studies to evaluate current operations and salvage criteria to reduce take associated with salvage,

(2) develop new procedures and modifications to improve the current operations, and (3) implement changes to the physical infrastructure of the facilities where information indicates such changes need to be made. Reclamation shall continue to fund and implement the CVPIA Tracy Fish Facility Program. In addition, Reclamation and DWR shall fund quality control and quality assurance programs, genetic analysis, louver cleaning loss studies, release site studies and predation studies. Funding shall also include new studies to estimate green sturgeon screening efficiency at both facilities and survival through the trucking and handling process.

By January 31 of each year, Reclamation and DWR shall submit to NMFS an annual progress report summarizing progress of the studies, recommendations made and/or implemented, and whole facility salvage efficiency. These reports shall be considered in the Annual Program Review.

Action IV.4.1 Tracy Fish Collection Facility (TFCF) Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency

Objective: Implement specific measures to reduce pre-screen loss and improve screening efficiency at Federal facilities**.**

Action: Reclamation shall undertake the following actions at the TFCF to reduce pre-screen loss and improve screening efficiency:

1) By December 31, 2012, improve the whole facility efficiency for the salvage of Chinook salmon, CV steelhead, and Southern DPS of green sturgeon so that overall survival is greater than 75 percent for each species.

    a) By December 31, 2011, Reclamation shall complete studies to determine methods for removal of predators in the primary channel, using physical and non-physical removal methods (*e.g.*, electricity, sound, light, CO_2), leading to the primary louver screens with the goal of reducing predation loss to ten percent or less. Findings shall be reported to NMFS within 90 days of study completion. By December 31, 2012, Reclamation shall implement measures to reduce pre-screen predation in the primary channel to less than ten percent of exposed salmonids.
    b) By March 31, 2011, Reclamation shall complete studies for the re-design of the secondary channel to enhance the efficiency of screening, fish survival, and reduction of predation within the secondary channel structure and report study findings to NMFS. NMFS shall review study findings and if changes are deemed feasible, Reclamation shall initiate the implementation of the study findings by January 31, 2012.
    c) No later than June 2, 2010, Reclamation shall submit to NMFS, one or more potential solutions to the loss of Chinook salmon and green sturgeon associated with the cleaning and maintenance of the primary louver and secondary louver systems at the TFCF. In the event that a solution acceptable to NMFS is not in place by June 2, 2011, pumping at the Tracy Pumping Plant shall cease during louver cleaning and maintenance operations to avoid loss of fish during these actions.

2) By December 31, 2011, Reclamation shall implement operational procedures to optimize the simultaneous salvage of juvenile salmonids and Delta smelt at the facility.

3) Immediately upon issuance of this biological opinion, Reclamation shall begin removing predators in the secondary channel at least once per week. By June 2, 2010, Reclamation shall install equipment to monitor for the presence of predators in secondary channel during operations. This could include an infrared or low light charged coupled device camera or acoustic beam camera mounted within the secondary channel.

4) Reclamation shall operate the facility to meet design criteria for louver bypasses and channel flows at least 75 percent efficiency.

5) Reclamation shall maintain a head differential at the trash rack of less than 1.5 ft. between the ambient Old River water surface elevation and the primary intake channel at all times.

6) By January 2, 2010, Reclamation shall install and maintain flow meters in the primary and secondary channels to continuously monitor and record the flow rates in the channel. Deviations from design flow criteria shall initiate immediate corrective measures to remedy deficiencies and return channel flows to design flow specifications.

7) Reclamation shall change its operations of the TFCF to meet salvage criteria, while emphasizing the following actions: (a) Primary Bypass Ratio; (b) Secondary Bypass Ratio; (c) Primary Average Channel Velocity; and (d) Secondary Average Channel Velocity.

8) Records of all operating actions shall be kept and made available to NMFS engineers upon request. NMFS shall be notified of any major or long-term deviations from normal operating design criteria within 24 hours of occurrence.

Action IV.4.2 Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency

Objective: Implement specific measures to reduce pre-screen loss and improve screening efficiency at state facilities**.**

Action: DWR shall undertake the following actions at the Skinner Fish Collection Facility:

1) By December 31, 2012, operate the whole Skinner Fish Protection Facility to achieve a minimum 75 percent salvage efficiency for CV salmon, steelhead, and Southern DPS of green sturgeon after fish enter the primary channels in front of the louvers.

2) Immediately commence studies to develop predator control methods for Clifton Court Forebay that will reduce salmon and steelhead pre-screen loss in Clifton Court Forebay to no more than 40 percent.

   a) On or before March 31, 2011, improved predator control methods. Full compliance shall be achieved by March 31, 2014. Failure to meet this timeline shall result in the cessation of incidental take exemption at SWP facilities unless NMFS agrees to an extended timeline.
   b) DWR may petition the Fish and Game Commission to increase bag limits on striped bass caught in Clifton Court Forebay.

3) Remove predators in the secondary channel at least once per week.

Action IV.4.3 Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting and Release Survival Rates

Objective: To improve overall survival of listed species at facilities through accurate, rapid salvage reporting and state-of-the-art salvage release procedures. This reporting is also necessary to provide information needed to trigger OMR actions.

Action: Reclamation and DWR shall undertake the following actions at the TFCF and the Skinner Fish Collection Facility, respectively. Actions shall commence by October 1, 2009, unless stated otherwise.

1) Sampling rates at the facilities for fish salvage counts shall be no less than 30 minutes every 2 hours (25 percent of operational time) year-round to increase the accuracy of salvage estimates used in the determination of trigger levels. Exceptions to the 30-minute count may occur with NMFS' concurrence under unusual situations, such as high fish densities or excessive debris loading.

2) By October 1, 2010, websites shall be created or improved to make salvage count data publicly available within 2 days of observations of the counts. Information available on the website shall include at a minimum:

   a) duration of count in minutes;
   b) species of fish salvaged;
   c) number of fish salvaged including raw counts and expanded counts;
   d) volume of water in acre-feet, and average daily flow in cfs;
   e) daily average channel velocity and bypass ratio in each channel, primary and secondary;
   f) average daily water temperature and electrical conductivity data for each facility; and
   g) periods of non-operation due to cleaning, power outages, or repairs.

3) Release Site Studies shall be conducted to develop methods to reduce predation at the

"end of the pipe" following release of salvaged fish. Studies shall examine but are not limited to:

a) potential use of barges to release the fish in different locations within the western Delta, with slow dispersion of fish from barge holding tanks to Delta waters;
b) multiple release points (up to six) in western Delta with randomized release schedule; and
c) conducting a benefit to cost analysis to maximize this ratio while reducing predation at release site to 50 percent of the current rate.

4) By June 15, 2011, predation reduction methods shall be implemented according to analysis in 3. By June 15, 2014, achieve a predation rate that has been reduced 50 percent from current rate.

5) Add salt to water within the tanker trucks hauling fish to reduce stress of transport. Assess use of other means to reduce stress, protect mucous slime coat on fish, and prevent infections from abrasions (*i.e*., commercially available products for this purpose).

6) All personnel conducting fish counts must be trained in juvenile fish identification and have working knowledge of fish physiology and biology.

7) Tanker truck runs to release salmonids should be scheduled at least every 12 hours, or more frequently if required by the "Bates Table" calculations (made at each count and recorded on the monthly report).

8) Reclamation and DWR shall use the Bates Table to maintain suitable environmental conditions for fish in hauling trucks. Trucks should never be overcrowded so that the carrying capacity of the tanker truck is exceeded.

Rationale: The process for salvaging listed salmonids and green sturgeon that are drawn into the pumping facilities is not efficient. For salmonids, at the Skinner Fish Protection Facility, loss rates can be as high as five fish lost for every fish salvaged. Most of this loss occurs in the forebay before the fish even encounter the fish screen louvers and the screening process. Conversely, at the Federal TFCF, most loss occurs because of poor screening efficiency in the louver array, although predation also occurs in front of the trash racks and in the primary channel leading to the primary louver array. Louver array cleaning protocols also lead to high loss rates because louvers are removed during cleaning, but pumping continues and fish are drawn directly into the facilities. The efficiency of the salvage process for green sturgeon is unknown, and this is a significant gap in the operational protocol for the facilities. The 2004 CVP/SWP operations Opinion identified terms and conditions to be implemented regarding salvage improvements, including evaluations for operational improvements. Some of those terms and conditions have been implemented but many have not.

Action IV.5 Formation of Delta Operations for Salmon and Sturgeon (DOSS) Technical Working Group

Objective: Create a technical advisory team .that will provide recommendations to WOMT and NMFS on measures to reduce adverse effects of Delta operations of the CVP and SWP to salmonids and green sturgeon and will coordinate the work of the other technical teams.

Action: The DOSS group will be comprised of biologists, hydrologists, and other staff with relevant expertise from Reclamation, DWR, CDFG, USFWS, and NMFS. Invitations to EPA, USGS, and Regional Water Quality Board biologists will be extended to provide expertise on issues pertinent to Delta water quality, hydrology and environmental parameters. By October 1, 2009, Reclamation shall, jointly with NMFS, convene the DOSS working group. The working group will have biweekly phone conferences, or more frequently if necessary for real-time operations, and meet at least quarterly to discuss and review information related to project operations and fisheries issues. Either Reclamation or NMFS may call for a special meeting of the DOSS group if they deem it necessary.

The team will:

1) provide recommendations for real-time management of operations to WOMT and NMFS, consistent with implementation procedures provided in this RPA;
2) review annually project operations in the Delta and the collected data from the different ongoing monitoring programs;
3) track the implementation of Actions IV.1 through IV.4;
4) evaluate the effectiveness of Actions IV.1 through IV.4 in reducing mortality or impairment of essential behaviors of listed species in the Delta;
5) oversee implementation of the acoustic tag experiment for San Joaquin fish provided for in Action IV.2.2;
6) coordinate with the SWG to maximize benefits to all listed species; and
7) coordinate with the other technical teams identified in this RPA to ensure consistent implementation of the RPA.

The DOSS team shall provide annual written reports to Reclamation, DWR, and NMFS, including a summary of major actions taken during the year to implement Action Suite IV of this RPA, an evaluation of their effectiveness, and recommendations for future actions. At the technical staff level, the working group will coordinate with the DAT, the SWG, and other workgroups to ensure coherent and consistent implementation of actions in the Delta. Every five years, the DOSS working group will produce a summary report of the previous five years of operations, actions taken, and the effectiveness of those actions in achieving the objectives of the Delta actions in this RPA. Included in this report will be recommendations for adaptive management changes consistent with the objectives of this RPA. The report will be provided to NMFS, Reclamation, DWR, CDFG and USFWS.

The DOSS group shall also provide a coordinating function for the other technical working groups, to assure that relevant information from all technical groups is considered in actions to implement this RPA.

Rationale: This RPA contains a series of measures to minimize adverse effects of project operations in the Delta. An interagency technical team is necessary to track implementation of these measures, recommend actions within the boundaries of the implementation procedures in this document, and to build expertise over time to recommend changes to Delta operations. Any significant changes to Operations will trigger re-initiation of this opinion.

Action IV.6 South Delta Improvement Program—Phase I (Permanent Operable Gates)

Action: DWR shall not implement the South Delta Improvement Program, which is a proposal to replace temporary barriers with permanent operable gates.

Rationale: In a separate formal consultation (2009/01239), NMFS issued a 2008 biological opinion on the installation and operation of temporary barriers through 2010 (NMFS 2008). That biological opinion concluded that the temporary barriers would not jeopardize the continued existence of listed species or adversely modify critical habitat. This CVP/SWP operations Opinion concludes that on the basis of the best information available, the proposed replacement of these temporary barriers with permanent operable gates will adversely modify critical habitat. NMFS has not identified an alternative to the proposed permanent gates that meets ESA obligations.

After analyses of the operations of the temporary barriers are completed, as specified in the 2008 biological opinion, DWR may request that Reclamation reinitiate consultation with NMFS on the South Delta Improvement Program or may pursue permitting under ESA section 10. Additionally, DWR may apply information developed from Action IV.1.2 to modify the barrier design.

V. Fish Passage Program

Introduction: The duration of the proposed action is more than two decades. The long time horizon of the consultation requires NMFS to anticipate long-term future events, including increased water demand and climate change. The effects analysis in this Opinion highlights the difficulty of managing cold water aquatic species below impassible barriers, depending entirely on a fluctuating and often inadequate cold water reservoir pool. The analysis shows that even after all discretionary actions are taken to operate Shasta and Folsom reservoirs to reduce adverse effects of water operations on listed anadromous fish, the risk of temperature-related mortality of fish and eggs persists, especially in critically dry years. This mortality can be significant at the population level. The analysis also leads us to conclude that due to climate change, the frequency of these years will increase.

Therefore, NMFS believes it is necessary for Reclamation, in cooperation with NMFS, other fisheries agencies, and DWR, to undertake a program to provide fish passage above currently impassable artificial barriers for Sacramento River winter-run, spring-run, and CV steelhead, and to reintroduce these fish to historical habitats above Shasta and Folsom Dams. Substantial areas of high quality habitat exist above these dams: there are approximately 60 mainstem miles above Lake Shasta and 50 mainstem miles above Lake Folsom. These high-elevation areas of suitable habitat will provide a refuge for cold water fish in the face of climate change.

An RPA requiring a fish passage program has recently been issued by the Northwest Region of NMFS, as part of the Willamette Projects Biological Opinion (NMFS 2008). This jeopardy biological opinion resulted from the operation of a series of Federal projects in Oregon. That RPA represents the state-of-the-art program to address passage concerns such as residualism (failure to complete the downstream migration) and predation. The following suite of actions is similar, but not identical, to those in the Willamette projects Opinion. There are several designs available for passage, and some are likely to be more effective in some locations than others. Consequently, while NMFS suggests that Reclamation learn from the Willamette experience, the actions allow Reclamation to follow different critical paths, particularly with respect to the construction of a downstream passage prototype.

The Fish Passage Program includes a fish passage assessment for evaluating steelhead passage above Goodwin, Tulloch, and New Melones Dams on the Stanislaus River. The assessment will develop information necessary for consideration and development of fish passage options for the Southern Sierra Diversity Group of CV steelhead. Although pilot testing of passage in the Stanislaus is encouraged, it is not specifically required.

The Fish Passage Program Action includes several elements that are intended to proceed in phases. The near-term goal is to increase the geographic distribution and abundance of listed species. The long-term goal is to increase abundance, productivity, and spatial distribution, and to improve the life history and genetic diversity of the target species. Several actions are included in this program, as indicated in the following outline of the program:

Near-Term Fish Passage Actions:

- NF 1. Formation of Interagency Fish Passage Steering Committee
- NF 2. Evaluation of Habitat Above Dams
- NF 3. Development of Fish Passage Pilot Plan
- NF 4. Implementation of Pilot Reintroduction Program
    - NF 4.1. Adult Fish Collection and Handling Facilities
    - NF 4.2. Adult Fish Release Sites above Dams, and Juvenile Fish Sites Below Dams
    - NF 4.3. Capture, Trapping, and Relocation of Adults
    - NF 4.4. Interim Downstream Fish Passage through Reservoirs and Dams
    - NF 4.5. Juvenile Fish Collection Prototype
    - NF 4.6. Pilot Program Effectiveness Monitoring and Evaluation
    - NF 4.7. Stanislaus River Fish Passage Assessment
- NF 5. Comprehensive Fish Passage Report

Long-Term Fish Passage Actions:

LF 1. Long-term Funding and Support for the Interagency Fish Passage Steering Committee.

LF 2. Long-term Fish Passage Program

- LF 2.1. Construction and Maintenance of Adult and Juvenile Fish Passage Facilities
- LF 2.2. Development of Supplementation and Management Plan
- LF 2.3. Construction and Maintenance of Long-term Adult and Juvenile Release Locations and Facilities.
- LF 2.4. Development of Fish Passage Monitoring and Evaluation Plan

NEAR-TERM FISH PASSAGE ACTIONS

NF 1. Formation of Interagency Fish Passage Steering Committee

Objective: To charter, and support through funding agreements, an interagency steering committee to provide oversight and technical, management, and policy direction for the Fish Passage Program.

Action: By December 2009, Reclamation shall establish, chair and staff the Interagency Fish Passage Steering Committee. The Committee shall be established in consultation with and the approval of NMFS and shall include senior biologists and engineers with experience and expertise in fish passage design and operation, from Reclamation, NMFS, DWR, CDFG, and USFWS. The Steering Committee also shall include academic support by including at least one academic member from a California University with and established fishery program. The committee shall be limited to agency membership unless otherwise approved by Reclamation and NMFS. Steering committee membership shall include on lead member and one alternate.

Rationale: Interagency coordination and oversight is critical to ensuring the success of the fish passage program.

NF 2. Evaluation of Salmonid Spawning and Rearing Habitat Above Dams

Objective: To quantify and characterize the location, amount, suitability, and functionality of existing and/or potential spawning and rearing habitat for listed species above dams operated by Reclamation.

Action: Beginning in January 2010 and continuing through January 2012, Reclamation, shall conduct habitat evaluations to quantify and characterize the location, amount, suitability, and functionality of existing and/or potential spawning and rearing habitat for listed species above the project reservoirs. Reclamation shall obtain the Steering Committee's assistance in designing and implementing the habitat evaluations. Evaluations shall be conducted using established field survey protocols such as the USFS Region 5

Stream Condition Inventory, Field Intensive and Field Extensive protocols; and habitat models including the Salmon Habitat Integrated Resource Analysis (Shiraz) in combination with the Distributed Hydrology Soil Vegetated Model (DHSVM) or RIPPLE. Shiraz is a life-cycle model that incorporates stream flow and temperature inputs from DHSVM to develop future projections of salmon population sizes. Ripple uses digital terrain information with aquatic habitat and biological data to identify habitat limitations that affect salmon production. Both modeling approaches have been applied in the Washington and Oregon assess the value of providing passage to salmonids to historically available habitat.

Rationale: The condition and suitability of historical habitats located above impassable barriers is likely to have changed considerably since last occupied by anadromous fish. The location, quantity, and condition of habitat must be inventoried and assessed in order to evaluate the current carrying capacity and restoration potential. This information is essential to determine where passage and reintroduction, if feasible, are most likely to improve reproductive success for listed fish.

NF 3. Development of Fish Passage Pilot Plan

Action: From January 2010 through January, 2011, Reclamation, with assistance from the Steering Committee, shall complete a 3-year plan for the Fish Passage Pilot program. The plan shall include: (1) a schedule for implementing a 3-year Pilot Passage program on the American River above Nimbus and Folsom dams, and on the Sacramento River above Keswick and Shasta dams; and (2) a plan for funding the passage program. This plan and its annual revisions shall be implemented upon concurrence by NMFS that it is in compliance with ESA requirements. The plan shall include, but not be limited to, the following:

1) Identify any operational requirements needed for the passage and re-introduction program.

2) Identify protocols for optimal handling, sorting, and release conditions for ESA-listed fish collected at Reclamation or partner agency-funded fish collection facilities when they are constructed.

3) Identify the number, origin, and species of fish to be released into habitat upstream of Reclamation dams, incorporated into the hatchery broodstock, or taken to other destinations.

4) Identify fish collection and transportation requirements (*e.g.*, four wheel-drive vehicles, smooth-walled annular tanks, large vertical slide gates, provisions for tagging/marking, *etc*.) for moving fish from below project dams to habitats above reservoirs, avoiding the use of facilities or equipment dedicated for other purposes (*e.g.*, existing transport trucks).

5) Identify optimal release locations for fish, based on access, habitat suitability, disease concerns, and other factors (*e.g.*, those which would minimize disease concerns,

recreational fishery impacts, interbreeding with non-native *O. mykiss* strains, regulatory impacts, special authorities for studies/construction, complications from upstream dams, *etc*.).

6) Identify and evaluate options for providing tailored ESA regulatory assurances for non-Federal landowners above the dams where species could be re-introduced.

7) Identify interim downstream fish passage options through reservoirs and dams with the objective of identifying volitional downstream passage scenarios and alternatives for juvenile salmon and steelhead migrating through or around project reservoirs and dams. If these options are not considered feasible, identify interim non-volitional alternatives. Near-term operating alternatives that are determined to be technically and economically feasible and biologically justified shall be identified by Reclamation and the steering committee agencies.

8) Describe scheduled and representative types of unscheduled, maintenance of existing infrastructure (dams, transmission lines, fish facilities, *etc*.) that could adversely impact listed fish, and describe measures to minimize these impacts.

9) Describe procedures for coordinating with Federal and state resource agencies in the event of scheduled and unscheduled maintenance.

10) Describe protocols for emergency events and deviations.

Reclamation and partner agencies shall annually revise and update the Fish Passage Pilot Plan. The revisions and updates shall be based on results of Fish Passage Pilot Plan activities, construction of new facilities, recovery planning guidance, predicted annual run size, and changes in hatchery management. By January 15 of each year, Reclamation shall submit a revised draft plan to NMFS. By February 15, NMFS shall advise Reclamation and partner agencies whether it concurs that the revised Fish Passage Plan is likely to meet ESA requirements. Reclamation and partner agencies shall release a final updated Fish Passage Pilot Plan by March 14 of each year.

Rationale: The Fish Passage Pilot Plan is a critical link between measures in the Proposed Action and this RPA and the long-term fish passage program. The plan will provide a blueprint for obtaining critical information about the chances of successful reintroduction of fish to historical habitats and increasing the spatial distribution of the affected populations. By including emergency operations within the Plan, field staff will have a single manual to rely on for all fish-related protocols, including steps that should be taken in emergency situations to minimize adverse effects to fish.

NF 4. Implementation of Pilot Reintroduction Program

Objective: To implement short-term fish passage actions that will inform the planning for long-term passage actions.

Actions: From January 2012 through 2015, Reclamation shall begin to implement the Pilot Reintroduction Program (see specific actions below). The Pilot Program will, in a phased approach, provide for pilot reintroduction of winter-run and spring-run to habitat above Shasta Dam in the Sacramento River, and CV steelhead above Folsom Dam in the American River. This interim program will be scalable depending on source population abundance, and will not impede the future installation of permanent facilities, which require less oversight and could be more beneficial to fish. This program is not intended to achieve passage of all anadromous fish that arrive at collection points, but rather to phase in passage as experience with the passage facilities and their benefits is gained.

Rationale: The extent to which habitats above Central Valley dams can be successfully utilized for the survival and production of anadromous fish is currently unknown. A pilot reintroduction program will allow fishery managers to incrementally evaluate adult reintroduction locations, techniques, survival, distribution, spawning, and production, and juvenile rearing, migration. The pilot program also will test juvenile collection facilities.

This action requires facility improvements or replacements, as needed, and establishes dates to complete work and begin operation. In some cases, work could be initiated sooner than listed above, and NMFS expects Reclamation and partner agencies to make these improvements as soon as possible.

Because these facilities will be used in lieu of volitional fish passage to provide access to historical habitat above the dams, this measure is an essential first step toward addressing low population numbers caused by decreased spatial distribution, which is a key limiting factor for Chinook salmon and CV steelhead.

Upstream fish passage is the initial step toward restoring productivity of listed fish by using large reaches of good quality habitat above project dams. Restriction to degraded habitat below the dams has significantly impaired reproductive success and caused steep declines in abundance.

NF 4.1. Adult Fish Collection and Handling Facilities

Beginning in 2012, Reclamation, with assistance from the Steering Committee, shall design, construct, install, operate and maintain new or rebuilt adult fish collection, handling and transport facilities at the sites listed below. The objective is to provide interim facilities to pass fish above project facilities and reservoirs.

Reclamation and partner agencies shall incorporate NMFS' Fish Screening Criteria for Anadromous Salmonids (NMFS 1997a) and the best available technology. During the design phase, Reclamation and partner agencies shall coordinate with NMFS to determine if the design should accommodate possible later connection to improved facilities, if necessary in years beyond 2015.

Reclamation and partner agencies shall complete all interim steps in a timely fashion to allow them to meet the following deadlines for completing construction and beginning operation of the facilities listed below. These steps may include completing plans and specifications. Reclamation and partner agencies shall give NMFS periodic updates on their progress. The order in which these facilities are completed may be modified with NMFS' concurrence, based on interim analyses and biological priorities.

1) Sacramento River Fish Facility – Collection facility shall be operational no later than March 2012.

2) American River Fish Facility – Collection facility shall be operational no later than March 2012.

NF 4.2. Adult Fish Release Sites above Dams and Juvenile Fish Sites Below Dams

Reclamation shall provide for the safe, effective, and timely release of adult fish above dams and juvenile fish below dams. The Fish Passage Plan must identify and release sites. Fish transport and release locations and methods shall follow existing State and Federal protocols. With assistance from the Steering Committee, and in coordination with applicable landowners and stakeholders, Reclamation shall complete construction of all selected sites by March 2012.

NF 4.3. Capture, Trapping, and Relocation of Adults

By March 2012, Reclamation shall implement upstream fish passage for adults via "trap and transport" facilities while it conducts studies to develop and assess long-term upstream and downstream volitional fish passage alternatives. At least one fish facility must be in place at terminal upstream passage points for each river that is subject to this measure. Facilities to capture adults currently exist at or below Keswick and Nimbus Dams, though these may need to be upgraded. The Pilot Program is a first step in providing anadromous fish passage to historical habitat above Project dams but will not be sufficient by itself.

The number of fish that shall be relocated is expected to vary depending on the source population, source population size, and the results of fish habitat evaluations and modeling of carrying and production capacity. The Steering Committee will work in consultation with the NMFS Southwest Fishery Science Center to develop adult relocation source populations and abundance targets. The Steering Committee shall evaluate the use of wild and hatchery sources and develop strategies that minimize risk to existing wild populations.

NMFS considers volitional passage via a fish ladder or other fishway to be the preferable alternative in most circumstances. In the short term, upstream passage can be provided with fish trap and transport mechanisms, while Reclamation evaluates program effectiveness and passage alternatives.

NF 4.4. Interim Downstream Fish Passage through Reservoirs and Dams

Beginning in 2012, following the emergence of the first year class of reintroduced fish, and until permanent downstream passage facilities are constructed or operations are established at Project dams, Reclamation shall carry out interim operational measures to pass downstream migrants as safely and efficiently as possible through or around Project reservoirs and dams under current dam configurations and physical and operational constraints, consistent with authorized Project purposes.

Near-term operating alternatives shall be identified, evaluated, and implemented if determined to be technically and economically feasible and biologically justified by Reclamation and partner agencies, within the framework of the Annual Operating Plan updates and revisions, and in coordination with the Fish Passage Plan Steering Committee. Interim devices shall be constructed to collect emigrating juvenile salmonids and emigrating post-spawn adult steelhead from tributaries, main stems above project reservoirs, or heads of reservoirs. Fish shall be safely transported through or around reservoirs as necessary and released below currently impassible dams.

Reclamation and partner agencies shall evaluate potential interim measures that require detailed environmental review, permits, or Congressional authorization as part of the Fish Passage Plan. Reclamation shall complete this component of the Plan by April 30, 2011, including seeking authorization (if necessary) and completing design or operational implementation plans for the selected operations. Measures to be evaluated include, but are not limited to, partial or full reservoir drawdown during juvenile outmigration period, modification of reservoir refill rates, and using outlets, sluiceways, and spillways that typically are not opened to pass outflow.

NF 4.5. Juvenile Fish Collection Prototype

Objective: To determine whether the concept of a head-of-reservoir juvenile collection facility is feasible, and if so, to use head-of-reservoir facilities in Project reservoirs to increase downstream fish survival. Safe and timely downstream passage of juvenile Chinook salmon and juvenile and adult post-spawn steelhead is a critical component to the success of the Fish Passage Program.

Beginning in January, 2010, with input from the CVP/SWP operations Fish Passage Steering Committee, Reclamation shall plan, design, build, and evaluate a prototype head-of-reservoir juvenile collection facility above Shasta Dam. Construction shall be complete by September 2013.

Because the head-of-reservoir fish collection concept is virtually untested, it would be imprudent to require such facilities without prior field studies, design, and prototype testing to validate the concept. For this measure, NMFS defines "prototype" to refer to temporary facilities intended for concept evaluation, not long-term operations. Further, "prototype" does not necessarily refer to a single concept; multiple concepts may be tested simultaneously. Possible options include, among others: (1) floating collectors in the reservoir near the mouths of tributaries, (2) use of curtained or hardened structures near mouths of tributaries, that block surface passage into reservoirs, (3) fish collection facilities on tributaries above the reservoir pools, and (4) a combination of the above to maximize collection in high flow and low flow conditions.

By the end of 2010, Reclamation, with assistance from the Fish Passage Steering Committee and concurrence by NMFS, shall identify a preferred location(s) and design(s) for construction of the prototype(s). Construction of the prototype facility(s) must be completed in time to conduct two years of biological and physical evaluations of the head-of-reservoir prototype collection facilities by the end of 2016. The Fish Passage Steering Committee shall have opportunity to comment on study proposals and a draft report on the effectiveness of the facilities, including recommendations for installing full-scale head-of-reservoir facilities at this and other reservoirs. By December 31, 2016, after receiving concurrence from NMFS and USFWS on the draft report, Reclamation and partner agencies shall make necessary revisions to the draft report and issue a final report. The report shall recommend technically and biologically feasible head-of-reservoir facilities, capable of safely collecting downstream migrating fish, and capable of increasing the overall productivity of the upper basins, then Reclamation and partner agencies shall include such facilities in the design alternatives that they consider in the Fish Passage Plan studies.

NF 4.6. Pilot Program Effectiveness Monitoring and Evaluation

From 2012 to 2015, Reclamation shall study, and provide annual reports on, the elements of the pilot program, including adult reintroduction locations, techniques, survival, distribution, spawning, and production; and juvenile rearing, migration, recollection, and survival. The objective is to gather sufficient biological and technical information to assess the relative effectiveness of the program elements and determine the feasibility of long-term passage alternatives. A final summary report of the 5-year pilot effort shall be completed by December 31, 2015.

NF 4.7. Stanislaus River Fish Passage Assessment

Objective: To develop information needed in order to evaluate options for achieving fish passage on the Stanislaus River above Goodwin, Tulloch, and New Melones Dams.

Action: By March 31, 2011, Reclamation shall develop a plan to obtain information needed to evaluate options for fish passage on the Stanislaus River above Goodwin, Tulloch and New Melones Dams and shall submit this plan to NMFS for review. This plan shall identify reconnaissance level assessments that are needed to support a technical evaluation of the potential benefits to CV steelhead that could be achieved with passage above the dams, a general assessment of logistical and engineering information needed, and a schedule for completing those assessments by December 31, 2016. Reclamation is encouraged to use information developed for the American and Sacramento Rivers in Action NF 3 above, when also applicable for the Stanislaus River.

By December 31, 2016, Reclamation shall submit a report, including the results of the assessments and proposed options for further consideration, to NMFS. By December 31, 2018, Reclamation shall include recommendations for fish passage on the Stanislaus River in the Comprehensive Feasibility Report (Action NF 6.) The report will outline the costs of potential projects, their biological benefits and technical feasibility, potential alternatives, and steps necessary to comply with all applicable statutes and regulations.

Rationale: This assessment process will develop foundational information necessary for consideration and development of fish passage options above New Melones Reservoir to relieve unavoidable effects of project operations on the Southern Sierra Diversity Group of CV steelhead and on adverse modification of critical habitat.

NF 5. Comprehensive Fish Passage Report

Objective: To evaluate the effectiveness of fish passage alternatives and make recommendations for the development and implementation of long-term passage alternatives and a long-term fish passage program.

Action: By December 31, 2016, Reclamation shall prepare a Comprehensive Fish Passage Report. The Report shall include preliminary determinations by Reclamation and partner agencies regarding the feasibility of fish passage and other related structural and operational alternatives. The report should include specific recommendations for improvements to highest priority sub-basins and/or features and to include recommendations for major operational changes. It will also include identification and evaluation of high priority actions and may suggest modifying the scope or timelines of these high priority actions, based on the predicted outcome of long-term efforts.

Re-initiation trigger: If the downstream fish passage improvements are determined not likely to be technically or biologically feasible at this milestone, then Reclamation and the Steering Committee shall identify other alternatives that would be implemented within the same timelines as those identified in this RPA. Reclamation and partner agencies shall submit specific implementation plans for alternative actions to NMFS, and NMFS shall evaluate whether the actions proposed in the implementation plans are likely to have the biological results that NMFS relied on in this Opinion. The alternatives must be within the same Diversity Group as the affected population, identify high elevation habitats above dams that provide similar habitat characteristics in terms of water temperatures, habitat structure (sufficient pool depths and spawning gravels), ability to withstand long-term effects of climate change, and must demonstrate an ability to support populations that meet the characteristics of a population facing a low risk of extinction according to the population parameters identified in Lindley *et al.* (2007), "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin." If Reclamation and partners believe that the proposed passage locations may not be feasible, the Fish Passage Steering Committee should be directed to develop early assessments of alternative actions that meet the performance standards described above in order to maintain the schedule proposed in this action. NMFS shall notify Reclamation and partner agencies as to whether the proposal is consistent with the analysis in this Opinion. If not, Reclamation will request re-initiation of consultation.

LONG-TERM FISH PASSAGE ACTIONS

In the event that the decision is made by 2016 to pursue a comprehensive fish passage program, the following actions will be implemented.

LF 1. Long-term Funding and Support to the Interagency Fish Passage Steering Committee

If the Comprehensive Fish Passage Report indicates that long-term fish passage is feasible and desirable, Reclamation shall continue to convene, fund, and staff the Fish Passage Steering Committee.

LF 2. Action Suite: Long-Term Fish Passage Plan and Program

Objective: Provide structural and operational modifications to allow safe fish passage and access to habitat above and below Project dams in the Central Valley.

Actions: Based on the results of the Comprehensive Fish Passage Report, Reclamation, with assistance from the Steering Committee, shall develop a Long-term Fish Passage Plan and implement a Long-term Fish Passage Program. Reclamation and partner agencies shall submit a plan to NMFS on or before December 31, 2016, which shall describe planned long-term upstream and downstream fish passage facilities and operations, based on the best available information at that time. The plan shall include a schedule for implementing a long-term program for safe, timely, and effective anadromous fish passage by January 31, 2020.

The Long-term Fish Passage Plan and Program shall target the following performance standards: (1) demonstrated ability to withstand long-term effects of climate change, (2) must support populations in the target watersheds that meet the characteristics of a population facing a moderate risk of extinction by year 5 (2025) and a low risk of extinction by year 15 (2030), according to the population parameters identified in Lindley *et al.* (2007), "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin."

The structural and operational modifications needed to implement the program shall be developed as high priority measures in the plan. The plan shall include an evaluation of a range of structural and operational alternatives for providing fish passage above Reclamation dams in the Sacramento, American, and Stanislaus River watersheds. Reclamation and partner agencies will evaluate the information gathered through plan development, the NEPA process, ESA recovery planning (including life cycle modeling developed as part of the recovery planning process), university studies, local monitoring efforts public comment, and other relevant sources, to determine which alternative(s), will provide the most cost-effective means to achieve adequate passage benefits to avoid jeopardy to ESA-listed fish from the water projects in the long term. Reclamation and partner agencies shall proceed with the action(s) that sufficiently address the adverse effects of the Project, in the context of future baseline conditions. Reclamation and DWR shall submit specific implementation plans to NMFS, and NMFS shall evaluate whether the actions proposed in the implementation plans meet ESA requirements, consistent with this Opinion. NMFS will notify Reclamation and partner agencies as to whether the proposal is consistent with ESA obligations.

Reclamation and DWR also shall analyze structural and operational modifications to provide downstream fish passage as part of the plan, following the same process as that for providing upstream passage.

The time frame for implementing the long-term passage measures may extend beyond the time frame of this Opinion. However, Reclamation and DWR must begin some actions during the term of this Opinion, including as investigating feasibility, completing plans, requesting necessary authorization, and conducting NEPA analysis

Rationale: This suite of actions ensures that fish passage actions will be taken by specified dates, or that the Project will be re-analyzed based upon new information. As noted in this Opinion, lack of passage is one of the most significant limiting factors for the viability of the affected populations of Chinook salmon and steelhead. As described in the effects analysis of the biological opinion, this also exposes populations to additional and significant stressors from project operations that also limits their viability and ability to survive below dams. Providing fish passage to historical spawning and rearing habitats would effectively mitigate for unavoidable adverse impacts of the projects on listed fish.

NMFS chose the passage in the Sacramento and American rivers based on the best available information at the time of this Opinion. The choice of location of passage facilities, as well as the method of passage, may change based on additional information, including additional assessment of necessity and feasibility of passage in the Stanislaus River. Passage methods may vary based on the specific requirements of each site, as well as fish behavior at a specific location. If information indicates that a different location or passage method is preferable, then Reclamation and DWR must coordinate with the Fish Passage Plan committee and obtain NMFS' concurrence that a proposed change is likely to meet ESA obligations.

Long-term fish passage should significantly increase abundance and spatial distribution of winter-run, spring-run, and CV steelhead because the fish will have access to upstream spawning and rearing habitat, and the juveniles will have access downstream to the ocean for growth to maturity. This action will address the Habitat Access pathway of critical habitat by improving access past physical barriers, thereby improving the status of PCEs for spawning, rearing, and migration of winter-run, spring-run, and CV steelhead populations.

<u>LF 2.1. Long-term Adult and Juvenile Fish Passage Facilities</u>

Based on the results of the Comprehensive Fish Passage Report and the Fish Passage Plan, and with the assistance of the Steering Committee, Reclamation shall construct long-term fish passage facilities necessary to successfully allow upstream and downstream migration of fish around or through project dams and reservoirs on the Sacramento and American Rivers by 2020, and Stanislaus River depending on results of study provided for in Action NF 4.7.

LF 2.2. Supplementation and Management Plan

Based on the results of the Comprehensive Fish Passage Report and the Fish Passage Plan, and with the assistance of the Steering Committee, in consultation with the NMFS Southwest Fishery Science Center, Reclamation shall develop and implement a long-term population supplementation plan for each species and fish passage location identified in V. *Fish Passage Program*, with adult recruitment and collection criteria developed with consideration for source population location, genetic and life history diversity, abundance and production. The purpose is to ensure that long-term abundance and viability criteria are met for all reintroduced populations, with contingencies for supplementing populations with wild and/or conservation hatchery fish if necessary. The plan shall be developed by 2020. The plan shall identify wild and/or hatchery sources for adult reintroductions and long-term supplementation, and the specific NMFS-approved hatchery management practices that qualify a hatchery for conservation purposes. Species-specific conservation hatchery programs may be developed to supplement reintroductions and maintain long-term performance standards for abundance and viability.

LF 2.3. Long-term Fish Passage Monitoring and Evaluation

Reclamation, through the Steering Committee shall develop a Long-term Fish Passage Monitoring and Evaluation Plan by 2020, to monitor all elements of the Long-term Fish Passage Program including adult reintroduction locations, techniques, survival, distribution, spawning, and production; and juvenile rearing, migration, recollection, and survival. The objective is to gather sufficient biological and technical information to assess the relative effectiveness of the program elements and determine the feasibility of long-term passage alternatives. Annual reports shall be submitted to NMFS by September 30 of each year.

11.3 ANALYSIS OF RPA

This section presents NMFS' rationale for concluding that with adoption of this RPA, Reclamation would avoid jeopardizing the listed species and adversely modifying their proposed and designated critical habitats. This rationale is presented for the following species and critical habitats that NMFS concluded would be jeopardized or adversely modified by the proposed action:

- Sacramento River winter-run and its designated critical habitat,
- CV spring-run and its designated critical habitat,
- CV steelhead and its designated critical habitat,
- Southern DPS of green sturgeon and its proposed critical habitat, and

- Southern Resident killer whales.

Each section summarizes the main stressors and the actions within the RPA that alleviate those stressors, both in the short-term and the long-term. This analysis relies heavily on the tables presented for each species. The supporting biological information for each action referenced in the table is contained in the "objective" and "rationale" sections for each action in the preceding section. Each action of the RPA is linked to at least one main stressor for at least one species, identified in the effects analysis and the integration and synthesis sections of this Opinion. Many RPA actions are designed to minimize adverse effects of project operations on multiple species and life stages.

11.3.1 Sacramento River Winter-Run Chinook Salmon and its Designated Critical Habitat

Throughout this Opinion, NMFS has explained that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS has explained the need for the proper functioning of the PCEs that comprise the critical habitat designation. In sections 9.1 and 9.2, NMFS summarized various project-related stressors that reduced the VSP parameters and the conservation value of PCEs.

The winter-run ESU is currently at a high risk of extinction. As described in the Status of the Species section of this Opinion, weaknesses in all four VSP parameters -- spatial structure, population size, population growth rate, and diversity -- contribute to this risk. In particular (1) multiple populations of this ESU have been extirpated; the ESU now is composed of only one population, and this population has been blocked from all of its historical spawning habitat; (2) habitat destruction and modification throughout the mainstem Sacramento River have dramatically altered the ESU's spatial structure and diversity; (3) the ESU is at risk from catastrophic events, considering the remaining population's proximity to Mt. Lassen and its dependency on the cold water management of Shasta Reservoir; (4) the population has a "high" hatchery influence (Lindley *et al*. 2007); and (5) the population experienced an almost seven fold decrease in 2007. In addition, many of the physical and biological features of critical habitat that are essential for the conservation of winter-run are currently impaired and provide limited habitat value.

The proposed action increases the population's extinction risk and continues to degrade the PCEs of critical habitat by adding numerous stressors to the species' baseline stress regime, as is generally depicted in figure 9-4. The RPA specifies many significant actions that will reduce the adverse effects of the proposed action on winter-run and its critical habitat. Many of the RPA actions specifically address key project-related limiting factors or threats facing the ESU and its critical habitat, as described in the "Objectives" and "Rationale" parts of the actions. Some of these factors are lack of passage to historical spawning habitat above Keswick and Shasta Dams, passage impediments (*e.g.*, RBDD), degraded quantity and quality of the remaining habitat downstream of Keswick and Shasta Dams, and the entrainment influence of the Federal and state export facilities. As shown in table 11-1, there is a need for both short-term and long-term actions, including:

- providing passage to and from historical habitat;
- increasing Shasta reservoir storage to provide for temperature control and improve the quantity and quality of downstream habitat;
- providing interim and long-term modifications to RBDD;
- providing increased rearing habitat;
- modifying operation of the DCC; and
- implementing a revised decision process for Delta operations, including timing and amount of export reduction..

Implementation of some RPA actions will reduce the adverse effects of project operations on winter-run and its critical habitat immediately or in the near term. Other actions will take longer to plan and implement, and will not provide needed results for many years. We discuss the near-term and long-term actions separately.

Near Term

In the near term, adverse effects of project operations to winter-run will be reduced primarily through the following measures:

1) Modifications to Shasta reservoir management will result in more reliable provision of suitable water temperatures for spawning and egg incubation in the summer months. The new year-round Shasta management program is expected to minimize frequency and duration of temperature related egg mortality in dry and critically dry years, thus reducing, though not eliminating, the population level stress of these temperature related mortalities. The new Shasta program will allow for an expanded range of habitat suitable for spawning and egg incubation in wetter year types (i.e. through meeting downstream compliance points more often). Over time, this will help to preserve diversity of run-timing and decrease the risk of a single event in a localized area causing a population level effect. Temperature related effects on winter-run will persist into the future, and cannot be fully off-set through Shasta reservoir storage actions, due to physical and hydrological constraints on the CVP system, and the delivery of water to non-discretionary CVP contractors (e.g. Sacramento River Settlement Contractors). Given a fixed supply of cold water in any given year starting in May, as an overall strategy, the RPA prioritizes temperature management in favor of winter-run due to their endangered status and complete dependence on suitable habitat downstream of Keswick for their continued survival.
2) Interim operations of RBDD (until 2012) will allow for significant increased passage of adult winter-run, a significant reduction in juvenile mortality associated with downstream passage, and elimination of emergency gate closures in early spring.
3) Continuation of installation of fish screens that meet NMFS criteria along the Sacramento River and Delta thereby reducing entrainment of winter run juveniles throughout their migration path down the Sacramento river and through the Delta.;
4) Additional closures of the DCC gates at key times of year triggered to winter-run needs, thereby will keep a greater percentage of winter-run emigrating through the northern Delta out to sea.

5) Old and Middle River reverse flow restrictions on combined exports in January through spring months, will significantly reduce winter-run juveniles that are drawn further into the Interior and Southern Delta, and therefore exposed to risks due to export facilities.
6) Additional measures will reduce entrainment and improve efficiency of salvage operations at both the State and Federal export facilities. Collectively, these measures will ensure that the winter-run that are exposed to the export facilities have a greater likelihood of survival.
7) Overall, the interim RBDD, DCC gate operations, and OMR restrictions are timed to minimize adverse effects to a greater proportion of the entire winter-run life history run-timing. By ensuring the persistence in a greater proportion of run-timing, more diversity is preserved within the ESU. This diversity of run-timing will ensure greater resiliency of the winter-run ESU to environmental changes. For example, ocean conditions and the timing and duration of upwellings may play a significant role in the survival of any given cohort of winter-run. However, modifying operations to allow for the expansion of ocean entry timing for winter-run will increase the probability that at least a portion of each cohort will enter the ocean when prey are readily available, thereby increasing the cohort's survival.

Long Term

In addition to the continuation of near-term actions, long-term actions are necessary to avoid an appreciable reduction in survival and recovery of the species. The long-term effects analysis for winter-run reveals that climate change and growth are likely to increase adverse effects especially associated with temperature related egg mortality on the Upper Sacramento River in the summertime. A prolonged drought could result in extinction of the species by resulting in significant egg mortality for three years in a row. In order to address the underlying issues of inadequate spatial structure and diversity and quality of critical habitat, and therefore, increased risk of extinction over the long-term, a passage program to provide for winter-run to access their historical habitat is necessary in order to avoid jeopardy. Such a program has many unknowns, and therefore cannot be relied upon to produce results in the near-term. In the long-term however, the RPA includes a structured passage program with pilot reintroductions, an interagency work team, and milestones and re-initiation triggers. This structured program, while not guaranteed to be effective, greatly reduces the likelihood of an appreciable reduction to winter-run survival and recovery in the long-term due to on-going project operations by allowing access of a portion of the population to historical cold-water, high elevation habitat. Furthermore, there are some near-term benefits to the passage pilot reintroduction program, including immediate expansion of the geographical rang of the single population.

In addition to upstream passage, the follow actions will minimize project effects in the long-term to the extent that the species is not jeopardized:

1. The RPA specifies long-term RBDD gate configuration is gates out all year. This will greatly reduce the significant losses associated with current and also the more modest losses associated with interim operations.
2. The RPA ensures that the Battle Creek experimental winter-run re-introduction program will proceed in a timely fashion. This Battle Creek program is critical in creating a second

population of winter-run. This second population increases the species spatial structure and diversity and should increase growth rate and abundance over time as well.

3. The RPA ensures that in the long-term, Salmonid rearing habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of project operations on winter-run critical habitat in the long-term and off-set effects of ongoing flood control operations. These habitat actions will increase the growth rates of individuals that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history, thereby increasing the viability of the ESU and reducing the likelihood of appreciable reductions in the survival or recovery of the species.

In conclusion, NMFS believes that if all parts of the RPA pertaining to Sacramento River winter-run Chinook salmon are implemented, the RPA is not likely to reduce appreciably the likelihood of survival and recovery of winter-run or adversely modify its critical habitat, in either the near term or the long term.

Table 11-1. Summary of actions to minimize or alleviate proposed action-related stressors on Sacramento River winter-run Chinook salmon and its designated critical habitat.

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Adult immigration and holding	RBDD gate closures from May 15 - Sept 15 every year until 2019.	~15 % of adults delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity; continues every year until 2019.	High	Action I.3.2: RBDD Interim Operations.	Action I.3.1: RBDD Operations After May 14, 2012.
Adult immigration and holding	RBDD emergency 10 day gate closures prior to May 15	Greater proportion of run blocked or delayed; sub lethal effects on eggs in fish and energy loss. These emergency gate closures have occurred twice in the past 10 years and the frequency of occurrence may increase with climate change.	High	Action I.3.2: RBDD Interim Operations.	Action I.3.1: RBDD Operations After May 14, 2012.

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Spawning	Reduced spawning area from moving TCP upstream in almost every year from April 15 to Sept 30	Introgression or hybridization with spring/fall-run/late fall-run Chinook salmon; loss of genetic integrity and expression of life history Density dependency - aggressive behavior among spawning fish could cause higher prespawn mortality, increased for suitable spawning sites, adults forced downstream into unsuitable areas Redd superimposition - spawning on top of other redds, destroys eggs	High Medium - may increase as abundance increases Medium - may increase as abundance increases	Action I.2.1: Maintain suitable water temperatures for winter-run Chinook salmon. Action I.2.2: Maintain minimum Shasta Reservoir storage. Action I.2.3: February forecast and plan of operation for the Sacramento River. Action I.1.4: Improve and maintain effectiveness of the Spring Creek temperature control curtain. Action I.4: Wilkins Slough Operations Action V: Fish Passage Program (Near-term actions)	Continued implementation of Action I.2.1. Continue implementation of Action I.2.2. Continue implementation of Action I.2.3. Continue implementation of Action I.1.4. Continue implementation of Action I.4. Action V: Fish Passage Program (Long-term actions)
Spawning	Water temperatures warmer than life history stage requirements below TCP, every year April 15 -Sept 30)	Prespawn mortality; reduced fecundity	High		

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Embryo incubation	Water temperatures warmer than life history stage requirements, every year from April 15 - Sept 30. (No carry-over storage target designed for fish protection is included in the proposed action. Without such a target, the risk of running out of coldwater in Shasta Reservoir increases.)	Egg mortality - 16 % in critically dry years and increases to 65% in critically dry years with climate change. On average, for all water year types, mortality is 5-12% with climate change and 2-3% without. 56F is exceeded at Balls Ferry in 30% of the years in August and 55% of the years in September Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of winter-run to survive during subsequent life stages (Campbell *et al*. 1998). Campbell *et al*. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	High	Action I.2.1: Maintain suitable water temperatures for winter-run Chinook salmon. Action I.2.2: Maintain minimum Shasta Reservoir storage. Action I.2.3: February forecast and plan of operation for the Sacramento River. Action I.1.4: Improve and maintain effectiveness of the Spring Creek temperature control curtain. Action I.4: Wilkins Slough Operations Action V: Fish Passage Program (Near-term actions)	Continued implementation of Action I.2.1. Continue implementation of Action I.2.2. Continue implementation of Action I.2.3. Continue implementation of Action I.1.4. Continue implementation of Action I.4. Action V: Fish Passage Program (Long-term actions)

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing and downstream movement	RBDD passage downstream through dam gates May 15 - Sept 15	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50 %; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 10 % of winter-run would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	High	Action I.3.2: RBDD Interim Operations	Action I.3.1: RBDD Operations After May 14, 2012

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing and downstream movement	Reduced quality of juvenile rearing habitat related to the formation of Lake Red Bluff when the RBDD gates are in.	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	Action I.3.2: RBDD Interim Operations Action I.6.1: Restoration of floodplain rearing habitat. Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass. Action I.6.3: Lower Putah Creek enhancements. Action I.6.4: Improvements to Lisbon Weir	Action I.3.1: RBDD Operations After May 14, 2012 Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4.
Juvenile rearing and downstream movement	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	Action I.5: Funding for CVPIA anadromous fish screen program	Continue implementation of Action I.5

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	Lack of channel forming flows and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process	Loss of rearing habitat and riparian habitat and natural river function impaired (e.g., formation of side channels, sinuosity); loss of cottonwood recruitment impacting food availability, juveniles spend longer time in areas of poor water quality, greater predation, less growth from less food sources, greater stress reduces response to predators	High	Action I.6.1: Restoration of floodplain rearing habitat. Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass. Action I.6.3: Lower Putah Creek enhancements. Action I.6.4: Improvements to Lisbon Weir	Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4.

Life Stage/ Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Smolt emigration	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics).	During dry and critical years in December and January, modeling estimates of monthly mortality of up to approximately 15 % of the total winter-run population entering the Delta at Freeport is associated with exports (Greene 2008). Of those winter-run entering the *interior* of the Delta (through DCC or Georgiana Slough), mortality is estimated to be approximately 66 % (range of 35-90 % mortality). This equates to approximately 5-20 % of the total population entering the Delta at Freeport. Anticipated delays in migration due to export operations.	High	Action IV.1.1: Monitoring and alerts to trigger changes in DCC operations. Action IV.1.2: DCC gate operation. Action IV.1.3: Engineering studies of methods to reduce loss of salmonids in Georgiana Slough and South Delta channels. Action IV.2.1: San Joaquin River inflow to export ratio. Action IV.2.2: Old and Middle River Flow Management. Action IV.3: Reduce the likelihood of entrainment or salvage at the export facilities. Action IV.4.1: Tracy fish collection facility improvements. Action IV.4.2: Skinner fish collection facility improvements. Action IV.4.3: Additional improvements at	Continue implementation of Actions IV.1 through IV.6.

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11.3.2 Central Valley Spring-Run Chinook Salmon and Its Designated Critical Habitat

As previously stated in the Status of the Species section, the spring-run ESU is currently likely to become endangered within the foreseeable future due to multiple factors affecting spatial structure, diversity, productivity and abundance. Specific factors include: (1) the ESU currently has only three independent populations. All three of these independent populations are in one diversity group, the Northern Sierra Nevada Diversity Group. The other diversity groups contain dependent populations; (2) habitat elimination and modification throughout the Central Valley have drastically altered the ESU's spatial structure and diversity; (3) the ESU has a risk associated with catastrophes, especially considering the remaining independent populations' proximity to Mt. Lassen and the probability of a large scale wild fire occurring in those watersheds (Lindley *et al*. 2007), (4) the presence of dams precludes access to historical spawning areas and (5) for some populations, the genetic diversity of spring-run has been compromised by hybridization with fall-run.

The effects of the proposed action and their affect on spring-run are contained in the sections of the Opinion on project effects and integration and synthesis. The effects are presented for the Clear Creek population, the mainstem Sacramento River population and for the other populations that are effected by project operations, by diversity group. Ultimately all spring-run must migrate through the Delta and are affected by Delta operations. The proposed action increases the extinction risk of spring-run and continues to degrade the PCEs of critical habitat by adding numerous stressors to the species' baseline stress regime and reducing the viability of all extant spring-run populations, as is generally depicted in figure 9-4. Throughout this Opinion, NMFS acknowledged that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS acknowledged the need for the proper functioning of the PCEs that comprise the critical habitat designation. In sections 9.3 and 9.4, NMFS summarized the various stressors that reduced the VSP parameters and conservation value of the PCEs.

The RPA specifies actions that, in total, will minimize the adverse effects of the proposed action on spring-run individuals, populations and the ESU and bring about the proper functioning of PCEs of its critical habitat. Many of the RPA actions, as described in their objectives and rationale, specifically address key limiting factors/threats facing the ESU and its critical habitat, for example, lack of passage to historic spawning habitat above Keswick and Shasta Dams, passage impediments (*e.g*., RBDD), degraded water quantity and quality of the habitat, and entrainment influence of the Federal and state export facilities. Table 11-2 provides the linkage between specific project related stressors identified in the Opinion's Integration and Synthesis, and the specific RPA actions necessary to minimize those stressors in both the near-term and the long-term. All actions that address spring-run in the RPA are necessary to minimize project effects to the extent where they do not appreciably reduce the likelihood of survival and recovery of the ESU in the near-term and the long-term, or adversely modify spring-run critical habitat. This written analysis summarizes some of the most significant RPA actions that NMFS relied on in its analysis.

The RPA contains numerous actions that minimize project effects to critical habitat of spring-run in both the near-term and the long-term. The rationales for the actions include specific PCEs addressed. It is not technologically or physically feasible, or necessary, to remove all adverse effects of project operations on critical habitat. These actions reduce adverse effects to the point where they no longer adversely modify critical habitat.

<u>Summary of RPA effects on Central Valley Spring-run Chinook Salmon in the Near-Term</u>

RPA actions that reduce adverse effects of project operations to spring-run and its critical habitat in the near-term include:

1) Clear Creek actions will be implemented immediately and will significantly reduce project effects to spring-run by stabilizing that population and thereby increasing the likelihood of survival of that one population in the near-term. Ensuring adequate flows to meet temperature requirements in most years, implementing new pulse flows to assist with adult migratory cues, and implementing geomorphic flows that will disperse restored spawning gravel all will minimize project effects to this population. The Clear Creek population is important to the viability of the ESU as a whole because of its geographic location; ie, if it becomes an independent population it could considerably increase the viability of the ESU. The actions in the RPA are not recovery actions per se, but they will ensure that ongoing project operations do not appreciably reduce the likelihood of recovery of this one population.

2) Modifications to Shasta reservoir management will primarily reduce adverse effects on winter-run. Effects of the year-round Shasta management program on spring-run are more difficult to predict and quantify. The Shasta RPA will result in more carryover storage in some years, as compared to current operations, and therefore, increase ability to meet suitable spring-run spawning and egg incubation temperatures in the Fall in some years, depending on ambient weather conditions and the extent of the cold water pool in Shasta reservoir. The new year-round Shasta management program is expected to minimize frequency and duration of temperature related egg mortality in dry and critically dry years, thus reducing, though not eliminating, the population level stress of these temperature related mortalities. Temperature related effects on spring-run in the mainstem Sacramento River will persist into the future, and cannot be fully off-set through Shasta reservoir storage actions, due to physical and hydrological constraints on the CVP system, and the delivery of water to non-discretionary CVP contractors (e.g. Sacramento River Settlement Contractors). Given a fixed supply of cold water in any given year starting in May, as an overall strategy, the RPA prioritizes temperature management in favor of winter-run due to their endangered status and complete dependence on suitable habitat downstream of Keswick for their continued survival. Despite continued significant project related temperature effects on mainstem spring run, the RPA, in total, does not appreciably reduce the likelihood of survival and recovery of spring-run ESU when all populations and diversity groups are considered.

3) Near-term improvements to Battle Creek through actions identified in the RPA are expected to expand the holding, spawning and rearing habitat for spring-run in Battle Creek. It is difficult to predict the exact timing of Battle Creek projects, though funding has been secured and work is projected to start on the first phase in Summer 2009. NMFS finds that the Battle Creek program is reasonably likely to occur and contribute to the spring-run population in the long-run; however, these beneficial effects to the population may or may not occur in the near-term.

4) Interim operations of RBDD (until 2012, or with an extension until 2013) will allow for significant increased passage of adult spring-run, and a significant reduction in juvenile mortality associated with downstream passage. Extending the "gates out" operation from May 15th until June 15th will allow a very large additional portion of spring run to migrate unimpeded by the diversion dam. This improved passage will increase the likelihood that these individuals will reach cold water pools necessary for summer holding life history in the near-term and will reduce effects of delayed passage on energy consumption and fecundity, thus improving the viability of populations above RBDD. Near-term effects of interim gate operations on remaining spring-run that are delayed due to the June 15th closure of gates will be offset by passage improvement restoration projects implemented over the next few years.. Abundance, growth rate, and spatial structure are expected to increase with the implementation of the passage restoration projects on Mill, Deer, and Antelope creeks.

5) Continuing installation of fish screens through the Anadromous Fish Screen Program along the Sacramento River and Delta will reduce juveniles entrainment of spring run throughout their migration path down the Sacramento river and through the Delta.

6) All populations of spring-run within the ESU must migrate through the Delta. Within the Delta, additional closures of the DCC gates at key times of year triggered to spring-run presence, will ensure that a greater percentage of spring-run emigrate through the northern Delta out to sea. These fish will avoid adverse effects of predation, water quality and hydrology in the Interior and Southern Delta.

7) Old and Middle River reverse flow restrictions on combined exports will significantly reduce project-related adverse effects on spring-run juveniles in January through June 15th. The OMR restrictions, triggered by spring-run (or their surrogates) in the salvage, will reduce the percentage of spring-run juveniles that are drawn further into the Interior and Southern Delta, and exposed to risks due to export facilities.

8) Additional actions at both the State and Federal export facilities will reduce entrainment and improve efficiency of salvage operations. Collectively, these measures will ensure that the spring-run that are exposed to the export facilities have a greater likelihood of survival.

9) Overall, the interim RBDD, DCC gate operations, and OMR restrictions are timed to minimize adverse effects to a greater proportion of the entire spring-run life history run-

timing. By ensuring the persistence in a greater proportion of run-timing, more diversity is preserved within the ESU. This diversity of run-timing will ensure greater resiliency of the spring-run ESU to environmental changes. For example,, ocean conditions and the timing and duration of upwellings may play a significant role in the survival of any given cohort of spring-run. However, modifying operations to allow for the expansion of ocean entry timing for spring-run will increase the probability that at least a portion of each cohort will enter the ocean when prey are readily available, thereby increasing the cohort's survival.

Summary of RPA effects on Central Valley Spring-run Chinook Salmon in the Long Term

The analysis in the Opinion demonstrates that long-term actions are needed, especially considering continued effects of climate change and increasing water demands due to growth. In addition to a continuation of near-term actions described above, RPA actions that reduce adverse effects of project operations to spring-run and its critical habitat in the long-term include:

1) Additional actions that will minimize project-related effects to the Clear Creek population in the long-term include: replacing the Whiskytown temperature control curtain and adaptively managing to habitat suitability/IFIM study results.

2) In the long-term, improvements to Battle Creek through actions identified in the RPA are predicted to significantly improve spring-run habitat and off-set project-related effects on the mainstem population by creating a stable population in Battle Creek.

3) Starting in 2013, RBDD will be operated in the "gates out" formation all year. This operation will allow for unimpeded spring-run migration upstream and downstream of the diversion dam.

4) Salmonid rearing habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of project operations on spring-run critical habitat in the long-term and off-set effects of ongoing flood control operations. These habitat actions will increase the growth rates of individuals that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history. Because all populations of spring-run migrate through this area, a portion of all populations will be likely to benefit from these rearing actions, thereby increasing the viability of the ESU and reducing the likelihood of appreciable reductions in the survival or recovery of the species.

5) In the long-run, in consideration of climate change, and in order to improve the likelihood of withstanding adverse effects associated with prolonged drought, the passage program will improve the diversity and spatial structure of the ESU by reintroducing spring-run to their historical habitat above Shasta reservoir. There is

uncertainty associated with the likelihood of this action succeeding. This consultation must take a long-term view, given the 21 year time horizon. Within the long-term view, it is likely that advances in technologies and experimental procedures will increase the likelihood of success of this action. In addition, the quality of much of the habitat above Shasta reservoir is in relatively pristine condition, improving the likelihood of success. The RPA includes a reinitiation trigger in the event that passage is deemed to be infeasible. There are also some near-term benefits associated with the pilot reintroduction program, including immediate expansion of the geographic range of the species.

In summary, with full implementation of the RPA, NMFS expects that the RPA will result in minimizing project related effects to the level where these effects do not appreciably reduce the likelihood of survival or recovery of spring-run, or adversely modify its critical habitat.

Table 11-2. Summary of actions to minimize or alleviate proposed action-related stressors on Central Valley spring-run Chinook salmon and its designated critical habitat. The table is organized by life stage then by the number of populations affected by a particular stressor. Acronyms for diversity groups are as follows: NWC – Northwestern California; BPL – Basalt and Porous Lava; NSN – Northern Sierra Nevada.

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Adult immigration and holding	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) delaying adult immigration	~70 % of the spring-run that spawn upstream of RBDD are delayed by approximately 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	High	Action I.3.2: RBDD Interim Operations	Action I.3.1: RBDD Operations After May 14, 2012
Adult immigration and holding	NWC: Clear	Water temperatures warmer than life history stage requirements during summer holding period	Water temp control to Igo; possibly some pre-spawn mortality in critically dry years when not enough cold water in Whiskeytown Lake	High	Action I.1.5: Clear Creek Thermal Stress Reduction.	Continue implementation of Action I.1.5.
Adult immigration and holding	NWC: Clear	Spring flows with little variability. Low summer flows (50 cfs), when b2 is unavailable	Limited cues for upstream migration resulting from spring flows with little variation. With low summer flows, Adults are impeded from accessing upstream holding areas.	High	Action I.1.1. Spring Attraction Flows	Continue implementation of Action I.1.1
Spawning	NWC: Clear	Loss of spawning gravel below Whiskeytown Dam – limited spawning habitat availability	Reduced spawning areas; spawning success diminishes	High	Action I.1.3: Clear Creek spawning gravel augmentation	Continue implementation of Action I.1.3
Spawning	NWC: Clear	Low summer flows (50 cfs), when b2 is unavailable	Adults spawn further downstream in less suitable conditions (*i.e.*, in areas with relatively warm water temps.)	High	Action I.1.6: Adaptively manage to Clear Creek habitat suitability/IFIM study results.	Continue implementation of Action I.1.6

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Embryo incubation	NWC: Clear	Water temperatures warmer than life history stage requirements in September only for fish that spawn below TCP (Igo)	Mortality varies with exceedance rate and number of redds; loss of some portion of those eggs; reduced chance of survival for fry	High	Action I.1.5: Clear Creek Thermal Stress Reduction	Continue implementation of Action I.1.5:

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Embryo incubation	BPL: Sacramento	Water temperatures warmer than life history stage requirements, during September and October	Under near-term operations (Study 7.1) mortality is expected to range from approximately 9% in wet years up to approximately 66 % in critically dry years, with an average of approximately 21 % over all water year types; under modeled climate change projections, average egg mortality over all water year types is expected to be 50 % and during the driest 15 % of years is expected to be 95 %. Sub-lethal effects, such as developmental instability and related structural asymmetry have been reported to occur to salmonids incubated at warm water temperatures (Turner *et al*. 2007, Myrick and Cech 2001, Campbell *et al*. 1998). These sub-lethal effects decrease the chance of spring-run to survive during subsequent life stages (Campbell *et al*. 1998). Campbell *et al*. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased salmon fitness.	High	Action Suite I.2: Shasta operations. Action I.1.4: Spring Creek temperature control curtain. Action I.4: Wilkins Slough Operations Action V: Fish Passage Program (Near-term actions)	Continued implementation of Action suite I.2. Continue implementation of Action I.1.4. Continue implementation of Action I.4. Action V: Fish Passage Program (Long-term actions)

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Lake Red Bluff and RBDD reportedly ranges from 5 to 50%; delayed emigration. Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 5 % of the spring-run ESU spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008).	High	Action I.3.2: RBDD Interim Operations	Action I.3.1: RBDD Operations After May 14, 2012

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	Action I.3.2: RBDD Interim Operations Action I.6.1: Restoration of floodplain rearing habitat. Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass. Action I.6.3: Lower Putah Creek enhancements. Action I.6.4: Improvements to Lisbon Weir	Action I.3.1: No later than May 2012, Reclamation shall operate RBDD with gates out all year Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4.
Juvenile rearing	All diversity groups and populations	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	Action I.5: Funding for CVPIA Anadromous Fish Screen Program	Continue implementation of Action I.5

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	All diversity groups and populations	Lack of channel forming flows in the Sacramento River and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process.	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	Action I.6.1: Restoration of floodplain rearing habitat. Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass. Action I.6.3: Lower Putah Creek enhancements. Action I.6.4: Improvements to Lisbon Weir	Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4.

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Smolt emigration	All diversity groups and populations	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Project-related mortality is significant. Of the spring-run entering the *interior* of the Delta (through DCC or Georgiana Slough), mortality is estimated to be approximately 66 % (range of 35-90 % mortality) (Brandes and McClain 2001; Newman 2008; Perry and Skalski 2008).	High	Action IV.1.1: Monitoring and alerts to trigger changes in DCC operations. Action IV.1.2: DCC gate operation. Action IV.1.3: Engineering studies of methods to reduce loss of Salmonids in Georgiana Slough and South Delta channels. Action IV.2.1: San Joaquin River inflow to export ratio. Action IV.2.2: Old and Middle River Flow Management. Action IV.3: Reduce the likelihood of entrainment or salvage at the export facilities. Action IV.4.1: Tracy fish collection facility improvements. Action IV.4.2: Skinner fish collection facility improvements. Action IV.4.3: Additional improvements at	Continue implementation of Actions IV.1 through IV. 6.

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11.3.3 Central Valley Steelhead and Its Designated Critical Habitat

The proposed action increases the extinction risk of CV steelhead and continues to degrade the PCEs of critical habitat by adding numerous stressors to the species' baseline stress regime and reducing the viability of all of the extant CV steelhead populations in the CVP-controlled rivers (Clear Creek, Sacramento River, American River, and Stanislaus River) and the Delta. Throughout this Opinion, NMFS acknowledged that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS acknowledged the need for the proper functioning of the PCEs that comprise the critical habitat designation. In sections 9.5 and 9.6, NMFS summarized the various stressors that reduced the VSP parameters and conservation value of the PCEs. In general, warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use have caused fitness reductions and degraded the PCEs of critical habitat in the past. The proposed action is expected to continue to degrade the VSP parameters and conservation value of the PCEs, and the effects of climate change and increased water demand in the future are expected to exacerbate conditions that reduce the long-term viability of CV steelhead.

The RPA specifies actions that, in total, will minimize the adverse effects of the proposed action on steelhead individuals, populations and the DPS and bring about the proper functioning of PCEs of its critical habitat. Many of the RPA actions, as described in their objectives and rationale, specifically address key limiting factors/threats facing the DPS and its critical habitat, for example, lack of passage to historic spawning habitat above Keswick and Shasta Dams, and Nimbus and Folsom Dams, and New Melones, Dam, passage impediments (*e.g.*, RBDD), degraded water quantity and quality of the habitat, hatchery fish compromising the genetic integrity of natural CV steelhead and entrainment influence of the Federal and state export facilities. Table 11-3 provides the linkage between specific project related stressors identified in the Opinion's Integration and Synthesis, and the specific RPA actions necessary to minimize those stressors in both the near-term and the long-term. All actions that address CV steelhead in the RPA are necessary to minimize project effects to the extent where they do not appreciably reduce the likelihood of survival and recovery of the DPS in the near-term and the long-term, or adversely modify CV steelhead critical habitat. This written analysis summarizes some of the most significant RPA actions that NMFS relied on in its analysis.

As show in table 11-3, the RPA acknowledges the need for both short-term and long-term actions, including:

- providing safe passage to and from historical habitat;
- improving the quantity and quality of habitat in all of the CVP-controlled streams through water releases;
- providing interim and long-term modifications to RBDD;
- providing increased rearing habitat;
- modifying the operation of the DCC; and

- implementing a revised decision process for Delta operations, including reduced exports.

The anticipated improvements to CV steelhead and its critical habitat are expected to begin immediately through implementation of various actions, and continue to increase over the term of this Opinion (through year 2030) with the implementation of the longer-term actions. While implementation of the RPA will occur during the term of this Opinion, its full effects on population metrics (*e.g.*, spatial structure, diversity, abundance, productivity) and the PCEs of critical habitat will occur over a considerable period of time after implementation. Therefore, NMFS expects the project operations, as modified by the RPA, to minimize effects to critical habitat so that it is not adversely modified.

In the near term, the provision of more cold water throughout the species' upstream migration, rearing, holding, and incubation period are expected to increase in-river production. RPA actions that address flow maintenance and stabilization will minimize redd dewatering and scouring, and stranding. Juveniles will be afforded more rearing habitat during their freshwater residency by reducing the inundation duration of Lake Red Bluff, and expanding access to rearing habitat within the Yolo Bypass and other areas within the Sacramento River Basin, in both the near-term and long-term. Modified operations of RBDD will provide unimpeded passage for more of the upstream spawning migration season of the upper Sacramento River and its tributaries populations. More smolts are expected to outmigrate into the Pacific Ocean as operations of the CVP and SWP are modified to reduce entrainment and mortality. Specifically, requirements in Actions Suite IV.2 will significantly increase the survival of CV steelhead smolts outmigrating from the San Joaquin River basin.

Overall, the interim RBDD, DCC gate operations, and OMR restrictions are timed to minimize adverse effects to a greater proportion of the entire steelhead life history run-timing. By ensuring the persistence in a greater proportion of run-timing, more diversity is preserved within the DPS. This diversity of run-timing will ensure greater resiliency of the CV steelhead DPS to environmental changes, for example, changed productivity in the ocean.

In the long-term, in addition to the continuation of the near-term actions, CV steelhead will be afforded the opportunity to spawn and rear in historical habitat upstream of Nimbus and Folsom Dams. Access to this historical habitat will provide steelhead with cold water temperatures necessary for increased spawning, incubation, and rearing success, especially in consideration of the environmental effects of climate change. Such a program has many unknowns, and therefore cannot be expected to immediately abate all up-river stressors in the near-term, although some near term benefits will occur, such as immediate improvements in the geographic distribution of the population to historic habitats, which would reduce jeopardizing risks to the ESU faced by individuals that remain below project dams. In the long-term however, the RPA includes a structured passage program with pilot reintroductions. Additionally, alternatives to the proposed fish passage actions may also be proposed by Reclamation and the Fish Passage Steering Committee, in the event that the proposed actions are determined to not be technically or biologically feasible, and provided they are capable of meeting similar performance standards in terms of population distribution with Diversity Groups, and viability according the parameters described in Lindley *et al.* (2007).

The long-term operation of RBDD will provide unimpeded passage opportunities for adults and juveniles, and reduce competition and predation from other salmonid species.

The genetic diversity of the CV steelhead DPS is compromised through hatchery operations, including those at Nimbus. Through preparation and implementation of a HGMP, in the long-term, genetic diversity of CV steelhead will increase, thereby increasing the viability of the DPS.

An important aspect of the RPA analysis for steelhead concerns the status of the Southern Sierra Diversity Group, which is critical to preserving spatial structure of the DPS. This diversity group, consisting of extant populations in the Calaveras, Stanislaus, Tuolumne, Merced and Mainstem San Joaquin rivers, is very unstable due to the poor status of each population. This status is due to both project-related and non-project related (baseline) stressors. In the near-term, a new flow schedule for the Stanislaus River and interim actions to increase flows at Vernalis and curtail exports will allow greater out-migration cues and survival of smolts past the state and federal export facilities. In the long-term, additional actions through additional flow to export ratios in the southern Delta, and channel forming flows and gravel augmentations in the Stanislaus river will further reduce project-related adverse-effects to this diversity group. Due to uncertainty in the flow to export ratio, the RPA six year acoustic tag experiment, which can be combined with experimental barrier technologies, will significantly enhance our knowledge base for future consultations and refinements of this RPA action. Ultimately, our analysis is clear that the long-term viability of this diversity group will depend not only on implementation of this RPA, but also on actions outside this consultation, most significantly increasing flows in the Tuolumne and Merced rivers. The State Water Resources Control Board has made establishing additional flows in these rivers a priority and intends to take action within the near-term. A future CVP/SWP operations consultation that will be triggered by implementation of San Joaquin Restoration Program flows will also provide further opportunities to update and refine actions critical to this diversity group.

In summary, with full implementation of the RPA, NMFS expects the adverse effects of project operations will be minimized to the point where the likelihood of survival and recovery of the DPS is not appreciably reduced and its designated critical habitat is not adversely modified.

Table 11-3. Summary of actions to minimize or alleviate proposed action-related stressors to Central Valley steelhead and its designated critical habitat. The table is organized by life stage then by the number of populations affected by a particular stressor. Acronyms for diversity groups are as follows: NWC – Northwestern California; BPL – Basalt and Porous Lava; NSN – Northern Sierra Nevada; SSN – Southern Sierra Nevada.

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Adult immigration and holding	NWC: Cottonwood / Beegum, Clear; BPL: Sacramento, Battle	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) delaying adult immigration	17 % of those that spawn above RBDD, delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity	High	Action I.3.2: RBDD interim Operations	Action I.3.1: RBDD operations after May 14, 2012
Adult immigration and holding	NWC: Clear	Water temperatures warmer than life history stage requirement for migration possible in lower reach near confluence with Sacramento River during August and September	Some adults may not enter mouth of Clear Creek, 1) delayed run timing, 2) seek other tributaries, 3) spawn in mainstem Sacramento R.; reduced in vivo egg viability	Low- except for critically dry years	Action I.1.5: Clear Creek thermal stress reduction	Continue implementation of Action I.1.5:
Adult immigration	SSN: Stanislaus River	Exposure to stressful water temperatures from the Delta to Riverbank during adult immigration	Delayed entry into river (CDFG 2007a); pre-spawn mortality; reduced condition factor	Medium	Action III.1.1: Establish Stanislaus Operations group Action III.1.2: Stanislaus River temperature management	Continue implementation of Actions III.1.1 and III.1.2

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Spawning	NWC: Clear	Loss of spawning gravel below Whiskeytown Dam – limited spawning habitat availability	Limited areas of suitable spawning sites. Spawning in sub-optimal habitat	Medium - but could be high without continued gravel augmentation	Action I.1.3: Clear Creek spawning gravel augmentation	Continue implementation of Action I.1.3
Spawning	NSN: American River	Folsom/Nimbus releases – flow fluctuations in the American River resulting in redd dewatering	Redd dewatering and isolation prohibiting successful completion of spawning	Medium	Action II.1: Lower American River flow management, particularly management following the ARG process	Continue implementation of Action II..1
Spawning	NSN: American River; BPL: Sacramento; and potentially all other populations within the NWC, NSN, and BPL diversity groups	Nimbus Hatchery *O. mykiss* spawning with natural-origin steelhead in the American River and in other CV streams	Reduced genetic fitness of CV steelhead through the spread of Eel River genes and potentially hatchery rainbow trout genes to many below-barrier sites (Garza and Pearse 2008).	High	Action II.6.1: Preparation of hatchery genetic management plan for steelhead Action II.6.2: Interim actions prior to submittal of draft HGMP for steelhead	Continue implementation of Actions II.6.1 and II.6.2

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Spawning	SSN: Stanislaus River	Unsuitable flows in the Stanislaus River restrict spawnable habitat and dewater redds	Limited spawning habitat availability according to Aceituno (1993). Instream flows typically drop in January from higher December levels when San Joaquin River water quality objectives are met. This increases the risk for redd dewatering and direct egg mortality.	High	Action III.1.1: Establish Stanislaus operations group Action III.1.3: Stanislaus River temperature management	Continue implementation of Actions III.1.1 and III.1.3
Spawning	SSN: Stanislaus River	Excessive fines in spawning gravel resulting from lack of overbank flow	Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site Fine material deposited in gravel beds because of lack of overbank flow to inundate floodplain and deposit fine material on floodplain, instead of in river (Kondolf *et al*. 2001).	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows	Continue implementation of Action III.2.2
Embryo incubation	NSN: American River	Exposure to stressful water temperatures in the American River during embryo incubation	Sub-lethal effects - reduced early life stage viability; direct mortality; restriction of life history diversity (*i.e.*, directional selection against eggs deposited in Mar. and Apr.)	Medium	Action II.3: Make structural improvements to improve cold water management Action V: Fish passage program (Near-term actions)	Continue implementation of Action II.3 Action V: Fish passage program (Long-term actions)
Egg incubation and emergence	SSN: Stanislaus River	Excessive fines in spawning gravel resulting from lack of overbank flow	Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other steelhead or fall-run; suppressed growth rates	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows	Continue implementation of Action III.2.2

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Egg incubation and emergence	SSN: Stanislaus River	Exposure to stressful water temperatures in the Stanislaus River during egg incubation and emergence	Egg mortality, especially for eggs spawned in or after March; Embryonic deformities (Deas *et al*. 2008) Temperatures may be operationally managed, depending on year type	Medium	Action III.1.1: Establish Stanislaus operations group Action III.1.2: Stanislaus River temperature management	Continue implementation of Actions III.1.1 and III.1.2 Action V: Fish passage program (Long-term actions)
Juvenile rearing	BPL: Sacramento River	Provision of higher flows and cooler water temps during the summer than occurred prior to the construction of Shasta Dam	Potential fitness advantage for resident *O.mykiss* over the anadromous form, which would drive an evolutionary (*i.e.*, genetic) change if life history strategy is heritable (Lindley *et al*. 2007).	High	Action V: Fish passage program (Near-term actions)	Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	NWC: Cottonwood / Beegum, Clear; BPL: Sacramento, Battle	Lake Red Bluff, river impounded May15 - Sept 15, plus 10 days in April during emergencies	Reduction in rearing habitat quality and quantity; delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	High	Action I.3.2: RBDD interim operations Action I.6.1: Restoration of floodplain rearing habitat Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass Action I.6.3: Lower Putah Creek enhancements Action I.6.4: Improvements to Lisbon Weir	Action I.3.1: RBDD operations after May 14, 2012 Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4
Juvenile rearing	All diversity groups and populations	Unscreened CVP diversions between Red Bluff and the Delta	Entrainment	High	Action I.5: Funding for CVPIA Anadromous Fish Screen Program	Continue implementation of Action I.5

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	All diversity groups and populations, excluding the SSN diversity group	Lack of channel forming flows in the Sacramento River and reversed natural flow pattern (high flows in summer, low flows in late fall/winter), modifies critical habitat, including impaired geomorphic process.	Flow regulation (proposed Project stressor) and levee construction and maintenance (baseline stressor) alter ecological processes that generate and maintain the natural, dynamic ecosystem. This loss of natural river function has reduced the quality and quantity of rearing and migratory habitats (Stillwater Sciences 2007), thereby reducing juvenile growth and survival.	High	Action I.6.1: Restoration of floodplain rearing habitat Action I.6.2: Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass Action I.6.3: Lower Putah Creek enhancements Action I.6.4: Improvements to Lisbon Weir	Continue implementation of Actions I.6.1, I.6.2, I.6.3, and I.6.4
Juvenile rearing	NWC: Clear Creek	Exposure to stressful water temperatures in Clear Creek during juvenile rearing	Limited over-summering habitat, reduced growth, increased susceptibility to disease and predation	High	Action I.1.5: Clear Creek thermal stress reduction	Continue implementation of Action I.1.5
Juvenile rearing	NWC: Clear Creek	Limited rearing habitat availability in Clear Creek resulting from low summer flows (< 80 cfs)	Limited rearing habitat availability; less food, reduced growth, increased predation risk	High	Action I.1.6: Adaptively manage to habitat suitability/IFIM study results	Continue implementation of Action I.1.6

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	NSN: American River	Folsom/Nimbus releases resulting in flow fluctuations; low flows	Fry stranding and juvenile isolation - observations of juvenile steelhead isolation in the American River were made in both 2003 and 2004 (Water Forum 2005a). Low flows limiting the availability of quality rearing habitat including predator refuge habitat	High	Action II.4: Minimize lower American River flow fluctuation effects	Continue implementation of Action II.4
Juvenile rearing	NSN: American River	Exposure to stressful water temperatures in the American River during juvenile rearing	Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation. Visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F (Water Forum 2005a). With the exception of 2005, from 1999 through 2007, daily mean water temperatures at Watt Avenue from August through September were warmer than 65°F for approximately 81 percent of the days, and during 2001, 2002, 2004, 2006, and 2007, water temperatures were often over 68°F (figure 30a). Under a drier and warmer climate change scenario (Study 9.5), modeled water temperatures at Watt Avenue from June through September under full build out of the proposed Project range from 65°F to 82°F (Reclamation 2009). Even if no regional climate change is assumed (Study 9.1), water temperatures at this location during this time period are expected to range from 63°F to 79°F.	High	Action II.2: Lower American River temperature management Action II.3: Make structural improvements to improve management Action V: Fish passage program (Near-term actions)	Continue implementation of Actions II.2 and II.3 Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	SSN: Stanislaus River	Lack of overbank flow in the Stanislaus River to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows Action V: Fish passage program (Near-term actions)	Continue implementation of Action III.2.2 Action V: Fish passage program (Long-term actions)
Juvenile rearing	SSN: Stanislaus River	Reduction in rearing habitat complexity in the Stanislaus River due to reduction in channel forming flows	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows	Continue implementation of Action III.2.2
Juvenile rearing	SSN: Stanislaus River	Unsuitable flows in the Stanislaus River for maintaining juvenile rearing habitat	Crowding and density dependent effects relating to reduced habitat availability. Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows Action III.1.3: Stanislaus River flow management	Continue implementation of Actions III.2.2 and III.1.3

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing and downstream movement	SSN: Stanislaus River	Predation in the Stanislaus River by non-native fish predators because rearing habitat is lacking	Juvenile mortality; Reduced juvenile production	High	Action III.2.2: Stanislaus River floodplain restoration and inundation flows Action III.1.3: Stanislaus River flow management Action III.2.3: Implement predation reduction projects	Continue implementation of Actions III.2.2, III.1.3, and III.2.3
Juvenile rearing	SSN: Stanislaus River	Exposure to stressful water temperatures in the Stanislaus River at the end of summer affecting rearing habitat	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	High	Action III.1.1: Establish Stanislaus operations group Action III.1.2: Stanislaus River temperature management	Continue implementation of Actions III.1.1 and III.1.2
Smolt emigration	SSN: Stanislaus River	Water temperatures warmer than life history stage (Mar - June)	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	High	Action III.1.1: Establish Stanislaus operations group Action III.1.3: Stanislaus River flow management)	Continue implementation of Actions III.1.1 and III.1.3

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Smolt emigration	NSN: American River	Exposure to stressful water temperatures in the American River during smolt emigration	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Medium	Action II.3: Make structural improvements to improve cold water management Action V: Fish passage program (Near-term actions)	Continue implementation of Action II.3 Action V: Fish passage program (Long-term actions)
Smolt emigration	SSN: Stanislaus River	Water temperatures warmer than life history stage (Mar - June)	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	High	Action III.1.1: Establish Stanislaus operations group Action III.1.2: Stanislaus River temperature management	Continue implementation of Action III.1.1 and III.1.2
Smolt emigration	SSN: Stanislaus River	Suboptimal flow in the Stanislaus River (March – June)	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	High	Action III.1.3: Stanislaus River flow management	Continue implementation of Action III.1.3

Life Stage/ Habitat Type	Diversity Group(s): Population(s)	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Smolt emigration	All diversity groups and populations	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Substantial mortality to steelhead from all diversity groups. Based on VAMP studies of fall-run, mortality ranges from 90 – 99 % from San Joaquin River release points to Chipps Island (SJRGA 2006). Similar results are assumed for steelhead, as shown through the CCF studies showing similar loss rates between steelhead and Chinook salmon (DWR 2008).	High	Action IV.1.1: Monitoring and alerts to trigger changes in DCC operations Action IV.1.2: DCC gate operation Action IV.1.3: Engineering studies of methods to reduce loss of Salmonids in Georgiana Slough and South Delta channels Action IV.2.1: San Joaquin River inflow to export ratio Action IV.2.2: Old and Middle River Flow Management Action IV.3: Reduce the likelihood of entrainment or salvage at the export facilities Action IV.4.1: Tracy fish collection facility improvements Action IV.4.2: Skinner fish	Continue implementation of Actions IV.1 through IV.6

						collection facility	

11.3.4 Southern DPS of Green Sturgeon and Its Proposed Critical Habitat

The Southern DPS of green sturgeon is at substantial risk to future population declines (Adams *et al*. 2007). The potential threats faced by the green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, habitat elimination and modification in the mainstem Sacramento River and Delta, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, and loss of juvenile green sturgeon due to entrainment Federal and State export facilities in the South Delta. In addition, many of the physical and biological features of critical habitat that are essential for the conservation of the Southern DPS of green sturgeon are currently impaired, and provide limited conservation value. The proposed action increases the population's extinction risk and continues to degrade the PCEs of their proposed critical habitat by adding numerous stressors to the species' baseline stress regime. Throughout this Opinion, NMFS acknowledged that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS acknowledged the need for the proper functioning of the PCEs that comprise the proposed critical habitat. In sections 9.7 and 9.8, NMFS summarized various stressors that reduced the VSP parameters and conservation value of the PCEs.

The RPA specifies many significant actions that will reduce the adverse effects of the proposed action on Southern DPS of green sturgeon and bring about the proper functioning of PCEs of its proposed critical habitat. Many of the RPA actions, as described in their objectives and rationale, specifically address key limiting factors/threats facing the DPS and its proposed critical habitat, for example, passage impediments, degraded water quantity and quality of the remaining habitat downstream of Keswick and Shasta Dams, and entrainment influence of the Federal and state export facilities. Table 11-4 provides the linkage between specific project related stressors identified in the Opinion's Integration and Synthesis, and the specific RPA actions necessary to minimize those stressors in both the near-term and the long-term. All actions that address the Southern DPS of green sturgeon in the RPA are necessary to minimize project effects to the extent where they do not appreciably reduce the likelihood of survival and recovery of the DPS in the near-term and the long-term, or adversely modify proposed critical habitat. This written analysis summarizes some of the most significant RPA actions that NMFS relied on in its analysis.

As show in table 11-4, the RPA acknowledges the need for both short-term and long-term actions, including:

- increasing Shasta reservoir storage to provide for temperature control and improve the quantity and quality of downstream habitat;
- providing interim and long-term modifications to RBDD to providing safe passage to and from spawning habitat;
- implementing studies on Southern DPS of green sturgeon population size, and life history and habitat needs in the short-term to improve management of the species and their habitat in the long-term;
- providing increased rearing habitat;
- modifying the operation of the DCC; and

- implementing a revised decision process for Delta operations, including reduced exports.

Minimization of adverse effects of project operations on the Southern DPS of green sturgeon and its proposed critical habitat are expected to begin immediately through implementation of various actions, and continue to increase over the term of this Opinion (through year 2030) with the implementation of the longer-term actions. While implementation of the RPA will occur during the term of this Opinion, its full effects on population metrics (*e.g.*, spatial structure, diversity, abundance, productivity) and the PCEs of critical habitat will occur over a considerable period of time after implementation. In the near term, precluding an emergency gate closure, delaying the gate closure until June 15th, and increasing the height of gate openings at RBDD will immediately minimize a significant portion of the adverse effects of RBDD on green sturgeon. An increase in survival of spawning adults, and the availability of more cold water that will provide more spawning habitat in more favorable spawning and embryo incubation temperature ranges, will likely result in an increased growth rate and diversity of the population in the long run. Also in the near-term, actions within the Delta will reduce the influence of the Federal and State export facilities, increase survival of juveniles by keeping them within the mainstem Sacramento River, and reduce entrainment and mortality.

In the long term, in addition to the continuation of the near-term actions, adverse effects of project operations will be further minimized with unimpeded passage opportunities for adults and juveniles at RBDD, and reduced competition and predation. Results from the near-term studies will aid in the management and recovery of the species and their proposed critical habitat on the long-term.

In summary, with full implementation of the RPA, NMFS expects that on-going project effects on Southern DPS of green sturgeon and its proposed critical habitat will be minimized to the extent the survival and recovery are not appreciably reduced, and critical habitat is not adversely modified.

Table 11-4. Summary of actions to minimize or alleviate proposed action-related stressors to the Southern DPS of green sturgeon and its proposed critical habitat.

Life Stage/Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Adult immigration and holding	RBDD gate closures from May 15 - Sept 15 every year and emergency 10-day gate closures delaying adult immigration.	Passage blocked, 55 miles of spawning habitat made inaccessible upstream of RBDD after May 15. Large aggregations (25-30) of mature adults observed below RBDD gates. Estimate 30 % of run blocked based on run timing. Also, mortalities associated with downstream passage under gates post-spawn, or after fish move above gates. Mortality greater on larger, more fecund females that can not fit through 18" opening Greater proportion of run blocked or delayed (40 -50%) based on run timing; Greater mortalities associated with downstream passage under gates post spawn, or after moving above gates, sub lethal effects on eggs in fish and energy loss. Occurred twice in the past 10 years, but the frequency of occurrence may increase with climate change	High	Action I.3.2: RBDD interim operations Action I.3.3. RBDD interim operations for Green Sturgeon Action I.3.4: Measures to compensate for adverse effects of RBDD interim operations on green sturgeon	Action I.3.1: RBDD operations after May, 2012 Continue implementation of Action I.3.4
Spawning	RBDD	Unnatural spawning site created below RBDD, portion of run (only one in CV) spawning in water 2 feet deep, channel aggradation below hydraulics from gates, eggs suffocate, physiological effects, delayed hatch, greater predation on eggs due to accumulation of predators below RBDD.	High	Action I.3.2: RBDD interim operations Action I.3.3. RBDD interim operations for Green Sturgeon Action I.3.4: Measures to compensate for adverse effects of RBDD interim operations on green sturgeon	Action I.3.1: RBDD operations after May, 2012 Continue implementation of Action I.3.4

Life Stage/Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Embryo incubation	Water temperatures warmer than life history stage requirements below Hamilton City.	For eggs and fry that are spawned in areas from RBDD to Hamilton City water quality is less suitable than above RBDD where temperatures are controlled for winter-run. Eggs suffocate from less flow, physiological effects, delayed hatch, greater predation on eggs due to presence of non-native introduced warm-water species.	Medium	Action I.2.1: Maintain suitable water temperatures for Southern DPS of green sturgeon. Action I.2.2: Maintain minimum Shasta Reservoir storage. Action I.2.3: February forecast and plan of operation.	Continued implementation of Action I.2.1. Continued implementation of Action I.2.2. Continued implementation of Action I.2.3.

Life Stage/Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile rearing	Increased juvenile mortality related to emigration when RBDD Dam gates are in (*i.e.*, May15 - Sept 15, plus 10 days in April during emergencies)	Based on passage estimates of when juveniles are present at RBDD (USFWS 1997-2007), approximately 100 % of the green sturgeon DPS that is spawned above RBDD would be exposed to higher concentrations of predators when the gates are in (TCCA 2008). Approximately 70 % of the entire green sturgeon DPS spawns above RBDD. Mortality of juvenile salmon emigrating past RBDD when the gates are in ranges from 5 -50 % (Vogel *et al*. 1988; Tucker 1998); mortality of juvenile green sturgeon emigrating past RBDD has not been estimated, but is expected to increase when the gates are in.	High	Action I.3.2: RBDD interim operations Action I.3.3. RBDD interim operations for Green Sturgeon Action I.3.4: Measures to compensate for adverse effects of RBDD interim operations on green sturgeon	Action I.3.1: RBDD operations after May, 2012 Continue implementation of Action I.3.4
	Reduced quality of juvenile rearing habitat related to the formation of Lake Red Bluff when the RBDD gates are in.	Reduction in rearing habitat quality and quantity; increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967.	High		
Juvenile rearing	Unscreened CVP diversions	Entrainment	High	Action I.5: Funding for CVPIA Anadromous Fish Screen Program	Continue implementation of Action I.5

Life Stage/Habitat Type	Stressor	Response/Rationale for Magnitude of Effect	Magnitude of Effect	Short-term Action to Minimize/Alleviate Stressor	Long-term Action to Minimize/Alleviate Stressor
Juvenile and subadult	Loss at export facilitiest Impaired movements through South Delta waterways due to temporary barriers or permanent gates	Entrainment of fish at the CVP and SWP in every month of the year. Louvers function well for larger fish but are inefficient for smaller fish. Fish behavior may make them susceptible to the cleaning practices of louvers. In louver studies, fish position themselves in front of the bottom edge of the louver along the channel bottom, where they held position for prolonged periods of time. Presence of green sturgeon juveniles and subadults in the South Delta as confirmed by salvage records. Presence occurs during operational season of barriers (April through November). Closure of waterways by temporary barriers or permanent gates inhibits movement of green sturgeon through these waterways. Fish located upstream of barriers are potentially trapped or delayed in their movements downstream by structures.	Unknown Unknown	Action IV.1.1: Monitoring and alerts to trigger changes in DCC operations Action IV.1.2: DCC gate operation Action IV.1.3: Engineering studies of methods to reduce loss of Salmonids in Georgiana Slough and South Delta channels Action IV.2.2: Old and Middle River flow management Action IV.3: Reduce the likelihood of entrainment or salvage at the export facilities Action IV.4.1: Tracy fish collection facility improvements Action IV.4.2: Skinner fish collection facility improvements. Action IV.4.3: Additional improvements at Tracy and Skinner fish collection facilities Action IV. 6: Formation of Delta operations for salmon and sturgeon technical working group Action IV.6: South Delta improvement program – phase I	Continue implementation of Actions IV.1 through IV.6

11.3.5 Southern Resident Killer Whales

NMFS evaluated effects of the proposed action on Southern Residents by evaluating effects on the availability of their preferred prey, Chinook salmon. NMFS considered effects on both listed and non-listed Chinook salmon. With respect to the listed winter-run and spring-run ESUs, the proposed action is likely to appreciably reduce the survival and recovery of the listed entities and conservation value of their designated critical habitat, which would increase their risk of extinction in the long term. If these stocks were to become extinct, there would be an increased likelihood of localized killer whale prey depletions on the Pacific coast.

As described in sections 11.3.1 and 11.3.2, full implementation of the RPA is expected to reduce adverse effects of project operations on ESA-listed winter-run and spring-run and their designated critical habitats to the point where there is not an appreciable reduction in the likelihood of survival or recovery or an adverse modification of critical habitat. NMFS anticipates that implementation of RPA actions will decrease the risk of extinction of winter-run and spring-run in the long-term, reducing the risk of localized prey depletions and thereby increasing the prey available to Southern Residents.

NMFS also considered effects of the proposed action on non-listed Chinook salmon that are available to Southern Residents (section 6.8.1.2.2). As discussed in section 6.8.1.2, we quantified effects of hatchery production and project operations on non-listed Chinook salmon available to Southern Residents. Hatchery programs included in the proposed action produce more Chinook salmon than are killed in project operations. However, artificial propagation can have harmful effects on the long-term fitness of salmon populations, and the current hatchery practices at Nimbus and Trinity River fish hatcheries are diminishing the long-term viability of these non-listed stocks over the long term. The proposed action did not identify time lines for reforming harmful hatchery practices that affect these stocks.

RPA Action Suite II.6 calls for development of hatchery management plans for fall-run at Nimbus Fish Hatchery and spring-run and fall-run at Trinity River Fish Hatchery, by June 2014. New hatchery management will be subject to future section 7 consultations and/or the 4(d) HGMP process. NMFS anticipates that implementing these RPA actions will provide long-range planning to reduce impacts of hatchery operations on natural fall-run and spring-run, increase the genetic diversity and diversity of run-timing for these stocks, and increase the likelihood that these stocks are retained as prey available to Southern Resident killer whales in the long term. Improving the genetic diversity and diversity of run timing of CV fall-run will decrease the potential for localized prey depletions and increase the likelihood that fall-run can withstand stochastic events, such as poor ocean conditions.

Many RPA actions intended to avoid jeopardy to listed winter-run and spring-run, or adverse modification of their critical habitat, are also expected to reduce adverse effects of the action on the short- and long-term abundance and the long-term viability of non-listed fall-run and late-fall run. The immediate cause of the recent fall-run decline is most likely a result of ocean conditions (Lindley *et al*. 2009). However, freshwater impacts and hatchery programs most likely contributed to the collapse (Lindley *et al.* 2009). The RPA actions address many of the freshwater impacts identified in Lindley *et al.* (2009). NMFS expects that these actions would reduce adverse impacts of the project in all years, under all hydrologic conditions. The actions include:

1) After 2012, there will be unrestricted up-stream and down-stream passage at RBDD. The interim measure of gates out on September 1 allows an additional 14 days unimpeded passage for adult fall-run.

2) A continued investment in fish screens along the Sacramento River and in the Delta would reduce entrainment of juvenile fall-run/late fall-run in unscreened diversions.

3) Improved rearing habitat in both the short-term and long-term in the Delta and lower Sacramento River (Liberty Island/Cache Slough) will improve juvenile fall-run survival.

4) Increased closures of DCC gates from October through January will reduce the percentage of juvenile outmigrants that enter the Interior Delta and are then subject to both direct and indirect mortality.

5) Additional Old and Middle River flow restrictions from January through June will reduce exposure of fall-run and late fall-run juveniles to export facilities and increase survival for fall-run leaving the San Joaquin River.

6) Improvements in salvage procedures at the Delta fish facilities will lead to higher survival of juveniles that enter the facilities and are subjected to the salvage process.

7) In the long term, implementation of fall-run hatchery management plans at Nimbus and Trinity River Hatcheries will increase genetic diversity of fall-run.

8) Increased gravel augmentation on Clear Creek and the Stanislaus River will increase spawning and rearing habitat for listed and non-listed salmonids.

9) Improved flows on Clear Creek, Stanislaus River, and the American River will enhance fall-run spawning and maintain spatial diversity between races.

10) Improved water temperature control on the Sacramento River, Clear Creek, American River, and Stanislaus River will provide more suitable habitat for Chinook salmon.

11) Greater storage levels in the fall for temperature control will improve temperatures for fall-run, as well as winter-run and spring-run.

12) Replacement of the Spring Creek temperature control curtain will provide cooler water temperatures to the Sacramento River in the fall.

13) Implementation of spring-run passage improvement projects (*i.e.*, mitigation for RBDD impacts) in the Sacramento River basin will improve fall-run passage and access to greater spawning and rearing habitat.

14) Improvements in San Joaquin River flows at Vernalis will not only improve survival of juvenile steelhead but fall-run as well

15) Export reductions based on fish densities at the fish salvage facilities will improve survival of non-listed salmonids, since they are similar in size at length.

16) Fish passage above project dams, although not intended for non-listed fish species, will benefit EFH by providing spatial and temporal separation between runs, thereby improving the genetic structure and space available for fall-run spawning (reduced competition, and introgression).

17) Restoration of Battle Creek is expected to improve EFH for fall-run as well as listed species.

18) Improvements in fish passage at flood control weirs will reduce stranding of both adult and juvenile non-listed salmonids and sturgeon.

19) Greater monitoring and reporting requirements for listed species will improve management of non-listed species as well.

20) A 6-year acoustical tag study of juvenile salmonids in the San Joaquin River and Delta will improve understanding of fall-run biological requirements.

The following actions in the RPA are expected to decrease the abundance of fall-run and late fall- run to some extent and may reduce viability in the long term:

1) Temperature control management for winter-run during the summer in the upper Sacramento River can reduce or eliminate the cold water available for fall-run spawning and egg incubation in September and October, most likely in dry or critically dry years. The RPA includes a new year-round program for temperature management at Shasta Reservoir, including requirements for carryover storage, and water temperatures until October 31. The new temperature regime will lead to more frequent End of September storage levels that will support cold water releases for spring-run and fall-run in September and October, thereby reducing the adverse effects of temperatures on fall-run and late fall-run as compared to the proposed action.

2) Temperature control management for steelhead on the American River during the summer can reduce the cold water pool available in October and November.

3) Segregation weirs on Clear Creek to reduce introgression with spring-run reduce habitat available for fall-run spawning.

4) Removal of the middle fish ladder at RBDD for green sturgeon to facilitate additional 18 inch gate opening delays passage of fall-run.

5) Wilkins Slough minimum flows in September and October to preserve cold water storage in Shasta Reservoir can delay upstream migration.

Effects numbered 3 through 5 are expected to occur in all years, during all hydrologic conditions; however, the effects, which include delayed arrival at spawning grounds or less available spawning habitat, are not anticipated to be severe enough to cause mortality of adult spawners. Additionally, RBDD will be removed in approximately three years, after which effects numbered 4 will not occur, and the dam removal will reduce adverse effects on fall-run thereafter.

Temperature control effects numbered 1 and 2 are expected to occur only during critically dry years, which represent less than 10 percent of historic years modeled and up to 25 percent of future years, based on a potential climate change scenario of dry, warming conditions (Study 8.0, 2030 Level of Development). These effects are expected to result in prespawn and early life-stage mortalities for fall-run in the mainstem Sacramento River and American River. In up to 25 percent of future years, temperature control effects numbered 1 and 2 could result in a reduction in future production of fall-run. In critically dry years, up to 8 percent of the Sacramento River population and up to 14 percent of the American River population could experience pre-spawn or egg mortality (Oppenheim 2009). A loss of 8 to13 percent future production from natural spawners in the mainstem Sacramento River and American River, respectively, would be a small reduction in the overall number of adult fish available to the whales from this stock, which is dominated by hatchery produced fish. The RPA is designed to conserve storage and will, therefore, improve the likelihood that sufficient cold water will remain in the fall, and the upper estimate of impacts will not be realized. Some impacts from temperature are likely to occur with or without the RPA, because they are linked to hydrologic factors, such as drought and climate variation.

The RPA will generally reduce adverse effects of project operation on naturally- spawning fall-run and late-fall run by improving adult passage and increasing juvenile survival. Implementation of fall-run hatchery management plans at Nimbus and Trinity River fish hatcheries will increase genetic diversity of fall-run. Increased diversity will decrease the potential for localized prey depletions and increase the likelihood that fall-run can withstand stochastic events, such as poor ocean conditions, and thereby provide a consistent food source in years with overall poor productivity. In some years temperature control actions may result in reductions in future production of fall-run in the Sacramento and American rivers; however, the aggregate of the RPA actions will reduce overall adverse effects of project operations to a level that is not likely to imperil this prey source .

In sum, the RPA is not likely to result in an increased extinction risk of winter-run and spring-run, and it is not likely to imperil the long-term viability of fall-run. Consequently, project operations under the RPA are not likely to result in local depletions of killer whale prey that could appreciably reduce the whales' likelihood of survival and recovery. Therefore, NMFS concludes that the RPA will not jeopardize the continued existence of Southern Resident killer whales.

11.3.6 Economic and Technological Feasibility of the RPA

When developing an RPA, NMFS is required by regulation to devise an RPA that is "economically and technologically feasible" in addition to avoiding jeopardy and adverse modification. These feasibility concerns were discussed and addressed in many ways throughout the period of November 2008 through May 2009, during the course of the consultation. During this period, NMFS developed an initial RPA by December 11, 2009, revised that RPA in response to feedback from the two science panels and DWR, Reclamation, CDFG, and USFWS. NMFS developed a second draft RPA by March 3, 2009, and revised that draft in response to additional feedback from the agencies prior to providing the final action. Some of the more complex RPA actions, including Shasta Storage, Habitat Rearing Actions, Passage Program, Stanislaus Flows and the San Joaquin River Inflow Export Ratio, went through many iterations of review, re-drafting, and refinement, involving interagency staff and management expertise, including biology, ecology, hydrology, and operations, in order to ensure that the actions were based on best available science, would be effective in avoiding jeopardy, and would be feasible to implement. NMFS also secured outside contractual services to provide additional modeling expertise in evaluating draft RPA actions.

Examples of Feasibility Concerns in RPA Actions

As a result of this iterative consultation process, NMFS considered economic and technological feasibility in several ways when developing the CVP/SWP operations RPA. Examples include:

1) Providing reasonable time to develop technologically feasible alternatives where none are "ready to go" – *e.g.*, the Delta engineering action (Action IV.1.3), and lower Sacramento River rearing habitat action (Action I.6.1);

2) Calling for a stepped approach to fish passage at dams, including studies and pilot projects, prior to a significant commitment of resources to build a ladder or invest in a permanent trap and haul program. A reinitiation trigger is built into this action in the event passage is not deemed feasible, prior to construction of permanent infrastructure;

3) Considering limitations of the overall capacity of CVP/SWP systems of reservoirs in determining feasibility of flow actions below reservoirs, and considering the hydrologic record and CALSIM modeling results (Shasta/Sacramento River, Folsom/American River, New Melones/Stanislaus River).

4) Tiering actions to water year type and/or storage in order to conserve storage at reservoirs and not unduly impact water supplies during drought (*e.g.*, see appendix 5);

5) Providing health and safety exceptions for export curtailments;

6) Using monitoring for species presence to initiate actions when biologically supported and most needed, in order to limit the duration of export curtailments;

7) Incorporating scientific uncertainty into the design of the action, when appropriate, in order to refine the action over time (*e.g.*, 6-year acoustic tag study for San Joaquin steelhead).

8) Incorporating performance goals into more complex actions (for example, Shasta storage, rearing habitat and San Joaquin acoustic tag study). A performance goal approach will allow for adaptation of the action over time to incorporate the most up-to-date thinking on cost-effective technologies or operations.

9) Allowing for interim, further constrained, water deliveries to TCCA through modified RBDD operations for 3 years, while an alternative pumping plant is being built.

The RPA includes collaborative research to enhance scientific understanding of the species and ecosystem, and to adapt actions to new scientific knowledge. This adaptive structure is important, given the long-term nature of the consultation and the scientific uncertainty inherent in a highly variable system. Monitoring and adaptive management are both built into many of the individual actions and are the subject of an annual program review. This annual program review will provide for additional opportunities to address any unforeseen concerns about RPA feasibility that may arise.

The rationale statements for individual actions explain more specific reasoning, and the administrative record contains specific hydrology and modeling results in support of the more complex actions (*e.g*., Shasta and San Joaquin storage/flows).

Water Supply Costs and Projected Impacts

NMFS examined water supply costs of the RPA as one aspect of considering economic feasibility. While only costs to the action agency are considered in determining whether a RPA meets the regulatory requirement of economic feasibility, NMFS is mindful of potential social and economic costs to the people and communities that historically have depended on the Delta for their water supply. Any water supply impact is undesirable. NMFS made many attempts through the iterative consultation process to avoid developing RPA actions that would result in high water costs, while still providing for the survival and recovery of listed species.

NMFS estimates the water costs associated with the RPA to be 5-7% of average annual combined exports: 5% for CVP, or 130 TAF/year, and 7% for SWP, or 200 TAF/year[39]. The combined estimated annual average export curtailment is 330 TAF/year. These estimates are over and above export curtailments associated with the USFWS' Smelt Opinion. The OMR restrictions in both Opinions tend to result in export curtailments of similar quantities at similar times of year. Therefore, in general, these 330 TAF export curtailments are associated with the NMFS San Joaquin River Ratio actions in the RPA.

NMFS also considered that there may be additional localized water costs not associated with South Delta exports. These may include, in some years, localized water shortages necessitating groundwater use, water conservation measures, or other infrastructure improvements in the New Melones service area, and localized impacts in the North of Delta in some years, associated with

[39] The proportional share between the CVP and SWP is attributable to CalLite programming and may not represent the true share of export reductions that would be allocated to each facility under actual conditions.

curtailments of fall deliveries used for rice decomposition. NMFS considered whether it was feasible to model and estimate any water costs associated with the Shasta or American River RPA actions, and discussed this issue with Reclamation. In general, it was decided that modeling tools were not available to assess these costs and/or that costs would be highly variable depending on adaptive management actions, and therefore, not meaningful to model.

To assess the economic feasibility associated with average annual water costs of 330 TAF, NMFS reviewed CVP/SWP project wide and statewide information regarding water availability. NMFS considered the following information as background to economic feasibility. This information is provided by the State Legislative Analyst's Office (California's Water: An LAO Primer, October 2008):

1) "The federal government has developed the most surface storage capacity in the state with over 17 MAF of capacity in ten reservoirs on multiple river systems. These reservoirs generally are part of the federal Central Valley Project (CVP), which serves about 3.1 million people, and provides irrigation water to over 2.6 million acres of land. The largest reservoir in the system is Shasta Lake with 4.6 MAF of capacity. The state, as part of the development of SWP, built Oroville Dam and reservoir on the Feather River system with a capacity of 3.5 MAF. The SWP provides all or part of the drinking water supply for 23 million people and provides irrigation water to about 755,000 acres of land."
2) "The federal government, through the Bureau of Reclamation, holds the most (in volume) water rights in the state with over 112 MAF of water held, mainly for delivery through the federal CVP. Second to this are the water rights held by the Imperial Irrigation District (44 MAF), serving mainly farms in the Colorado River region. Two private gas and electric companies hold rights to over 41 MAF of water collectively, mainly for hydroelectric power. The state, through DWR, holds rights to about 31 MAF of water."

3) "Water dedicated for environmental uses, including instream flows, wild and scenic flows, required Sacramento-San Joaquin River Delta (the Delta) outflow, and managed wetlands use, declines substantially between wet and dry years—a 62 percent reduction. Available water supplied to agricultural and urban users actually increases in dry years. From wet to dry years, urban use increases by 10 percent and agricultural use increases by 20 percent. The main reason for this increase is the need in dry years for more developed water for agricultural irrigation and residential landscaping."

4) "Agricultural use of water is significant. California agriculture uses roughly 30 MAF of water a year on 9.6 million acres. California's vast water infrastructure— including the development of the State Water Project, Central Valley Project, and Colorado River, as well as local and regional groundwater supply projects—was developed to provide water for irrigation (among other purposes), with agriculture using about 80 percent of California's developed water supply." (LAO, 2008)

NMFS also considered information on relative deliveries of water in the state, including Figure 8 from Blue Ribbon Task Force Delta Vision report, and Figure 10 from the same report, showing the relative importance of Delta exports relative to other sources of water supplies (taken from

DWR 2005 California Water Plan Update). To assess the relative impact of export reductions on Southern California urban uses, NMFS reviewed a presentation by Metropolitan Water District, entitled "Metropolitan's Water Supply Planning," January 31, 2009, and reviewed Figure 11 from the Delta Vision report showing the potential range of demand reductions and supply augmentations from different strategies (taken from DWR 2005 Water Plan Update).

NMFS considered the above water cost estimates in the context of the larger set of facts on California's water supply to determine whether the RPA is economically feasible. NMFS believes that a cost of 5-7 percent of the project capacity is not unreasonable for a multi-species ESA consultation, given the factual context of the Delta ecosystem and water delivery system. 330 taf reduction can be compared to 30 MAF for agriculture statewide, according to LAO. In addition, these amounts can be compared to the water rights held by the federal and state governments (112 MAF, and 31 MAF respectively, according to LAO).

Most important, NMFS evaluated the 5-7 percent combined export reduction in the context of future water demand and supply in California. The Delta is only one source of water supply. According to other planning documents (DWR's California Water Plan Update, 2005), water agencies are already planning for and adjusting to reduced supplies from the Delta. Alternative supplies include: water transfers, demand reduction through conservation, conjunctive use/groundwater use during droughts, wastewater reclamation and water recycling, and desalination. For example, urban water use efficiency is estimated by DWR to potentially result in between 1.2 to 3.1 MAF annual water savings, and recycled municipal water is potentially estimated to result in .9 to 1.4 MAF annual water savings. The state of California has had an active Integrated Watershed Management Program for almost 10 years. Projects funded through these local water infrastructure investments are coming on line, and will help offset decreased water supply from the Delta.

Furthermore, NMFS considered RPA water costs in the context of b(2) water assets of 800 taf. As the Opinion explains, for purposes of the effects analysis, NMFS could not be reasonably certain that b(2) water would be available at a specific place and time needed to address adverse effects of the project on a listed species. Therefore, the Opinion analysis and RPA actions developed to avoid jeopardy and adverse modification of critical habitat are independent of the availability of b(2) assets, and are silent about how these assets should be used. The Secretary of the Interior retains discretions over how b(2) assets are dedicated to eligible water actions throughout the water year. It is NMFS understanding that water actions taken by Reclamation to implement the RPA are eligible actions. If the Secretary of the Interior so chooses, dedication of b(2) water assets to the RPA actions could completely or significantly offset the projected water costs of the RPA. In addition, limited EWA assets associated with the Yuba Accord may be available, in part, to offset water costs of the SWP. In the proposed project description, these assets were dedicated to VAMP export curtailments. The VAMP export curtailments will be replaced, in part, by the new San Joaquin River Ratio action.

In evaluating economic feasibility, NMFS examined the direct costs of the modified operations to the Federal action agency, Reclamation. According to the LAO, 85% of Reclamation's costs are reimbursed by water users, and 95% of DWR's SWP costs are reimbursed:

> Irrigation water users pay about 55 percent of CVP reimbursable costs ($1.6 billion), while municipal and industrial water users are responsible for the remaining 45 percent (or about $1.3 billion). These reimbursements are paid through long-term contracts with water agencies. The total capital cost to construct the CVP as of September 30, 2006, is about $3.4 billion. The federal Bureau of Reclamation calculates how much of the capital construction cost is reimbursable from water users. Currently, users pay about 85 percent of total costs. In contrast, more than 95 percent of SWP's costs are reimbursable from water users. The costs assigned to such CVP purposes as flood control, navigation, and fish and wildlife needs are not reimbursable and are paid by the federal government.

(LAO, 2008) Through this arrangement, costs to the action agency itself are minimized.

NMFS also reviewed and evaluated water cost information provided by DWR. In general, the DWR information reinforced the NMFS estimates of water costs. On March 20, 2009, DWR provided estimates of water costs associated with the March 3, 2009, draft of the RPA (letter from Kathy Kelly to Ronald Milligan; Reclamation 2009b). These modeled costs were discussed in several technical team meetings and remain the only modeled projections of water costs of the RPA that NMFS is aware of. DWR estimated that combined CVP/SWP costs, as compared to operations under D1641, are 800 taf to 1.0 MAF (or about 15%-17%). However, because the salmon and smelt are near the export facilities during much of the same time of year (winter to spring), many export curtailments are multi-species in nature. Therefore, DWR estimates that, the average combined water supply impact of the NMFS RPA, layered on top of the USFWS smelt RPA, is an additional 150 taf to 750 taf, (or about 3% to 15%).

The San Joaquin river ratio action changed significantly between the March 3, 2009, draft of the RPA and the final RPA. Specifically, the duration of the period changed from 90 to 60 days, in order to better focus the action on the species' biological requirements, and the ratios were more closely refined to reflect water year type in order to reflect actual available water in the watershed and in acknowledgement that acquiring (or requiring, if the SRCWB acts) additional flows on the Tuolumne and Merced rivers could be difficult or uncertain in the near-term. Both of these refinements would reduce, perhaps substantially, DWR projected water costs, and would most likely make them consistent with NMFS estimates. On April 28, 2009, DWR provided an additional analysis of on the economic impacts of estimated water costs of the March 3, 2009, draft RPA (letter from Kathy Kelly to Ronald Milligan; DWR 2009). DWR estimated that the impact of the RPA would range from $320 million to $390 million per year. The methodology used multipliers estimated indirect and well as direct impacts. Again, these costs were predicated on RPA actions that were modified after March 3rd, and would have reduced water costs.

<u>Project Costs</u>

In addition to water costs, Reclamation and DWR will incur project costs associated with certain RPA actions (*e.g.*, the fish passage program). The State of California has authorized $19.6 billion in water-related general obligation bonds since 2000, and these bonds often contain provisions for environmental conservation related purposes (LAO, 2008). Over $3 billion has been spent through the Calfed Bay-Delta Program. The CALFED ROD contains a commitment to fund projects through the Ecosystem Restoration Program. Similarly, the CVPIA AFRP funds eligible restoration projects, using federal authorities. Some of the projects in the RPA may qualify for those sources of funds.

Summary

In summary, for all the above reasons, NMFS finds that the costs associated with the RPA, while not insignificant, do not render the RPA economically infeasible. Overall, the RPA is both technologically and economically feasible.

11.3.7 Consistency with the Intended Purpose of the Action and the Action Agencies' Legal Authority and Jurisdiction

As noted in the introduction to this RPA, regulations provide that an RPA must be an alternative that, "can be implemented in a manner consistent with the intended purpose of the action, [and] that can be implemented consistent with the scope of the federal agency's legal authority and jurisdiction." 50 CFR 402.02. This RPA meets both of these criteria.

First, this RPA is consistent with the intended purpose of the action. According to the BA, "[t]he proposed action is the continued operation of the CVP and SWP." (CVP and SWP operations BA, P. 2-1) Specifically, Reclamation and DWR "propose to operate the Central Valley Project (CVP) and State Water Project (SWP) to divert, store, and convey CVP and SWP (Project) water consistent with applicable law and contractual obligations." (CVP and SWP operations BA, p.1-1) Changes in operation of the projects to avoid jeopardizing listed species or adversely modifying their critical habitats require that additional sources of water for the projects be obtained, or that water delivery be made in a different way than in the past (*e.g.*, elimination of RBDD), or that amounts of water that are withdrawn and exported from the Delta during some periods in some years be reduced. These operational changes do not, however, preclude operation of the Projects.

Second, the RPA may be implemented consistent with the scope of the federal agency's legal authority and jurisdiction. The Rivers and Harbors Act of 1937, which established the purposes of the CVP, provided that the dams and reservoirs of the CVP "'shall be used, first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power.'" (CVP and SWP operations BA, p. 1-2). The CVP was reauthorized in 1992 through the CVPIA, which modified the 1937 Act and added mitigation, protection, and restoration of fish and wildlife as project purposes. The CVPIA provided that the dams and reservoirs of the CVP should be used "'first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement." (CVP and SWP operations BA p. 1-3) One of the stated purposes of the CVPIA is to address impacts of the CVP on fish and wildlife. CVPIA, Sec. 3406(a). The CVPIA gives Reclamation broad authority to mitigate for the adverse effects of the projects on fish and wildlife, and nothing in the Rivers and Harbors Act of 1937 requires any set amount of water delivery.

In addition to adding protection of fish and wildlife as second tier purposes of the CVP, the CVPIA set a goal of doubling the natural production of anadromous fish in Central Valley rivers and streams on a long-term sustainable basis, by 2002. Sec. 3406(b)(1). This goal has not been met. Instead, as detailed in this Opinion, natural production of anadromous fish has declined precipitously. A 2008 report on the CVPIA anadromous fish program by independent reviewers (Cummins *et al*. 2008), recommended by the Office of Management and Budget and requested by Reclamation and the USFWS, stated that

> "it is far from clear that the agencies have done what is possible and necessary to improve freshwater conditions to help these species weather environmental variability, halt their decline and begin rebuilding in a sustainable way. A number of the most serious impediments to survival and recovery are not being effectively addressed, especially in terms of the overall design and operation of the [CVP] system."

One of the review panel's specific recommendations was that the agencies

> "should develop a more expansive view of the authorities at their disposal to address the problems, especially with regard to water management and project operations. The agencies have followed a more restrictive view of their authorities than appears legally necessary or appropriate to the seriousness of the mission. "

The report notes that the CVPIA contains a "long list of operational changes, actions, tools, and authorities – some quite specific and discrete, some general and on-going – that Interior is to use to help achieve the anadromous fish restoration purposes of the CVPIA . . . ." (Cummins *et al*. 2008 at 5) The report then describes development of a Final Restoration Plan that would utilize these authorities, but concludes that "[t]he agencies implement the CVPIA . . . in a way that bears little resemblance to the integrated, coordinated, holistic vision of the Final Restoration Plan." (Cummins *et al*. 2008 at 9)

Most relevant to this consultation, the review panel observed that

> "[i]t would seem that CVPIA activities and personnel should be central to the OCAP plan, the Section 7 consultation, and the agencies' efforts to satisfy the requirements of the ESA (that is, after all, one of the directives of the CVPIA). The panel received no information or presentations on the involvement of the CVPIA program or personnel in the ESA consultation effort . . . and in the determination of what actions the agencies should be taking to meet the ESA."

(Cummins *et al*. 2008 at 11)

Reclamation and DWR operate their respective projects in close coordination, under a Coordinated Operations Agreement (COA). The COA was authorized by Congress in Public Law 99-546. Consequently, the COA "is the federal nexus for ESA section 7 consultation on operation of the SWP. Because of commitments expressed in the COA and the Congressional mandate to Reclamation to operate the CVP in conjunction with the SWP, the operations of the two projects are linked . . . .” (CVP/SWP operations BA, p. 1-10) DWR stated in a recent letter to Ren Lohoefener, Regional Director of the USFWS, “For purposes of consultations under the . . . ESA, the operations of the SWP and CVP are intentionally and inextricably connected . . . . ESA protection of Delta species under the BO is impossible without the participation and cooperation of the Department.” (DWR 2009a). Consequently, DWR asserted its standing to request reinitiation of consultation, regardless of whether Reclamation did so.

Moreover, state law gives DWR authority to provide for needs of fish and wildlife independent of the connection of the two water projects. According to the BA, DWR

> “is required to plan for recreational and fish and wildlife uses of water in connection with State-constructed water projects and can acquire land for such uses (Wat. Code Sec. 233, 345,346, 12582). The Davis-Dolwig Act (Wat. Code Sec. 11900-11925) establishes the policy that preservation of fish and wildlife is part of State costs to be paid by water supply contractors, and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund.”

(CVP/SWP operations BA, page 1-4) DWR, like Reclamation, has broad authority to preserve and enhance fish and wildlife.

The Preamble to the ESA consultation regulations states that “a Federal agency’s responsibility under section 7(a)(2) permeates the full range of discretionary authority held by that agency,” and that the Services can prescribe a RPA “that involves the maximum exercise of Federal agency authority when to do so is necessary, in the opinion of the Service, to avoid jeopardy.” 51 Fed. Reg. 19925, 19937 (June 3, 1986). The independent review panel concluded that despite Congressional authorization and direction more than 16 years ago to restore anadromous fish populations in Central Valley rivers and streams, Reclamation continues to take an unduly narrow view of its authorities in carrying out Congress’ mandate. The legal foundation of this RPA is a broader view of Reclamation’s authorities, one that is consistent with the CVPIA, the ESA, and the independent review panel’s recommendations.

12.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the Project in the Central Valley, California. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

The following are further examples of when reinitiation of consultation is warranted:

1. The project agencies are currently developing and evaluating a plan to construct a diversion on the Sacramento River and a canal around the Delta, as part of the Bay Delta Conservation Plan (BDCP) planning effort. Such a reconfiguration of the water conveyance system would take careful planning to avoid jeopardizing Sacramento River and north Delta species, as well as several years of environmental review and permitting, and would trigger a re-initiation of this Opinion as a result of changing various operations of the CVP and SWP. We expect that the collaborative research that is part of this RPA will inform this planning effort as it proceeds.

2. When performance goals are not met, for example, in RPA Actions I.2.1 and I.6.1.

3. RPA Action V: If the downstream fish passage improvements are determined not likely to be technically or biologically feasible at this milestone, then Reclamation and the Steering Committee shall identify other alternatives that would be implemented within the same timelines as those identified in this RPA. Reclamation and partner agencies shall submit specific implementation plans for alternative actions to NMFS, and NMFS shall evaluate whether the actions proposed in the implementation plans are likely to have the biological results that NMFS relied on in this Opinion. If Reclamation and partners believe that the proposed passage locations may not be feasible, the Fish Passage Steering Committee should be directed to develop early assessments of alternative actions that meet the performance standards described above in order to maintain the schedule proposed in this action. NMFS shall notify Reclamation and partner agencies as to whether the proposal is consistent with the analysis in this Opinion. If not, Reclamation will request reinitiation of consultation.

4. Recommended changes outside the range of flexibility specified in the "Implementation Procedures" sections of many of the RPA actions must receive written review and concurrence by NMFS and may trigger reinitiation of consultation.

Reclamation may request NMFS to confirm the conference opinion on the proposed critical habitat of the Southern DPS of North American green sturgeon as a biological opinion if the proposed critical habitat designation becomes final. The request must be in writing. If NMFS reviews the proposed action and finds that there have been no significant changes to the action or in the information used during the conference, NMFS will confirm the conference opinion as a biological opinion for the Project, and no further section 7 consultation will be necessary.

13.0 INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits any taking of endangered species without a permit or exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined to include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). Protective regulations adopted pursuant to section 4(d) of the ESA extend the prohibition to threatened species. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). Under the terms of section 7(b)(4) and 7(o)(2), taking that is incidental to and not intended as part of the proposed action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of the incidental take statement (ITS).

The reasonable and prudent measures described below are non-discretionary and must be implemented by Reclamation and DWR, for the exemption in section 7(o)(2) to apply. Reclamation and DWR have a continuing duty to regulate the activity covered in this incidental take statement. If Reclamation and/or DWR fail to comply with the terms and conditions of this incidental take statement, they may no longer be in compliance with the ESA. In order to monitor the impact of incidental take, Reclamation and DWR must report the progress of the action and its impact on each listed species to NMFS, as specified in this incidental take statement [50 CFR 402.14(i)(3)].

This ITS is applicable to all activities related to the long-term operations of the CVP and SWP, as described in appendix 1 to this Opinion and revised by the proposed RPA in section 11 (hereafter referred to as Proposed Action), including dams and reservoirs, power plants and pumping facilities, administration of water contracts, implementation of habitat mitigation measures, operation of hatchery programs, fish salvage facilities, and research and monitoring activities.

Take of threatened green sturgeon is currently not barred by section 9 of the ESA. When the rule proposed on May 21, 2009 (74 FR 23822) under section 4(d) of the ESA becomes effective as a final rule, all take of threatened green sturgeon not in conformance with that rule will be prohibited under the ESA. Upon the effectiveness of the final green sturgeon take rule, compliance with this Incidental Take Statement provides exemption for take under section 7(o).

13.1. Amount or Extent of Anticipated Take

Incidental take of endangered winter-run, threatened spring-run, threatened CV steelhead, and threatened Southern DPS of green sturgeon will occur as a result of implementing the CVP/SWP operations, as described in Appendix 1 of this Opinion, and as modified by the RPA provided in section 11 (hereafter referred to as Proposed Action). Reservoir operations are expected to continue to alter the natural hydrological cycle (*i.e.*, through higher summer releases and lower releases in the spring compared to the historical) in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, the American River downstream of Folsom Dam, and the Stanislaus River downstream of New Melones Dam.

Due to the inherent biological characteristics of aquatic species, such as listed anadromous salmonids and sturgeon, the large size and variability of the river systems, and the operational complexities of hatchery actions, it is generally not possible to quantify numbers of individuals that may be taken incidental to the many components of the Proposed Action. Tables 13-1 through 13-4, below, describe the amount or extent of take by listed species, life history stage, stressor, and location within the action area. The following sections, organized by type of activity within the Proposed Action, specify an *amount* of take where possible (*i.e.,* collection of adults, monitoring programs, fish salvage estimates, unscreened diversions), but otherwise, specify a geographic and temporal *extent* of take. As the Proposed Action is implemented through time, incidental take in the form of adult and juvenile passage mortality and sublethal take due to water quality and quantity are expected to decrease.

If less take occurs from the Proposed Action than is anticipated, this does not indicate that the actions comprising the RPA are not necessary to avoid jeopardizing listed species. The amount or extent of take described below is a maximum to avoid loss of the section 7(o)(2) exemption and reinitiation of consultation. In addition, section 11.2.1.3 of the RPA requires fish monitoring to determine when certain actions must be initiated, modified, or stopped. The numbers of fish detected through monitoring that trigger certain actions should not be confused with predicted (exempted) take.

13.1.1 Administration of Water Supply Contracts

This consultation addresses the long-term operations of the CVP and SWP, including the overall impacts of the total volume of water diverted from the Central Valley (*e.g.*, higher summer flows, lower spring flows, water temperature, *etc*). The volume of water delivered may be reduced from full contract amounts, consistent with the terms of individual contracts. In addition, take from the administration of water transfers is included in CVP/SWP operations for this consultation. However, this consultation does not address ESA section 7(a)(2) compliance for individual water supply contracts. Reclamation and DWR should consult with NMFS separately on their issuance of individual water supply contracts, including analysis of the effects of reduced water quality from agricultural and municipal return flows, contaminants, pesticides, altered aquatic ecosystems leading to the proliferation of non-native introduced species (*i.e.*, warm-water species), or the facilities or activities of parties to agreements with the U.S. that recognize a previous vested water right.

In the event that Reclamation determines that delivery of quantities of water to any contractor is nondiscretionary for purposes of the ESA, any incidental take due to delivery of water to that contractor would not be exempted from the ESA section 9 take prohibition in this Opinion.

Table 13-1. Amount or extent of incidental take of Sacramento River winter-run Chinook salmon.

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adult/ immigration	RBDD gates may be closed starting June 15 of each year until 2012	Non-lethal: delay in spawning, more energy consumed Lethal: pre-spawn mortality, less fecundity.	The extent of incidental take is all winter-run that migrate past RBDD on or after June 15. Incidental take will be exceeded if RBDD gates go down prior to June 15.	None starting in 2012 when the gates are up year round
Spawning	Reduced spawning area	Non-lethal, with long-term viability consequences: Introgression or hybridization with spring-run/fall-run/late fall-run; loss of genetic integrity and expression of life history Sublethal/lethal take: Reduced fecundity, density dependency as population increases (competition for spawning sites, prespawn mortality, redd superimposition)	Extent of incidental take of otherwise suitable spawning habitat downstream of the established TCP where water temperature exceeds 56ºF. Incidental take will be exceeded if the water temperature exceeds 56ºF upstream of the established TCP. In addition, if TCP performance goals in the RPA action are exceeded, then take is exceeded for this action, and Reclamation shall reinitiate consultation.	Extent of incidental take reduced from short term by implementation of Action V: Fish Passage Program (Long-term actions)

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adult migration, spawning	Fish passage	Non-lethal: Handling to capture, trap, and relocate adults Lethal: Handling mortality, pre-spawn mortality	Non-lethal take will be exempted for the number of adult winter-run determined by the Interagency Fish Passage Steering Committee pursuant to Action V, NF3, #1 and 3 as necessary for the pilot program, provided that NMFS concurs in writing with the specific handling procedures associated with the Fish Passage Pilot Plan. Lethal take is covered, provided that the Fish Passage Pilot Plan was implemented in its entirety.	Incidental take is not authorized at this time for the long term fish passage actions.

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Embryo incubation	Water temperatures above 56ºF for optimal incubation and development	Depending on water temperature: Sublethal: Physical and physiological deformities during embryonic development Lethal: Mortality	Extent of incidental take limited to those fish that spawn downstream of the established TCP, where water temperature exceeds 56ºF. All eggs deposited downstream of the established TCP are assumed lethal take. Frequency expected to increase during multiple dry/critically dry years Extent of incidental take reduced by implementation of Action V: Fish Passage Program (Near-term actions). If TCP performance goals in the RPA action are exceeded, then take is exceeded for this action, and Reclamation shall reinitiate consultation	Extent of incidental take reduced from short term by implementation of Action V: Fish Passage Program (Long-term actions)

Life Stage/ Habitat Type	**Stressor**	**Type of incidental take**	**Amount or Extent of Take: Short term**	**Amount or Extent of Take: Long term**
Juvenile rearing and downstream movement	RBDD passage downstream through dam gates when they are closed June 15 – August 31 of each year	Lethal: Mortality resulting from predation	Extent of incidental take is all juveniles (approximately 13% of each cohort) exposed to predation (which ranges from 5-50%) as they pass through Lake Red Bluff and RBDD from June 15-August 31 of each year. Incidental take will be exceeded if RBDD gates go down any time outside of the June 15-August 31 time period	None starting in 2012 when the gates are up year round.
Juvenile rearing and downstream movement	Reduced quality of juvenile rearing habitat related to the formation of Lake Red Bluff when the RBDD gates are down from June 15-August 31 of each year.	Non-lethal take: Delayed juvenile emigration, change in riparian habitat, change in river conditions, change in food supply	Extent of incidental take is the 6- mile long Lake Red Bluff that forms annually from June 15 through August 31 when the RBDD gates are down. Incidental take will be exceeded if Lake Red Bluff is created (*i.e.*, when the RBDD gates go down) any time outside of June 15-August 31	None starting in 2012 when the gates are up year round

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	Screened CVP diversions on the Sacramento River to the Delta	Non-lethal: Harassment Lethal: Mortality	Extent of incidental take is all juveniles (which may be up to 5%) exposed to the screens. Type of incidental take would be harassment, and most would be returned to the river unharmed through the bypasses. A small portion of the exposed fish would likely die.	Same as short term

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing and downstream movement	Unscreened CVP diversions between Red Bluff and the Delta	Lethal: Mortality	Extent of incidental take is all juveniles exposed to and entrained (with subsequent mortality) through unscreened CVP diversions. This take is exempted for an interim 5 years, pending future section 7 consultations on individual contract renewals and/or individual fish screens associated with the AFSP and implementation of RPA Action I.5. Incidental take is exceeded if a CVP contractor exceeds their diversion volume or if currently compliant screens are removed or allowed to lapse into disrepair to the point that they no longer meet NMFS fish screening criteria (NMFS 1997a).	Less than short-term, as each unscreened CVCP diversion is screened through the CVPIA AFSP

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	Lack of channel-forming flows, loss of rearing habitat and riparian habitat, loss of riparian vegetation, impaired geomorphic process	Non-lethal: Reduced rearing opportunities, reduced growth Lethal: Mortality through predation.	Extent of incidental take is all juveniles exposed to the stressors throughout the mainstem Sacramento River	Extent of incidental take will be reduced from short-term with continued implementation of Action Suite I.6 and Action V: Fish passage program (Long-term actions).

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Smolt emigration	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics).	Non-lethal: monitoring and alerts triggering DCC operations, entrainment into Central and South Delta, harassment, handling, and research at the export facilities Lethal: Indirect mortality associated with predation, direct mortality associated with the Federal and State fish facilities and the CHTR process.	DCC operation: The extent of take is the frequency of DCC opening prior to December 15 (when water, and therefore, fish, are entrained into the interior Delta). Various RPA actions, like OMR flow management and export curtailments, reduce the (1) duration that winter-run are in the Delta, (2) the potential for indirect predation, and (3) the potential for entrainment at the export facilities. Various RPA actions at the fish facilities will reduce entrainment loss and salvage of those fish. Winter-run loss at the Federal and State fish facilities, combined, is not expected to exceed 2 percent of the annual JPE that enters the Delta throughout the cohort-year. If performance goals in any applicable RPA action (that has them) are exceeded, then take is exceeded for that action, and Reclamation shall reinitiate consultation.	Take will be further reduced with implementation of measures to reduce pre-screen loss, improve screening efficiency, and improve predator control methods in Clifton Court Forebay and at the "end of the pipe."

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adults and juveniles	Monitoring as provided in RPA section 11.2.1.3	Non-lethal: Harassment, capture, handling Lethal: Mortality through stress	The amount of non-lethal take is all adults and juveniles that are captured and handled, including incidental mortalities that will likely occur through standard monitoring techniques.	Same as short term
Juvenile/smolt	Contra Costa Water District Pumping Facilities (Rock Slough Diversion): operation of Pumping Plant #1 on Rock Slough (the waters within the Contra Costa Canal and the immediate waters of Rock Slough surrounding the entrance to the Contra Costa Canal);	Lethal: Entrainment, increased predation	5 juvenile winter-run per year entrained and subsequently die.	5 juvenile winter-run per year entrained and subsequently die. When the Rock Slough diversion is screened (expected to be before year 2018) sometime in the future, incidental take will not be expected, and therefore, will not be authorized.

Table 13-2. Summary of incidental take of Central Valley spring-run Chinook salmon. Acronyms for diversity groups are as follows: NWC – Northwestern California; BPL – Basalt and Porous Lava; NSN – Northern Sierra Nevada.

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Adult immigration and holding	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	RBDD gates may be closed starting June 15 of each year until 2012	Non-lethal: more energy consumed, delay in migration for an average of 20 days, less fecundity Lethal: pre-spawn mortality,	The extent of incidental take is all spring-run (approximately 15%) that migrate past RBDD on or after June 15. Incidental take will be exceeded if RBDD gates go down prior to June 15.	None starting in 2012 when the gates are up year round
Adult immigration and holding	NWC: Clear	Water temperatures during summer holding period	Non-lethal: more energy consumed, less fecundity Lethal: pre-spawn mortality	Extent of take is the habitat downstream of the Igo gage that exceeds 60ºF during summer holding from June 1 through September 15. In critically dry years, extent of incidental take is likely higher when there is not enough cold water in Whiskeytown Lake to sustain 60ºF down to the Igo gage.	Same as short term

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Adult immigration and holding	NWC: Clear	Spring attraction flows	Non-lethal: delay in migration, less fecundity Lethal: pre-spawn mortality, limited cues for upstream migration resulting from spring flows with little variation. With low summer flows, Adults are impeded from accessing upstream holding areas.	Extent of incidental take is all spring-run that migrate past RBDD between June 15 and August 31 that cannot migrate up Clear Creek because of lower flows	Incidental take will be reduced starting in 2012, as late-arriving spring-run will not be subjected to migrational delays at RBDD when the gates are up year round.
Spawning	NWC: Clear	Limited spawning habitat availability	Sub-lethal: Increased competition Lethal: reduced spawning success	Extent of take is the proportion of each cohort that is subjected to increased competition and reduced spawning success as a result of limited spawning gravel.	Same as short term
Embryo incubation	NWC: Clear	Warm water temperatures downstream of Igo in September	Depending on water temperature: Sublethal: Physical and physiological deformities during embryonic development Lethal: Mortality	Extent of take is the habitat downstream of Igo where water temperature exceeds 56ºF and redds are constructed	Likely reduced in the future with implementation of Action I.1.6

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Embryo incubation	BPL: Sacramento	Water temperatures warmer than life history stage requirements, during September and October	Depending on water temperature: Sublethal: Physical and physiological deformities during embryonic development Lethal: Mortality	Extent of incidental take limited to those fish that spawn downstream of the established TCP, where water temperature exceeds 56ºF. All eggs deposited downstream of the established TCP is assumed lethal take. Frequency expected to increase during multiple dry/critically dry years If TCP performance goals in RPA action are exceeded, then take is exceeded for this action, and Reclamation shall reinitiate consultation	Extent of incidental take reduced from short term by implementation of Action V: Fish Passage Program (Long-term actions)

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Juvenile rearing	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	RBDD passage downstream through dam gates when they are closed June 15 – August 31 of each year	Lethal: Mortality resulting from predation	Extent of incidental take is all juveniles (less than 0.1% of each cohort) exposed to predation (which ranges from 5-50%) as they pass through Lake Red Bluff and RBDD from June 15-August 31 of each year. Incidental take will be exceeded if RBDD gates go down any time outside of the June 15-August 31 time period	None starting in 2012 when the gates are up year round.
Juvenile rearing	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	Reduced quality of juvenile rearing habitat related to the formation of Lake Red Bluff when the RBDD gates are down from June 15-August 31 of each year.	Non-lethal take: Delayed juvenile emigration, change in riparian habitat, change in river conditions, change in food supply	Extent of incidental take is the 6-mile long Lake Red Bluff that forms annually from June 15 through August 31 when the RBDD gates are down. Incidental take will be exceeded if Lake Red Bluff is created (*i.e.,* when the RBDD gates go down) any time outside of June 15-August 31.	None starting in 2012 when the gates are up year round

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Juvenile rearing	All diversity groups and populations	Screened CVP diversions on the Sacramento River to the Delta	Non-lethal: Harassment Lethal: Mortality	Extent of incidental take is all juveniles (which may be up to 5%) exposed to the screens. Type of incidental take would be harassment, and most would be returned to the river unharmed through bypasses. A small portion of the exposed fish would likely die.	Same as short term

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Juvenile rearing	All diversity groups and populations	Unscreened CVP diversions between Red Bluff and the Delta	Lethal: Mortality	Extent of incidental take is all juveniles (estimated 538 juveniles annually) exposed to and entrained (with subsequent mortality) through unscreened CVP diversions. This take is exempted for an interim 5 years, pending future section 7 consultations on individual contract renewals and/or individual fish screens associated with the AFSP and implementation of RPA Action I.5. Incidental take is exceeded if a CVP contractor exceeds their diversion volume or if currently compliant screens are removed or allowed to lapse into disrepair to the point that they no longer meet NMFS fish screening criteria (NMFS 1997a).	Less than short-term, as each unscreened CVP diversion is screened through the CVPIA AFSP

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Juvenile rearing	All diversity groups and populations	Lack of channel forming-flows, loss of rearing habitat and riparian habitat, loss of riparian vegetation, impaired geomorphic process.	Non-lethal: Reduced rearing opportunities, reduced growth Lethal: Mortality through predation.	Extent of incidental take is all juveniles exposed to the stressors throughout the mainstem Sacramento River	Extent of incidental take will be reduced from short-term with continued implementation of Action Suite I.6 and Action V: Fish passage program (Long-term actions).

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Smolt emigration	All diversity groups and populations	Cumulative direct and indirect loss associated with export operations (loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Non-lethal: monitoring and alerts triggering DCC operations, entrainment into Central and South Delta, harassment, handling, and research at the export facilities Lethal: Indirect mortality associated with predation, direct mortality associated with the Federal and State fish facilities and the CHTR process.	DCC operation: The extent of take is the frequency of DCC opening prior to December 15 (when water, and therefore, fish, are entrained into the interior Delta. Various RPA actions, like OMR flow management and export curtailments, reduce the (1) duration that spring-run are in the Delta, (2) the potential for indirect predation, and (3) the potential for entrainment at the export facilities. Various RPA actions at the fish facilities will reduce entrainment loss and salvage of those fish. Spring-run loss at the Federal and State fish facilities, combined, is not expected to exceed 1 percent based on marked late fall-run as surrogates that enter the Delta throughout the cohort-year. If performance goals in any applicable RPA action (that has them) are exceeded, then take is exceeded for	Take will be further reduced with implementation of measures to reduce pre-screen loss, improve screening efficiency, and improve predator control methods in Clifton Court Forebay and at the "end of the pipe."

Life Stage/Habitat Type	Diversity Group(s): Population(s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or extent of Take: Long term
Adults and juveniles	All diversity groups and populations	Monitoring as provided in RPA section 11.2.1.3	Non-lethal: Harassment, capture, handling Lethal: Mortality through stress	The amount of non-lethal take is all adults and juveniles that are captured and handled, including incidental mortalities that will likely occur through standard monitoring techniques.	Same as short term
Juvenile/smolt	All diversity groups and populations	Contra Costa Water District Pumping Facilities (Rock Slough Diversion): operation of Pumping Plant #1 on Rock Slough (the waters within the Contra Costa Canal and the immediate waters of Rock Slough surrounding the entrance to the Contra Costa Canal)	Non-lethal: Harm resulting from delays in migration, diminishment of physical status due to delays in migration; injury due to exposure to reduced water quality parameters (*i.e.*, water temperature, dissolved oxygen, contaminants) Lethal: Entrainment, increased predation	10 juvenile spring-run per year entrained and subsequently die	10 juvenile spring-run per year entrained and subsequently die. When the Rock Slough diversion is screened sometime in the future (expected to be before year 2018), incidental take will not be expected, and therefore, will not be authorized.

Table 13-3. Summary of incidental take of Central Valley steelhead. The table is organized by life stage then by the number of populations affected by a particular stressor. Acronyms for diversity groups are as follows: NWC – Northwestern California; BPL – Basalt and Porous Lava; NSN – Northern Sierra Nevada; SSN – Southern Sierra Nevada.

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adult immigration and holding	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	RBDD gates may be closed June 15 through September 1 of each year until 2012	Non-lethal: more energy consumed, delay in migration for an average of 20 days Lethal: pre-spawn mortality, less fecundity Non-lethal take more likely	The extent of incidental take is all steelhead that migrate past RBDD before September 1. Incidental take will be exceeded if RBDD gates go up after September 1.	None starting in 2012 when the gates are up year round
Adult immigration and holding	NWC: Clear	High water temperatures near confluence with Sacramento River during August and September	Non-lethal: (1) Delayed migration into Clear Creek, (2) seek other tributaries, (3) spawn in mainstem Sacramento R.; reduced in vivo egg viability	Extent of incidental take is the habitat downstream of the Igo gage that exceeds 60ºF in August and September. In critically dry years, extent of incidental take is likely higher when there is not enough cold water in Whiskeytown Lake to sustain 60ºF down to the Igo gage. Incidental take is exacerbated in the early part of the run by migration delays from RBDD gate closure through September 1	Incidental take will be reduced starting in 2012, as early-arriving steelhead will not be subjected to migrational delays at RBDD when the gates are up year round.
Spawning	NWC: Clear	Limited spawning habitat availability	Sub-lethal: Increased competition Lethal: reduced spawning success	Extent of take is the proportion of each cohort that is subjected to increased competition and reduced spawning success as a result of limited spawning gravel.	Same as short term

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Spawning	NSN: American River	Flood releases	Lethal: Redd scour, resulting in egg mortality	Extent of take is expected to be limited to releases from Nimbus Dam that are greater than 50,000 cfs during egg incubation (*i.e.*, January through May), which occurs approximately once every 5 years (CVP/SWP operations BA).	Same as short term
Spawning	NSN: American River; BPL: Sacramento ; and potentially all other populations within the NWC, NSN, and BPL diversity groups	Nimbus Fish Hatchery *O. mykiss* spawning with natural-origin steelhead in the American River and in other CV streams	Non-lethal: Reduced genetic fitness	Extent of incidental take from Nimbus Fish Hatchery is unknown, but will be immediately reduced upon implementation of Action II.6.2	Extent of incidental take should be reduced considerably upon implementation of an HGMP

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Spawning, egg incubation, and emergence	SSN: Stanislaus River	Excessive fines in spawning gravel resulting from lack of overbank flow	Sublethal: Increased energy attempting to "clean" excess fine material from spawning site Lethal: Egg mortality due to superimposition or spawning in suboptimal sites, or from lack of interstitial flow	Incidental take is expected to the extent that poor spawning bed conditions persist, as the proposed frequency of channel mobilizing flows of 5,000 cfs may not result in mobilizing flows at higher levels which perform greater geomorphic work. Incidental take will decrease with implementation of Action V: Fish passage program (Near-term actions)	Through time, the extent of incidental take through poor spawning bed conditions will be reduced from the short term as habitat restoration continues. Incidental take will also decrease with implementation of Action V: Fish passage program (Long-term actions)
Embryo incubation	NSN: American River	Exposure to stressful water temperatures in the American River during embryo incubation	Sub-lethal effects - reduced early life stage viability; restriction of life history diversity (*i.e.*, directional selection against eggs deposited in March and April) Lethal: direct mortality	The extent of incidental take is the stretch of the American River where the mean daily water temperature first begins to exceed 54°F, downstream to the downstream extent of steelhead spawning habitat at approximately RM 6, just upstream of Paradise Beach. Incidental take is expected to be reduced with implementation of Action V: Fish passage program (Near-term actions)	Incidental take will decrease with implementation of the structural improvements to improve cold water management, and Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Egg incubation and emergence	SSN: Stanislaus River	Warm water temperatures during egg incubation and emergence	Depending on water temperature: Sub-lethal: Embryonic deformities Lethal: Egg mortality, especially for eggs spawned in or after March;	Extent of incidental take is the river downstream of Orange Blossom Bridge, where water temperature exceeds 55ºF, from January through May. Extent expected to increase during critically dry years Extent of incidental take reduced by implementation of Action V: Fish Passage Program (Near-term actions)	Extent of take expected to be reduced from short term with implementation of Action V: Fish passage program (Long-term actions)
Juvenile rearing	BPL: Sacramento River	Higher flows and cooler water temperatures during the summer	Non-lethal: Increased residualism, reduced diversity	The amount or extent of take cannot be quanitified. Residualized *O. mykiss* as a result of improved rearing habitat conditions from the cooler water temperatures in the summer could contribute to the steelhead population, but the extent is unknown. The higher flows and cooler water in the summer is certainly a beneficial effect on the juveniles emigrating from the tributaries.	Same as short term

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	NWC: Cottonwood/ Beegum, Clear; BPL: Sacramento, Battle	Reduction in rearing habitat quantity and quality with the formation of Lake Red Bluff when the RBDD gates are down from June 15-August 31 of each year.	Non-lethal take: Delayed juvenile emigration, change in riparian habitat, change in river conditions, change in food supply	Extent of incidental take is the 6-mile long Lake Red Bluff that forms annually from June 15 through August 31 when the RBDD gates are down. Incidental take will be exceeded if Lake Red Bluff is created (*i.e.,* when the RBDD gates go down) any time outside of June 15-August 31.	None starting in 2012 when the gates are up year round
Juvenile rearing	All diversity groups and populations	Screened CVP diversions on the Sacramento River to the Delta	Non-lethal: Harassment Lethal: Mortality	Extent of incidental take is all juveniles (which may be up to 5%) exposed to the screens. Type of incidental take would be harassment, and most would be returned to the river unharmed through bypasses. A small portion of the exposed fish would likely die.	Same as short term

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	All diversity groups and populations	Unscreened CVP diversions between Red Bluff and the Delta	Lethal: Mortality	Extent of incidental take is all juveniles (estimated 394 juveniles annually) exposed to and entrained (with subsequent mortality) through unscreened CVP diversions. This take is exempted for an interim 5 years, pending future section 7 consultations on individual contract renewals and/or individual fish screens associated with the AFSP and implementation of RPA Action I.5. Incidental take is exceeded if a CVP contractor exceeds their diversion volume or if currently compliant screens are removed or allowed to lapse into disrepair to the point that they no longer meet NMFS fish screening criteria (NMFS 1997a).	Less than short-term, as each unscreened CVCP diversion is screened through the CVPIA AFSP

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	All diversity groups and populations, excluding the SSN diversity group	Lack of channel-forming flows in the Sacramento River, loss of rearing habitat and riparian habitat, loss of riparian vegetation, impaired geomorphic process.	Non-lethal: Reduced rearing opportunities, reduced growth Lethal: Mortality through predation.	Extent of incidental take is all juveniles exposed to the stressors throughout the mainstem Sacramento River	Extent of incidental take will be reduced from short-term with continued implementation of Action Suite I.6
Juvenile rearing	NWC: Clear Creek	Exposure to high water temperatures	Non-lethal: Limited over-summering habitat, reduced growth, increased competition Sub-lethal: Increased susceptibility to disease and predation Lethal: Increased predation	Extent of incidental take is rearing habitat downstream of Igo from June 1 through September 15 where water temperature exceeds 60ºF. Incidental take is exceeded if water temperature is greater than 60ºF upstream of Igo between June 1 and September 15.	Same as short term

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	NWC: Clear Creek	Limited rearing habitat availability resulting from low summer flows (< 80 cfs)	Non-lethal: reduced growth, increased competition Lethal: increased predation risk	Extent of take is the difference between the habitat necessary and the habitat available for the population of steelhead	Extent of incidental take will be reduced in the future with implementation of Action I.1.6
Juvenile rearing	NSN: American River	Folsom/Nimbus releases resulting in flow fluctuations; low flows	Sub-lethal: Reduced availability of quality rearing habitat Lethal: Fry stranding, juvenile isolation, increased predation	Extent of incidental take is limited to Folsom/Nimbus releases of greater than 4,000 cfs, which is not expected to occur frequently. Ramping rates also minimize incidental take. The extent of incidental take is exceeded if flow increases or decreases exceed the ramping rates	Same as short term

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	NSN: American River	Exposure to stressful water temperatures in the American River during juvenile rearing	Sub-lethal: Disease, thermal stress Lethal: Predation	The extent of take is potential rearing habitat downstream of the Watt Avenue Bridge, or the established TCP, where water temperature exceeds 65°F between May 15 and October 31. Incidental take would be reduced with implementation of the structural improvements and Action V: Fish passage program (Near-term actions) Incidental take is exceeded if the water temperature exceeds 65°F upstream of the Watt Avenue Bridge or TCP between May 15 and October 31	The extent of take will decrease with implementation of the structural improvements and Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	SSN: Stanislaus River	Reduction in rearing habitat complexity due to lack of channel forming flows	Sub-lethal: Stress, suppressed growth rates Lethal: Increased predation	The extent of incidental take will be the frequency and duration of flows that do not inundate the floodplain and provide rearing habitat complexity after implementing Action III.1.3. Take will be higher in the drier water year types than the wetter water year types. Extent of incidental take will be reduced by implementation of Action V: Fish Passage Program (Near-term actions) The extent of incidental take is exceeded if the frequency and duration of flows provided in Action III.1.3 are not met.	Very little amount or extent of take, if any, as a result of implementing the floodplain restoration and inundation flows, coupled with implementation of Action V: Fish passage program (Long-term actions)
Juvenile rearing and downstrea m movement	SSN: Stanislaus River	Predation	Sub-lethal: Injury Lethal: Mortality	Amount or extent of incidental take is unknown, but the level of predation is expected to be reduced from current levels from increased flows and cold water	Incidental take is expected to decrease with implementation of Action III.2.3

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	SSN: Stanislaus River	Exposure to stressful water temperatures in the Stanislaus River at the end of summer affecting rearing habitat	Sub-lethal: Metabolic stress; starvation; poor growth; Lethal: Loss to predation	Extent of take is habitat that exceeds 65ºF downstream of Orange Blossom Bridge, especially during critically dry years, from July through September Incidental take will be reduced with the implementation of Action V: Fish passage program (Near-term actions). The extent of incidental take is exceeded if the water temperature exceeds 65ºF upstream of Orange Blossom Bridge, during July through September.	Same as short term, but further reduced take with implementation of Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Smolt emigration	SSN: Stanislaus River	Warm water temperatures warmer than life history stage (Mar - June)	Sub-lethal: Thermal stress Lethal: Mortality resulting from failure to escape river before temperatures rise in lower river reaches	Extent of incidental take is the Stanislaus River downstream of Orange Blossom Bridge from January through May when temperatures are above 57ºF. This is likely to occur more frequently during critically dry years, particularly in May. Incidental take will be reduced with the implementation of Action V: Fish passage program (Near-term actions) The extent of incidental take is exceeded if water temperatures exceed 57ºF upstream of Orange Blossom Bridge during January to May, and particularly in May.	Same as short term. Incidental take will be further reduced with implementation of Action V: Fish passage program (Long-term actions)
Smolt emigration	NSN: American River	Exposure to stressful water temperatures in the American River during smolt emigration	Sub-lethal:Physiological effects – reduced ability to successfully complete the smoltification process Lethal: increased susceptibility to predation	Extent of incidental take is habitat that exceeds mean daily water temperatures greater than 54°F during smolt emigration (*i.e.*, January through June). Incidental take will be reduced with implementation of structural improvements and Action V: Fish passage program (Near-term actions)	Extent of incidental take will decrease from short term with the continued implementation of the structural improvements and Action V: Fish passage program (Long-term actions)

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Smolt emigration	All diversity groups and populations	Cumulative direct and indirect loss associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics)	Non-lethal: monitoring and alerts triggering DCC operations, entrainment into Central and South Delta, harassment, handling, and research at the export facilities Lethal: Indirect mortality associated with predation, direct mortality associated with the Federal and State fish facilities and the CHTR process.	DCC operation: The extent of take is the frequency of DCC opening prior to December 15 (when water, and therefore, fish, are entrained into the interior Delta. Various RPA actions, like OMR flow management and export curtailments, reduce the (1) duration that CV steelhead are in the Delta, (2) the potential for indirect predation, and (3) the potential for entrainment at the export facilities. RPA Actions IV.2.1 and IV.2.2 specifically address San Joaquin River flows and export curtailments to minimize take of CV steelhead emigrating from the San Joaquin River basin. Various RPA actions at the fish facilities will reduce entrainment loss and salvage of those fish. Incidental take is limited to the salvage of 3,000 unmarked juvenile and adult CV steelhead that enter the Delta throughout the year from multiple cohorts. If performance goals in any applicable RPA action (that has them) are exceeded, then take is exceeded for that action, and Reclamation shall reinitiate consultation.	Similar to short term. Incidental take of CV steelhead emigrating from the San Joaquin River is expected to decrease with implementation of Action IV.2.1 Phase 2 and utilizing the results of the acoustic tagging studies to increase survival of emigrating CV steelhead from the San Joaquin River Basin.

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adults and juveniles	All diversity groups and populations	Monitoring as provided in RPA section 11.2.1.3	Non-lethal: Harassment, capture, handling Lethal: Mortality through stress	The amount of non-lethal take is all adults and juveniles that are captured and handled, including incidental mortalities that will likely occur through standard monitoring techniques.	Same as short term
Juvenile/ smolt	All diversity groups and populations	Contra Costa Water District Pumping Facilities (Rock Slough Diversion): operation of Pumping Plant #1 on Rock Slough (the waters within the Contra Costa Canal and the immediate waters of Rock Slough surrounding the entrance to the Contra Costa Canal)	Non-lethal: Harm resulting from delays in migration, diminishment of physical status due to delays in migration; injury due to exposure to reduced water quality parameters (*i.e.*, water temperature, dissolved oxygen, contaminants) Lethal: Entrainment, increased predation	10 juvenile steelhead per year entrained and subsequently die.	10 juvenile steelhead per year entrained and subsequently die. When the Rock Slough diversion is screened sometime in the future (expected to be before year 2018), incidental take will not be expected, and therefore, will not be authorized.

Life Stage/ Habitat Type	Diversity Group(s): Population (s)	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juveniles/ smolts	SSN: Stanislaus River	Monitoring	Non-lethal: Handling stress Lethal: Mortality	Non-lethal take of 60-80 juveniles per year, including smolts, from Rotary Screw Traps at Caswell and Oakdale, based on past years' encounter rates (and under current population levels) and longer sampling season of December through June. Incidental mortalities are exempt this monitoring.	Incidental take is expected to increase as the population increases.
Adults	SSN: Stanislaus River	Monitoring	Non-lethal: Harassment, handling stress, delayed migration Lethal: Mortality	Non-lethal take of 10-25 adults per year from the counting weir on the lower Stanislaus River, based on past years' encounter rates (and under current population levels) and a longer sampling season of September through March. Incidental mortalities are expected to be no more than 2 adults per year.	Incidental take is expected to increase as the population increases.

Table 13-4. Summary of incidental take of Southern DPS of green sturgeon.

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adult immigration and holding	RBDD gates may be closed starting June 15 of each year until 2012.	Non-lethal: passage blocked, more energy consumed, less fecundity, studies Lethal: downstream passage of adults under gates	Non-lethal take of adults for studies provided in Appendix 2-B The extent of incidental take is all green sturgeon at the tail end of the spawning migration that are precluded access above RBDD on or after June 15. Injury, impingement, or mortality of adults migrating downstream when RBDD gates are down are also exempt, contingent on notification requirement (see section 13.1.2.2).	None starting in 2012 directly or indirectly resulting from RBDD when the gates are up year round
Spawning	RBDD gates may be closed starting June 15 of each year until 2012.	Non-lethal: eggs suffocate, physiological effects, delayed hatch, greater predation on eggs due to accumulation of predators below RBDD.	All green sturgeon that spawn downstream of RBDD after the RBDD gates close on or after June 15	None starting in 2012 directly or indirectly resulting from RBDD when the gates are up year round

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Embryo incubation	Water temperatures warmer than life history stage requirements from RBDD to Hamilton City.	Lethal and sub-lethal take: Mortality of eggs and fry resulting from less suitable water quality, including suffocation of eggs from less flow, physiological effects, delayed hatch, and greater predation on eggs and fry due to presence of non-native introduced warm-water species.	Extent of incidental take is water temperatures from RBDD to Hamilton City that exceed life history stage requirements following the implementation of Action Suite I.2. Frequency expected to increase during multiple dry/critically dry years If TCP performance goals in the RPA action are exceeded, then take is exceeded for this action, and Reclamation shall reinitiate consultation	Considerably less than short term (if any), as more green sturgeon will spawn upstream of RBDD when the gates are up year round
Eggs, larvae, juvenile, adults	Studies in Appendix 2-B	Non-lethal: adults for radiotelemetry, egg extraction; juvenile tagging, lab experiments Lethal: Eggs, larvae, and juveniles collected for genetic sampling	Amounts of lethal and non-lethal take according to the proposed studies in Appendix 2-B, including: Up to 10 adult green sturgeon annually for 3 years. Of those, up to 2 females and 4 males will be also spawned. Up to 100 juvenile wild green sturgeon will be captured and retained per year for 3 years.	Same as short term until studies are completed

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	Increased juvenile mortality related to emigration when RBDD gates are closed from June 15 through August 31	Lethal take: Mortality resulting from predation	Extent of incidental take is all juveniles exposed to predation as they pass through Lake Red Bluff and RBDD from June 15-August 31 of each year. Incidental take will be exceeded if RBDD gates go down any time outside of the June 15-August 31 time period	None starting in 2012 when the gates are up year round
Juvenile rearing	Reduced quality of juvenile rearing habitat related to the formation of Lake Red Bluff when the RBDD gates are in.	Non-lethal take: Reduction in rearing habitat quality and quantity; change in riparian habitat, change in river conditions, change in food supply.	Extent of incidental take is the 6-mile long Lake Red Bluff that forms annually from June 15 through August 31 when the RBDD gates are down. Incidental take will be exceeded if Lake Red Bluff is created (*i.e.*, when the RBDD gates go down) any time outside of June 15-August 31	None starting in 2012 when the gates are up year round

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Eggs, larvae, juvenile--rearing	Screened CVP diversions on the Sacramento River to the Delta	Non-lethal: Harassment Lethal: Mortality	Extent of incidental take is all eggs, larvae, and juveniles exposed to the screens. Type of incidental take would include harassment for those eggs, larvae, and juveniles that would be returned to the river unharmed through the bypasses. Lethal take through entrainment into the diversions is expected for a portion of the eggs and larvae.	Same as short term

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile rearing	Unscreened CVP diversions	Lethal: Mortality	Extent of incidental take is all juveniles exposed to and entrained (with subsequent mortality) through unscreened CVP diversions. This take is exempted for an interim 5 years, pending future section 7 consultations on individual contract renewals and/or individual fish screens associated with the AFSP and implementation of RPA Action I.5. Incidental take is exceeded if a CVP contractor exceeds their diversion volume or if currently compliant screens are removed or allowed to lapse into disrepair to the point that they no longer meet NMFS fish screening criteria (NMFS 1997a).	Less than short-term, as each unscreened CVP diversion is screened through the CVPIA AFSP.

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Juvenile and subadult	Cumulative direct and indirect loss and salvage associated with export operations (DCC operations, loss in Delta interior, loss at export facilities, creation of artificial freshwater system, altered hydrodynamics).	Non-lethal: entrainment into Central and South Delta, harassment, handling, and research at the export facilities during the salvage and CHTR process. Lethal: Indirect mortality associated with predation, direct mortality associated with the Federal and State fish facilities and the CHTR process.	Various RPA actions, like OMR flow management and export curtailments, reduce (1) the potential for indirect predation, and (2) the potential for entrainment at the export facilities. Various RPA actions at the fish facilities will reduce entrainment loss and salvage of those fish. Green sturgeon salvage and loss is highly variable, but is not expected to exceed the 10-year historical average of 74 and 106 juveniles, respectively, per year. If performance goals in any applicable RPA action (that has them) are exceeded, then take is exceeded for that action, and Reclamation shall reinitiate consultation	Take will be further reduced with implementation of measures to reduce pre-screen loss, improve screening efficiency, and improve predator control methods in Clifton Court Forebay and at the "end of the pipe."

Life Stage/ Habitat Type	Stressor	Type of incidental take	Amount or Extent of Take: Short term	Amount or Extent of Take: Long term
Adults and juveniles	Monitoring as provided in RPA section 11.2.1.3	Non-lethal: Harassment, capture, handling Lethal: Mortality through stress	The amount of non-lethal take is all adults and juveniles that are captured and handled, including incidental mortalities that will likely occur through standard monitoring techniques.	Same as short term
Green Sturgeon juveniles, subadults, adults	Treatment of Clifton Court Forebay with Cobber-based herbicides	Sublethal: diminishing olfactory responses by altering membrane potentials and responses to odor stimuli, altering cellular membrane function. Lethal: mortality.	4 days between July 1 and August 31, up to twice per season	4 days between July 1 and August 31, up to twice per season

13.1.2 Operation of CVP and SWP Dams and Reservoirs

13.1.2.1 Flood Control Operations

Heavy rainfall within upstream basins during the winter and spring months is likely to trigger flood control operations and reservoir releases to downstream areas at CVP and SWP reservoirs in 10-25% of the years, resulting in short-term, high flow, events in Clear Creek, the upper Sacramento River, American River and the Stanislaus River. Extremely high flow events may:

- scour Chinook salmon and steelhead redds, and result in the injury and mortality of Chinook salmon and steelhead eggs and sac-fry;
- displace and disperse sac-fry and larval fish stages downstream into unsuitable habitats for their life stage.
- strand and isolate winter-run, spring-run, and CV steelhead fry and juveniles from the mainstem river channels. If additional high flow events do not follow within a short period of time, these isolated juveniles may be lost to predation, lethal water temperatures conditions, or dessication.

Flood control releases can occur multiple times a year, depending on the Corps' flood control curves for filling project reservoirs. In general, these impacts are less than an unregulated river due to the presence of the dam. The frequency of occurrence is likely to increase with implementation of the RPA, due to maintaining higher storage levels through the winter months in Shasta Reservoir.

Take of adult winter-run, spring-run, CV steelhead, and green sturgeon is not anticipated due to flood control operations.

13.1.2.2 Red Bluff Diversion Dam

Delays to upstream migration of adult winter-run, spring-run, CV steelhead, and green sturgeon at the RBDD are expected to decrease considerably due to the extended gate openings in the RPA, and completely eliminated after completion of the Red Bluff Pumping Plant. Average delays of 11 days (range from 1- 40 days) have been reported by radio-tagging experiments on spring-run (USFWS 1990). Delays in migration are expected to increase the chance that spawning will be unsuccessful. In 10-25 percent of years (dry and critical), it is expected that some adult spring-run spawners will be unable to access tributary streams above the RBDD, due to low flows and thermal barriers developing at the tributary mouth during the time the fish were delayed in their migration. The potential amount of take is difficult to predict, but take will be reduced due to interim gate openings until 2012, and completely eliminated after 2012 when the new pumping plant becomes operational. Likewise, approximately 30 percent of adult green sturgeon are blocked from spawning above RBDD under current operations. The level of spawning success below RBDD is unknown, but is presumed to be lower than in the river reaches above RBDD. Incidental take in the form of migration delays, pre-spawn mortality, lower fecundity, increased juvenile predation, and reduced rearing habitat associated with the interim operations of the RBDD (incidental take is not expected with gates out year round starting in year 2012)

Interim operations at RBDD for green sturgeon provide for 18-inch gate openings. These gate openings, coupled with a considerably reduced duration of gates down operation (2.5 months compared to 4 months plus a provision for a 10-day emergency closure from the 2004 CVP/SWP operations Opinion), would likely allow adult green sturgeon to pass downstream underneath the RBDD gates uninjured. A provision in RPA Action I.3.3 allows the RBDD technical team to modify the opening to 12 inches if necessary to maintain the structural integrity of the dam and/or adequate attraction flows for salmonids at the fish ladders, or in consideration of other real-time fish migratory issues. In the event that adult green sturgeon are impinged, injured, or suffer mortality as a result of implementing RPA Action I.3.3, that incidental take is covered. As a condition of this take authorization, any observation of an impinged, injured or dead green sturgeon must reported within 24 hours to the NMFS Sacramento Area Office Supervisor At (916) 930-3600, followed by written documentation through electronic mail to maria.rea@noaa.gov.

13.1.2.3 Water Temperatures and Flows

In wet and above normal years, water temperatures are in the preferred range for winter-run, spring-run, CV steelhead, and green sturgeon for at least a portion of: (1) Clear Creek from Whiskeytown Dam to the Powerline Crossing Road (RM 5); (2) the Sacramento River from Keswick Dam to Red Bluff; (3) the American River from Nimbus Dam to Watt Avenue; and (5) the Stanislaus River from Goodwin Dam to Riverbank.

Dry hydrologic conditions or moderate precipitation will create low instream flows below CVP and SWP controlled reservoirs. Operation of the reservoirs during these hydrologic conditions will result in some incidental take, including:

- dewatering of some winter-run, spring-run, and CV steelhead redds, and egg and pre-emergent fry mortality.
- mortality of juvenile CV steelhead resulting from high water temperatures (*e.g.,* Clear Creek and American River).
- Reduced availability and suitability of winter-run, spring-run, and CV steelhead habitat for juvenile rearing and emigration.
- Adult salmonids not being able to reach spawning areas within tributary streams by creating thermal barriers and subjecting them to increased poaching or predation in summer holding pools.

13.1.3 Maintenance of Project Facilities

13.1.3.1 Screened and Unscreened Water Diversions

Take from each screened CVP diversion that meets NMFS (1997a) fish screen criteria is expected to be less than the 5 percent (of the fish exposed to the screen). NMFS (1997a) were specifically designed to protect fry-sized salmonids, and green sturgeon eggs and larvae are smaller. Therefore, a greater proportion of green sturgeon eggs and larvae than salmonid fry are expected to be entrained (and die) at the screened CVP diversions. Non-lethal take is expected to occur as juvenile fish are bypassed through and around pumps back to the river. Additional mortality occurs from predation at fixed release sites, since predators learn to take advantage of a steady supply of disoriented fish.

The CVP/SWP operations BA analyzed the impact 123 unscreened diversions located downstream of RBDD based on previous studies at unscreened diversions (Hanson 2001), and average juvenile passage from 1994 through 1999 at RBDD (Gaines and Martin 2002 *op. cit*. CVP/SWP operations BA). Timing and quantity of diversions was based on the monthly averages for CVP contractors with unscreened diversions from 1964 through 2003. A summary of the estimated entrainment by month is presented in table 13-5. Adequate funding of the CVPIA - AFSP (RPA Action I.5) is expected to reduce the amount and extent of juvenile loss to unscreened diversions.

Take for unscreened CVP diversions is authorized for an interim 5 years, pending future section 7 consultations on individual contract renewals and/or individual fish screens associated with the AFSP and implementation of RPA Action I.5. Prior to the 5-year time frame, NMFS will reassess the status of screening or protecting fish from these diversions and assess the status of this incidental take exemption.

Table 13-5. Estimated monthly entrainment of juvenile salmonids for 123 unscreened diversions in the Sacramento River based on historic water usage (Project + Base supply) and fish passage estimates from 1994 to 1999 at Red Bluff Diversion Dam (summarized from Tables 11-12 through 11-16 in the CVP/SWP operations BA).

	April	May	June	July	August	Sept.	Oct.	Total
Average flow (cfs)	10,404	9,435	11,110	13,082	9,683	6,730	7,013	
Winter-run	4	2	0	342	3,545	3,241	308	7,442
Spring-run	439	82	3	0	0	0	14	538
O. mykiss	18	132	37	26	117	62	2	394
Fall-run	6,754	4,237	3,645	1,788	685	53	1	17,163
Late fall-run	371	285	127	196	495	117	23	1,613
Green sturgeon	0	24	36	96	43	1	0	200

13.1.4 Monitoring and Research Studies Associated with Project Operations and Facilities

The adaptive management process described in the Proposed Action, is based on the continuation of monitoring programs both upstream and in the Delta. The information obtained from these programs is used in making real time decisions regarding project operations. Incidental take for these monitoring programs can be quantified and has been previously authorized under individual section 10 permits, but presented here as they are interdependent with CVP/SWP operations. Upstream monitoring consists of fish ladder counts at RBDD; carcass surveys; redd counts; and juvenile monitoring on Clear Creek, Sacramento River (RBDD trapping, Knights Landing, Sacramento Trawl), American River, and other tributaries. In the Delta, monitoring consists of Chipps Island Trawl, Tracy and Skinner Fish Collection Facilities (described later), and CCWD monitoring at Old River, Rock Slough and the new Victoria Canal diversions. On the San Joaquin River, juvenile monitoring will continue with trawling at Mossdale and in the Stanislaus River.

Fisheries studies that capture and collect juvenile CV steelhead in the Stanislaus River by screw traps will evaluate New Melones Reservoir operations on anadromous salmonids. Based on past sampling by screw traps at the Oakdale sampling site, up to 60 steelhead smolts and pre-smolts may be captured and released below the trapping site. Previous sampling experience with screw traps in the Stanislaus River indicates that all captured steelhead can be maintained in good physical condition and released unharmed back into the river.

Non-lethal take, and any associated incidental mortalities, associated with all monitoring required in this Opinion are covered through this ITS, including, but not limited to, implementation of the Steelhead Monitoring Program (*e.g.*, through fyke nets on the Sacramento River, rotary screw traps, weirs, and acoustic tagging studies), implementation of the CVPIA Tracy Fish Facility Program research studies, SWP CHTR studies, and creation of a new monitoring site located on the Sacramento River between RBDD and Knights Landing.

Additional take is associated with proposed monitoring and research studies linked with the movements and behavior of green sturgeon in the Sacramento River and Delta systems as part of the RPA for RBDD. Study designs require that up to 10 adult green sturgeon be captured annually for 3 years (30 fish) and tagged with internal acoustic transmitters. Each year, up to 6 adult green sturgeon will be retained for spawning purposes prior to tagging (2 females and 4 males), and then subsequently released back into the river. Furthermore, up to 100 juvenile wild green sturgeon will be captured and retained per year for 3 years (300 fish). The fish will be grown out to a size at which they can also be successfully tagged with acoustic transmitters and released back into the Sacramento River and Delta systems to monitor movements and behavior. Depending on the success of the captive hatchery produced juvenile green sturgeon population, wild fish will be replaced with captive stock as they become available. The above take is expected to be non-lethal. However, incidental mortalities resulting from the green sturgeon monitoring and research studies are covered in this ITS.

13.1.5 Operations in the Delta

In the Delta, incidental take in the form of death, injury, and harm to juvenile and adult winter-run, spring-run, CV steelhead, and southern DPS of green sturgeon is anticipated due to changes in the Delta hydrology created by the operation of the DCC gates and at Jones (CVP) and Harvey Banks (SWP) export pumping plants (Delta pumping plants). This take includes reduced survival of juvenile winter-run, spring-run, CV steelhead, and green sturgeon diverted through the DCC into the central Delta from: (1) elevated water temperatures and poorer water quality within the central Delta; (2) losses due to entrainment at unscreened water diversions within the central Delta; (3) predation associated with the waterways of the central and southern Delta; (4) reverse flow conditions as a result of CVP/SWP pumping; and (5) direct loss at the Delta pumping facilities within the southern Delta. In addition, delays and increased straying are expected when adult salmonids encounter the backside of the DCC gates in the closed position after moving upstream through the Mokelumne River system from the San Joaquin River system.

CV steelhead emigrating from the San Joaquin River basin will also face mortality, injury, and harm through greater diversion into the Old River, Turner Cut, and Columbia Cut due to the influence of the CVP/SWP export pumps. Negative flows in Old and Middle River will increase exposure time to higher water temperature, increased predation, increased contaminants, and direct losses at CVP/SWP export pumps. Incidental take through the collection, handling, trucking, and release of salvaged juveniles and adults at the Tracy and Skinner Fish Collection Facilities is expected to decrease as exports and negative OMR flows are reduced due this RPA and the USFWS' Opinion on delta smelt.

Incidental take at the unscreened Rock Slough diversion into Contra Costa Canal is expected to continue in the near-term (next 3 years), but at much lower levels than historically due to: (1) less volume of water diverted, (2) greater use of other screened facilities to compensate for Rock Slough diversions, and (3) construction activities associated with the enclosing the canal. In the long-term take is expected to be non-existent due to canal encasement and construction of a new fish screen at the Rock Slough Headworks (Reclamation 2009).

Operation of the DCC gates and Delta pumping plants are expected to cause mortality of winter-run, spring-run, green sturgeon, and CV steelhead emigrating from the Sacramento River basin through entrainment into the central Delta where survival rates are expected to be demonstrably reduced compared to the mainstem Sacramento River and northern Delta channels. In most years these losses will be minimized by intermittent DCC gate closures from October through January and mandatory closures from February 1 to May 20 (SWRCB, D-1641). Current mortality of winter-run, spring-run and CV steelhead juveniles that are diverted into the central Delta ranges from 33 to 95 percent (Brandes and McLain 2001, USFWS 2001-2004) depending on a variety of factors. These mortalities are generally attributed to increased residence time, a longer migration route, reverse flows, altered salinity gradient, predation, elevated water temperatures, contaminants, and reduced food supply (CDFG 1998; McEwan 2001, Vogel 2004) with an estimated reduction of the population entering the Delta from the upper Sacramento River basin of 5 to 20 percent due to the losses in the Delta interior. While losses at the CVP and SWP Delta pumping facilities can generally be quantified through observations of salvaged fish at the Tracy and Skinner Fish collection facilities, the difference in through-Delta mortality as a result of proposed operation of the Delta pumping plants is difficult to detect and quantify because dead or injured juvenile fish cannot be readily observed or accounted for. Overall, implementation of the RPA actions are expected to reduce the level of mortality at the export pumps (*i.e.,* through DCC gate closures, OMR flow restrictions, new flow criteria for the San Joaquin River, and implementation of the actions in the USFWS' 2008 biological opinion to protect Delta smelt.

13.1.6 Quantification of Incidental Take at the CVP and SWP Delta Pumping Facilities

Loss of winter-run, spring-run and CV steelhead juveniles is monitored at the CVP and SWP Delta pumping facilities utilizing different methods, as provided below.

Expanded losses based on salvaged fish are quantified in table 13-6. These numbers are difficult to assess due to the difficulty in determining the race of the salvaged salmonids, which is determined based on the size of the fish at date of capture from look-up tables. There is significant overlap in the size criteria, especially between spring-run and fall-run.

Table 13-6. Combined CVP/SWP salvage and loss by ESA-lised species, hatchery and wild fish combined from 1993-2009 (source: CDFG database).

Year	Steelhead Salvage	Steelhead Loss[a]	Spring-run Loss[b,c]	Winter-run Loss[c]	Green Sturgeon Salvage	Green Sturgeon Loss[d]
1993	16,972			1,922		
1994	1,361			1,004		
1995	2,437		38,581	1,351	125	166
1996	5,380		33,466	7,611	108	144
1997	963		57,083	518	113	150
1998	1,008		28,259	2,886	112	149
1999	2,571		128,172	4,173	108	144
2000	9,272		98,801	8,307	21	28
2001	12,819	38,270	41,396	23,392	15	20
2002	3,590	9,435	14,581	10,048	84	112
2003	12,850	29,526	42,904	29,551	18	24
2004	9,773	22,852	11,575	26,591	0	0
2005	3,597	6,960	30,927	5,337	16	21
2006	3,797	11,654	13,633	3,853	204	271
2007	5,635	9,070	5,257	5,332	185	246
2008	3,831	9,529	12,005	6,901	8	11
2009[e]	1,312	3,098	6,916	1,461	0	0
total	97,168	140,394	563,556	140,238	1,117	1,485
average	5,715	15,599	37,570	8,249	74	106

[a] Steelhead loss expansion based on Chinook salmon loss rates for CVP and SWP (Clark 2009),

[b] Spring-run loss represents only those fish identified by length-at-size, unknown how many spring-run are actually salvaged.

[c] Winter-run and spring-run losses include ad-clipped fish

[d] Green sturgeon loss assumes 95 percent louver efficiency (Kynard and Horgan 2001) with cleaning loss applied (*i.e.*, salvage (1/.75) = time louvers are lifted out of water. Cleaning time varies from 4 hrs/day to 12 hrs/day, depending on debris load, averaged to 6 hrs/day or 25% of time

[e] 2009 salvage numbers are preliminary as of 5/04/09

The losses in table 13-3 do not include losses at the Tracy Fish Facility when the louvers are raised for cleaning, nor does it include predation losses at the release site.

13.1.6.1 Juvenile Winter-Run

In an effort to better identify juvenile Chinook salmon, DWR has conducted genetic studies for several years at the CVP and SWP fish facilities. Although preliminary, these studies have shown roughly 50 percent of those fish identified by size as winter-run are genetically winter-run (Sheila Greene, pers. comm. 2008). Based on the actions provided in the RPA to minimize direct and indirect losses, combined incidental take of juvenile winter-run will not exceed 2 percent (based on size criteria described above, which is actually approximately 1 percent genetically determined winter-run) of the estimated JPE between the CVP and SWP pumping plants.

13.1.6.2 Juvenile Spring-Run

Similar to winter-run, genetic studies have been conducted on spring-run (based on the size of the fish at date of capture from look-up tables) at the CVP and SWP fish facilities to determine its genetic race. Although preliminary, these studies have shown that less than 50 percent of those fish identified by size as winter-run are genetically winter-run (most were genetically fall-run). However, for Chinook salmon, the losses are probably overestimated due to the inability to identify individuals to race (*e.g.*, most Chinook salmon reported to be within the spring-run size category are actually fall-run).

Incidental take of yearling spring-run is based on observations of CWT late fall-run uniquely marked at Coleman National Fish Hatchery and released in the upper Sacramento Basin as spring-run surrogates. These uniquely marked late fall-run are expected to serve as appropriate surrogates for spring-run because they would be released to begin their emigration and smoltification passage through the Delta at approximately the same time and size as wild spring-run. Spring-run surrogate release groups will be identified by NMFS, in consultation with USFWS and CDFG. Since the surrogates would experience the same conditions in the Sacramento River, NMFS anticipates that they will be entrained at the export facilities at comparable rates to the wild fish. Using marked late fall-run as surrogates, incidental take of spring-run is not expected to exceed 1 percent. Take will be calculated with the standard loss estimation procedures applicable at the respective fish collection facilities.

Due to expanded monitoring efforts in the upstream tributaries, wild spring-run juveniles are being tagged with CWTs as they migrate downstream to the Sacramento River. In 2003, there were 97,529 tagged in Butte Creek and 36,415 tagged in the Yuba River (CDFG 2004b). Since it is standard practice at the Delta Fish Collection Facilities to kill all Chinook salmon that are CWT tagged for identification purposes, a certain amount of lethal take is expected for these wild spring-run. In the 2002-2003 Sacramento River winter-run Chinook Incidental Take Report (DWR 2004), no wild spring-run were reported at the Delta fish collection facilities, however six tags were recovered from the USFWS Sacramento trawl and Chipps Island trawl studies in April and May. NMFS expects that in April and May a small number of tagged wild spring-run will be entrained and therefore killed during the sampling process (*i.e.*, 10 minute counts) at the Delta Fish Collection Facilities.

13.1.6.3 Juvenile Steelhead

Although estimates of steelhead abundance exist (*e.g.*, figures 4-4 and 5-12), NMFS is not aware of any DPS-wide estimate of CV steelhead abundance in order to determine an appropriate level of incidental take. Therefore, until population estimates can be made that are representative of the DPS, the incidental take will be based on the historical salvage.

Incidental take of steelhead is based on yearly observations of unmarked steelhead at the CVP's Tracy and SWP's Skinner fish collection facilities during the period of October 1 through September 30. Until a suitable JPE is developed, the combined cumulative salvage of unmarked juvenile and adult CV steelhead at the CVP and SWP Delta pumping facilities is not expected to exceed 3,000 unmarked juvenile and adult CV steelhead. Generally, these fish are returned alive to the Delta waters through the collection, trucking and release program at the CVP and SWP pumping facilities.

Given the current status of CV steelhead in the Southern Sierra Nevada Diversity Group, and that at the export facilities, the origin of steelhead cannot be determined, incidental take of CV steelhead will be revisited under term and condition 13.4.2(a) and again following results of the acoustic tagging studies pursuant to RPA Action IV.2.2.

13.1.6.4 Green Sturgeon

There is no known population estimate for green sturgeon in order to determine an appropriate level of incidental take. Therefore, until a population estimate can be made, the incidental take will be based on the historical salvage. Green sturgeon salvage and loss is highly variable, but is not expected to exceed the 10-year historical average of 74 and 106 juveniles, respectively, per year. As the Proposed Action is implemented in the future, the green sturgeon population is expected to increase to varying degrees, resulting in an increase in incidental take. Therefore, incidental take should be reassessed at every NMFS status review (*i.e.*, every 5 years) and adjusted as new information becomes available.

13.1.7 Fish Facilities Studies

Incidental take associated with Fish Facilities studies and evaluations are conducted with the objective of improving the fish salvage process (table 13-5). These studies include incidental take that occurs above and beyond the normal salvage operations due to additional handing and stress associated with such actions as gill netting, electro-shocking, and seining within or around the facility. No direct mortality was reported in 2008, however, the estimated non-lethal take based on salvage data and run timing was 232 winter-run, 6,679 spring-run, 791 steelhead, and 11 green sturgeon (table 13-7). Studies are also conducted on fish collection, trucking, and handling at the Skinner Fish Facility. The added stress of these studies on fish could potentially disrupt feeding, reduce the health, and impair the smoltification process.

Table 13-7. Estimated incidental take associated with studies conducted at the Tracy Fish Facility based on historical salvage data from 1998-2002.

Estimated incidental take from Tracy Fish Facility Studies 2008- 2010								
Proposed Studies	**Winter-run**		**Spring-run**		**Steelhead****		**Green**	**Sturgeon**
	Non-lethal	Lethal	Non-lethal	Lethal	Non-lethal	Lethal	Non-lethal	Lethal
Abandoned Intake Channel	0	0	0	0	0	0	0	1
CO2 Predator Removal	16	1	38	1	25	1	1	1
Fish Holding	18	0	0	0	6	0	1	0
Holding Tank Screen	2	0	268	0	6	0	2	0
Debris Study	0	1	2	1	0	1	1	1
New Secondary System (lab)	0	0	0	0	0	0	0	0
Predator Numbers	12	60	29	60	19	60	0	0

Above Ground Tank	5	0	4	0	3	0	1	0
Crab Screen Study	36	0	445	0	118	0	1	0
Full Facility Evaluation	71	0	2888	0	161	0	1	0
Holding Tank Swirl Test	71	0	2895	0	132	0	1	0
Louver Cleaning Test	0	1	0	1	2	1	1	1
Predator Impacts for VAMP	1	0	110	0	319	24	1	0
Total by species*	232	**63**	6679	**63**	791	**87**	11	**4**
*2008 actual mortality reported = 0 **steelhead includes hatchery+ wild								

13.1.8 CCWD Diversion

From 1994 to 1996, CDFG estimated expanded juvenile losses (*i.e*., entrainment losses plus losses due to predation) of 257 winter-run, 2,215 spring-run, and 738 steelhead. Since NMFS' 2004 CVP/SWP operations Opinion was issued, CCWD initiated several improvements that reduce the entrainment at the Rock Slough diversion. These include: (1) the Canal Encasement Project currently under construction; (2) the Alternative Intake Project scheduled to be completed in the summer of 2010; (3) reduced diversions at Rock Slough, since Old River Intake became operational in 1998; and (4) a Water Use Efficiency Program. The Canal Encasement Project will eliminate tidal flows into the unscreened canal, significantly reducing entrainment, predation, and improving the feasibility of screening the Rock Slough intake. In addition, due to other agreements with CDFG, SWRCB, and USFWS, the CCWD must cease diversions for 30 days in April in order to protect larval delta smelt that can become entrained in the fish screen. These operating criteria minimize contact between juvenile salmonids and their food supply, and the fish screen, in the spring. Direct losses due to entrainment are not expected to exceed 5 winter-run juveniles, 10 spring-run juveniles, and 10 steelhead annually based on the last 10 years of monitoring behind the Pumping Plant and Headworks (table 13-8). This incidental take does not account for extrapolated losses due to predation in the Contra Costa Canal and losses through the pumping plant.

Under CVPIA section 3406(b)(5), Reclamation is required to construct a fish screen at CCWD's Rock Slough intake. The USFWS granted Reclamation an extension on fish screen construction until December 2008. On March 26, 2009, Reclamation again requested a 10-year extension of the construction completion date until 2018 and amendment of the Los Vaqueros Biological Opinion (letter from Carl Dealy, Reclamation, to Susan Moore, USFWS). If, and when, a fish screen is eventually built on Rock Slough, incidental take is not expected to occur. At such time as a fish screen on Rock Slough becomes operational, the authorized incidental take in this ITS will no longer apply.

Table 13-8. Summary of ESA listed fish captured at the Rock Slough Headworks and Pumping Plant #1 and water diverted from 1998-2008 (Source CVP/SWP operations BA table 13-30).

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	totals

Winter	1	0	0	0	0	0	0	0	0	0	0	1
Spring	0	0	0	0	0	0	6	4	4	0	0	14
Fall/LF	0	0	3	0	0	0	7	10	1	0	0	21
Steelhead (Ad-clip)	0	0	0	0	0	0	0	0	0	0	8	8
Steelhead (no-clip)	0	0	0	0	0	0	0	3	2	1	0	6
Steelhead unknown	0	0	0	0	0	0	0	1	0	0	0	1
Green Sturgeon	0	0	0	0	0	0	0	0	0	0	0	0
Water diverted in TAF	68	43	51	27	36	27	31	35	43	39	6	408

13.1.9 Implementation of Sacramento River Basin Salmonid Rearing Habitat Improvements (*i.e.*, RPA Action Suite I.6)

Rearing habitat improvement projects described in the RPA could be implemented in the mainstem Sacramento River and in any part of the tributary subbasins (*e.g.*, Feather River, American River, San Joaquin River, and Clear Creek). Some habitat projects will have negative effects during construction (*e.g.*, increased turbidity, sediments, short-term and temporary disturbances, and contamination from machinery). These are expected to be minor, occur only at the project scale, and persist for a short time. The inundation of the Yolo Bypass is expected to cause incidental take from these short-term adverse effects, and from predation within the project area from non-native introduced fish species.

Take of listed salmonids resulting from rearing habitat improvement projects developed to implement this RPA and authorized, funded, or carried out by Reclamation and DWR that are consistent in type, design, and implementation to those covered by the ESA Section 7 Formal Programmatic Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Implementation of the CVPIA and CALFED CY 2003-2010, falls within the take provisions of that Biological Opinion (NMFS 2003). Take resulting from projects that fall outside of the explicit criteria in the CVPIA or CALFED Opinions will require separate and subsequent consultation.

13.1.10 Operation of the Nimbus Fish Hatchery Steelhead Program

The RPA requires actions to ensure that the Nimbus Fish Hatchery Steelhead Program does not reduce the viability of the listed steelhead residing in the lower American River (*i.e.*, below Nimbus Dam). NMFS considers fish that are the offspring of hatchery and wild, or hatchery fish that spawn in-river, to be natural, non-hatchery fish. Thus, the juveniles that result from hatchery fish spawning in-river would be protected under the ESA (*e.g.*, progeny of hatchery spring-run that spawn in the Feather River, or progeny of hatchery-reared steelhead that spawn in the American River would be considered listed under the ESA). Incidental take associated with the Nimbus Fish Hatchery Steelhead Program is covered through this ITS for an interim period of 2 years from issuance of this Opinion, with the expectation that a Nimbus Fish Hatchery HGMP will be completed at that time and subsequent take will be authorized through the 4(d) process.

Nimbus Fish Hatchery annually handles wild steelhead that return with hatchery steelhead up the fish ladder. Current hatchery protocol is to release all unclipped steelhead back to the river to spawn. These fish undergo some handling stress and disorientation in the process. Adults may be delayed from spawning by 1 to 2 days, or may drop back downstream from the stress of handling. Additional stress will result from those fish that encounter the hatchery barrier weir and are blocked from migrating further upstream to spawn. These fish may become injured while trying to pass through the weir and drop back downstream. Steelhead and salmon have been observed to drop back downstream after entering fish ladders and encountering barrier weirs at RBDD and Iron Gate Hatchery on the Klamath River. It is likely that steelhead that drop back downstream on the American River will either spawn later in time or stray into other rivers to spawn.

Based on the historical rate of steelhead that enter the Nimbus Fish Hatchery (table 13-9), NMFS anticipates that less than 150 wild steelhead will enter the Nimbus Fish Hatchery annually. The number of unmarked steelhead that encounter the Nimbus Fish Hatchery represents a significant (*i.e*., 30 to 50 percent) portion of the in-river spawning population below Nimbus Dam. The average in-river population is 300 adult spawners based on redd counts from 2002 through 2007 (Hannon and Deason 2007).

Table 13-9. Steelhead adult returns to Nimbus Fish Hatchery (source: CVP/SWP operations BA)

Year	total return (hatchery + wild)	Number unclipped (wild)	Percent unclipped
2001	2,877	50	1.7
2002	1,253	69	5.5
2003	873	27	3.1
2004	1,741	17	1.0
2005	2,772	118	4.3
2007	2,673	116	4.3

An unquantifiable amount of take is also anticipated as a result of the interrelated and interdependent effects of Nimbus Fish Hatchery operations. These effects primarily stem from straying, competition for space, and hybridization between wild fish and hatchery-produced salmon and steelhead. A recent report examining the decline of the Sacramento River fall-run found that hatcheries have reduced the variation and diversity of the overall abundance of Chinook salmon in the Central Valley, leaving them unsuited to handle varying changes in ocean conditions (Lindley *et al*. 2009). Remnant populations of spring-run and winter-run were found better suited to cope with recent changes in ocean conditions because of life-history diversity that can buffer environmental changes (*e.g*., spawning in summer, or at higher elevations leads to delayed ocean entry at a larger size than fall-run) that confers survival advantages upon entry into the ocean environment.

13.1.11 Fish Passage Program

RPA Action V, NF4, requires the implementation of a Pilot Reintroduction Program, in January 2013. As there is currently only one population of winter-run, non-lethal take will be exempted for the number of adult winter-run determined by the Interagency Fish Passage Steering Committee, pursuant to Action V, NF3, #1 and 3, as necessary, for the pilot program, provided that NMFS concurs in writing with the specific handling procedures associated with the Fish Passage Pilot Plan. NMFS does not anticipate any pre-spawn mortality associated with the pilot program. However, any incidental mortality associated with the pilot program is covered.

Incidental take through this ITS is not covering spring-run above Shasta Dam on the Sacramento River, CV steelhead above Folsom Dam on the American River, or CV steelhead above New Melones Dam on the Stanislaus River. The Interagency Fish Passage Steering Committee shall convene and determine the best source population of spring-run and steelhead to utilize for each of the rivers in this pilot reintroduction program. Once this is established, Reclamation shall apply for an ESA section 10(a)(1)(A) research permit to cover the activities.

In addition, NMFS is not approving any incidental take coverage for the long-term fish passage actions.

13.2 Effect of the Take

In the accompanying formal biological opinion, NMFS has determined that the anticipated level of incidental take associate with project operations, as modified by the RPA, is not likely to jeopardize the continued existence of winter-run, spring-run, CV steelhead, or Southern DPS of green sturgeon.

13.3 Reasonable and Prudent Measures

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon.

1. Reclamation and DWR shall monitor the extent of incidental take of winter-run, spring-run, green sturgeon, and CV steelhead, associated with the operation of the CVP's Jones and SWP's Harvey Banks pumping facilities.

2. Reclamation shall seek to develop an alternative technique to quantify incidental take of listed anadromous salmonid species at the Federal and State export facilities.

3. Reclamation shall minimize the adverse effects of flow fluctuations associated with CVP-controlled stream operations on listed anadromous fish species spawning, egg incubation, and fry and juvenile rearing.

4. Reclamation and DWR shall monitoring all incidental take associated with CVP and SWP operations.

5. Reclamation and DWR shall annually report to NMFS the incidental take resulting from the implementation of the Proposed Action.

13.4 Terms and Conditions

Reclamation and DWR must comply or ensure compliance by their contractor(s) with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. Reclamation and DWR shall monitor the extent of incidental take of winter-run, spring-run, green sturgeon, and CV steelhead, associated with the operation of the CVP's Jones and SWP's Harvey Banks pumping facilities.

    a. Reclamation and DWR shall calculate winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon loss at the Jones and Banks pumping plants on a real-time basis from October 1 through June 30 each year. Loss and salvage shall be computed using formulas developed in consultation with CDFG and USFWS and approved by NMFS.

    b. Reclamation and DWR shall monitor the loss of juvenile winter-run at the CVP and SWP Delta pumping facilities and will use that information to determine whether the anticipated level of loss is likely to exceed the authorized level of 2 percent, cumulatively, of the estimated number of juvenile winter-run entering the Delta annually.

    c. Reclamation and DWR shall monitor the loss of identified spring-run surrogate release groups at the CVP and SWP Delta pumping facilities and use that information to determine whether the cumulative estimated level of loss is expected to exceed 1%.

    d. Reclamation and DWR shall monitor the salvage of CV steelhead at the CVP and SWP Delta pumping facilities and use that information to determine whether the cumulative estimated level of salvage is expected to exceed 3,000 unclipped steelhead (juveniles and adults combined) at the CVP and SWP Delta pumping facilities. Incidental take of CV steelhead shall be reported as salvage and calculated loss.

    e. Reclamation and DWR shall monitor the loss of juvenile green sturgeon at the CVP and SWP Delta pumping facilities and use that information to determine whether the cumulative estimated level of loss is expected to exceed 110 juveniles annually (previous 10-year average).

    f. If the estimated rate of loss approaches the incidental take level anticipated for any of the anadromous fish species at the SWP Harvey Banks pumping facility combined with the estimated take at the CVP Jones pumping facility is exceeded, Reclamation and DWR shall immediately convene the WOMT to explore additional measures which can be

g. DWR shall collect additional data at the Clifton Court Forebay, the John Skinner Fish Collection Facility, and the Harvey Banks pumping plant to monitor the incidental take of winter-run, spring-run, steelhead, and green sturgeon and to develop and implement improvements to pumping facility operations to further reduce or minimize losses of listed salmonids.

h. DNA tissue samples and CWT samples from juvenile winter-run, spring-run, and steelhead at the Tracy and Skinner fish collection facilities shall be collected by DWR or CDFG for genetic analysis or tag removal/reading pursuant to the sampling protocols established by the IEP Salmon Genetics Project Work Team. Tissues shall be stored at the CDFG tissue bank at Rancho Cordova for subsequent analysis by Oregon State University or similar lab approved by NMFS. Whole fish or heads for CWT processing and identification shall be stored at the USFWS Bay/Delta Office in Stockton. All samples shall be clearly marked according to office protocol and a log maintained at each storage facility.

b. Reclamation and DWR shall submit weekly reports to the interagency DAT and an annual written report to NMFS describing, as a minimum, the estimated salvage and loss of winter-run, spring-run, steelhead, and green sturgeon associated with operations of the Jones and Harvey Banks pumping facilities, respectively.

2. Reclamation shall seek to develop an alternative technique to quantify incidental take of listed anadromous salmonid species at the Federal and State export facilities.

a. In coordination with NMFS, Reclamation shall select and fund an independent contractor to determine the best technique to quantify incidental take of winter-run, spring-run, CV steelhead, and the Southern DPS of green sturgeon at the Federal and State export facilities. Reclamation shall submit a final report to NMFS by December 31, 2010, summarizing the recommendations for quantifying incidental take, with the selection of a proposed technique. The technique for quantifying take shall be implemented immediately upon NMFS' concurrence. In the event that this measure is not implemented immediately and reflected in the annual report per term and condition 3.a. below, take authorization for CV steelhead shall cease on December 31, 2011. Incidental take, especially for CV steelhead, but for the other listed anadromous fish species as well, may be adjusted based on the application of the new technique to quantify incidental take at the Federal and State export facilities.

3. Reclamation shall minimize the adverse effects of flow fluctuations associated with CVP-controlled stream operations on listed anadromous fish species spawning, egg incubation, and fry and juvenile rearing.

a. Reclamation shall schedule maximum ramping down rates of non-Glory Hole (*i.e*., non-flood control) releases from Whiskeytown Reservoir according to the table, below (estimated at RM 3.03). Ramping rates for releases greater than 300 cfs shall be made after consultation with the Clear Creek Technical Team, considering: time of year, time of day, timing the change to occur with natural changes in-flow and/or turbidity, size of fish present in the creek, species and protected status of vulnerable fish, the amount of water required, and relative costs or benefits of proposed flow. Reclamation shall time flow decreases so that the most juvenile Chinook salmon and steelhead experience the stage decrease during darkness. Maximum ramping rate of flow releases from Whiskeytown Dam into Clear Creek shall be accomplished based on the following targets within the precision of the outlet works or the City of Redding powerplant equipment.

Discharge	**Ramping Rate**
600-330 cfs	16 cfs / hour
330-105 cfs	15 cfs / hour
105-50 cfs	14 cfs / hour

b. During periods outside of flood control operations and to the extent controllable during flood control operations, Reclamation shall ramp down releases in the American River below Nimbus Dam as follows:

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

c. During periods outside of flood control operations and to the extent controllable during flood control operations, Reclamation shall ramp releases in the Stanislaus River below Goodwin Dam as follows:

Existing Release Level (cfs)	Rate of Increase (cfs)	Rate of Decrease (cfs)

at or above 4,500	500 per 4 hours	500 per 4 hours
2,000 to 4,499	500 per 2 hours	500 per 4 hours
500 to 1,999	250 per 2 hours	200 per 4 hours
300 to 499	100 per 2 hours	100 per 4 hours

4. Reclamation and DWR shall monitor all incidental take associated with CVP and SWP operations.

   a. Reclamation shall implement all aspects of RPA section 11.2.1.3

5. Reclamation and DWR shall annually report to NMFS the incidental take resulting from the implementation of the Proposed Action.

   a. Reclamation and DWR shall provide an annual written report to NMFS no later than October 1 of each year. This report shall provide the data gathered and summarize the results of winter-run, spring-run, CV steelhead, and green sturgeon monitoring and incidental take associated with the CVP and SWP operations. All mortalities must be minimized and reported, including those from special studies conducted during salvage operations.

   b. Reclamation and DWR shall provide reports and updates to NMFS by the specified dates, as provided in various RPA actions (*e.g.*, section 11.2.1.3 #3, Action I.1.3, Action Suite I.2).

   c. Unless otherwise specified during the implementation of these terms and conditions, all reports and updates shall be sent to:

      Supervisor
      Sacramento Area Office
      National Marine Fisheries Service
      650 Capitol Mall, Suite 8-300
      Sacramento California 95814-4706
      FAX: (916) 930-3629
      Phone: (916) 930-3600

14.0 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. NMFS thinks the following conservation recommendations are consistent with these obligations, and therefore, should be implemented by Reclamation:

1. In proposing the SRWRP for a future section 7 consultation, Reclamation should first ensure that Shasta Reservoir storage and cold water pool requirements are met, as provided in RPA Action I.2.2, and that all construction-related and operational impacts of the SRWRP, both upstream and in the Delta, are analyzed in consideration of the operations and effects on listed species and critical habitats of the CVP and SWP that were analyzed in this consultation.

2. Reclamation and DWR should continue to work with the BDCP process to develop a scientifically-based, alternative conveyance program for the Delta that conserves all ESA-listed anadromous fish species in the Central Valley. This effort should evaluate a new point of diversion in the Sacramento River without adding new stressors to listed fish and their critical habitats. If NMFS determines that locations and operations are available which minimize adverse effects to all listed species and designated critical habitats, then Reclamation and DWR should pursue alternative locations and operations for Delta diversions.

3. Reclamation should continue to fund CALFED ERP restoration actions, consistent with previous commitment and funding levels, and to fulfill CALFED ROD commitments. DWR should support continued state funding to CDFG to further implementation of the CALFED ERP.

4. Reclamation should conduct studies to determine the economic feasibility and extent of biological benefits to listed species and critical habitats of completely removing the RBDD from the Sacramento River.

5. DWR should continue to fund the Amended Delta Fish Agreement (Amendment) to mitigate, compensate for, and enhance habitat for anadromous salmonids in the Central Valley. Past actions under this agreement have improved upstream habitats and conditions for spring-run, fall-run, and steelhead and have contributed to the current status of the species. Ongoing actions identified in the Amendment should be continued, if the benefits of past actions are to be maintained. NMFS expects that this Amendment will also support implementation of actions specified in this RPA, such as re-introduction of winter-run to Battle Creek and habitat improvements at the Yolo Bypass, Liberty Island and other areas.

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