Endangered Species Act
Section 7 Consultation

DRAFT BIOLOGICAL OPINION

On the

LONG-TERM CENTRAL VALLEY PROJECT AND STATE WATER PROJECT OPERATIONS CRITERIA AND PLAN

National Marine Fisheries Service
Southwest Region

December 11, 2008

TABLE OF CONTENTS

List of Tables

List of Figures

DRAFT BIOLOGICAL OPINION

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

ACTIVITY: Long-Term Operations Criteria and Plan for the Central Valley Project and State Water Project

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1.0 BACKGROUND AND CONSULTATION HISTORY

1.1 Purpose

The purpose of this draft biological opinion (Opinion) is to determine, based on the best scientific and commercial information available, whether the Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP, hereafter referred to as the proposed action), as proposed by the Bureau of Reclamation (Reclamation), is likely to jeopardize the continued existence of the following species:

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

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 Department of Water Resources (DWR), and a multitude of pumps and 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 NOAA's National Marine Fisheries Service's (NMFS) winter-run Opinion on the proposed action.

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.

1.4 Consultation History

On October 22, 2004, NMFS issued its Opinion on the proposed long term CVP and SWP OCAP (NMFS 2004, hereafter referred to as 2004 OCAP 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 OCAP based on new 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 initiation package.

- Biweekly interagency OCAP 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 OCAP 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 OCAP BA, and in particular, the draft project description; and
- An April 22, 2008, species list.

On May 19, 2008, NMFS received Reclamation's May 16, 2008, request to initiate formal consultation on OCAP. 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 an initiation 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 initiate formal consultation. NMFS described additional information necessary to initiate consultation. In addition, on July 17, 2008, NMFS offered additional comments on the OCAP 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 initiation 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 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 OCAP 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 initiate formal consultation. In its October 1, 2008, letter, Reclamation also committed to providing, by mid-October 2008: responses to comments and initiating 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. On November 21, 2008, NMFS issued a letter to Reclamation, indicating that Reclamation had provided sufficient information to initiate formal consultation on the effects of OCAP, 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 1.5.7, below).

This document is NMFS' draft 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. The final version of this draft Opinion will supersede the 2004 OCAP Opinion. This draft Opinion is based on (1) the initiation package provided by Reclamation, including the OCAP 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 Chinook salmon; (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 draft Opinion analyzes the effects of the proposed action, including the Trinity Division, on listed Central Valley anadromous fish species and Southern Residents. NMFS, with agreement from Reclamation, will analyze the effects of the Trinity River Division portion of the proposed action on SONCC coho salmon in the subsequent biological opinion.

1.5.2 ESA Consultation on Central Valley Hatcheries

CVP and SWP hatcheries within the Central Valley include the Livingston Stone National Fish Hatchery, Coleman National Fish Hatchery, Feather River Hatchery, Nimbus Fish Hatchery, and Trinity River Hatchery. The USFWS, which manages the Livingston Stone and Coleman National Fish Hatcheries, has requested a separate ESA section 7 consultation on those hatcheries. Therefore, the Livingston Stone and Coleman National Fish Hatcheries are not considered in this consultation. The Feather River Fish Hatchery 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 Feather River Hatchery). Therefore, the Feather River Hatchery is not considered in this consultation.

The Trinity River Hatchery is part of the Trinity River Division of OCAP. Consistent with how NMFS will address the effects of the Trinity River Division (see section 1.5.1, above), NMFS will defer the consideration of effects from Trinity River Hatchery, as it pertains to any effects on SONCC coho salmon, to the reinitiation of the TRMFR Program formal consultation and NMFS' October 12, 2000, Opinion. However, fall-run production from Trinity River Hatchery will be considered in the analysis of effects on Southern Residents.

In summary, of the CVP and SWP hatcheries, the operation of Nimbus Fish Hatchery, and the production of fall-run from Trinity River Hatchery, will be analyzed in this consultation.

1.5.3 ESA Consultation Linkage to the Operation of Oroville Dam

The Oroville Project (Oroville Dam and related facilities, including the Feather River Fish Hatchery) is part of the SWP. However, because the hydroelectric facility is not Federal, DWR has been operating the Oroville Project under a FERC license. The Oroville Project is currently undergoing relicensing with FERC. The FERC license expired in January 2007, and until a new license is issued, DWR will operate to the existing FERC license. FERC is currently in consultation with NMFS regarding the effects of relicensing the Oroville Project. Because the effects of the Oroville Project are considered in the ongoing FERC consultation, operation of Oroville Dam is not considered in this consultation.

1.5.4 Inspector General's Report for the 2004 OCAP Opinion

On October 8, 2004, the inspectors general of the departments of Interior and Commerce received a letter from 19 members of the U.S. House of Representatives, requesting a review of allegations that Interior's Bureau of 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)." On July 8, 2005, Johnnie E. Frazier (Office of Audits, Seattle Regional Office) issued Final Audit Report No. STL-17242-5-001 to NMFS. The objectives of the audit were to (1) identify the review process used to issue the 2004 OCAP Opinion on Reclamation's CVP and DWR's SWP, and (2) determine whether NMFS – in developing the 2004 OCAP Opinion – followed the consultation process for issuing biological opinions that is defined by its policies, procedures, and normal practices. The Inspector General's recommendations have been incorporated into the current formal consultation on Reclamation's long-term OCAP.

1.5.5 Independent Peer Reviews of the 2004 OCAP Opinion

In 2005, NMFS initiated peer reviews of its 2004 OCAP Opinion through the CALFED Bay-Delta Program (CALFED) and Center of Independent Experts (CIE). In general, the peer reviews' 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 OCAP Opinion. Many of the recommendations pertained to the Opinion. However, because NMFS utilized the modeling and results from the 2004 OCAP BA, many of the recommendations also pertained to the way the proposed action was analyzed in the 2004 OCAP BA. Pursuant to NMFS receiving the peer review reports, NMFS requested the NMFS-Southwest Fisheries Science Center (SWFSC) to evaluate the peer reviews. The NMFS-SWFSC issued a report to NMFS on May 25, 2006, concluding that the three peer reviews offered generally valid and helpful critiques of the science underlying the Opinion. The OCAP BA and this draft Opinion incorporated most of the peer review recommendations, as appropriate.

1.5.6 Peer Reviews throughout the Current Reinitiated OCAP Consultation

1.5.6.1 Temperature Management and Modeling Workshop

The peer reviews of the 2004 OCAP 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 OCAP BA and NMFS' Opinion. 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. 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, the Review Panel of subject matter experts 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 the Salmonid Recovery Plan temperature objectives (Deas *et al*. 2008). The OCAP BA and this draft Opinion considered the recommendations from Deas *et al*. (2008).

1.5.6.2 Peer Review of NMFS' 2008 Draft OCAP Opinion

NMFS sought to have a peer review of its 2008 draft OCAP Opinion through CALFED and the CIE. The CALFED review format involves convening of a Review 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 Review 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 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 this peer review is that CIE identifies a group of reviewers who will receive the materials for review. They conduct their review guided by Terms of Reference and questions provided by NMFS. The reviewers work independently, and after the specified review period, they provide individual review reports to CIE and NMFS.

The CALFED peer review of the draft OCAP Opinion occurred in two phases. The first phase was to evaluate and comment on NMFS analytical framework that would form the basis for this draft OCAP 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 peer review panel requested additional information from NMFS in order for it to provide meaningful feedback and recommendations to assist us in the development of the OCAP Opinion. Specifically, the peer review panel requested a copy of the OCAP BA, making it clear that their intention was not to peer review the OCAP BA, but to understand the information presented in the OCAP 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 OCAP Opinion were addressed in the current reinitiated OCAP consultation. After NMFS fulfilled the peer review panel's requests (at the time, the most recent draft of the OCAP 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 peer review panel's October 31, 2008, document, "Independent Review of the 2008 NMFS Analytical Framework for its OCAP Biological Opinion." Section 2.0, below, begins with a note to the peer reviewers regarding the recommendations from the independent review of the 2008 NMFS Analytical Framework.

The second phase of the CALFED peer review is the review of this draft OCAP Opinion. The purpose of this independent review is 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 OCAP Opinion. In addition, CIE is peer reviewing this draft OCAP Opinion. NMFS will consider all comments and recommendations received from the peer reviewers in its development of the final Opinion.

1.5.7 Litigation and Settlement

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 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 Opinion to December 15, 2008.

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 court-ordered interim remedies until the final OCAP Opinion is issued by March 2, 2009.

1.6 Term of the Opinion

This biological opinion is effective through December 31, 2030.

2.0 Analytical Approach

NOTE TO REVIEWERS: On October 31, 2008, the CALFED Science Review Panel delivered its *Independent Review of the 2008 NMFS Analytical Framework [AF] for its OCAP Biological Opinion*. In summary, the Panel noted:

> *The Panel strongly encourages the continued development of the AF into the next phase of implementation. We recommend: (a) clear documentation of the logic used in selecting which effects are potentially important and which are ultimately quantified, (b) further extension of the existing AF to relate individual effects to population responses and then to species risks, so the AF culminates in a table similar to Table 1 from Lindley et al. (2007), (c) more specific definition of baseline conditions and evaluation of the CALSIM-II simulated scenarios for their realism, (d) development of a bookkeeping method to keep track of the uncertainties and conservatism of assumptions (protective of the species) associated with the various steps in the analyses and how combining uncertainties and assumptions from the multiple individual steps might affect a final overall assessment of jeopardy or no jeopardy, and (e) some formatting and organization details to improve clarity.*

As a result of these recommendations, NMFS has made, and continues to develop, revisions to this Analytical Approach section. In general, the approach remains the same, but materials have been added or refined to address some of the comments provided by the Panel. Not all recommendations have been addressed as of this draft and several sub-sections are unfinished. We hope, however, that the following presentation has improved in clarity and overall logical presentation.

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 action.

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

- Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*);
- Central Valley spring-run Chinook salmon (*O. tshawytscha*);
- Central Valley steelhead (*O. mykiss*);
- Central California Coast steelhead (*O. mykiss*);
- Southern Oregon/Northern California Coast coho salmon (*O. tshawytscha*);
- Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*);
- Southern Resident killer whales (*Orcinus orca*)
- Designated critical habitats for listed salmonids; and
- Proposed critical habitat for Southern Distinct Population Segment 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 critical habitat analysis because the primary effects to the species and habitat are related to the physical, chemical, and biotic changes to the ecosystem caused by the proposed action. Our listed species analysis follows on the critical habitat analysis as we use the effects on habitat to determine effects on the listed species. 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 action. Finally, we discuss the presentation of all of these analyses within the biological 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 a reduction is expected or not, but not on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (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 "likelihood of viability" as an equal standard to bridge between the Viable Salmonid Populations framework (McElhany *et al.* 2000) and the jeopardy standard. A designation of a high risk of extinction or low likelihood of viability indicates that the species faces significant risks from internal and external processes that can drive a species 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-level scales.

"'Jeopardize the continued existence of' means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." (50 CFR 402.02). 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-manager's review draft of the Central Valley was issued, and comments received. A public review draft of the recovery plan is likely to be issued in 2009. Lindley *et al*. (2007) was relied on heavily 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 ensure that the proposed action does not "reduce appreciably the likelihood of survival and recovery…"

Destruction or Adverse Modification Standard. For critical habitat, NMFS does 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 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. Section 7 of the ESA and the implementing regulations (50 CFR 402), and associated guidance documents (*e.g.,* USFWS and NMFS 1998) require biological 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 effect 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 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.

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 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 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 to 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 apply a logic path for evaluating the effects of the action and follow a basic hierarchical organization of the elements and areas within a critical habitat designation. The reasoning and decision-making steps are outlined in table 2-1. Figure 2-2 contains the basic hierarchical organization of critical habitat.

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 2-3 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.

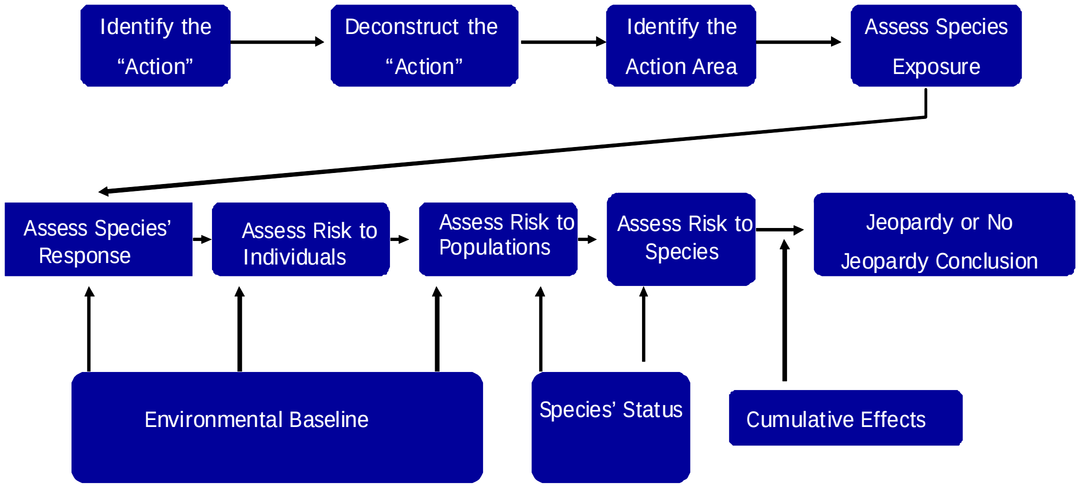


Figure 2-1. General Conceptual Model for Conducting Section 7 as Applied to Analyses for Listed Species.

Table 2-1. 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 one or more 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

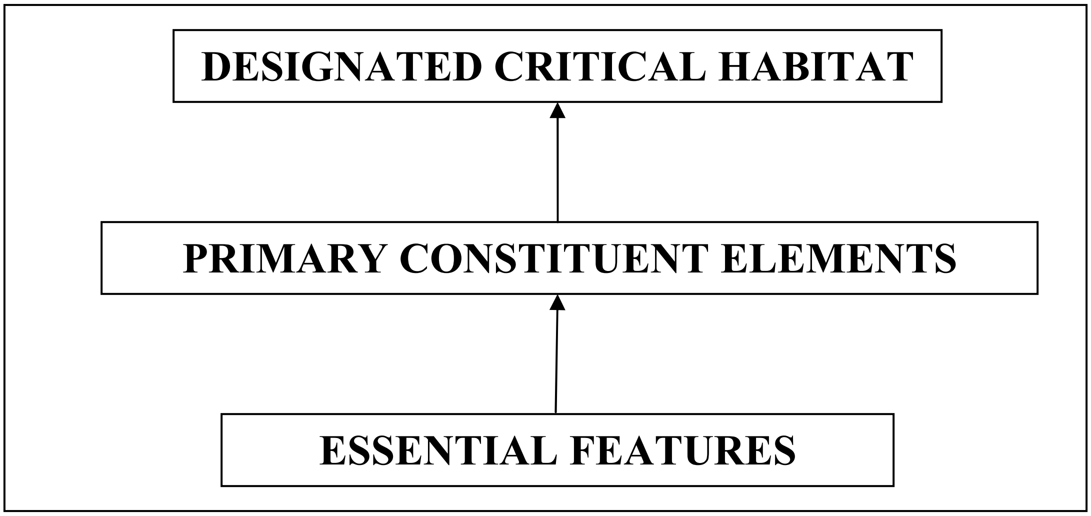


Figure 2-2. Conceptual model of the hierarchical structure that is used to organize the destruction or adverse modification assessment for critical habitat. This structure is sometimes collapsed for actions with very large action areas that encompass more than one specific area or feature.

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 2-3. General set of information collected to track proposed action effects and resulting exposure, response, and risk to elements of critical habitat.

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 PCE are conditions such as clean spawning gravels, appropriate timing and duration of certain water temperatures, and water quality free of pollutants.

Therefore, reductions in the quantity, quality, or availability of one or more essential feature 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 needs of the species (for example, juvenile survival is a limiting factor in recovery of the species and the habitat element supports juvenile survival).

In our assessment, we combine information about the contribution of constituent elements of critical habitat (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 constituent elements 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 2-4 illustrates the basic model of the critical habitat analysis following the hierarchical organization of critical habitat and the comparison between the reference condition of the conservation value of critical habitat and the conservation value of critical habitat with action implementation.

2.3.2 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 as those "species" have been listed, which can include 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).

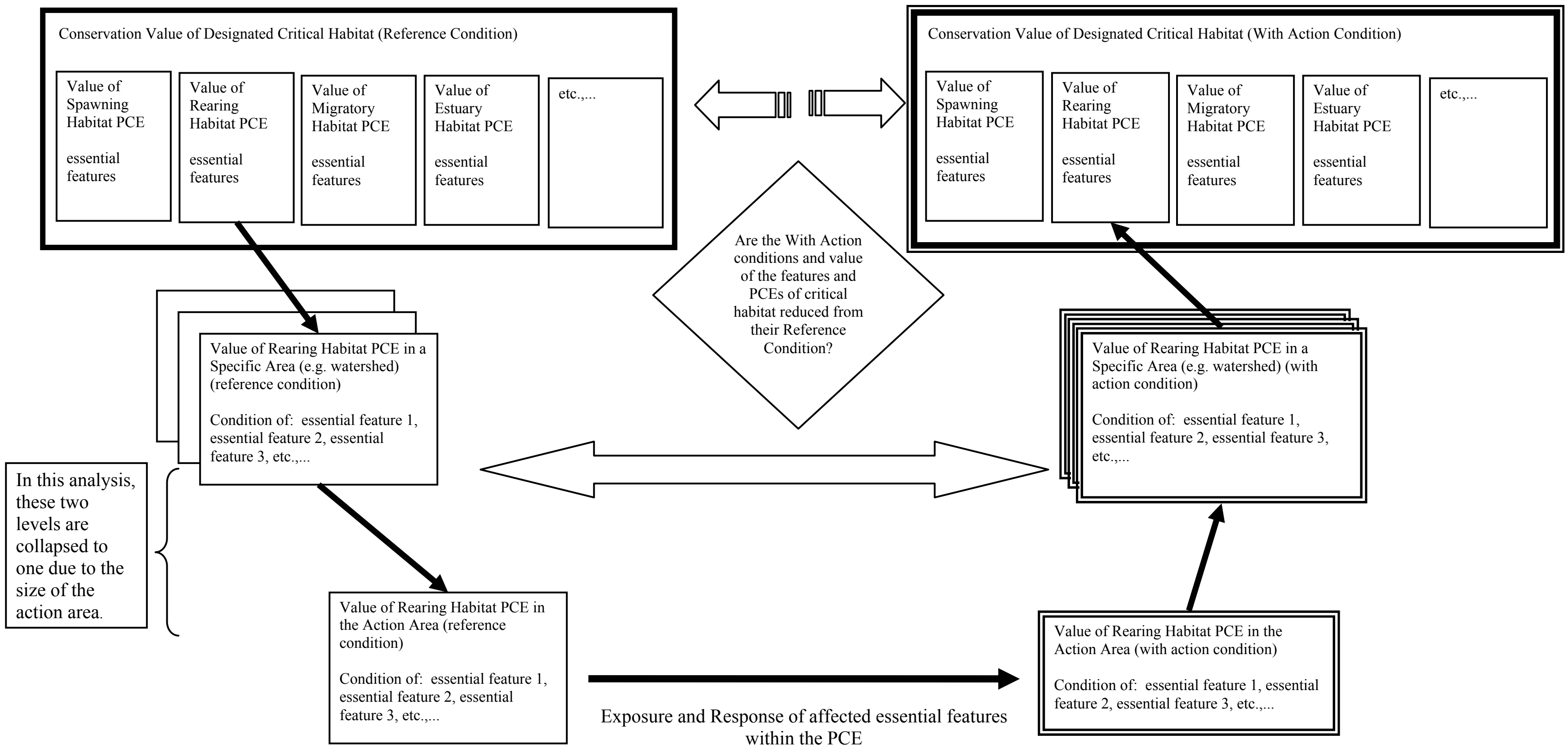


Figure 2-4. Conceptual diagram of the critical habitat analyses presented in this biological opinion. For illustration purposes, the Rearing Habitat PCE for listed salmonids is pulled out to show the basic flow of the analysis. Full analyses consider the effects to all PCEs and essential features of critical habitat.

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 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 individual, 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 life cycle of a Pacific salmonid is provided in figure 2-5.

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.

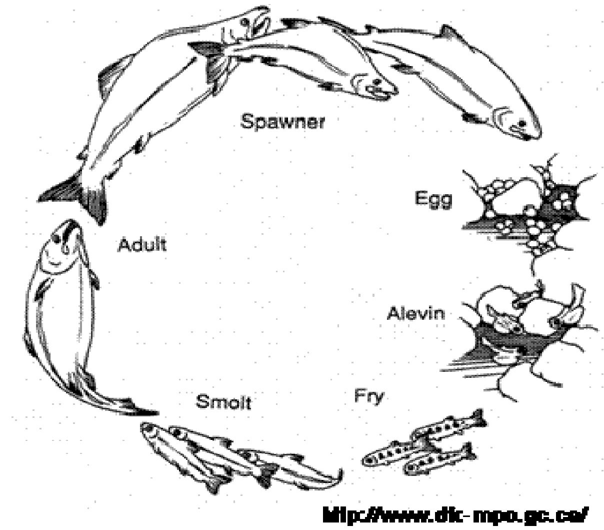


Figure 2-5. Conceptual diagram of the life cycle of a Pacific Salmonid.

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 will be 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. Absolute changes in the number of smolts that survive their migration to the ocean 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).

Similarly, in some sturgeon species growth rate is most sensitive to young-of-the-year and juvenile survival and less sensitive to annual adult fecundity and survival (Caswell 2001). Thus, habitat alterations that decrease the survival of young of the year 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. Particularly at low abundances, small reductions across multiple life stages can have significant consequences, and can even be sufficient to cause the extirpation of a population through the reduction of future abundance and reproduction of the species (see for example, figure 9 in Naiman and Turner 2000).

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 2-6. 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.

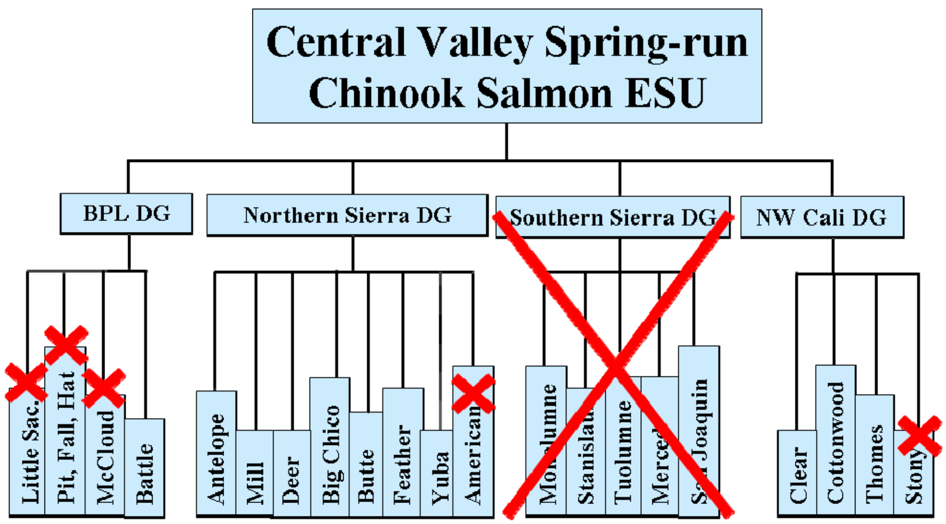


Figure 2-6. Population structure of the Central Valley spring-run Chinook salmon. Red crosses indicate populations and diversity groups that are currently extirpated.

For example, the Central Valley Domain Technical Recovery Team (TRT) recommended that for winter-run, spring-run, and CV steelhead, all extant populations should be secured and that, "…*every extant population be viewed as necessary for the recovery of the ESU*" (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 2-2 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 similar logic path and hierarchical approach (figure 2-7) as the set of questions outlined for critical habitat in table 2-1, with modifications to address issues particular to listed species concerns.

Also similar to the critical habitat analyses, 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 2-8 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 later life stages are more likely to have resulting population level effects than impacts to early life stages.

Table 2-2. 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 of 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

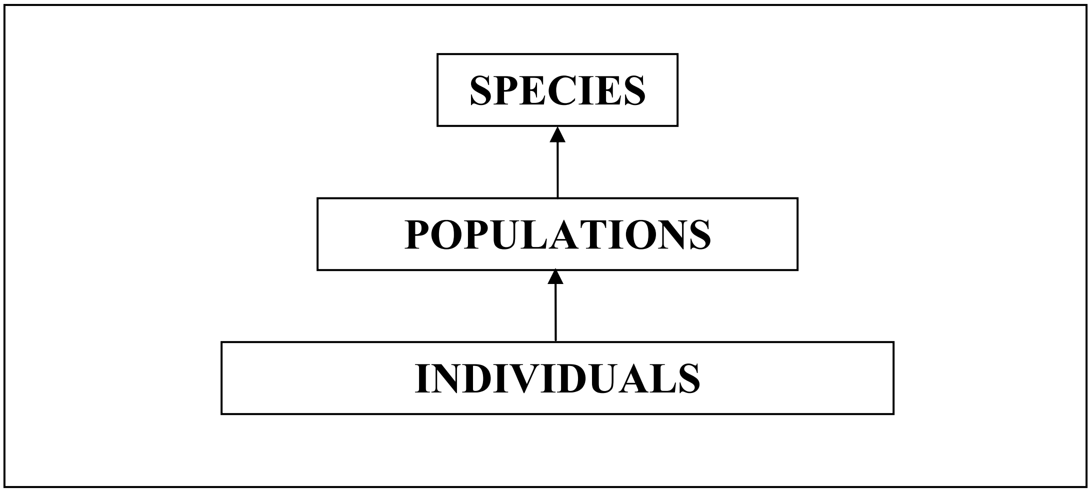


Figure 2-7. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment.

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 2-8. General set of information collected to track effects of the proposed action and resulting exposure, response, and risk to listed species.

2.3.2.1 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 a viable salmonid population (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 Evolutionarily Significant Units (ESU) or Distinct Population Segments (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 10. 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 as well. 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 (figure 2-9). 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

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.

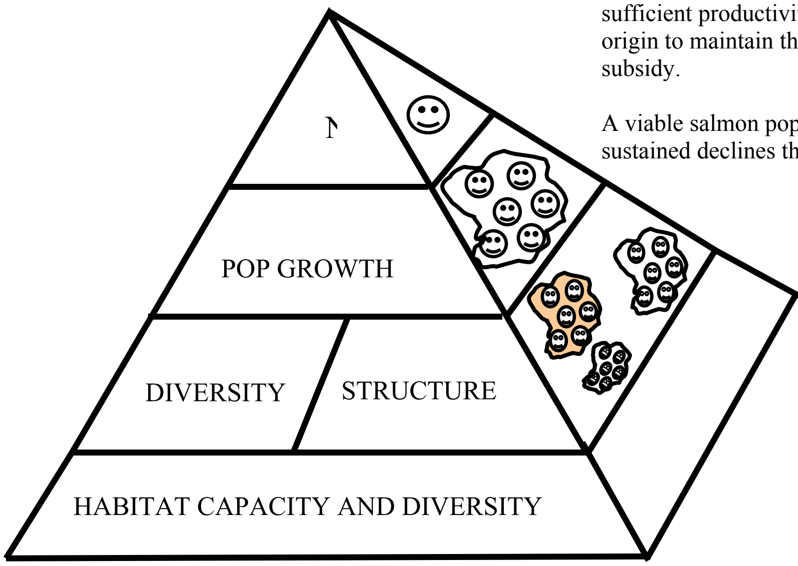
PRODUCTIVITY (POPULATION GROWTH RATE)

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 2-9. Viable Salmonid Population (VSP) Parameters and Their Attributes.

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 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 2-10). 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 2-5) 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.

2.4 Evidence Available for the Analysis

In order to conduct this analysis, NMFS examined multiple sources of information available through published and unpublished material. The primary source of initial information was the OCAP BA, produced for this consultation. Included within the OCAP 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.

[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.

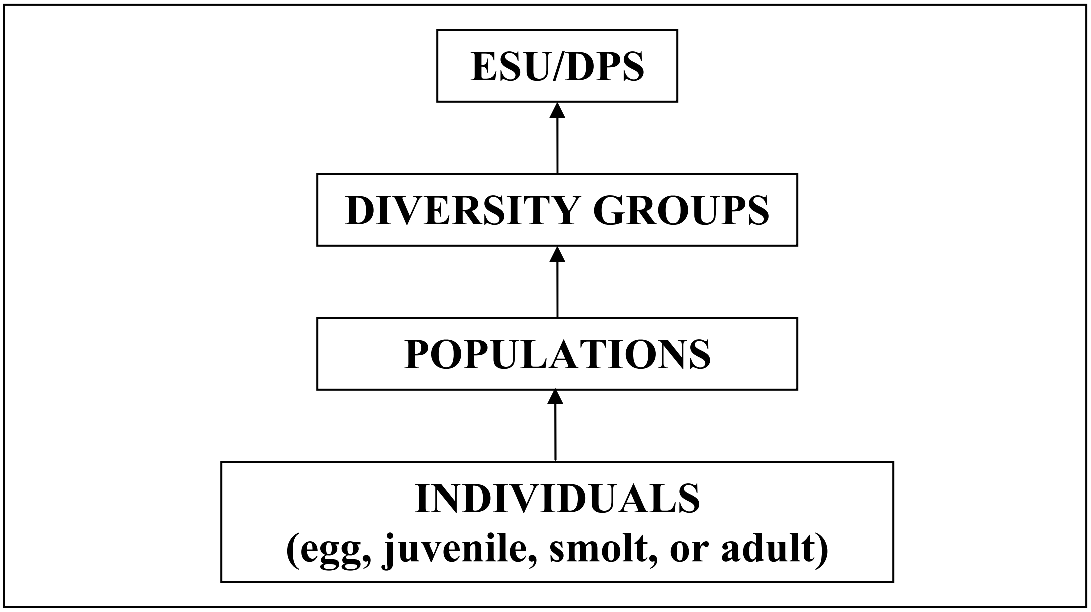


Figure 2-10. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for anadromous salmonids.

We conducted electronic literature searches using several electronic databases available through NMFS' Northwest Science Center and UC Davis. NMFS 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 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.

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.

NMFS considered other lines of evidence of adverse consequences or the absence of such consequences. The following provides a list of additional resources that we considered in the development of our analysis:

- Final rules listing the Central Valley species 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;
- Previously issued NMFS Opinions;
- Recommendations from the various reviews and peer review reports (see sections 1.5.4, 1.5.5, and 1.5.6, above);
- NMFS-Southwest Fisheries Science Center reviews (*e.g*., ocean productivity, declarations, climate change);
- Declarations pursuant to PCFFA *et al. v*. Gutierrez *et al*.;
- NMFS' draft recovery plan for 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; and
- CDFG's Grand Tab database

2.4.1 Other tools used in the analysis

Reclamation and DWR utilized the following models in their analyses and development of the OCAP BA. Figure 2-11 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.
- River temperature:
  - Reclamation Temperature: Monthly time step, 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, 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, computes salmon spawning losses for the Trinity, Sacramento, American, and Stanislaus Rivers based on the Reclamation Temperature Model estimates.
  - SALMOD: Weekly time step, simulates population dynamics for all four runs of Chinook salmon in the Sacramento River between Keswick Dam and 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 urilized an interactive spreadsheet model developed by DWR to estimate interior Delta survival of emigrating salmonids from the Sacramento River. This model, the Delta Surivial Model, utilized user inputs of export rate and Delta inflow to determine absolute and relative survival of salmonids moving throught the Delta interior and remaining in the main stem Sacarmento 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 PTM module of the DSM 2 model above, as well as the relative survival in the Delta interior and the export related interior mortality, which were calculated internally in the model.

2.4.2 Critical Assumptions in the Analysis

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

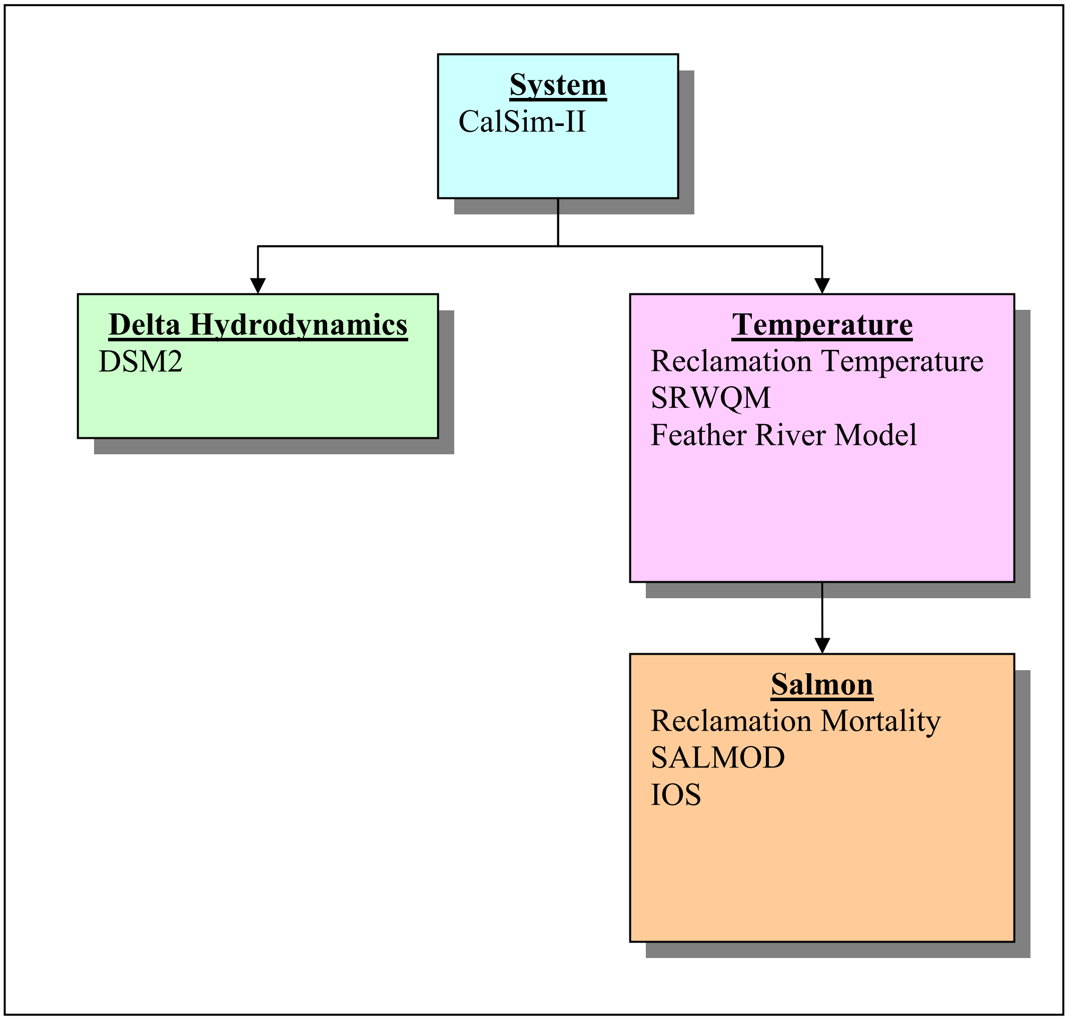


Figure 2-11. Models used in the development of the OCAP BA, and their information flow with respect to each other (OCAP BA: figure 9-1).

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 tern 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 OCAP 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 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 OCAP BA (p.9-41) assumes a 1.9 million acre feet 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. --OCAP BA Chapter 2 (project description). --OCAP BA Chapter 9 (Modeling and Assumptions) -- CDEC data: ~10 years of actual data. Provides real time data on recent past operations.	Chapter 2 (project description) has many gaps regarding the description of the proposed action.
CVPIA 3406 B(2) [hereafter referred to as "b(2)"]is not reasonably certain to be available for tributaries during and after the spring	Most or all of the water available in b(2) would be allocated earlier in the year for Delta smelt. The Secretary of Interior makes b(2) allocation decision at the end of the water year, thereby effectively precluding predictable allocations through an ongoing consultation process. By mutual agreement with Reclamation, we will make this assumption throughout the Opinion.
Use CDEC data for last ~10 years (or more to get critically dry years) as an approximation of temperature (7 Day Average Daily Maximum) impacts through 2030.	In most cases, Reclamation/DWR have not proposed specific temperature targets or operations, so we will use recent past results as an indicator of future results.
We added 1-3°F to projected water temperatures to incorporate the effects of future climate change.	Appendix R provides sensitivity modeling based on various climate change scenarios. The projected temperature increases ranged from 1-3°F.

2.5 Integrating the Effects

The preceding discussions describe the various quantitative and qualitative models, decision frameworks, and ecological foundations for the analysis 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.

Many of the methods described above focus the analysis 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 both 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 outline 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 2-12 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 biological 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 provides 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 will evaluate the 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.

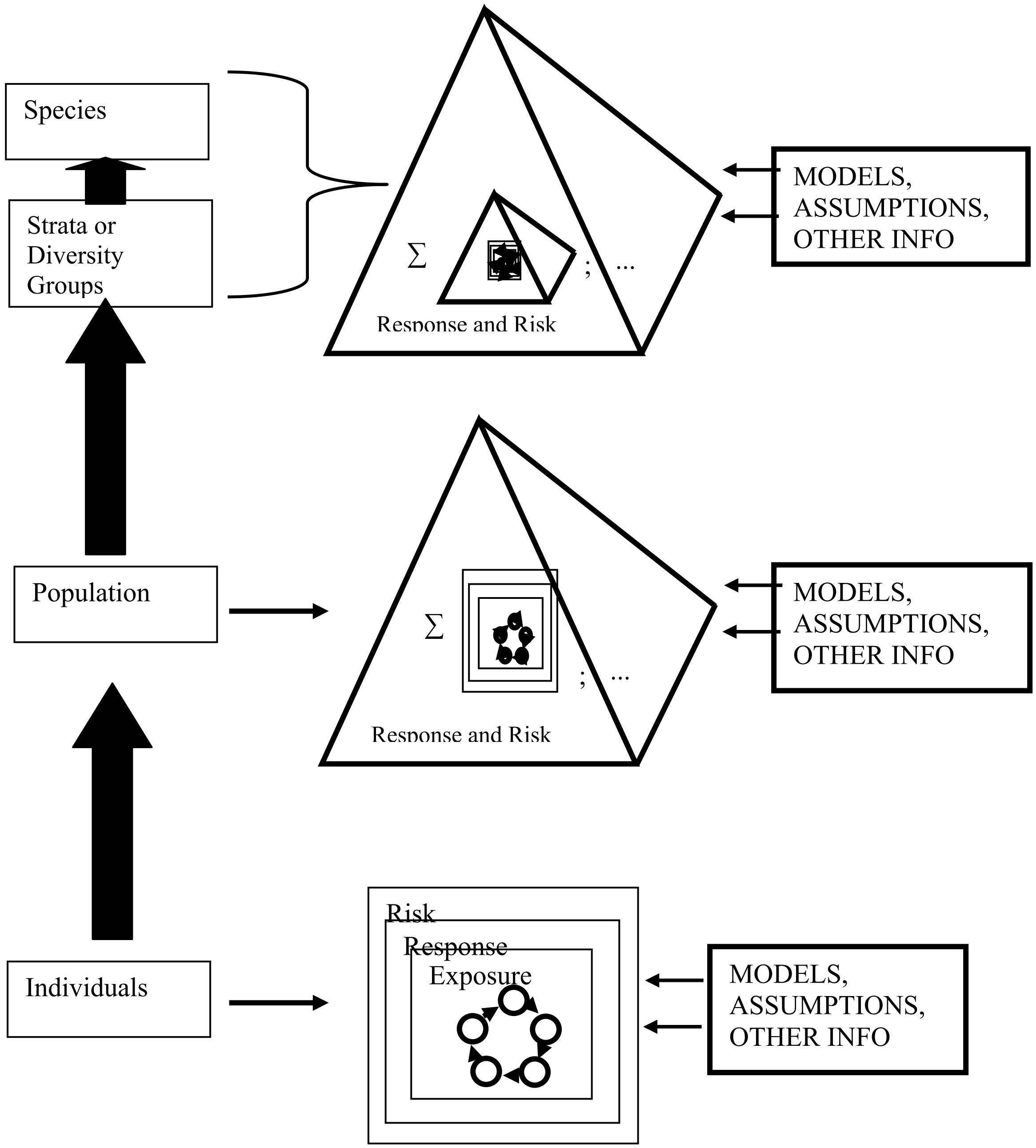


Figure 2-12. Conceptual diagram of the overall analytical approach utilized in this Opinion. The individual level includes exposure, response, and risk to individuals of the species and a consideration of the life cycle and life history strategies. Population level includes consideration of the response 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."

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 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. This information forms part of the foundation of our exposure, response and risk analyses.

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 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 2-2 and 2-19 of this section.

3.0 PROPOSED ACTION

The proposed action is the continued operation of the CVP and SWP. In addition to current day operations, several other actions 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 the Red Bluff Diversion Dam (RBDD); and (5) Alternative Intake Project for the Contra Costa Water District.

3.1 Project Description

The appendix to this Opinion provides a detailed description of the proposed action, duplicated from chapter 2 of the OCAP BA.

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) Feather River from Lake Oroville to its confluence with the Sacramento River; (3) Clear Creek from Whiskeytown Reservoir 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:

- Sacramento River winter-run Chinook salmon evolutionarily significant unit (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 distinct population segment (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 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, CVP/SWP Delta facilities are not likely to adversely affect CCC steelhead.

4.1.2 CCC Steelhead Designated Critical Habitat

The 2008 OCAP 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). Primary constituent elements (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 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, Factors for Decline, Population Trends, and Critical Habitat

4.2.1 Chinook Salmon

4.2.1.1 General Life History

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, 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 at the time of river entry, thermal regime and flow characteristics of their spawning site, 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 65°F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70°F, and that fish can become stressed as temperatures approach 70°F.

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 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 55°F to 57°F (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 41°F to 56°F [44°F to 54°F (Rich 1997), 46°F to 56°F (NMFS 1997), and 41°F to 55.4°F (Moyle 2002)]. A significant reduction in egg viability occurs at water temperatures above 57.5°F and total embryo mortality can occur at temperatures above 62°F (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61°F and 37°F, 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, 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 Red Bluff Diversion Dam (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 (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 2001). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon), MacFarlane and Norton (2001) 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, 1998, 1998a). 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

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]	Medium	Medium	High	Medium	Medium	Medium	Medium					Medium
Sac. River[2]											Medium	Medium

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. R. @ Red Bluff[3]	Low						Low / Medium	Medium	Medium	Medium	Medium	Medium
Sac. R. @ Red Bluff[2]	Medium	Medium					Low	High	High	High	Medium	Medium
Sac. R. @ Knights L.[4]	Medium	Medium	Medium	Low				Low	Low	Low	Medium	Medium
Lower Sac. R. (seine)[5]	High	High	Medium	Low / –					Low	Low	Medium	High
West Sac. R. (trawl)[5]	Low	High	High	High							Low	Medium

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

Sources: [1]Yoshiyama *et al.* (1998); Moyle (2002); [2]Myers *et al.* (1998); [3]Martin *et al.* (2001); [4]Snider and Titus (2000); [5]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 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 17,334 (table 4-2) in 2006, followed by a precipitous decline in 2007 that continued in 2008.

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.

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[1]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated Juvenile Production Estimate (JPE)[2]
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[3]	9,195	0.18	1.13	1,100,000[4]
median	**2,186**	**1,759**	**1.94**	**2.59**	**354,164**

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

[2]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

[3]CDFG (2008)

[4]NMFS preliminary estimate

4.2.1.2.2 Factors Responsible for the Current Status of Winter-Run, Spring-Run, and CV Steelhead

4.2.1.2.2.1 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 and quality of spawning and rearing habitat. 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[2] 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.

The Suisun Marsh Salinity Control Gates (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 OCAP Opinion, the boat lock has remained open since the 2001-2002 control season (OCAP 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 delays at RBDD include delayed, but eventual successful spawning, to prespawn mortality.

4.2.1.2.2.2 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 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 (Mount 1995, Ayers

[2] 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.

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 Chinook salmon 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; (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.).

4.2.1.2.2.2.1 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 TAF of water since 1916 for irrigation along the west side of the Sacramento River. The installation and removal of the diversion dam 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

5-2), 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 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.

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 diversion dam (D. Killiam, CDFG, 2008 pers com). This makes flow fluctuations more a concern since such a large proportion of the run is spawning so close to Keswick Dam.

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 prcent 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.

4.2.1.2.2.2.2 Red Bluff Diversion Dam (RBDD)

RBDD is owned and operated by Reclamation. The Tehama-Colusa Canal Authority (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 and Smith 1984; USFWS 1987, 1989, 1990; Hallock 1989; and CDFG 1998), the OCAP 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 encounters 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 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.

4.2.1.2.2.3 **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 watersheds 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.

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 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.

4.2.1.2.2.4 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 U.S. Army Corps of Engineers (Corps) and other 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.

4.2.1.2.2.5 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*. OCAP 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 (OCAP 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 or the threatened 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 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.

4.2.1.2.2.6 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 [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 Feather River Fish Hatchery (FRFFH) 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 Chinook salmon, 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- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon 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 Livingston Stone National Fish Hatchery 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.

4.2.1.2.2.7 Over Utilization

4.2.1.2.2.7.1 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). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to 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 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 rate 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). In 1996 and 1997, NMFS issued a biological opinion which 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 dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other 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 return of fall-run Chinook salmon to Central Valley in 2007, there was a complete closure of the commercial and recreational ocean Chinook salmon fishery in 2008. As a result, there will likely be more 4- and 5-year old winter-run and spring-run returning to spawn in 2009.

Ocean harvest rates of spring-run are thought to be a function of the CVI (Good *et al*. 2005). 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 in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of spring-run. There is essentially no ocean harvest of steelhead.

4.2.1.2.2.7.2 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 and Schiewe 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, holding adult spring-run are easily targeted by anglers when they congregate 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).

4.2.1.2.2.8 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, C*eratomyxosis shasta* (C-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, Anderson-Cottonwood Irrigation District (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).

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. 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.

4.2.1.2.2.9 Environmental Variation

4.2.1.2.2.9.1 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 (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 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 Chinook salmon are similar. Therefore, the unusual and poor ocean conditions that caused the drastic decline in returning fall run Chinook salmon 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).

4.2.1.2.2.9.2 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; OCAP 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 (OCAP 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 at 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 El Niño Southern Oscillation (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 Northwest Fisheries Science Center Climate Change and Ocean Productivity website[3] 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

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

populations returning in 2009 and 2010[1]. 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*. (2008) 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.* (2008) 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*. (2008) index values for 2007 and 2008, there is sufficient information to provide an indication of the likely ocean conditions for those two years, which can then be compared to 2005 and 2006.

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*. (2008) 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*. (2008) 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, 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*. (2008) 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 make 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.

4.2.1.2.2.9.3 Global Climate Change

Climate change is postulated to have 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, Reganda *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.* 2004). 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.* 2004). 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.

4.2.1.2.2.10 Non-Native Invasive Species

As currently seen in the San Francisco estuary, 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.

4.2.1.2.2.11 Ecosystem Restoration

4.2.1.2.2.11.1 CALFED

Two programs included under CALFED, the Ecosystem Restoration Program (ERP) and the 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 thousand acre feet 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.

4.2.1.2.2.11.2 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.

4.2.1.2.2.11.3 Iron Mountain Mine Remediation

Environmental Protection Agency'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.

4.2.1.2.2.11.4 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).

4.2.1.2.2.12 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 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.

4.2.1.2.3 Likelihood of 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 subunits, 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 subunit are required to ensure the viability of the subunit, and hence, the ESU.

In order to determine the current likelihood of viability of winter-run, 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 viability for the endangered winter-run ESU based on the viable salmonid population 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).

4.2.1.2.3.1 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 6, the winter-run population was on an increasing trend since the mid-1990s when considering the 5-year moving average, until the precipitous decline in 2007, which was sustained 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), NMFS concludes that winter-run are at an increased risk of extinction based on population size.

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

Criterion	Risk of Extinction: 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.

4.2.1.2.3.2 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 a reasonable goal 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 risk of extinction in the foreseeable future.

4.2.1.2.3.3 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 individual is equally likely to mate with every other mature individual of the opposite gender. 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 4 or more years. Therefore, NMFS concludes that winter-run are at a high risk of extinction based on spatial structure.

Over the lifetime of this Opinion (through year 2030), it may be feasible to increase spatial structure through efforts on Battle Creek or elsewhere.

4.2.1.2.3.4 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 Livingston Stone National Fish Hatchery (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.

4.2.1.2.3.5 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 *et al*. (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 spawn 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 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. 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 believe that the winter-run ESU is currently not viable.

4.2.1.2.4 Sacramento River Winter-Run Chinook Salmon Critical Habitat Analysis

4.2.1.2.4.1 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 the winter-run ESU, 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.

4.2.1.2.4.2 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, and modifying hydrology. All of these activities result in changes to essential features of winter run critical habitat that are necessary for their conservation.

4.2.1.2.4.3 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^{o}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.

4.2.1.2.4.3.1 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.

4.2.1.2.4.3.2 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.

4.2.1.2.4.3.3 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. The OCAP BA (Table 2-5) provides the flow requirements in the 1060 MOA and WRO 90-05. Adequate temperatures in the mainstem 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.

4.2.1.2.4.3.4 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 of that habitat depends on Reclamation's modeled February and subsequent monthly forecasts, which consider Reclamation's commitments, including those to settlement contractors, water service contractors, D-1641 requirements, and projected end of September storage volume. Based on these commitments, Reclamation determines how far downstream 56^{o}F 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 56^{o}F at RBDD, they also provide the exception that the water temperature compliance point 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 (OCAP BA page 2-40). The annual change in TCP has degraded the conservation value of spawning habitat (based on water temperature). Once a TCP has been identified and established, it generally does not change. Therefore, water temperatures are typically adequate for successful, egg incubation, and fry development for those redds constructed upstream of the TCP.

4.2.1.2.4.3.5 Habitat Areas and Adequate Prey that are not Contaminated

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.

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

4.2.1.2.4.3.6 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.

4.2.1.2.4.3.7 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 a passage impediment.

Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River. Although actual entrainment rates are not known, Reclamation (2008) calculated 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, are entrained through the DCC into the interior Delta, therefore, not providing a safe migratory corridor to San Francisco Bay and the Pacific Ocean.

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

4.2.1.2.4.3.8 Sacramento River Winter-Run Chinook Salmon Critical Habitat Summary

Critical habitat for winter-run is comprised 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, 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 does not provide the conservation value necessary for the recovery 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 adult spring-run tributaries from the Sacramento River 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^{o}F, although salmon can tolerate temperatures up to 65^{o}F before they experience an increased susceptibility to disease.

Table 4-4. The temporal occurrence of adult (a) and juvenile (b) Central Valley spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac.River basin[1,2]			Medium	Medium	High	High	Medium	Medium	Medium			
Sac. River[3]			Medium	Medium	Medium	Medium	Medium					
Mill Creek[4]			Low	Medium / High	High	High / Medium	Medium / Low	Low / –				
Deer Creek[4]			Low	Medium / High	High	High / Medium	Medium / –					
Butte Creek[4]		Medium	Medium	Medium	Medium	Medium	Medium					

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River Tribs[5]	Low	Low	Low							Low	High	High
Upper Butte Cr[6].	High	High	Low	Low	Low	Low				Low	Low	Medium
Mill, Deer, Butte Creeks[4]	High	High	Low	Low	Low	Low				Low	Low	Low
Sac. River at RBDD[3]	High	Low	Low	Low	Low / –						High	High
Sac. River at Knights Landing[7]	Low	Low	High	High	Medium						Medium	High

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

Sources: [1]Yoshiyama *et al*. (1998); [2]Moyle (2002); [3]Myers *et al*. (1998); [4]Lindley *et al*. (2007); [5]CDFG (1998); [6]McReynolds *et al*. (2005); Ward *et al*. (2002, 2003); [7]Snider and Titus (2000)

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 young-of-the-year (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 spring. 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 Chinook salmon 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 spring-run in the Sacramento River at Knights Landing occurs in December, and again in March and April. 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).

On the Feather River, significant numbers of spring-run, as identified by run timing, return to the FRFH. In 2002, the FRFH reported 4,189 returning spring-run, which is below the 10-year average of 4,727 fish. However, 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 Chinook salmon 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 4-1). 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. Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}C 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.

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 in Butte and Deer Creek, 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 Chinook salmon 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.

4.2.1.3.2 Factors Responsible for the Current Status of Central Valley Spring-Run Chinook Salmon

The factors responsible for the current status of spring-run are the same as those in subsection 4.2.1.2.2, "Factors Responsible for the Current Status of Winter-Run, Spring-Run, and CV Steelhead," above.

4.2.1.3.3 Likelihood of Viability of the Central Valley Spring-Run Chinook Salmon ESU

The earlier analysis to determine the likelihood of viability of winter-run described the process that NMFS uses to apply the VSP concept in McElhany *et al*. (2000). In order to determine the current likelihood of viability of the spring-run ESU, we used the historical population structure of spring-run presented in Lindley *et al*. (2007, figure 4-2) 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. In addition, there are two additional extant populations, in the Feather River below Oroville Dam, and in the mainstem Sacramento River below Keswick Dam. These two populations likely established themselves following the construction of Oroville Dam and Keswick Dam, respectively. Of the 19 independent populations 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, but rely on the three extant independent populations for their continued survival.

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

4.2.1.3.3.1 Population Size

As provided in table 9, 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 abundance. Abundance is generally dominated by the Butte Creek population. Other independent and dependent populations are smaller. The cohort replacement rate behaved similarly. The 5-year moving average cohort replacement rate, however, has remained above 1.0 since 1993.

Table 4-5. Central Valley spring-run Chinook salmon population estimates with corresponding cohort replacement rates for years since 1986 (CDFG 2007).

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated JPE[1]
1986	24,263	-	-	-	**4,396,998**
1987	12,675	-	-	-	**2,296,993**
1988	12,100	-	-	-	**2,192,790**
1989	7,085	-	0.29	-	**1,283,960**
1990	5,790	12,383	0.46	-	**1,049,277**
1991	1,623	7,855	0.13	-	**294,124**
1992	1,547	5,629	0.22	-	**280,351**
1993	1,403	3,490	0.24	0.27	**254,255**
1994	2,546	2,582	1.57	0.52	**461,392**
1995	9,824	3,389	6.35	1.70	**1,780,328**
1996	2,701	3,604	1.93	2.06	**489,482**
1997	1,431	3,581	0.56	2.13	**259,329**
1998	24,725	8,245	2.52	2.58	**4,480,722**
1999	6,069	8,950	2.25	2.72	**1,099,838**
2000	5,457	8,077	3.81	2.21	**988,930**
2001	13,326	10,202	0.54	1.94	**2,414,969**
2002	13,218	12,559	2.18	2.26	**2,395,397**
2003	8,902	9,394	1.63	2.08	**1,613,241**
2004	9,872	10,155	0.74	1.78	**1,789,027**
2005	14,312	11,926	1.08	1.23	**2,593,654**
2006	8,716	11,004	0.98	1.32	**1,579,534**
2007	7,819	9,924	0.79	1.05	**1,416,972**
median	8,868	9,659	1.05	2.30	1,498,256

[1]NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, assuming a female to male ratio of 6:4, and pre-spawning mortality of 25 percent. NMFS utilized the female fecundity value of 4,900 eggs/femals in Fisher (1994) for spring-run Chinook salmon. The remaining survival estimates used the winter-run values for calculating JPE.

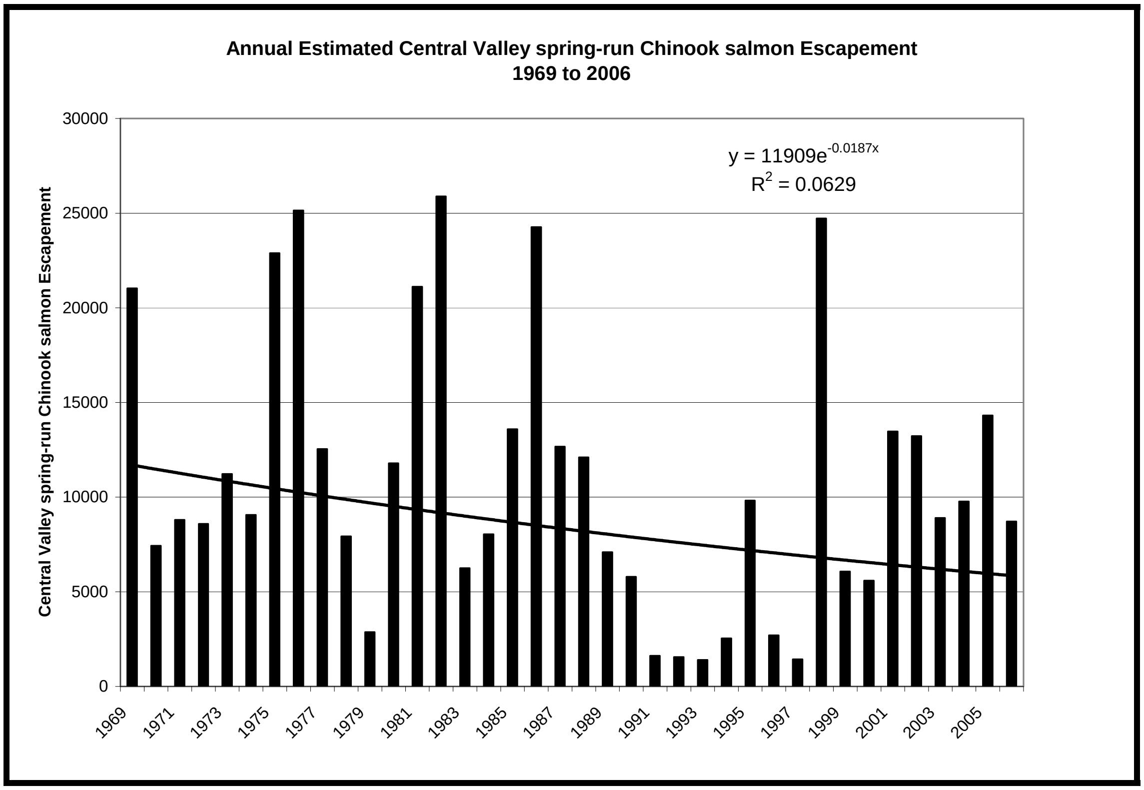


Figure 4-1. Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1969 through 2006 (PFMC 2002, 2004, CDFG 2004b, Yoshiyama 1998, GrandTab 2006).

4.2.1.3.3.2 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, however, shows an increasing trend since the mid 1990s.

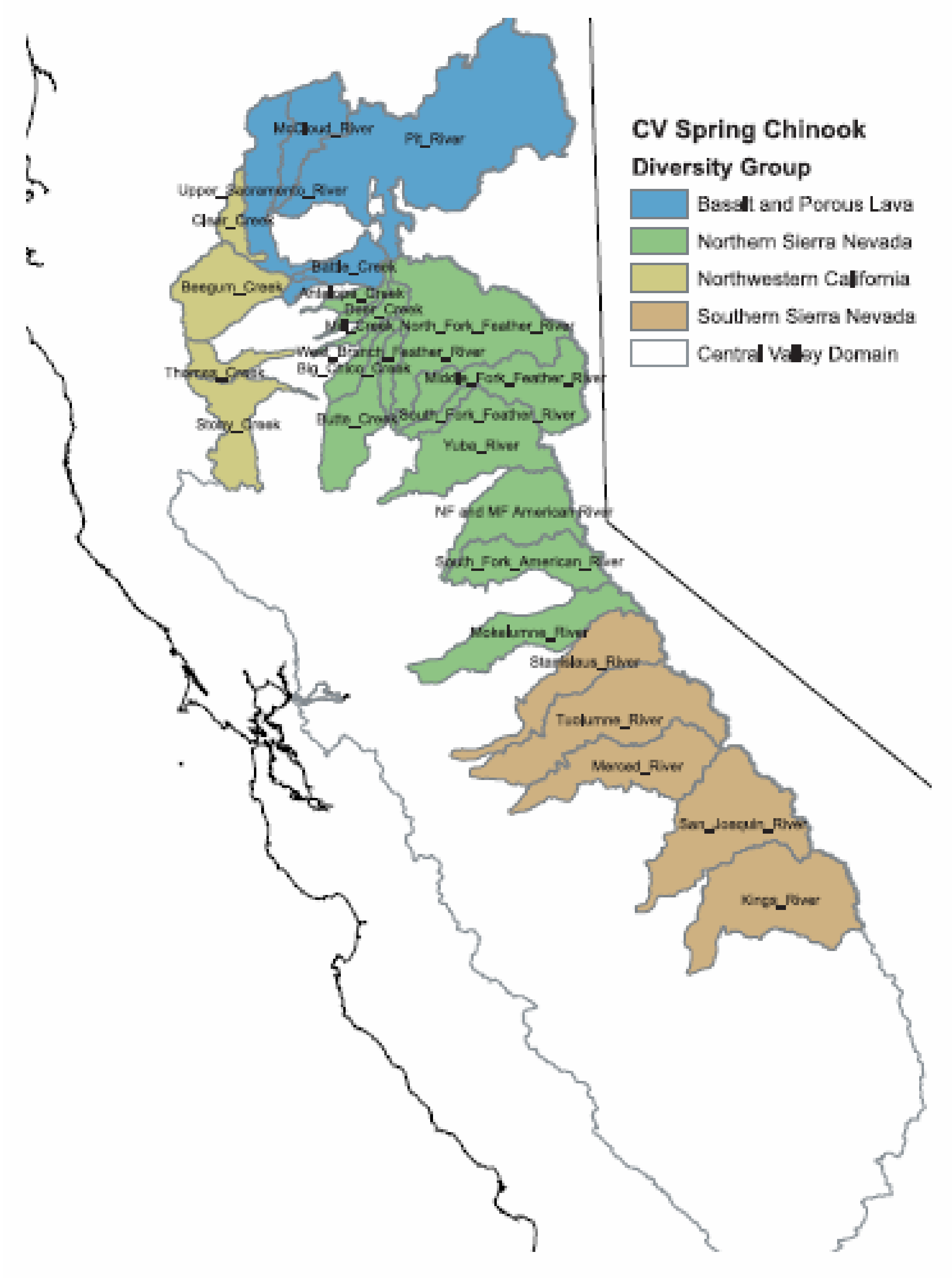


Figure 4-2. Salmonid ecoregions within the Central Valley as applied to CV spring-run Chinook salmon (replicated from Lindley *et al*. 2007).

4.2.1.3.3.3 Spatial Structure

Lindley *et al*. (2007) indicated that there are three viable independent populations (Butte, Mill, and Deer Creeks), but in combination, they represent a small portion of the historical spring-run ESU, and their current distribution makes the spring-run ESU vulnerable to catastrophic disturbance. There are also dependent populations of spring-run in the Big Chico, Antelope, Clear, Thomes, and Beegum Creeks. Clear Creek has been a focus of habitat restoration, and to date, up to 200 spring-run spawners have utilized Clear Creek in a single spawning season. In addition, as mentioned earlier, the extant Feather River and mainstem Sacramento River populations probably do not represent historical entities (Lindley *et al*. 2007). The genetic status of the spring run population in the Yuba River is unknown at this time, and it is suspected that this population may be somewhat dependant on the FRFH spring-run population. The 3 current independent populations have been reduced from the 19 historical independent populations of spring-run, resulting in a significant reduction in their distribution.

4.2.1.3.3.4 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 Feather River Hatchery 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 Feather River Hatchery spring-run fry were planted at the base of Whiskeytown Dam during the 3-year period 1991−1993 (DFG 1998 *op. cit*. OCAP BA). These hatchery fish behave more like fall-run (spawn later than spring-run in Deer, Mill, and Butte Creeks), likely increases introgression of the the spring- and fall- runs, and reduces diversity.

4.2.1.3.3.5 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 their current distribution has been severely constricted. Therefore, spring-run are at moderate risk of extinction over an extended period of time.

4.2.1.3.4 Central Valley Spring-Run Chinook Salmon Critical Habitat Analysis

4.2.1.3.4.1 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.

4.2.1.3.4.2 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 focused primarily to ensure an adequate quantity and quality of water for successful adult winter-run migration, holding, spawning, and incubation may be limiting the amount of cold water to ensure successful incubation of any spring-run eggs spawned on the mainstem Sacramento River. Operations of the CVP and SWP do not affect spawning habitat within Mill, Deer, and Butte Creeks, and most of the streams with dependent populations on the west side of the Sacramento River.

4.2.1.3.4.3 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.

4.2.1.3.4.4 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 (Reclamation and TCCA 2002). Less than 1 percent of spring-run juveniles are potentially impacted by passing under the dam during their downstream migration (Reclamation and TCCA 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 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.

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.

4.2.1.3.4.5 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.

4.2.1.3.4.6 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 survival and 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 *et al.* 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.

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).

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.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River[1,3]												
Sac R at Red Bluff[2,3]												
Mill, Deer Creeks[4]												
Sac R. at Fremont Weir[6]												
San Joaquin River[7]												

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River[1,2]												
Sac. R at Knights Landing (KL)[2,8]												
Sac. River @ KL[9]												
Chipps Island (wild)[10]												
Mossdale[8]												
Woodbridge Dam[11]												
Stan R. at Caswell[12]												
Sac R. at Hood[13]												

Relative abundance: ■ = High □ = Medium ▒ = Low

Sources: [1]Hallock *et al.* (1961); [2]McEwan (2001); [3]USFWS (unpublished data); [4]CDFG (1995); [5]Hallock *et al.* (1957); [6]Bailey (1954); [7]CDFG Steelhead Report Card Data; [8]CDFG (unpublished data); [9]Snider and Titus (2000); [10]Nobriga and Cadrett (2003); [11]Jones & Stokes Associates, Inc. (2002); [12]S.P. Cramer and Associates, Inc. (2000, 2001); [13]Schaffter (1980, 1997)

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 4-3). 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 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.

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."

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.

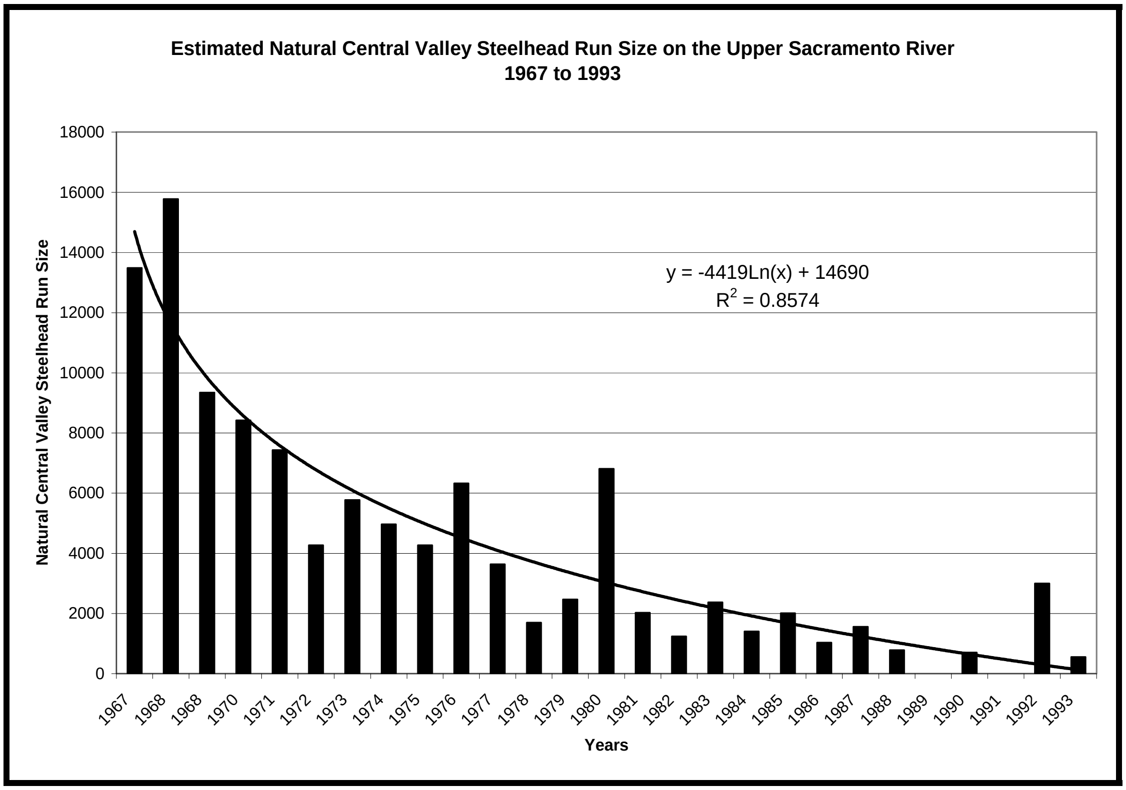


Figure 4-3. Estimated natural Central Valley steelhead escapement in the upper Sacramento River based on RBDD counts. Note: Steelhead escapement surveys at RBDD ended in 1993 (from McEwan and Jackson 1996).

Recent monitoring has detected small self-sustaining populations 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) has 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 Chinook salmon 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." 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 4-4).

4.2.2.2.2 Factors Responsible for the Current Status of Central Valley Steelhead

The factors responsible for the current status of CV steelhead are similar to those in subsection 4.2.1.2.2, “Factors Responsible for the Current Status of Winter-Run, Spring-Run, and CV Steelhead,” above. The following provides additional information on the effect of water quality resulting from water development in the San Joaquin River basin.

4.2.2.2.2.1 Additional Water Quality

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 4-7). The data derived from the CDEC files 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).

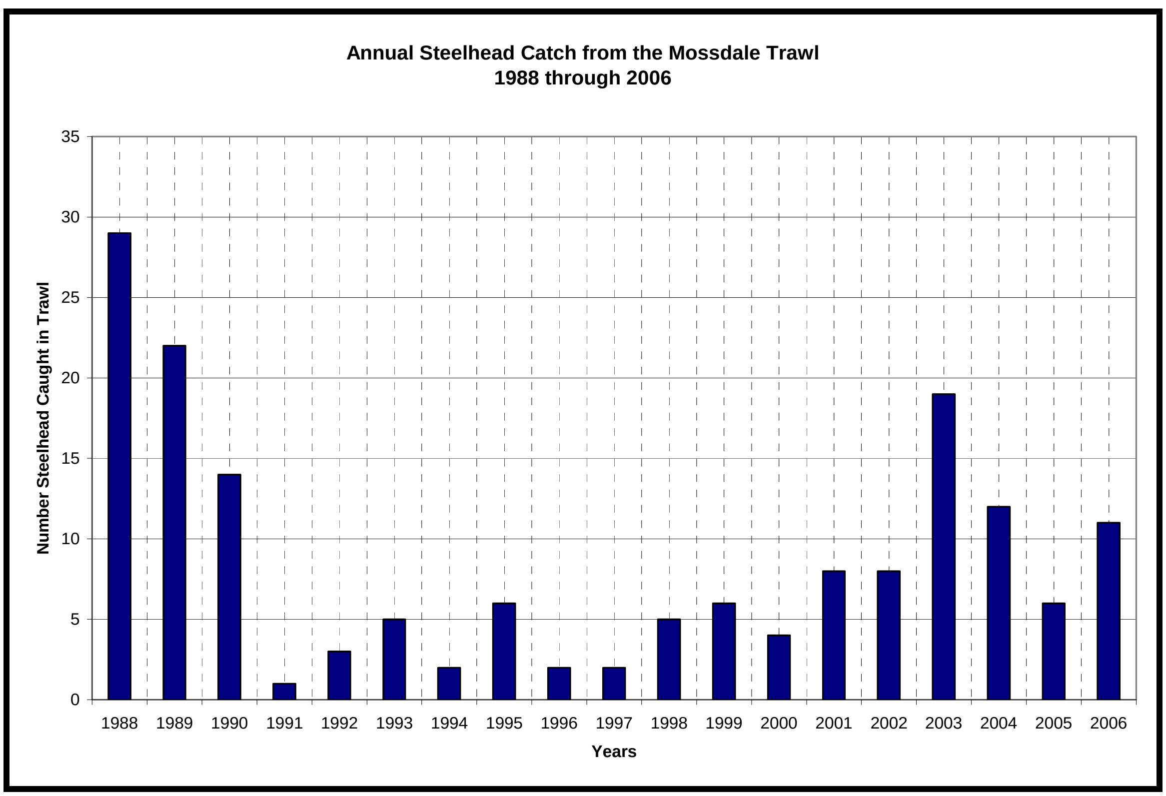


Figure 4-4. Annual number of Central Valley steelhead caught while Kodiak trawling at the Mossdale monitoring location on the San Joaquin River (Marston 2004, SJRG 2007).

Table 4-7. Monthly occurrences of dissolved oxygen depressions below the 5mg/L criteria in the Stockton deepwater ship channel (Rough and Ready Island DO monitoring site) water years 2000 to 2004.

	Water Year					
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	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*	0	2	4	0	8
Annual Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = 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 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 Chinook salmon.

4.2.2.2.3 Likelihood of Viability of the Central Valley Steelhead DPS

The earlier analysis to determine the likelihood of viability of winter-run described the process that NMFS uses to apply the VSP concept in McElhany *et al*. (2000). In order to determine the current likelihood of viability of the CV steelhead DPS, we used the historical population structure of CV steelhead presented in Lindley *et al*. (2006) 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 7 provides various quantitative criteria to evaluate the risk of extinction. The following provides the evaluation of the likelihood of viability for the threatened CV steelhead DPS based on the VSP parameters of population size, population growth rate, spatial structure, and diversity.

4.2.2.2.3.1 Population Size

As provided above and in figure 7, 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).

4.2.2.2.3.2 Population Growth Rate

CV steelhead has shown a pattern of a negative growth rate since the late 1960s (figure 7). Good *et al*. (2005) provided no indication that this trend has changed since the last CV steelhead population census in 1993.

4.2.2.2.3.3 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. 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. CV steelhead may have been extirpated from their entire historical range in the San Joaquin Valley and most of the larger basins of the Sacramento River. Now, only 2 clusters contain watersheds with habitat that remains accessible to CV steelhead (Lindley *et al*. 2006). 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.

4.2.2.2.3.4 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.

4.2.2.2.3.5 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.

4.2.2.2.4 CV Steelhead Critical Habitat Analysis

4.2.2.2.4.1 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, 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.

4.2.2.2.4.2 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 Central Valley steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e*., above RBDD 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 adverse effects upon salmonids spawning below them.

4.2.2.2.4.3 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 Chinook salmon.

4.2.2.2.4.4 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, respectively. Juvenile CV steelhead that try to migrate past RBDD in its gates down position 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 also exposed to degraded migration corridors, as they are exposed to degraded water quality in 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 central Delta through the 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 canals, handling, trucking, and release. The current condition of freshwater migration corridors in the Sacramento River, San Joaquin River, and Delta are very degraded.

4.2.2.2.4.5 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.

4.2.2.2.4.6 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 survival and 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 (NMFS 2005). 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 2006). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et al* 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). 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. Southern DPS of green sturgeon have been detected in these seasonal aggregations.

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. The life cycle of Southern DPS of green sturgeon can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age; (2) larvae and post-larvae less than 10 months of age; (3) juveniles less than or equal to 3 years of age; and (4) coastal migrant females between 3 and 13 years, and males between 3 and 9 years of age (Nakamoto *et al*. 1995, McLain 2006).

Known historic and current spawning occurs in the Sacramento River (Adams *et al.* 2002, Beamesderfer *et al.* 2004). 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. Both white and green sturgeon likely 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 spring-run and CV 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.

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. It appears 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 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 recoveries were in the Columbia River estuary (CDFG 2002).

Kelly *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. 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*. (2006) 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 15^{o}C and 23^{o}C. When ambient temperatures in the river dropped in autumn and early winter (<10^{o}C) 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. Similar behavior is exhibited by adult green sturgeon on the Sacramento River based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205). The documented presence of adults in the Sacramento River during the spring and summer months, and the presence of larval green sturgeon in late summer in the lower Sacramento River, indicate spawning occurrence, and it appears adult green sturgeon could utilize a variety of freshwater and brackish habitats for up to 9 months of the year (Beamesderfer 2006).

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966). Adult green sturgeon caught in Washington state waters have also been found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Adults of the Southern DPS of green sturgeon begin their upstream spawning migrations into the San Francisco Bay by at least March, reach Knights Landing during April, and spawn between March and July (Heublein *et al*. 2006). Peak spawning is believed to occur between April and June (table 4-8) and thought to occur in deep turbulent pools (Adams *et al*. 2002). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFG (2002) indicated that the Southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City, possibly to Keswick Dam. Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to reach sexual maturity only after several years of growth (10 to 15 years), and spawn every 3 to 5 years, based on sympatric white sturgeon sexual maturity (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, 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. Spawning females broadcast their eggs over suitable substrate, which is thought to consist of predominately large cobbles, but can range from clean sand to bedrock (USFWS 2002). According to Heublein (2006), all adults leave the Sacramento River prior to September 1.

Table 4-8. The temporal occurrence of (a) adult, (b) larval and post-larval (c) juvenile and (d) coastal migrant Southern DPS of green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Upper Sac. River[1,2,3]			Medium	Medium/High	High	High/Medium	Medium	Medium	Medium	Medium	Medium	
SF Bay Estuary[4,8]			Medium	Medium	Medium	Medium	Medium	Medium	Medium			

(b) Larval and post-larval (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RBDD, Sac River[5]					Medium	High	High	Medium				
GCID, Sac River[5]					Medium	High	High	Medium	Low	Low		

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

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South Delta*[6]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[6]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Sac-SJ Delta[5]				Medium	Medium	Medium	Medium	Medium	Medium	Medium		
Suisun Bay[5]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pacific Coast[3,7]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

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

* Fish Facility salvage operations

Sources: [1]USFWS (2002); [2]Moyle *et al*. (1992); [3]Adams *et al*. (2002) and NMFS (2005); [4]Kelly *et al*. (2007); [5]CDFG (2002); [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al*. (1995); [8]Heublein *et al*. (2006)

Green sturgeon larvae hatch after approximately 169 hours at a water temperature of 15°C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14°C and 17°C. Temperatures over 23°C resulted in 100 percent mortality of fertilized eggs before hatching. Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. After approximately 10 days, the yolk sac becomes greatly reduced in size and the larvae begin feeding, growing rapidly, and young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in June and July at lengths ranging from 24 to 31 mm fork length (CDFG 2002, USFWS 2002). The mean yearly total length of post-larval green sturgeon captured in rotary screw traps at the RBDD ranged from 26 mm to 34 mm between 1995 and 2000, indicating they are approximately 2 weeks old. The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximately 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, unpublished data) indicating they are approximately 3 weeks old (Van Eenennaam *et al.* 2001).

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. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al.* 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*. (2005) 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. These data suggest that 9- to 10-month old fish hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. During these early life stages, larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolmoides*) have been recorded on the Rogue River preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005).

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15°C and 19°C 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 on the Sacramento River system range from 4°C to approximately 24°C, and is a regulated system with several dams controlling flows on its mainstem (Shasta and Keswick Dams), and its tributaries (Oroville, Folsom, and Nimbus Dams).

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 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 Southern DPS of green sturgeon per year (Adams *et al*. 2002). 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 (table 4-9, figures 4-5 and 4-6). The average number of Southern DPS of green sturgeon taken 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 (2006b) indicate spawning populations 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 that 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.

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.

Table 4-9. The annual occurrence of juvenile 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

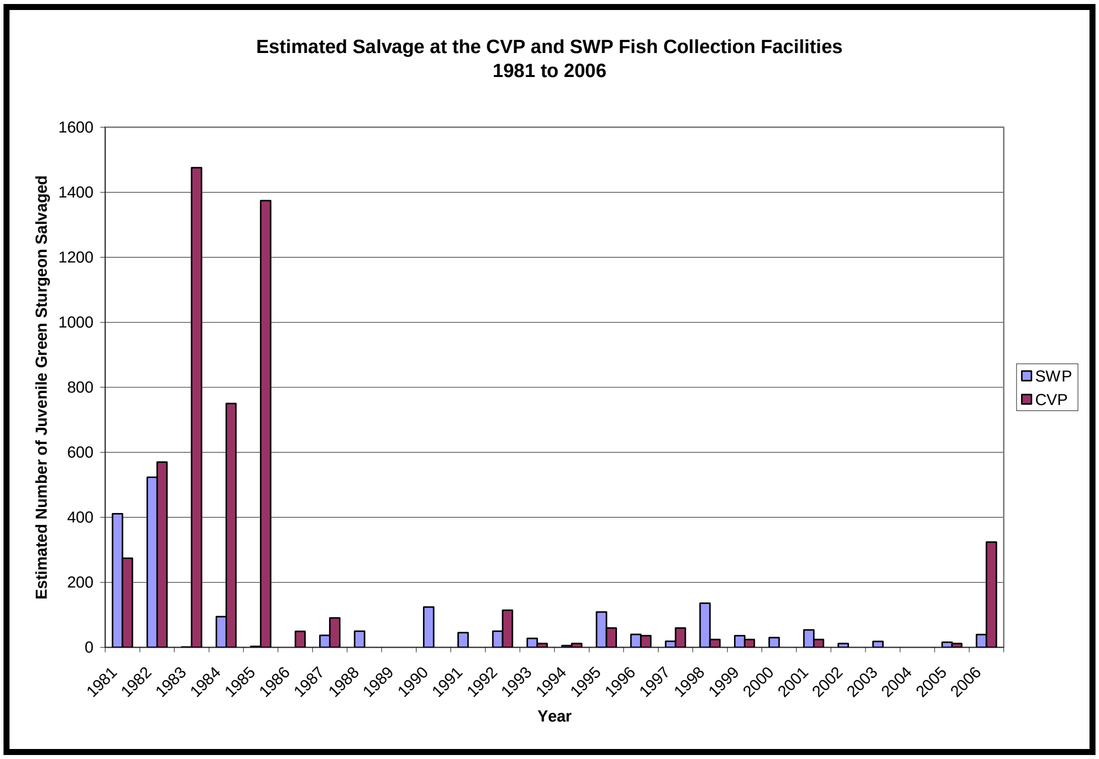


Figure 4-5. Estimated number of juvenile Southern DPS of North American green sturgeon salvaged from the SWP and the CVP fish collection facilities (Beamesderfer *et al.* 2007, CDFG 2002, Adams *et al.* 2007).

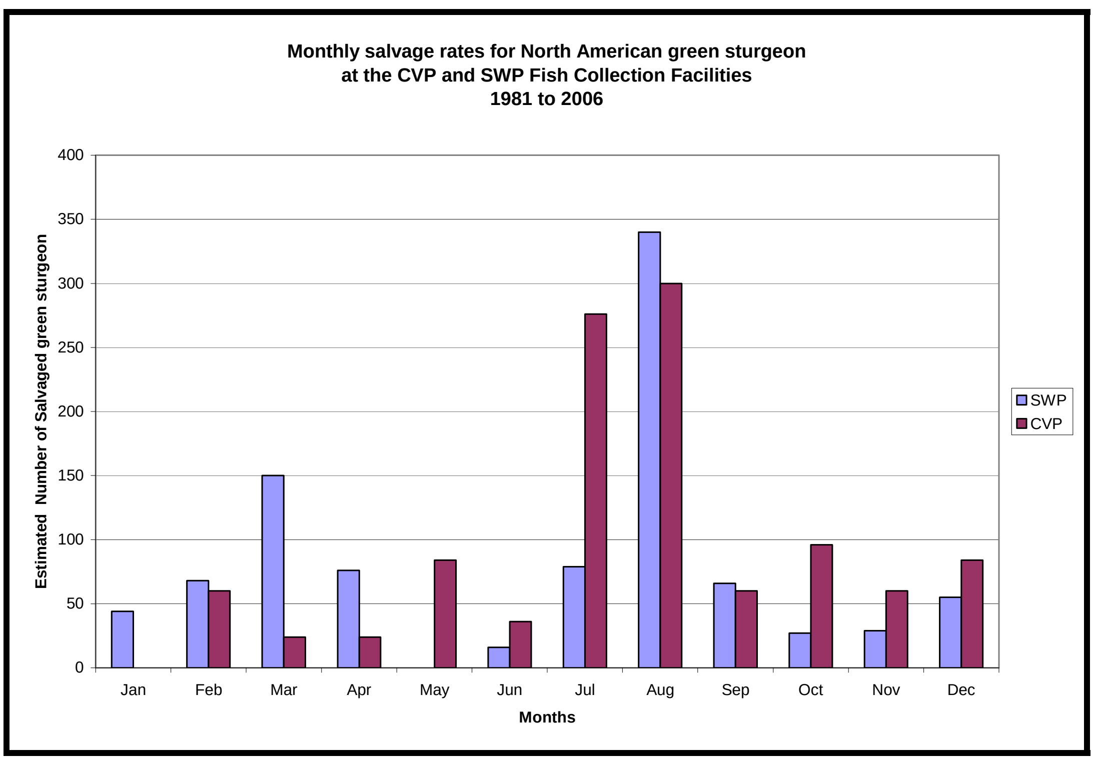


Figure 4-6. Estimated number of Southern DPS of North American green sturgeon salvaged monthly from the SWP and the CVP fish collection facilities (CDFG 2002, unpublished CDFG records).

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

[*Placeholder to develop/complete*]

4.2.3.3.1 Population Size

4.2.3.3.2 Population Growth Rate

4.2.3.3.3 Spatial Structure

4.2.3.3.4 Diversity

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

4.2.3.4 Southern DPS of Green Sturgeon Proposed Critical Habitat Analysis

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 prey items for larval, juvenile, subadult, and adult life stages.

4.2.3.4.2.2 Substrate Type or Size

Substrate suitable for egg deposition and development (*e.g.*, bedrock sills and shelves, cobble and gravel, or hard clean sand, 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 adults (*e.g.*, substrates for holding and spawning).

4.2.3.4.2.3 Water Flow

A flow regime (*i.e.*, magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.

4.2.3.4.2.4 Water Quality

Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.

4.2.3.4.2.5 Migratory Corridor

A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (*e.g*., an unobstructed river or dammed river that still allows for safe and timely passage).

As indicated above, adult Southern DPS of green sturgeon spawn in the upper Sacramento River between March and July, with peak spawning believed to occur between April and June. The closure of the gates at RBDD from May 15 through September 15 preclude all access to spawning grounds above the dam during that time period. As the fish ladders at RBDD are not passable for green sturgeon, and the high water velocities flowing through the small gaps under the dam gates do not allow upstream passage past the dam, those that do not pass RBDD prior to May 15 would either spawn downstream of RBDD, or not spawn at all.

According to Heublein (2006), all adults leave the Sacramento River prior to September 1. Those that migrate upstream past RBDD prior to May 15 would not be able to migrate back downstream until after the RBDD gates are pulled on September 15.

Juvenile green sturgeon first appear in USFWS sampling efforts at RBDD in 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.

4.2.3.4.2.6 Depth

Deep (≥5 m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.

4.2.3.4.2.7 Sediment Quality

Sediment quality (*i.e*., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

4.2.3.4.3 For Estuarine Habitats

4.2.3.4.3.1 Food Resources

Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages.

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

4.2.3.4.3.3 Water Quality

Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth and viability of all life stages.

4.2.3.4.3.4 Migratory Corridor

A migratory pathway necessary for the safe and timely passage of Southern DPS fish within estuarine habitats and between estuarine and riverine or marine estuaries and riverine or marine habitats.

4.2.3.4.3.5 Depth

A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages.

4.2.3.4.3.6 Sediment Quality

Sediment quality (*i.e*., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

4.2.3.4.4 For Nearshore Coastal Marine Areas

4.2.3.4.4.1 Migratory Corridor

A migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats.

4.2.3.4.4.2 Water Quality

Nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels 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.

4.2.3.4.4.3 Food Resources

Abundant prey items for subadults and adults, which may include benthic invertebrates and fishes.

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

4.2.4 Southern Resident Killer Whales

4.2.4.1 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" and "strategic" under the Marine Mammal Protection Act (MMPA; May 29, 2003, 68 FR 31980). The final recovery plan for Southern Residents was issued in January of 2008 (NMFS 2008a). This section summarizes information taken largely from the recovery plan, as well as new data that became available more recently. For more detailed information about this DPS, please refer to the Final Recovery Plan for Southern Resident Killer Whales, which can be found on the internet at www.nwr.noaa.gov.

4.2.4.2 Range and Distribution

SR killer whales 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 4-7). 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 nmi (160 km) in a single day (Erickson 1978, Baird 2000). To date, there is no evidence that Southern Residents travel further than 50 km offshore (Ford *et al*. 2005).

Figure 4-7. Geographic Range (light shading) of the Southern Resident Killer Whale DPS. Source: Wiles (2004).

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).

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 2008, table 4-10). 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 2008a). 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 run in the Columbia River (M. B. Hanson, pers. obs., in Krahn *et al*. 2004).

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

4.2.4.3 Limiting Factors and Threats

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.

4.2.4.3.1 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.

4.2.4.3.1.1 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 (2 percent), pink (3 percent) steelhead and sockeye (*O. mykiss*, *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), 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.

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	

4.2.4.3.1.2 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 in the 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 kg 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).

4.2.4.3.1.3 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 and NWFSC unpubl. data).

4.2.4.3.1.4 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; figure 5 in Ford and Ellis 2006). NWFSC evaluated the age of kills relative to the age distribution of Chinook in a fisheries management model, FRAM (table 4-12, 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 Pike, Pulliam and Charnov 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 *et al*. 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, 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 in inland waters, even when other species are more abundant, combined with information indicating that the whales consume salmon year round, makes it reasonable to expect that Southern Residents likely prefer Chinook salmon when available in coastal waters.

4.2.4.3.1.5 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 abundance (Alaska, British Columbia, and Washington) with decreased survival of resident 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 Resident killer whales, 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.

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 salmon). 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 (CTC 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*., ISAB 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 4.2.1.2.2.9.

4.2.4.3.1.6 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 PBDEs 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 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.

4.2.4.3.2 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 killer whales (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 (Hickie *et al*. 2007).

4.2.4.3.3 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 adversely 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, 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 from 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).

4.2.4.3.4 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.

4.2.4.4 Abundance, Productivity 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 (5.4 surviving calves over 25 years; Olesiuk *et al*. 1990, Bain 1990). 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 4-8). 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 Resident killer whales 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.

4.2.4.5 Extinction Risk

A PVA for Southern Residents was conducted by the 2004 biological review team (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.

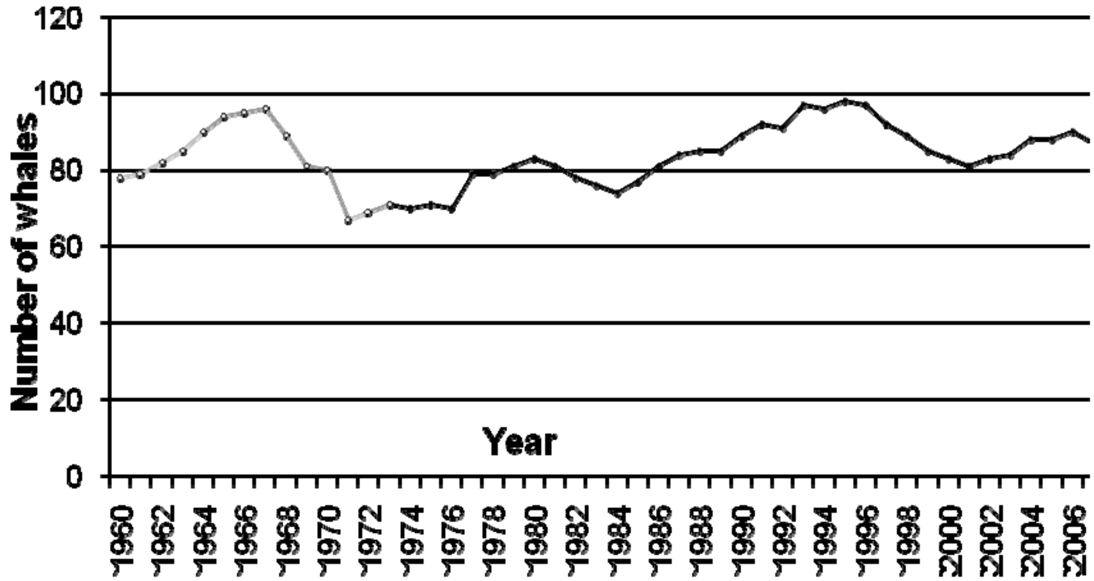


Figure 4-8. Population size and trend of Southern Resident killer whales, 1960-2008. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk *et al*. (1990). Data from 1974-2008 (diamonds, black line) were obtained through photo-identification surveys of 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 reference 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).

The action area for the proposed action encompasses the entire range or a large portion of the species range and their proposed or designated critical habitat in this consultation. Therefore, we refer the reader to the *Status of the Species* section for information on the species' biology, ecology, status, and population trends.

5.1 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, fall-run, late-fall run, and CV steelhead.

5.1.1 Spring-Run

Since 1998, spring-run have shown an increasing trend in abundance from 50 in 1998 to 200 adults in 2007 (figure 5-2). Flows are managed below Whiskeytown Dam using b(2) water and are consistently 200 cfs from October through June. During the summer months, flows are maintained to provide adequate holding and rearing temperatures for adult spring-run per the 2004 OCAP Opinion. Juvenile spring-run from the Feather River 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 Hatchery have been observed spawning in Clear Creek.

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.

5.1.2 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 Ecosystem Restoration Program. 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 (table 5-1). The 5-year average is 290 adults based on a conservative 2 fish/redd assumption. The highest number of redds, in 2007, were counted in January, and the highest density was in the first mile below Whiskeytown Dam (USFWS 2007a). 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 in table 5-1, indicating that straying of hatchery steelhead is probably low in Clear Creek.

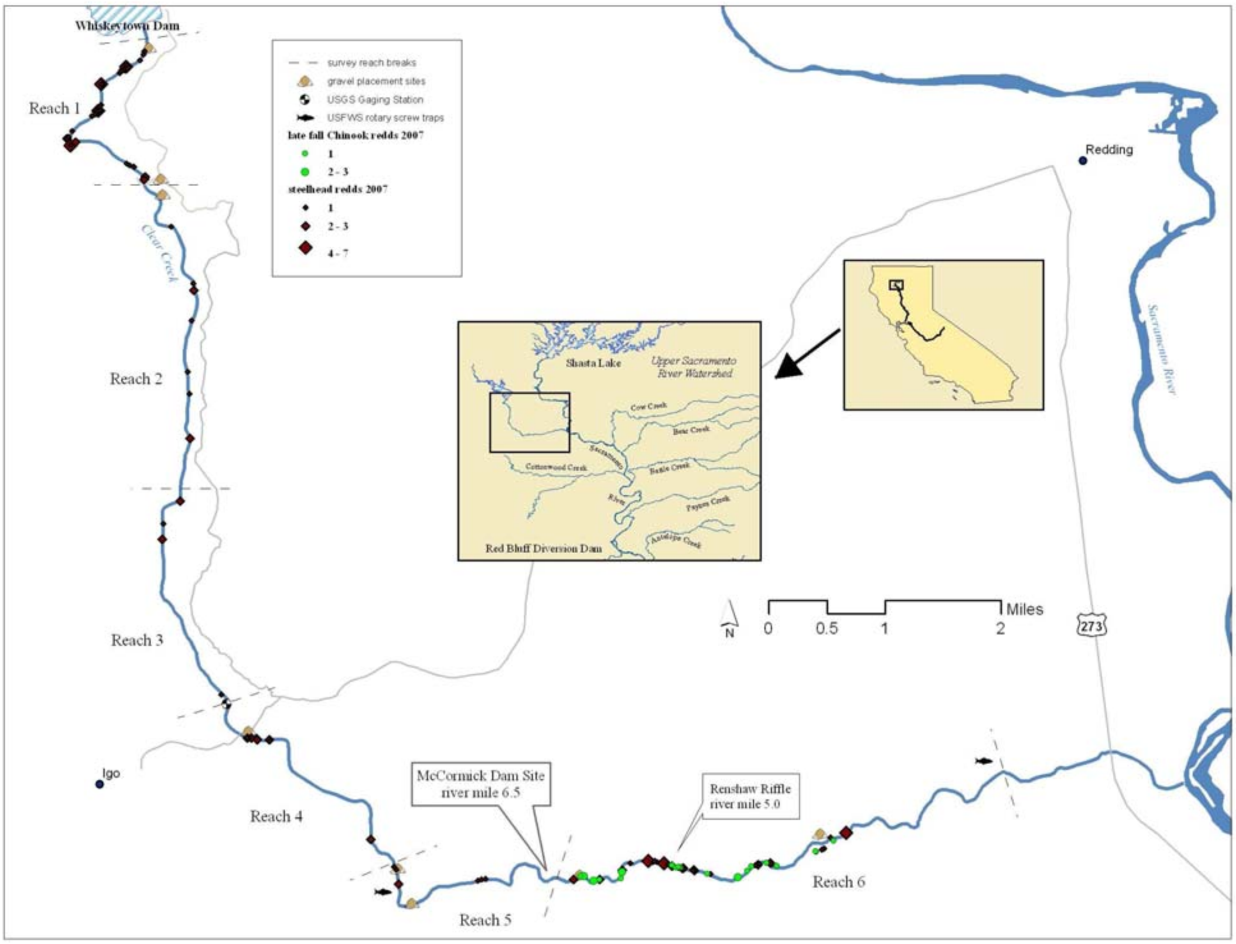


Figure 5.1. Map of upper Sacramento River, showing the relative location of Clear Creek and the distribution of steelhead and late fall-run redds in 2007 (USFWS 2007a).

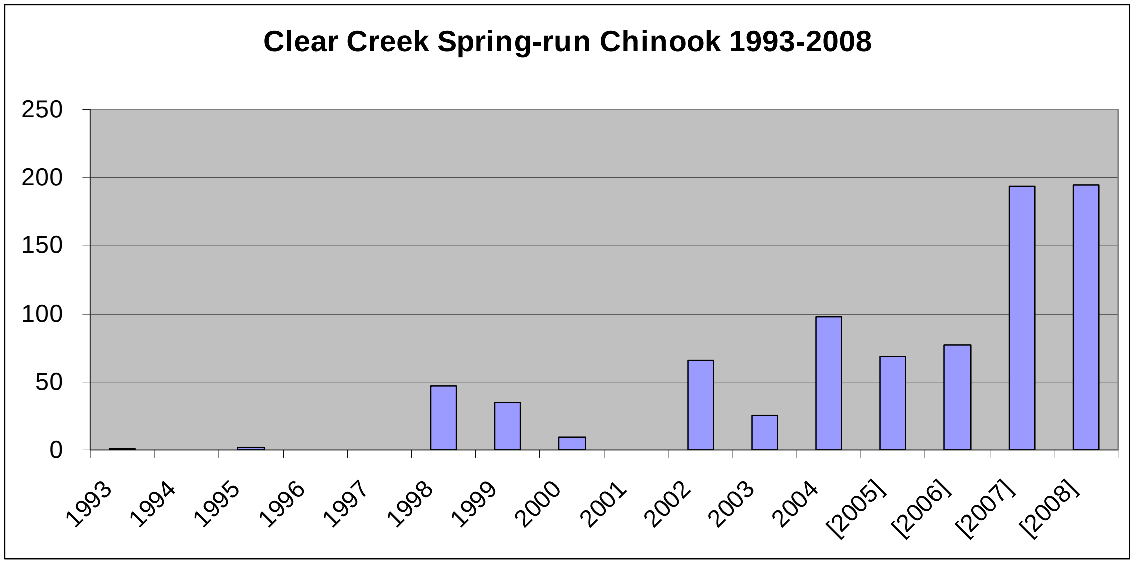
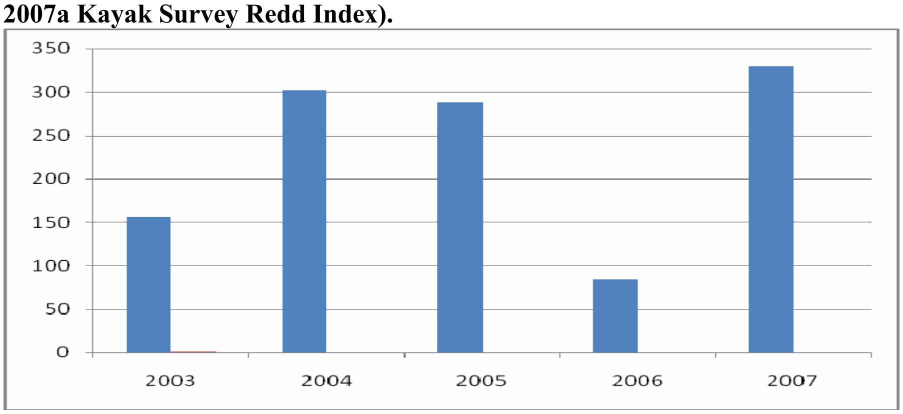


Figure 5-2. Clear Creek spring-run escapement 1993-2008 (CDFG data).

Table 5-1. Abundance of CV steelhead in Clear Creek from 2003-2007 based on 2 fish per redd. (USFWS 2007a Kayak Survey Redd Index).



5.1.3 Historical Conditions

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 represents 17 percent of the average flows in the Sacramento River (OCAP BA). However, since implementing the Trinity ROD flows in 2004, less water has been diverted from the Trinity River 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 (figure 5-3).

Releases are reduced to 80 cfs in the summer to install the fish barrier weir which separates spring-run from fall-run. The modeled releases do not change significantly between water years or between conditions today and in the future (figure 5-3). All modeled runs assume the use of b(2) water would continue into the future. In critically dry years modeled releases decrease 40 to 70 cfs from October through May, but would not be significant because they occur during the winter. Releases 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, low flows in June of 100 cfs are not expected to cause significant temperature related effects.

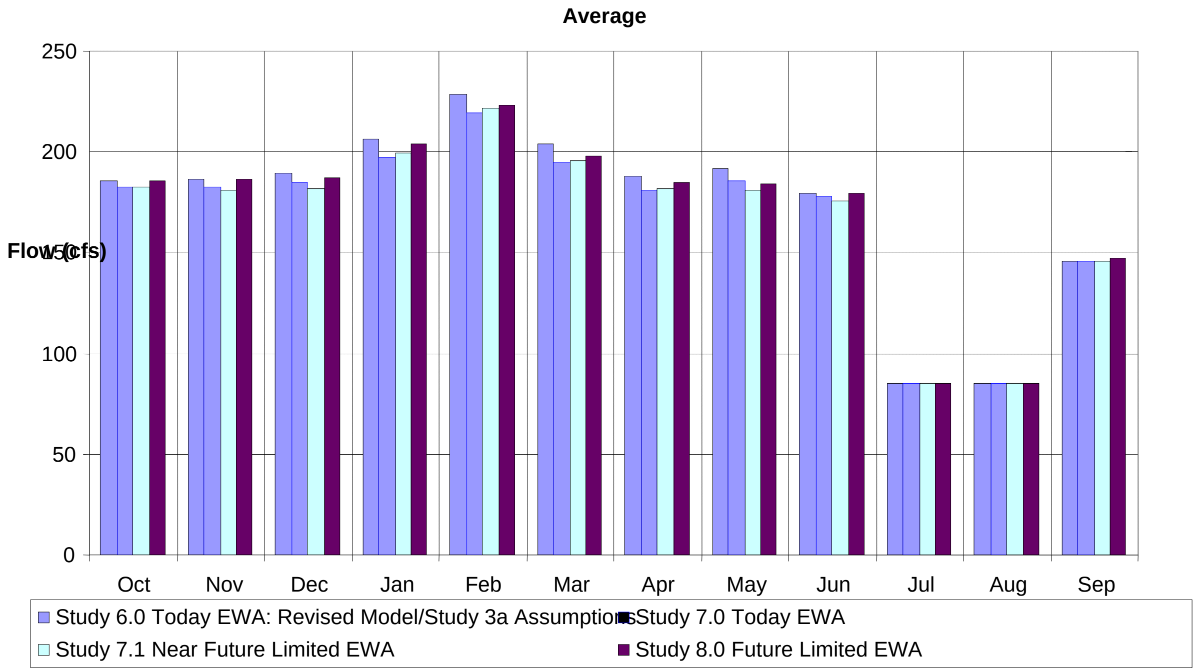


Figure 5-3. Clear Creek long-term average monthly flows as modeled in CALSIM 1923-2003 (OCAP BA figure 10-30).

The historic pre-Whiskeytown Dam hydrograph in figure 5-4 shows a much different flow pattern than the current hydrograph. 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).

5.1.4 Future Baseline Stress Regime Excluding CVP/SWP Effects

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 5-5). 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 OCAP Opinion). Flows that scour redds and mobilize gravel usually occur at 3,000 cfs or more (OCAP 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 before spawning starts (figure 5-6).

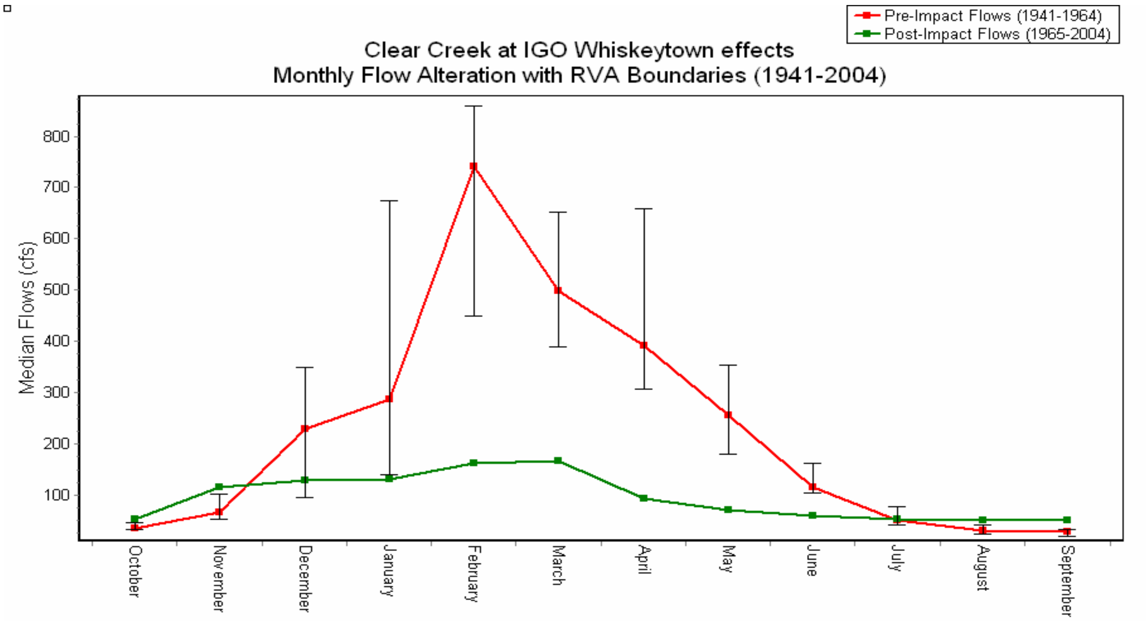


Figure 5-4. Clear Creek monthly flows comparing pre-Whiskeytown Dam (1941-1964) to post dam (1965-2004) flows. The vertical lines represent the range of variability analysis boundaries (OCAP BA figure 3-21).

5.2 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 5-7), and provides habitat for winter-run, spring-run, fall-run, late-fall run, CV steelhead, and Southern DPS of green sturgeon. Table 5-2 provides the life history timing of these species in the upper Sacramento River.

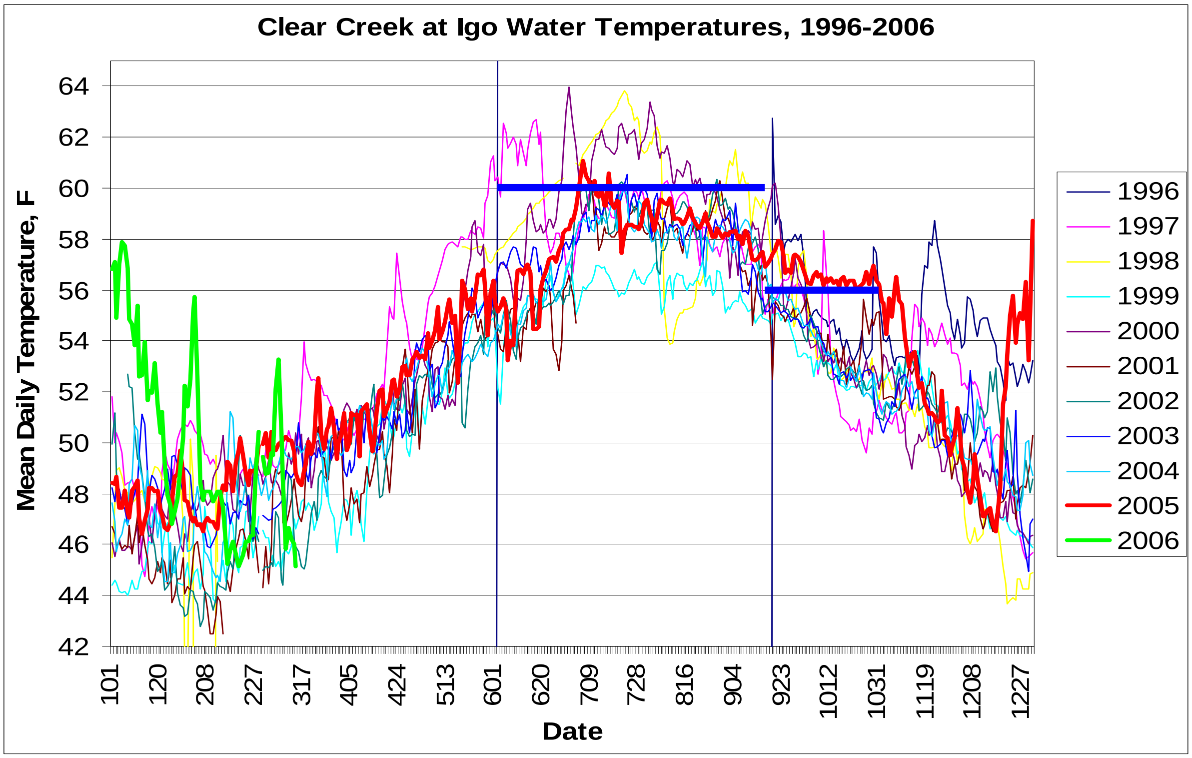


Figure 5-5. Clear Creek historical mean daily water temperatures 1996 – 2006. Note: temperature objectives implemented after 2004 OCAP Opinion.

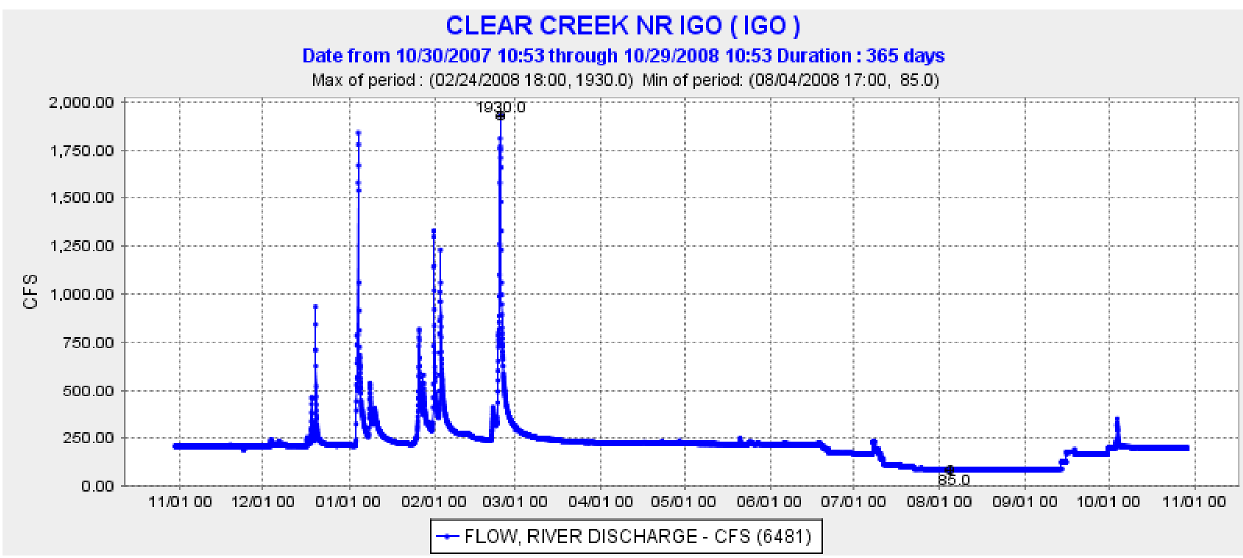


Figure 5-6. Clear Creek average daily flows measured at Igo gage 10/30/07 – 10/30/08 (CDEC data).

Table 5-2. 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

5.2.1 Winter-Run

The status of the winter-run salmon in the upper Sacramento River is typical of most endangered species populations. A sharp downward decline followed by a years of low abundance (figure 5-8). Winter-run are so close to becoming extinct that even random stochastic events common to small populations could extirpate the remaining adults in less than 3 years. 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 over turning could spill enough oil or contaminants to wipe out an entire year class. The winter-run population is completely dependent on coldwater releases from Shasta Dam in order to sustain the remnant population. In 1979, the population was over 200,000 adults, but today less than 3,000 return. A rapid decline occurred from 1967 to 1979 after completion of the RBDD (figure 5-8). Over the next 20 years, the population remained static and reached a low point in 1994 of only 186 adults. At that point, the run was basically extinct, 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 TCD on Shasta Dam, opening the RBDD gates, and restrictions in the ocean harvest, the population would fail to exist in the wild. In the last 8 years, the number of adults returning has steadily increased to 17,153 in 2006, and then fell sharply to 2,488 in 2007 (figure 5-8). The preliminary estimate of the winter-run in 2008 is 2,850 (CDFG 2008).

A conservation program at Livingston Stone National Fish Hatchery (LSNFH) located at the base of Keswick Dam annually supplements the in-river production by releasing on average 250,000 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.

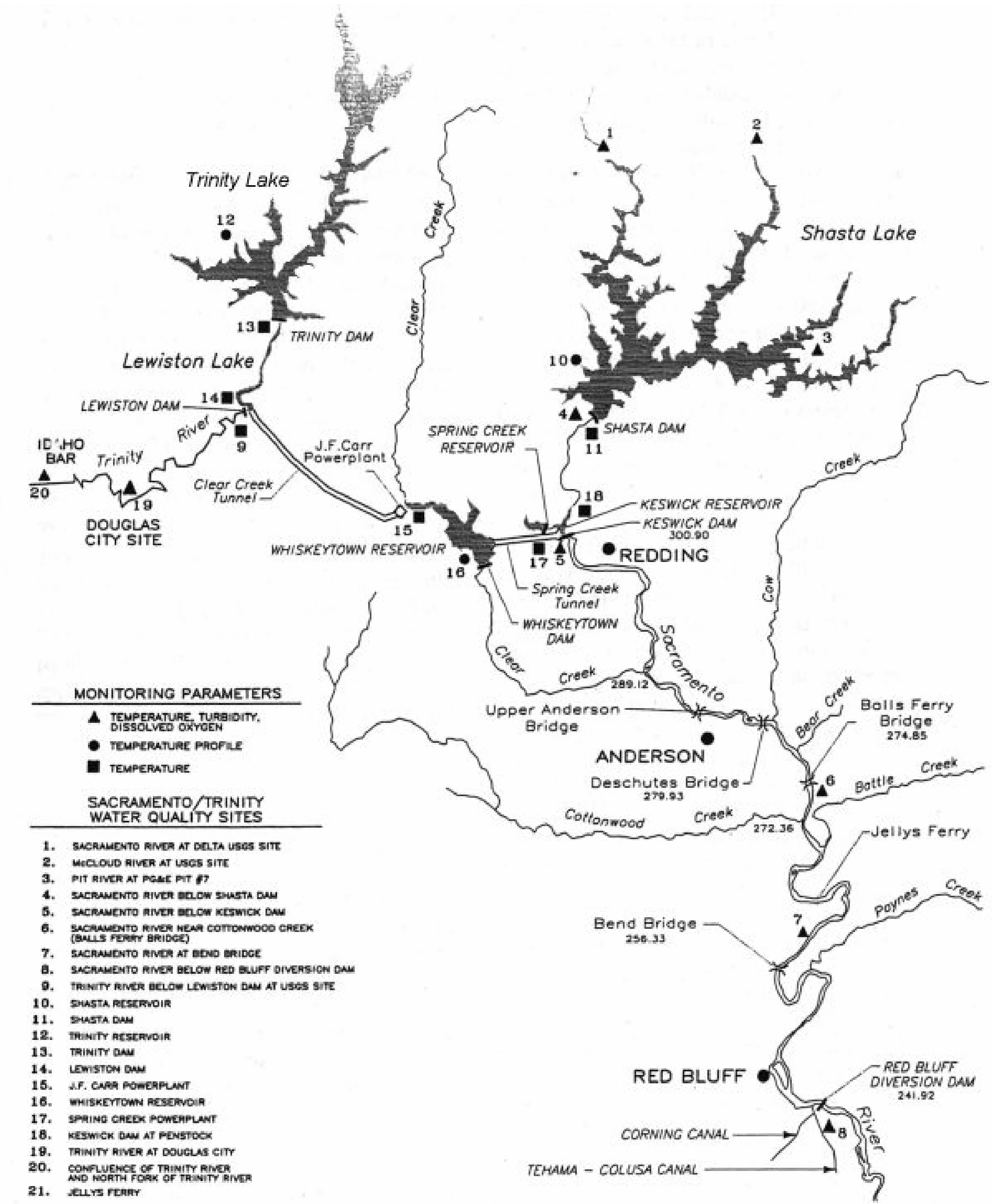


Figure 5-7. Map of the upper Sacramento River, including various temperature compliance points and river miles (OCAP BA figure 6-2).

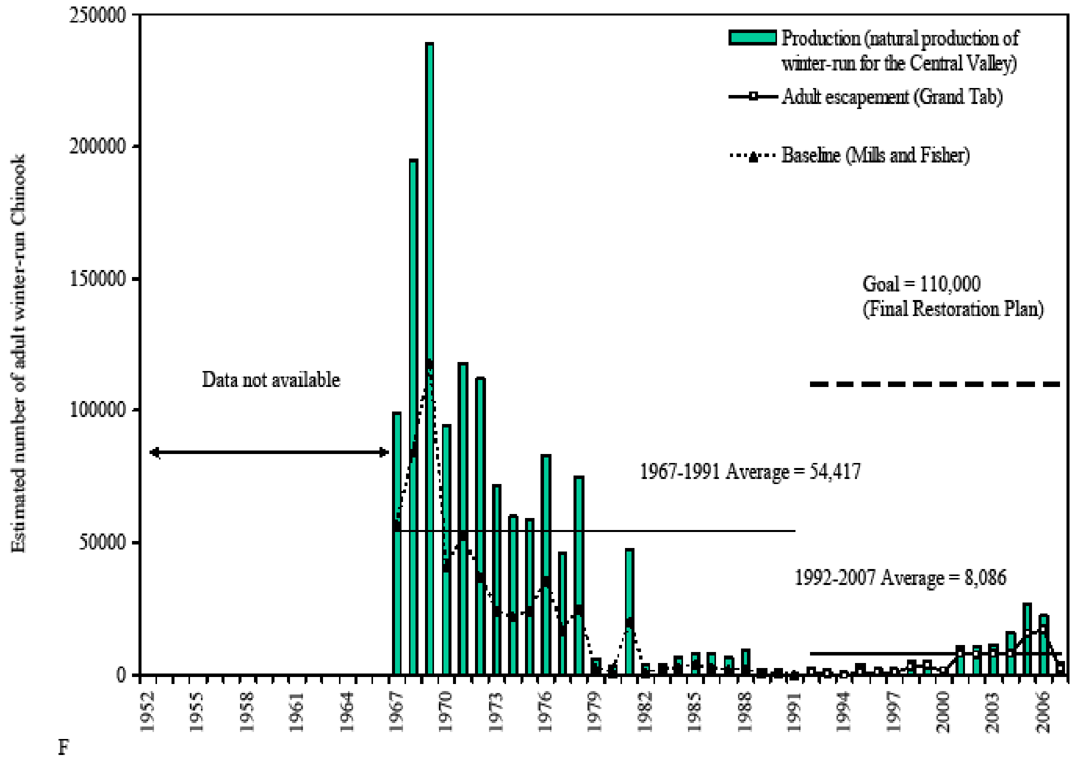


Figure 5-8. Estimated yearly adult natural production and in-river adult escapement of winter-run from 1967 - 2007 based on RBDD ladder counts (Hanson 2008[4]).

5.2.2 Spring-Run

The status of the spring-run population within the mainstem Sacramento River has declined from a high of 25,000 in the 1970s to the current low of less than 800 counted at RBDD (figure 5-9). Significant hybridization with fall-run has made identification of a spring-run in the mainstem very difficult to determine. There is speculation as to whether a true spring-run still exists 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.

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

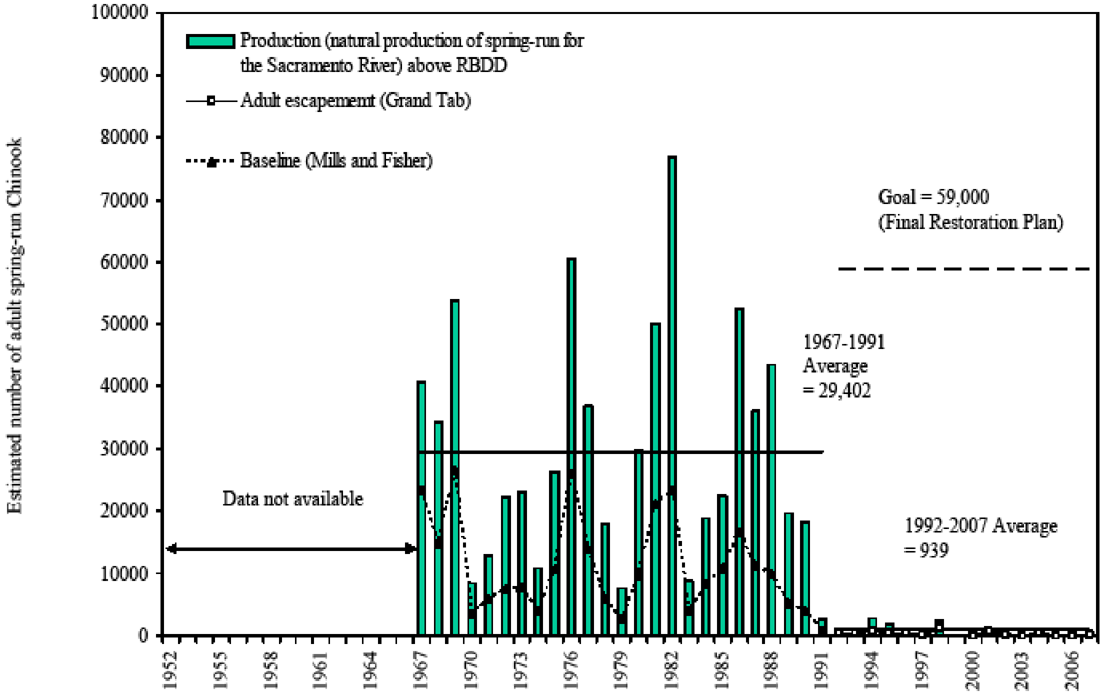


Figure 5-9. Estimated yearly spring-run escapement and natural production above RBDD (Hanson 2008).

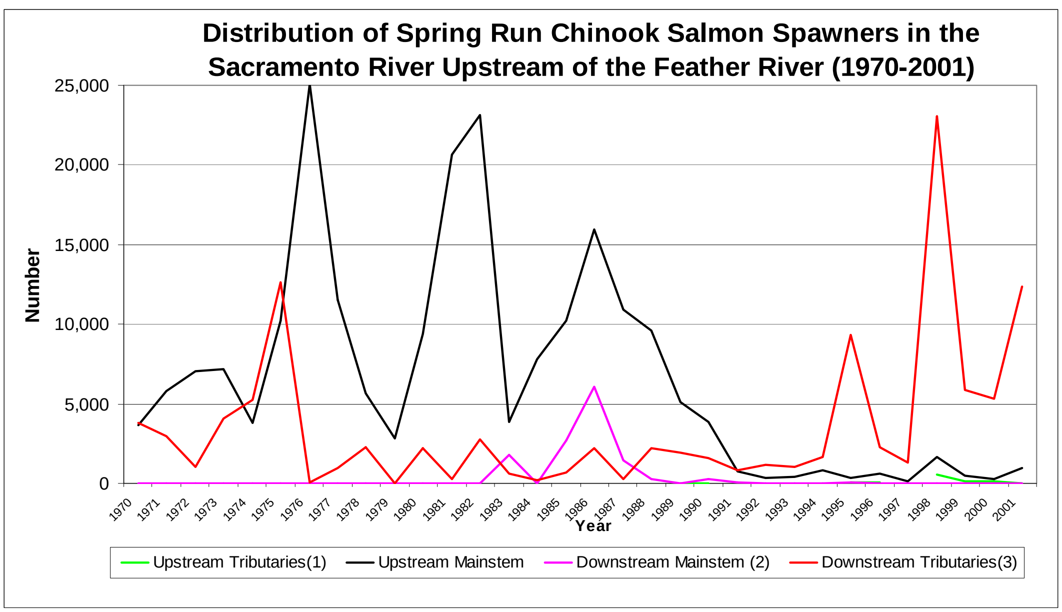


Figure 5-10. Distribution of spring-run above and below RBDD from 1970 -2001 (CDFG Grand Tab).

Since 2000, the spring-run counts at RBDD have fluctuated from years where zero 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 zero 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.

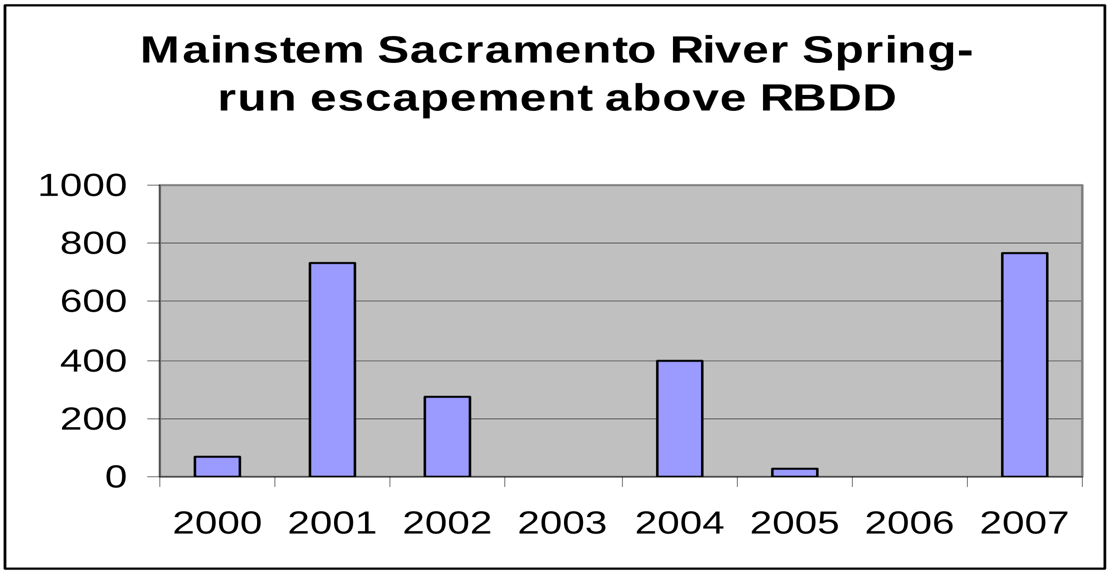


Figure 5-11. Spring-run escapement counted at Red Bluff Diversion Dam from 2000 – 2007 (CDFG GrandTab 2008).

5.2.3 CV Steelhead

Estimates of CV steelhead abundance in the mainstem Sacramento River typically use the RBDD counts for 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 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 (figure 5-12). CV steelhead passage above RBDD after 1991 can be estimated based on the average of the 3 largest tributaries (*i.e.*, Battle Creek, Clear Creek and Cottonwood Creek). The average of these tributaries for the last 14 years (1992 through 2005) is 1,282 adults, which represents a continuous decline from the 1967 through 1991 average RBDD count of 6,574 (figure 5-12). The decline in CV steelhead abundance is similar to winter-run and spring-run declines.

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-falls spawning in January. Since resident trout redds are smaller than steelhead redds and late-fall salmon 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 (Jim Hopelain per.com 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).

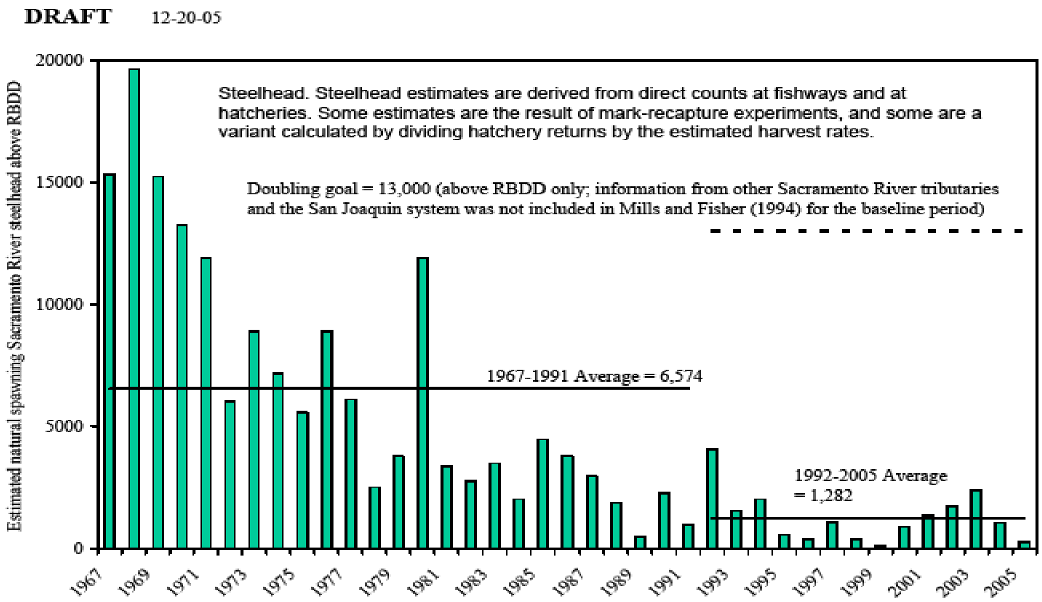


Figure 38. Estimated yearly number of natural spawning of steelhead on the Sacramento River, upstream of the RBDD (Mills and Fisher, 1994). Data for 1992-2005 is from CDFG, Red Bluff.

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).

5.2.4 Southern DPS of Green Sturgeon

The status of green sturgeon in the upper Sacramento River is unknown at this time. Population estimates are based on small sample sizes, intermittent reporting, and inferences made from white sturgeon catches. Population surveys have been conducted by CDFG in San Pablo Bay incidental to white sturgeon monitoring. The size of the green sturgeon population is estimated indirectly through a ratio of green sturgeon to white sturgeon caught in trammel nets. The estimates of sub-adult green sturgeon abundance ranged from 175 during 1993 to 8,421 during 2001.

The spawning migration begins in late February, with peak activity from mid-April to mid-June. 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). This type of behavior has been observed in spawning populations in other rivers. Post-spawn adults migrate downstream with the first significant increase in flows and turbidity following storm events.

During the spring and summer, the main processes influencing green sturgeon are in the freshwater environment (figure 5-13). Spawning requires sufficient instream flows for passage of reproductive adults and effective fertilization. Temperature, dissolved oxygen and suitable in-river habitats influence larval survival. Ecological processes and stressors begin to influence green sturgeon immediately during their first summer (figure 5-13). These stressors are cumulative to the impacts of temperature, salinity, and flow during green sturgeon's first fall and winter.

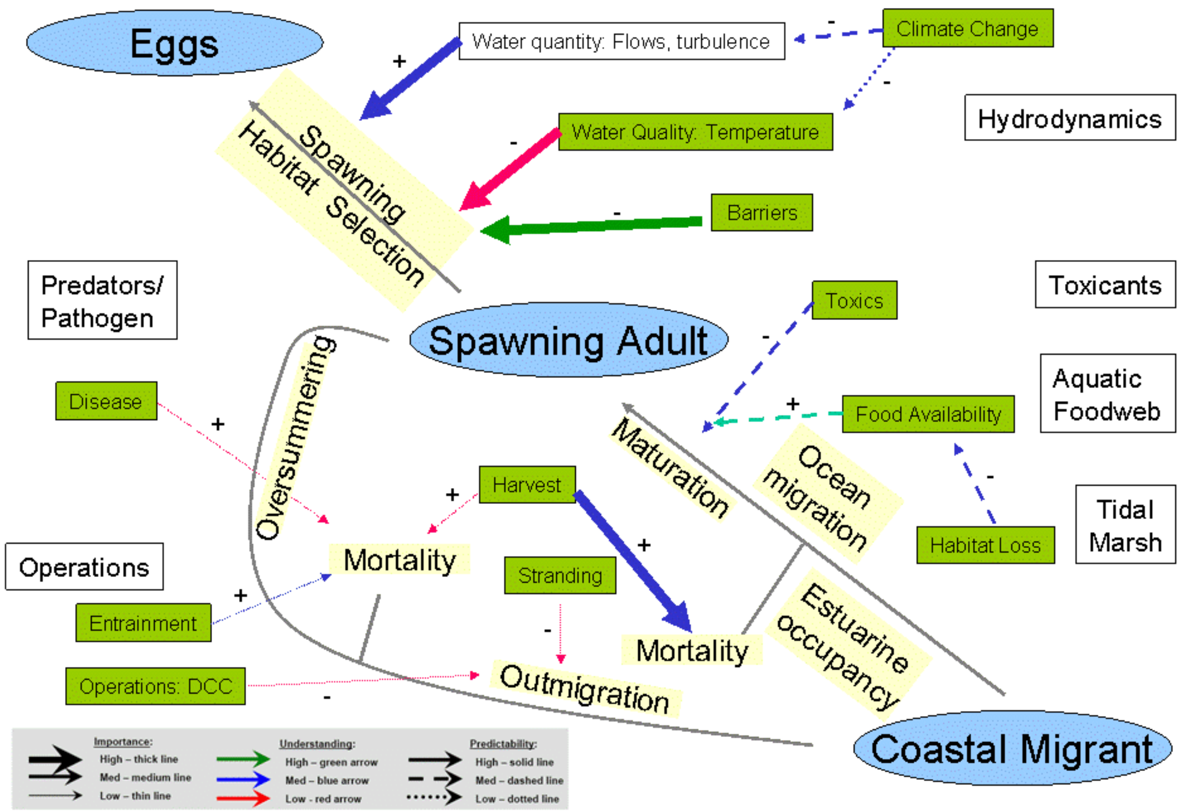


Figure 5-13. Green sturgeon conceptual life history: Coastal Migrant to Eggs Submodel (Israel and Klimley 2008).

Survival of eggs and larvae requires specific water quality parameters like temperature, dissolved oxygen, 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 are 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).

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). Rotary screw trap data from RBDD and GCID show a declining trend in juvenile production since the 1990s (figure 5-14). Recent data from RBDD indicate that very little production took place in 2007 and 2008 (13 and 3 respectively). 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 5-15). 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 young-of-the-year are small enough to be entrained in water diversions, although their benthic behavior likely limits this impact.

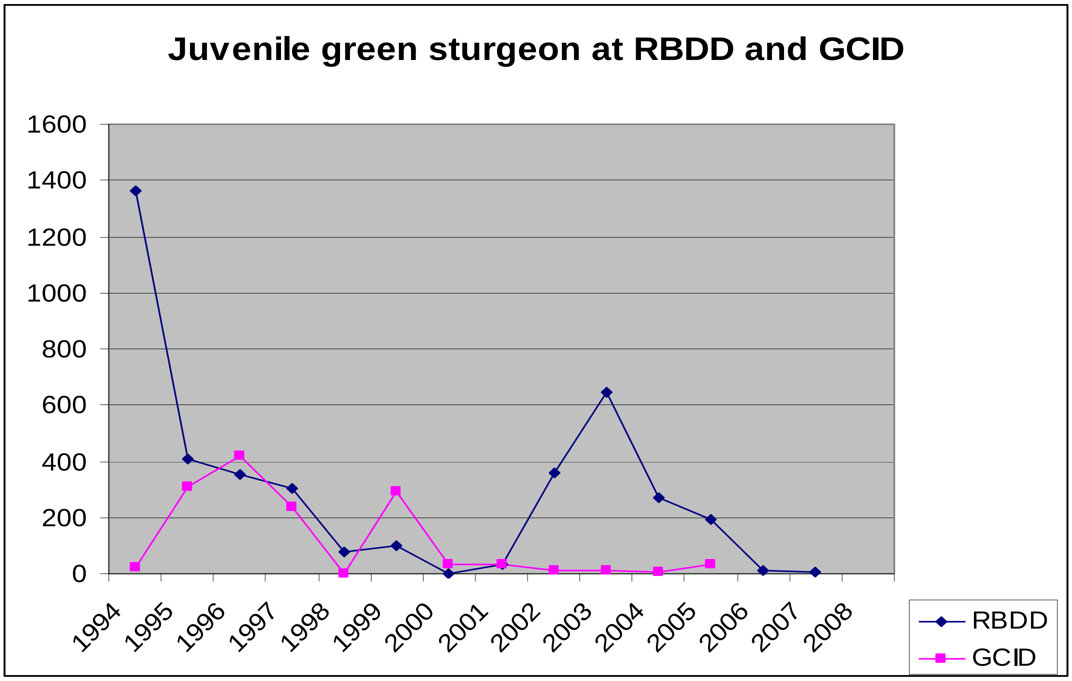


Figure 5-14. Rotary screw trap data of juvenile green sturgeon caught at RBDD and GCID from 1994-2008 (OCAP BA).

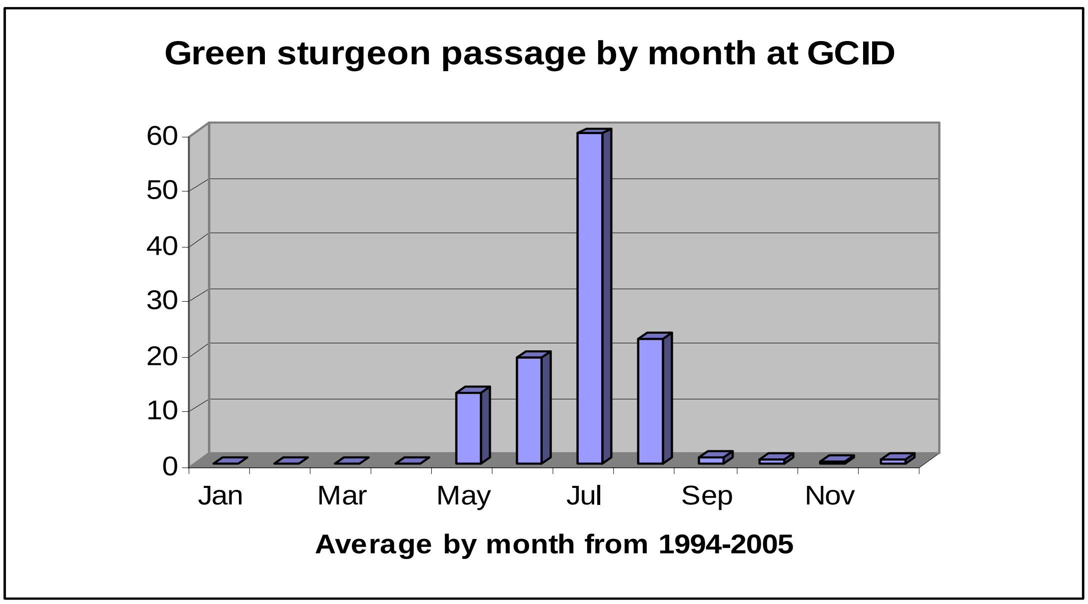


Figure 5-15. Juvenile green sturgeon average catch by month at GCID (1994-2005, OCAP BA).

5.2.3 Historical Conditions

The historical pre-Shasta Dam hydrograph shows a much different flow pattern than the current hydrograph (figure 5-16). Average monthly flows decreased 25 percent in the winter/spring (16,000 cfs to 12,000 cfs), and increased 58 percent during the summer/fall (5,000 cfs to 12,000 cfs).

The current hydrograph shows reduced springtime flows and much higher summer flows. This pattern is necessary to support winter-run and green sturgeon spawning, since Shasta Dam blocked access to historical cold-water springs in the upper McCloud River. Releases of water for irrigation and other Project purposes are also timed to occur during summer months when demand is high. This dual purpose is practical (because it provides benefits to both listed species and water users), but ecologically unsound because it prevents riverine processes and natural succession of riparian communities. 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.

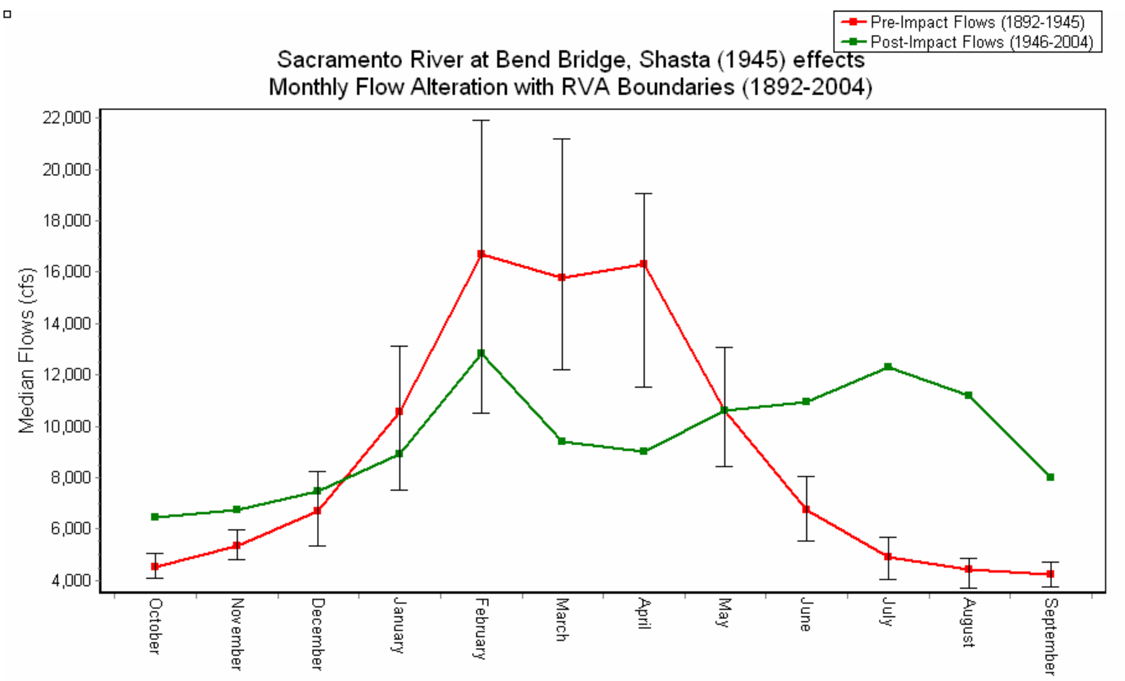


Figure 5-16. Sacramento River at Bend Bridge monthly flows comparing pre-Shasta Dam (1892-1945) and post Shasta (1946 -2004) flows. Vertical lines represent the range of variability analysis boundaries (OCAP BA figure 3-20).

5.2.4 Future Baseline Stress Regime 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 green sturgeon). These fish are subjected to a host of baseline stressors to which the project effects are added (figure 5-17). In the freshwater environment baseline stressors include: a loss of 80-90 percent of the historical spawning and rearing habitat (100 percent for winter-run), altered flow patterns, water diversions, fish hatcheries, agricultural return flows, contaminants (pesticides and herbicides), bank stabilization (rip rap, armoring, revetment), river narrowing, less variability in flows, less variability in aquatic habitat, less channel complexity, less food production, less cover and shelter, gravel mining activities, increased predation (pike minnow, smallmouth bass, stripped bass), competition from introduced species better suited to regulated rivers, loss of large woody debris, loss of shaded aquatic habitat, urbanization, increased population growth, reduced resources (water) due to competing demands, increased risk from catastrophic events (oil spills, forest fires, landslides, *etc*.), and climate change. In the estuarine environment baseline stressors include: a loss of 94 percent of the historical marsh habitat essential for growth and rearing, dredging, pile driving, proliferation of boat docks and marinas, river deepening and channelizing, sand mining, predation (striped bass, largemouth bass), introduced invasive species, and exposure to harmful contaminants (selenium, copper, ammonia, wastewater treatment effluent). In the ocean environment baseline stressors include: commercial and sport harvest, predation (seals, killer whales), pollution from surface runoff, variable ocean productivity, and climate change to name a few. Some of these stressors 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. Some delay growth or ocean entry reducing survival rates.

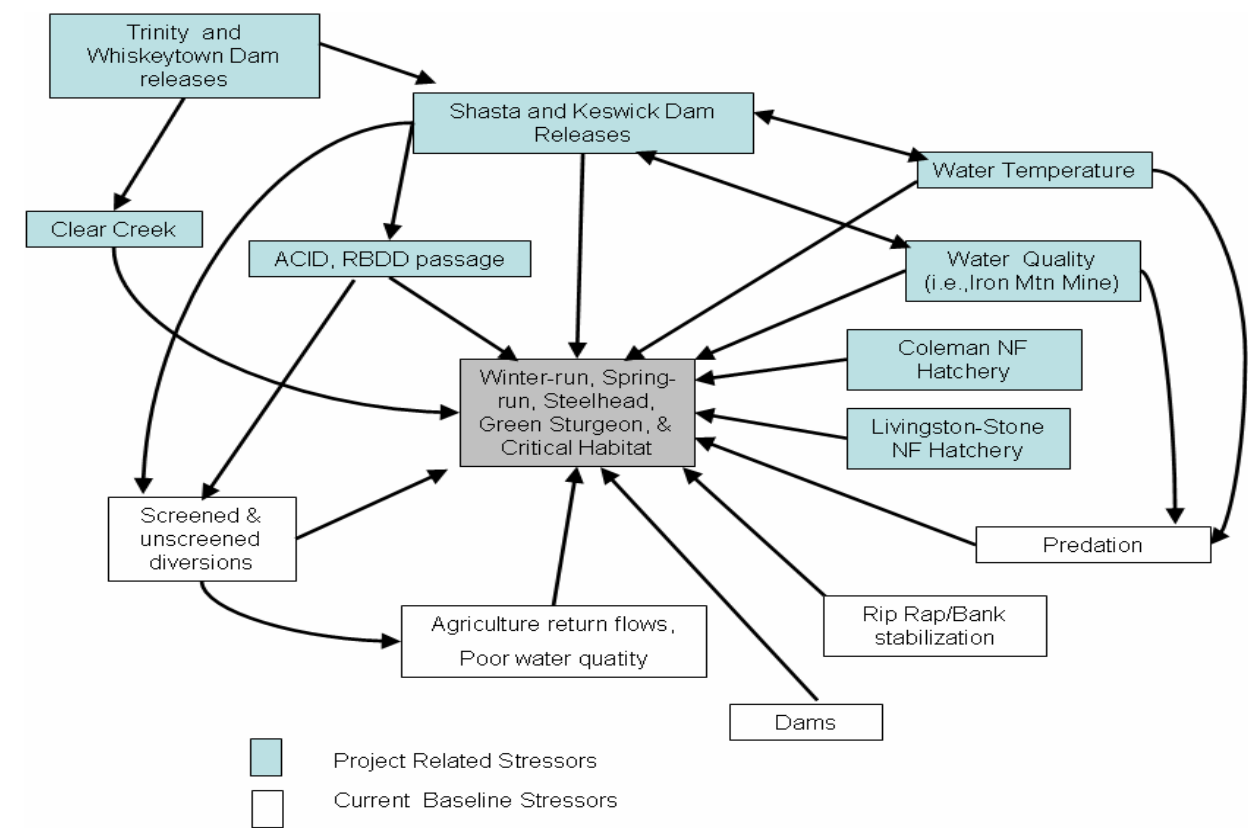


Figure 5-17. Conceptual model of current baseline and project-related stressors on listed species in the mainstem Sacramento River.

The upper Sacramento River is the only spawning area used by winter-run in the Central Valley, although occasional strays have been reported in Battle Creek and Clear Creek. Since fish passage was improved in 2001 at the ACID diversion 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. 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 allow salmonids to pass upstream, but completely block green sturgeon.

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

5.3.1 CV Steelhead

The American River is a tributary to the Sacramento River (figure 5-18) and provides habitat for 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 are available for two years during the early 1970s (Staley 1976), for three years in the early 1990s (Water Forum 2005a), and from 2002 through 2007 (Hannon and Deason 2008). Using wire fyke traps to capture and mark fish, Staley (1976) estimated the abundance of in-river steelhead to be 19,583 during the 1971/1972 run and 12,274 during the 1973/1974 run. A bimodal length frequency of steelhead captured in the traps suggests that a proportion of resident (*i.e.*, non-anadromous) *O. mykiss* may have been included in the steelhead population estimates reported in Staley (1976). The smaller mode was centered at about 16 inches, potentially representing non-anadromous *O. mykiss*, and the larger mode was centered at about 26 inches, suggesting a phase of marine growth. About 50 percent of the *O. mykiss* were greater than about 22 inches. Despite the potential influence of resident *O. mykiss* in Staley's estimates, it is apparent that the abundance of steelhead spawning in the river has substantially declined since the early 1970s based on recent estimates reported in Water Forum (2005a) and Hannon and Deason (2008, figure 5-19).

Run size estimates of 305, 1,462 and 255 naturally spawning steelhead for the 1990/1991, 1991/1992 and 1992/1993 spawning seasons, respectively, were reported in 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 480[5] (Hannon and Deason 2008). That is, 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

[5] Population abundance was estimated based on redd survey data and an assumed number of redds per female. The low population estimate of about 160 in 2005 was made assuming each female spawned using two redds, whereas the high population estimate of about 480 in 2003 was made assuming 1 redd per female.

Nimbus Hatchery (Water Forum 2005a). 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.

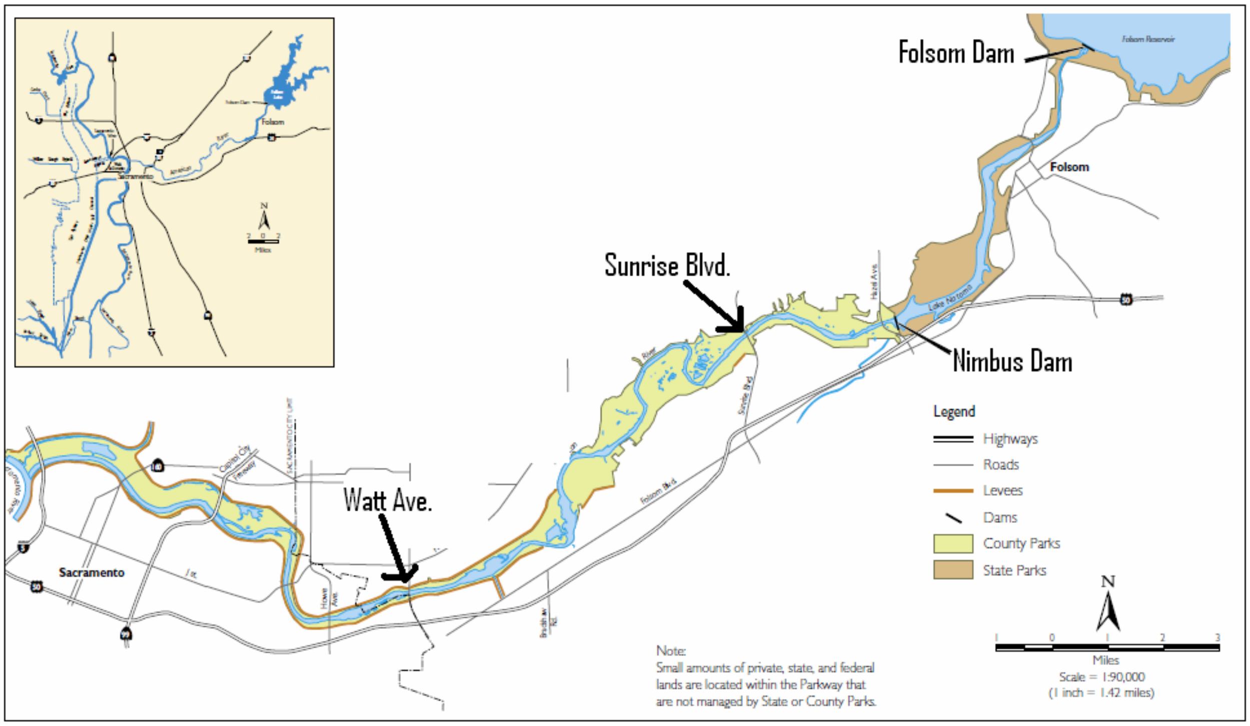


Figure 5-18. Map of lower American River. Modified from Water Forum (2005a).

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 loss 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 the section titled *Assess Species Response.*

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.

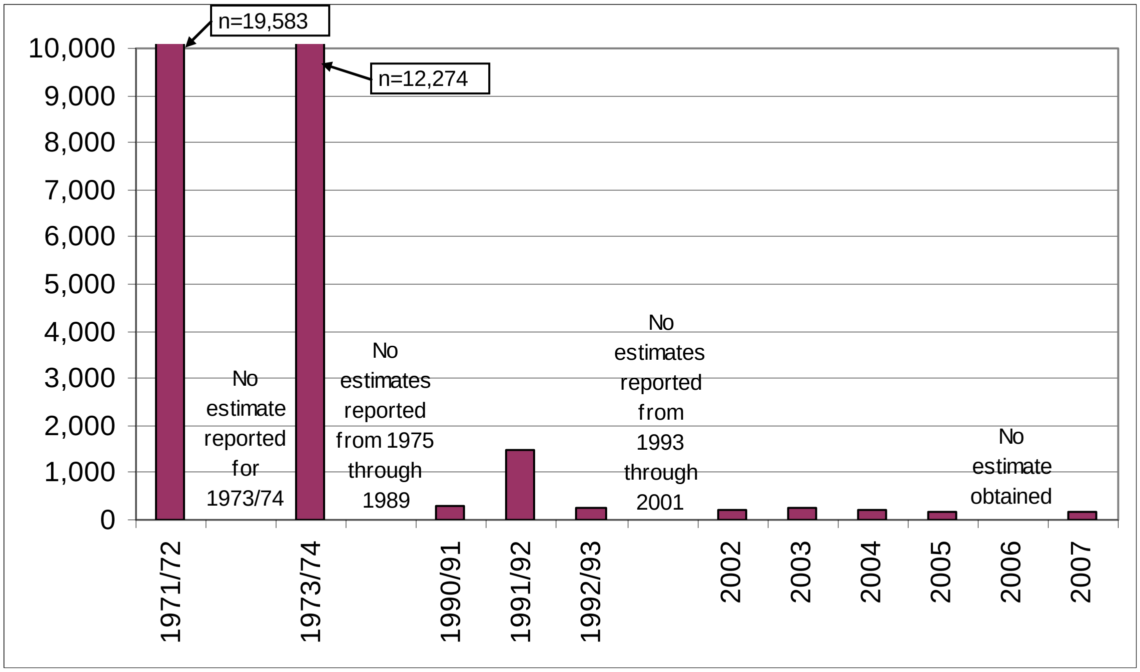


Figure 5-19. Population estimates of steelhead spawning in the lower American River. Estimates for 1971/72 and 1973/74 were generated using a mark-recapture procedure (Staley 1976), estimates from the early 1990s were reported in Water Forum (2005a), and estimates for 2002 through 2007 were obtained through redd survey monitoring assuming each female steelhead had two redds (Hannon and Deason 2008).

5.3.2 Historical Conditions

The following discussion on the historical condtions in the American River watershed was derived from Gerstung (1971), Yoshiyama *et al*. (1996), and SWRI (2001). Details and extensive discussions are available in Gerstung (1971) and Yoshiyama *et al.* 1996, whereas SWRI (2001) presents a concise summary of those discussions.

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)*."

SWRI (2001) provided a concise summary of dam construction and related habitat elimination in the American River:

"*In 1895 Old Folsom Dam, a 68-ft. high power dam, was constructed about 27 miles upstream from the mouth of the American River and prevented anadromous salmonids from reaching the forks of the river. Although a fish ladder was built for Old Folsom Dam in 1919, an effective fish ladder was not built until 1931 (Sumner and Smith 1940; Gerstung 1971). Thus, anadromous salmonids were virtually restricted to the lower 27 miles of the American River from 1895 through 1931.*

In 1899 the North Fork Ditch Company constructed a 16-ft. high dam on the North Fork American River near Auburn, located a few miles downstream of the confluence with the Middle Fork American River. Although a rock chute fishway was built for the dam in 1912 that may have allowed passage for steelhead, it did not provide effective passage for salmon (Sumner and Smith 1940; Gerstung 1971).

In 1939 the 140-ft. high North Fork Debris Dam was constructed on the North Fork American River about two miles upstream of the confluence with the Middle Fork American River. Anadromous salmonid passage facilities were not provided, and this impassable barrier eliminated anadromous salmonid access to the North Fork American River (Sumner and Smith 1940)."

Between 1944 and 1947, annual counts of summer-run steelhead passing through the fish ladder during May, June, and July at Old Folsom Dam (RM 27) 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 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.

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. In addition, 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).

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 5-20).

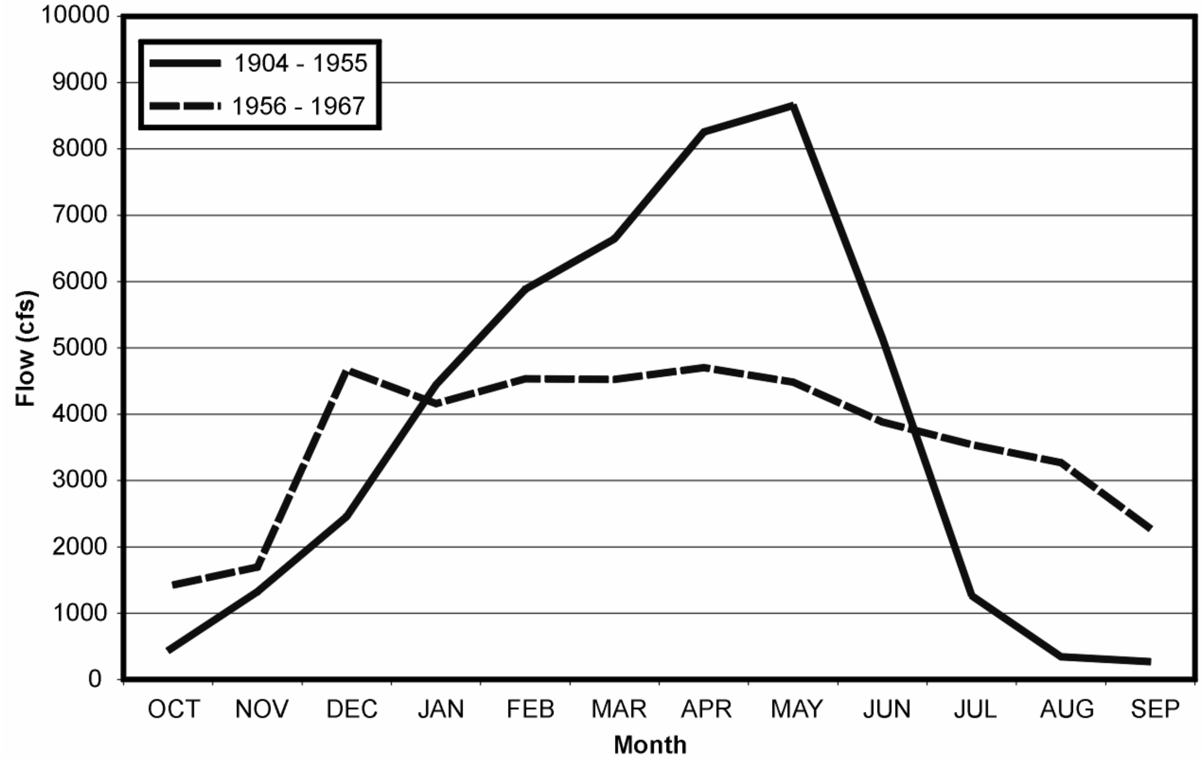


Figure 5-20. Mean monthly flow of the lower American River at the Fair Oaks gage (1904-1955) and after (1956-1967) operation of Folsom and Nimbus Dams (Gerstung 1971).

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 5-21). 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 21 is from the Fair Oaks gage in the lower part of the river, thus, although summer water temperatures are cooler in the lower river after 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.

5.3.3 Future Baseline Stress Regime excluding CVP/SWP Effects

Excluding stressors resulting from American River Division operations, current 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.

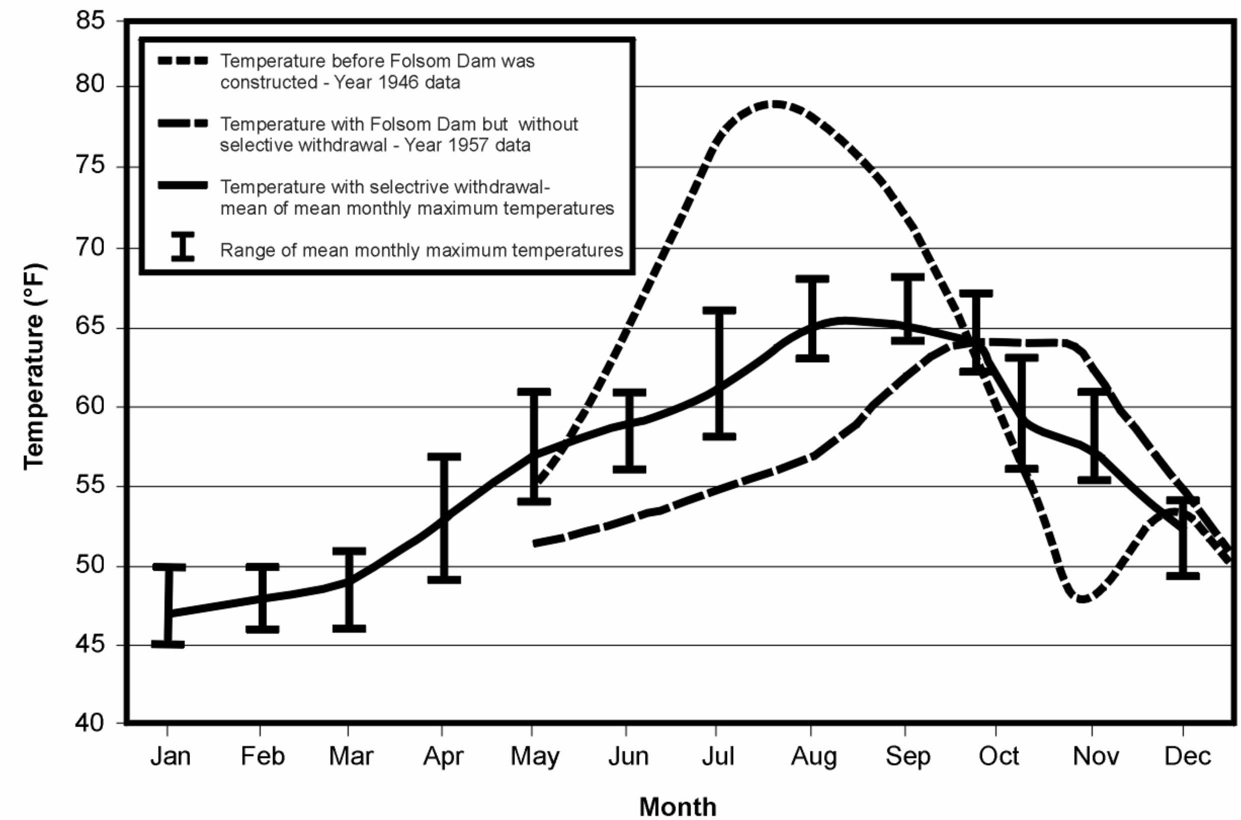


Figure 5-21. Water temperatures recorded at the Fair Oaks gage on the lower American River prior to and after construction of Folsom and Nimbus Dams (Gerstung 1971).

The proposed action includes the operation of Folsom and Nimbus Dams. 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. The following discussion on the habitat alterations in the American River watershed was directly taken 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.

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. Modification of river flows resulting from the operation of Folsom Dam and Reservoir has likely affected the potential for regeneration of cottonwood. Flows that had historically occurred during the seed dispersal period for cottonwood shifted from the late spring/early summer to late summer or no longer occur. Also, artificial flow fluctuations can cause the stranding of fish in ponds and depressions on the floodplain when high flows recede.

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).

5.4 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 5-22). 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.

5.4.1 CV Steelhead

CV steelhead is the only anadromous ESA-listed species that occurs in the Stanislaus River, and 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 Rivers, and Calaveras, are the only remaining representatives of the San Joaquin River diversity group of the Central Valley steelhead DPS. 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 on these rivers in tailwater conditions controlled by the dams. 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 in the tributaries suggest that existing populations of CV steelhead on the Stanislaus, Tuolumne, Merced, 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 out migration flows. Zimmerman *et al.* (2008) have documented CV steelhead in the Stanislaus, Tuolumne and Merced Rivers based on otolith microchemistry.

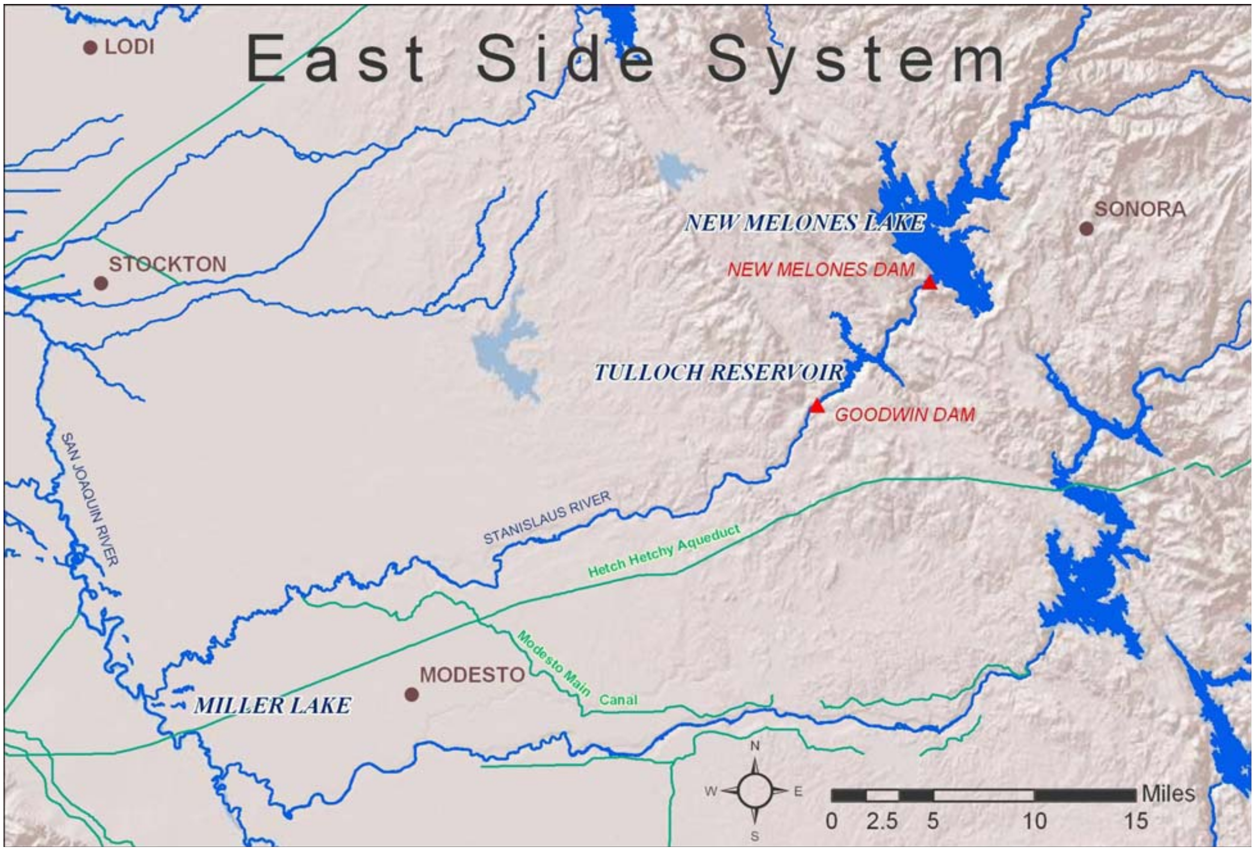


Figure 5-22. Map of the East Side Division (OCAP BA figure 2-10).

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 2005).

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. Steelhead migrate during the winter and spring of the year, as juveniles, from the rearing areas described above 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.

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 4-4).

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 5-22.

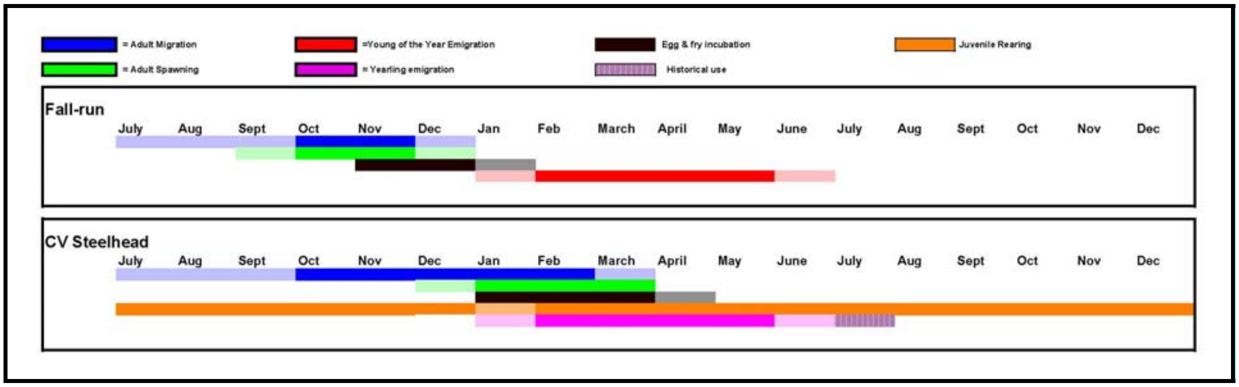


Figure 5-23. Temporal occurrence of fall-run and steelhead in the Stanislaus River, California. Darker shading indicates peak use.

Construction of Goodwin Dam in 1912 has excluded steelhead from one hundred 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 current draft recovery plan calls for reintroduction of steelhead above New Melones Dam, but no changes in critical habitat have yet been proposed.

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 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 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.

5.4.2 Historical Conditions

The unimpaired hydrograph of the Stanislaus River followed the pattern of low flows at the end of the summer, increasing flows in 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 5-3). 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.

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 on 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.

5.4.3 Future Baseline Stress Regime Excluding CVP/SWP Effects

Excluding stressors resulting from East Side Division operations, 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.

Table 5.3. 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 proposed action includes the operation of Goodwin, Tulloch and New Melones Dams. 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). Goodwin Dam was completed in 1912, blocking steelhead and spring-run from all of their historic spawning habitat in the Stanisalus 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 (Yoshiyama *et al*. 1996). Presently, expression of steelhead diversity in the lower Stanislaus River is constrained by water operations from senior water rights holders, senior to the CVP and SWP and D-1641 water quality standards. Lindley (2006) also suggests 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."

Loss of natural river function and morphology is a major stressor to the aquatic resources of the Stanisalus 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 large woody debris in the river that are used by fish and other species. 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.

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 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 CWA section 303(d) list], although it is not clear how much of that contaminant is present in the biologically active methylated form.

Water temperature can be a stressor in the Valley floor segments of the rivers of the San Joaquin Basin, particularly in summer months. On the Stanislaus River, flow releases required to meet D-1641 water quality standards at Ripon typically result in water temperatures of 65ºF or lower at Orange Blossom Bridge until September. In past practice, Reclamation has often proposed to reduce flows at that time, to as low as 100 cfs and CDFG and the federal fishery agencies have negotiated for acquisition of additional water for fish needs through b(3) or from CDFG fish agreement flows, if available.

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

5.5.1 Occurrence of Species in the Delta

The Sacramento-San Joaquin Delta 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 retuning to the ocean as juveniles or post-spawn adults (for steelhead and green sturgeon, figure 5-24). 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.

5.5.1.1 Temporal Occurrence

Figure 5-25 provides the temporal distribution of listed anadromous fish species within the Delta.

5.5.1.1.1 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 (Reclamation 2008; 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 late 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.

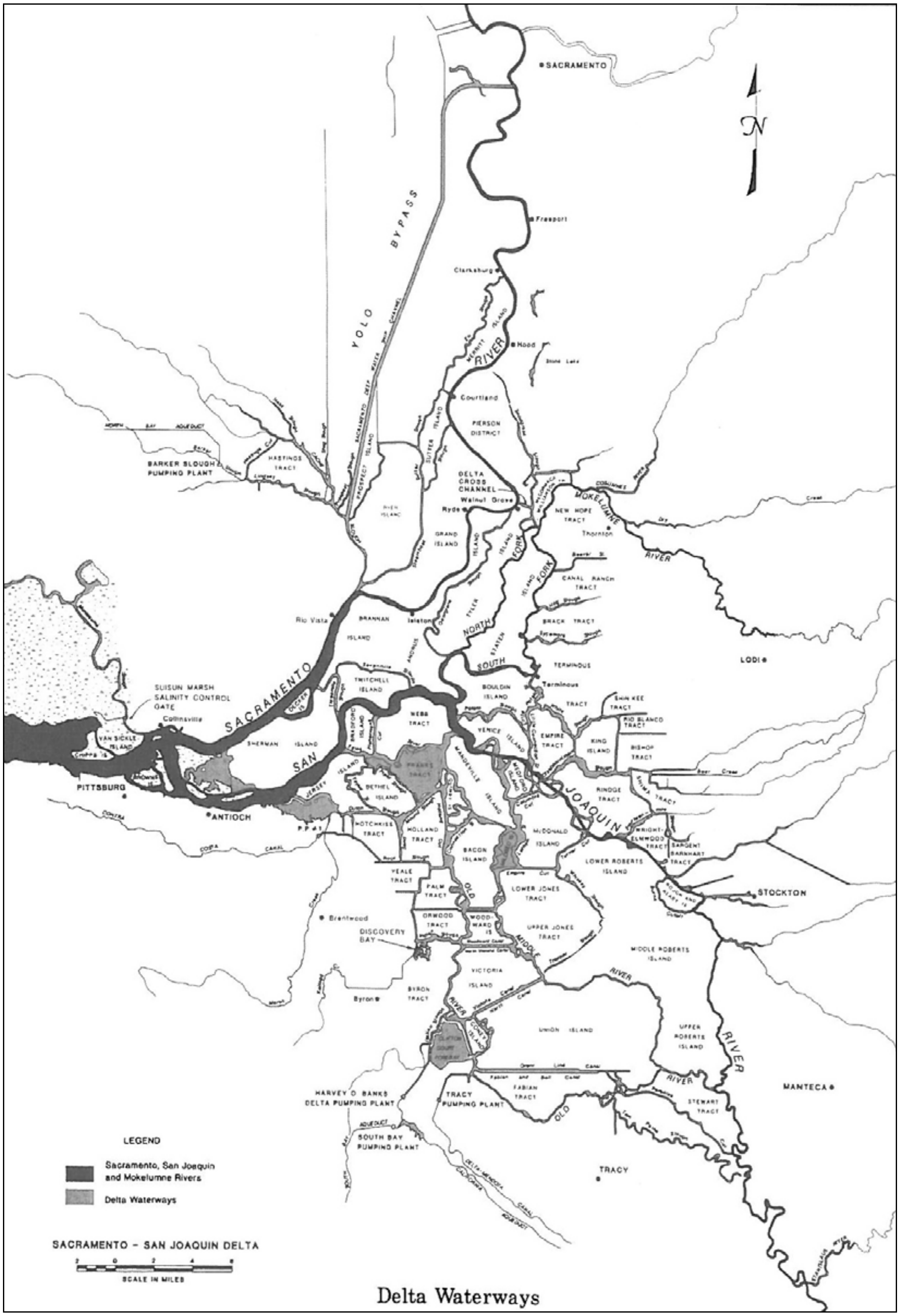


Figure 5-24. Map of Delta waterways.

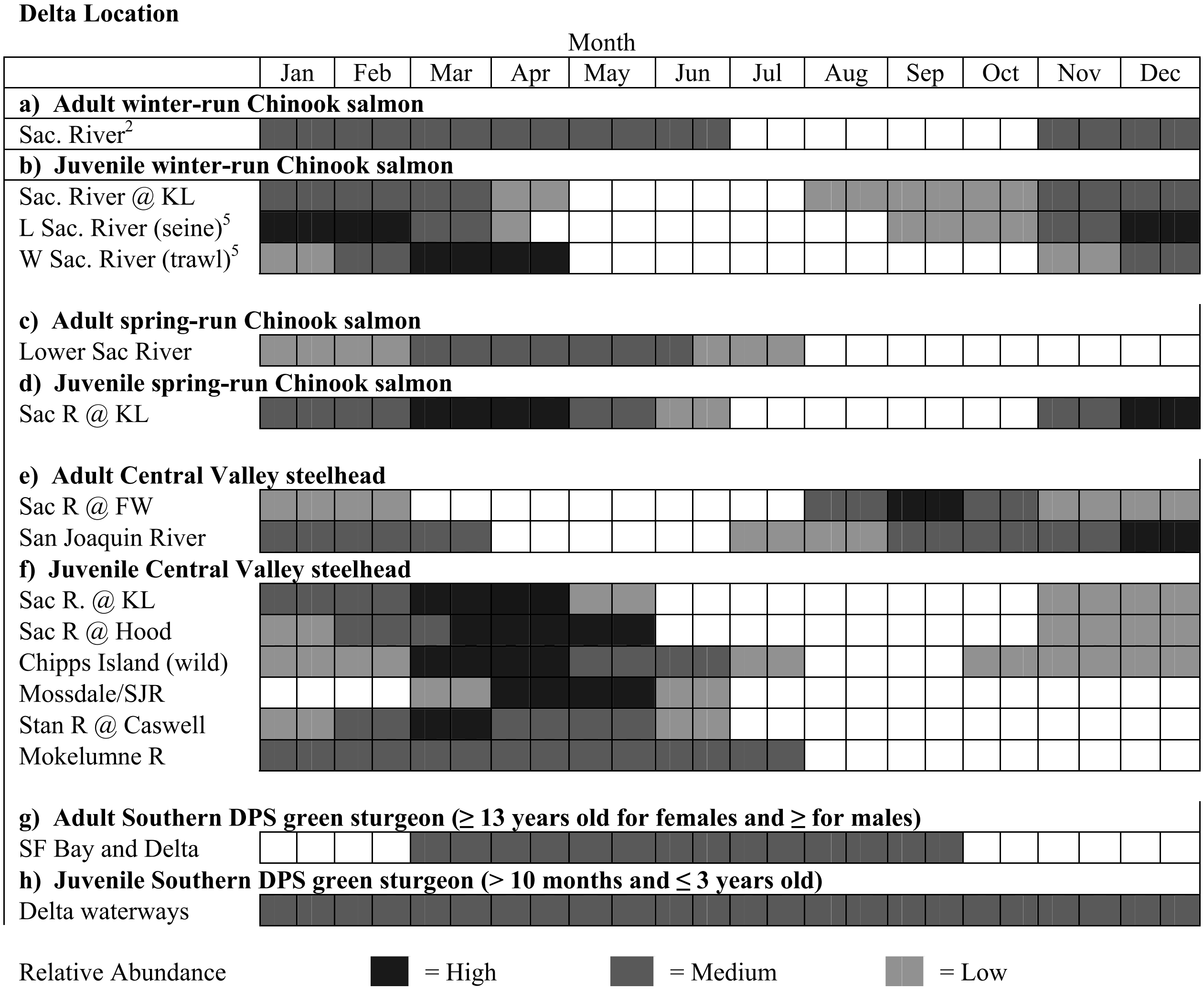


Figure 5-25. Temporal distribution of anadromous fish species within the Delta (KL = Knights Landing, FW = Fremont Weir).

5.5.1.1.2 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. 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.

5.5.1.1.3 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. Runbacks 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 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.

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 2001, Reclamation 2008). 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 (Reclamation 2008, Nobriga and Cadrett 2001).

5.5.1.1.4 Southern DPS of Green Sturgeon

Adult green sturgeons 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, Kelley *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 in 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.

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. Sub-adults are believed to reside year round in these estuaries prior to moving offshore as adults.

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. 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.

5.5.1.2 Spatial Distribution

5.5.1.2.1 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. 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.

Juvenile winter-run emigrants are susceptible to being "carried" into the Central and South Delta by the flow splits through the DCC (when open), Georgiana Slough, Three Mile Slough, and Broad Slough (confluence of the San Joaquin River with the Sacramento River) and subsequently being entrained by the effects of pumping at the CVP and SWP once entering the Central Delta. Fish that move into the DCC from the Sacramento River during the "open" periods in November, December and January, enter Snodgrass Slough and thence the Mokelumne River system. The Mokelumne River splits into northern and southern forks near Dead Horse Island and flows to either side of Staten Island before rejoining at the island's southwestern tip. Georgiana Slough connects with the Mokelumne River just downstream of the Staten Island confluence. The Mokelumne River system empties into the San Joaquin River mainstem approximately 3 miles downstream from the Georgiana Slough confluence at river mile 22 (RM 22) of the San Joaquin River. The mouth of the Mokelumne River is in close proximity to the mouth of Old River (RM 23) and Middle River (RM 26), through which water is conveyed towards the CVP and SWP pumping facilities in the South Delta. A substantial tidal oscillation exists in this portion of the San Joaquin River system, on the order of 3 to 5 miles, which carries fish exiting the Mokelumne River into the zone of entrainment created by the CVP and SWP water diversions in the south.

The percentages of juvenile winter-run that are carried into the channels leading off of the Sacramento River are a function of the flows in the mainstem of the Sacramento River, fish behavior at the splits, ambient light levels, and tidal conditions (Vogel 2004, 2008; Horn and Blake 2004). Delay of migration through the Delta interior channels and the eventual disposition of the fish are dependent on river flows in the San Joaquin River basin, tides, pumping rates at the CVP and SWP, and other indirect effects, such as predation, water quality, and agricultural diversions (Vogel 2004, 2008; Kimmerer and Nobriga 2008). Recovery of hatchery-reared winter-run at the CVP and SWP fish collection facilities indicate that any fish originating in the Sacramento River basin has the potential to be entrained at the pumps.

In summary, 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 waterways (Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island), South Delta waterways 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 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.

5.5.1.2.2 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 rout 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.

Like winter-run juveniles, spring-run juveniles are also susceptible to being carried into the waterways of the Central and South Delta by the flow splits encountered on the Sacramento River when passing one of the aforementioned channel mouths. If fish survive passing through the interior of the Central Delta, they can subsequently be entrained by the effects of pumping at the CVP and SWP after entering the San Joaquin River within the vicinity of Old and Middle Rivers.

The percentages of juvenile spring-run that are carried into the channels leading off of the Sacramento River are a function of the flows in the mainstem of the Sacramento River, fish behavior at the splits, ambient light levels, and tidal conditions (Vogel 2004, 2008; Horn and Blake 2004). Delay of migration through the Delta interior channels and the eventual disposition of the fish are dependent on river flows in the San Joaquin River basin, tides, pumping rates at the CVP and SWP, and other indirect effects, such as predation, water quality, and agricultural diversions (Vogel 2004, 2008; Kimmerer and Nobriga 2008). Recovery of fin clipped hatchery-reared and coded wire tagged (CWT) spring-run at the CVP and SWP fish collection facilities indicate that any fish originating in the Sacramento River basin has the potential to be entrained at the pumps.

In summary, juvenile spring-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 waterways (Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island), South Delta waterways 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 any significant numbers of juvenile spring-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.

5.5.1.2.3 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 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 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.

Recoveries of fin-clipped steelhead smolts at the CVP and SWP fish collection facilities from the different steelhead hatcheries in the Central Valley indicate that any steelhead smolt originating in the Central Valley has the potential to be entrained into the South Delta under the influence of the state and Federal water diversion projects. 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.

5.5.1.2.4 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 sturgeons 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. The juveniles are believed to inhabit the waters of the Delta for the first 3 years of their life before moving out to the ocean.

5.5.2 Delta Environmental Status

The diversion and storage of natural flows by dams and diversion structures on Central Valley watersheds has depleted stream flows in the tributaries feeding the Delta 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 DO levels, and decreased recruitment of gravel and LWD. More uniform flows year round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation (Mount 1995).

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 Chinook salmon survival in the Sacramento River is also directly related with 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 as well as in the maze of Delta waterways surrounding the intensively farmed islands within the legal Delta boundaries. 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 the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the 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 predation problems in Clifton Court Forebay; and (4) increased exposure to large populations of 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.

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of armored levees to increase channel flood capacity 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 escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

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 other 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 bar 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, PAHs, and other organics and nutrients [California Regional Water Quality Control Board-Central Valley Region (Regional Board) 1998) they can potentially destroy aquatic life necessary for salmonid survival (NMFS 1996a, b). PS and 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.

5.5.2.1 Delta Hydrodynamics

5.5.2.1.1 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 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 5-26 and 5-27), 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 5-27 and 5-28). 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).

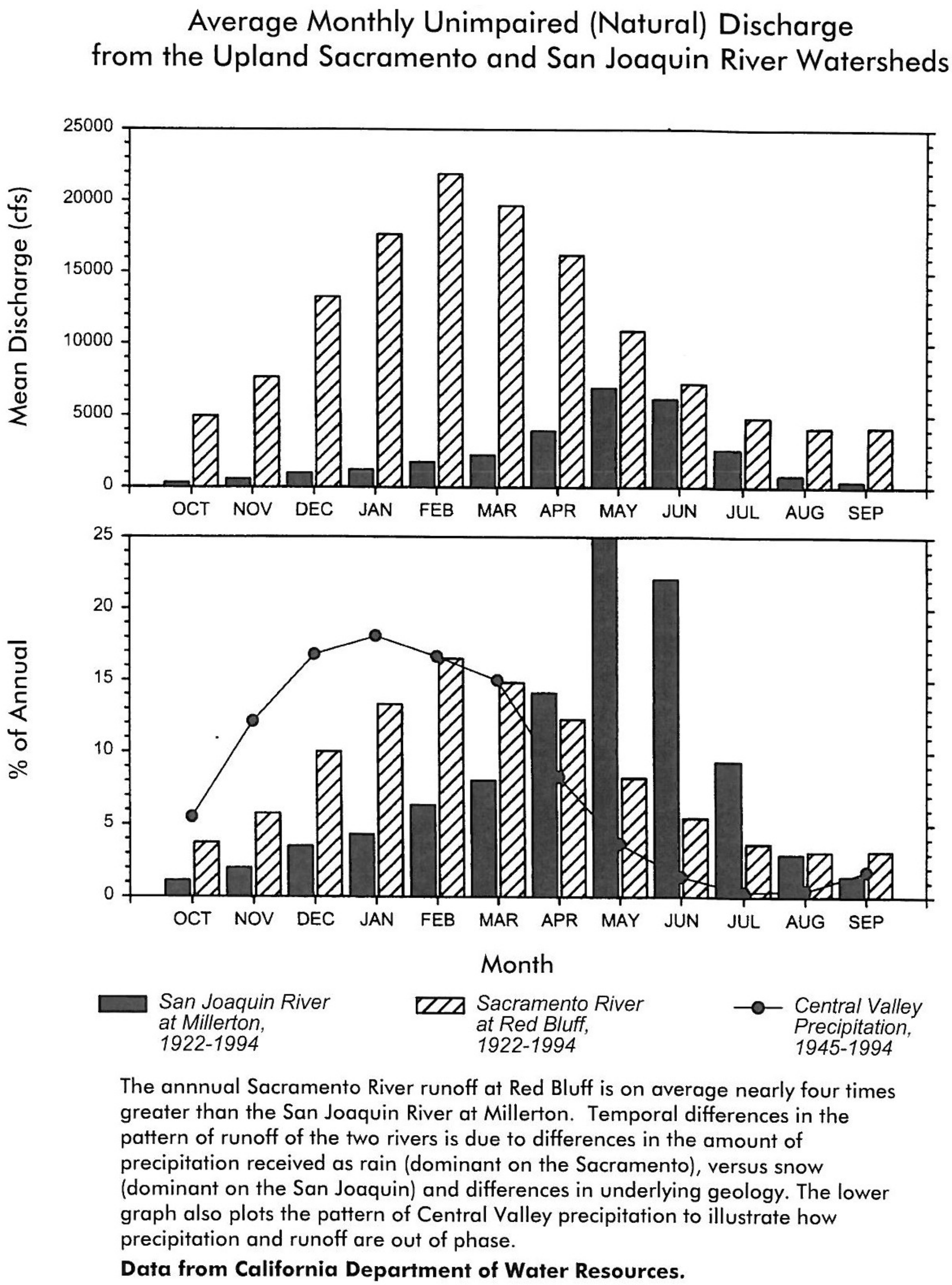


Figure 5-26. Average monthly unimpaired (natural) discharge from the upland Sacramento and San Joaquin River watersheds (The Bay Institute 1998).

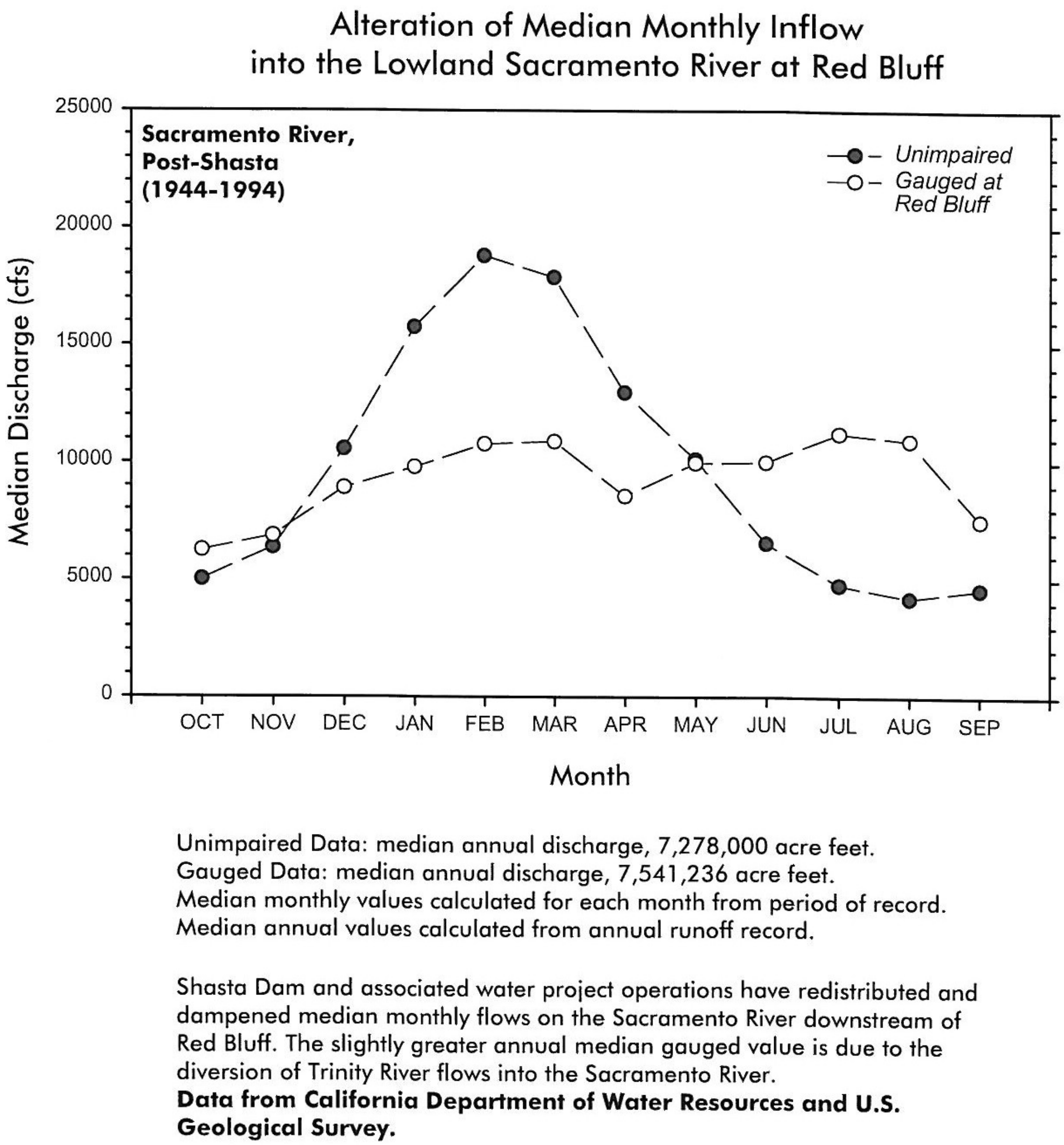


Figure 5-27. Alteration of median monthly inflow into the lowland Sacramento River at Red Bluff (The Bay Institute 1998).

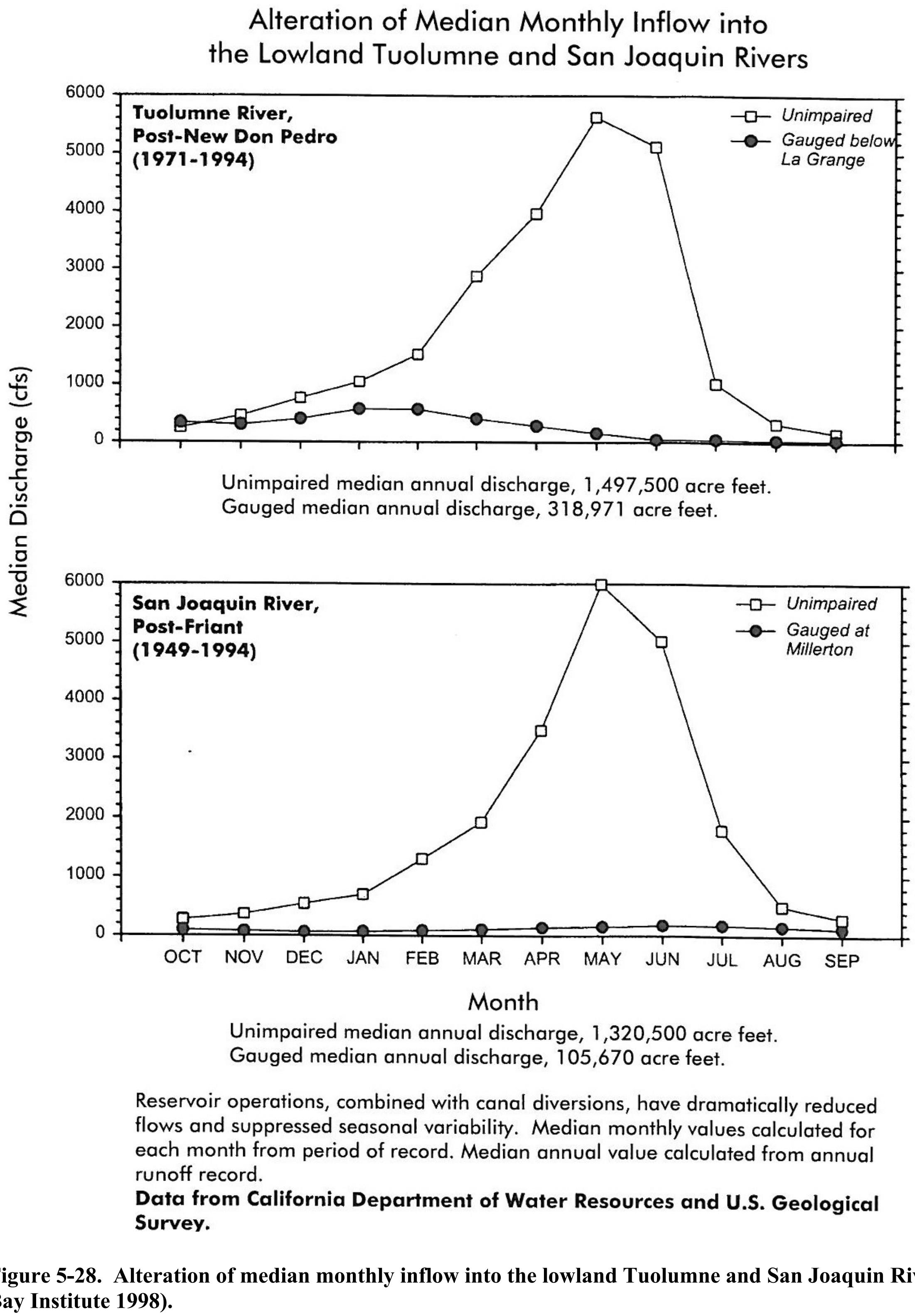


Figure 5-28. Alteration of median monthly inflow into the lowland Tuolumne and San Joaquin Rivers (The Bay Institute 1998).

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. The operations of the dams and water transfer operations of the CVP and SWP have reduced the winter and spring flows into the Delta, while artificially maintaining elevated flows in the summer and late fall periods. 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. Releases of water to the Delta during the normally low flow summer period have had several impacts on Delta ecology and hydrology. Since the projects started transferring water through the Delta, the normal variability in the hydrology of the Delta has diminished. 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 5-29 and 5-30). 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.

6.6.3.2. 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.

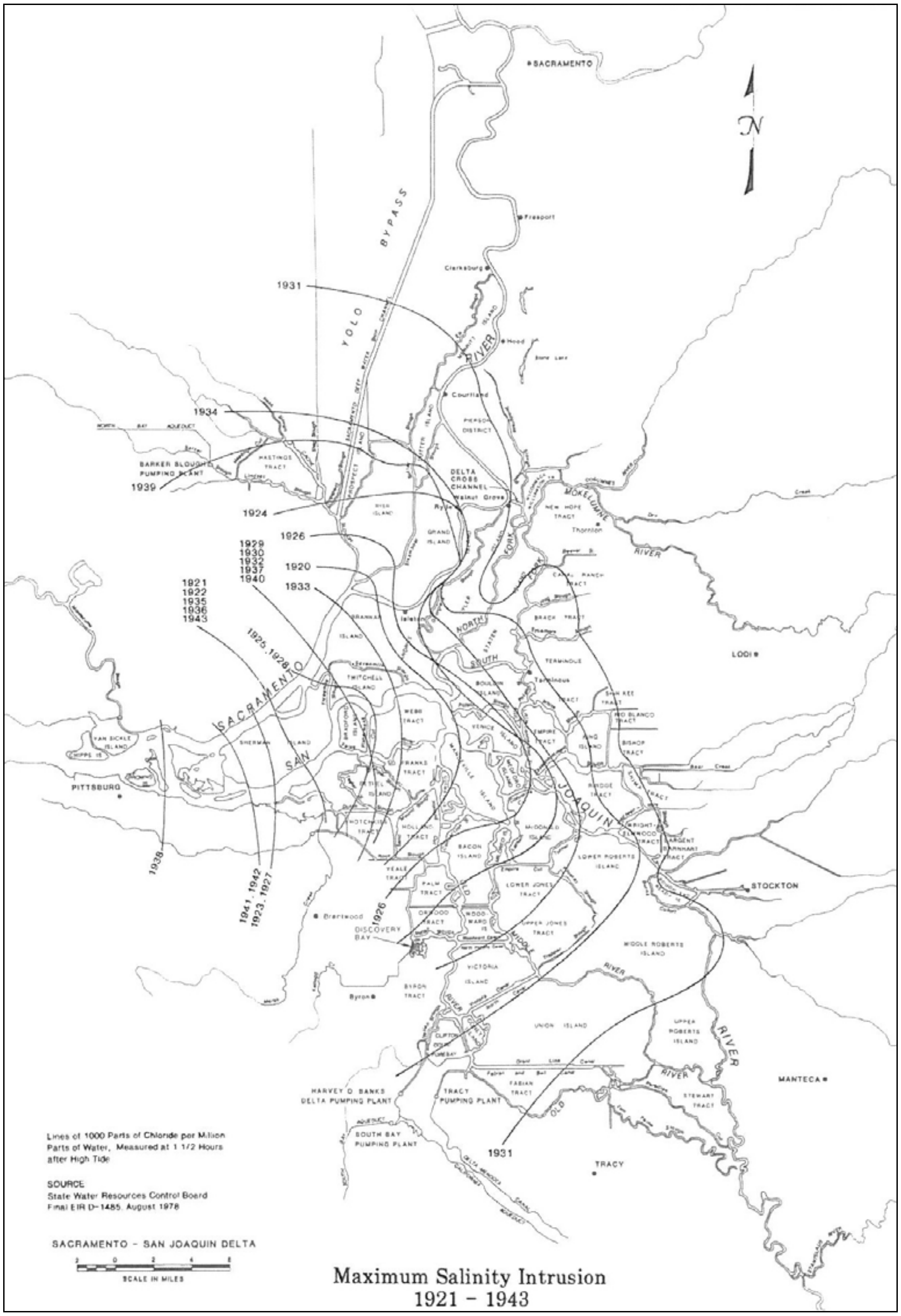


Figure 5-29. Maximum salinity intrusion for the years 1921 through 1943 (Pre-project conditions in Central Valley –Shasta and Friant Dams non-operational; Sacramento-San Joaquin Delta Atlas, DWR).

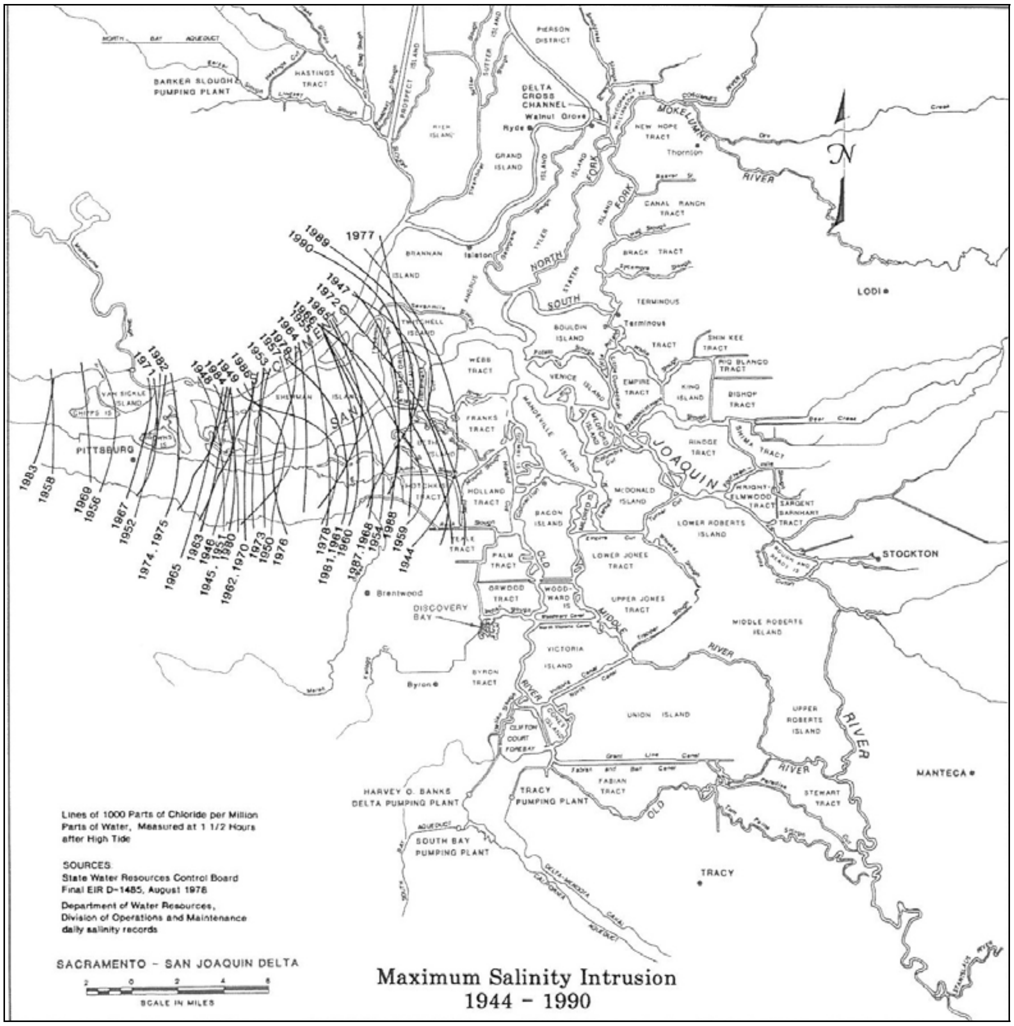


Figure 5-30. Maximum salinity intrusion for the years 1944 through 1990 (Project era; Sacramento-San Joaquin Delta Atlas, DWR).

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 carry a small proportion of the river's discharge through several farmed Delta Islands. Elk Slough branches off of the mainstem near the town of Clarksburg and flows in a southwesterly direction, separating Merritt Island from Prospect Island. 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 Deep Water Ship Channel. 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 5-24). 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. 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. 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 water remains in the main channel of the Sacramento River until it encounters the mouth of Georgiana Slough, a short distance downstream from the mouth of the DCC. 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 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 main stem 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 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. This is most obvious when examining net flow patterns in channels to the south of the San Joaquin River in the CALSIM II studies conducted for the OCAP consultation.

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 strongly positive and flow towards the ocean. However, under certain conditions, such as low Delta outflow and high pumping rates, a proportion of the flows entering the west Delta can be redirected towards the pumps. 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 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).

6.0 EFFECTS OF THE PROPOSED ACTION

6.1 Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. 1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This draft Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat as defined in 50 CFR 402.02. Instead, this biological opinion relies upon the statutory provisions of the ESA to complete the following 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.

In the section 3, "Description of the Proposed Action," of this Opinion, NMFS provided an overview of the proposed action. In section 4, "Status of the Species and Critical Habitat," NMFS provided an overview of the threatened and endangered species and critical habitat in this consultation. In section 5, "Environmental Baseline," NMFS provided the current status of the listed species in this consultation for each Division, and also characterized each Division by other stressors that the listed species and their habitat are exposed to without being exposed to the additional stressors caused by the proposed action.

Regulations that implement section 7(a)(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). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. 1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, we evaluate the available evidence to identify the direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of the listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering spawning substrate, altering ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or noise disturbance). Once we have identified the effects of an action, we evaluate the available evidence to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). We then use the evidence available to determine if these reductions, if any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild. The following analysis of effects is presented for the listed species first, followed by the analysis of effects on proposed and designated critical habitats. NMFS acknowledges that this is a reversal of the approach we described in sections 2.3.1 and 2.3.2. The final Opinion will be consistent with regard to the order of presentation between the analytical approach and this section.

To evaluate the effects of the proposed action, NMFS deconstructed the proposed action into its component parts, and identify likely exposures, responses, and risks to the listed anadromous fish species and Southern Residents within the action area, based on the best available information.

The primary information used in this assessment include 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.

6.2 Clear Creek and Whiskeytown Dam

6.2.1 Deconstruct the Action

6.2.1.1 Water Quantity/Hydrograph

In the absence of suitable flow information, Reclamation follows the CVPIA Anadromous Fisheries Restoration Plan (AFRP) guidelines (USFWS 2001) which 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^{o}F temperatures in stream sections utilized by spring-run Chinook salmon." CALSIM modeling (Figure 6.3) shows that slightly less than the AFRP guidelines will be released over the long-term. 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. 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 (OCAP BA). Since steelhead spawning has been observed throughout the 17 miles of Clear Creek (USFWS 2007a), it is reasonable to assume that spawning habitat would be reduced by low flows in dry years. The OCAP BA states for steelhead on Clear Creek, "during dry years flows for attraction, holding, and upstream migration could be less than optimal."

Spring-run enter Clear Creek from April through September and spawn from August through October. Modeled and actual flows in July and August are 85 cfs in all years (figure 5-3 and 5-6). Flows in September would be 150 cfs, except in critically dry years when they would drop to 30 cfs. During the driest of years, low flows would be expected to cause competition for suitable spawning sites and superimposition of redds. In the past, Instream Flow Incremental Methodology (IFIM) studies based on Physical Habitat Simulation (PHABSIM) developed for fall-run 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 (OCAP 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. Spawning attraction flows of 500 cfs were recommended in October and November for fall-run. The interim flow schedule developed for Clear Creek was intended to maintain salmon and steelhead until studies 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 reducing the amount of habitat available for spring-run spawning (USFWS 2007b). 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) is 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 (USFWS 2007b). 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 suitable for CV steelhead spawning. As the number of spring-run in Clear Creek increases, the lack of suitable flows will reduce the available spawning habitat, which in turn reduces the reproductive success of an individual and eventually results in a decrease in the population.

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 fish biologists and non-governmental organizations. Flood control 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.

Historically, flood releases from Whiskeytown Dam were those that were greater than the minimum instream flows that were proposed in May 1963 (USFWS schedule), 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 the 1963 USFWS schedule in table 6-1 below, as described in the project description. Based on the more recent IFIM studies, minimum flows of 50 cfs in September and October would not be sufficient to support water temperature objectives and instream habitat needs for spring-run spawning and incubation (table 6-1). For modeling purposes, CALSIM assumed no b(2) water is available for Clear Creek when Trinity Reservoir drops below 600,000 TAF. This would only occur in the driest 10 percent of years (OCAP-BA figure 10-12). However, NMFS assumes for this consultation that b(2) flows would be limited in some years since it will be used first for Delta export curtailments (*i.e.,* 2008 delta smelt court ruling, and forth coming USFWS OCAP Opinion) before it is allocated for Clear Creek.

Table 6-1. Minimum flow schedule at Whiskeytown Dam from 1963 USFWS proposal and 2001 CVPIA AFRP flow guideline (OCAP BA table 2-4).

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	

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 under the majority of flood events. The probability of an uncontrolled spill from Whiskeytown Dam is 50 percent or every other year (OCAP BA). The reservoir acts to spread out the change in flow rate following rapidly declining river stage. Flow changes under proposed operations are less than those that occurred prior to flow regulation. Therefore, the risk of stranding and isolation is reduced in the future compared to the historical unimpaired flow conditions.

6.2.2 Assess the Species Response

The higher flow rates along with channel restoration, dam removal, and gravel augmentation have lead to increasing anadromous fish populations in Clear Creek (figure 5-2). It is uncertain how much is attributable to just the increase in flows. 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. Flows could be improved during the summer when they drop to their lowest point, typically about 80 cfs. The 1985 IFIM studies found optimum flows for steelhead and salmon during May through October was 300 cfs (OCAP BA figure 5-4). More juvenile rearing habitat could be provided with higher flows in the summer if there was adequate cold water in Whiskeytown Reservoir. However, currently, the low flows and physical barrier weir are being used in combination to separate spring-run and fall-run. Until a Fishery Management Plan is developed, an adaptive management approach to higher releases during the summer would have to involve the Clear Creek Technical Team and the B2 Interagency Team.

6.2.2.1 Water Quality and Habitat Suitability

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 Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30, to protect spring-run spawning (figure 5-5). 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 temperature control device on Whiskeytown Dam and storage capability is limited to 700,000 AF. Therefore, water temperature can only be managed by controlling releases (figure 6-2).

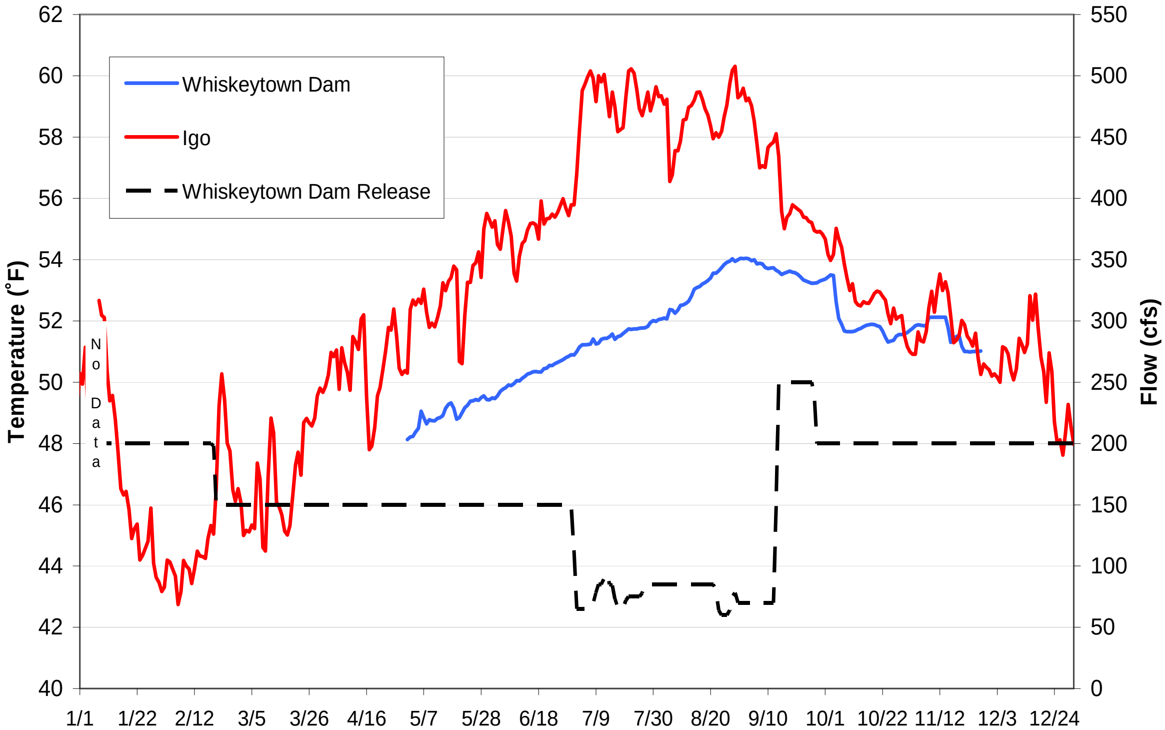


Figure 6-1. Actual Clear Creek mean daily temperatures at Igo (red), Whiskeytown (blue), and flow (dashed line) measured in 2002, a dry year (OCAP BA figure 11-12).

In general, the water temperatures 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, would therefore, be the hardest to meet (figure 6-2). For each month, there is little difference between the baseline and future conditions (Study 7.0 vs Study 8.0) because there is little change in the flows (figure 5.3). 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 are probably underestimated. Therefore, NMFS would expect water temperatures to be exceeded more often in the future. 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 salmon during dry water years.

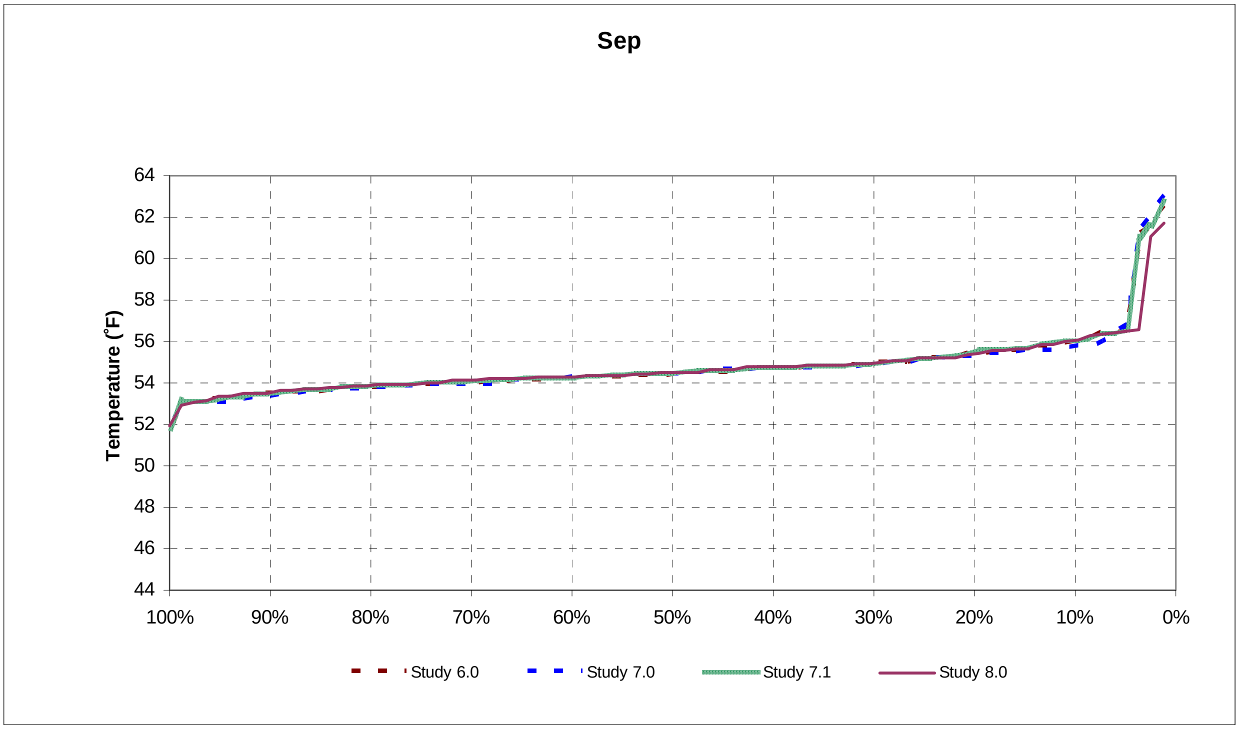


Figure 6-2. Clear Creek September water temperature exceedence plot at Igo gauge (OCAP BA figure 10-42).

Water temperature in Clear Creek is maintained with b(2) releases. Typically, flows are increased after September 15 to meet the temperature objectives. Since NMFS assumes that most of the b(2) water in the future will be used in the Delta, then there would be less water available in Clear Creek to maintain temperature control than modeled.

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 Ecosystem Restoration Program. 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.

6.2.2.2 Spring Creek Tunnel

Water diverted from the Trinity River passes through Whiskeytown Reservoir in the Spring Creek tunnel to Keswick Reservoir. A temperature curtain was installed on Whiskeytown Dam to prevent mixing of surface water with the colder water being diverted from the Trinity River. An inspection of the temperature curtain in 2008 found unidentified problems with the integrity of the curtain (Milligan 2008). The timing and volume of the diversion pattern has a direct impact on water temperatures in both Clear Creek and the Sacramento River. Since implementation of the Trinity ROD flows, less water is diverted from the Trinity River and higher temperatures have been observed, making it difficult to meet the 2004 NMFS temperature objectives. The pattern of diversions to Spring Creek Tunnel can range from 200 to 3,400 cfs (figure 6-3).

Since water diverted through Whiskeytown Reservoir is usually warmer in April, May and June than the temperature objective required in the Sacramento River (56^{o}F) for winter-run spawning, diversions through the Spring Creek Tunnel are significantly reduced in those months. When water is diverted through Spring Creek Tunnel and Power Plant, the releases from Shasta Dam can be reduced to conserve cold water for later in the year. The water from Spring Creek and the Shasta Dam TCD are thermally mixed in Keswick Reservoir to meet the in-river temperature objectives. Water temperatures in the Spring Creek Tunnel range from 65 to 75^{o}F during April, May, and June of a dry year (figure 6-4). These conditions make it difficult to divert water from the Trinity River and still meet temperature objectives in 10-20 percent of the historic water years modeled. Under future conditions with climate change, July, August and September diversions from Spring Creek Tunnel (already at 55^{o}F) would have to be reduced, necessitating a greater reliance on Shasta Reservoir releases than what was modeled.

6.2.3 Assess the Risk to Individuals

Spring-run abundance is increasing as a result of passage improvements, restoration projects, and temperature control, however, suitable flows will need to be maintained with b(2) water. The proposed releases are significantly reducing the amount of habitat available for spring-run spawning (USFWS 2007b). Higher flows (*i.e*., 450 to 600 cfs) from September through December are necessary to increase reproductive success as abundance increases. In the worst-case scenario, flows would drop to 30 to 50 cfs in a dry year, which would prevent passage upstream to spawning areas below Whiskeytown Dam. Implementation of the Trinity ROD flow schedule will cause water temperatures to increase in Clear Creek and in the Spring Creek Tunnel. Higher water temperatures in September will cause some spring-run egg mortality in 10 percent of the years (dry years), which will limit reproductive success to wet and above normal water years. Climate change will increase reliance on Shasta Dam releases for temperature control instead of Trinity River diversions. Whiskeytown Dam prevents the spatial and temporal separation of spring-run from fall-run.

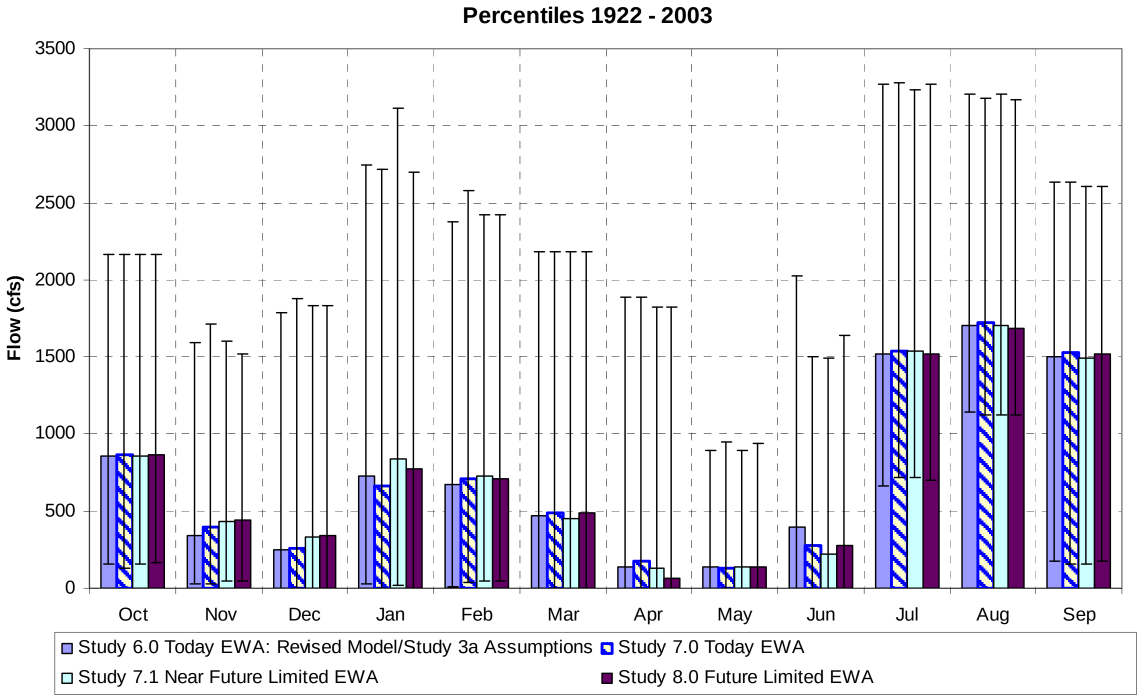


Figure 6-3. Spring Creek Tunnel 50th Percentile Monthly Releases with the 5th and 95th as the Bars (OCAP BA figure 10-36).

6.2.4 Assess the Risk to the Population

Anadromous, resident, and riverine forms of *O. mykiss* are found in Clear Creek. Recent 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 17 miles of stream they are likely to be impacted more often by low flows and high temperatures during the summer rearing period. Modeling shows that flows are suitable and water temperatures generally meet steelhead needs, except that daily maximums exceed temperature limits in July and August. These temperatures would not be prolonged enough to cause individuals harm, but they might cause fish to move upstream to cooler areas, reducing the availability of rearing habitat. In the worst-case scenario, flows will be reduced to the minimums (30-50 cfs), if b(2) water is not available. 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.

6.2.5 Effects of the Action on Spring-run and CV Steelhead Critical Habitat in Clear Creek

The value of critical habitat is reduced by not providing sufficient flows to maintain the suitability and availability of spawning habitat for spring-run salmon. Reducing the depth and velocity of flows will reduce reproductive success and productivity of some individuals. As the spring-run population expands downstream, the lack of high enough flows will limit the ability of the population to increase. For CV steelhead, the value of critical habitat will be reduced in dry years by unsuitable water temperatures during the summer rearing period. The value of winter-run critical habitat is reduced by the lack of cold water releases from Spring Creek Tunnel entering Keswick Reservoir.

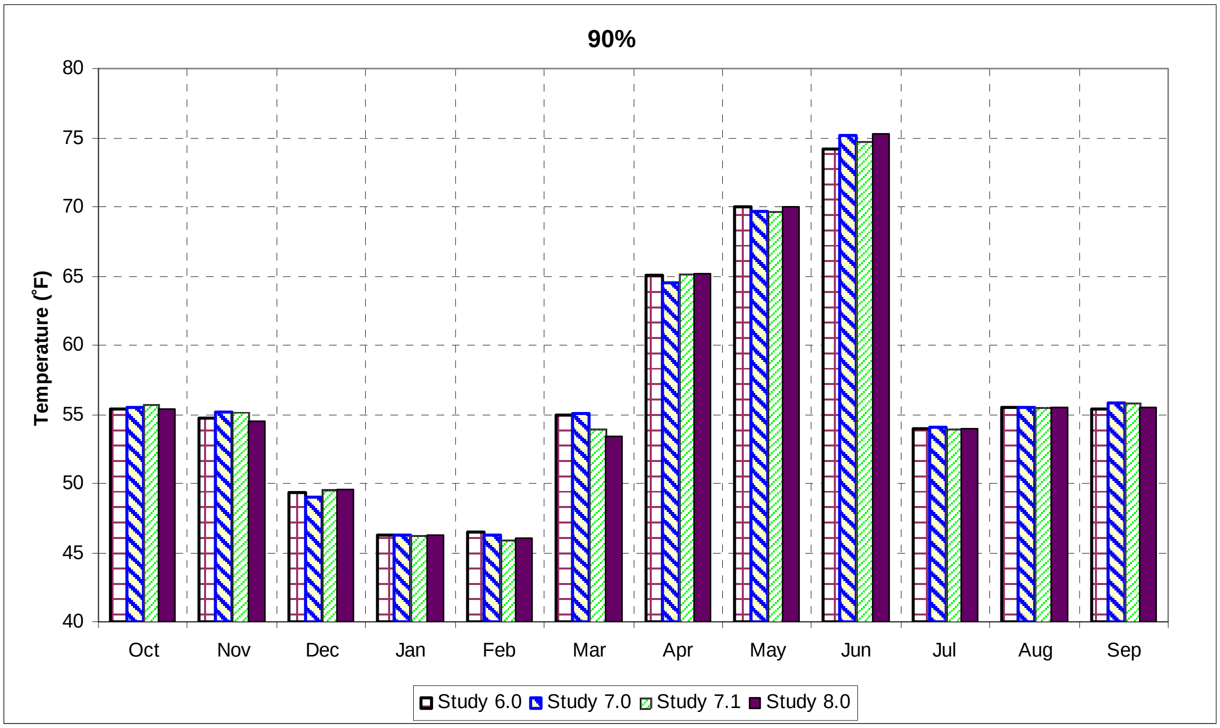


Figure 6-4. Spring Creek Tunnel modeled water temperatures at 90 percent exceedence hydrology (critically dry conditions, OCAP BA figure 10-57).

6.3 Shasta Division and Sacramento River Division

6.3.1 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 6-2). This is the same 8 months out, 4 months in operation that has occurred for the last 10 years. Once the new pumping plant becomes operational in the year 2020, the gates will be opened for 10 months, closed for 2 months plus 10 days in May (Table 6.3.2). Future operations will close the gates 5 days later (*i.e.*, May 20 instead of May 15) which would allow the tail end (up to 15 percent of the run) of the winter-run spawners unimpeded access upstream and improve passage for spring-run spawning above RBDD. Currently, an estimated 35-40 percent of the green sturgeon passing RBDD are completely blocked by the May 15 gate closure.

6.3.1.1 Temporal Distribution

Based on recent RBDD ladder counts the percentage of adults encountering delays would be approximately 15 percent for winter-run, 70 percent of spring-run, 40 percent for CV steelhead, and 35 percent for green sturgeon (TCCA 2008 Appendix B1, figure 6-5). Delays impact any adults spawning in the mainstem or tributaries above RBDD (*e.g.*, Clear Creek, Cow Creek, 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, which continues the pattern of introgression and hybridization that has occurred since RBDD was built in the late 1960s (USFWS studies).

Table 6-2. Proposed Red Bluff Diversion Dam Gate Closures (OCAP BA).

Existing (2008)	**Near-Future (2009-2019)**	**Future (2020-2030)**
May 15 – Sept. 15	May 15 – Sept. 15	May 20 – May 29 and July 1-Sept 1
10-day emergency closure	10-day emergency closure	10-day emergency closure
4 months gates in	4 months gates in	2 ½ months gates in

Adult CV steelhead encountering the RBDD 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 Red Bluff Pumping Plant is built and operational delays to Chinook salmon would be reduced, but still present for spring-run and fall-run. Green sturgeon would still be completely blocked from upstream spawning areas during May and June in both the near-future and future operation since they are not able to use the fish ladders.

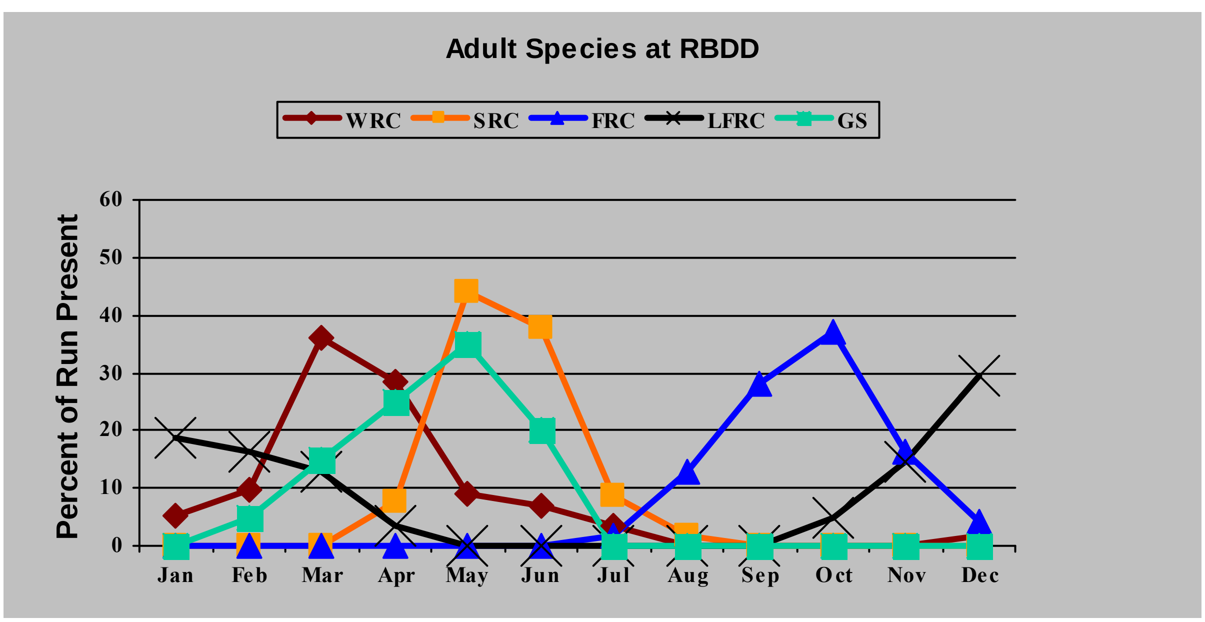


Figure 6-5. Run timing by month at Red Bluff Diversion Dam for Winter-Run Chinook (WRC) brown, Spring-Run Chinook (SRC) orange, Fall-Run Chinook (FRC) blue, Late Fall-Run Chinook (LFRC) black, and Green Sturgeon (GS) green (TCCA 2008).

Green sturgeon adults migrate upstream from March through July, with the peak of spawning occurring from April through June (September 8, 2008, FR 52084). Spawning habitat for green sturgeon occurs both above and below RBDD and ACID. The RBDD gate closure blocks almost all 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 (Richard Corwin, USBR, Red Bluff, pers. comm. Also Michael Urchov pers comm). 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). Lindley (2006) indicates that adult green sturgeon drop back downstream to as far as the GCID diversion dam.

In 2007, approximately 10-12 adult green sturgeon were observed killed before they could spawn by the RBDD gates due to an early gate closure (USBR 2007 report). Early gate closures 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 population. Reclamation proposes to change the opening at the bottom of the gates 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 2008 OCAP BA asserts that adult green sturgeon can pass through a 6-10 inch opening based on limited (3 accoustically tagged adults) data and undefined body depth. Experts in green sturgeon from UCD 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 injury fish due to the turbulence after they pass through. Therefore, even though mortality may be reduced with the new protocol, 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.

Juvenile salmonids and green sturgeon that encounter the RBDD experience higher predation rates from predatory fish that wait below the dam for fish that are swept under the gates. Vogel *et.al.* (1988) have shown that predation may be as high as 50 percent for those juveniles that encounter the gates down. However, a more recent study (Tucker 1997) 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 (figure 6-6, table 6-3). 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), approximately 100 percent of green sturgeon, 10 percent of winter-run, 5 percent of spring-run, and 1 percent of CV steelhead would be exposed to higher concentrations of predators when the gates are in (TCCA 2008). These percentages represent only the proportion of the runs that spawn above RBDD and not the entire population.

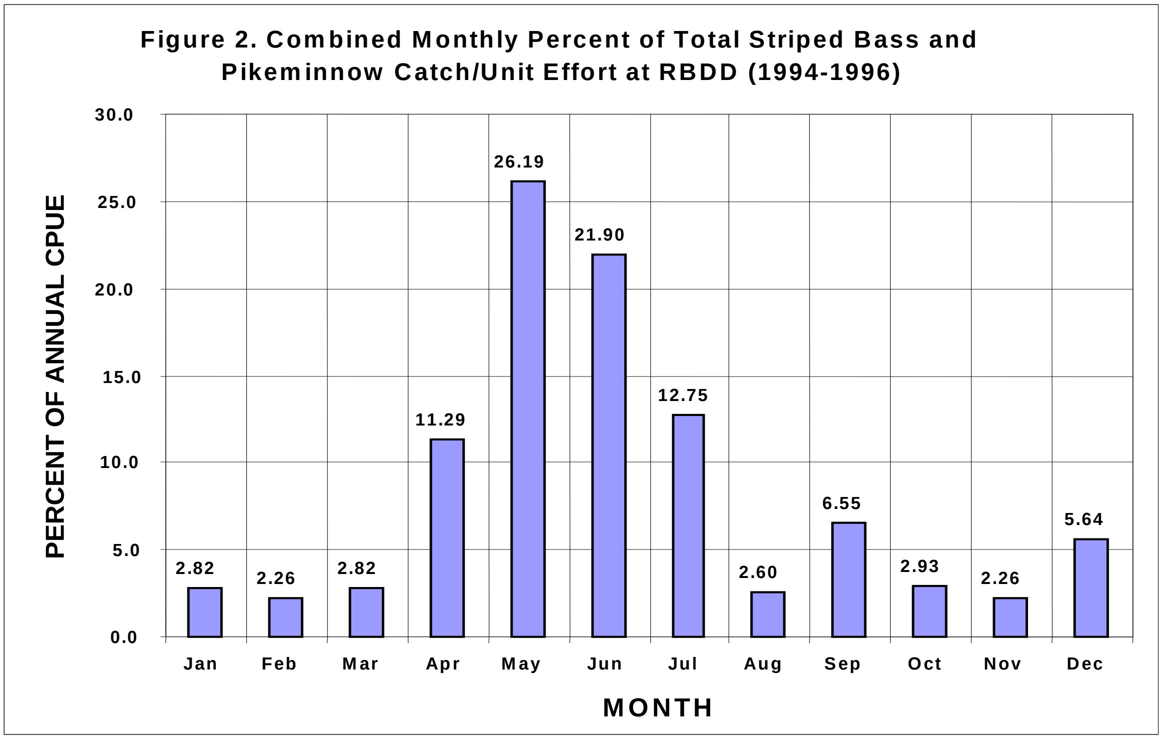


Figure 6-6. Presence of predators at RBDD by month from 1994-1996 (TCCA 2008).

"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)

6.3.1.2 Water Quantity/Hydrograph

6.3.1.2.1 Carryover Storage in Shasta Reservoir

Carryover storage in September will be significantly reduced in the long-term (-121 TAF) future compared to the base (Study 8.0 vs 7.0, table 6-4). 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 6-3. Estimated monthly hazard estimate used to assess predation in the E.A. *Gobbler* sub-routine of the Fishtastic! juvenile analysis module (Tucker 1997, 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(2)	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

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, the greater the cold water pool. The requirement for 1.9 MAF EOS was a reasonable and prudent alternative (RPA) in the 1992 NMFS winter-run Opinion. 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 OCAP Opinion.

Table 6-4. 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 (OCAP 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

Reclamation proposes continuation of the 90 percent exceedence forecast for determining water allocations early in the year (February 15 forecast). However, Reclamation has proposed not to manage Shasta operations to the previous 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 a target of 1.9 MAF. Based on the historical 82-year period, CALSIM results show there will be about a 4 percent increase in the number of years that 1.9 MAF will not be met (figure 6-7). Overall, there is not much difference between model runs, Figure 20 shows that 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 6-8). 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.

Reclamation has not proposed any alternative 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 20 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 (OCAP BA table 9-23).

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 6-9). 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. Therefore, this PCE of critical habitat becomes less suitable and juvenile productivity is reduced.

The minimum flows proposed in the OCAP BA are 3,250 cfs from September to February and 2300 cfs in a critically dry year (table 6-5). Typically, flows are much higher than 3,250 cfs in the spring and summer (April through September) because releases are being made to support temperature control and irrigation demand (releases average between 10,000 and 14,000 cfs). Therefore, since b(2) water is not reasonably certain to be available, it would most likely reduce fall-run spawning habitat and potentially dewater redds that were spawned at higher flows. The worst-case scenario, 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).

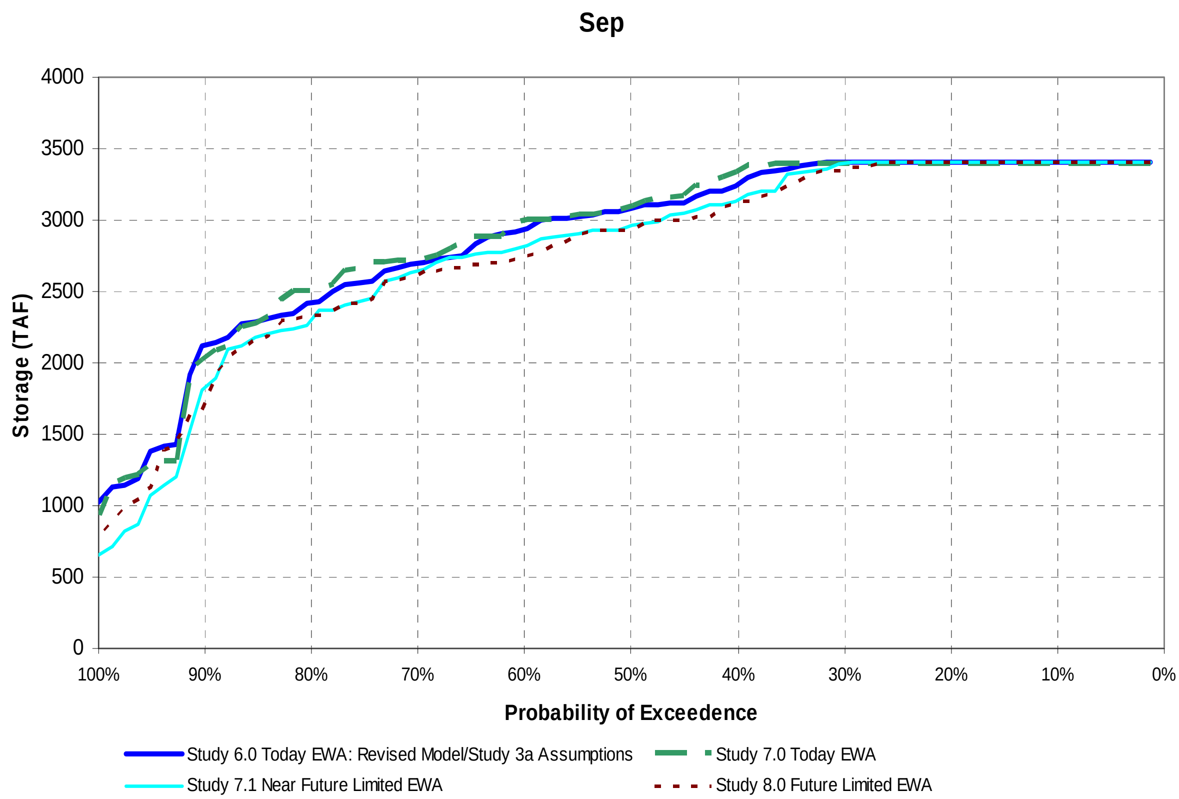


Figure 6-7. Exceedance plot of Shasta 1.9 MAF target September storage in Shasta Reservoir. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and study 8.0 represents future operations (OCAP BA figure 11-37).

Flow studies using IFIM and PHABSIM have shown that winter-run salmon WUA peaked around 10,000 cfs when the ACID gates are in and 4,000 - 5,000 cfs with the gates out. The ACID gates are usually in from April to November. Therefore, current 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 worsecase scenario mentioned above for dry years when conserving storage drives the flows to minimums in the fall.

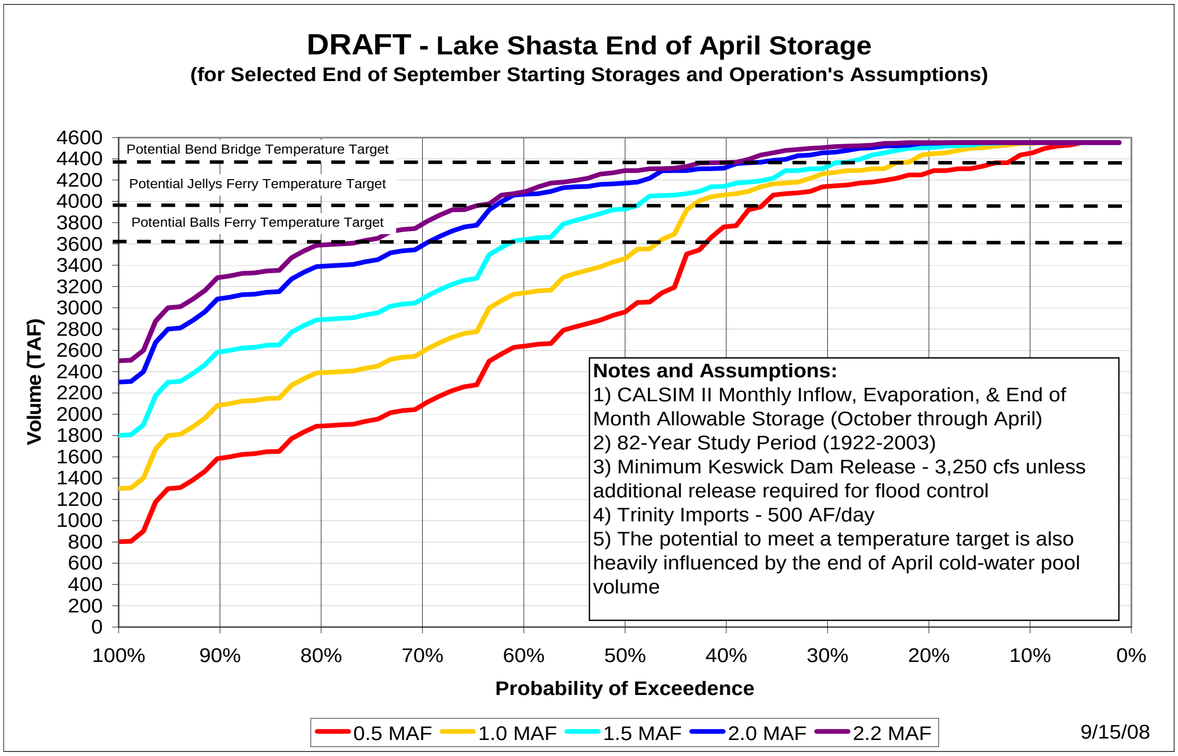


Figure 6-8. Draft exceedance plot of Shasta End of April Storage using selected End of September starting storages and operational assumptions (Supplemental data included with Reclamation's October 1, 2008, transmittal letter).

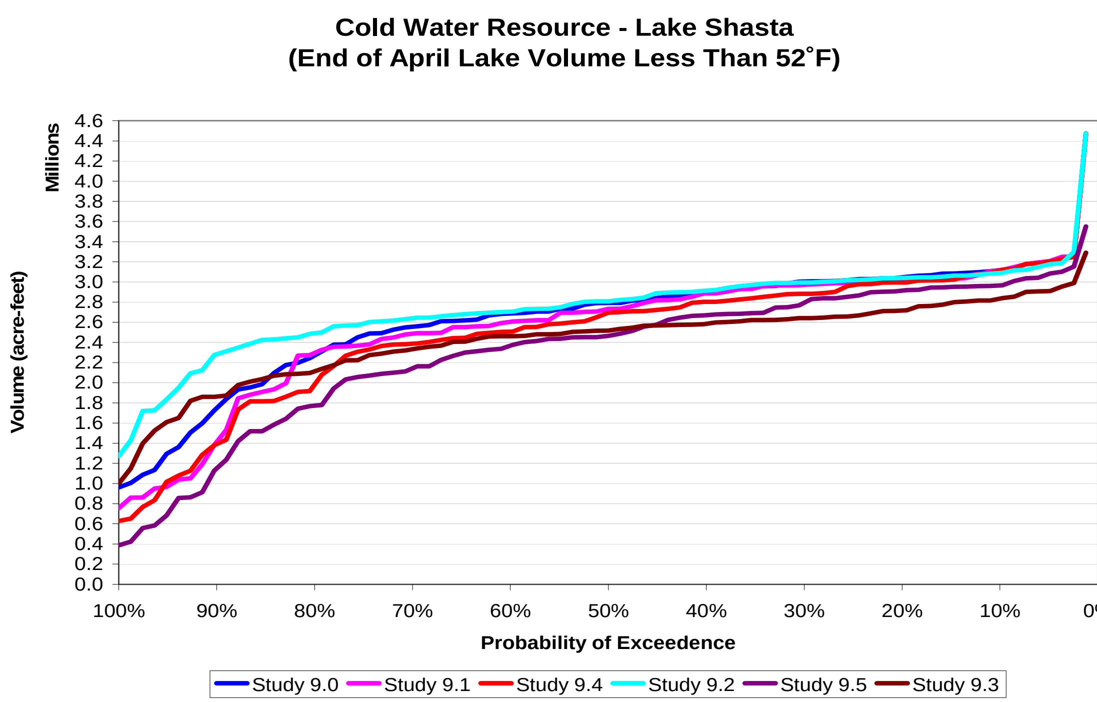


Figure 6-9. Shasta Lake coldwater pool volume at end of April with climate change scenarios. All studies except 9.0 include 1 foot sea level rise. Study 9.0 is future conditions with D-1641. (OCAP BA figure 11-83).

Table 6-5. Proposed minimum flow requirements and objectives (cfs) on the Sacramento River below Keswick Dam (OCAP BA table 2-5).

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

Note: * No regulation. NMFS assumes that D-1641 standards, temperature control, and water allocations w result in higher flows.

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 U.S. Army Corps of Engineers 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.

In addition, Reclamation proposed to meet Delta water quality and flow standards contained in the State Water Resources Control Board Decision 1641 (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 Delta standards on upstream ESA-listed fish species was never analyzed during the 1995 Delta Accord, and has since become more problematic as new species have been listed (*i.e*. spring-run and CV steelhead).

6.3.1.3 Water Quality and Habitat Suitability

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 6-6). 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, 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, per.comm). 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, per.comm).

Table 6-6. Temperature targets from the 2004 OCAP Opinion used as evaluation criteria. Temperature targets are mean daily. Target points in the Sacramento and American River are determined yearly with input from the SRTTG and American River ops 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	

Table 6-7 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 Sacramento River winter-run and fall-run early life temperature tolerances. They 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 in USFWS (1998) were about the same as that used by Reclamation in the 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 in recent years (OCAP BA figure 11-38). Water temperatures exceed the 56°F objective at Balls Ferry in 50 percent of years in September and 10 percent of years from May through June under (Study 7.1) near-term, and (Study 8.0) future conditions (figure 6-10). Using the incremental exposure rates in table 6-7 and the modeled temperatures in figure 6-10, the loss rates for winter-run would be 8 percent egg mortality for those eggs exposed to 57°F in 50 percent of the years, 15 percent egg mortality for those eggs exposed to 58°F in 25 percent of years, 25-50 percent egg mortality for those eggs exposed to 59-60°F, in 10 percent of years, and 50-100 percent egg mortality for those eggs exposed to 60-62°F 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 climate change predictions, which would increase water temperatures from 1-3°F.

Table 6-7. Relationship between water temperature and mortality of Chinook salmon eggs and pre-emergent fry used in the Reclamation egg mortality model (OCAP BA table 6-2).

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 (±0.5°F). 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 6-8) shows for all four CALSIM 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 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 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 adopted a more conservative approach than what is represented by the models.

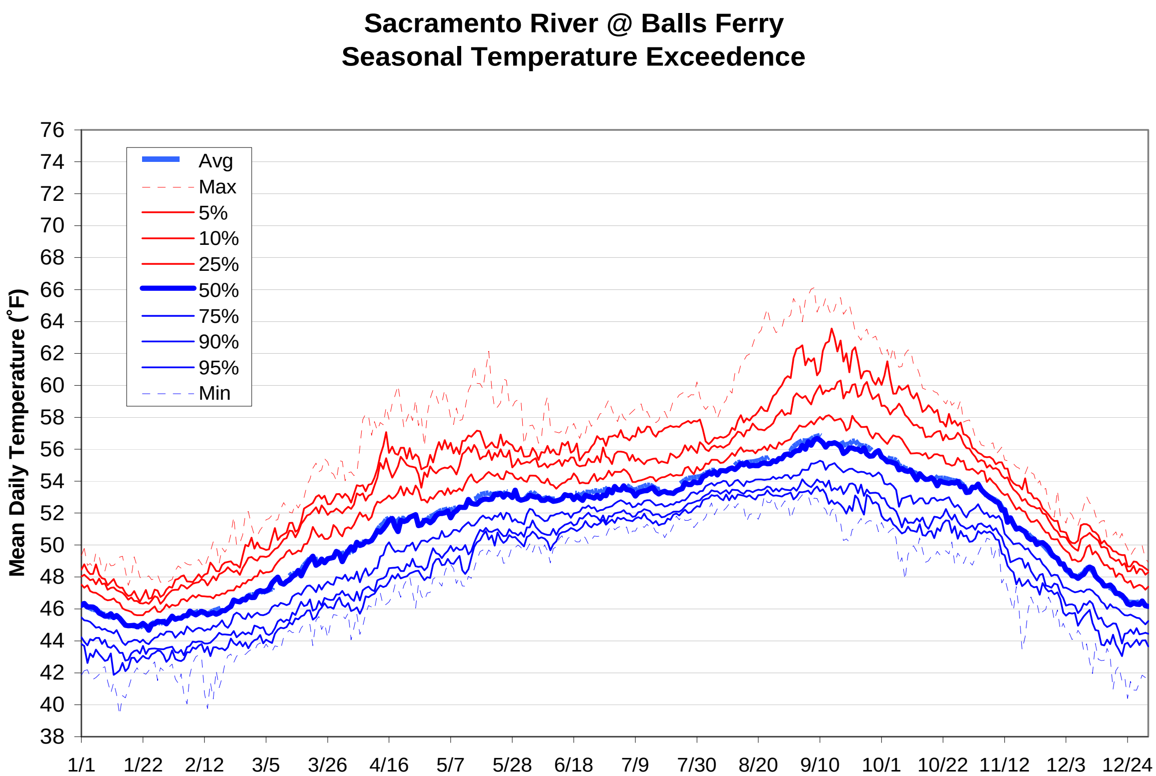


Figure 6-10. Water temperature exceedence at Balls Ferry under Study 8.0 from CALSIM and weekly temperature modeling results (OCAP BA figure 11-35).

Table 6-8. 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 model shows approximately 5 percent less average egg mortality and in critical years 30 percent less mortality OCAP BA (figure 6-11 compared to figure 9-32). 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 predicted to be 1-2 percent due to water temperature effects. During critically dry years mortality increases in the future from 10 percent to 15 percent over the base. The critically dry years represent 15 percent of the years modeled and increase by one year (11 to 12 dry years) compared to the 2004 base.

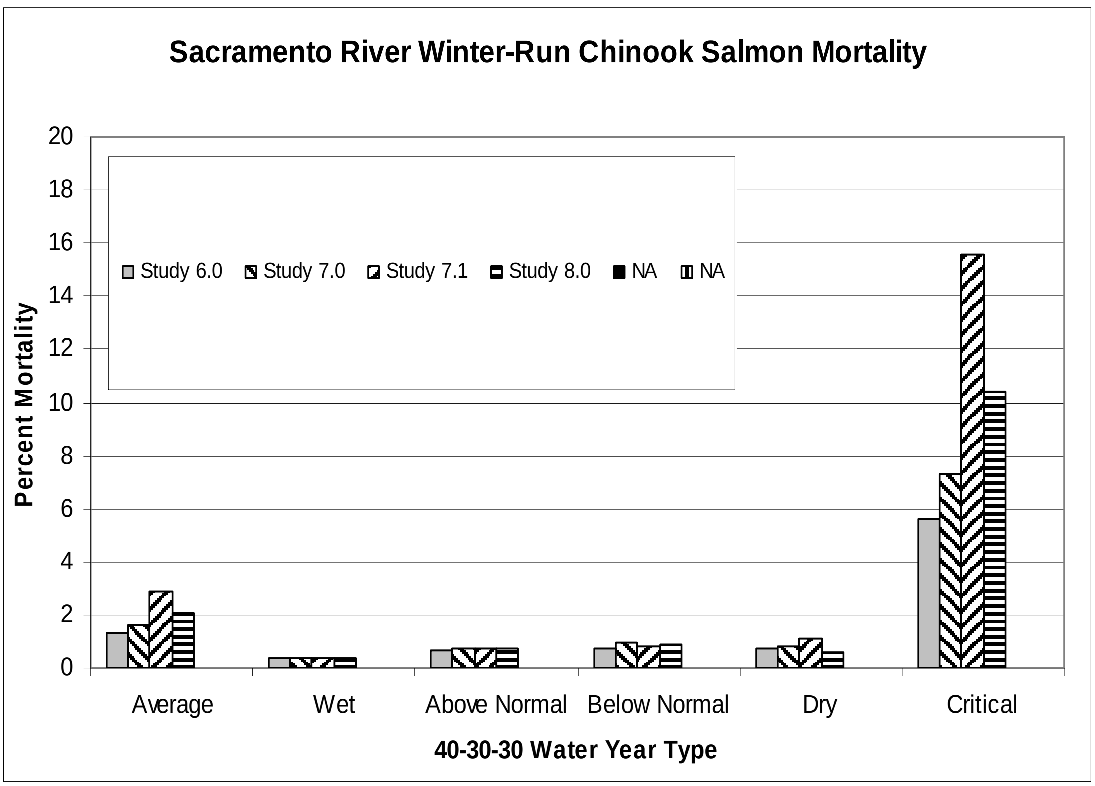


Figure 6-11. 2008 Winter run average mortality by water year type at Balls Ferry. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (OCAP BA figure 11-39).

Water temperatures at Bend Bridge would be unsuitable for spawning and incubation (exceed 56°F) 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.

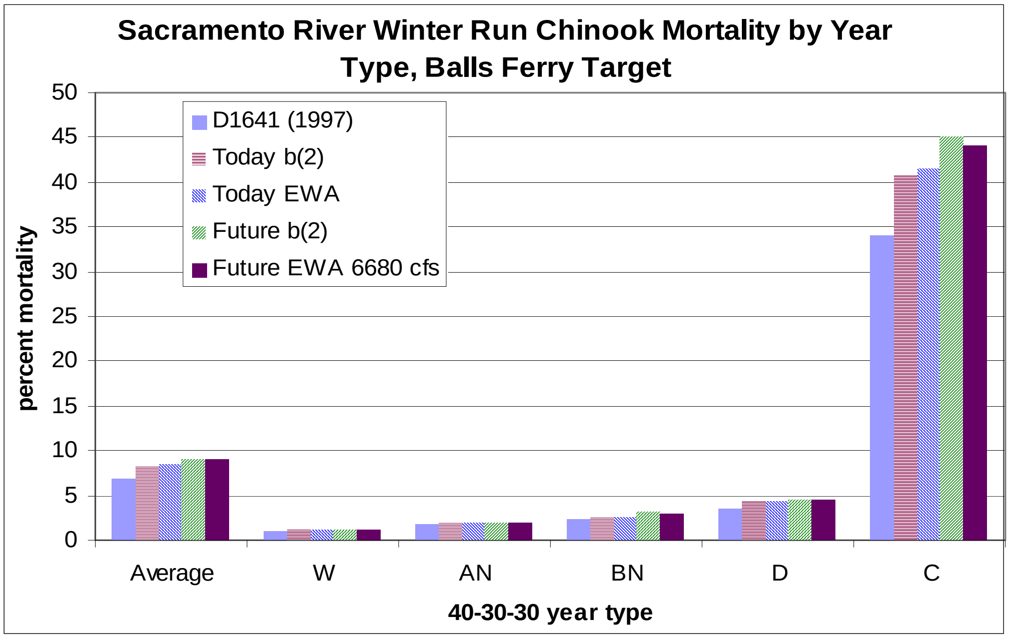


Figure 0–1 2004 Winter-run average mortality by water year type at Balls Ferry temperature target.

Juvenile winter-run typically leave the upper Sacramento River (Keswick Dam to RBDD) by the end of October (figure 6-12) where they are beyond the reach of temperature control. Temperature control is usually not necessary after October 30 as ambient air temperatures cool the river.

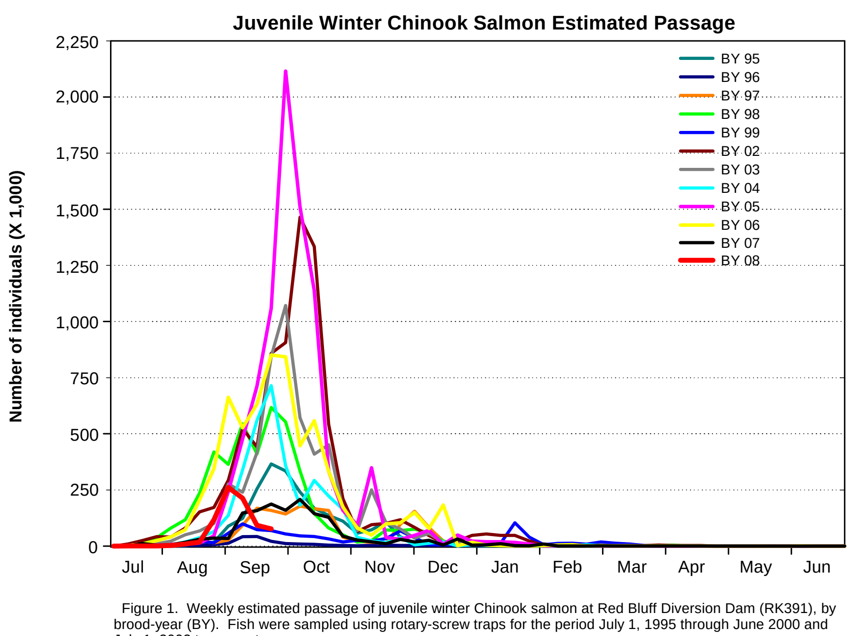


Figure 6-12. Juvenile winter-run passage at Red Bluff Diversion Dam 1995 through 2008 (USFWS BDAT 2008).

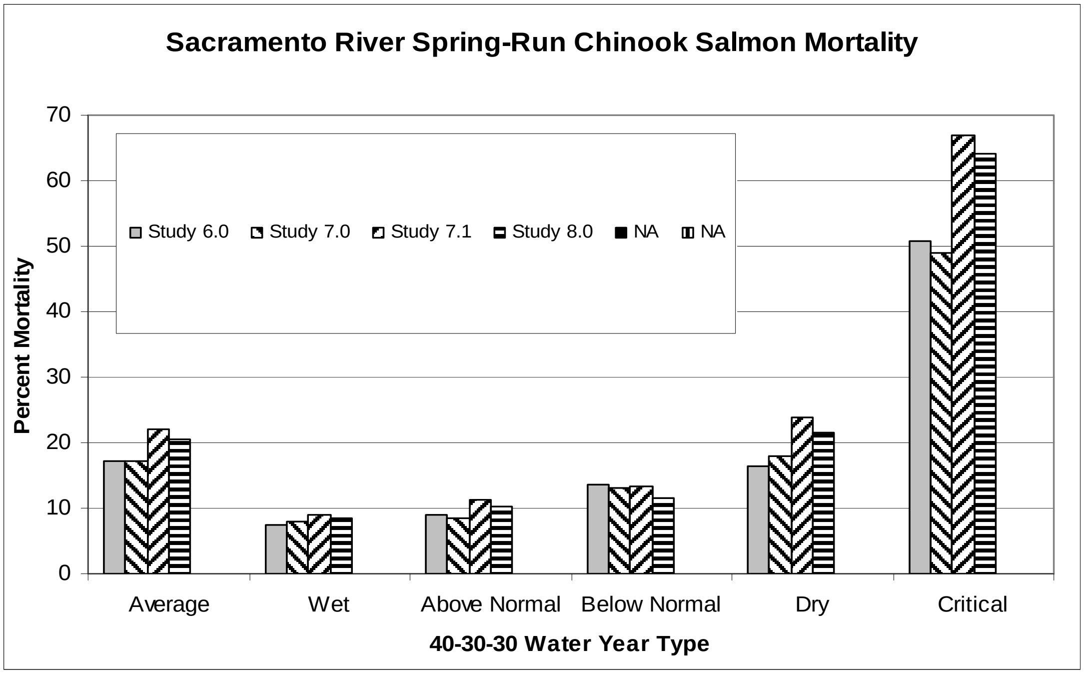


Figure 11-41. Spring run egg mortality from Reclamation egg mortality model by water year type. Study 6.0 represents 2004 operations, study 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (OCAP BA figure 11-41).

CV steelhead mortality was not estimated using Reclamation's Mortality Model, but using late fall-run as a surrogate (because they spawn at the same time) 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. 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 temperature control point been moved upstream by the SRTTG in response to one of the 4 factors above to protect winter-run eggs and fry (figure 6-14). Multiple day exceedences have become the norm and can be expected to continue under future operations. This indicates that the current temperature management system is not effective, if it were the compliance point should move downstream, providing more suitable spawning and rearing habitat. 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 operating protocol works well for winter-run but typically runs out of cold water for spring-run and fall-run.

Juvenile downstream migration patterns have been altered by the presence of dams that shorten the growth period. Juvenile winter-run and spring-run emigrate earlier than historical, since they are hatched much further downstream and have less distance to travel. Therefore, they reach habitat containing unsuitable water quality at a much smaller size and experience higher rates of predation from introduced warm water fish species. Recent trends in warm water predatory fish species show dramatic increases in populations (largemouth bass, smallmouth bass and other introduced centrarchids) due to the growth of aquatic weeds in the delta and the use of rock rip-rap for bank armoring.

Water temperatures at Colusa are 64-66°F in both wet and dry years in September (figure 6-14) when the peak of the juvenile winter-run are emigrating downsteam. The preferred optimum water temperature for juvenile rearing is 53-57°F, and water temperatures less than 64°F are required for smoltification (OCAP 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. 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 (OCAP BA figure 6-6). Past studies using coded wire tags (CWT) showed poor survival rates for hatchery released fall-run and late-run juveniles from the upper Sacramento River (Battle Creek) to Chipps Island (USFWS 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.

6.3.1.4 Green Sturgeon

Based on figure 6-4 and table 6-9, water temperatures are suitable for green sturgeon spawning and rearing as far downstream as Hamilton City, which is also the location of the GCID diversion. Recent acoustical data (Vogel 2008) indicates that the farthest downstream spawning has been observed is Hamilton City.

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 ^{o}F 4/26	
				May	Exceed 56 ^{o}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 ^{o}F at Bend 3 days	
				July	Exceed 56 ^{o}F at Bend 4 days	
	*First year that TCD was used				Conserve cold water	Jelly's Ferry
				Sept	Exceed 56 ^{o}F at Jelly's 8/29	
					to 9/13	
				Oct	Exceed 56 ^{o}F at Jelly's 9/20-9/30	
1998	2308	4061	Bend Bridge	June	Exceed 56 ^{o}F at Bend 3 days	
				June	Exceed 56 ^{o}F at Bend 4 days	
				Sept	temp exceed 56 since Sep 12	Jelly's Ferry
1999	3441	4256	Bend Bridge	August	Exceed 56 ^{o}F at Bend 4 days	
2000	3327	4153	Bend Bridge	June	Exceed 56 ^{o}F at Bend 3 days	
				July	Conserve cold water	Jelly's Ferry
				August	Conserve cold water	Ball's Ferry
				Oct	Exceed 56 ^{o}F at Balls 3 days	
2001	2985	4020	Jelly's Ferry	July	Exceed 56.5 ^{o}F at Jelly's 2 days	
				August	Exceed 56 ^{o}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 ^{o}F at Jelly's 5/18/2003	
2003	2558	4537	Bend Bridge	May	Exceed 56 ^{o}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 ^{o}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 ^{o}F at Bend 3 days	Airport Road
			(below Clear Creek)			
Key:						
Above Normal & Wet						
Below Normal & Dry						
Critical						

Figure 6-14. Historical exceedances and temperature control point locations in the upper Sacramento River from 1992 through 2008.

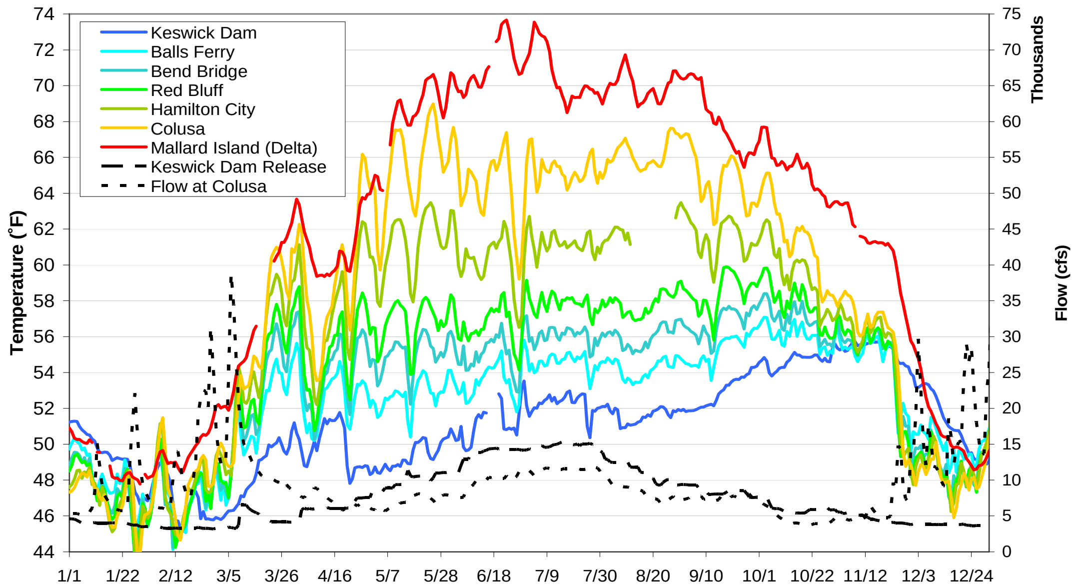


Figure 6-14. Sacramento River mean daily temperature and flow at selected locations in a dry water year, actual measured temperatures in 2001 (OCAP BA figure 11-1).

Table 6-9. Temperature norms for green sturgeon life stages in the Central Valley (Mayfield and Cech 2004, NMFS 2006).

General Life Stage	Suitable	Tolerable	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

6.3.1.5 Sacramento River Water Reliability Project (SRWRP)

The proposed action is 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). This new diversion would service the City of Sacramento, Roseville, Placer County Water Agency (PCWA), and Sacramento Suburban Water District (SSWD). A Feasibility Study was authorized under Public Law 106-554 dated April 24, 2000 consistent with the Water Forum Agreement on the American River. The primary purpose of this agreement was to develop a Sacramento River diversion that would supply water to the rapidly expanding north Sacramento (Natomas) – Placer region while protecting the fishery, wildlife, recreational, and aesthetic value of the lower American River. Instead of water agencies diverting CVP water and riparian rights water from the American River, the point of diversion would be relocated to the Sacramento River thereby allowing the potential for higher flows on the American River beneficial to salmonids. The new diversion would be built to accommodate the following water supply demands (USFWS 2008):

- 35 TAF of PCWA's contract water from the CVP for M &I
- 29 TAF of SSWD's water from PCWA's Middle Fork Project through an exchange with the CVP during dry and critical years.

- 30 TAF of the City of Roseville's water supply from Folsom through an exchange with CVP water due to Water Forum Agreement limitation.
- 81.8 TAF of the City of Sacramento's water right. This water would be prioritized to meet demand first from the American River at Fairbairn (existing), second at north Natomas (proposed above), and third at the Sacramento River diversion (existing). The annual diversion at Fairbairn is subject to Water Forum limitations in dry years.

A total of nearly 176 TAF of water future water demand would be shifted from the American River (Folsom Reservoir) to the Sacramento River (Shasta Reservoir) which has a higher capacity and more reliable water supply. However, the City of Sacramento's portion (81.8 TAF) of the diversion (61% of the capacity) is per its senior water rights on the Sacramento River and is not part of the Federal action considered. Under the No Action Alternative the City of Sacramento would observe the Water Forum Agreement limitations on the American River and develop its own water intake with a145 cfs capacity near the same location.

For purposes of this ESA consultation a separate biological opinion would be written to analyze the construction related impacts; such as removal of shaded riverine aquatic cover (SRA), dredging, pile driving, and entrainment of fish. Impacts considered under the OCAP consultation from this project 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. Water supply impacts from this new diversion are modeled in Study 8, future conditions. In addition, juvenile fish losses associated with the operation and maintenance of yet another large fish screen in the Sacramento River would have to be added to the cumulative effects (note: include analysis of continued screen loss at all CVP and SWP diversions including new projects like SRWRP, CCWD, and City of Stockton).

Impacts not considered in either OCAP or construction of the SRWRP; (1) impacts to critical habitat below the diversion point from reduction in Sacramento River flows (-365 cfs between Natomas and American R. confluence), (2) impacts to Shasta storage (included above), (3) less of a flow trigger for adults migrating upstream and juveniles migrating downstream, less habitat available, (4) interrelated and interdependent effects of growth inducement within the project area on the Sacramento River (*i.e.*, increased non-point pollution from roads, increased wastewater discharge, increased boat traffic) and (5) the cumulative impact of another fish screen operating in the future condition (*i.e.,* add another 5 percent loss for screen contact).

Mean daily average flows at Verona just upstream of the new diversion is 10,000 cfs (range 42,000 cfs in winter to 5,000 cfs in summer in dry years). Therefore, the new diversion would reduce flows in the Sacramento River below the diversion by approximately 3 to 4 percent of the average daily flows, and 7 percent of the average flows in critically dry years. A reduction of that magnitude by itself is not significant, however incrementally it is significant in combination other new diversions like Freeport (285 cfs), City of Stockton (200 cfs), and CCWD (200 cfs).

6.3.1.6 Losses from Screened and Unscreened Diversions on the Sacramento River

Table 6-10. Estimated Entrainment at water diversions.

Number of juvenile fish entrained	Screened CVP Diversions (ACID, TCCA, GCID)	Unscreened Diversions (Project water only)	Percentage of juvenile population
Winter-run		7,440	0.37
Spring-run		537	
Fall run/late fall-run		18,775	
CV steelhead		393	
Green sturgeon		199	unknown

6.3.1.7 Climate Change

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 modeling in OCAP (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^{o}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.

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 6-15). Reclamation's mortality model was not run for CV steelhead because steelhead 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 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 baseline (Study 9.0). September carryover storage is less than 1.9 MAF during average dry years (1928 to 1934) in all scenarios except Study 9.2 wetter, less warming (OCAP 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 Sacramento River since they spawn in the late winter when water temperatures are not as critical to incubation. However, resident forms of *O. mykiss* spawns in May when water temperatures exceed 56^{o}F at Bend Bridge in 25 percent of future water years (OCAP BA figure 10-83). This life history pattern represents a reserve that anadromous forms can interbreed with if there are too few CV steelhead (Zimmermen 2007). 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.

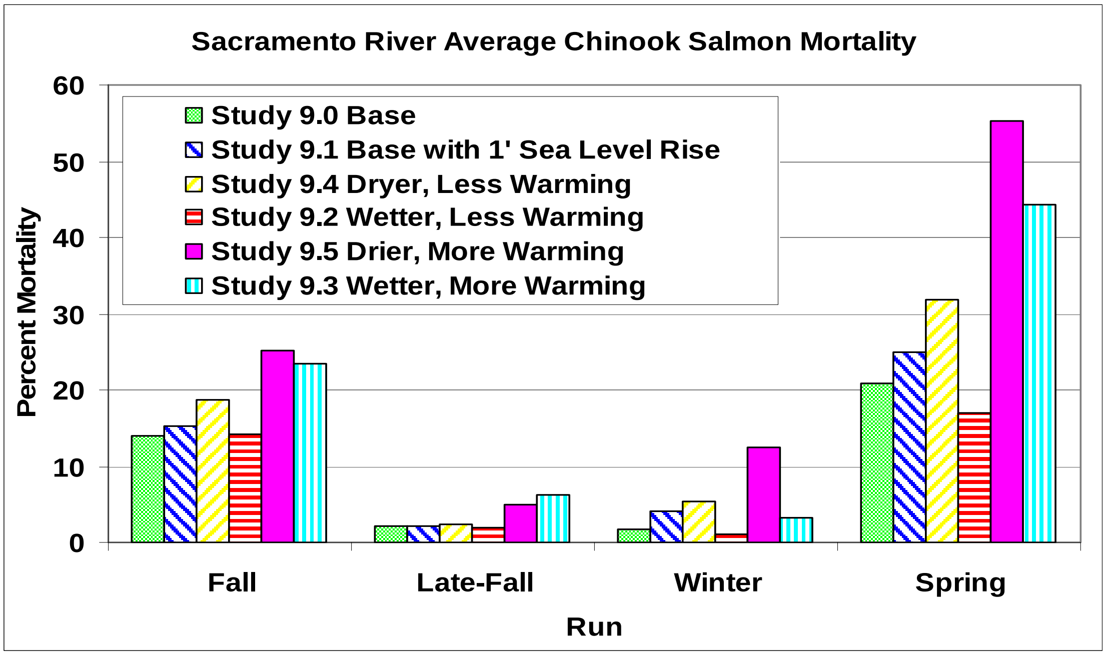


Figure 6-15. Sacramento River average Chinook salmon mortality by run and climate change scenario from Reclamation salmon egg mortality model. All studies except 9.0 include 1foot sea level rise. Study 9.0 is future conditions with D-1641 (OCAP BA figure 11-82).

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 °F objective at Balls Ferry in July, August, September, and October. The highest water temperatures approach 60°F 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 then those modeled. In order to overcome the impacts of climate change new operating criteria needs to be developed that allows for greater storage of water earlier in the year. This would involve the cooperation of the USCOE in developing new flood control curves and integration with state and Federal reservoirs. (DWR 2008) recommends investigating the feasibility of fish passage over dams to access colder water at higher elevations.

6.3.2 Assess the Risk to the Individuals

Table 6-11 provides a summary of effects considered in the OCAP BA and this consultation.

The following provides a summary of effects of the proposed action in Clear Creek and upper Sacramento River:

- Reduced spring-run spawning habitat in Clear Creek due to inadequate flows
- Loss of spring-run and steelhead juveniles in Clear Creek in 4 –10 percent of driest years modeled due to warm temperatures
- Reduction in habitat available in Clear Creek without b(2) water to support flows above minimums

Table 6-11. Summary of effects considered in the OCAP BA and this consultation, and those effects not considered in this consultation.

Effects in OCAP BA	Effects considered in this consultation	Effects not considered in this consultation
Water temperature (SRWQM)	Water temperature (SRWQM)	
	Shasta TCD efficiency	
Suitable flows (CALSIM)	Suitable flows (CALSIM)	
Carryover storage	Carryover storage	
Egg Mortality (USBR Model)	Egg Mortality (USBR Model)	
Fry Mortality	Fry Mortality	
Smolt Mortality (IOS Model)	Smolt Mortality (IOS Model)	
Reduced spawning habitat	Reduced spawning habitat	
Reduced rearing habitat	Reduced rearing habitat	
Unscreened CVP diversions	Unscreened CVP diversions	
	Screened diversions	
	Truncated migration period (Intrinsic Potential Model)	
	Iron Mtn Mine Remediation	
	ACID Dam operations	
Red Bluff Diversion Dam	Red Bluff Diversion Dam	
Red Bluff Pumping Plant	Red Bluff Pumping Plant	
	Redd Bluff Lake	
	Wilkins Slough requirement	
SRWRP (water only)	SRWRP(water & diversion)	
Cold water on steelhead	Cold water on steelhead	
Fish Hatcheries	Fish Hatcheries	
Critical habitat (SALMOD)	Critical habitat (SALMOD)	
VSP	VSP	
Climate Change	Climate Change	
Cumulative Effects	Cumulative Effects	

- Lack of pulse flows in April and May to attract spring-run adults. Flows are flat-lined all year at 200 cfs except in the summer. This lack of variability in the flows limits the expression of different life history patterns.
- Less cold water available from Spring Creek Tunnel, therefore, reduced suitability of habitat for spring-run and steelhead in Clear Creek. Also, impacts to winter-run spawning and incubation in the Sacramento River.
- On average loss of 121 TAF End of September carry-over storage in Shasta Reservoir will cause reduce the ability to control water temperature in the Sacramento River in all water years. The loss in storage will reduce the suitability of spawning and rearing habitat for juvenile winter-run, spring-run, and fall-run.
- Operations of ACID and RBDD will block or delay adult winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon. Adults will either spawn below these diversions or experience a reduction in fecundity from delays. Some adults may be forced to spawn on the mainstem if delays prevent access to tributaries. Adults that

spawn below RBDD would be exposed to water temperatures >60°F, therefore, would these individuals would experience a complete loss of eggs and pre-emergent fry. Green sturgeon adults that are forced to spawn below RBDD would be cut off from a majority of spawners above RBDD, therefore these individuals would be expected to: (1) have fewer opportunities to spawn, (2) spawn in less suitable habitat, and (3) return to the ocean without spawning.

- Direct mortality associated with early RBDD gate closures on adult green sturgeon spawners. Current openings >12 inches under gates may still cause harm and injury to adults as they migrate downstream, or try and go back and forth between holding pools.
- Operations of RBDD will cause higher predation rates on juvenile winter-run, CV steelhead, and green sturgeon as they pass through Red Bluff Lake and the diversion gates (*i.e.*, 45 percent to 50 percent during May).
- Juvenile emigration is shortened temporally and spatially for winter-run, spring-run and green sturgeon due to position of dams. Therefore, individuals leave earlier at smaller sizes, reducing the probability of survival downstream to the Delta. Juveniles that leave up to 3 months earlier would be expected to hold up when they reach unsuitable temperatures (*i.e.*, downstream of Colusa). Exposure to warm water predators would be greater.
- Moving the temperature compliance point upstream in most years reduces the potential for expansion downstream. Salmon and steelhead are imprinted on the area that they spawn in, therefore, they will continue to return to spawn further and further upstream. This increases the probability that one event like an oil spill could wipe out all an entire year class.
- Water temperatures are exceeded in 30 percent of years in August, and 55 percent years in September. Exceedances will reduce the productivity of winter-run, spring-run and some fall-run salmon.
- Average mortality of eggs and pre-emergent fry increases 2 percent in all years for winter-run, 4 percent for spring-run, and 0 percent for steelhead (based on late fall-run).
- The highest increase in mortality occurs during critically dry years (15 percent of years modeled, when winter-run mortality increases from 6 to 16 percent, spring-run increases from 50 to 68 percent, and steelhead increases from 22 to 24 percent. These losses would be significant for spring-run and winter-run, but not for steelhead.
- Green sturgeon spawning below RBDD would become unsuitable as warmer temperatures creep upstream, thus putting more reliance on the unavailable habitat above RBDD.
- Screened and unscreened diversions will continue to take 1-5 percent of juveniles through contact with fish screens, loss in bypasses, and loss from predators.
- The current flow regime on the Sacramento River limits the variability (less complexity of habitat types) essential for fish species to cope with changes in the environment. Thus making juvenile salmonids more susceptible to poor ocean conditions.
- Spring-run spawning in the mainstem Sacramento River will be eliminated in the near future.
- Winter-run spawning in the mainstem Sacramento River will be reduced and less likely to recover.

- The resident life-history pattern for CV steelhead will be favored over anadromy on the mainstem Sacramento River. The increase in resident forms will increase predation on winter-run eggs and fry since they co-occur in the same spawning and rearing habitat.
- Climate change increases average mortality in all year from 2 percent to 12 percent for winter-run, from 20 percent to 55 percent for spring-run, and from 2 percent to 6 percent for steelhead. In critically dry year (15 percent of years) climate change would cause 65 percent mortality of winter-run, 95 percent mortality of spring-run (in the upper Sacramento River only), and 4 percent for CV steelhead (based on late fall-run). For green sturgeon climate change would limit spawning to the upper most reaches of the Sacramento River where habitat is blocked by ACID (5 miles) and RBDD (60 miles).

6.3.3 Assess the Risk to the Population

- Winter-run - Likelihood of survival and recovery is reduced by temp impacts from moving TCP upstream, smaller spawning area, 15 percent adults delayed at RBDD, juvenile predation at RBDD, earlier emigration pattern due to shorter distance to travel (dam blocks access to historical rearing areas, probability of catastrophic events wiping out population increases with climate change impacts. Population is so stressed in the baseline that any additional impact is likely to cause extinction.

- Spring-run - Likelihood of survival and recovery is reduced because of higher spawning temperatures in September (SRWQM), higher egg and fry mortality (Reclamation model) delays at RBDD, hybridization/introgression with fall-run will continue without spatial or temporal separation of the runs.

- CV steelhead – Likelihood of survival and recovery is not impacted, delays at RBDD minor, juvenile predation at RBDD probably not greater than what naturally would occur if predators spread out along river. The ACID fish ladder could be used to count CV steelhead from August to November since it stays in longer than the RBDD fish ladders, which would cover the peak adult emigration period on the mainstem Sacramento River. This would be a good monitoring tool to determine whether steelhead spawn below Keswick Dam in the area controlled by project operations.

- Green sturgeon:
    - Injury and death of adult spawners is likely to continue from the operation of RBDD gates in the existing condition and future condition. The only change in operation for the next 11 years (end of study 7.1 near term in the year 2019) is an increase in the opening under the gates from 6-12 inches. Emergency gate closures are proposed to continue when irrigation demand is high in the spring. Although emergency gate closures have occurred only twice in the last 10 years, the likelihood that they will increase in the future is high given the current low storage level in Shasta (1.2 MAF, 50 percent of capacity) and the predicted lower storage levels from increased demands and climate change (Studies 8.0 and 9.0-9.5).
    - Adult spawners are not able to pass the RBDD or ACID fish ladders, therefore, they are completely blocked from reaching preferred upstream spawning areas (At

least 5 miles spawning habitat with the coldest water is completely blocked by ACID, and 55 miles is blocked to approximately 35-40 percent of the run that spawn above RBDD). It is unknown what happens to adults that spawn below RBDD, and if they do spawn what the success rate is compared to the more favorable upstream areas. The number of adults that are killed and injured will be reduced but not eliminated by a 10-month gate opening in the future (*i.e*., after 2019), if a new pumping plant is built, but that is contingent on funding and land acquisition. Therefore, the likelihood of survival and recovery is reduced due to: (1) direct mortality of spawners passing under the RBDD gates (note: a 12-inch opening may not be large enough and may kill the largest, oldest, most fecund females in the population while allowing smaller size males under gates); (2) blocked passage to and from the majority of known spawning habitat; (3) reduced spawning potential from delayed passage, eggs reabsorbed, or use of unsuitable habitat downstream of RBDD; and (4) reduced spring-time flows may delay adults in moving upstream before RBDD gates are closed.

- o Project operations can negatively impact green sturgeon in the Sacramento River by restricting seasonal spring flows necessary as triggers for spawning and juvenile outmigration. Seasonal flows during the spawning migration seem to be correlated with the number of adults spawning in the Sacramento River (Israel 2008).
- o Since green sturgeon are such long-lived species the impacts of operations would occur gradually over many years, but combined with additional impacts in the Delta, climate change and fishing the population would no longer be sustainable.

6.3.4 Effects of the Action on Winter-run, Spring-run, CV Steelhead Critical Habitat, and Southern DPS of Green Sturgeon Proposed Critical Habitat

6.3.5 Project Effects on Critical Habitat (Sacramento River and Clear Creek)

As described by the CHART (NMFS 2005) and critical habitat designation final rules (June 16, 1993, 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 upper Sacramento River and Clear Creek provide 3 of the 6 PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for CV steelhead, spring-run and winter-run. The upper Sacramento River also falls within the area proposed for critical habitat for green sturgeon (proposed September 8, 2008, 73 FR 52084). Critical habitat impacted by the proposed Project includes the Sacramento River from Keswick Dam to the Delta (302 miles) and Clear Creek from Whiskeytown Dam to the confluence with the Sacramento River (17 miles).

6.3.5.1 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 DPS, 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. Recent studies on Clear Creek (USFWS 2007) using smaller gravel size suitable for steelhead has found that steelhead utilized all newly added injection sites. Spawning habitat on Clear Creek is improving with restoration efforts, gravel augmentation, and increased flows for temperature control. However, the value of spawning habitat is reduced under future operations in critically dry years by warm water releases from Whiskeytown Dam. In critically dry years there will be less spawning habitat available causing competition and redd superimposition which will reduce productivity and egg survival.

For winter-run and spring-run, spawning habitat is consistently reduced by temperature control to smaller and smaller areas below Keswick Dam and Whiskeytown Dam. Project operations maintain cooler water for spawning than what historically occurred in the same time and space. 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 Project reservoirs tends to dampen the seasonal variation in water temperatures. This moderation of water temperatures combined with a loss in spawning habitat above the dams may have profound effects on the life history patterns. Warmer water temperatures during the spring-run salmon 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.

A sizable rainbow trout fishery exists in the tailwaters below Keswick Dam. Resident rainbow trout have been observed by fishermen feeding heavily on winter-run eggs and newly emerged fry on the Sacramento River, so much so that fishermen mimic egg patterns and fish on top of winter-run redds in order to catch large rainbow trout. The loss of temporal and spatial separation has put spawning winter-run and spawning rainbow trout in close proximity to one another. Although, resident trout and winter-run salmon evolved together in the same river they were never concentrated into the same spawning areas as they are today. Competition for food and space between the 4 runs of salmon and CV steelhead reduces the value of the spawning habitat for any one species.

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 strand and/or isolate juveniles rearing along 5 miles of habitat above the diversion dam. 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.

6.3.5.2 Rearing Habitat

Stream flows within the Sacramento River and Clear Creek have been changed by the operations of Shasta, Keswick, Whiskeytown, and Spring Creek Dams. Generally, the changes have increased flows during the summer and fall, and decreased flows in the winter and spring compared to historical conditions (figures 5-4 and 5-16). 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 large wooded debris, and less shaded aquatic riparian habitat. The TNC 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. Singer (2007) confirmed the recent work of others that the loss of spring-summer flows from the Sierra cause high salinity in the Bay-Delta estuary. Therefore, higher spring-time flows, similar to what has been implemented on the Trinity River, would also improve water quality problems associated with salinity intrusion in the Delta. Singer (2008) cautions that a strategy of altering flows to rehabilitate the river should only be implemented with a detailed investigation of the downstream impacts of dam re-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, rip-rap, and armoring to keep the river in place. The reduction in rearing habitat quality has decreased the survival of juvenile salmonids and green sturgeon 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 then historically. Therefore, critical habitat along the entire 300 miles has been adversely modified 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 the dam (*i.e.,* estimated at 10,300 trout per mile), then competition for food and space could reduce the value of this PCE.

6.3.5.3 Migratory Corridors

Designated critical habitat for all 4 listed species is adversely modified by the presence of barriers to upstream and downstream migrations. Part of the value of migratory corridors for critical habitat is unobstructed passage of emigrating fish through the upper Sacramento River to the spawning areas. This characteristic of the PCE will be permanently modified by the continued operation of the RBDD and ACID diversion dam. Adult salmonids are blocked and/or delayed in passing these obstructions. All adult green sturgeon spawners are completely blocked from access to 5 miles of spawning habitat above ACID and a portion of the run is completely blocked by RBDD. 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 adversely modifies 6 miles (or 15 miles of shoreline) of critical habitat for winter-run, spring-run and CV steelhead (RBDD EIS/EIR 2007). 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, steelhead and green sturgeon are disoriented and confused as they migrate downstream through the lake, similar to what happens on the Columbia River above 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 can be built.

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 3 miles above ACID). This seasonal loss of habitat reduces food availability, shelter, and cover and cause 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 spring-run salmon, juvenile winter-run salmon, juvenile fall-run salmon, and juvenile green sturgeon 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, late fall-runs, 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.

6.3.5.4 Climate Change

Climate change as modeled is likely to reduce the value of PCEs in the critical habitat by increasing water temperatures which will reduce the availability of suitable spawning and rearing habitat. Cold water in Shasta Reservoir will run out sooner in the summer impacting winter-run and spring-run spawning habitat. 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 and green sturgeon. Juveniles would be expected to concentrate in areas of cold water refugia like in the few miles below dams where competition for food, space, and cover would be intense. Due to the restricted habitat available below the dams and lack of spatial and temporal separation density dependent mortality is anticipated to occur. 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). Climate change would favor the fall-run over all other species. 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.

6.3.5.5 Green Sturgeon

The freshwater PCEs for proposed Southern DPS of green sturgeon critical habitat are summarized below:

1) Food: In freshwater rearing areas abundant aquatic insects like fly larvae. Adequate

2) Substrate: clean sand, cobble, or bedrock sills. Adequate

3) Water flow: stable spawning flows in summer that maintain water temperatures within the range for egg, larval, and juvenile rearing (52-64°F), spawning flows 198-306 m^3/s, post-spawning flows for downstream migration 174-417 m^3/s in the late summer and greater than 100 m^3/s in the winter (FR 52084). Convert to cfs

4) Water quality: temperatures for egg incubation 14-16°C from March – August, temperatures below 24°C for juvenile rearing, dissolved oxygen 61.78 – 76.06 mg O_2 hr. Adequate

5) Migratory corridor: Unimpeded passage between estuaries and spawning/rearing habitat (*i.e*., passage that does not alter the behavior such that its survival or the overall viability of the species is compromised) Not adequate see RBDD and ACID above
6) Water depth: Holding pools greater than 5 m with adequate water quality and flow to maintain adults and subadults over summer. Limited to areas between ACID and RBDD, need to quatifiy.

7) Sediment quality: Sediments free of contaminants like selenium and pesticides. Unknown, but assume upper Sacramento has heavy metals, pesticides and herbicides (rice farming)

Conclusion for green sturgeon. Passage is impeded at ACID and RBDD altering behavior and survival of the species. Also, the value of spawning and rearing habitat may be limited by the number of holding pools > 5 m available to adults and sub adults.

6.4 American River Division

6.4.1 Deconstruct the Action

Naturally-produced lower American River steelhead 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 6-15). "Current baseline stressors" are those which are not the result of CVP operations, although CVP operations may exacerbate the effect of the stressor. An example of a current 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 2005b).

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 Project. 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 (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).

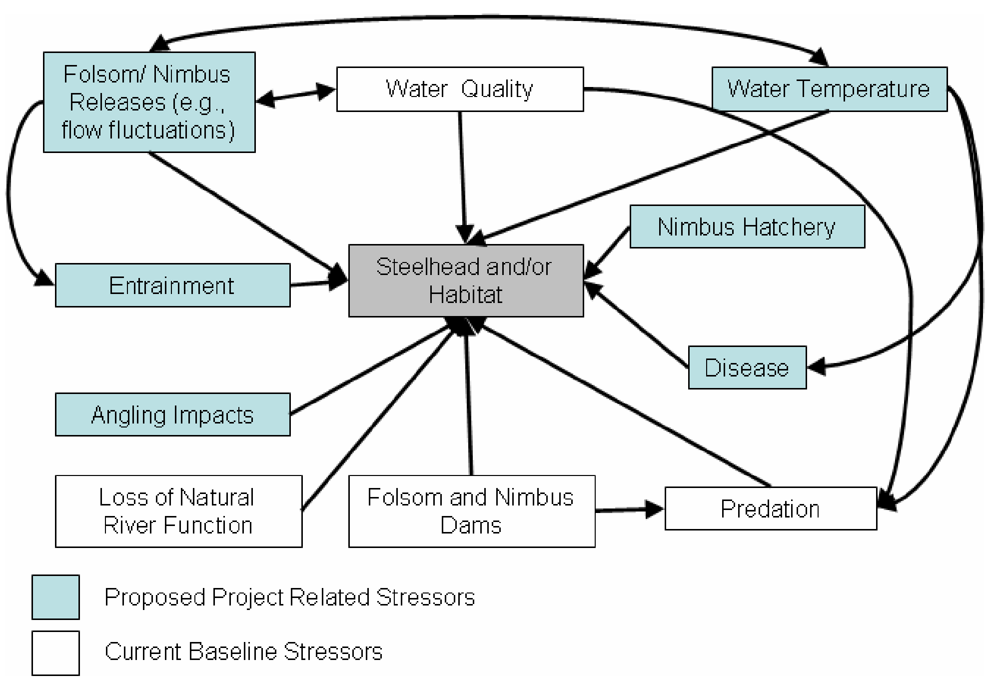


Figure 6-15. Conceptual model of the stress regime affecting naturally-produced American River steelhead.

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 6-12.

6.4.3 Assess Species Response

Now that the exposure of American River steelhead to the proposed Project has been described, the next step is to assess how these fish are likely to respond to the proposed Project-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 Project are presented in table 6-12. There may be other stressors acting on lower American River steelhead than those identified in table 6-12. However, this effects analysis intends to identify and describe the most important stressors to these fish.

This effects analysis assumes that impacts on lower American River steelhead expected to occur with implementation of the proposed Project will be similar to, or more severe than, the impacts associated with the American River Division of the CVP, which have occurred in the recent past (*e.g.*, within the last 10 years). This assumption is reasonable because the proposed Project 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 OCAP 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 OCAP 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 is not expected to reduce water temperature-related or flow fluctuation impacts.

Table 6-12. 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-December through early April	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-December through early April	Nimbus Hatchery – natural-origin steelhead spawning with hatchery O. mykiss	Reduced genetic diversity	Reduced reproductive success
Spawning Primarily upstream of Watt Ave. area	Late-December through early April	Angling impacts – catch-and-release impacts, illegal harvest	Mortality if hooked in critical areas (e.g., gills) or if illegally harvested	Reduced survival
Embryo incubation Primarily upstream of Watt Ave. area	Late-December through May	Water temperatures warmer than life stage requirements	Reduced early life stage viability; direct mortality	Reduced survival
Embryo incubation Primarily upstream of Watt Ave. area	Late-December through May	Folsom/Nimbus releases – redd scour	Egg and alevin mortality	Reduced survival
Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Folsom/Nimbus releases – flow fluctuations; low flows	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	Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation	Reduced growth; Reduced survival
Smolt emigration Throughout entire river	January through June	Water temperatures warmer than life stage requirements	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Reduced growth; Reduced survival

The OCAP BA states that the "*project description…is consistent with the proposed flow management standard*." Based on the information provided in the OCAP 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 OCAP 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 2.7.1); (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 *6.4.4.3.2 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[6]. 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

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[6] 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.

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 OCAP 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, flows will exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (OCAP 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 (USFWS 2003).

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 6-16).

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 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 6-17).

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 from 1994 through 2007); and (2) monitoring was not conducted during many release events and, consequently, impacts were not documented.

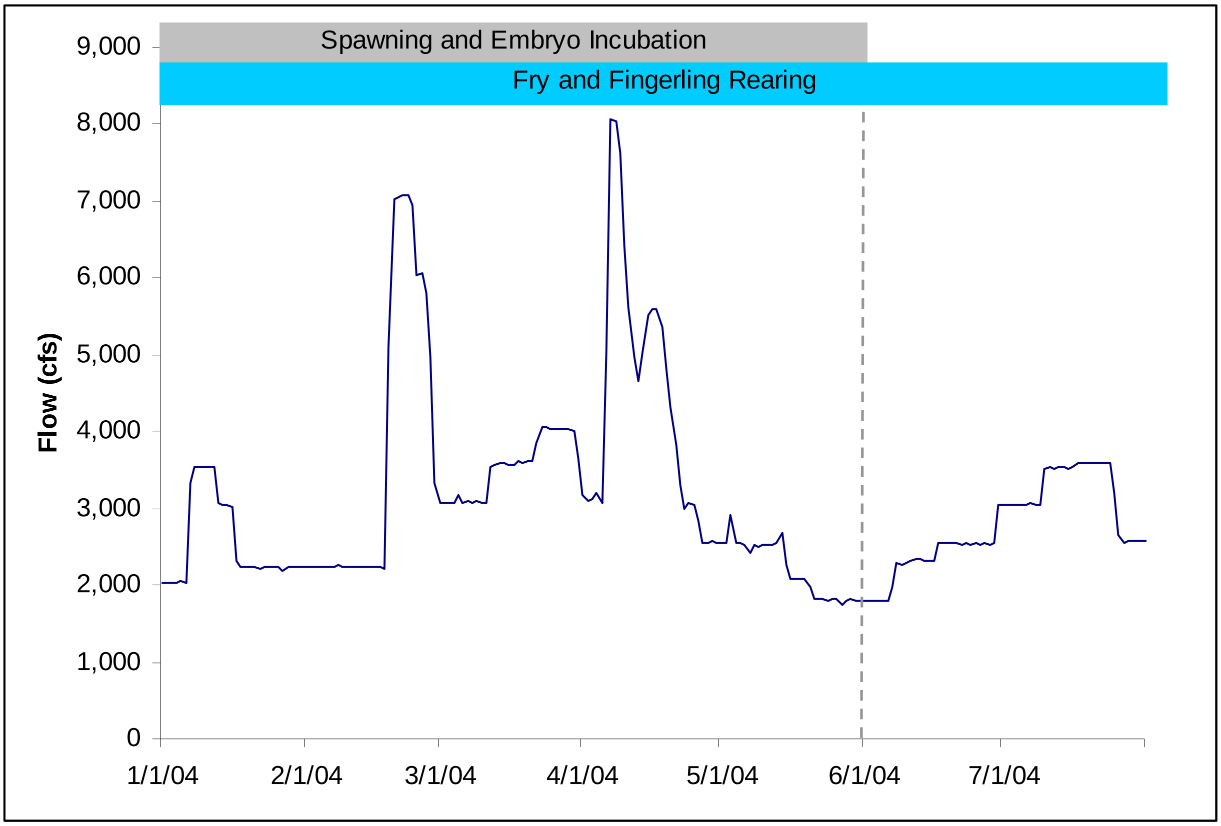


Figure 6-16. Mean daily release rates from Nimbus Dam in January through July of 2004. The timing of the steelhead life stages that are most vulnerable to flow fluctuations during these months are displayed.

Juvenile steelhead isolation has also been reported to occur in the lower American River. For example, Water Forum (2005b) 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 2005b).

In addition to flow fluctuations, low flows also can adversely 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.

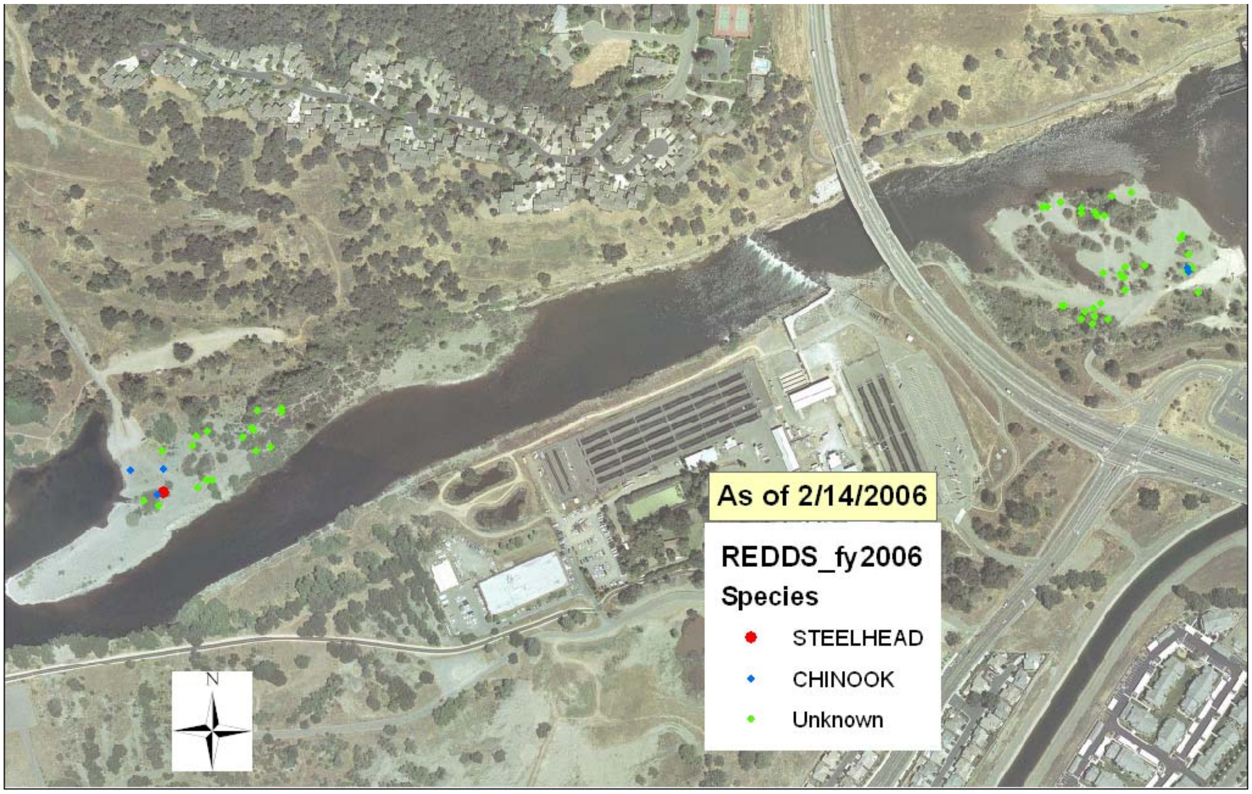


Figure 6-17. Dewatered redds at Nimbus Basin and Sailor Bar, February 2006 (figure was modified from Hannon and Deason 2008).

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 Project 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 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 Project. 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 6-18).

Modeled water temperatures also demonstrate that steelhead eggs will be exposed to stressful conditions with implementation of the proposed Project. Exceedence plots of water temperatures near Sunrise are expected to always be at or above 50°F during March, April, and May (figures 6-19, 6-20, and 6-21). 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. A meaningful analysis of the effects of climate change on lower American River water temperatures was not included in the OCAP BA.

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 assumptions in section 2). 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 6-22). 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.

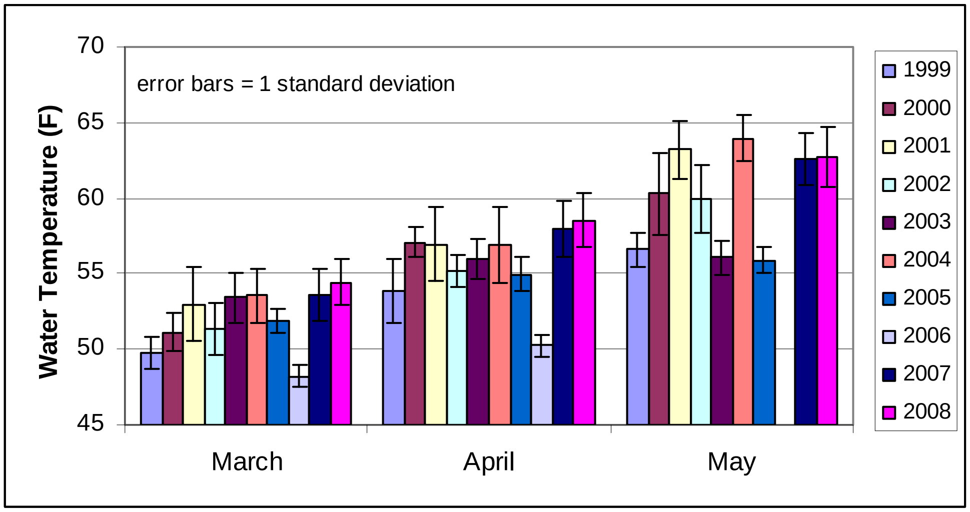


Figure 6-18. Lower American River water temperature during March, April, and May from 1999 through 2008 represented as the mean of the daily average at the Watt Avenue gage (Original data were obtained from http://cdec.water.ca.gov/).

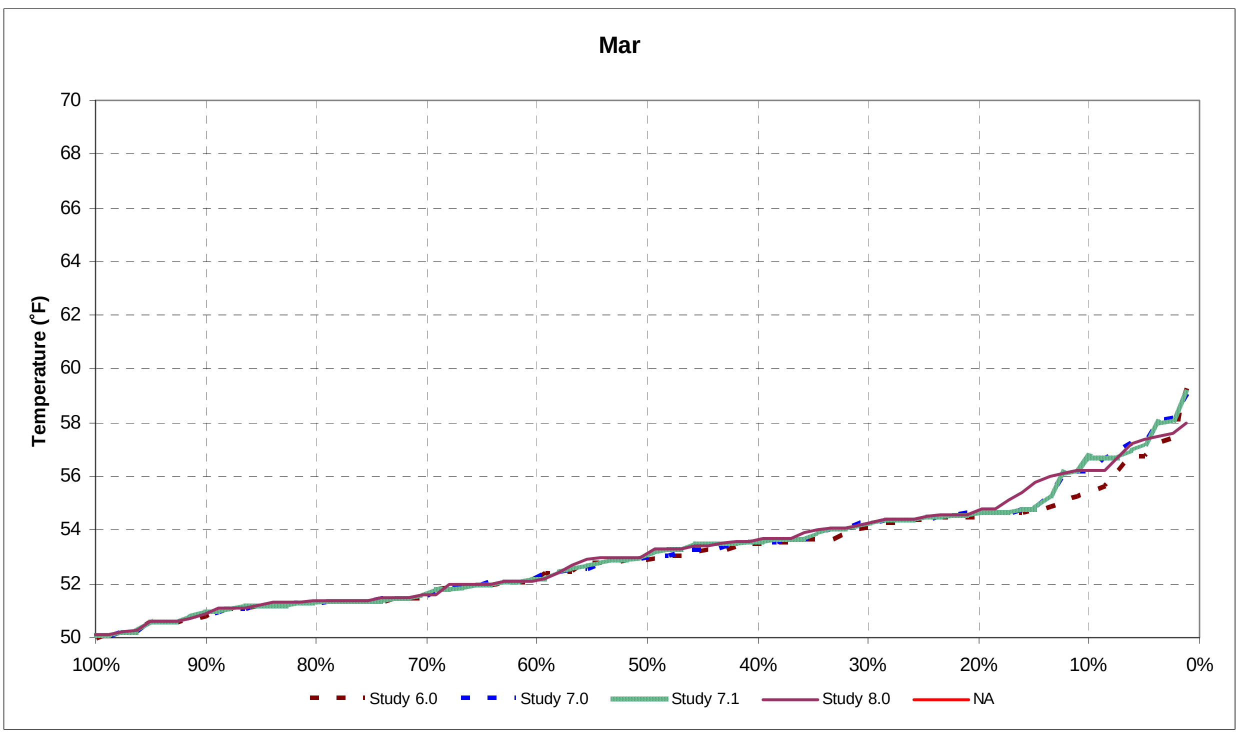


Figure 6-19. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during March (OCAP BA).

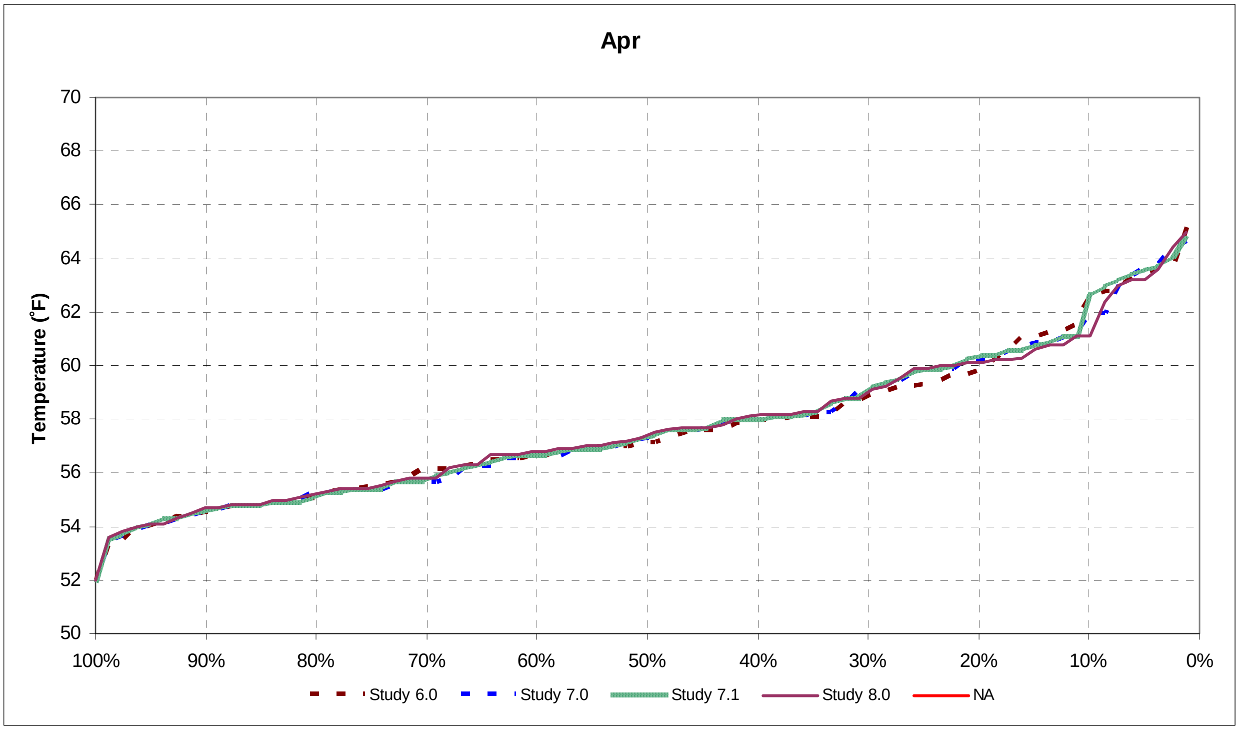


Figure 6-20. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during April (OCAP BA).

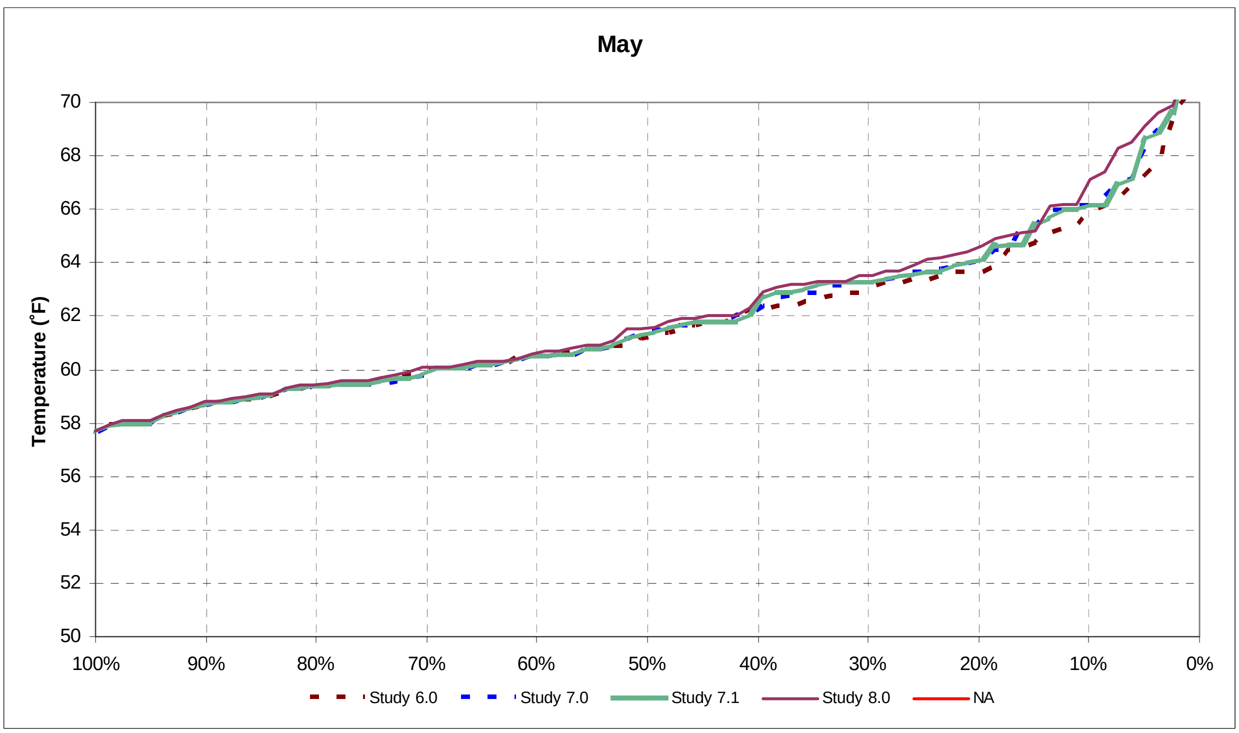


Figure 6-21. Exceedence plot of modeled water temperatures in the lower American River near the Sunrise area during May (OCAP BA).

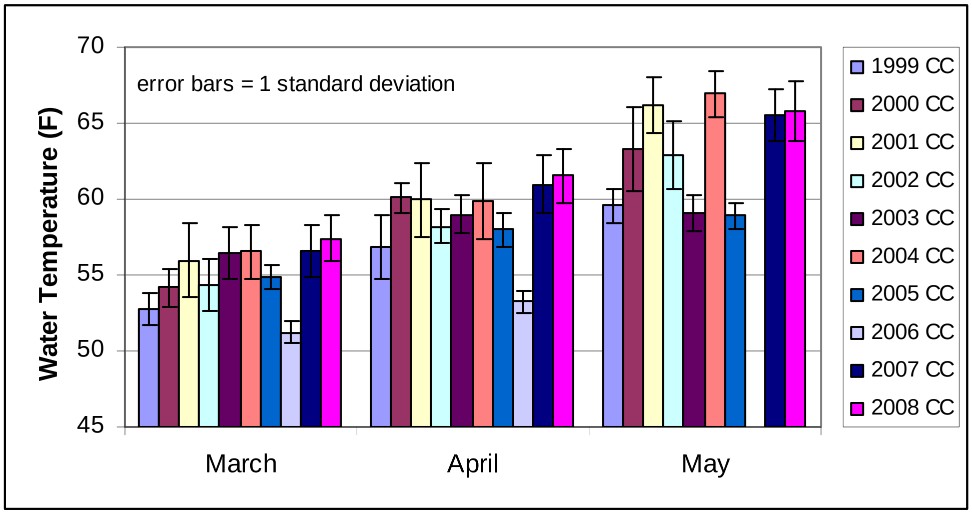


Figure 6-22. Lower American River water temperature during steelhead from 1999 through 2008 represented as the mean of the daily average at the Watt Avenue gage plus 3°F to incorporate potential climate change effects (see Key Assumptions in Chapter 2). Years are labeled in the legend with "CC" to denote 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 6-23). 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 2005b).

Figure 6-23. Anal vent inflammation in a juvenile steelhead from the American River (Water Forum 2005a).

According to CDFG, the juvenile steelhead immune system properly functions up to about 60°F, and then is dramatically compromised as water temperatures increase into the upper 60s (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 34a).

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 6-24b), with levels over 65°F throughout August and September in all years if temperatures increase by 3°F (figure 6-24c). Figures 6-24a, b, and c are likely conservative general representations of the range of summer water temperatures that are expected with implementation of the proposed Project 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 OCAP BA to be 800 TAF.

Based on water temperature modeling results presented in the 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 6-25 and 6-26). It should be noted that the modeled water temperatures presented in figures 6-25 and 6-26 are monthly estimates, which do not capture diurnal variation. As such, NMFS assumes that with the continued implementation of the proposed Project, 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 tolerance limits (~77.0 °F) of Nimbus Fish Hatchery steelhead under laboratory conditions (Cech and Myrick 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 and Wagner 1973, 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 6-18). 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 6-22).

Modeled water temperatures demonstrate that even without warming associated with climate change, the proposed Project 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 29) and for 95 percent of the distribution in April (figure 6-20). By May water temperatures are expected to nearly always be warmer than about 58°F (figure 6-21) and in June modeling results suggest that they will always be over 62°F (figure 6-25a).

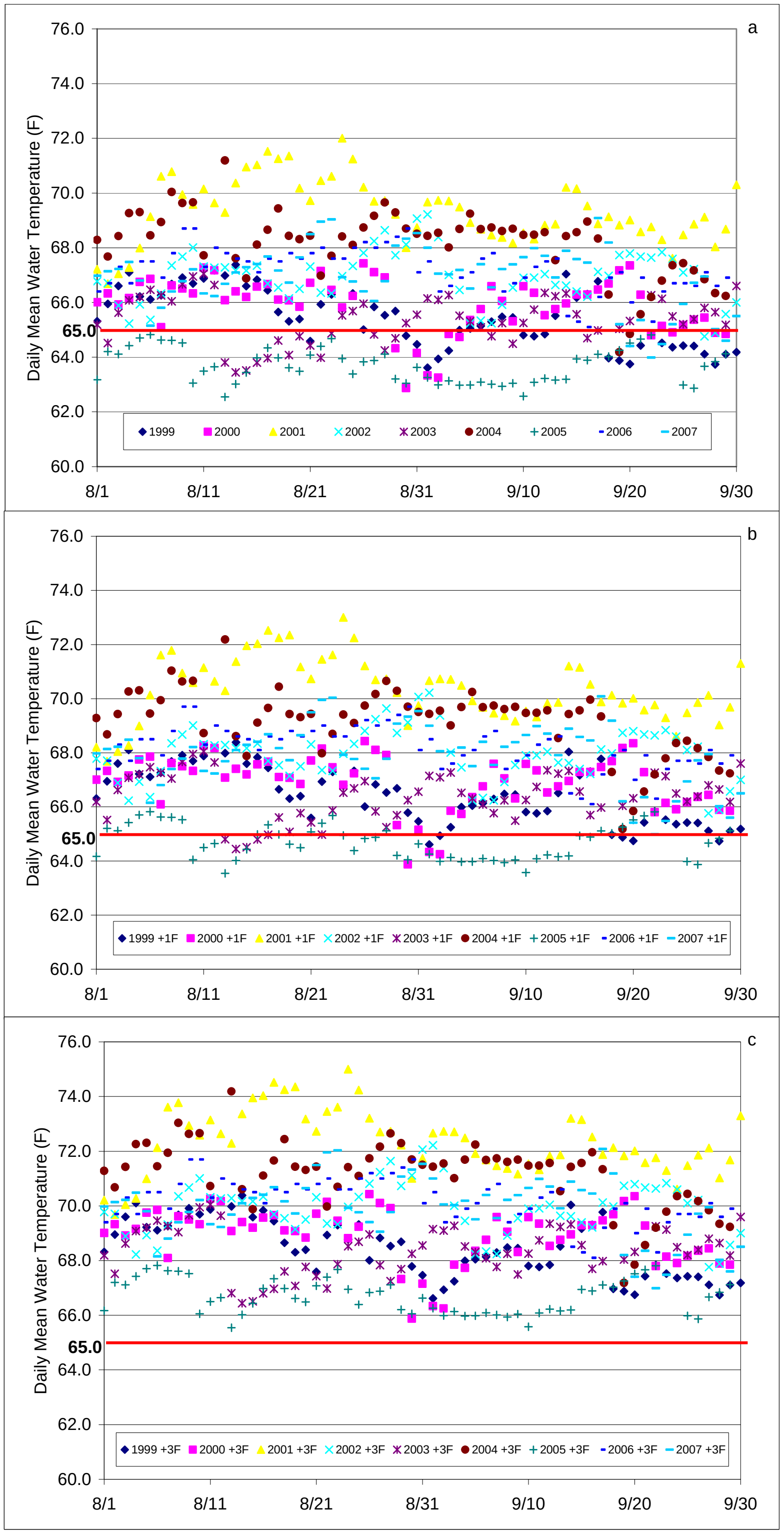


Figure 6-24 a, b, and c. Lower American River water temperature during August and September from 1999 through 2007 represented as the daily mean at the Watt Avenue gage (a). Figures b and c show these same water temperatures plus 1°F and 3°F, respectively, to incorporate potential climate change effects (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/.

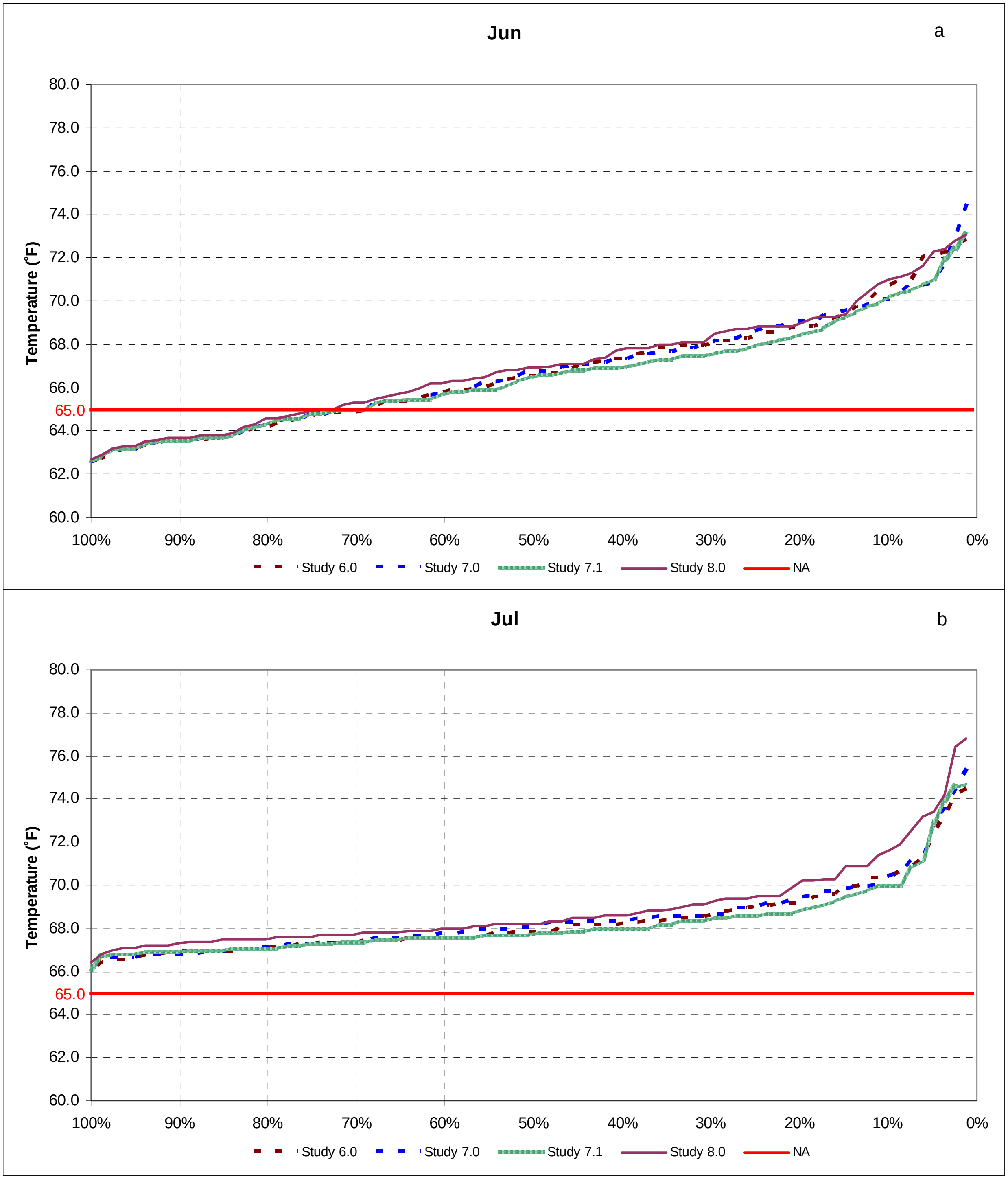
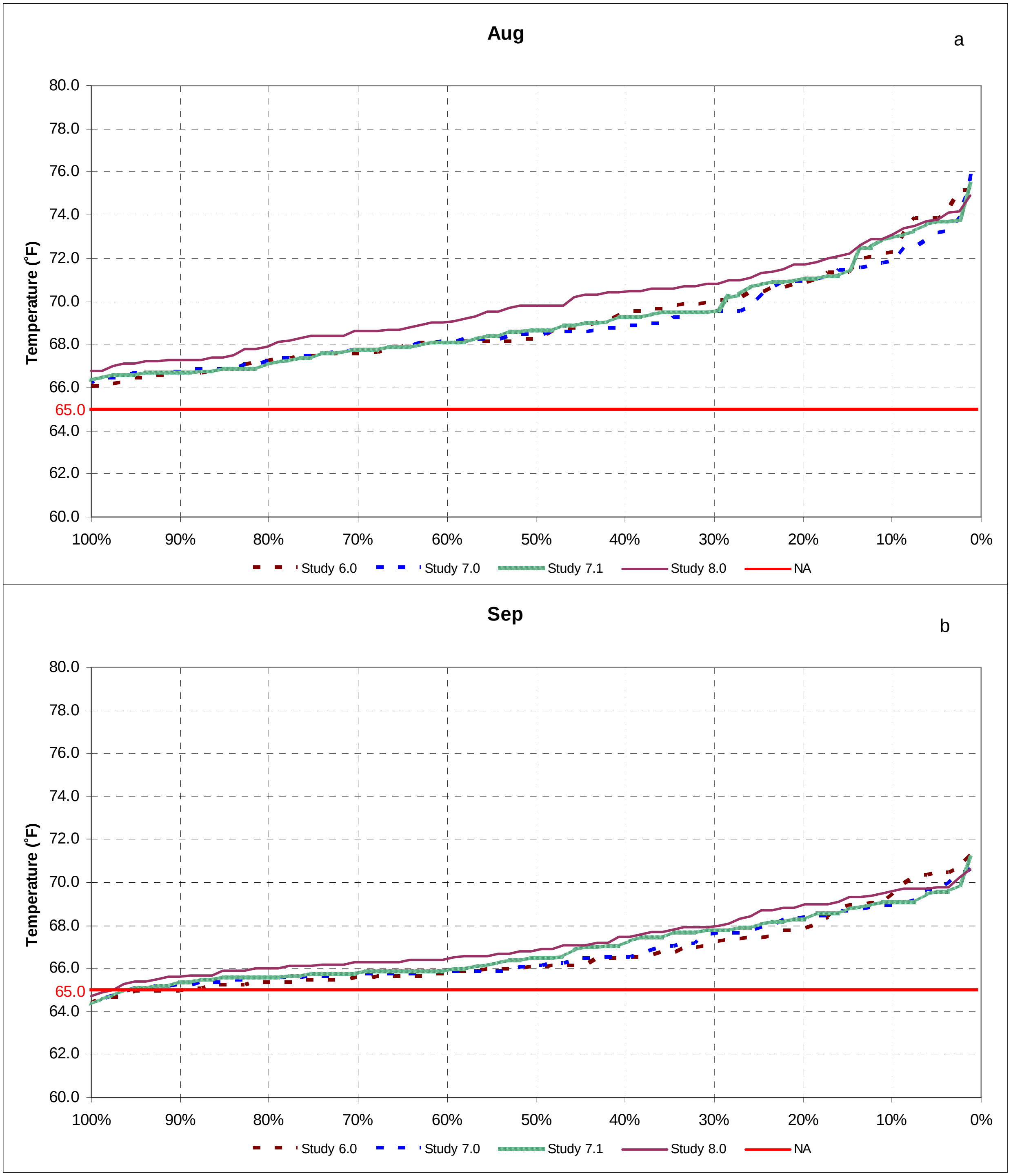


Figure 6-25a and b. Exceedence plots of modeled water temperatures in the lower American River near Watt Avenue during June (a) and July (b) (OCAP BA). For this analysis, the 65°F line was added in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F.



Figures 6-26a and b. Exceedence plots of modeled water temperatures in the lower American River near Watt Avenue during August (a) and September (b) (OCAP BA). 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 (2005b), 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.

6.4.3.4 Nimbus 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). Although unknown, these trout could have been used as broodstock for steelhead production, 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)."

6.4.3.5 Angling Impacts

In the American River, impacts on naturally-spawned steelhead from angling are considered a proposed action-related effect because: (1) Nimbus Fish Hatchery produces steelhead intended for harvest in the American River as mitigation for adverse effects caused by the CVP and its continued implementation (*i.e*., the proposed action); and (2) impacts on naturally-spawned steelhead increase due to increased effort by anglers attempting to harvest hatchery-origin steelhead.

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 fish are hooked in critical locations (*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.

6.4.4 Assess Risk to Individuals

Based on the effects to 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 6-12).

6.4.5 Assess Risk to 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 carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability and utilization of properly functioning conditions (habitats) and the connections between such habitats. Properly functioning condition defines the freshwater habitat conditions necessary for the long-term survival of Pacific salmon populations. As described above, habitat conditions in the lower American River are adversely affected by the proposed Project 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 proposed Project has substantial negative effects on the spatial structure of American River steelhead. Further reductions to the spatial structure of a population which has 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 adversely 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 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 Hatchery operations, relative to the historic diversity.

In addition to the adverse effects on the spatial structure and diversity, the proposed Project 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 Project operations has been documented at both the egg and juvenile life stages. The fitness consequences (e.g., water temperature related bacterial inflammation of the anal vent of juveniles) described above also would be expected to negatively effect the population growth rate.

The combined effect of the proposed Project 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 *Status* section above and Lindley *et al.* 2007), 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 can have serious consequences for the persistence of salmon populations. 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.

6.4.6 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.

Steelhead spawning and rearing PCEs in the American River are expected to be adversely affected by flow and water temperature conditions associated with the proposed Project. High flows during flood control operations result in steelhead redd scour, while flow fluctuations 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.

6.5 East Side Division, New Melones Reservoir

6.5.1. Deconstruct the Action

CV steelhead in the lower Stanislaus 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 “Current baseline stressors” are those which are not the result of CVP operations, although CVP operations may exacerbate the effect of the stressor. The following conceptual model illustrates how those two groups of stressors may affect steelhead.

6.5.1.1 Conceptual Model

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 that may affect particular life history stages of steelhead when they are in the Stanislaus River. A conceptual model of those key elements is presented in figure 6-27. In summary, the proposed New Melones operations will create an altered hydrograph as compared to the unimpaired flows and as compared to baseline conditions (i.e. releases for D-1641 standards and senior water rights). The dampening of flood events and freshets eliminates the geomorphic processes that are important to steelhead to replenish and rejuvenate spawning riffles and to inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. The dampening of flood events also eliminates or reduces the intensity and duration of freshets and storm flows that would otherwise convey smolting steelhead to the ocean and create a clear signature for the river. A more moderate hydrograph has eliminated periodic channel forming flows and the dam captures sediment that would otherwise be transported downstream, resulting in channel incision that further reduces the chance of inundated floodplain habitat. 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. Indirect effects of the New Melones 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.

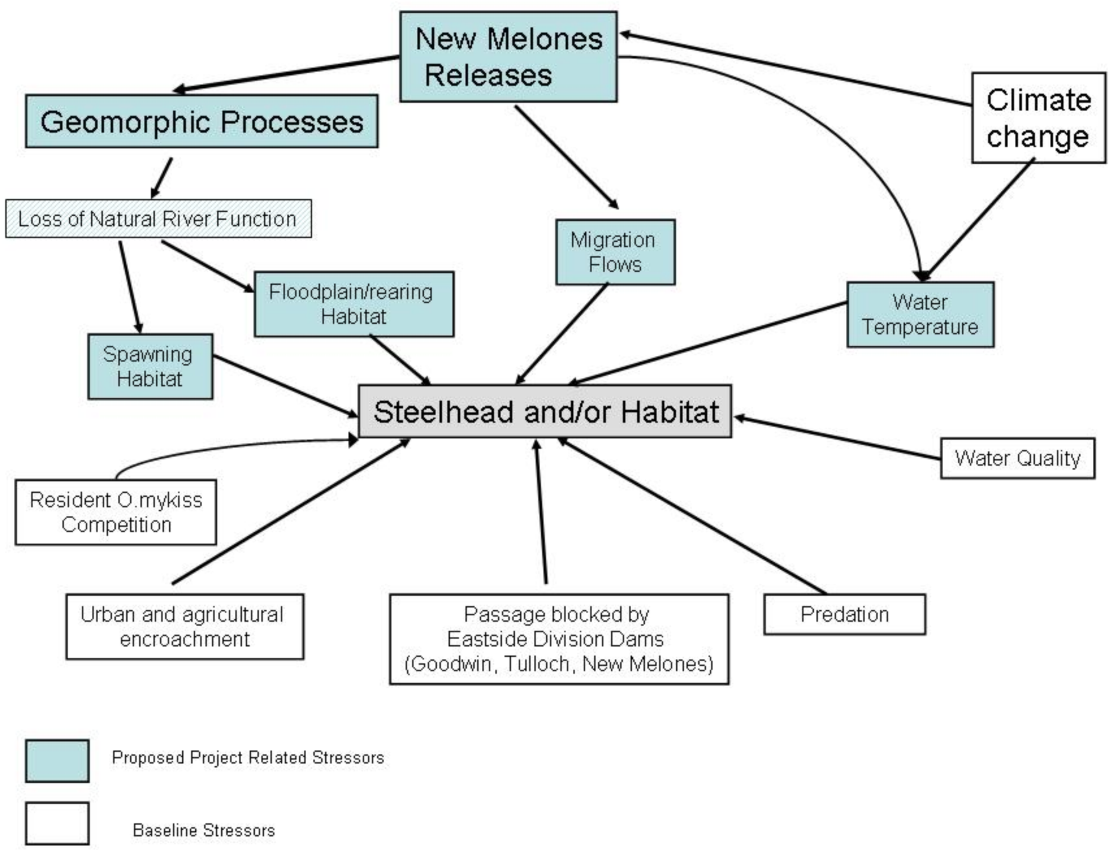


Figure 6-27. Conceptual model of project-related stressors of steelhead and habitat in the Stanislaus River, California.

6.5.1.2 Operational Assumptions

Dam operations typically alter the downstream hydrograph from the unimpaired hydrograph. The Biological Assessment is inconsistent regarding the current and proposed operations of New Melones Reservoir. The Project Description (Ch 2) 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 Ch 9 and 10, but no narrative description was provided. New Melones appears to be operated within the bounds of the fundamental operating criteria (Ch2 Pg 2-65), 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 (BA Page 2-65), 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 BA suggests that many operational criteria of the IPO were not met;
4. Future operations under the New Melones Transitional Operation Plan 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 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 (table UU);
5. Because 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.
6. The amount of b(2) water, is not secured in any year unless end of year storage exceeds 1.7 MAF;
7. The San Joaquin River Agreement and VAMP are scheduled to sunset in 2011, so it is assumed that New Melones operations solely will be responsible for meeting the San Joaquin River flow requirements of D-1641.

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 steelhead life stage and the stressors associated with the proposed Project. A few steps are involved in assessing steelhead exposure. First, the steelhead life stages and associated timings are identified. As information on steelhead in the San Joaquin River system is limited, we assume that steelhead life history timing is similar throughout the Central Valley Streams, although timing for steelhead use on the Stanislaus is used where known (figure 5-23 above).

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 Stanislaus River. The salmonid spawning reach is limited to the 23 miles immediately below Goodwin Dam (AFRP 1996). 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 Stanislaus River into the San Joaquin River as smolts.

The last step in assessing steelhead exposure is to overlay the temporal and spatial distributions of proposed Project-related stressors on top of the temporal and spatial distributions of lower Stanislaus River steelhead. This overlay represents the completed exposure analysis and is presented in table 6-17, which is the summary of baseline and proposed action related stressors on CV steelhead in the Stanislaus River.

6.5.3 Assess the Species Response

6.5.3.1 Geomorphic Effects of Altered Hydrograph

Salmonid spawning habitat availability and quality has been reduced on the order of 40 percent since 1994 (Kondolf *et al*. 2001). Steelhead prefer spawning gravels with a greater proportion of smaller gravels than fall-run. As smaller particles are mobilized at lower flows than larger particles, the degradation of spawning gravels has a greater proportionate effect on 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. Occurrence of even 10% fine materials in fall run redds caused egg mortality of up to 100 percent (Ligand 2000).

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. The reduction in peak, channel-forming, flows over time is summarized in Table 6.13 (from Kondolf *et al.* 2001). Since the operation of New Melones Dam, channel forming flows have been reduced to zero (Table YY from Kondolf *et al.* 2001). Channel forming flows are important to rejuvenate spawning beds and floodplain rearing habitat and to recruit allochthonous nutrients and large wood into the river.

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 measures owing to the very low numbers of steelhead observed in the Stanislaus River.

Table 6.13. 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

6.5.3.2 Temperature Effects

Construction of the dams on the Stanislaus Rivers 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 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) b(2) or b(3). The analysis of temperature effects presented in the OCAP 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 steelhead temperature needs, except in July in dry years, when the average temperature at Orange Blossom Bridge would exceed 65ºF at Orange Blossom Bridge by one degree.

However, we cannot assume that b(2) or b(3) water are committed for fishery uses. The OCAP 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 6-14 compares the flow schedule used for critically dry years in the model with the September 2008 50 percent flow projection. The projection identifies significantly lower flows than what are modeled for a similar year type, and likely resulting in unsuitable temperatures for steelhead.

Without clearer operational criteria to ensure that instream temperature standards are met, steelhead will be subjected to increased sublethal and lethal temperature effects.

Table 6-14. Comparison of projected monthly Stanisalus River flows (cfs) from September 2008 50 percent forecast and OCAP 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

6.5.3.3 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 steelhead and fall-run (table 6-15). As steelhead flow needs are somewhat lower than Chinook salmon needs, the total amount of water needed for maximum instream habitat support is less than 155 TAF, but more than 98.3 TAF fishery agreement allotment to CDFG.

Table 6-15. 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).

Life Stage	Steelhead Flow	Steelhead Timing	Chinook Salmon Flow	Chinook Salmon 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 6-16). The CDFG Fish Agreement allotment alone is less than what steelhead need, and their allocation schedule is predominantly directed by Chinook salmon needs. Consequently steelhead are likely to have unmet flow needs in 59 percent of years, based on recent history, and may also be adversely affected by operations that target higher flows for salmon than are appropriate for steelhead.

Table 6-16. Occurrence of High Allocation, Mid-Allocation and Conference Year types for New Melones Transitional Operation Plan, based on New Melones Operations since 1982 (CDEC 2008).

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%

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 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 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 5 percent in wet years to 19 percent in critically dry years (figure 6-27).

6.5.4 Effects of the Action on Central Valley 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.

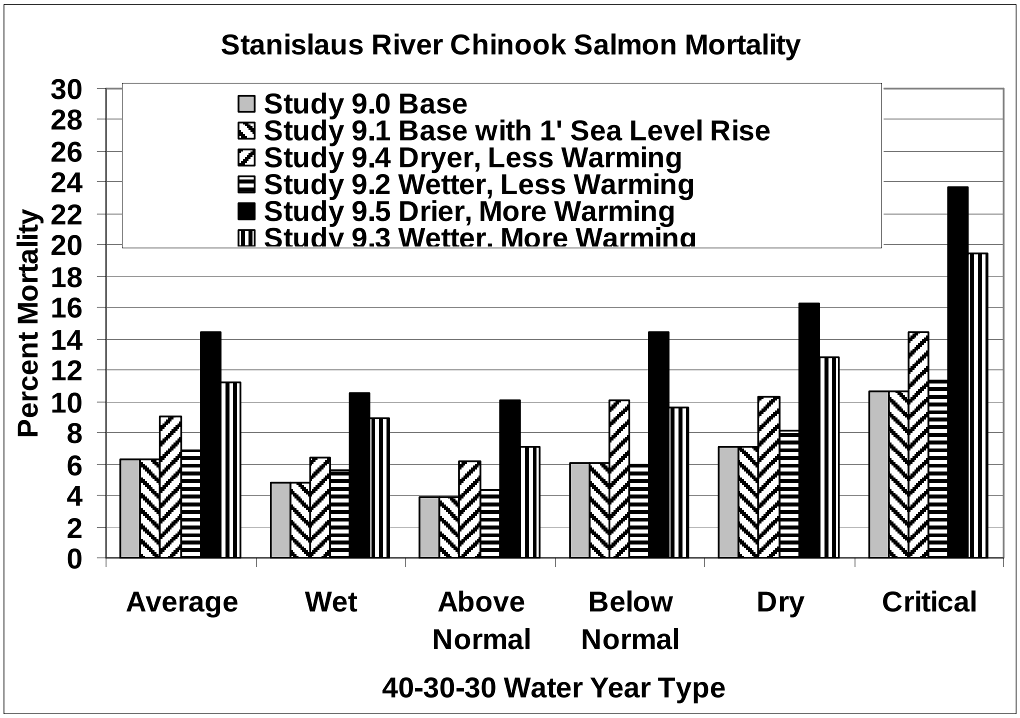


Figure 6-27. Stanislaus River fall-run Chinook salmon egg mortality with climate change scenarios from Reclamation salmon egg mortality model. All studies except 9.0 include 1-foot sea level rise. Study 9.0 is future conditions with D-1641 (OCAP BA figure 11-89).

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 steelhead habitat use in the Stanislaus River is not available, if relevant information for Fall Run will be used as a surrogate comparison, if available.

6.5.4.1 Spawning Sites

Steelhead spawning habitat on the Stanislaus River is affected by East Side Division operations in four categories: (1) flow releases to maintain appropriate temperatures for spawning and egg incubation, (2) flow releases to maximize the amount of spawnable habitat available, (3) gravel replenishment to offset the lost spawnable material blocked by the dams, and (4) flow releases to support geomorphic processes that remove fine sediment from spawning gravels and maintain interstitial flows.

6.5.4.2 Temperature

Because 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 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 41), 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 steelhead likely can be met for future operations without climate change, but 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 OCAP BA to assure that modeled conditions reflect proposed operations. To assure that temperature values are met for spawning habitat, specific temperature criteria of 35-51ºF at Oakdale need to be met from December through February to avoid adverse modification of spawning habitat.

6.5.4.3 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 steelhead. The PHABSIM results indicated steelhead spawning was maximized at 200 cfs. Flows that fall below that level between December and February are projected to occur 50 percent of the time in January and 10% 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 steelhead needs, thus management actions to protect both species may conflict. Lack of channel complexity exacerbates conflicting needs of the species.

6.5.4.4 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, CMC 2000). 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 steelhead spawning, but it is rapidly mobilized at flows as low as 280 cfs (Kondolf 2001). Spawning gravel additions are not of sufficient volume to offset the deficits created by the loss of recruitment from upstream sources (over 1 million cubic yards) but can strategically maintain the quality of heavily used spawning riffles.

6.5.4.5 Spawning Habitat Quality and Geomorphic Processes

Since the construction of New Melones Dam, channel forming flows of 5,000 cfs have increased the 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. This further increases the flows needed to obtain overbank flow and decreases the likelihood of occurrence. 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.

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. Current operations will continue this degradation of spawning habitat conditions. Strategic management of high flows during flood control operations could provide needed gravel movement to keep spawning areas clean with freshly redeposited gravel.

6.5.4.6 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 forming flows of 5,000 cfs have increased the return interval from 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 large woody debris which provides cover, nutrients and habitat complexity, including undercut banks and side channels. Current operations will continue this degradation of rearing habitat conditions. Strategic management of high flows during flood control operations could provide needed overbank flow and scouring to restore these habitat values.

Salmonid habitat improvement projects should continue to be funded by CVPIA funds received from water deliveries and should focus on actions to restore floodplain connectivity for juvenile rearing.

6.5.4.7 Freshwater Migration Corridors

Under proposed operations the freshwater migration corridors on the Stanislaus River will continue to require juvenile 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 steelhead outmigrants is only representative of the lowest migratory volumes historically experienced by 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 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 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.

In summary, although East Side Division operations are not projected to change substantially in the future, the continued habitat degradation by ongoing operations on PCEs for spawning, freshwater rearing, and freshwater migration corridors will adversely modify critical habitat for Central Valley Steelhead.

6.5.5 Summary of the Effects

Likelihood of survival and recovery of steelhead is reduced by:

- continued habitat degradation by ongoing operations
- lack of specificity in operations that can protect conditions for fish
- lack of specificity in how other parties can affect conditions for fish
- impacts on New Melones operations as a result of D-1641 requirements if no VAMP
- impacts on San Joaquin River diversity group:
    - because of East Side Division operations on the Stanislaus River
    - because of unspecified pulse flows on the Tuolumne and Merced Rivers without VAMP,
- If future conditions are drier, warmer or both, instream temperatures will be increased resulting in an adverse reduction of usable spawning, rearing and freshwater migratory habitat, and increased egg mortality of up to 25 percent. These factors will reduce the productivity and abundance of this already diminished population.

6.5.6 Species Effect

VSP Considerations

Diversity: Combine w/ steelhead effects from other CVP streams . SJR diversity group is distinct and important.

Spatial: SJR pops very limited. Impacts to SJR pops affect both spatial and genetic diversity factors.

Abundance: Hard to translate percent habitat loss to # loss when population is so low…

Productivity: T constraints - > increased mort + lower productivity

Table 6-17. Summary of effects within the East Side Division.

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Steelhead						
Adult immigration and Spawning	Dec thru Feb	no access to historical spawning and holding areas	Truncated run;	Dam prevents access to historic upstream spawning and rearing areas. Dam operations can create up to 23 miles of habitat with some suitable attributes	Dam operations can provide either beneficial or adverse effects, depending how done	loss of 54 miles of spawning habitat, representing all of the historic spawning and holding habitat. Operations can replace less than 50% of lost habitat and only in reaches that were historically unsuitable for spawning.
Spawning	Dec-Feb	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.	Reduced suitable spawning habitat; less spawning effort leading to lower productivity for species. For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	Dam operations for flood management and non-contract deliveries, and agricultural and housing encroachment onto floodplain terraces removes geomorphic flows and overbank inundation. Dam prevents recruitment of new spawning gravel.	Proposed operations exacerbate peak flow dampening, further reduce geomorphic processes. Causes siltation of spawning gravels, loss of suitable spawning sized gravel	changes in gravel bed permeability (mesick?) increased fines; 30% spawning habitat lost since 1994, Kondolf

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Egg incubation and emergence	Dec-March	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.	egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other steelhead or fall-run Chinook; suppressed growth rates;	Dam operations for flood management and non-contract deliveries, and agricultural and housing encroachment onto floodplain terraces removes geomorphic flows and overbank inundation for fine material deposition to occur out of the river bed.	Proposed operations exacerbate peak flow dampening, further reduce geomorphic processes (increased channel incision, reduced potential for overbank flow).	Ligand reduced survival proportional to presence of fines on Tuolumne; Mesick - permeabilities again
Egg incubation and emergence	Jan-March	T > 52º F	Egg mortality	Winter instream temperatures conducive to egg incubation and emergence when CDFG fish flow allocations target flow at this time.	Proposed operations cite no criteria for operational protection of steelhead egg incubation and emergence.	Myrick and Cech - temperature requirements - likelihood of exceedance>

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Juvenile rearing	Year round Jan-April (14 months)	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 ;	Application of pesticides and fertilizers for agricultural production and landscaping runoff into stream. Waterway listed as impaired (Diazinon?). Dormant sprays regularly applied to orchards	Dam operations for flood management support agricultural and housing encroachment onto floodplain terraces and increase sources of contaminants.	
Juvenile rearing	Year round Jan-April (14 months)	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;	Dam operations for flood management and non-contract deliveries, and agricultural and housing encroachment onto floodplain terraces removes geomorphic flows and overbank inundation. Dam prevents access to historic rearing habitat upstream.	Proposed operations exacerbate peak flow dampening, further reduce geomorphic processes.	Qualitative: Yolo basin growth studies; Cosumnes River FP studies; any data from Kondolf on lost acreage?

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Juvenile rearing	Year round Jan-April (14 months)	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;	This condition occurs particularly in late summer when D-1641 standards in Delta are met by means other than Stanislaus River releases.	Under proposed action, this condition occurs particularly in late summer when D-1641 standards in Delta are met by means other than Stanislaus River releases, and in years when carryover storage less than 1MAF. For the latter, fish allocations are unpredictable and available water for fish (CDFG 98 TAF) may be prioritized for Fall-run Chinook needs.	Look at % change in habitat from optimal 250 CFS at OBB to 100cfs at obb.

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Juvenile rearing and out-migration	All year with increase Feb-May during out-migration	predation by non-native fish predators	reduced juvenile survival and production	Gravel mining pits captured to run of river provide habitat for introduced predatory fist and holding areas for striped bass	Reduced flow regimes allow instream warming earlier in spring, allowing predatory fish to become more active during smolt outmigration. Narrow pulse flow window increases smolt exit time, and increases risk of predation	Predation rates on fall-run Chinook salmon very high (Tuolumne studies) E-fishing at Oakdale Rec confirms similar predation risk for Steelhead smolts, even despite larger size. Greater risk from striped bass in Stanislaus.
Juvenile rearing	Year round Jan-April (14 months)	unsuitable end of summer temperatures (> 65º F) in rearing habitat	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Dam operations for flood management and non-contract deliveries, and agricultural and housing encroachment onto floodplain terraces removes geomorphic flows and overbank	Proposed operations purport to meet < 65º F in model runs and in BA conclusions, but PD will not commit to protecting this temperature. Recent dry years experience that	mortality and sublethal effects (Myrick and Cech)

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
				inundation. Dam prevents access to historic rearing habitat.	flows could be drastically reduced	
Smoltification	Jan-April?	T > 51° F	missing triggers to elect anadromous life history	Dam prevents access to historic upstream spawning and rearing areas.	Proposed operations make no consideration of providing appropriate temperatures for smoltification	reduced diversity by failure to elect anadromous life history. Need more info on diff T needs for Juv rearing and initiating smoltification. Myrick and Cech?

Life history stage	Life Stage Timing	Stressor	Species Response	Baseline stress regime	Project Related Stressors	Probable fitness reduction
Smolt emigration	(Feb?) Mar-June	Suboptimal flow	failure to escape stream 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	Upstream diversions of SJR and tributaries curtail flow in SJR at confluence of Stanislaus River. Dry years result in worse conditions. Without VAMP, Stanislaus emigration flows limited to large storm events on full reservoir; limited to no flow/temp signature into the Delta. Pulse flows under VAMP very narrow time frame that truncates life history strategy.	Without VAMP contributions from other Tributaries, flow in main stem SJR is less and temperatures rise to suboptimal and lethal conditions at Mossdale by June. Instream VAMP-like flow from Stanislaus is not sufficient to offset losses from upstream tribs in main stem to Vernalis. b(2) not reliably available to offset these effects.	note presence of smolts in stream in May - will die? Not exercise anadromy? Chinook surrogate studies (CDFG 2008 models

6.6 Delta Division

As shown below, the Delta Division is very complex, with multiple facets of baseline and operational stressors that need to be considered in our analysis. Therefore, this section does not follow tightly with the analytical approach described in section 2. However, this section also does not detract from the critical elements in our analysis of effects on the listed species and their critical habitats within the Delta Division.

6.6.1 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 OCAP studies (6.0, 7.0, 7.1, and 8.0) as well as five climate change scenarios modeled in the future Study 9.0 (See OCAP BA chapter 9).

6.6.1.1 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). Based on the four modeling comparisons done for the OCAP BA, the annual Delta inflow decreases in all study comparisons when future conditions are compared to current conditions (table 6-13). 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 6-13. Differences in long-term average annual Delta inflow and the 1929 – 1934 drought as modeled under the four OCAP studies (OCAP 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 6-23). The highest modeled inflows occur in the period from January through April due to flood flows 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 6-24 through 6-29). 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.

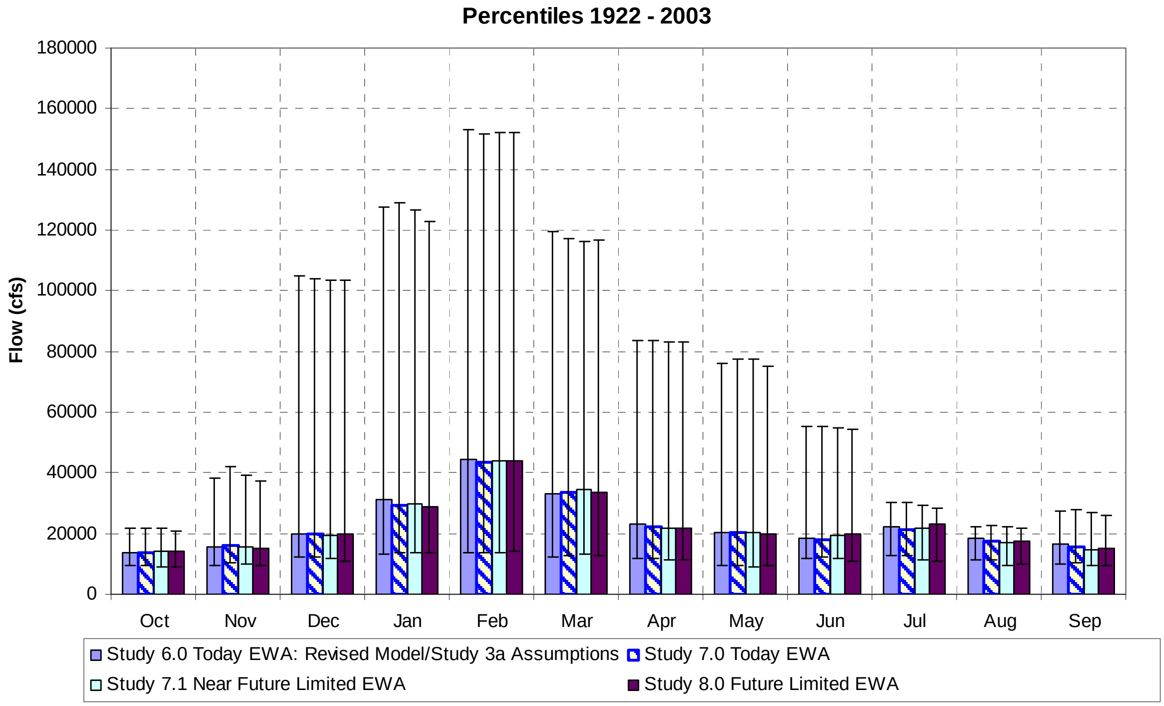


Figure 6-23. Monthly Delta inflow as measured at the 50th Percentile with 5th and 95th percentile whisker bars shown (OCAP BA figure 12-2).

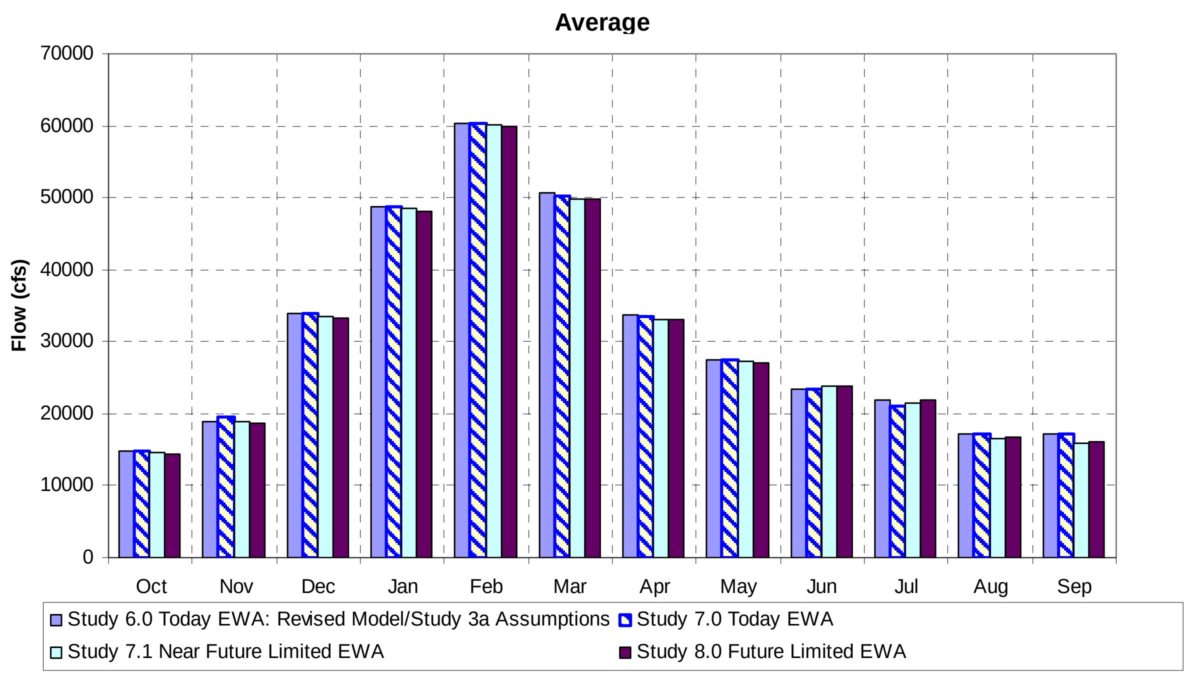


Figure 6-24: Average monthly Total Delta Inflow (OCAP BA figure 12-3).

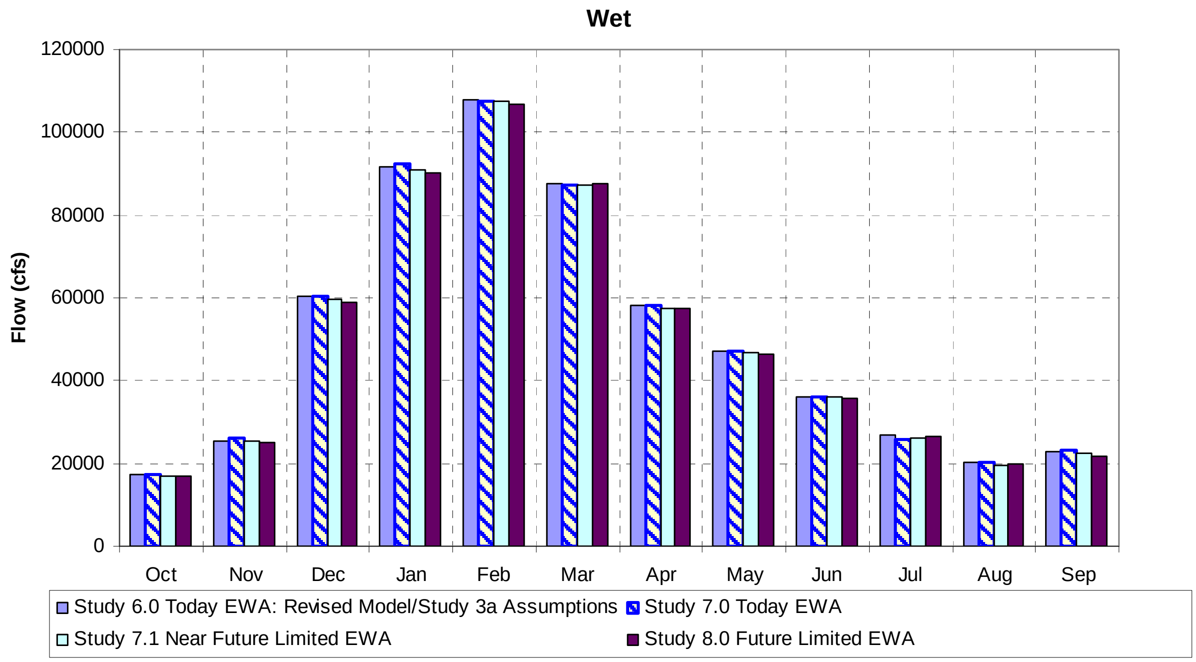


Figure 6-25: Average wet year (40-30-30) monthly total Delta inflow (OCAP BA figure 12-4).

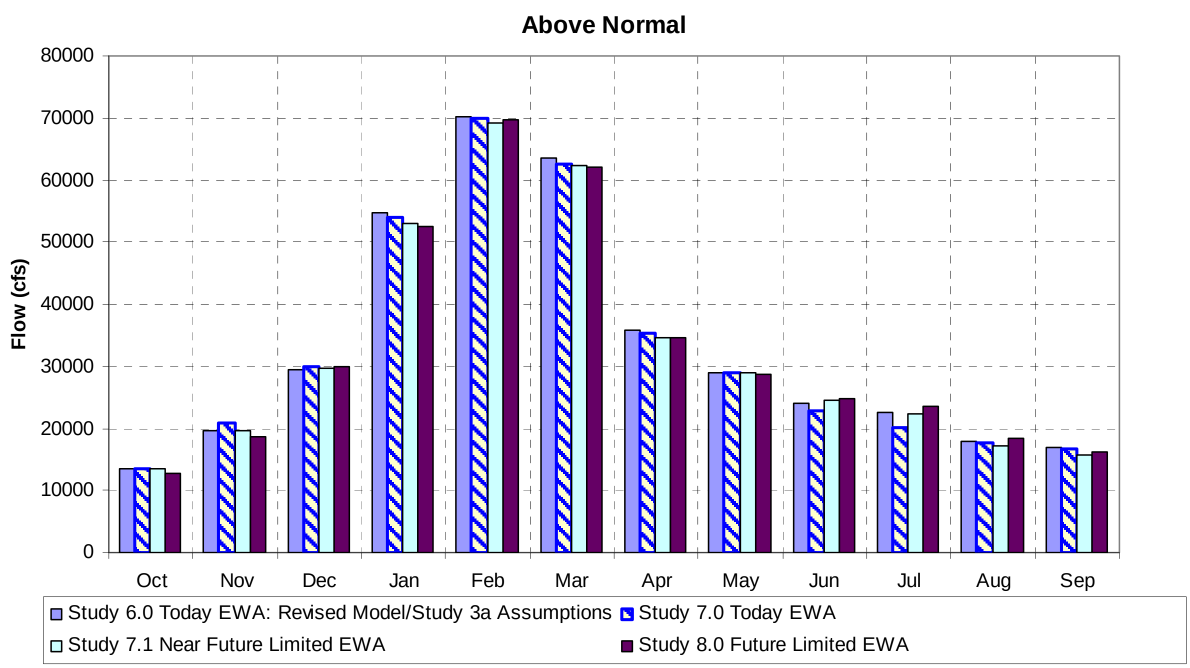


Figure 6-26: Average above normal year (40-30-30) monthly total Delta inflow (OCAP BA figure 12-5).

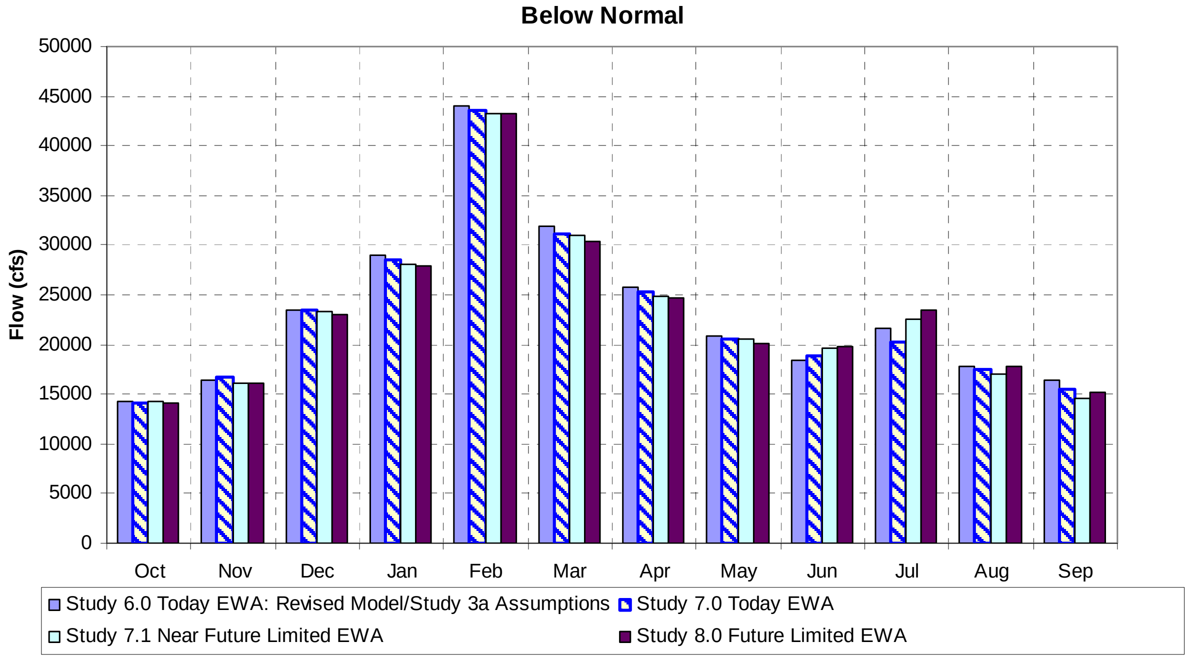


Figure 6-27: Average below normal year (40-30-30) monthly total Delta inflow (OCAP BA figure 12-6).

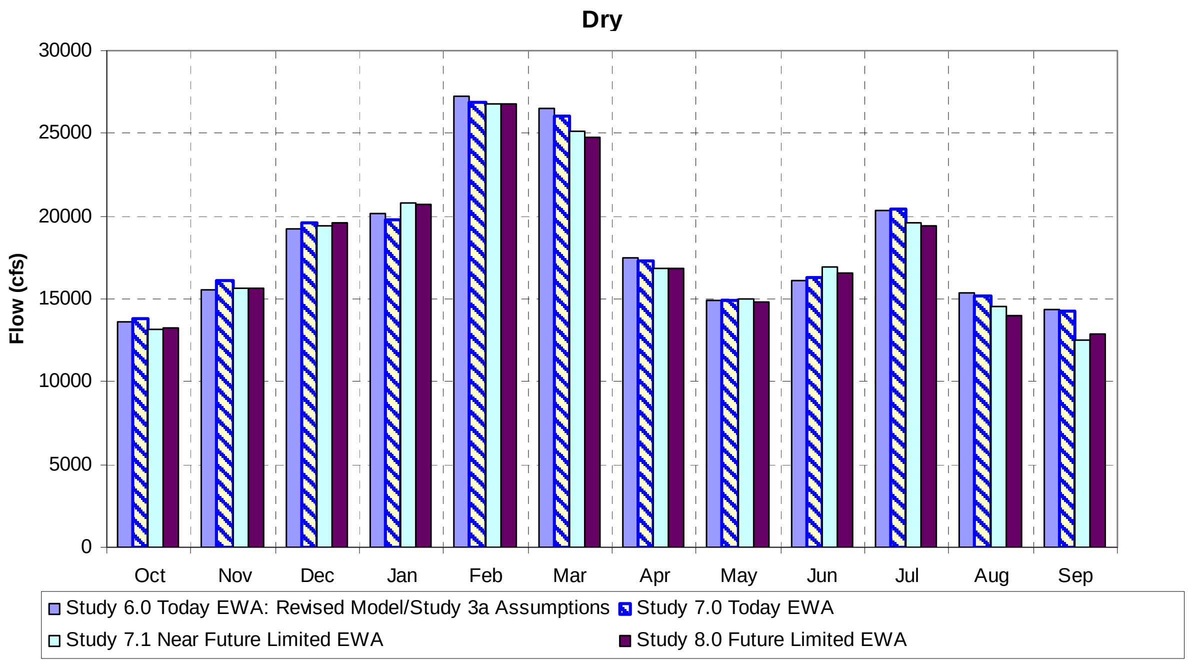


Figure 6-28: Average dry year (40-30-30) monthly total Delta inflow (OCAP BA figure 12-7).

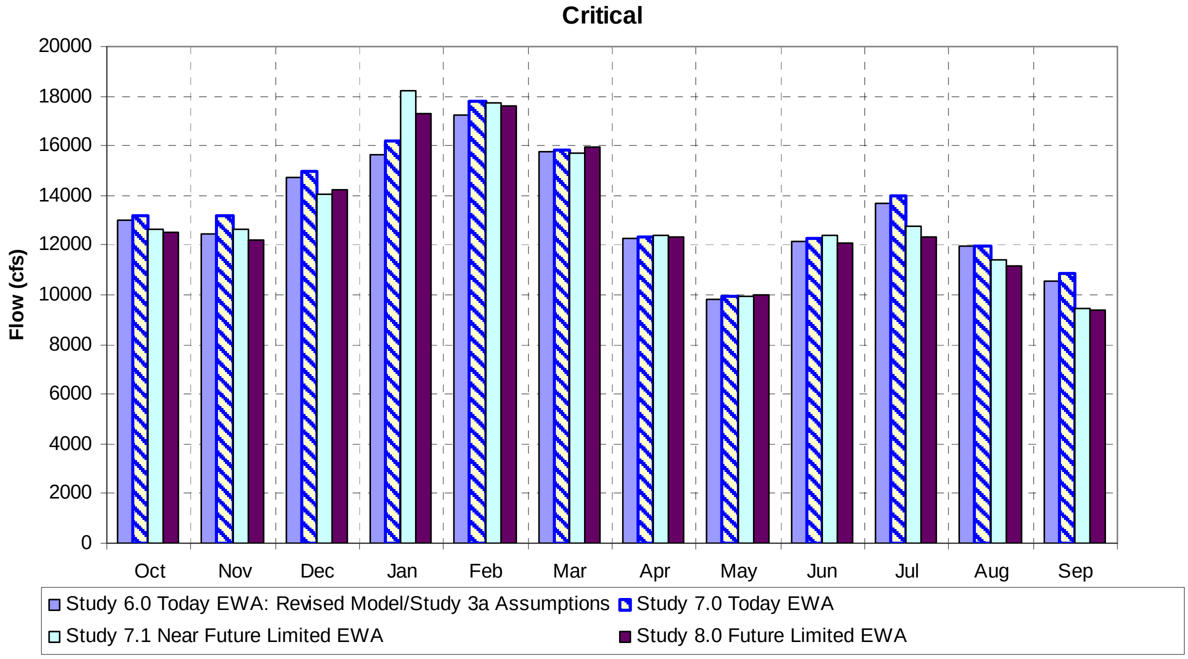


Figure 6-29: Average critically dry year (40-30-30) monthly total Delta inflow (OCAP BA figure 12-8).

6.6.1.2 Delta Outflow

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 6-14).

Table 6-14. Differences in long-term average annual Delta outflow and the 1929 – 1934 drought as modeled under the four OCAP studies (OCAP 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 Inflow	-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 6-30 through 6-36).

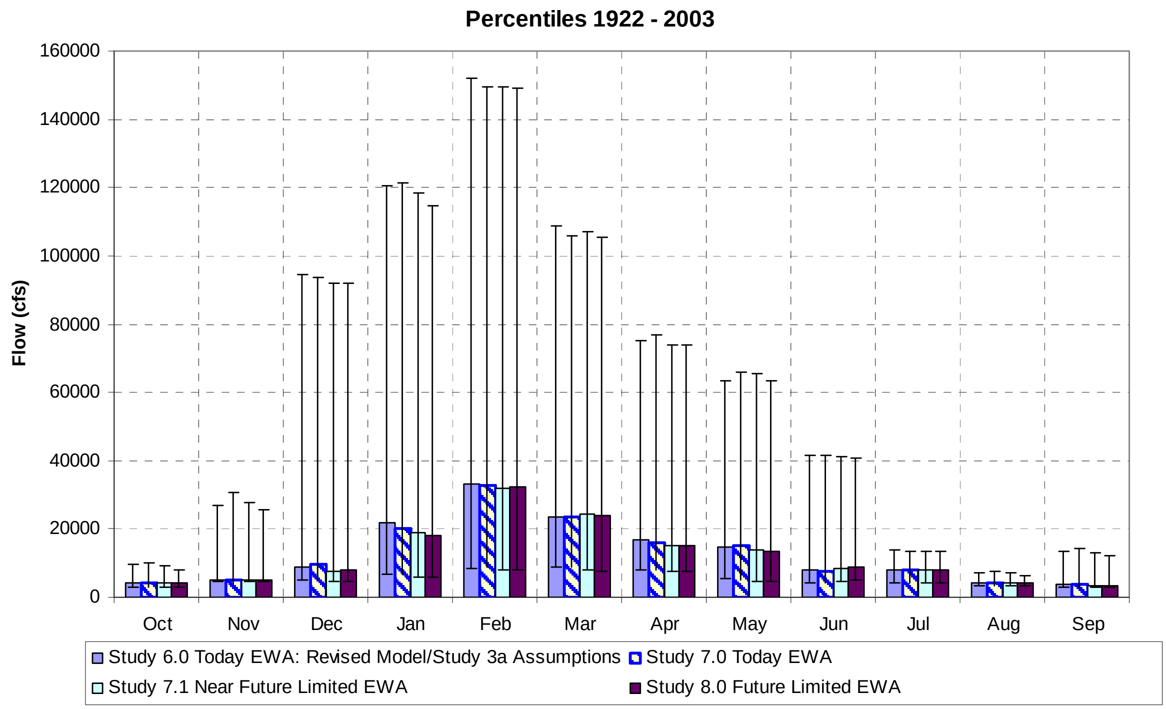


Figure 6-30. Monthly Delta outflow as measured at the 50th percentile with 5th and 95th percentile whisker bars shown (OCAP BA figure 12-10).

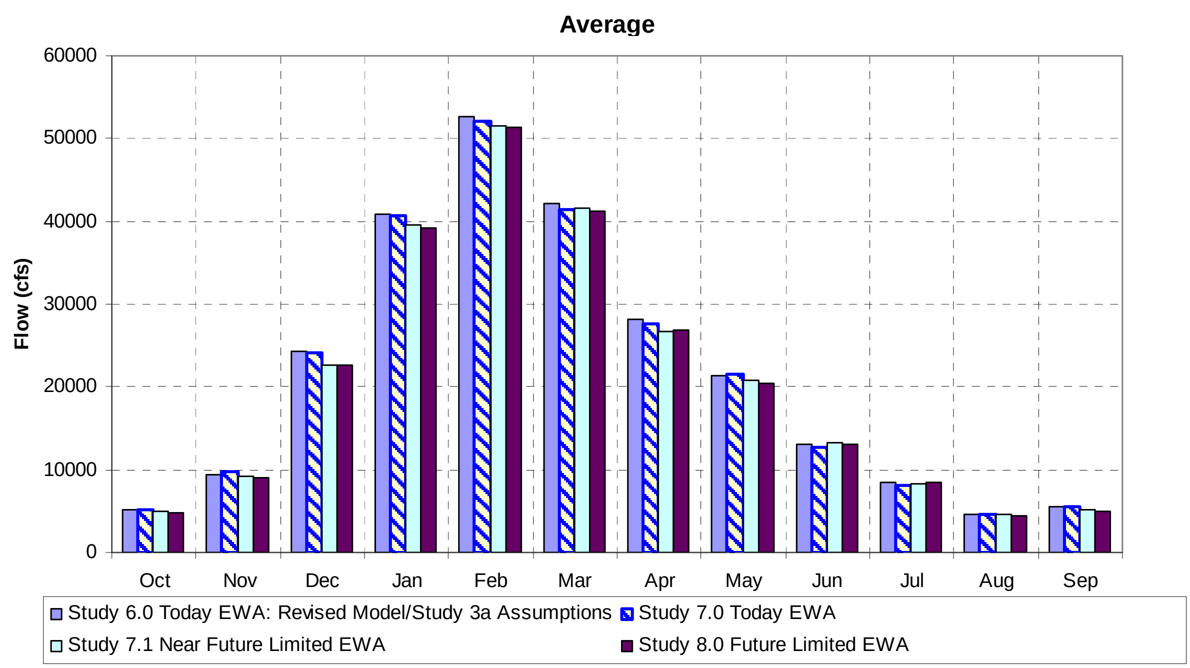


Figure 6-31. Average monthly total Delta outflow (OCAP BA figure 12-11).

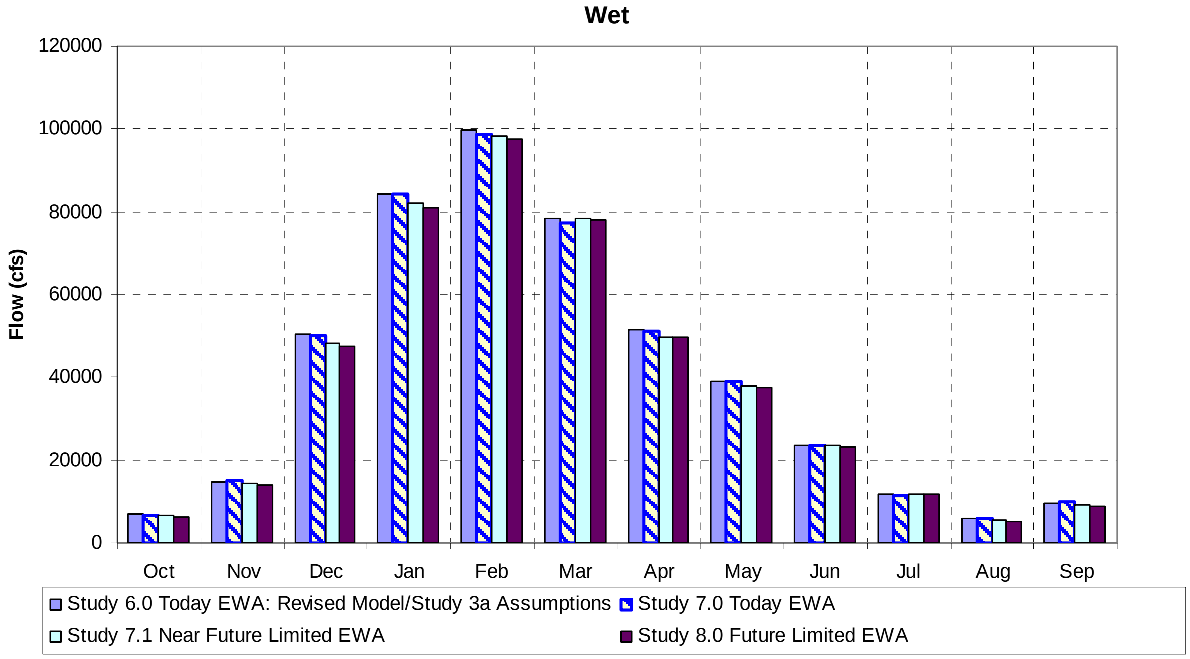


Figure 6-32. Average wet year (40-30-30) monthly delta outflow (OCAP BA figure 12-12).

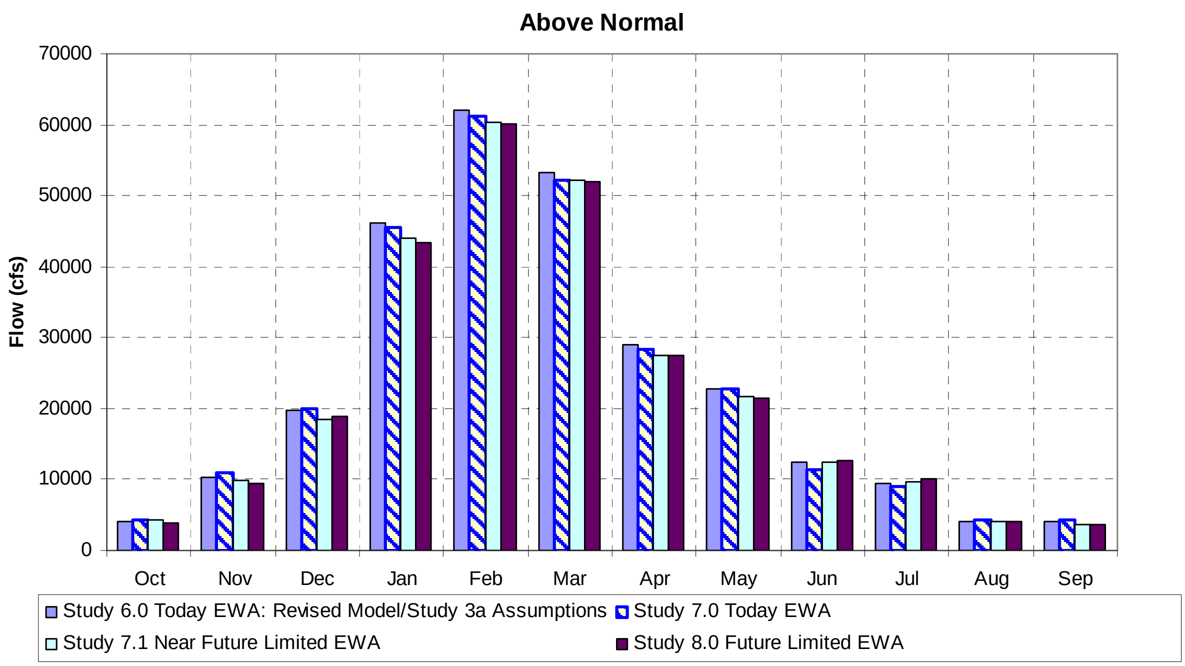


Figure 6-33. Average above normal year (40-30-30) monthly Delta outflow (OCAP BA figure 12-13).

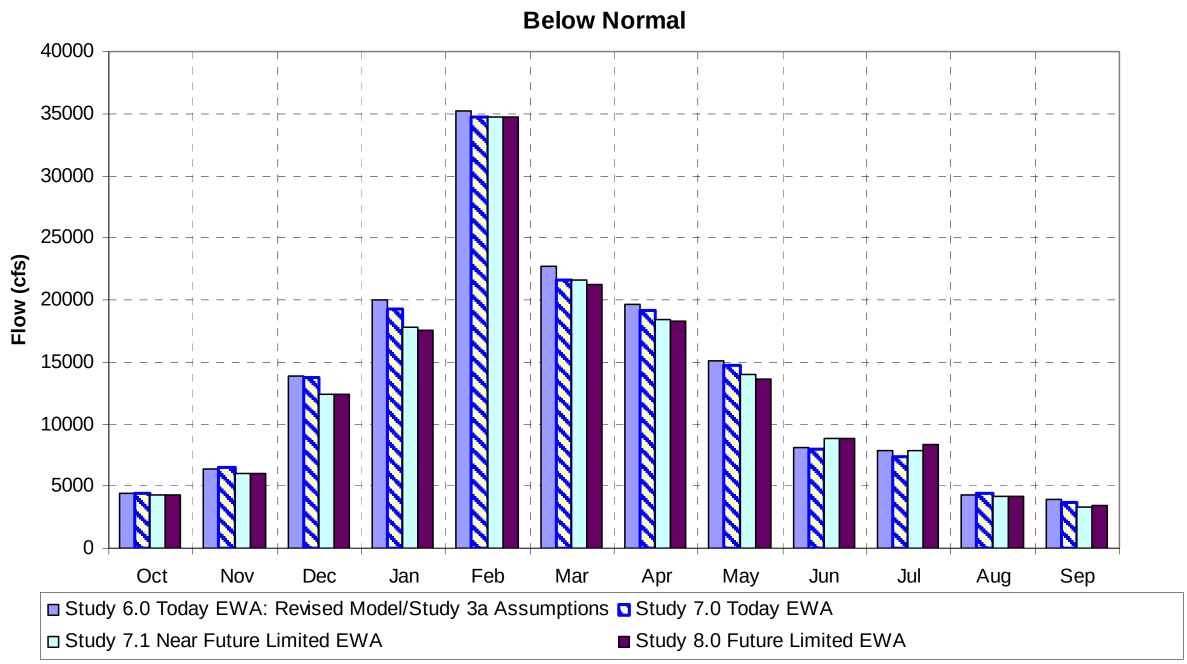


Figure 6-34. Average below normal year (40-30-30) monthly Delta outflow (OCAP BA figure 12-14).

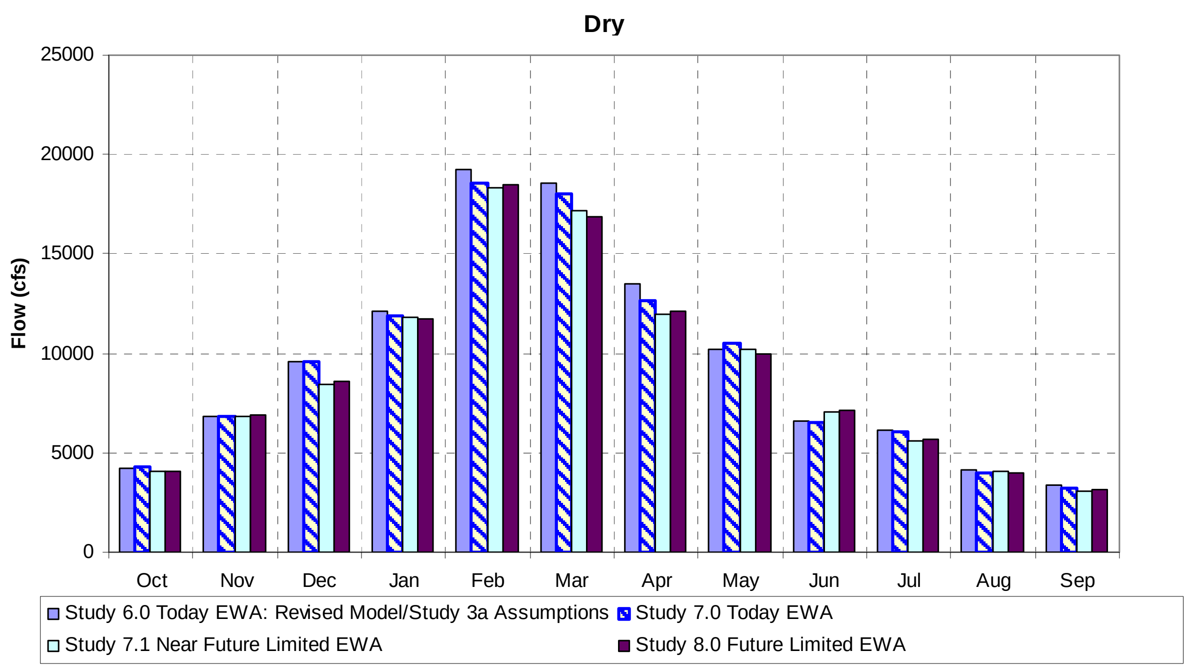


Figure 6-35. Average dry year (40-30-30) monthly Delta outflow (OCAP BA figure 12-15).

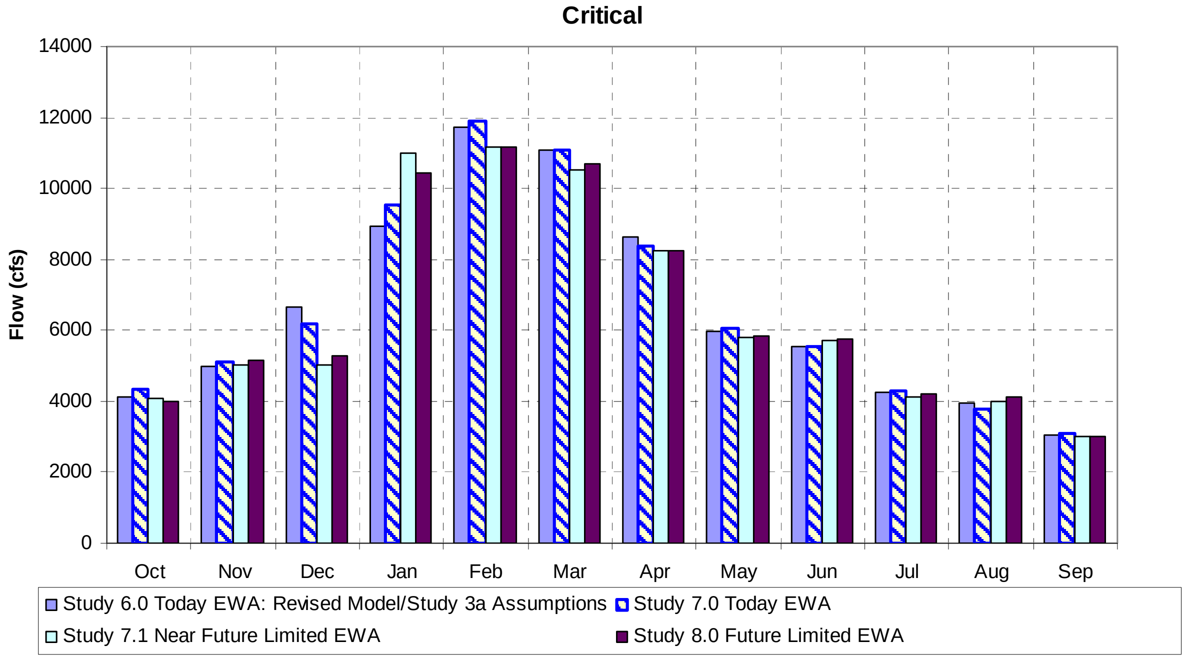


Figure 6-36. Average critically dry (40-30-30) monthly Delta outflow (OCAP BA figure 12-16).

6.6.1.3 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 more opportunistic pumping pattern because of 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 a more opportunistic 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 6-37 (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 6-38 through 6-43). 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 OCAP 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 6-44). 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 6-45 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 6-46 through 6-50).

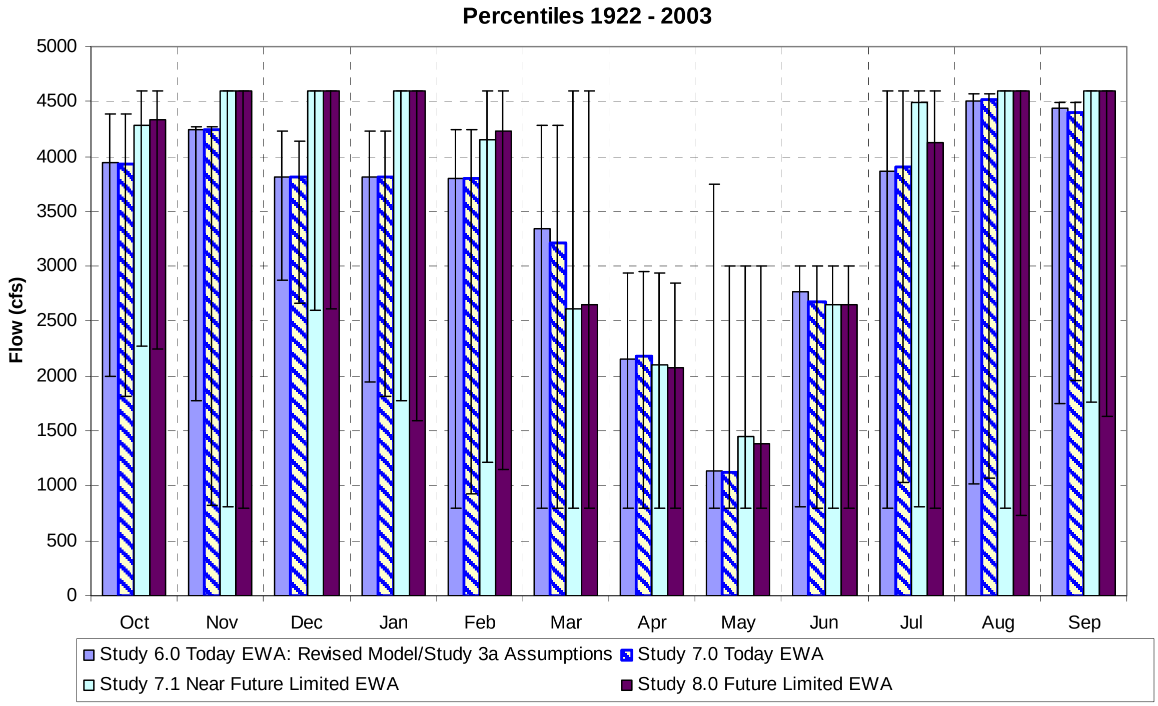


Figure 6-37. Monthly CVP export pumping rate, 50th percentile with 5th and 95th percentile whisker bars (OCAP BA figure 12-18).

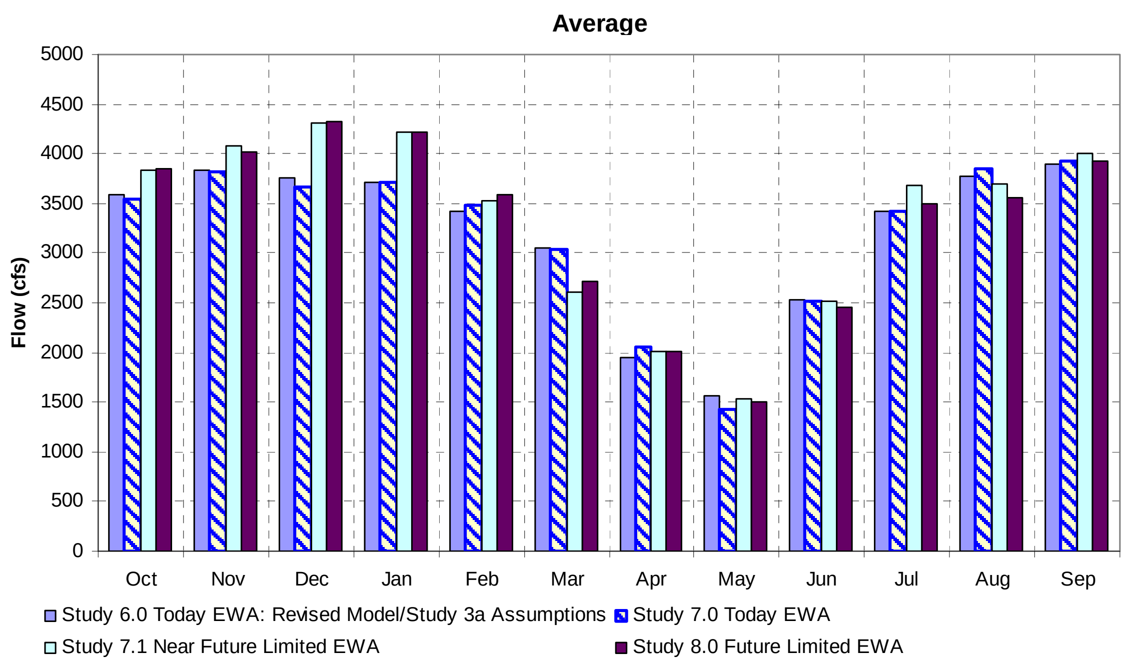


Figure 6-38. CVP monthly average export rate (OCAP BA figure 12-19).

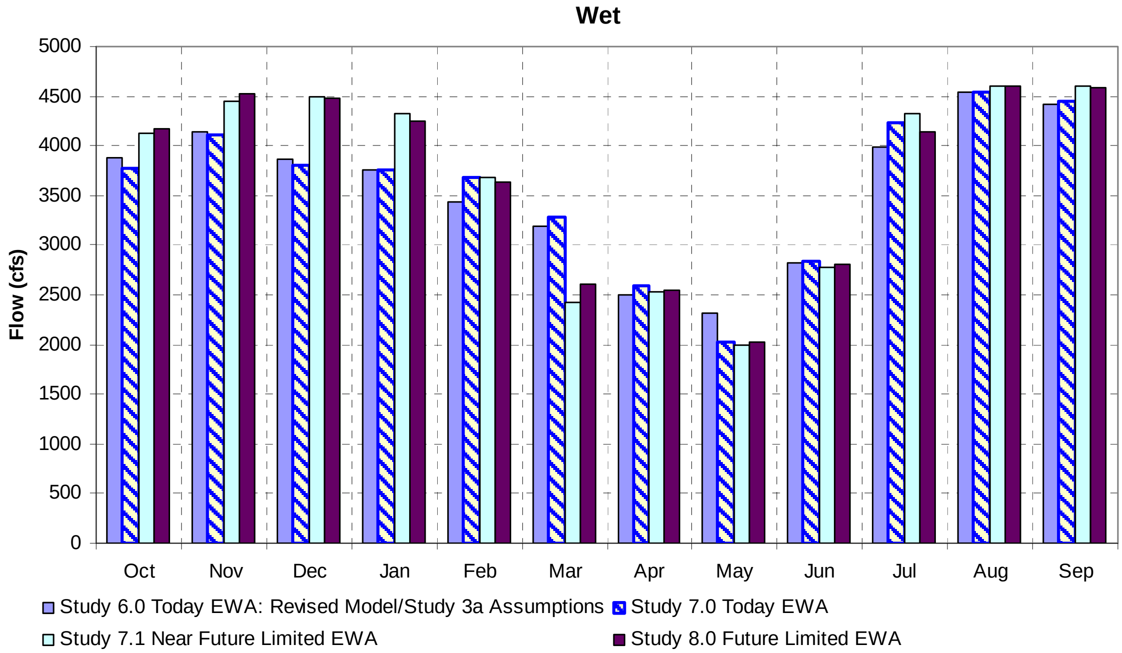


Figure 6-39. Average wet year (40-30-30) monthly CVP export rate (OCAP BA figure 12-20).

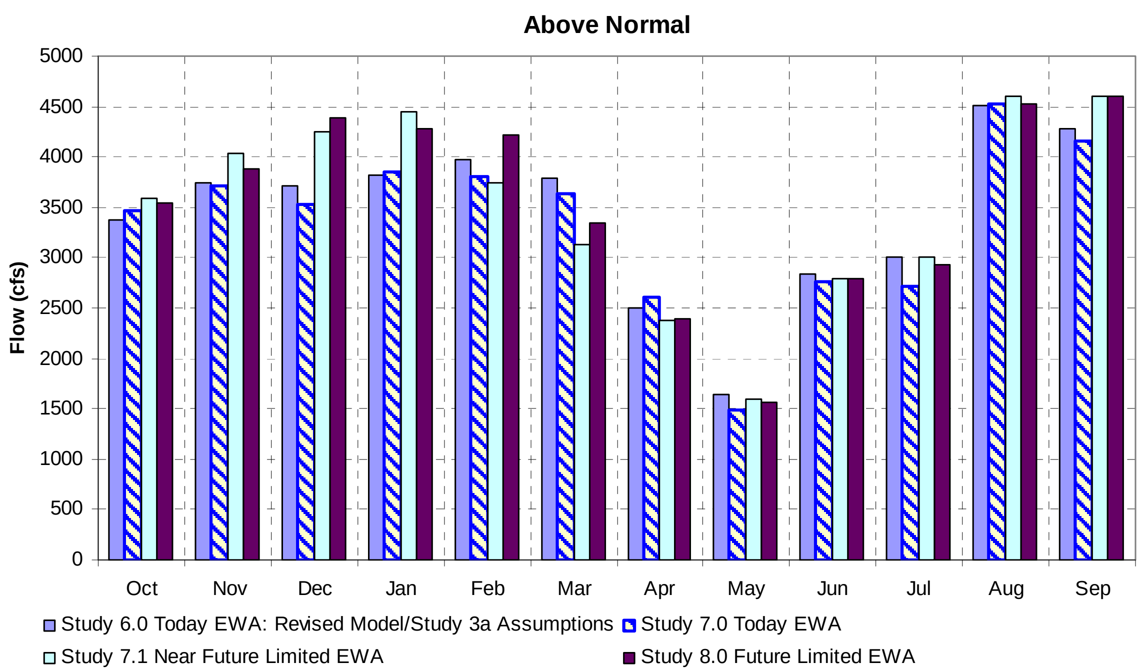


Figure 6-40. Average above normal year (40-30-30) monthly CVP export rate (OCAP BA figure 12-21).

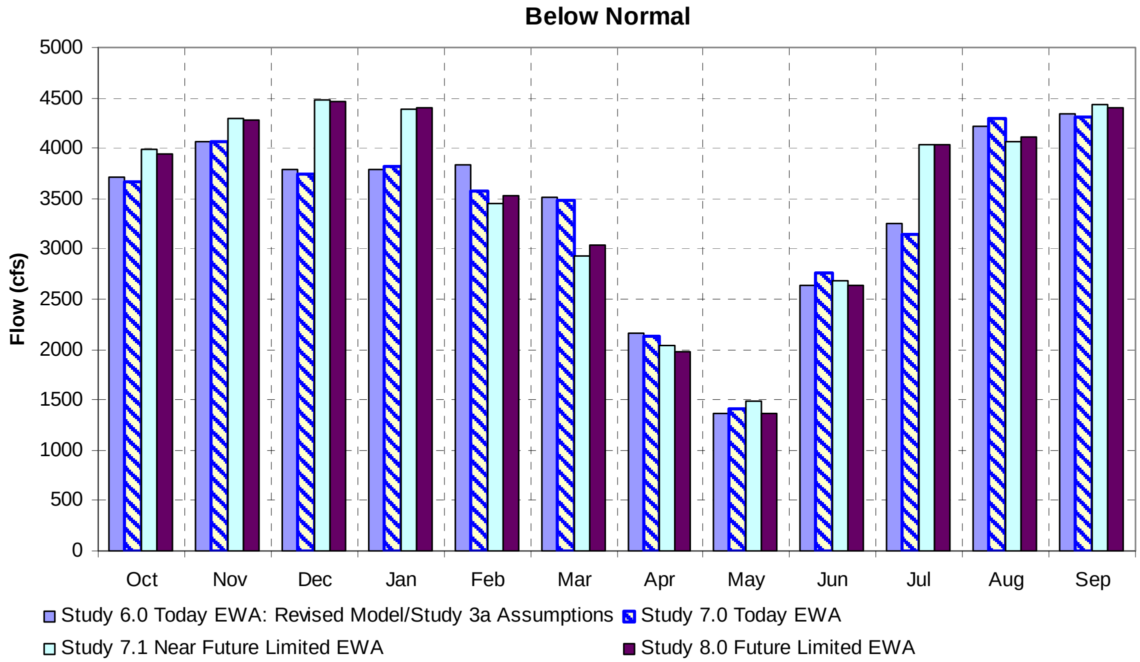


Figure 6-41. Average below normal year (40-30-30) monthly CVP export rate (OCAP BA figure 12-22).

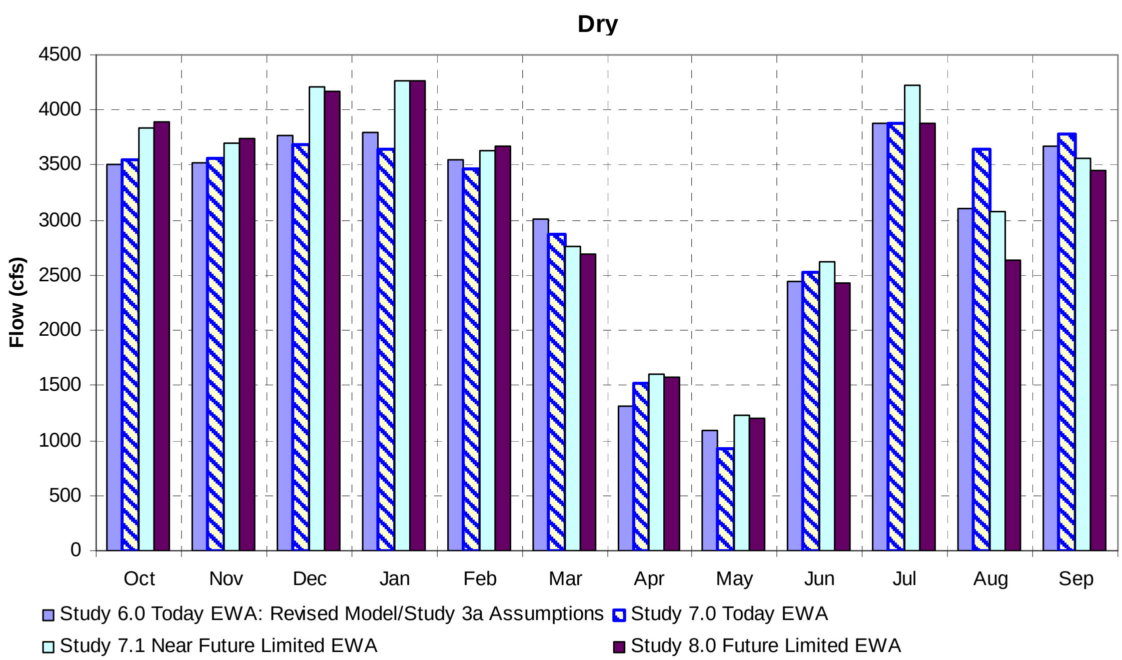


Figure 6-42. Average dry year (40-30-30) monthly CVP export rate (OCAP BA figure 12-23).

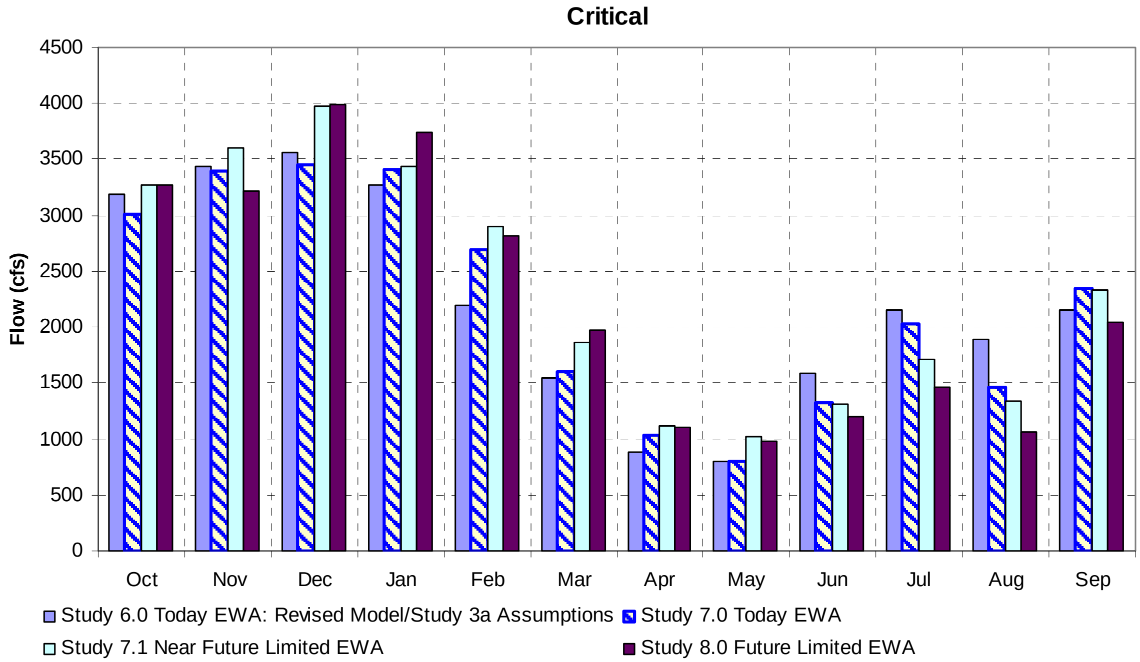


Figure 6-43. Average critically dry year (40-30-30) monthly CVP export rate (OCAP BA figure 12-24).

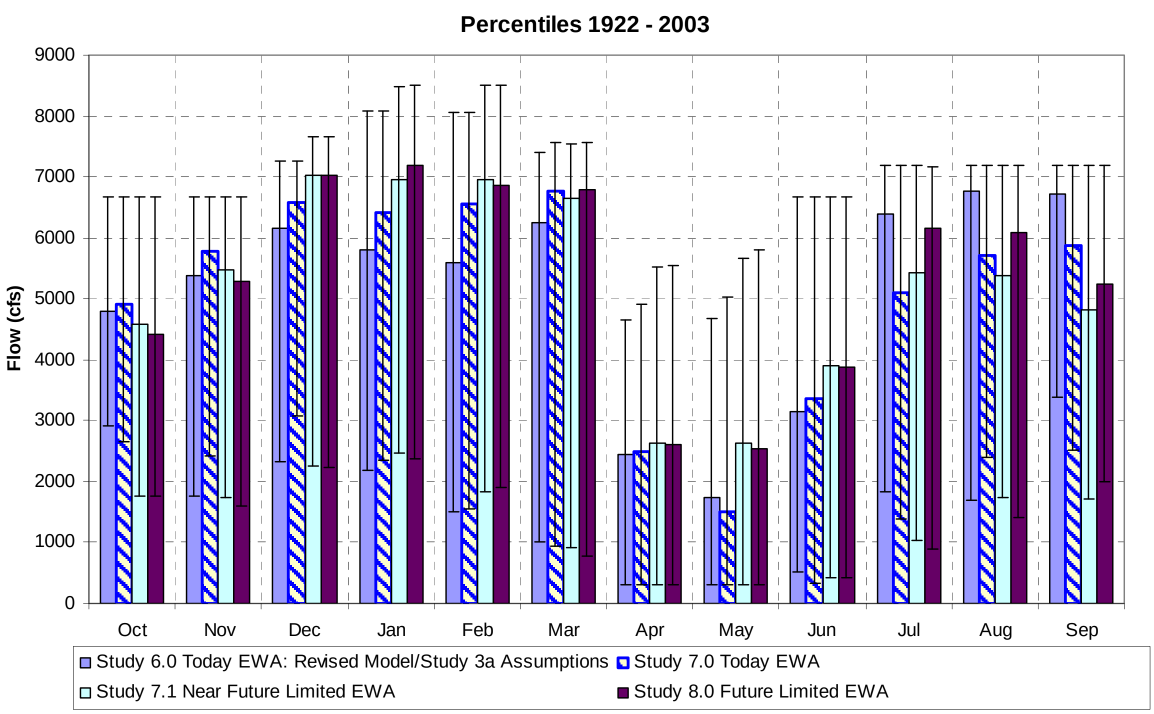


Figure 6-44. Monthly SWP export pumping rate, 50th percentile with 5th and 95th percentile whisker bars (OCAP BA figure 6-25).

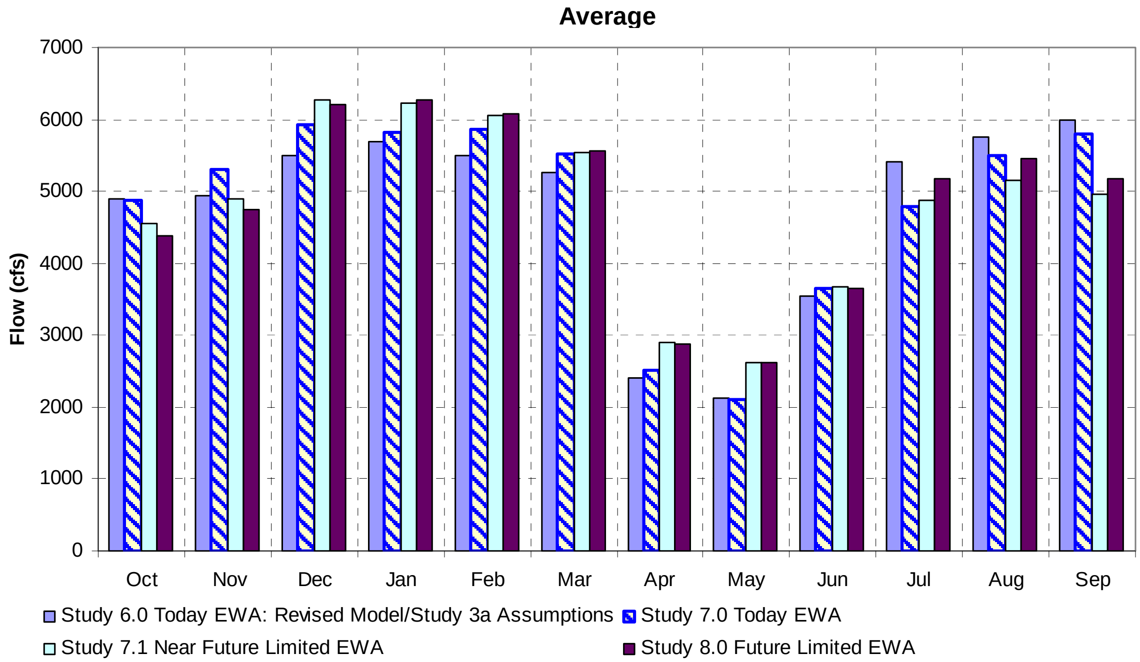


Figure 6-45. SWP monthly average export rate (OCAP BA figure 12-26).

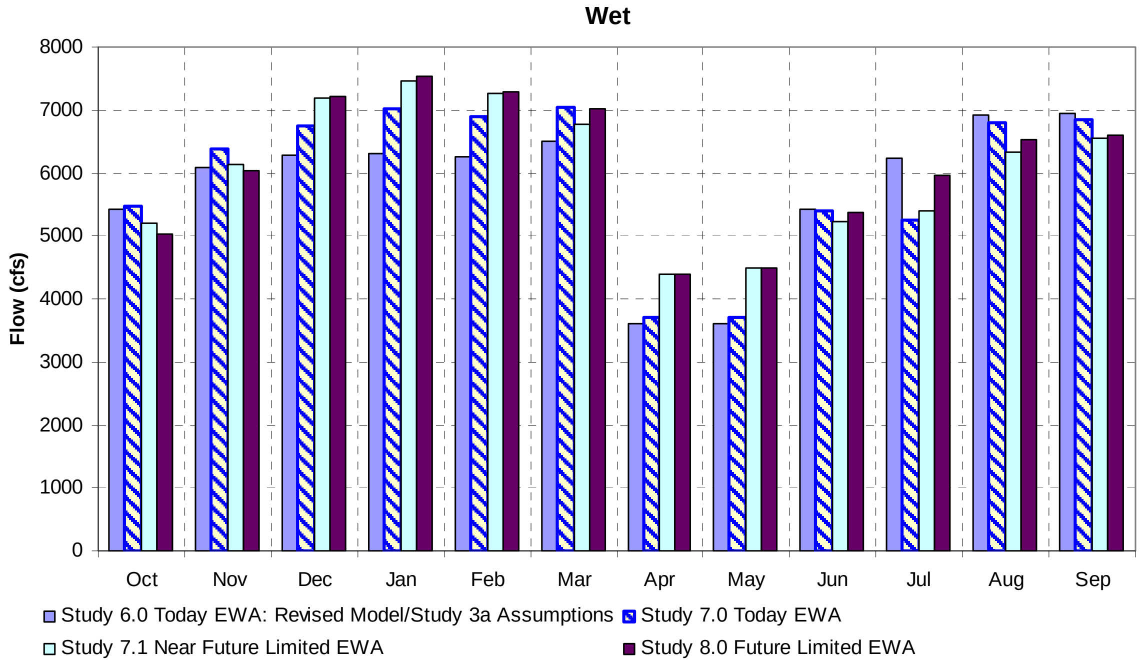


Figure 6-46. Average wet year (40-30-30) monthly SWP export rate (OCAP BA figure 12-27).

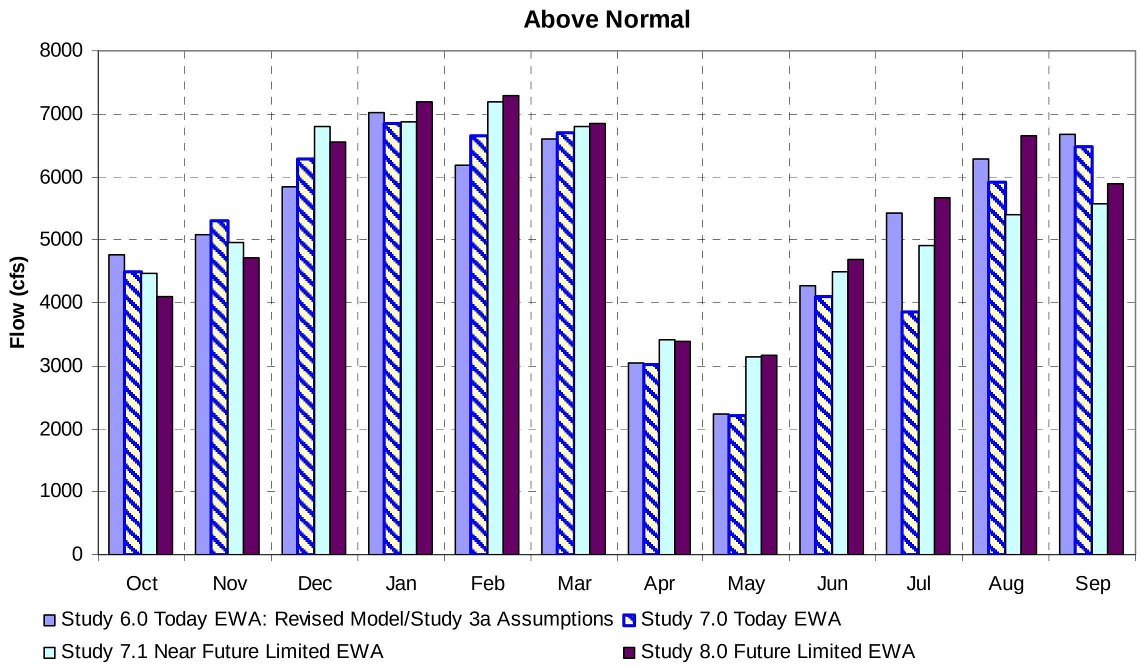


Figure 6-47. Average above normal year (40-30-30) monthly SWP export rate (OCAP BA figure 12-28).

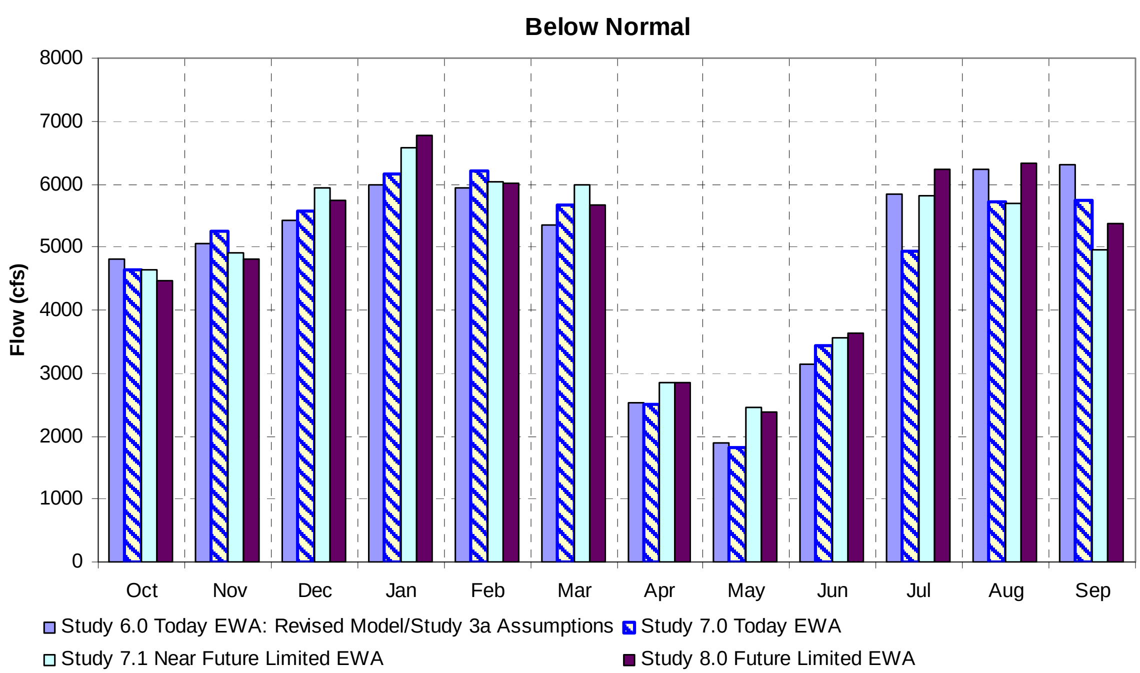


Figure 6-48. Average below normal year (40-30-30) monthly SWP export rate (OCAP BA figure 12-29).

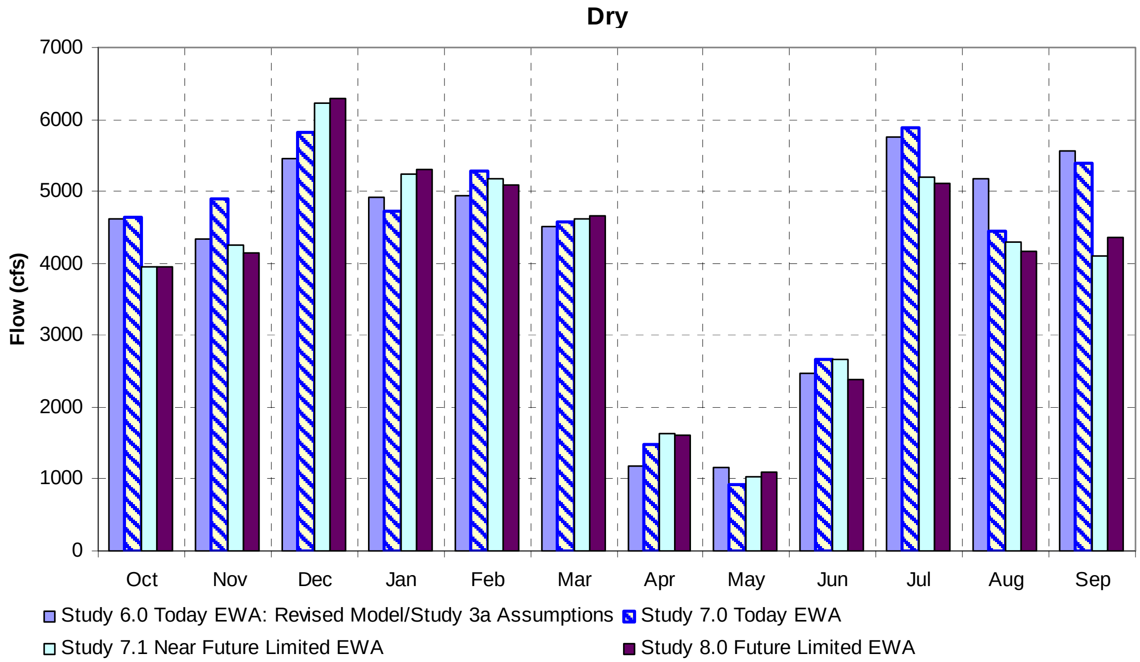


Figure 6-49. Average dry year (40-30-30) monthly SWP export rate (OCAP BA figure 12-30).

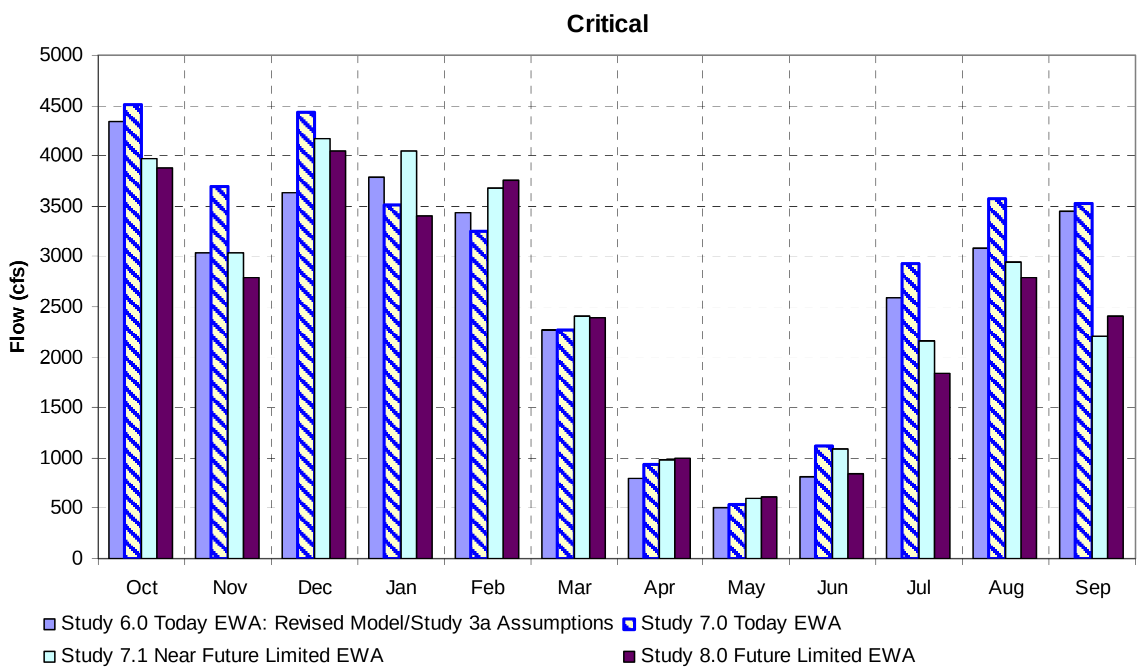


Figure 6-50. Average critically dry year (40-30-30) monthly SWP export rate (OCAP BA figure 12-31).

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 modeling conducted for the North Bay Aqueduct indicates that there are minor differences between the current operational actions (Studies 6.0 and 7.0) and the proposed future operations (Studies 7.1 and 8.0). The largest increase is the difference in pumping levels modeled for the current operations (Study 7.0) and the operations modeled for the 2004 opinion (Study 6.0) of 43 TAF. 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 design capacity of 175 cfs. The modeling for the current operations (Study 7.0) and the future operations (Study 8.0) have only a minor increase in diversion volumes (10 TAF) while near term (Study 7.1) was modeled to have a reduction of 3 TAF from current operations.

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 and more water is exported compared to the winter and spring months when the E/I ratio is restricted to a 35 percent maximum (February through June). 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 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 OCAP 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, the modeling completed for the OCAP BA indicates that Delta inflows will decrease approximately 200 to 300 TAF annually under the future conditions. Likewise, Delta outflow will decrease approximately 300 to 400 TAF annually under the future operations. Most of this decrease will occur in the winter and spring due to limited EWA resources to decrease pumping levels during this time period. 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 current operations. 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 opportunistically increase its exports in the months of December, January, and February to the greatest extent possible. The rational 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. 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 OCAP BA is that the limited EWA assets will preclude pumping reductions to benefit fish.

6.6.2. Direct Entrainment

6.6.2.1. Tracy Fish Collection Facility - Current and Future Operations

The Tracy Fish Collection Facility (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.

Fish passing through the TFCF are 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 remain unchanged in the future operations of the TFCF. This is generally from December through June. When listed fish are not present, sampling intervals will be 10 minutes every 2 hours. 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.

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 *et al*. (1960 *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.

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 OCAP 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 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 due 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. Report due 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. 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 system. 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. This loss 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 numbers 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.

6.6.2.2. 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 flowing through the screens is first diverted into Clifton Court Forebay, a large artificially flooded embayment that serves as a storage reservoir for the pumps. Water drawn from the forebay first passes a floating debris boom which is designed to intercept floating debris and guide it to a 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. Degradation of the screening efficiencies during louver cleaning is likely though, as flows and hydraulics are altered in the other bays and the necessary bypass ratios must be maintained for optimal efficiency.

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, as 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 Tracy Fish Collection Facility, 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, 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 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.

6.6.2.3 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 (Gingriss 1997, DWR 2008). Gingriss (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. 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. 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 (Gingriss 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 aggressive 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 supposition that increased pumping will require the forebay to be operated more frequently to supply the additional volumes of water pumped by the Banks Pumping Plant over the current levels. With each operation of the radial gates to draw water into the forebay, the potential to draw listed salmonids into the forebay exists. 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.*, winter-run, spring-run, and CV steelhead). 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).

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 remains in the forebay for extended periods. 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. 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 E*geria 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 fish listed 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 160 highway 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 is 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).

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 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 35 percent for the CVP for fish from the point they enter Clifton Court Forebay or encounter the trashracks at the CVP (table 22).

Table 22: 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)	16.54
CVP[4]	Percent survival	Running Percent
Pre-screen Survival[5]	85 percent (15 percent loss)	85
Louver Efficiency[6]	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 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. 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.
5. Prescreen survival in front of the trashracks and primary louvers at the TFCF have not been verified, but are assumed to be 15 percent.
6. 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.

6.6.5.5 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 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. CV steelhead have a longer period of vulnerability, based on their extended periods of emigration as 1 to 2 year old smolts. 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. 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, the applicant 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 6-15, 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. 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 6-16 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 1975 and 1991 by the DSM II model (OCAP BA Appendix G). The applicant has 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. In table 6-17, 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. These tables are followed by a series of tables extrapolating entrainment levels for the individual runs of Chinook salmon, Central Valley steelhead, and green sturgeon, based on the changes in the magnitude of pumping rates (expressed as a percentage) between the current and future conditions at each of the two pumping facilities and the current average level of entrainment at each facility, grouped by month and water year type.

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 6-15. 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 then 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	106686	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 6-16. Projected Old and Middle River Net Flows (in cfs) in Wet and Above Normal Water Years for the Months of December through March (OCAP BA Appendix G).

Study	December	January	February	March	Average
Study 7.0	-8099	-5552	-1847	-1052	-4138
Study 7.1	-9618	-5999	-2063	-311	-4498
Study 8.0	-9649	-6664	-2795	-1051	-5040

Projected 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	609	-286	-4319	-7706	-2926
Study 7.1	-1865	-2616	-3487	-7803	-3943
Study 8.0	-1805	-2632	-3542	-7975	-3989

Projected 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	-6691	-7349	-7439	-6667	-7037
Study 7.1	-8535	-8594	-6574	-6426	-7532
Study 8.0	-7873	-8910	-7012	-6359	-7538

Projected 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	-1530	-1856	-6527	-9957	-4976
Study 7.1	-2473	-2489	-6721	-10195	-5469
Study 8.0	-2495	-2783	-6837	-10814	-5732

Projected 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	-7249	-5199	-2515	-3086	-4512
Study 7.1	-6763	-5852	-3054	-4236	-4976
Study 8.0	-7492	-5727	-2304	-4379	-4975

Projected 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	-1566	-1573	-3748	-6093	-3245
Study 7.1	-2199	-1920	-2910	-5267	-3074
Study 8.0	-2246	-1898	-2616	-3676	-2609

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 San Joaquin River and the Calaveras River (steelhead and fall-run Chinook salmon) 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.

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.

Table 6-17. 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 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 Calveras 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.

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 is actually increasing. This is expected to pull more water southwards towards the pumps, drawing any late emigrating fish towards the pumps in the central and southern Delta regions. This will adversely impact the migration rate of these late emigrating fish during a time when water quality, particularly water temperatures, are 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.

In the analysis completed for Delta smelt, Reclamation 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 (Nobriga and Kimmerer 2008). NMFS considers this information useful in analyzing the potential “zone of effects” for entraining emigrating juvenile and smolting salmonids, particularly the later which have reduced swimming vigor and tend to move with the ambient currents downstream (Williams 2006). Given the data derived from the OCAP BA Appendix G, flows in Old and Middle River are consistently in excess of the -2000 ± 500 cfs threshold for entrainment (*i.e.*, more upstream flow). 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. Assuming that juvenile and smolting Chinook salmon and steelhead will also experience similar entrainment effects as Delta smelt adults, then increased upstream flows will carry more fish towards the pumps in the near future and future conditions compared to the current modeled conditions.

During wet, above normal and critically dry water year types, the greatest level of negative net flows in Old and Middle River 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 Chinook salmon 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 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.

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 6-17). 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 future (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 three-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 are substantially increased in the April and May period, which corresponds to the peak of outmigration for YOY spring-run Chinook salmon and fall-run Chinook salmon YOY. 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.

6.6.2.6. 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. In the 2008 biological assessment for the OCAP consultation, Reclamation presented data that regressed the loss of older juvenile Chinook salmon against exports (figure 6-51) 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. 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 OCAP 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 6-52). 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 6-53).

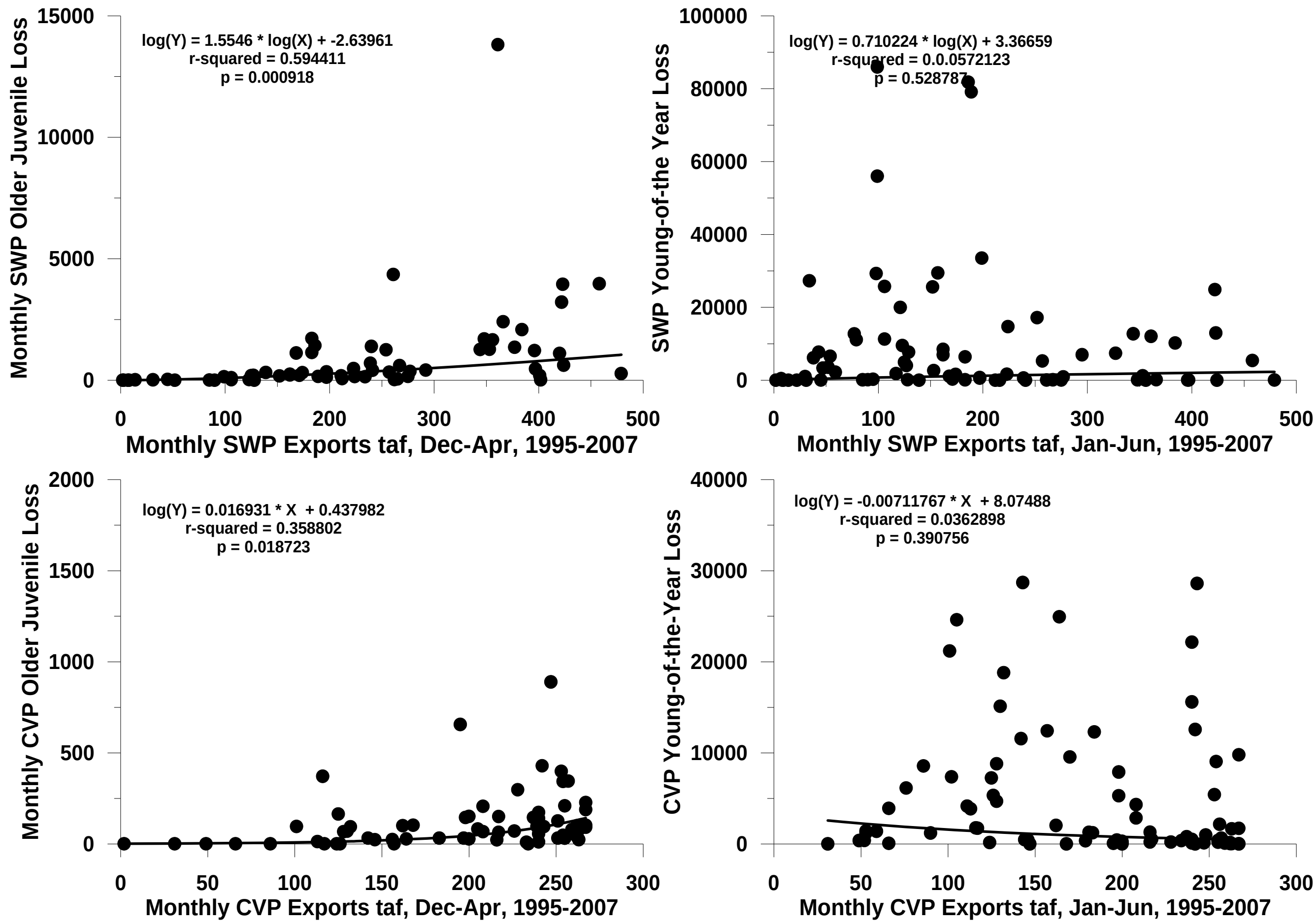


Figure 6-51. Monthly juvenile Chinook salmon loss versus average exports, December through June, 1993 through 2006, at each facility; SWP and CVP (OCAP BA figure 13-40).

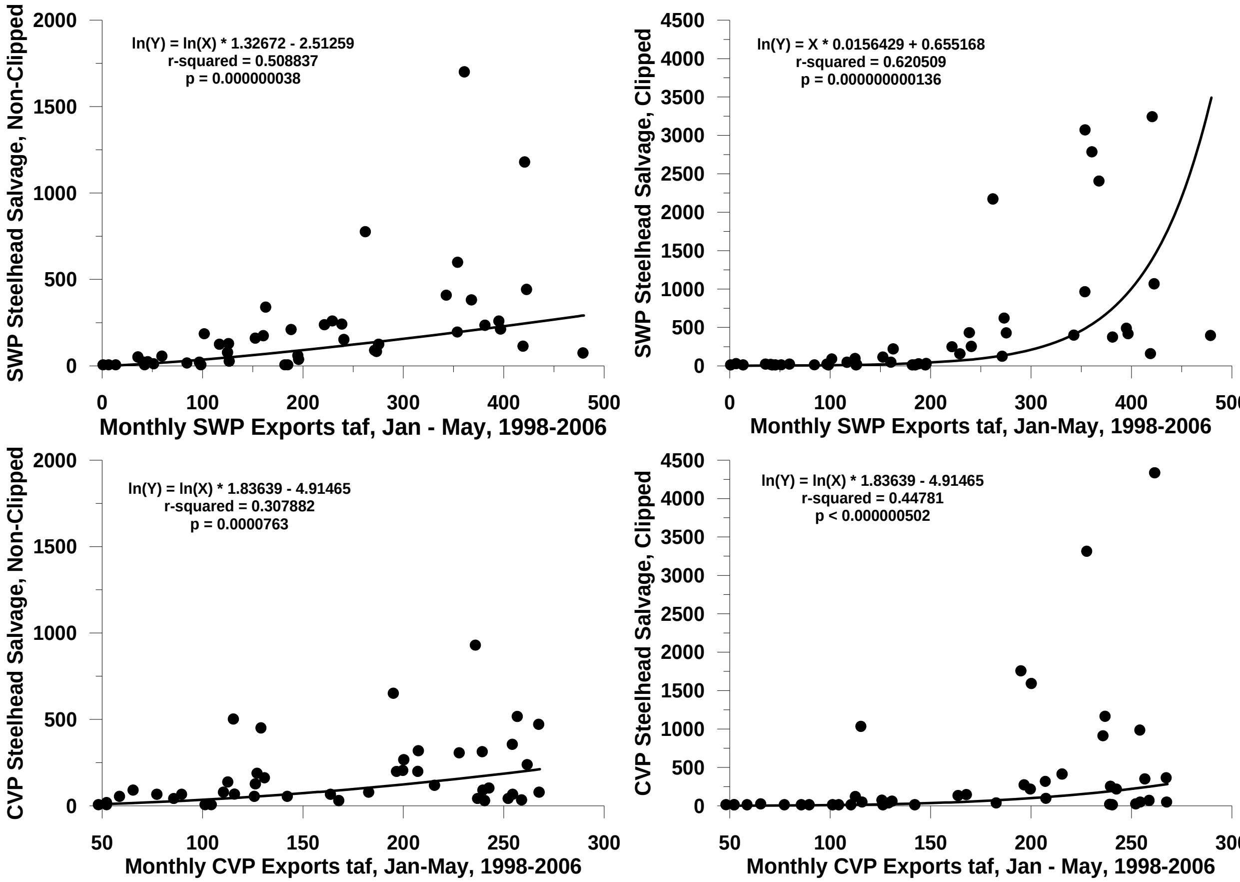


Figure 6-52. Monthly steelhead salvage versus average exports, January through May, 1998 through 2006, at each facility; SWP and CVP (OCAP BA figure 13-45).

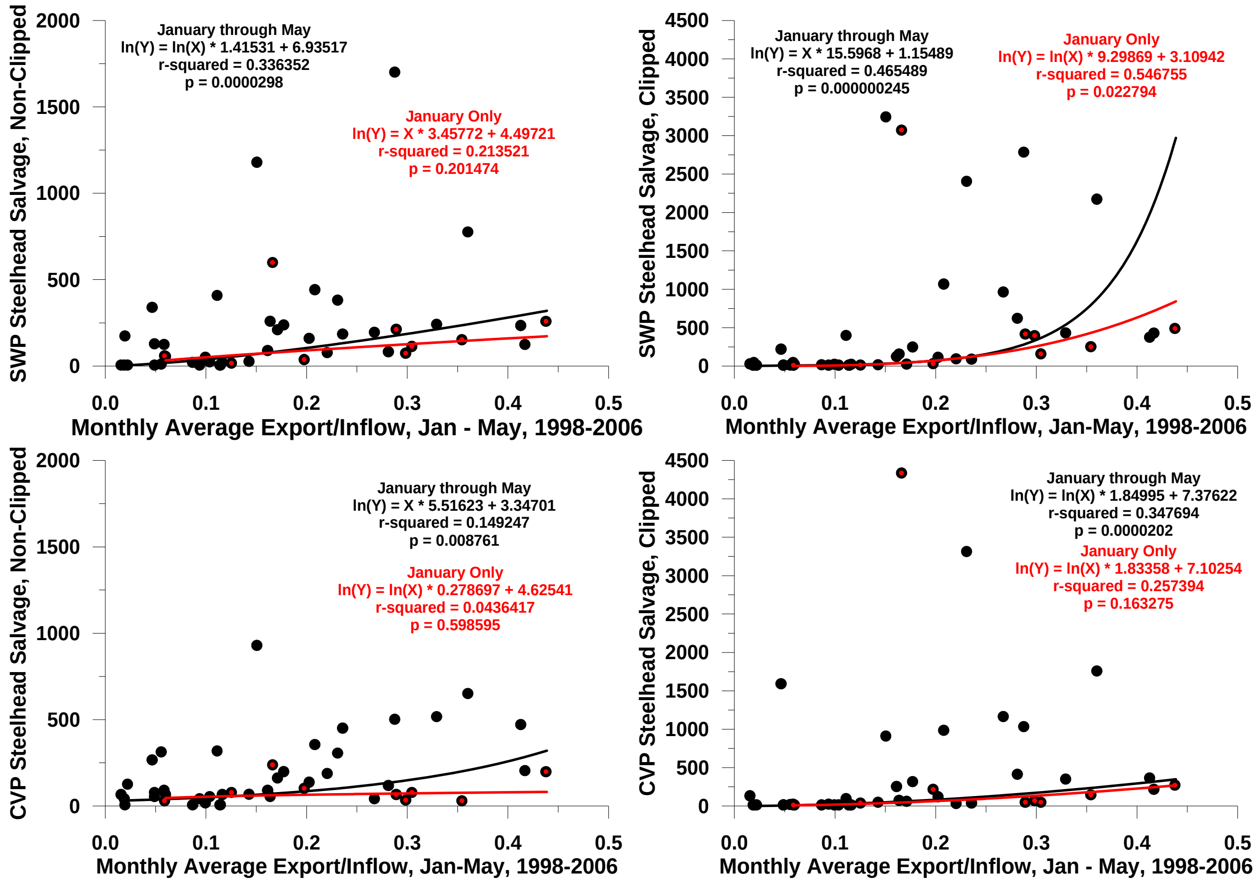


Figure 6-53. Monthly steelhead salvage versus average Export/Inflow ratio in TAF, January through May, and January alone, 1998 through 2006, at each facility; SWP and CVP (OCAP BA figure 13-46).

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 Delta Cross Channel experiments, the Delta Interior experiments, the Delta Action 8 experiments, and the Vernalis Adaptive Management Plan 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.

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 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 larger 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 complexity and number of potential models for the VAMP data, however, a more thorough model selection procedure using Reversible Jump MCM is recommended.

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 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 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.

6.6.3 Indirect Mortality Within the Delta

6.6.3.1 Overview of Mortality Sources

Survival of salmonids migrating through the Delta is affected by numerous variables, some related to the proposed project, 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.

6.6.3.2 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"[7] 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 (2008) conducted another study with acoustically tagged Chinook salmon smolts released on the Sacramento River near Old Town Sacramento in late 2006 and early 2007. 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 predation). Two releases were made, one in December 2006 and one in January 2007. 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 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 2008 for more details). This data indicates that there are reach specific characteristics for loss rates due to intrinsic factors in those channels (*e.g.*, predation). A study run concurrently by Perry and Skalski (2008) in the same region and time frame produced similar results to Vogel's study. 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 in December 2006, ($\hat{S}_{Delta}$ = 0.351, SE = 0.101) was lower than the subsequent release made in January 2007, ($\hat{S}_{Delta}$ = 0.543, SE = 0.070). 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 6-18). The operation of

[7] 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.

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 and remained closed during the entire second release. 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 6-54).

Table 6-18. 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				
A) Steamboat & Sutter Sl	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 Sl	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				
A) Steamboat & Sutter Sl	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 Sl	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 2008). 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.

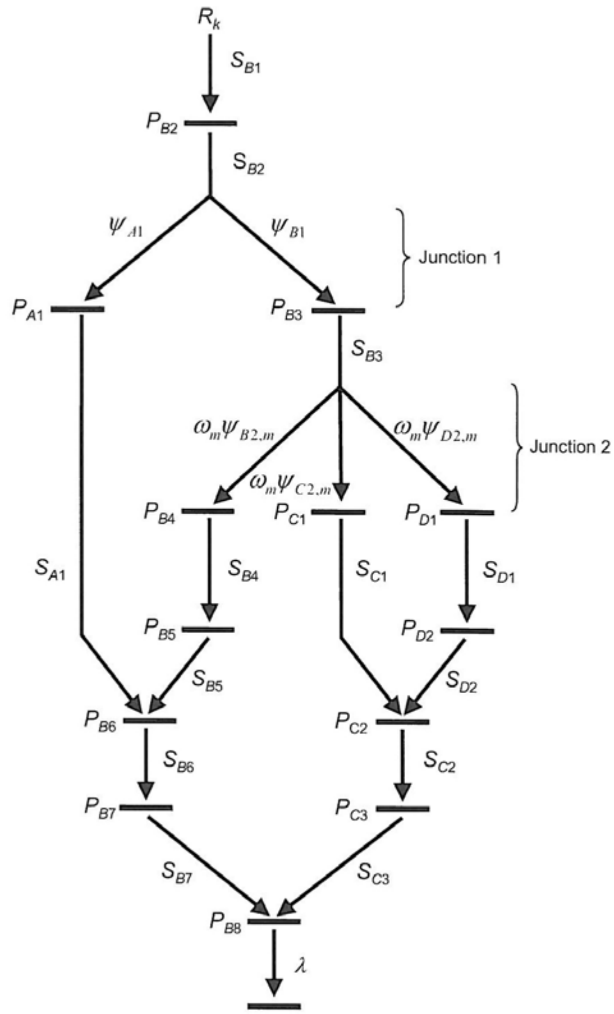


Figure 6-54. Schematic of the mark recapture model used by Perry and Skalski (2008) used to estimate survival (S_{hi}), detection (P_{hi}), and route entrainment (ψ_{hi}) probabilities of juvenile late-fall Chinook salmon migrating through the Sacramento-San Joaquin River Delta for releases made on December 5, 2006, and January 17, 2007.

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. 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 (San Joaquin River Group Authority (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. 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 export levels when moving downstream in the San Joaquin River. The study also found that fish could pass through the culverts on the Head of Old River barrier (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. 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.

6.6.3.3 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 OCAP BA, Delta smelt sections for a more detailed explanation).

6.6.3.4 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 phenomena 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.

6.6.4 Clifton Court Aquatic Weed Control Program

6.6.4.1 Effects of the Aquatic Weed Control Program Herbicides on Listed Fish

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 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. Previous applications have followed the label directions, which limit copper concentration in the water to 1,000 µg/L [1part 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.

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 2003) 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. 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)).

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.

Current USEPA 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 (CCC) 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. 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.

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.

6.6.4.2 Summary

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 (figure 6-55). 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 adversely 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.

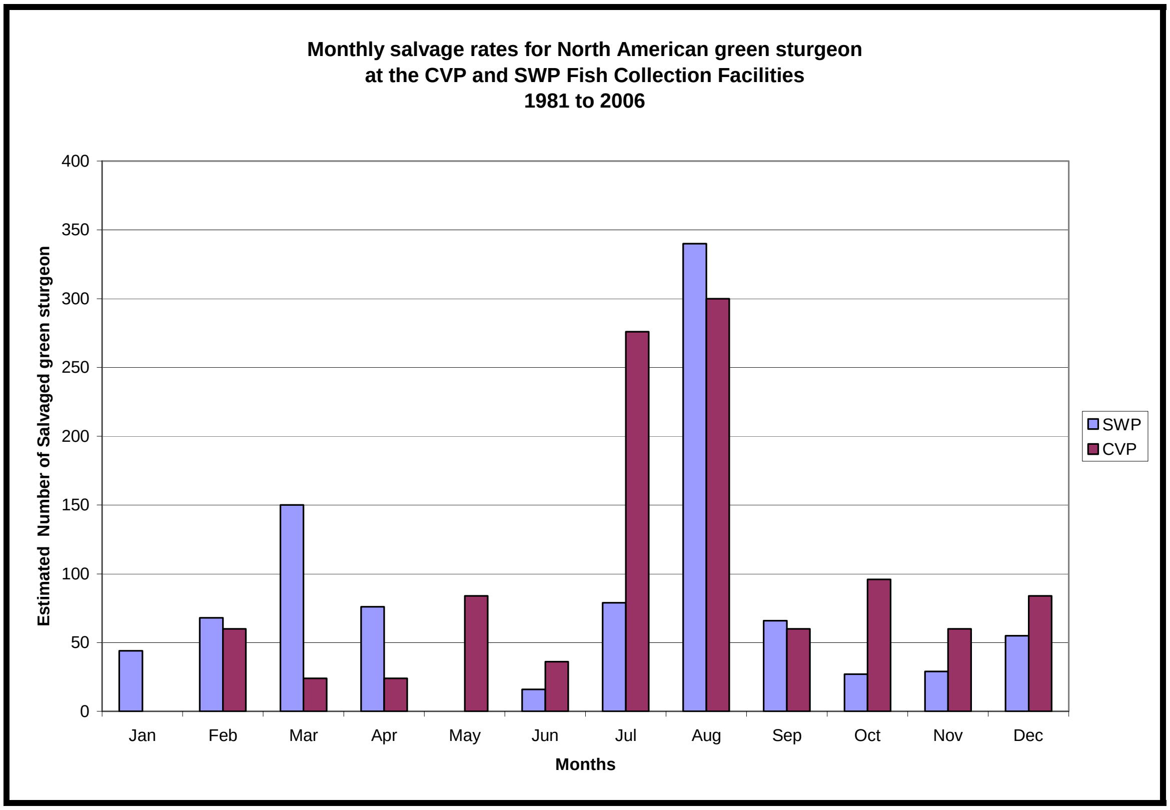


Figure 6-55. Estimated number of North American green sturgeon (southern DPS) salvaged monthly from the State Water Project and the Central Valley Project fish collection facilities (CDFG 2002, unpublished CDFG records).

6.6.5 South Delta Improvement Program – Stage 1

NMFS expects that the operation of the permanent gates proposed for the South Delta Improvement Program (SDIP) will have many of the same effects as described for the temporary barriers 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 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. Therefore, individual effects of the barriers on the future conditions must be inferred from the modeling output, or derived from other sources of information.

As described in previous sections, future pumping rates are expected to increase during the April and May time frame over the current conditions. This period coincides with the proposed operations of the permanent barriers. 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 barriers, including maintaining surface water elevations for South Delta agricultural diverters and enhancing the opportunity to maximize CVP and SWP diversion rates without impacting the South Delta diverters, enable the projects to maintain increased diversion rates over the "no barrier" condition during the time frame of the OCAP consultation. Operations of the barriers from June through November likewise enable the projects to sustain higher levels of pumping by avoiding impacting South Delta water elevations and reducing the electrical conductivity levels in the South delta waterways by "trapping" high quality Sacramento River water upstream of the permanent barriers.

6.6.5.1 Hydraulics

The operation of the agricultural barriers 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 barriers ("Obermeyer" style dams). Barriers 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 barrier structures. Estimates of the volume of flood tide allowed to pass over the barriers are approximately 80 percent of the unimpeded flow without the barriers (or their operations). The current temporary barriers are significantly less, allowing 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 barriers are inflated and their crest elevations manipulated to retain the water pushed upstream by the 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. Under proposed operations, the crests of 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, but will be maintained above the high tide elevation (OCAP BA pages 2-132 and 2-133). 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. The results of this method of barrier operations is that a larger proportion of water will be moved past each of the three dams at the different barrier locations on each flood tide (80 percent of normal tidal volume). This "cell" of water will then essentially become trapped behind the barriers and moves progressively "downstream" towards the lowest dam crest elevation between the three agricultural barriers. 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.

6.6.5.2 Fish Movement and Predation

Under the temporary barriers operational conditions, fish (*i.e.*, juvenile salmon and steelhead) that have not been entrained by the SWP at Clifton Court, 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 culverts, 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 barrier, and thus more will be "trapped" by the raised barrier on the falling tide due to the greater volume of water passed through the position of the barrier. The differences in the level of predation associated with the alternative barrier operations protocols 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 (see earlier discussion in the temporary barriers project section. 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). This condition may create localized turbulent flow over the structure. The placement of the four barriers 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 barriers, will have to negotiate at least two barriers to move through the system. The argument that the barriers only occupy a small footprint in the South Delta and therefore do not create an additional risk of predation is false. The barriers create a predation gauntlet that migrating fish must negotiate to complete their downstream journey if they enter the South Delta channels.

The additional environmental stressors created by the implementation of the SDIP will add to the already existing stressors present in the San Joaquin River basin. The nearly century long blockage of east side tributaries to the San Joaquin River by dams has substantially reduced the useable spawning and rearing areas for CV steelhead to short reaches below the dams. Low water flows, exacerbated by high valley floor temperatures have shrunk the suitable thermal regime for oversummering steelhead.

6.6.5.3 Particle Tracking Simulations

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 barrier operations. The particle tracking simulations conduced for the SDIP proposal indicated that entrainment in the lower San Joaquin River watershed is of great concern to fisheries management. In the simulations, 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 when the HORB is not installed. 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 substantial 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 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 OCAP 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" condition is further degraded by the future export increases modeled in Studies 7.1 and 8.0 as modeled in the OCAP BA, which have extended periods of elevated pumping levels over the current conditions.

The PTM simulations for the SDIP proposal also addressed the barrier operations at the Head of Old River during VAMP conditions. Results indicated that when the barrier 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 50 percent) or retained within the waterways of the South and Central Delta. With the HORB 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, SJRGA 2007) supports this aspect of the modeling results. Another characteristic of the closed HORB 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 pull water from the San Joaquin River 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 HORB 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. This resulted in 14.9 percent of the particles reaching Chipps Island after 30 days. In simulations where the HORB was not installed, a lower percentage of the particles reached Chipps Island then under the barrier installed situation, having been quickly entrained into Old River and subsequently captured at the CVP.

6.6.5.4 Summary of Effects

In summary, the proposed SDIP has questionable utility to minimizing the take of San Joaquin River basin fish, based on the PTM simulations and the initial results of radio and acoustic telemetry studies. The eventual entrainment of San Joaquin River fish by the state and Federal export pumping through the channels lower down on the San Joaquin River (*e.g.*, Turner and

Columbia Cuts) after they pass by the HORB is contradictory to the stated purpose of the fish barrier portion of the SDIP proposal. The agricultural barriers 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. As described previously, the agricultural barriers and the enhanced pumping regimen 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 will increase the loss of fish over the current conditions. The purported benefit of the SDIP proposal to fisheries management was the HORB, 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 HORB operations were also believed to have been protected by the barrier. Based on the PTM simulation results and the early telemetry findings, this protective aspect of the HORB appears to be overstated, and in fact the operation of the HORB 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 the HORB is in operation. In order to achieve the stated goals of the SDIP fish barrier, additional actions, such as greatly increased San Joaquin River flows in excess of the 2:1 inflow to export ratio coupled with additional measures to prevent fish from entering the channels in the lower sections of the San Joaquin River (*i.e.*, Turner and Columbia Cuts, Middle River, and Old River) need to be assessed and implemented to reduce entrainment of listed fish below current conditions.

6.6.5.5 Critical Habitat

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 PCE's 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 enhanced pumping environment fostered by the SDIP proposal. As described above, listed steelhead will be prevented from using portions of the Delta by the HORB. 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 reduced as proposed. In addition to the installation of the barriers, the SDIP proposes to dredge certain channels of the South Delta to enhance conveyance of water for diversion, reduce scouring, and increase water depth for private water diversions located upstream of the proposed agricultural barriers. 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. These types of changes were inadequately analyzed in the SDIP documents, and this flaw was carried forward into the OCAP BA.

Listed fish will more than likely pass through these channels when the HORB is not in operation, and the altered habitat will become part of their migrational corridor. It is highly 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 CV steelhead originating in the San Joaquin River watershed when compared to the current situation for the aforementioned reasons. The proposed action do not incorporate any actions to enhance the aquatic environment from its current standing nor do they 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 the fall-run is unlisted, they share similar habitat requirements with the 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 North American green sturgeon (proposed September 8, 2008, 73 FR 52084). Like the Central Valley 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 dropped. 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 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.

6.6.6 Delta Cross Channel

The DCC was constructed by Reclamation in the early 1950's 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.

In 1995, the Water Quality Control Plan (WQCP) for the Bay Delta (95-1) instituted special 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 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 (see OCAP 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. 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; OCAP BA Appendix E). During the periods of winter-run emigration (*i.e*., September to June) through the lower Sacramento River, 5 to 30 percent of the Sacramento River flow (monthly average) can be diverted into the interior of the Delta through the DCC when both gates are open; with the gates closed, approximately 15 to 20 percent (monthly average) of the flow is diverted down the Georgiana Slough channel[8] (OCAP BA Appendix E). Peak flows through Georgiana Slough can be almost 30 percent of the Sacramento River flows. However, in most years, the peak of winter-run emigration past the DCC occurs from late November through January, based on USFWS trawl and seining data (USFWS 2001, 2003, 2006; Low *et al.* 2006);

[8] Instantaneous percentages can be much higher depending on the interaction of river flow and tidal flow as describe in Horn and Blake (2004).

when 10 to 20 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). 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 two-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 exposed them 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. Furthermore, 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 amount of flow entering said branch, and can vary considerably throughout the tidal cycle. 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 Vogel's (2008) 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.

As presented above, changes in Delta hydrodynamic conditions associated with CVP and SWP export pumping inhibit the function of Delta waterways as migration corridors. Export pumping rates will create unnatural flow conditions (*i.e.*, net negative flows) in the central and south Delta. Net flows during December and January generally will be eastward (*i.e.*, reverse flows) instead of westward in the lower San Joaquin River. North of the CVP and SWP Delta pumping plants, net flows in Old and Middle rivers will be southward instead of northward. As a result of these changes in the hydrodynamic conditions, some salmon and steelhead smolts are expected to be diverted from their primary rearing and migration corridors in other regions of the Delta. A number of these fish will eventually arrive at the CVP and SWP fish salvage facilities while substantially more fish are expected to be lost along the way in the Delta channels leading to the pumping facilities. Mortality is expected to result from entrainment in over 2,050 unscreened water diversions, predation by introduced species, food supply limitations, elevated water temperature, and poor water quality (CDFG 1998). However, from February though May, exports will be reduced to comply with SWRCB D-1641 Delta Standards (*i.e.*, 35 percent E/I ratio). This reduction in exports is theorized to improve the Delta hydrodynamic conditions and increase survival rates over those experienced in December and January. The reduction in exports is anticipated to reduce the net negative flows southwards towards the pumps and therefore create less "pull" on fish in the lower reaches of the San Joaquin River where fish from the Georgiana Slough and Mokelumne River systems first enter the San Joaquin River system. Nevertheless, based on the modeling conducted for the OCAP consultation, pumping during this period will increase above current modeled conditions.

With mandatory closure of the DCC gates from February 1 through May 20 (pursuant to SWRCB D-1641), approximately 50 percent of juvenile winter-run outmigration and 70 to 80 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. These fish will be less subject to decreased survival rates through the Delta related to the effects of CVP and SWP Delta export pumping. The segment of the population that migrates earlier than the mandatory closures will be exposed to the effects of the DCC gates (when in the open configuration). All fish will be exposed to entrainment into Georgiana Slough, which will potentially entrain 20 to 30 percent of eh 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 (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. 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 (see Vogel 2008, 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 to 54.3 percent).

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. 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. If the Delta Cross Channel 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. Recent radio tagging studies on adult fall-run Chinook salmon 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 (CDFG) 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.

6.6.7 Contra Costa Water District

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.

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 fro 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. Therefore, the analysis discussed below is based on assumed diversions at the unscreened Rock Slough Intake only, and therefore represents worse case effects.

In the 1993 winter-run Opinion, NMFS required monitoring for winter-run. Based on CDFG sampling during the period from1994 through 1996, mortality from entrainment in the Rock Slough Intake occurs 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 per year.

However, since that time most of CCWD water diversions have shifted to newer, screened facilities at Old River. In addition, current pumping rates at Rock Slough have been reduced in the winter months compared to the historical conditions (OCAP 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 one 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 6-20) 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.

It is expected that entrainment in the future will 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 the July 3, 2007, NMFS Opinion on the Alternative Intake Project). 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.

Table 6-20. 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**

6.6.8 North Bay Aqueduct at Barker Slough Intake

DWR operates the North Bay Aqueduct (NBA) intake in the range from 30 to 140 cfs. Project deliveries range from 27 TAF in dry years to 42 TAF in above normal years. If DWR were to deliver the full contracted amount, deliveries could be as high as 70 TAF. The modeling studies conducted for this consultation indicate that there are only minor differences in the annual volume of water diverted at the NBA between the current operations and the proposed future operations. The near future Study (7.1) was 3 TAF less than current operations, while the future Study 8.0 increased diversion by 10 TAF annually. The increase in diversion rate is not expected to affect any listed salmonids due to properly functioning positive barrier screens installed at the facility. The screens, which were designed to protect Delta smelt larvae exceed the approach and sweeping velocities criteria required by NMFS to be protective of salmonids (*i.e.*, have lower approach and greater sweeping velocities to protect the weakly swimming Delta smelt larvae). Furthermore, the location of the NBA on Barker Slough is substantially removed form the expected migrational corridors utilized by emigrating Chinook salmon and steelhead smolts in the North Delta system. NMFS does not expect that take will occur at the NBA facility during the stated operational actions.

6.6.9 Climate Change

Reclamation has conducted an analysis of the potential implications of climate change for the CVP and SWP that is intended to examine the sensitivity of CVP/SWP operations and system conditions to a range of future climate conditions that may evolve over the consultation horizon (2030) of the OCAP BA (for more detailed explanation see OCAP BA Appendix R). It develops four climate change scenarios intended to bookend the range of possibilities arising from available climate projection information. The bookends span the range of outcomes developed under the assumptions of CALSIM II Study 8 (Future Conditions) with respect to two variables: precipitation and temperature. All four scenarios are based on the assumptions, derived from published sources, that sea level will rise approximately 30 cm by 2030, and that the tidal range will increase by 10 percent. To address the possibility that changes in habitat and entrainment rates might affect listed salmonids and green sturgeon under the four climate change scenarios, this evaluation consists of six separate model runs. These runs were:

Study 9.0	Baseline conditions without sea level rise (SLR). Conditions are based on Study 8 but with only D1641 regulatory constraints.
Study 9.1	Baseline conditions with 1 foot SLR.
Study 9.2	Climate projection #1 "Wetter, less warming" climate with SLR.
Study 9.3	Climate projection #2 "Wetter, more warming" climate with SLR.
Study 9.4	Climate projection #3 "Drier, less warming" climate with SLR.
Study 9.5	Climate projection #4 "Drier, more warming with SLR.

The purpose of Study 9.1 is to convey information on the impact of SLR on the future of OCAP operations before addressing climate change scenarios.

The general results of the models indicate that future warming is expected to cause a greater fraction of the annual runoff from the Central Valley watersheds to occur during winter and early spring and a reduced fraction of the annual runoff to occur during late spring and summer. This reflects the predicted change from less snowmelt derived runoff to greater precipitation driven runoff in the region's watersheds, particularly those watersheds originating in lower elevations (*i.e.*, northern Sierra and Cascade mountain ranges). The climate change models predict that factors affecting the annual precipitation levels, rather than changes in air temperature, would have a greater effect on annual runoff. The models also predicted that changes in the mean-annual deliveries and carryover storage were more sensitive to the annual precipitation changes than the changes in air temperature. SLR created greater salinity intrusion into the western delta which created significant decreases in the amount of CVP and SWP deliveries. Although the salinity intrusion created more variability in the X2 position, this intrusion was mitigated in the "wetter" scenarios by increased upstream runoff and delta outflow.

The climate modeling for the four different combinations of air temperature and precipitation indicated that for the "wetter" climates (Studies 9.2 and 9.3), the frequency of "wet" hydrological years increased over the baseline conditions, while dry and critically dry years were reduced. Hydrologic year types classified as above normal increased marginally over the baseline conditions, while years classified as below normal were essentially unchanged. Conversely, the climate models for drier climates (Studies 9.4 and 9.5) showed a substantial decrease in "wet" years and a substantial increase in "critically dry" years. Above normal year types were slightly more frequent in the drier climate scenarios than in the baseline conditions, while below normal year types were significantly lower in the drier, less warming climates compared to the control baseline (see OCAP BA Appendix R figure 34 for more detail).

The results from the applicant'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 6-21 and 6-22).

6.6.10 Vernalis Adaptive Management Plan

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 two-year's hydrology, based on the San Joaquin River Basin 60-20-20 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 San Joaquin River Agreement (SJRA) and have agreed to pay 4 million dollars per year ($4,000,000) to the San Joaquin River Group Authority (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 (OCAP BA pages 2-67 and 2-68). The VAMP target flows and export rates are contained in table 6-23, 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 Central Valley 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).

Table 6-21. 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 6-22. 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	Wetter, More Warming	Drier, Less Warming	Drier, More Warming
		Velocity	Velocity	Velocity	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

Table 6-23. 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 OCAP 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.

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 enroute. 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 Central Valley steelhead that would "normally" be present in these areas over the summer.

6.6.11 Summary and Integration 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 has 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 and 2008) 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.

The current suite of projects under consultation for the OCAP 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. Increased water diversions during the periods of listed salmonid outmigrations will unquestionably lead to increased take of listed salmonids from both the Sacramento River and San Joaquin River basins at the water diversion facilities. The magnitude of these increases remains unresolved due to the uncertainty of the metrics used in the determinations of this take. Likewise, the uncertainty 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 remains undefined. However, 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[9]. Due to the low numbers of individuals in these populations, there is a lack of resiliency,

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[9] The resilience of the Sacramento River population of Sothern DPS green sturgeon is unknown. Currently, there are no accurate estimates of the standing population of green sturgeon (*i.e.*,

which reduces the ability of the fish populations to recover from chronic take issues. Furthermore, although the incremental increase in take was considered in the BA, only the average take, as derived from the average entrainment over several years was considered. Historical data indicates 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 OCAP not only maintains the current trajectory of loss seen today, but increases 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 enhancement resulting from these operations as described.

The effects of the ongoing CVP and SWP operations are both overtly and subtly intertwined with the functioning of the Delta ecosystem. Historically, the Delta received freshwater inflow in response to the inflows of the Sacramento River basin to the north and the San Joaquin River basin to the south. Additional inflows from the river basins entering the eastern Delta (Cosumnes, Mokelumne, and Calaveras Rivers) were at times important, depending on local precipitation events in those watersheds. As previously described, the Sacramento River basin to the north is a winter rain driven system. Typically precipitation peaked in January; with most rain events occurring between December and February (see Figure 1). Increases in the river flow lagged slightly behind the precipitation peak and as explained earlier, winter flood flows spread out across the multiple basins in the Sacramento Valley. This had the effect of muting the flood peak, prolonging the elevated flows in the Sacramento River system, diminishing the velocity of the river flows in the flooded habitat, and providing refuge for salmon fry, juveniles, and smolts moving downstream in the system during these high water events. It is also certain that other native fishes, which evolved in the Central Valley, took advantage of these seasonal flood plains to rear, forage, and spawn (Moyle *et al*. 2007). Currently the manipulation of the hydrograph through the operations of the project's reservoirs, as well as other reservoirs in the watershed, alter the timing and magnitude of the wintertime flow peaks that serve as environmental cues for life history traits in native fish. This includes migrational timing cues for juvenile salmonids moving downstream and adult fish (salmonids and green sturgeon) making spawning runs upstream. Reduction of these cues mutes the plasticity of the life history traits in the Central Valley's salmonid stocks, and therefore restricts the display of life history strategies that take advantage of different environmental conditions that are available to these fish (bet hedging strategies).

In order to protect upland areas surrounding the river from flood damage and enhance the reliability of water conveyance through the Central Valley and the Delta, levees were constructed along the margins of the rivers and regional waterways. However, these armored levees also prevented the river from inundating the historic floodplains surrounding the river channel and severed the natural connectivity between the river and its surrounding uplands. This reduced the available habitat for juvenile salmonid rearing along the river to a narrow band running along the levee face where vegetation may, or may not be present, depending on levee maintenance practices. Isolation of the river from the natural floodplains has also reduced the input of organic

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abundance) comprising the Southern DPS and therefore estimates of the different population parameters are unavailable.

materials and nutrients from allochthonous sources on the floodplains. This input of allochthonous material is essential for the energy budget of the riverine system (The Bay Institute 1998). The lack of input of organic material from the floodplain reduces the energy budget of the river which therefore limits the growth potential of juvenile salmonids, steelhead, and green sturgeon rearing in the river through diminishment of energy flow through the food web in the river.

Similar patterns of floodplain dependency and use evolved in the San Joaquin River basin, which had a different temporal pattern of runoff compared to the Sacramento River system (The Bay Institute 1998). The San Joaquin River watershed originates in the Southern Sierra Nevada mountain range. Elevations are typically over 12,000 feet along the ridges of the range. Precipitation falls as snow over much of this watershed, which feeds the San Joaquin River and its tributaries with snowmelt later in the spring and early summer months (April through June in most years). Previously, flood flows spread out over large tracts of marshland in the San Joaquin Valley and the historic populations of fall-run, late fall-run, and spring-run Chinook salmon as well as steelhead that populated this basin, reared within these inundated tracts of land during their downstream migrations to the Delta. Perhaps even more so than the Sacramento River, the San Joaquin River basin has been cut off from its flood plains and the river's hydrograph altered to the point that very little discernable snowmelt or spring runoff signature is left (see Figure 3) in the valley floor sections of the river basin. Most of the snowmelt runoff has been captured behind the large reservoirs lining the eastern side of the valley, leaving little flow through the valley floor sections of the San Joaquin River and the east side tributaries. The CVP controls two of the major reservoirs in this basin, New Melones on the Stanislaus River and Millerton on the San Joaquin River. The significance of these alterations in flow through the valley floor sections of the watershed can be illustrated by the extirpation of the San Joaquin River spring-run Chinook salmon population below Friant Dam in the late 1940's. Following the completion of the Friant –Kern Canal in the late 1940's, only a minimal flow of water was allowed downstream below Friant Dam to supply riparian water diverters. The river channel was frequently dewatered below these diversions as the allotment of water was fully diverted by the irrigators. The tail water section of the river became disconnected from the lower San Joaquin River and within a few years, the spring-run Chinook salmon run in the San Joaquin River below Friant Dam was extirpated. Currently, the migrational cue for juvenile fall-run Chinook salmon and smolting steelhead to leave the east side tributaries in the San Joaquin Basin is the 30-day pulse flows conducted during the VAMP actions. By relying on only one highly defined period of outflow, the plasticity of the two salmonid populations is artificially constrained to exhibit emigration tendencies for the mid-April to mid-May time period.

Taken in combination, the temporal alterations in runoff and the manipulation of the magnitude of flows have created conditions that will reduce the abundance of downstream emigrating juvenile salmonids and sturgeon through the disconnection of the river with its flood plains. Reducing the magnitude of the river flows reduces the frequency of inundation on currently available flood plains, such as the Yolo bypass. This reduces the available space for rearing, as well as diminishing the potential food base for rearing fish. Loss of these assets reduces the ability to sustain higher populations of the different runs of Chinook salmon moving downstream. Studies conducted by Sommer *et al.* (2001a, 2001b, 2005) on the Yolo bypass indicated that juvenile Chinook salmon grew faster on the floodplain than those fish that remained in the river, were larger upon entering the Delta, and had survival rates at least as high as those remaining in the river. Stranding issues appeared to be minimal based on their studies (Sommer *et al.* 2005).

One of the functions of the extensive network of armored levees is to ensure continuity of water conveyance through the Delta and the rivers feeding into it, an attribute that supports and accentuates the goals of the proposed project. A side effect of armored levees is the reduction in riparian and nearshore habitat along the margins of rivers and Delta waterways. As fish move through the Delta waterways, whether under the influence of the ambient river currents or the draw of the project pumps, they are exposed to miles of armored levee shorelines and their nearshore aquatic habitat. Levees typically increase the water depth near the foot of the levee structure and therefore decreases shallow water habitat, leaving only a narrow margin of emergent aquatic plants such as tules and cattails. This is particularly true in narrowed channels or outside bends where water velocities are accentuated. This reduction in nearshore and shallow water habitat affects ocean-type Chinook salmon life histories more so than the stream-type life histories. Within the Central Valley, fall-run Chinook salmon and YOY spring-run Chinook salmon that emigrate in spring and early summer as fry and fingerlings are most affected by the reduction of the nearshore habitat. However, winter-run juveniles, which display a mix of stream and ocean-type life history strategies, may also be affected. Winter-run Chinook salmon enter the Delta as sub-yearlings and rear for approximately three months in the Delta before transitioning to the marine phase of their life history. This life history strategy is illustrated by their entry into the Delta in the November through January time period, but their subsequent appearance several months later in the Chipps Island trawls in the western Delta and the export salvage in the South Delta during February and March when they are actively moving seawards as smolts. It is unclear whether Central Valley steelhead smolts and juvenile green sturgeon make use of the shallow water habitat along the river's edge to the same extent as the smaller sized fall-run and spring-run YOY Chinook salmon emigrants. Based on the analysis of several studies conducted in northern estuaries (Bottom *et al.* 2005 and Fresh *et al.* 2005), steelhead have the characteristic behaviors of stream-type Chinook salmon, and should remain within the deeper portions of the estuarine waterways and move through the system rather quickly, rather than loitering along the river margins in nearshore habitat.

The decrease in the biological value of the nearshore habitats is due to the simplification of the available habitat structure. This is represented by a reduction in habitat complexity, loss of refugia from high velocity flows in the river, and the diminishment of allochthonous material input from the terrestrial component of the river's edge, which all enhance the functional value of the nearshore aquatic environment for ocean-type Chinook salmon juveniles or those fish exhibiting this life history behavior (*i.e.*, winter-run Chinook salmon juveniles). The loss of habitat value leads to a reduction in the abundance of ocean-type Chinook salmon fry and juveniles resulting from a loss of habitat quality within the Delta region. The groups of Central Valley Chinook salmon that will most likely be affected are YOY spring-run Chinook salmon, juvenile winter-run Chinook salmon, and fall-run Chinook salmon. A reduction in productivity among these groups is also likely since those fish that survive passage through the Delta may not grow as rapidly and are thus smaller at ocean entry compared to fish that have reared in more suitable nearshore conditions. 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.

Conversely, the reduction in suitable nearshore habitat created by armored levees is less likely to affect larger stream-type fish that move through the Delta and estuary quickly and make little use of the nearshore environment prior to entering the ocean (represented by yearling sized spring-run Chinook salmon, late fall-run Chinook salmon, and steelhead).

Predation on emigrating fish is a major concern within the waterways of the Delta. There are abundant populations of piscine predators within the Central Valley and the waters of the Delta. Historically, the major piscine predator was the Sacramento pikeminnow, a native to the Central Valley watersheds. In the 1880's, non-native striped bass were introduced to the San Francisco Bay estuary from the east coast and rapidly colonized the region's waterways. The striped bass is a significant predator in the Delta and San Francisco Bay systems, consuming a wide variety of prey items, including Chinook salmon and steelhead. It spawns in both the Sacramento and San Joaquin River systems and makes use of the river systems, estuary, and coastal oceans as part of its life history. The CDFG currently estimates (2007) that the striped bass population greater than or equal to 3 years of age is comprised of approximately 800,000 individuals (± 400,000). Another introduced predator, the large mouth bass, has also become prevalent in the waters of the Delta, particularly in the central, eastern, and southern Delta waterways. Operations of the CVP and SWP have provided a stable freshwater environment for this species of fish which has allowed it to proliferate. Concurrent to the increase in the largemouth bass population (as well as centrarchids in general), the non-native Brazilian waterweed (*Egeria densa*) has shown a rapid increase in its infestation of the Delta over the past 20 years (Brown and Michniuk 2007). This non-native plant provides enhanced habitat conditions for largemouth bass (and centrarchids in general). *Egeria densa* requires a stable freshwater environment. It is intolerant of even low levels of salinity (> 5 parts per thousand) and dies back in cold weather. *Egeria densa* is most common in the central, eastern, and southern portions of the Delta, which also corresponds to the higher population densities of largemouth bass and other centrarchids (Brown and Michniuk 2007). These are also the waterways most influenced by the project's pumping operations. Native fish species do not appear to benefit from the increase in *Egeria densa* patches. One of the habitat characteristics of the *Egeria densa* infestation is the constriction of channels when both nearshore margins on either side of the channel become choked with the plant, leaving only the deeper central channel open. These dense stands of *Egeria densa* prevent utilization of the nearshore environment by ocean type Chinook salmon fry and fingerlings that may be migrating through these channels. These juvenile fish are forced to migrate through the Delta in the more open mid-channel habitats, which makes them more vulnerable to predation by both the striped bass that move through the open channel habitat searching for prey, and to the centrarchid predators that hang on the margin of the *Egeria densa* stands, waiting in an ambush position to attack prey as it swims by. The combination of *Egeria densa* infestations, increased populations of predators such as centrarchids, and the expected increases in water drawn through these channels under aggressive water operations will decrease the abundance of Chinook salmon populations, particularly those exhibiting ocean type life histories that rely on nearshore habitat for rearing.

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 temporary and permanent barriers 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 Central Valley steelhead and fall-run Chinook salmon 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 conservation and recovery goals of having viable populations represented in each of the historic geographical regions in which the different populations originally occurred.

6.7 Suisun Marsh

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 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. 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. The effects of the proposed action on Southern Residents are currently under evaluation, and will be incorporated into the final biological opinion. The assessment will be based on short-term effects on prey availability, and long-term effects on Chinook salmon in the Central Valley (*i.e.*, listed and non-listed, hatchery and natural, winter-run, spring-run, fall-run, and late fall-run).

I. 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). There are no interrelated or interdependent actions associated with the proposed action.

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. 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 Global Climate Change

The world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 to 1.0 meters in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g.*, salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Summer droughts along the South Coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to over take native fish species and impact predator-prey relationships (Peterson and Kitchell 2001, Stachowicz *et al.* 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2°C and 7°C by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by precipitation rather than snowfall. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods.

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 the proposed Project from the issuance of a final Opinion through year 2030. This section is based on analyses provided in section 6.0, "Effects of the Proposed Action," above. In this section, NMFS performs two evaluations: whether it is reasonable to expect the proposed Project is not likely to: (1) reduce the likelihood of both survival and recovery of the species in the wild, and (2) result in the destruction or adverse modification of designated or proposed critical habitat (as determined by whether the critical habitat will remain functional to serve the intended conservation role for the listed anadromous species or retain its current ability to establish those features and functions essential to the conservation of the species). The *Analytical Approach* section described the analyses and tools we have used to complete this analysis.

In our *Status of the Species* section, NMFS summarized the current likelihood of extinction of each of the listed species. We described the factors that have led to the current listing of each species under the ESA across their ranges. These factors include past human activities and climatological trends and ocean conditions that have been identified as influential to the survival and recovery of the listed species. Beyond the continuation of the human activities affecting the species, we also expect that ocean condition cycles and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover.

The criteria recommended for low risk of extinction (table 4-3) for Pacific salmonids are intended to represent a species and populations that are able to respond to environmental changes and withstand adverse environmental conditions. Thus, when our assessments indicate that a species or population has a moderate or high likelihood of extinction, we also understand that future adverse environmental changes could have significant consequences on the ability of the species to survive and recover. Also, it is important to note that an assessment of a species having a moderate or high likelihood of extinction does not mean that the species has little or no potential to survive and recover, but that the species faces moderate to high risks from internal and external processes that can drive a species to extinction. With this understanding of both the current likelihood of extinction of the species and the potential future consequences for species survival and recovery, NMFS will analyze whether the effects of the proposed Project are likely to in some way increase the extinction risk each of the species faces.

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 this 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.

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. As a result, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential to the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality.

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 17,334 (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 Stress Regime on 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 table 9-1.

A recently released Opinion on the current use of pesticides in the Central Valley reported that the uses of chlorpyrifos, diazinon, and malathion pesticides products that contaminate aquatic habitat in the Sacramento River and Bay/Delta result in both individual fitness level consequences and subsequent population level consequences for winter-run (NMFS 2008). That Opinion concluded that the current use of pesticides in the Central Valley is likely to jeopardize the continued existence of the Sacramento River winter-run Chinook salmon ESU.

9.1.3 Summary of Proposed Project Effects on Winter-run Chinook Salmon

Proposed Project-related effects to winter-run are summarized in table 9-2. Detailed descriptions regarding the exposure, response, and risk of winter-run to these stressors are presented in section 6.

Table 9-1. Winter-run Chinook salmon stressors excluding CVP/SWP-related effects.

Freshwater	Estuarine	Marine
Pollution from surface runoff	Pollution from surface runoff	Pollution from surface runoff
Agricultural return flows	Dredging, pile driving	Variable ocean productivity
Predation (native, non-native, resident *O. mykiss*, and pinnipeds*)*	Predation (introduced warm water species, pinnipeds)	Predation (*e.g.*, seals, sea lions, killer whales)
Water diversions (screened and unscreened)	Loss of 94 percent of tidal marsh habitat	Ocean harvest (commercial and sport)
Contaminants (pesticides, herbicides, and heavy metals from EPA remediation actions)	Contaminants (pesticides, herbicides, selenium)	
Bank stabilization (rip rap, armoring, revetment)	Construction and maintenance of boat docks and marinas	
River narrowing due to bank stabilization	River deepened and channelized Corps projects	
Less channel complexity	Less channel complexity	
Less food production	Less food production	
Less cover and shelter	Less cover and shelter	
Mining activities (loss of gravels, sedimentation, heavy metals)	Sand mining, heavy metals	
Lack of LWD and SAR	Competition for space and food from non-native invasive species and plants	
Climate change (warmer water temperature)	Sea-level rise	
Urbanization, oil spills	Urbanization, oil spills	
Increased probability of catastrophic events due to smaller spawning area		

As shown in table 9-2, proposed Project-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) effectively 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 2-6).

Table 9-2. Exposure and summary of winter-run responses to proposed Project-related stressors.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult Immigration and Holding	April-August	RBDD gate closures from May 15 - Sept 15 every year	15% of adults delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity; continues every year with greater impacts during additional early closure for emergencies	Reduced survival and reduced reproductive success
		RBDD emergency 10 day gate closures	Greater proportion of run blocked or delayed; sub lethal effects on eggs in fish and energy loss	Reduced reproductive success
Spawning Primarily upstream of RBDD	April-August	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; overlap in run timing, fewer adults spawning; loss of genetic integrity and expression of life history	Reduced reproductive success
			Competition; aggressive behavior towards spawning fish could cause higher prespawn mortality	Reduced survival and reduced reproductive success
			Redd superimposition; spawning on top of other redds, destroys eggs	Reduced survival and reduced reproductive success
			density dependency; increased fighting for suitable spawning sites, adults forced downstream into unsuitable areas	Reduced reproductive success
		Temp > 56 F in spawning habitat below TCP, every year April 15 -Sept 30)	Prespawn mortality; some adults may move upstream as far as Keswick Dam, others may have reduce fecundity	Reduced survival and reduced reproductive success
Embryo Incubation	April-October	exposure to temp. > 56F in gravel, every year from April 15 - Sept 30	Mortality varies with exceedance rate	Reduced survival
		No proposed carry-over target in Shasta Reservoir, for all years	Loss of eggs due to high temperature; increased tendency to run out of cold water in Shasta earlier and more often	Reduced survival and reduced reproductive success
		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	Reduced reproductive success

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
		predation by resident rainbow trout	reduced juvenile abundance	Reduced reproductive success
Juveniles and pre-smolts Upstream of and including RBDD	July - March	exposure to temp. > 65F	Thermal stress	Reduced survival
		competition from multiple salmonids	reduced growth, smaller size at emigration	Reduced growth
		flow fluctuations caused by ACID dam removal in November	juvenile standing and isolation; juveniles killed or subjected to predation and higher temps in side channels	Reduced reproductive success
		RBDD passage downstream through dam gates May15 - Sept 15, plus 10 days in April during emergencies	Mortality as juveniles pass through Red Bluff Land and RBDD reportedly ranges up to 55%; delayed emigration	Reduced survival
		RBDD Lake, 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
	July - March	incidental take from the RBDD Pumping Plant	death from contact with fish screen, diversion pumps, and bypasses; sub lethal effects from going through pumps, loss of scales, disorientation	Reduced survival
		rearing area is located further downstream than historical rearing area	smaller size at emigration, increased predation; earlier immigration	Reduced survival and reduced growth

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Smolt emigration RBDD to Colusa	Sept - Nov	reversed hydrologic pattern (high flows in summer, low flows in fall), modifies critical habitat for 300 miles downstream to Delta, creates a freshwater ecosystem in Delta instead of allowing for variability, all year, every year	Riparian habitat altered, 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
		shortened migratory corridor due to Shasta and Keswick Dam blocking upstream rearing and spawning areas	smaller size at emigration, increased predation; earlier immigration	Reduced survival and reduced growth
Smolt emigration Colusa to Sacramento		Low fall flows	emigration delayed, higher predation; fewer smolts survive to the Delta	Reduced survival
		Future Sac R Reliability Project, new water diversion at Elverta (RM 74.7) would divert 176 TAF/year	construction impacts deferred to a separate Opinion, contact with fish screen, disorientation, > predation, impacts from loss of habitat, loss of food in water; higher demands for water on Sacramento and American Rivers, less storage in Shasta and Folsom= less cold water available for temp. control upriver, habitat loss, higher predation, continued contact with fish screen from operations and maintenance into the future	Reduced survival
Smolt emigration Delta		Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
all stages	April - August for adults and Feb - Mar for juveniles	Hatcheries (LSNFH and Coleman NFH) impacts both adults and juveniles when present in the action area, competition, hybridization, straying, reduced genetic fitness	hatchery fall-run juveniles compete with wild fish for food and space, hatchery winter-run released in Feb. after peak of wild fish immigration past RBDD spend very little time in-river; Beneficial for LSNFH (conserves genetics and increases abundance, stop gap measure to prevent extinction), Adverse effects from Coleman NFH (13 million fall-run released into upper Sacramento River in November and December when wild winter-run present)	Reduced growth of natural-origin winter-run
all stages	April-October	Climate Change impacts on water temperature and flows by the year 2030, assume 1-3 °F warming in most rivers	loss of eggs due to high temperature, juveniles immigrate earlier at smaller size, loss of thermal refugia on valley floor; increased tendency to run out of cold water in Shasta earlier and more often, juvenile survival is reduced	Reduced reproductive success

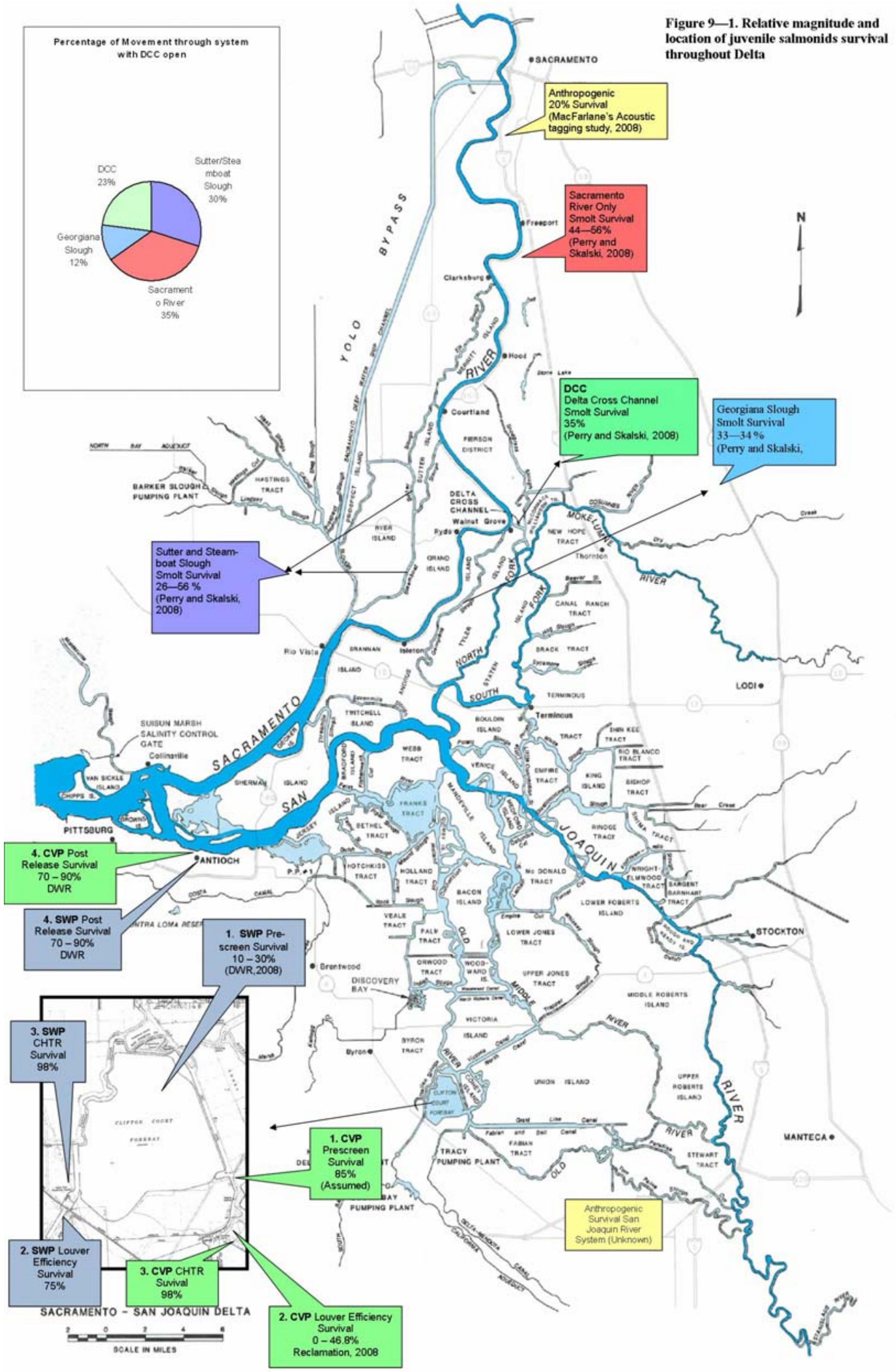

Figure 9-1. Relative magnitude and location of juvenile salmonids survival throughout the Delta.

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. 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 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) entraining juveniles into the Central and South Delta; and (5) 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 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[10] 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

[10] D-1641 provides for a 45-day discretionary closure of the DCC gates between 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).

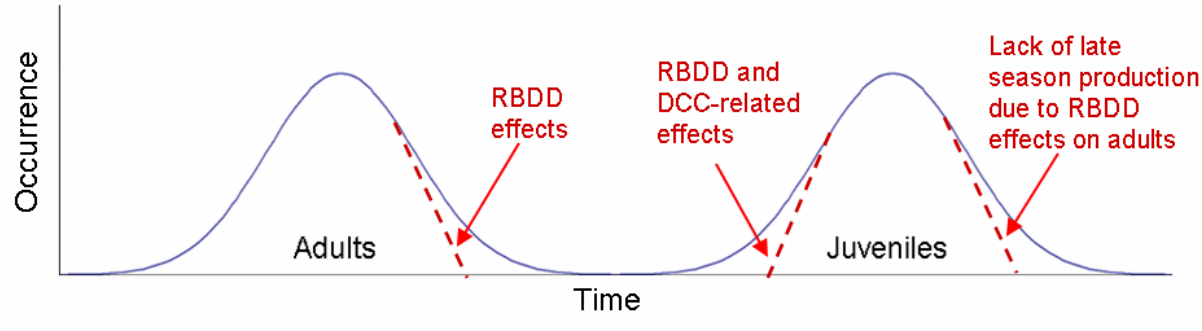

Figure 9-2. General depiction of proposed Project-related effects on the temporal distribution of adult and juvenile winter-run during their inland residency. Winter-run adults delayed or blocked by RBDD during the late portion of their spawning run effectively reduces their occurrence on the spawning 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 *et al*. 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 Project, the probability that these smolts will enter an ocean environment with favorable conditions for 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.

In addition to impacts to the spatial structure and diversity, the proposed Project 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 spawning and embryo incubation; (3) increasing predation of juveniles when the RBDD gates are down; (4) entraining juveniles into the Central and South Delta (figure 9-1); (5) entraining and impinging juveniles at the pumps (both direct and indirect loss); and (6) loss associated with the CHTR program. The cumulative effect of proposed Project-related mortality at multiple life stages, continues to increase the extinction risk of the winter-run Chinook salmon 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 lower than the survival 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).

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 Project (*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.

9.1.4 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 and increases the population's extinction risk.

Based on the analysis of available evidence, NMFS concludes that the viability, and therefore the likelihood of both survival and recovery of the Sacramento River winter-run Chinook salmon ESU, will be appreciably reduced with implementation of the proposed action (table 9-3).

Table 9-3. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the Sacramento River Winter-run Chinook Salmon ESU. 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 project 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 project	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 project	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

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 comprised of seven physical and biological features that are essential for the conservation of winter-run. 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.

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 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 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.

The value of critical habitat would improve considerably without the effects of the CVP/SWP. RBDD, ACID diversion dam, and DCC would not impede upstream or downstream migration. Shasta Reservoir would likely have considerably more water, and more cold water, available for spawning habitat, although the quality of spawning habitat would remain the same with the spawning gravel injection. The value of rearing habitat may continue to be degraded by the channelized, leveed, and riprapped river reaches and sloughs, and with the many unscreened diversions throughout the Sacramento River. However, riparian vegetation would likely reestablish the reach of the Sacramento River that is annually inundated by Lake Red Bluff and improve the value of rearing habitat in that reach.

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. The 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, 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. 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.

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 Project will further degrade the value of spawning, rearing, and migratory habitat. However, reoperation of RBDD in the future full build out scenario will slightly improve the value of rearing and migratory habitat.

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 9-4).

Table 9-4. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Sacramento River winter-run Chinook salmon 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 one or more 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

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. Extant spring-run populations occur in Butte, Big Chico, Deer, Mill, Antelope, Battle, Clear, Cottonwood/Beegum, and Thomes Creeks. In addition, early-returning Chinook salmon persist within the mainstem Sacramento River[11], within the Feather River Hatchery population spawning in the Feather

[11] 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

River[12] below Oroville Dam, and in the Yuba River below Englebright Dam. 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 Project as they migrate, hold, or rear within the Sacramento River and Delta.

This section 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 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 of the various populations. 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.

9.3.1 Status of Central Valley Spring-Run Chinook Salmon ESU

Lindley *et al*. (2007) stated that perhaps 15 of the 19 historical 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 known as spring-run, although they recognized that phenotypic Chinook salmon persist within the Feather River Hatchery population spawning in the Feather River below Oroville Dam and in the Yuba River below Englebright Dam. All of those populations 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). One other spring-run population seems to persist in this diversity group in Big Chico Creek, 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 and in Battle Creek, although, similar to the 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 this dependency is not known. Lindley *et al.* (2007) seemingly conclude that these populations are entirely composed of strays as those authors stated that the spring-run have been extirpated from the entire diversity group.

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salmon exhibiting spring-run Chinook salmon behavior (*e.g*., upstream migration during spring and spawning during early fall) in the mainstem Sacramento River represent a distinct spring-run population, although hybridization with fall-run Chinook salmon has likely occurred. This assumption is somewhat supported by a recent study of Central Valley salmon genetics, which generally indicated that run timing remains an important factor in describing genetic structure in the Central Valley (Garza *et al*. 2008).

[12] 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.

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.

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. The current distribution of viable populations makes spring-run vulnerable to catastrophic disturbance. All three extant independent populations are in basins whose headwaters lie 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, 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 Stress Regime for the Central Valley Spring-run Chinook Salmon ESU

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 effects in freshwater, estuarine, and marine environments have greatly diminished the viability of the ESU, and continue to do so. These anthropogenic effects are similar to those that affect winter-run (table 9-1). In addition, the pesticides Opinion that concluded jeopardy for winter-run also concluded jeopardy for spring run.

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 dam removal, habitat restoration, gravel augmentation, temperature control and increased flows. Successful restoration programs have been funded by CALFED and the CVPIA. The spring-run population in Clear Creek has gone from zero to 200 adults in the last 12 years. Most of the spring-run are descendents from introduced Feather River Hatchery stock in the 1990s. These fish enter Clear Creek from March to June (based on passage at RBDD) and hold over in the upper reaches below Whiskeytown Dam where coldwater releases are available year round. Flows are typically augmented with b(2) water to maintain adequate water temperatures in the summer and fall. In August, the USFWS installs a temporary picket weir to separate incoming fall-run from hybridizing with the spring-run already in the upper reaches. Most spring-run juveniles emigrate from Clear Creek as post-emergent fry from November through January. Spring-run abundance is expected to increase to the maximum habitat available, which is dependent on the availability of flows. The majority of flows in Clear Creek are derived from Trinity River diversions to Spring Creek Tunnel and Keswick Dam.

9.3.3.1.2 Future Baseline Stress Regime on Clear Creek 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 population. The general baseline stress regime for Clear Creek spring-run in freshwater, estuarine, and the marine environment is depicted in table 9-1. More specifically, baseline stressors within Clear Creek include a lack of natural recruitment of spawning gravels and a lack of suitable habitat during the summer for juvenile rearing and adult holding.

9.3.3.1.3 Summary of Proposed Project Effects on Clear Creek Spring-run Chinook Salmon

Proposed action-related effects to spring-run within Clear Creek are summarized in table 9-5. Detailed descriptions regarding the exposure, response, and risk of spring-run to these stressors are presented in section 6.2.3.

9.3.3.1.4 Assess Risk to Clear Creek 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 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 RBDD operations; (2) providing flows and water temperatures within Clear Creek 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.

Table 9-5. Exposure and summary of spring-run responses to proposed action-related stressors within Clear Creek.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult immigration and holding	March – Sept.	temp > 60 F during summer holding period	temp control to Igo; possibly some pre-spawn mortality in critically dry years when not enough cold water in Whiskeytown Lake	Reduced reproductive success
		RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) force fish to use inefficient ladders	~70 percent of the spring-run that spawn upstream of RBDD are delayed by about 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	Reduced reproductive success
Spawning	Sept. - early Oct.	Smaller spawning area due to temperature management down to Igo Gage and physical barrier at fish weir	density dependency effects & redd superimposition; limited carrying capacity of stream will dictate population size; possible loss of some individuals that spawn below Igo or come in late and spawn below weir with fall-run	Reduced reproductive success and reduce survival
		loss of spawning gravel below Whiskeytown Dam	reduced spawning areas; spawning success diminishes	Reduced reproductive success
		temp > 56 F	loss of eggs and sac-fry; fewer juveniles survive	Reduced reproductive success
		low summer flows (< 80 cfs)	adult passage limited to upstream holding areas; adults spawn further downstream in less suitable conditions	Reduced survival
Embryo incubation	Sept. - December	exposure to temp. > 56 F 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 chance of survival for fry	Reduced reproductive success
Smolt emigration Delta		Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
all stages	adults in September, juveniles from October to May	Hatcheries, Feather River Spring-run Program greatest impact on Clear Creek, Mill Creek through competition, hybridization, increased straying, reduced genetic fitness	Introgression - spring-run hybridized with fall run, loss of genetic fitness; Leads to one homogenous run (fall-run) with less variability in life history and resiliency to major events like forest fires, volcanic eruptions, or climate change	reduced fitness of wild fish
all stages	April-October	Climate Change impacts on water temperature and flows by the year 2030, assume 1-3 F warming in most rivers	loss of spawning habitat in tributaries, loss of eggs due to high temperature, juveniles immigrate earlier at smaller size; fewer spring-run populations in tribs, loss of over-summering holding pools	Reduced reproductive success

Operation of the CVP/SWP adversely 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 (OCAP 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 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 tributary habitats. Spring-run that are delayed at RBDD and cannot access Clear Creek holding and 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 (USFWS studies).

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 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 more vulnerable to predation and generally less robust than 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 9-1). In addition, proposed Project-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 they may be exposed to RBDD when the gates are in on their downstream migration, in which case, their juvenile mortality would increase.

All of the above factors which reduce the spatial structure, diversity, and abundance 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 of the population. In the year 2019, RBDD will be reoperated to gates in only about 2½ months of the year. That will provide a portion of each year's spawners unimpeded migration opportunity past RBDD. However, the negative impacts of the proposed action far outweigh the benefit of the reduced RBDD gates out window, and especially in consideration of the temporal scale of not reoperating until 2019.

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 table 9-1.

The proposed action affects Beegum and Thomes 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 Beegum and Thomes Creek are the same stressors described for Clear Creek spring-run in table 9-5. That is, RBDD adversely affects 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. This delay decreases 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. RBDD and Delta entrainment effects have fitness consequences for individual spring-run from both Beegum and Thomes Creeks. Considering the extremely small spring-run population sizes in these creeks, along with RBDD effects and the magnitude of proposed action-related loss of Chinook salmon migrating through the Delta (figure 9-1), it is likely that the proposed action also has population-level effects 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 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 (unpublished data from 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. 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 Stress Regime on Mainstem Sacramento River 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 population. The general baseline stress regime for mainstem Sacramento River spring-run in the freshwater, estuarine, and marine environment is depicted in table 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 caused an 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.

9.3.4.1.3 Summary of Proposed Project 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 9-6. Detailed descriptions regarding the exposure, response, and risk of spring-run to these stressors are presented in section 6.

Operation of the CVP/SWP decreases the abundance of spring-run in the mainstem Sacramento River and the proposed Project is expected to continue to do so. In September and October, chronic exposure of spring-run eggs to warm water temperatures is expected to result in direct mortality. For example, results from the egg mortality model used in the OCAP BA show that under near-term operations (Study 7.1) mortality is expected to range from about 9 percent in wet years up to about 66 percent in critically dry years, with an average of about 21 percent over all water year types (OCAP BA figure 11-41).

Given that direct mortality to spring-run eggs is expected with chronic exposure to warm water temperatures under the proposed action, it is reasonable to assume that those eggs that do survive will experience sub-lethal effects. These sub-lethal effects decrease the chance of spring-run to survive during subsequent life stages (Campbell *et al*. 1998). 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). Campbell *et al*. (1998) concluded that chronic thermal stress produced both selectively lethal and sub-lethal effects that increased structural asymmetry and directly decreased the fitness of coho salmon.

Those spring-run eggs that do survive to hatch and emerge from the gravel, potentially with a reduced potential for survival due to exposure to warm water temperatures during development, are then subject to a considerable amount of proposed action-related mortality as juveniles as they rear and migrate downstream. 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 data presented in MacFarlane *et al*. (2008) include 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, proposed action-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.

Table 9-6. Exposure and summary of Sacramento River spring-run Chinook salmon responses to proposed action-related stressors.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult immigration and holding	March – Sept.	RBDD gate closures from May 15 – Sept. 15 (plus 10 days in April) force fish to use inefficient ladders	~70 percent of the spring-run that spawn upstream of RBDD are delayed by about 20 days on average, more energy consumed, greater pre-spawn mortality, less fecundity	Reduced reproductive success
Adults	April - July	Smaller spawning area from moving TCP upstream	Introgression -Hybridization with fall run	loss of genetic integrity and expression of life history
		same as above	low numbers of spawning adults, 0-40 redds counted in Sept	Reduced reproductive success
		same as above	density dependency effects	merged life history
	September	temp > 56 F		
	October	temp > 60 F during spawning		
Embryo incubation	August - December incubation	exposure to temp. > 56 F in September, and > 60 F in October	Under near-term operations (Study 7.1) mortality is expected to range from about 9% in wet years up to about 66% in critically dry years, with an average of about 21%over all water year types; under modeled climate change projections, average egg mortality over all water year types is expected to be 55% and during the driest 15% of years is expected to be 95%	Reduced survival
Juveniles	October-April	exposure to temp. > 65F	truncated emigration timing	reduced expression of life-history strategy
	May15 - Sept 15, plus 10 days in April during emergencies	RBDD passage downstream through dam gates	delays, disorientation, higher predation	reduced survival
	May15 - Sept 15, plus 10 days in April during emergencies	RBDD Lake, river impounded	delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	reduced survival, slower growth, less food

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
		rearing area is located further downstream than historical	reduced growth, smaller size at emigration	reduced survival, greater predation as they move downstream
Smolt emigration Delta	Oct -May	Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival
all stages	adults in September, juveniles from October to May	Hatcheries, Feather River Spring-run Program greatest effect on adults in Clear Creek, Mill Creek, Sacramento River, and the Stanislaus River through competition, hybridization, increased straying, reduced genetic fitness	Introgression -adults hybridized with fall run, hatchery fish trucked to San Pablo Bay so probably no impacts on wild fish until they get to the ocean	reduced fitness of wild fish
all stages	April-October	Climate Change impacts on water temperature and flows by the year 2030, assume 1-3 F warming in most rivers	loss of spawning habitat in tributaries, loss of eggs due to high temperature, juveniles immigrate earlier at smaller size	Reduced reproductive success

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 adversely affected by the proposed action in a number of ways, including, but not limited to: (1) delaying adult immigration through RBDD operations; (2) providing water temperatures 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 mainstem Sacramento River spring-run population.

Operation of the CVP/SWP adversely affects the diversity of spring-run in the mainstem Sacramento River 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 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 (OCAP 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 (USFWS studies).

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). 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 9-1).

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.

9.3.4.2 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 table 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 9-6. That is, RBDD adversely affects adult immigration and proposed Project-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). RBDD and Delta effects have fitness consequences for individual spring-run from Battle Creek. Considering the extremely small spring-run population sizes in Battle Creek, along with the effect of RBDD on upstream migration and the magnitude of proposed project-related loss of juvenile Chinook salmon migrating through the Delta (figure 9-1), 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 Creek Spring-Run Chinook Salmon

Very few spring-run Chinook salmon are found in Antelope Creek, although some adult fish have been observed in the watershed in all but three years since consistent abundance estimates have been reported beginning in1992. The largest adult spring-run migration into Antelope Creek since 1992 was estimated at 154 fish in 1998 (http://www.delta.dfg.ca.gov/afrp/). Clearly, this dependent population falls into the high risk of extinction category with respect to abundance (table 4-3). The baseline stress regime for Antelope Creek spring-run includes all non-CVP/SWP stressors that were previously described (see Table 9-1) as well as stressors within Antelope Creek, 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 proposed Project adds to this stress regime. Similar to Clear Creek, Beegum Creek, Thomes Creek, and Battle Creek, Antelope Creek is upstream of RBDD, and therefore, the spring-run attempting to return to Antelope Creek are also delayed for an average of 21 days during the middle portion of the returning run. As previously described, these delays affect the fitness of spring-run by potentially directly reducing their survival (prespawn mortlity) or by reducing their reproductive success (lower fecundity or reduced egg viability). Considering the extremely small spring-run population size in Antelope Creek, along with the effect of RBDD on upstream migration and the magnitude of proposed project-related loss of juvenile Chinook salmon migrating through the Delta (figure 9-3), it is likely that the proposed action has population-level effects on Antelope Creek spring-run.

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 composed of only one diversity group containing 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 population's proximity to Mt. Lassen and the probability of a large scale wild fire occurring in those watersheds (Lindley *et al*. 2007). The proposed action does not improve any of these factors and increases the population's extinction risk by reducing the spatial structure, diversity, and abundance of spring-run populations, including all of the populations within the Northwestern California diversity group (*i.e*., Clear, Beegum, and Thomes Creeks) as well as the mainstem Sacramento River population in the Basalt and Porous Lava diversity group.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to appreciably reduce the viability, and therefore the likelihood of both the survival and recovery of the Central Valley spring-run Chinook salmon ESU (table 9-7).

9.4 Central Valley Spring-Run Chinook Salmon Critical Habitat

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

9.5 Central Valley Steelhead

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, Pitt, and McCloud Rivers), the northern Sierra Nevada (Feather, Yuba, and American Rivers), and the southern Sierra Nevada (Stanislaus River) diversity group (Lindley *et al*. 2007).

Table 9-7. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on the Central Valley Spring-run Chinook Salmon ESU. 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 project 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 project	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 project	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

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 Future Baseline Stress Regime for the Central Valley Steelhead DPS

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 steelhead in the freshwater, estuarine, and marine environment is depicted in table 9-8. Baseline stressors on CV steelhead are similar to those that affect winter-run and spring-run.

Extensive habitat elimination and degradation has been a primary factor causing the threatened status of CV steelhead. Specifically, physical habitat modifications (*e.g*., dam construction and river straightening and associated riprap applications) and other anthropogenic effects on habitat have greatly diminished the viability of the DPS. For example, the recently released pesticides Opinion concluded that uses of chlorpyrifos, diazinon, and malathion pesticides products that contaminate aquatic habitat in the Sacramento River and Bay/Delta result in both individual fitness level consequences and subsequent population level consequences for steelhead (NMFS 2008). Similar to the conclusions reached for winter-run and spring-run, that Opinion concluded that the current use of pesticides is likely to jeopardize the continued existence of the CV steelhead DPS.

Table 9-8. CV steelhead stressors excluding CVP/SWP-related effects.

Freshwater	Estuarine	Marine
Pollution from surface runoff	Pollution from surface runoff	Pollution from surface runoff
Agricultural return flows	Dredging, pile driving	Variable ocean productivity
Predation (native, non-native, and pinnipeds*)*	Predation (introduced warm water species, pinnipeds)	Predation (*e.g.*, seals, sea lions)
Water diversions (screened and unscreened)	Loss of 94 percent of tidal marsh habitat	
Contaminants (pesticides, herbicides, and heavy metals from EPA remediation actions)	Contaminants (pesticides, herbicides, selenium)	
Bank stabilization (rip rap, armoring, revetment)	Construction and maintenance of boat docks and marinas	
River narrowing due to bank stabilization	River deepened and channelized Corps projects	
Less channel complexity	Less channel complexity	
Less food production	Less food production	
Less cover and shelter	Less cover and shelter	
Mining activities (loss of gravels, sedimentation, heavy metals)	Sand mining, heavy metals	
Lack of LWD and SAR	Competition for space and food from non-native invasive species and plants	
Climate change (warmer water temperature)	Sea-level rise	
Urbanization, oil spills	Urbanization, oil spills	

9.5.3 Northwestern California Diversity Group

9.5.3.1 Clear Creek Steelhead

9.5.3.1.1 Status of Clear Creek Steelhead

[*Section in Preparation*]

9.5.3.1.2 Future Baseline Stress Regime on Clear Creek Steelhead Excluding CVP/SWP Effects

This section describes the environmental baseline upon which we will add the effects of the proposed Project in order to help assess the response and risk to the population. The general baseline stress regime for steelhead in the freshwater, estuarine, and marine environment is depicted in table 9-8.

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 represented in section 6.

9.5.3.1.4 Assess Risk to Clear Creek 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) 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 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) providing flows and water temperatures within Clear Creek that are stressful to steelhead; (2) entraining juveniles into the Central and South Delta; and (3) 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 Clear Creek steelhead population.

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.

9.5.3.2 Stony, Thomes, Cottonwood/Beegum, and Putah Creek Steelhead

[*Section in Preparation*]

Table 9-9. Exposure and summary of steelhead responses to proposed action-related stressors within Clear Creek.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adults	August - March	water temp. > 65 F 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
	December - March	lack of adequate spawning gravels	adults spawn in same areas, reduced success	Reduced reproductive success
	April -June	lack of channel forming flows due to presence of dam	less diversity, adults tend to spawn in same areas every year, limits suitable spawning areas; reduced production of eggs and fry, possible crowding from late-fall Chinook	Reduced reproductive success
Eggs	December - March	water temp. < 56 F during spawning and incubation	none	none expected
Juveniles	May - Sept	low summer flows (< 80 cfs)	higher water temp., less food, less space, less growth, > predation	reduced survival
		high temps	same as above	
Smolt emigration Delta		Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival
all stages	adults August - March, juveniles all year	Hatcheries (Coleman, Nimbus, Feather) release steelhead juveniles into river as mitigation for loss habitat above dams	hatchery smolts compete with wild fish for food and space in river, also cause wild fish to immigrate at same time (Pied Piper effect), adults stray into Clear Creek and other tribs.	reduced fitness, reduce growth rates of wild fish
all stages	April-October	Climate Change impacts on water temperature and flows by the year 2030, assume 1-3°F warming in most rivers	none expected for adults due to winter-time spawning period, for juveniles may favor anadromous life history over resident, warmer temps may leave lower reaches of Clear Creek unsuitable for rearing	Reduced reproductive success

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) however, this life history pattern has not been observed in the upper Sacramento River basin. Rotary screw trap data at RBDD indicate that most juvenile steelhead observed there are resident forms based on timing and size.

9.5.4.1.2 Future Baseline Stress Regime on 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 9-10. Detailed descriptions regarding the exposure, response, and risk of steelhead to these stressors are presented in section 6.

Table 9-10. Exposure and summary of Sacramento River steelhead responses to proposed action-related stressors.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adults	August - March	constant water temp August - October < 56 F, no variability	favors residency, residents out compete anadromous forms for food and space	Reduced reproductive success
	May15 - Sept 15, plus 10 days in April during emergencies	RBDD gate closures force adults to use inefficient fish ladders	17% delayed in spawning, more energy consumed, greater pre-spawn mortality, less fecundity	Reduced reproductive success
Eggs				
Juveniles	May15 - Sept 15, plus 10 days in April during emergencies	RBDD passage downstream through dam gates	delays, disorientation, higher predation	reduced survival
	May15 - Sept 15, plus 10 days in April during emergencies	RBDD Lake, river impounded	delayed juvenile emigration, increased predation; change in riparian habitat, change in river conditions, change in food supply, every year since 1967	reduced survival, slower growth, less food
Smolt emigration Delta		Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival
all stages	adults August - March, juveniles all year	Hatcheries (Coleman and Nimbus) impacts both adults and juveniles when present in the action area, competition, hybridization, straying, reduced genetic fitness	hatchery smolts compete with wild fish for food and space in river, also cause wild fish to immigrate at same time (Pied Piper effect), 15% return to the hatchery after release, adults stray into Clear Creek and other tribs	reduced fitness, reduce growth rates of wild fish
all stages	April-October	Climate Change impacts on water temperature and flows by the year 2030, assume 1-3 F warming in most rivers	none expected for adults due to winter-time spawning, for juveniles may favor anadromous life history over resident	unknown for mainstem population

9.5.4.1.4 Assess Risk to Mainstem Sacramento River Steelhead

[*Section in Preparation*]

9.5.4.2 Battle, Cow, Stillwater, Churn, Sulphur, Salt, Olney, and Paynes Creek Steelhead

[*Section in Preparation*]

9.5.5 Northern Sierra Nevada Diversity Group

9.5.5.1 American River Steelhead

9.5.5.1.1 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 1976), 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 Stress Regime on American River Steelhead Excluding CVP/SWP Effects

Excluding stressors resulting from American River Division operations, current 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 6.4.

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 9-11. 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 American River steelhead is presented in that section.

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) 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 above, habitat conditions in the lower American River are adversely affected by the proposed Project 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 proposed Project has substantial negative effects on the spatial structure of American River steelhead. Further reductions to the spatial structure of a population which has 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 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 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 Project operations has been documented at both the egg and juvenile life stages. The fitness consequences (*e.g.*, water temperature related bacterial inflammation of the anal vent of juveniles) described above also would be expected to negatively affect the population growth rate.

Table 9-11. Exposure and summary of steelhead responses to proposed action-related stressors within the American River.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Spawning Primarily upstream of Watt Ave. area	Late-December through early April	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-December through early April	Nimbus Hatchery – natural-origin steelhead spawning with hatchery O. mykiss	Reduced genetic diversity	Reduced reproductive success
Spawning Primarily upstream of Watt Ave. area	Late-December through early April	Angling impacts – catch-and-release impacts, illegal harvest	Mortality if hooked in critical areas (e.g., gills) or if illegally harvested	Reduced survival
Embryo incubation Primarily upstream of Watt Ave. area	Late-December through May	Water temperatures warmer than life stage requirements	Reduced early life stage viability; direct mortality	Reduced survival
Embryo incubation Primarily upstream of Watt Ave. area	Late-December through May	Folsom/Nimbus releases – redd scour	Egg and alevin mortality	Reduced survival
Juvenile rearing Primarily upstream of Watt Ave. area	Year-round	Folsom/Nimbus releases – flow fluctuations; low flows	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	Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation	Reduced growth; Reduced survival
Smolt emigration Throughout entire river	January through June	Water temperatures warmer than life stage requirements	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Reduced growth; Reduced survival

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Smolt emigration Delta	January through June	Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival

The combined effect 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 *Status* section above and Lindley *et al.* 2007), 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 can have serious consequences for the persistence of salmon populations. 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.

9.5.5.2 Antelope, Mill, Deer, Big Chico, Butte, Bear, Dry, Auburn/Coon Steelhead

[*Section in Preparation*]

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

[*Section in Preparation*]

9.5.6.1.2 Future Baseline Stress Regime on Stanislaus River Steelhead Excluding CVP/SWP Effects

[Section in Preparation]

9.5.6.1.3 Proposed Action Effects on Stanislaus River Steelhead

Proposed action-related effects to Stanislaus River steelhead are summarized in table 9-12. 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 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.

Table 9-12. Exposure and summary of Stanislaus River steelhead responses to proposed action-related stressors.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult immigration and Spawning	Dec thru Feb	no access to historical spawning and holding areas	Truncated run;	loss of 54 miles of spawning habitat, representing all of the historic spawning and holding habitat. Operations can replace less than 50% of lost habitat and only in reaches that were historically unsuitable for spawning.
Spawning	Dec-Feb	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.	Reduced suitable spawning habitat; less spawning effort leading to lower productivity for species. For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	changes in gravel bed permeability (Mesick?) increased fines; 30% spawning habitat lost since 1994, Kondolf
Egg incubation and emergence	Dec-March	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.	egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other steelhead or fall-run Chinook; suppressed growth rates;	Ligand reduced survival proportional to presence of fines on Tuolumne; Mesick - permeabilities again
Egg incubation and emergence	Jan-March	$T > 52^{\circ}$ F	Egg mortality	Myrick and Cech - temperature requirements - likelihood of exceedance>

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Juvenile rearing	Year round Jan-April (14 months)	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 ;	
Juvenile rearing	Year round Jan-April (14 months)	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;	Qualitative: Yolo basin growth studies; Cosumnes River FP studies; any data from Kondolf on lost acreage?
Juvenile rearing	Year round Jan-April (14 months)	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;	Look at % change in habitat from optimal 250 CFS at OBB to 100cfs at obb.
Juvenile rearing and out-migration	All year with increase Feb-May during out-migration	predation by non-native fish predators	reduced juvenile survival and production	Predation rates on fall-run Chinook salmon very high (Tuolumne studies) E-fishing at Oakdale Rec confirms similar predation risk for Steelhead smolts, even despite larger size. Greater risk from striped bass in Stanislaus.
Juvenile rearing	Year round Jan-April (14 months)	unsuitable end of summer temperatures (> 65° F) in rearing habitat	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	mortality and sublethal effects (Myrick and Cech)
Smolt emigration	Jan- June	T > 51° F later in the life stage period (i.e., late-May and June)	missing triggers to elect anadromous life history	reduced diversity by failure to elect anadromous life history. Need more info on diff T needs for Juv rearing and initiating smoltification. Myrick and Cech?

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Smolt emigration	Jan. - June	Suboptimal flow primarily later in the life stage period (i.e., late-May and June)	failure to escape stream 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	note presence of smolts in stream in May - will die? Not exercise anadromy? Chinook surrogate studies (DFG 2008 models
Smolt emigration Delta	Jan. - June	Direct and indirect loss associated with operation of Jones and Banks pumping plants	Substantial proposed Project-related mortality (figure 9-1)	Reduced survival

As described above, habitat conditions in the Stanislaus River and the Delta are adversely affected by the proposed action by several factors including: [*Section in Preparation*]

Based on the available evidence, it is apparent that the proposed action has substantial negative effects on the spatial structure of Stanislaus River steelhead. Further reductions to the spatial structure of a population which has already been blocked off from all of its historic spawning habitat certainly adds to its risk of extinction.

The diversity of Stanislaus River steelhead also is expected to be adversely affected by the proposed action. [*Section in Preparation*]

In addition to the negative effects on the spatial structure and diversity, the proposed action is expected to reduce the abundance of Stanislaus River steelhead at multiple life stages. This cumulative effect throughout the life cycle is important considering that Naiman and Turner (2000) demonstrated how even slight reductions in survival from one life stage to the next can have serious consequences for the persistence of salmon populations. [*Section in Preparation*]

The combined effect of the proposed action on the spatial structure, diversity, and abundance of Stanislaus River steelhead, reduces the viability of the population. 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 East Side Division operations, further increasing the risk of extinction of Stanislaus River steelhead.

9.5.6.2 San Joaquin, Merced, Tuolumne, Calaveras, and Mokelumne Steelhead

[*Section in Preparation*]

9.5.7 Assess Risk to the Central Valley Steelhead DPS

The proposed action is expected to have population level consequences for the Clear Creek, mainstem Sacramento River, American River, and Stanislaus River steelhead populations. These population level consequences decrease the viability of each of the four populations. For CV ESUs and DPS's 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[13], the viability of all four extant steelhead diversity groups is expected to be decreased with implementation of the proposed Project. In consideration of the status and future baseline stress regime of the species, these diversity group- and population-level consequences identified above greatly increase the extinction risk of the species. Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to appreciably reduce the viability, and therefore the likelihood of both the survival and recovery of the CV steelhead DPS (table 9-13).

[13] 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.

Table 9-13. 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 project 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 project	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 project	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

9.6 Southern DPS of North American Green Sturgeon

9.6.1 Status of Southern DPS of Green Sturgeon

[*Section in development*]

9.6.2 Future 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.

9.6.3 Summary of Proposed Project Effects on Southern DPS of Green Sturgeon

Delays in migration of adult green sturgeon due to the installation and operation of the TBP or the SDIP phase 1 facilities are possible. Adult green sturgeon that are trapped behind the temporary barriers or 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 sturgeons 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 OCAP 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 ($\leq 17^{o}$C or 62 ^{o}F) in the Sacramento River downstream to Hamilton City during the critical egg fertilization and incubation period following spawning activities. Water temperatures in excess of 17^{o}C (62 ^{o}F) 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.

9.6.4 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.

9.6.5 Assess Risk to the Southern DPS of Green Sturgeon

The proposed action is expected to have population level consequences for the mainstem Sacramento River. In consideration of the status and future baseline stress regime of the species, these population-level consequences greatly increase the extinction risk of the species. Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to appreciably reduce the viability, and therefore the likelihood of both the survival and recovery, of the Southern DPS of North American green sturgeon (table 9-14).

Table 9-14. 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 project 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 project	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 project	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

9.7.1 Southern DPS of Green Sturgeon Proposed Critical Habitat

9.7.2 Status of Proposed Southern DPS of Green Sturgeon Critical Habitat

Specific PCEs essential for the conservation of the Southern DPS of green sturgeon in freshwater riverine systems include:

1. Food Resources
2. Substrate size or type
3. Water Flow
4. Water Quality
5. Migratory Corridor
6. Water Depth
7. Sediment Quality

The status of proposed critical habitat is currently and largely affected by:

4. Water Quality: 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 (15^{o}C) 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 (15^{o}C/ 59^{o}F) to sub optimal where egg hatching success decreases and malformations in embryos increase above 17 ^{o}C/62 ^{o}F.

5. 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.

6. 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 number 5 above, migratory corridor blockage.

The specific PCEs for estuarine areas include:

1. Food Resources
2. Water Flow
3. Water Quality
4. Migratory Corridor
5. Water Depth
6. Sediment Quality

The status of proposed critical habitat is currently and largely affected by:

4. 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.

9.7.3 Project Effects on proposed Southern DPS of Green Sturgeon Critical Habitat

Project effects on proposed critical habitat are very similar to those described above in section 9.7.2, 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 value of the migratory corridor PCE would improve, however, it will still be degraded, 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.

9.7.4 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 9-15).

9.8 Southern Resident Killer Whales

[*Section in Preparation*]

Table 9-15. 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	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 one or more 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

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' draft Opinion that the long-term CVP and SWP OCAP, as proposed, is not likely adversely affect Central California Coast steelhead and their designated critical habitat. In addition, the long-term CVP and SWP OCAP is likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern DPS of North American green sturgeon. The long-term CVP and SWP OCAP is 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, and proposed critical habitat for the Southern DPS of green sturgeon. Finally, the consultation on the effect of the proposed action on Southern Resident killer whales is ongoing. Therefore, NMFS has not reached a conclusion for that species.

11.0 REASONABLE AND PRUDENT ALTERNATIVES

[*Provided in a separate document*]

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.

13.0 INCIDENTAL TAKE STATEMENT

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 by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by Reclamation so that they become binding conditions of any grant, permit or contract issued for Plan implementation, as appropriate, for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this Incidental Take Statement. If Reclamation (1) fails to assume and implement the terms and conditions; or (2) fails to require contractors, grantees, or permitees to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to NMFS as specified in the Incidental Take Statement [50 CFR 402.14(i)(3)].

13.1 Amount or Extent of Take Anticipated

[*The rest of the incidental take statement is in development*.]

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:

[*The rest of this section is in development*]

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