UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

MAY 12 2014

In response refer to:
WCR-2013-1

Michael J. Farrell
Colonel, U.S. Army
Commander
U.S. Army Engineer District, Sacramento
1325 J Street
Sacramento, California 95814-2922

Dear Colonel Farrell:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure) for the U.S. Army Corps of Engineers' (Corps) operation and maintenance of Daguerre Point Dam on the Yuba River. The biological opinion reviews the effects of the action on federally listed threatened Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), the threatened Southern distinct population segment of green sturgeon (*Acipenser medirostris*), and their designated critical habitat in accordance with section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

On August 13, 2013, the U.S. District Court, Eastern District of California, ordered NMFS to file a new biological opinion by May 12, 2014. Your request for reinitiation of formal consultation, which included the final biological assessment, was received on October 22, 2013.

The proposed action is the Corps' continued operation and maintenance of Daguerre Point Dam on the lower Yuba River. Operation and maintenance at Daguerre Point Dam includes operation of the fish ladders (flow gates, baffle boards, debris removal), sediment management, flashboard management, a river stage gage, a contract for operation of fish counting system in the fish ladders and a contract for the installation of flashboards on the dam.

The attached document is NMFS' final biological opinion on the Corps' operation and maintenance of existing fish passage facilities at Daguerre Point Dam on the Lower Yuba River, in accordance with section 7 of the ESA. The Corps requested ESA consultation in two separate BAs submitted to NMFS on October 22, 2013:

(1) U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River; and

(2) U.S. Army Corps of Engineers Authorized Operation and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River.

It is NMFS understanding that the October 22, 2013, submittal was limited to the Corps' discretionary activities. Effects of the Corps discretionary activities associated with operation and maintenance of Englebright Dam and Englebright Reservoir are addressed in a separate consultation.

The attached final biological opinion supersedes the February 29, 2012, NMFS biological opinion on operations of Englebright Dam/Englebright Lake and Daguerre Point Dam on the Yuba River, California. The attached final biological opinion is based on: (1) the biological assessment provided by the Corps on October 22, 2013; (2) key information included in the 2007 *Lower Yuba River Fisheries Agreement* (Yuba Accord), and 2014 *Final Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead*, published by NMFS (2014), and the *Yuba Accord Monitoring and Evaluation Program* draft interim report (RMT 2013); and (3) scientific literature and reports. A complete administrative record of this consultation is on file at the NMFS, California Central Valley Office.

Based on the best available scientific and commercial information, including our review of the biological assessment, this biological opinion concludes that implementation of the proposed action is not likely to jeopardize the above species or adversely modify designated critical habitat. NMFS has included Reasonable and Prudent Measures and discretionary terms and conditions that will minimize incidental take associated with the proposed action.

If you have any questions regarding this correspondence please contact Mr. Gary Sprague in our California Central Valley Area Office, 650 Capitol Mall, Suite 5-100, Sacramento, California 95814. Mr. Sprague may be reached by telephone at (916) 930-3615 or by Fax at (916) 930-3629.

Sincerely,

Maria Rea

for William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: Randy P. Olsen
Chief, Operations and Readiness Branch
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, CA 95814

Doug Grothe
Park Manager
Harry L. Englebright Lake
U.S. Army Corps of Engineers
P.O. Box 6
Smartsville, CA 95977-0006

Lisa H. Clay
Senior Assistant District Counsel
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, CA 95814

Copy to File: ARN 151422SWR2013SA00280

Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	**U.S. Army Corps of Engineers**
ACTION:	**Operation and Maintenance of Daguerre Point Dam and Fish Ladders**
CONSULTATION CONDUCTED BY:	**National Marine Fisheries Service, West Coast Region**
COVERED SPECIES:	**Threatened Central Valley spring-run Chinook salmon evolutionarily significant unit (ESU), threatened California Central Valley steelhead distinct population segment (DPS), and threatened Southern DPS of North American green sturgeon**
CRITICAL HABITAT:	**Central Valley spring-run Chinook salmon ESU, California Central Valley steelhead DPS, and Southern DPS of North American green sturgeon**
FILE NUMBER:	**151422SWR2013SA00280**
PCTS TRACKING	**WCR-2013-1**
DATE ISSUED:	MAY 12 2014

Contents

(I) INTRODUCTION AND BACKGROUND

(A) Environmental Setting

The proposed action is located on the Yuba River in Yuba and Nevada counties, California. The Yuba River watershed is historical habitat for the threatened Central Valley (CV) spring-run Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit (ESU), threatened California Central Valley (CCV) steelhead (*O. mykiss*) distinct population segment (DPS), and the threatened Southern DPS of North American green sturgeon (green sturgeon) (*Acipenser medirostris*). Within the Yuba River watershed, Englebright Dam defines the present upstream extent of CV spring-run Chinook salmon and CCV steelhead. Daguerre Point Dam defines the present upstream extent of green sturgeon. The sympatric Central Valley fall/late fall-run Chinook salmon (*O. tshawytscha*) is an unlisted salmon ESU that occupies the lower Yuba River and is significantly more abundant that the threatened species.

The Yuba River watershed has a history of hydraulic mining, which resulted in geographic changes that continue to affect the Yuba River today. The upper watershed has multiple dams and facilities that store water for delivery and energy generation. Downstream of Englebright Dam is a narrow gorge (called the Narrows), followed by an extensive area of placer mining debris called the Yuba Gold Fields.

(1) Englebright Dam

Englebright Dam is at river mile 24.1 on the Yuba River. The dam was constructed in 1941 to retain hydraulic mining debris. It is 260 feet high and stores 70,000 acre-feet of water. The area downstream of Englebright Dam is referred to as the lower Yuba River, and the area upstream is referred to as the upper Yuba River. The U. S. Army Corps of Engineers (Corps) administers the operation and maintenance of Englebright Dam.

Englebright Dam has no fish ladders. Salmon, steelhead, and sturgeon have been blocked from accessing the upper Yuba River and watershed since 1941. Since 1963 flow releases from Englebright Reservoir have been generally governed by guidelines outlined within the Federal Energy Regulatory Commission (FERC) licenses, commonly referred to as “FERC minimum flows.” Since 2008 the Lower Yuba River Accord has governed the minimum flows. The Lower Yuba River Accord is an agreement that addresses water issues downstream of Englebright Dam.

The majority of the time releases from the Englebright Reservoir into the lower Yuba River are made through two hydroelectric power facilities, one of which (Narrows II) is located just downstream of the base of the dam and the other (Narrows I), is located approximately 0.2 mile downstream. Water releases from the reservoir are administered by the Yuba County Water Agency (YCWA) and Pacific Gas and Electric Company (PG&E) for hydroelectric power generation, irrigation and maintenance of the downstream riverine ecosystem.

(2) Daguerre Point Dam

Daguerre Point Dam is 12.6 miles downstream of Englebright Dam. Daguerre Point Dam is 24 feet high and was built in 1910 to retain hydraulic mining debris. The dam is not operated for flood control because of the uniform flow over the crest of the dam (ogee crest/ogee spillway), and the entire reservoir behind the dam has been filled with hydraulic mining debris and sediments. Daguerre Point Dam has two fish ladders, designed for adult salmonids. Green sturgeon are unable to ascend the fish ladders. There are three conjunctive-use irrigation diversions from the Daguerre Point Dam pool, and the three diversions have a combined capacity of 1,085 cubic-feet-per-second (cfs).

(3) Upper Yuba River

There are major, human-made fish passage barriers upstream of Englebright Dam. By one count there are over 90 dams and diversions in the Yuba River watershed. A significant amount of water is annually diverted out of the watershed.

(II) CONSULTATION HISTORY

(A) 2002 Consultation with the Corps on Operations of Englebright Dam and Daguerre Point Dam on the Yuba River, California

On March 27, 2002, NOAA's National Marine Fisheries Service (NMFS) issued a biological opinion (BiOp) which analyzed the effects of the Corps' operations of Englebright and Daguerre Point Dams on the Yuba River in Yuba and Nevada Counties, California, on threatened CV spring-run Chinook salmon and threatened CCV steelhead. The BiOp covered a five-year period, and concluded that the proposed action was not likely to jeopardize the continued existence of the CV spring-run Chinook salmon ESU or CCV steelhead DPS, and was not likely to destroy or adversely modify designated critical habitat for these species over that time period. The 2002 BiOp expired on March 27, 2007.

In December 2006, the South Yuba River Citizens League (SYRCL) and Friends of the River, filed suit in U.S. District Court against both the Corps and NMFS under the Administrative Procedures Act. The suit was amended on March 12, 2007, after a required 60-day notice period, to include complaints under the ESA. The plaintiffs alleged that NMFS unlawfully issued an inadequate BiOp and failed to reinitiate consultation with the Corps. The suit further alleged that the Corps had failed to comply with the requirements of the BiOp, including improving the effectiveness and reliability of the existing fish ladders at Daguerre Point Dam, developing a plan to remove sediment from the ladders and egress at Daguerre Point Dam, and augmenting spawning gravels in reaches downstream of Englebright Dam.

(B) 2007 Consultation with the Corps on Operations of Englebright and Daguerre Point Dams on the Yuba River, California

On March 23, 2007, the Corps delivered to NMFS' Sacramento Area Office, an initiation package including a cover letter requesting the initiation of formal consultation under section 7 of the Endangered Species Act (ESA) for the proposed action along with a biological assessment (BA) and Essential Fish Habitat assessment for the proposed action. Included in the Corps' March 23, 2007, cover letter was a request for the extension of the timeframe covered by the 2002 BiOP in order to maintain coverage for the proposed action until a new consultation could be completed and a new long-term BiOp issued.

On April 27, 2007, NMFS issued a preliminary BiOp, which analyzed the effects of continuation of operation of the proposed action for a period of one year. On November 21, 2007, NMFS adopted the preliminary BiOp as the final BiOp for the proposed action, which analyzed the effects of long-term continuation of operation of the proposed action into the foreseeable future (NMFS 2007). Both of these BiOps concluded that the proposed action would not jeopardize CV spring-run Chinook salmon, CCV steelhead, or green sturgeon, or destroy or adversely modify designated CVspring-run Chinook salmon and CCV steelhead critical habitat.

(C) U. S. District Court, Eastern District of California, 2010 Ruling and 2011/2012 NMFS Consultation with the Corps on Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir

On July 8, 2010, a Federal judge determined that the existing NMFS BiOp on the operation of Englebright and Daguerre Point dams was inadequate. NMFS was directed to provide a more explicit analysis of effects to the species and to include analysis of the effects of hatcheries, the San Francisco Bay Delta, overall salmonid viability, poaching, and global warming on the species. NMFS was also asked to explain how the species will be able to tolerate cumulative effects such as the Wheatland project (a new water-delivery project).

On October 17, 2011, the Corps provided NMFS with a draft BA on the proposed action. On December 2, 2011, NMFS notified the Corps that the draft BA was insufficient to initiate section 7 consultation pursuant to section 402.14(c) Initiation of formal consultation . On January 27, 2012, the Corps initiated formal consultation on the proposed action and submitted the final BA and references to NMFS. On February 29, 2012, NMFS issued a BiOp.

(D) 2012 Consultation with the Corps on the Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir on the Yuba River, California

In response to the July 2010 remand of the 2007 BiOp, the Corps provided NMFS with a draft BA on the proposed action on October 17, 2011. On December 2, 2011, NMFS notified the Corps that the draft BA was insufficient. On January 27, 2012, the Corps initiated formal consultation on the proposed action and submitted the final BA and references to NMFS. NMFS provided a draft of the BiOp to the Corps and its applicants on February 27, 2012. Comments were provided to NMFS on February 28, 2012. NMFS provided the final BiOp to the Corps on February 29, 2012, in accordance with the deadline set by the U.S. District Court.

The February 29, 2012, BiOp concluded that the operation and maintenance of these two dams as proposed by the Corps would likely jeopardize the continued existence of CV spring-run Chinook salmon, CCV steelhead, and the Southern distinct population segment of green sturgeon, and result in the adverse modification of their critical habitat. The 2012 BiOp includes a reasonable and prudent alternative (RPA) that modifies the proposed action to avoid jeopardizing the species and adversely modifying their critical habitat.

NMFS received many comments on the 2012 BiOp. The comments were of both a technical and legal nature. NMFS met with the Corps and stakeholders to discuss issues associated with the BiOp. Over 900 written comments were submitted to NMFS. Written comments were received from the Corps (letter dated July 3, 2012), Yuba County Water Agency (letter dated June 29, 2012), Pacific Gas and Electric (letter dated July 12, 2012), Nevada Irrigation District (letter dated July 11, 2012), and from the Brophy Water District - Dry Creek Mutual Water Company – Hallwood Irrigation Company – South Yuba Water District – Wheatland Water District (letter dated September 24, 2012).

In response to the comments NMFS held a number of meetings with the Corps and its attorneys to address legal issues, and held a series of meetings with the Corps and key stakeholders to address the technical issues in the BiOp.

(E) Current Consultation

On February 26, 2013, the Corps sent a letter to NMFS requesting reinitiation of formal consultation "for ongoing activities at Englebright and Daguerre Point Dams, and for operation of the fish ladders at Daguerre Point Dam." On April 11, 2013, NMFS provided a written response to the Corps identifying the necessary information for reinitiation of formal consultation under section 7 of the Endangered Species Act. As set forth in 50 CFR §402.16, reinitiation of formal consultation is appropriate where discretionary Federal agency involvement or control over an action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in any incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the BiOp, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In this case, the Corps has determined that reinitiation of consultation is necessary in order for the Corps to provide NMFS with additional information and clarification on subjects that include the following:

(1) To more accurately and specifically define the scope of the Corps' authorities and discretion, for purposes both of appropriately defining the proposed action and ensuring that any RPA measures are within the scope of the Corps' legal authority and jurisdiction. *See* 50 C.F.R. § 402.02,

(2) To more clearly define the scope of the proposed action area, and the determination of which other activities are interrelated and interdependent with the proposed action,
(3) To provide additional information regarding the nature of the Corps' proposed activities at Englebright and Daguerre Point Dams, and
(4) To provide the most recent scientific and technical information regarding the listed species and the effects of the proposed action on them.

As described in CFR 402.14(c), formal consultation is initiated through a request that must include the following six pieces of information:

(1) Include a description of the proposed action to be covered. The Corps should describe with specificity the character of their involvement with existing structures associated with the proposed action, the boundaries of discretion, and the extent of the discretion that the Corps is proposing to exercise. This includes describing areas of non-discretion, where the scope of the Corps' discretion is specifically constrained.
(2) Include a description of the specific area that may be affected by the proposed action.
(3) Included a description of any listed species or critical habitat that may be affected by the proposed action.
(4) Include a description of the manner in which the action may affect any listed species or critical habitat, and an analysis of any direct, indirect, or cumulative effects.
    (a) Direct Effects: Effects to listed species of designated critical habitat that occur during implementation of the project,
    (b) Indirect Effects: Effects to listed species that occur later in time or offsite, but are reasonably certain to occur, and
    (c) Cumulative Effects: For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within an action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions are not included here because they require separate consultation pursuant to section 7 of the ESA.
(5) Include relevant reports, including any environmental impact statements, environmental assessments, BAs or other analysis prepared regarding the proposal.
(6) Include any other relevant studies or other information available on the action, the affected listed species, or critical habitat.

In order to meet the requirements of CFR 402.14(c), to initiate formal consultation; and 50 CFR 402.14(d), to provide the best scientific and commercial data available; NMFS recommended that the Corps develop an updated BA to evaluate the potential effects of the action on listed species and designated critical habitat, pursuant to 50 CFR 402.12. NMFS identified that consultation will begin once NMFS has received a final BA that includes a proposed project description and addresses all of the information necessary to evaluate the effects of the action on listed species and critical habitat.

(F) 2012 Biological Opinion

On November 6, 2012, the Yuba County Water Agency submitted a 60 day notice of intent to sue the Corps and NMFS, pursuant to section 11(g) of the Endangered Species Act. The intent to sue was based on alleged violations of the Endangered Species Act and its implementing regulations. In a letter dated November 13, 2012, the South Yuba River Citizens League submitted a 60 day notice of intent to sue the Corps for allegedly not implementing reasonable and prudent alternative actions and allegedly unauthorized take of species listed under the Federal Endangered Species Act.

At the request of the Corps, on November 27, 2012, NMFS modified the schedule for implementation of the reasonable and prudent alternative in the February 29, 2012 BiOp. The schedule modifications were based on new information about the Corps authorities and ability to meet the schedules in the BiOp.

On January 11, 2013, the South Yuba River Citizens League filed for relief under the Administrative Procedure Act regarding the extensions of time given to the Corps by NMFS. The South Yuba River Citizens League requested an injunction and order for NMFS to rescind its November 27, 2012, letter. On January 28, 2013, the South Yuba River Citizens League and Friends of the River filed an amended complaint for declaratory and injunctive relief against NMFS and the Corps. The amended complaint requested the same relief as the January 11, 2013, filing and requested the Court to find the Corps in violation of the Endangered Species Act.

(III) BACKGROUND

(A) Section 7 Setting

The Corps' authorized operations and maintenance (O&M) and planning activities associated with the proposed action includes making minor modifications to the fish ladders at Daguerre Point Dam. The Corps' O&M of the fish ladders at Daguerre Point Dam does not include major ladder reconfigurations or reconstruction. According to the Corps Regulation (No. 1165-2-119) titled "Modifications to Completed Projects" (Corps 1982), such activities would require additional Congressional authorization and appropriation of necessary funding. Consequently, the proposed action is comprised of O&M of the existing fish passage facilities at Daguerre Point Dam, and specified conservation measures.

The Corps has identified the following authorities as governing their discretion and the proposed action (Corps 2013b):

(1) The California Debris Act (Ch 183, §1, 27 Stat. 507,
(2) The Rivers and Harbors Act of 1935, Public Law No. 409,

(3) Flood Control Act of 1970, Section 216,
(4) National Dam Inspection Act of 1972,
(5) Water Resources Development Act 1986, Section 906(b), Section 1106, and Section 1135,
(6) Water Resources Development Act 1996, Section 206,
(7) National Dam Safety Program Act of 1996 (Public Law 92-367),
(8) Public Law 109-460, and
(9) Engineer Regulation 1105-1-100, Appendix G, paragraph 13(c).

The Chief of Engineers has authority to modify projects without further authorization from Congress within strictly defined limits, i.e., as long as the scope of the project, including the function and purpose of the project, and the area served by the project, is not materially changed. This understanding, set forth in detail in a 1951 report by the Chief of Engineers, was approved in the report of a special subcommittee to the House Public Works Committee in 1952, Report on the Civil Functions Program of the Corps of Engineers, United States Army to the House Committee on Public Works, 82d Congress, 2d Session 1 (1952) (Corps 2013b).

The Corps requested ESA consultation in two separate BAs submitted to NMFS on October 22, 2013:

(1) U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River (Corps 2013a), and
(2) U.S. Army Corps of Engineers Authorized Operation and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River (Corps 2013b).

Previous ESA consultations have been conducted addressing various Corps projects and their activities on the Yuba River (see Consultation History above). Those consultations encompassed activities at both Englebright Dam and Daguerre Point Dam (projects). However, the October 22, 2013, submittal was limited to the Corps' discretionary activities associated with Englebright Dam and reservoir and a separate BA was submitted at the same time for the Corps' discretionary activities associated with Daguerre Point Dam. The Corps evaluated these projects separately in two BAs because "each dam has a separate authorization and appropriation, and because the actions at Englebright and Daguerre are wholly separate and are not dependent upon each other to operate."

The Corps limited their proposed action in the Daguerre Point Dam BA to discretionary actions, and determined that the proposed action may affect and is likely to adversely affect CV spring-run Chinook salmon, and CCV steelhead. The Corps determined that adverse effects to CV spring-run Chinook salmon critical habitat, and CCV steelhead critical habitat are discountable and/or insignificant. For the southern DPS of green sturgeon the Corps determined that the proposed action may affect, but is not likely to adversely affect green sturgeon and its critical habitat. Discretionary actions for which the Corps determined the effects were: "may affect, but is not likely to adversely affect", or "may affect and is likely to adversely affect", or "discountable, or insignificant", were carried forward in the Corps request for consultation.

Actions for which the Corps determined there would be no effects, and actions for which the Corps determined they have no discretion were not carried forward and are not subject to this consultation.

In the Daguerre Point Dam BA (Corps 2013b) the Corps deconstructed their Yuba River activities into five categories as follows:

(1) Future Corps Actions Requiring Separate ESA Consultation,
(2) Non-Discretionary Actions,
(3) Discretionary Actions with No Effects to Listed Species or Critical Habitat,
(4) Englebright Dam and Reservoir, and
(5) O&M of Existing Fish Passage Facilities at Daguerre Point Dam.

Future Corps Actions Requiring Separate ESA Consultation: The Corps has identified that ESA issues related to the outgrants associated with the two hydropower facilities adjacent to Englebright Dam will be addressed through the Federal Energy Regulatory Commission. This will occur through the ESA consultations for the hydropower relicensing processes. The anticipated dates for new outgrants are 2016 and 2023. At this time the specifics associated with the Federal Power Act licenses for the hydropower facilities and for the specifics to be included in the new outgrants have not been determined.

Non-Discretionary Actions: The Corps has determined that a number of actions associated with Daguerre Point Dam and Englebright Dam that are non-discretionary. These include security and safety inspections. The Corps has provided information the about their authority, and which actions over which they have discretion. The ESA regulations state "Section 7 and the requirements of this part apply to all actions in which there is discretionary Federal involvement or control." (50 CFR Ch. IV, section 402.03 Applicability). Therefore, the Corps has not proposed these actions for consultation, and they are not covered by this BiOp and take statement.

Discretionary Actions with No Effects to Listed Species or Critical Habitat: The Corps has identified a number of actions associated with Englebright Dam and Englebright Reservoir as having no effects on listed species or designated critical habitat. These actions include:

- Ongoing Maintenance of Recreational Facilities;
  - Maintenance Facilities Upkeep,
  - Roads and Parking Area Maintenance,
  - Sign and Waterway Marker Maintenance,
  - Maintenance of Recreation Area Buildings,
  - Wastewater Monitoring Plan Implementation,
  - Campground Repairs and Renovations,
  - Campground Fire Break Clearing,
  - Park Office Facility Upkeep,
  - Grounds Maintenance, and
  - Narrows Day Use Facility Improvements.

- Continued Administration of Maintenance Service Contracts; and
  - Janitorial Service and Garbage Pickup, and
  - Water Quality Testing.

- Continued Administration of Outgrants.
  - Easement for Use of Power Generation Facilities to YCWA and PGE,
  - Power Transmission Line Easement to PG&E for Narrows I, and
  - Road Right of Way Easement to YCWA for Narrows II.

For the first two categories of actions (Ongoing Maintenance of Recreation Facilities, and Continued Administration of Maintenance Service Contracts), all of the activities are upstream of Englebright Dam. Currently, no ESA listed anadromous fish species are present upstream of Englebright Dam, nor is there any designated critical habitat upstream of Englebright Dam. The upstream extent of critical habitat on the Yuba River for salmonids is Englebright Dam, and for green sturgeon it is Daguerre Point Dam. For the first two subcategories, no effects from these Corps actions are expected to persist downstream of Englebright Dam. The Corps has determined that these actions would have no effect on ESA listed anadromous fish species or designated critical habitat.

For the action subcategory of "Continued Administration of Outgrants" the Corps has identified that the actions are "The administration of ongoing outgrants consists of monitoring for compliance of the terms and conditions of the outgrant." These outgrants include: 1) road right of way permits and easements, 2) a telephone line license, 3) power transmission line easements, and 4) the concessionaire lease at the Englebright Lake marina. The Corps has identified that only actions associated with these outgrants are the annual compliance inspection. The Corps has identified that "These inspections constitute administrative actions and not activities that have the potential to affect listed species or their critical habitats in the lower Yuba River." While future Corps actions to enforce compliance with outgrants conditions do have the potential to affect ESA listed anadromous fish species and/or designated critical habitat downstream of Englebright Dam, the specifics of those future actions cannot be determined at this time, and the timing and extent of those actions is undetermined at this time. Therefore it is not possible to include the potential effects of undetermined actions on ESA listed anadromous fish species in this consultation or to concur with an effects determination.

Operations and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam:
The remaining proposed actions that "may affect" listed species are the subject of this consultation and are described in detail in the Corps' BA (Corps 2013b) and are summarized as follows:

- Operation and maintenance of the fish passage facilities at Daguerre Point Dam,
- Maintenance of the staff gage at Daguerre Point Dam,
- Administration of a right-of-way (license) issued to CDFW for VAKI Riverwatcher operations at Daguerre Point Dam,
- Administration of a right-of-way (license) issued to Cordua Irrigation District for flashboard installation, removal and maintenance at Daguerre Point Dam,

- Protective Conservation Measures (annual funding availability and ongoing implementation is reasonably certain to occur based on past operations),
- Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan,
- Administration of a long-term Flashboard Management Plan at Daguerre Point Dam,
- Implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam,
- Voluntary Conservation Measures for Habitat Enhancement Purposes (planned for implementation, but less certain and subject to funding availability).
    - Gravel Injection in the Englebright Dam Reach of the lower Yuba River, and
    - Large Woody Material Management Program

(B) ESA Recovery Planning

(1) California Central Valley Salmonid Recovery Planning

In 2009, NMFS released a draft recovery plan for CV salmon and CCV steelhead that specifically addresses the recovery goals and needs for CV spring-run Chinook salmon and CCV steelhead (NMFS, 2009). The draft plan states that reintroducing CV spring-run Chinook salmon and CCV steelhead populations into the upper Yuba River basin above Englebright Dam would contribute to the recovery of both species by increasing their abundance, improving their spatial structure and diversity, and reducing their overall extinction risk. There are several reasons why reintroducing these species into the upper Yuba River basin is likely to be successful and promote their recovery. First, both species historically occurred in the upper basin (Lindley *et al*., 2004, Yoshiyama *et al*., 1996) and studies suggest that multiple areas in the upper basin could support both species (DWR, 2007, Stillwater Sciences, 2012). Second, available evidence suggests that a significant portion of the summer holding habitat in the upper basin is expected to remain thermally suitable for both species throughout the 21st century, despite increased warming from global climate change (Lindley *et al*., 2007). Third, the upper Yuba River watershed is separated by a considerable distance from the small number of watersheds that support extant CV spring-run Chinook salmon (*e.g.*, Deer Creek, Mill Creek, and Butte Creek) and establishing a population in this upper watershed would reduce the risks to CV spring-run Chinook salmon from catastrophic events such as a volcanic eruption at Mt. Lassen or major wildfires. Fourth, the Yuba River watershed has an ample supply of water to support both species with one of the highest annual discharges (~2,300,000 acre-feet/year) in the Central Valley (Lindley *et al*., 2004).

The *Final Central Valley Chinook Salmon and Steelhead Recovery Plan* will be published in the spring of 2014. The final plan identifies the reintroduction of CV spring-run Chinook salmon and CCV steelhead into the upper Yuba River as a number 1 action priority.

(C) Lower Yuba River Fisheries Agreement

The 2007 *Lower Yuba River Fisheries Agreement* (Yuba Accord) established flows in the lower Yuba River until the 2016 expiration of YCWA's hydropower license for the Yuba River Hydroelectric Development Project. Minimum instream flow schedules for the lower Yuba River were developed through negotiations between YCWA, California Department of Fish and Game (CDFG), South Yuba River Citizens League, Friends of the River, Trout Unlimited, and the Bay Institute. The U. S. Fish and Wildlife Service (USFWS) and NMFS participated in the discussions, but did not sign the Yuba Accord. The USFWS and NMFS participate in the River Management Team processes, with the signatories.

(D) Hydropower Licensing and Water Deliveries

Several major hydroelectric power and water delivery projects are in the Yuba River watershed and influence operation and flows at Englebright Dam and flows at Daguerre Point Dam. These are the (1) Yuba River Development Project (FERC Project No. 2246), (2) Narrows I Project (FERC License No. 1403), (3) the Yuba-Bear Project (FERC Project No. 2266), (4) Drum-Spaulding Project (FERC Project No. 2310), Hallwood-Cordua diversion at Daguerre Point Dam (Corps License No. DACW03-01-592), and (5) South Yuba/Brophy diversion at Daguerre Point Dam (expired Corps License No. DACW05-3-85-537). The Corps licenses are only for access.

(E) VAKI Riverwatcher Fish Counter

A VAKI Riverwatcher infrared and photogrammetric system is installed in the fish ladders at Daguerre Point Dam. The Corps licenses the California Department of Fish and Wildlife to operate the VAKI Riverwatcher.

(IV) PROPOSED ACTION (Description of the Proposed Action)

The ESA section 7 regulations define "action" as: *"…all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. Examples include, but are not limited to: …(d) actions directly or indirectly causing modifications to the land, water, or air"* (50 CFR 402.02).

As described above, the Corps requested ESA consultation through two separate BAs submitted to NMFS on October 22, 2013:

(1) U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River (Corps 2013a).

(2) U.S. Army Corps of Engineers Authorized Operation and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River (Corps 2013b).

The proposed action, that is the subject of this consultation, is described in the U.S. Army Corps of Engineers' Ongoing Operation and Maintenance of Daguerre Point Dam on the Yuba River BA (Corps 2013b). In the BA, the Corps limited its proposed action to discretionary activities. The description of the proposed action provided below comes primarily from the BA.

The Corps has identified the following authorities as governing their descretion with respect to the proposed action (Corps 2013b):

(1) The California Debris Act (Ch 183, §1, 27 Stat. 507,
(2) The Rivers and Harbors Act of 1935, Public Law No. 409,
(3) Flood Control Act of 1970, Section 216,
(4) National Dam Inspection Act of 1972,
(5) Water Resources Development Act 1986, Section 906(b), Section 1106, and Section 1135,
(6) Water Resources Development Act 1996, Section 206,
(7) National Dam Safety Program Act of 1996 (Public Law 92-367),
(8) Public Law 109-460, and
(9) Engineer Regulation 1105-1-100, Appendix G, paragraph 13(c)

Previous ESA consultations have been conducted addressing various Corps projects and their activities on the Yuba River (see Consultation History above). Those consultations encompassed activities at both Englebright Dam and Daguerre Point Dam. However, the October 22, 2013 submittal was limited to the Corps' discretionary activities associated with Daguerre Point Dam, and a separate BA was submitted at the same time for the Corps' discretionary activities associated with Englebright Dam and Englebright reservoir. The Corps evaluated these two projects separately in two BAs because "each dam has a separate authorization and appropriation, and because the actions at Englebright and Daguerre are wholly separate and are not dependent upon each other to operate." The Corps determined in their Daguerre Point Dam BA that some actions were no effect and some actions May Affect But Are Not Likely to Adversely Affect listed anadromous salmonids or their critical habitat.

This BiOp is in response to the Corps' request for consultation regarding ongoing operation and maintenance of its facilities on and around Daguerre Point Dam. Consultation on the Corps' operation and maintenance at Englebright Dam and Englebright reservoir is a separate consultation.

(A) Proposed Action Components

The formal section 7 consultation, for which this BiOp has been prepared, includes Corps discretionary actions pertaining to O&M of the fish passage facilities at Daguerre Point Dam, including administration of outgrants associated with O&M of the facilities, and conservation measures. The proposed action is consistent with the Congressional authorization (Rivers and Harbors Act of 1935) for Daguerre Point Dam, and consists of the following components:

(1) Operation and maintenance of the fish passage facilities at Daguerre Point Dam
(2) Maintenance of the staff gage at Daguerre Point Dam

(3) Administration of a right-of-way (license) issued to CDFW for VAKI Riverwatcher operations at Daguerre Point Dam
(4) Administration of a right-of-way (license) issued to Cordua Irrigation District for flashboard installation, removal and maintenance at Daguerre Point Dam
(5) Protective Conservation Measures (annual funding availability and ongoing implementation is reasonably certain to occur based on past operations)
(6) Voluntary Conservation Measures for Habitat Enhancement Purposes (planned for implementation, but less certain and subject to funding availability).

In addition, Corps discretionary activities also include the review of requests for temporary right-of-ways (permits) or use of portions of Corps owned right-of-ways associated with Daguerre Point Dam. All requests for permits for temporary right-of-ways or use of portions of the Government owned right-of-ways are carefully reviewed to determine that such use will not adversely affect maintenance operations, or the safety and functioning of the project structures. Each request is processed on a case-by-case basis. No specific requests are presently identified, and the Corps review of such requests is not included in formal consultation for this BA.

The Corps asserts that the Corps has no water rights or authority to regulate water rights on the Yuba River. The Corps also asserts that because water right issues on the Yuba River are not within the Corps' authority or discretion to regulate, they are not part of the proposed action.

Description of Project Action Components

The following descriptions were taken from the Corps BA for Daguerre Point Dam (Corps 2013b).

(1) Operation and Maintenance of the Fish Passage Facilities at Daguerre Point Dam

Daguerre Point Dam (Figure IV-1) is located on the lower Yuba River approximately 11.5 River Miles (RM) upstream from the confluence of the lower Yuba and lower Feather rivers. Concrete fish ladders are located on both the North and South abutments of the Dam **(**Figure IV-2, Figure IV-3). The park personnel of the Corps administer the operation and maintenance of the fish ladders, in coordination with CDFW.

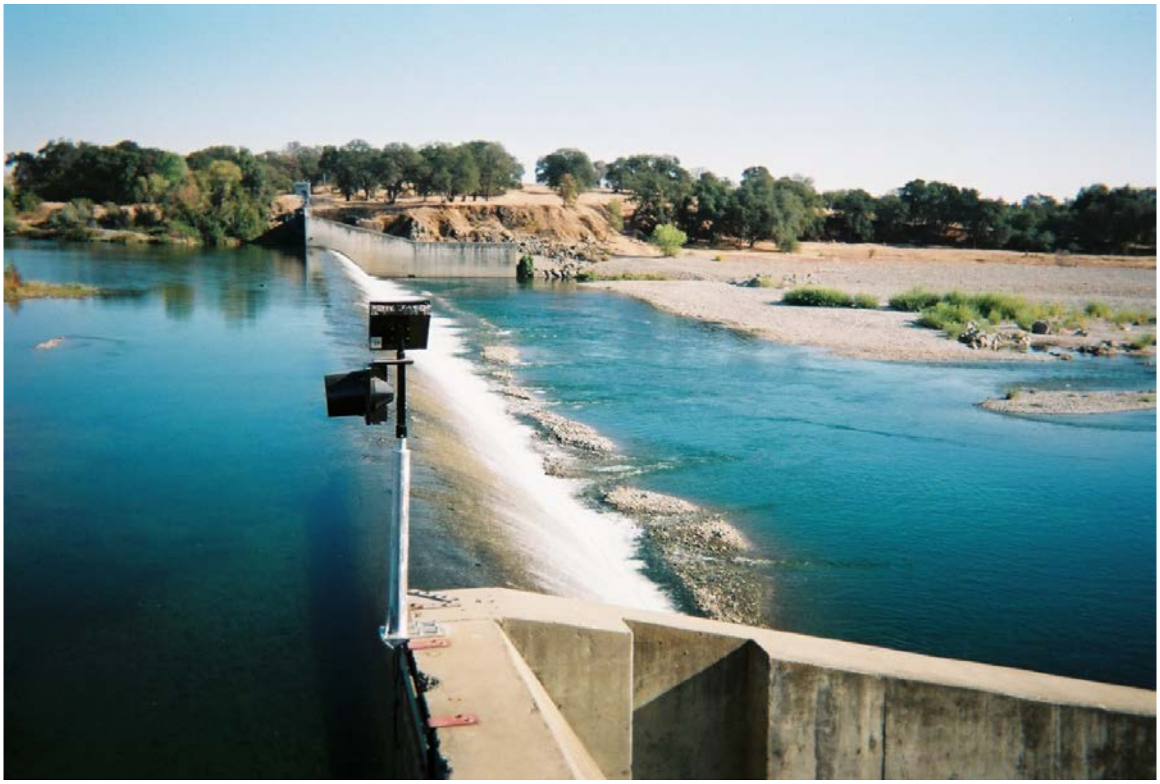


Figure IV-1. Daguerre Point Dam (photo by D. Simodynes, October 9, 2009).

(a) Fish Ladder Operations

Fish ladder operations consist of adjusting the fishway gates, within-ladder flashboards, and the fish ladder gated orifices. Fishway gates allow water to enter the fish ladders, and the fish ladder gated orifices regulate the point where upstream migrating fish can most easily enter the ladders. Within-ladder flashboards influence flow hydraulics within the bays of the ladders.

The Corps continues to operate the fish ladders at Daguerre Point Dam to improve fish passage. The Corps' past operational criteria required that the fish ladders at Daguerre Point Dam be physically closed when water elevations reached 130 feet, or when flows were slightly less than 10,000 cfs (SWRCB 2003), and to keep them closed until the water recedes to an elevation of 127 feet (CALFED and YCWA 2005). Presently, the Corps is collaborating with resource agencies (CDFW, NMFS) and the Yuba Accord River Management Team (RMT) to improve fish passage by keeping the ladders open at all river elevations. The proposed action includes continuation of this collaboration, and keeping the ladders open.

Figure IV-2. North fish ladders at Daguerre Point Dam (Corps 2013b).

Figure IV-3. South fish ladders at Daguerre Point Dam (Corps 2013b).

Within-ladder flashboards were installed in the lower bays of the south fish ladder during June 2010 by CDFW. Adjustment of these within-ladder flashboards influence hydraulics and have been shown to improve adult anadromous salmonid attraction flows to the south ladder (Grothe 2011). The proposed action includes the continued collaboration with CDFW regarding adjustment of these within-ladder flashboards.

(b) Fish Passage Facility Maintenance

The Corps coordinates with CDFW and NMFS to determine when maintenance of the fish passage facilities at Daguerre Point Dam is to be conducted, which is when it is least stressful to fish. Corps and CDFW joint maintenance activities include cleaning the bays of the fish ladders, cleaning the grates covering the fish ladder bays, and other minor maintenance activities. Since the spring of 2010, the Corps and NMFS have been holding meetings to coordinate regarding maintenance activities and other issues pertaining to the lower Yuba River. The proposed action includes the continuation of the Corps-NMFS coordination meetings.

CDFW is responsible for inspecting and clearing debris from the upper portion of the ladders containing the VAKI Riverwatcher devices, and the Corps is responsible for all other parts of the ladders. Presently, Pacific States Marine Fisheries Commission (PSMFC) staff, in collaboration with CDFW, operate the VAKI Riverwatcher devices and make observations of the fish ladders on an approximately daily basis, and the Corps coordinates with them regarding observations of debris or blockages, and/or adult salmonid upstream passage observations. Any debris that could affect fish passage is removed as soon as possible when personnel can safely access the area. Since August 2010, the Corps has also conducted sub-surface inspections of the ladders, after NMFS advised the Corps of the possibility of sub-surface blockage. The proposed action includes continuation of the routine maintenance of removal of debris from the fish ladders.

(c) Daguerre Point Dam Fish Passage Sediment Management Plan

The proposed action includes continued implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan. The Corps routinely removes the gravel and sediment that accumulates upstream of Daguerre Point Dam. The Corps, through collaboration with NMFS, CDFW, and USFWS, developed an updated Daguerre Point Dam Fish Passage Sediment Management Plan in February 2009 (Corps 2009). The purpose of the plan is to describe the methods used to manage the sediment that accumulates upstream of Daguerre Point Dam in order to improve flows to the ladders at Daguerre Point Dam, to provide suitable adult salmonid migratory habitat conditions upstream of the Daguerre

Point Dam fish ladders, and to provide attraction to the ladders downstream of Daguerre Point Dam. Details of the plan include the following.

Upstream of Daguerre Point Dam, adequate water depth will be maintained across the upstream face of the dam to allow unimpeded fish passage from the ladders to the main channel of the lower Yuba River upstream from Daguerre Point Dam. An adequate water depth is defined as a “channel” at least 30 feet wide when measured from the face of the dam upstream, and 3 feet deep when measured from the crest of the dam to the riverbed.

Water depth measurements will be taken across the upstream face of the dam to determine the depth of the channel during June of each year. If the flows are too high in June to take the measurements, they will be taken as soon as conditions are safe. If the water depth measurements show that the channel is still at least 30 feet wide by 3 feet deep, no sediment removal is required for that year. If the water depth measurements show that sediment has encroached and the channel has filled in to less than 30 feet wide by 3 feet deep, sediment removal will be conducted during the month of August. During sediment removal, the channel will be widened to 45 feet and deepened to 5 feet.

A tracked excavator will be used to remove the sediment/gravel (Figure IV-4). The excavator will be cleaned of all oils and greases, and will be inspected and re-cleaned daily as necessary to insure no contaminants are released into the lower Yuba River. All hydraulic hoses and fittings also will be inspected to insure there are no leaks in the hydraulic system.

Figure IV-4. Excavator removing sediment above Daguerre Point Dam during August 2011.

> Material removed shall be managed in one of two ways. If all required permits can be obtained (expected to occur during the summer of years when excavation is necessary), then it is anticipated that the excavated material will be placed on a downstream bank of the lower Yuba River approximately ¼ mile downstream of Daguerre Point Dam (Corps 2013b). Materials will be placed in a location that will provide an opportunity for the gravel to be mobilized by the river during high flow conditions and transported downstream to augment downstream spawning gravels. If permits cannot be obtained or conditions do not allow for the downstream placement, then the material will be removed and stored above the ordinary high water mark until both permits are obtained and it can be moved downstream to a location where the gravel can be mobilized by the river during high flow conditions and transported downstream.

(2) Staff Gage Maintenance

Hydrologic facilities consist of a staff gage on the right abutment of Daguerre Point Dam. As described in the Daguerre Point Dam O&M Manual (Corps 2013b), the Corps' Engineering Division is responsible for maintaining, reading, and filing all records obtained from this gage. The proposed action includes continuation of the routine maintenance activities associated with the staff gage.

(3) Administration of a License Issued to CDFW for VAKI Riverwatcher Operations at Daguerre Point Dam

The Corps administers a license to CDFW (DACW05-3-03-550) to install and operate electronic fish counting devices, referred to as a VAKI Riverwatcher infrared and photogrammetric system, in the fish ladders at Daguerre Point Dam and is revocable at will by the Corps (Amendment 2 to License DACW05-3-03-550). The proposed action includes continued administration of this license, which remains in effect until 2018.

The license specifies that CDFW shall pay the cost, as determined by the Corps, of producing and/or supplying any utilities and other services furnished by the Government or through Government-owned facilities for the use of CDFW, including CDFW's proportionate share of the cost of operation and maintenance of the Government-owned facilities by which such utilities or services are produced or supplied. The Government is under no obligation to furnish utilities or services.

The license further specifies that CDFW shall keep the premises in good order and in a clean, safe condition by and at the expense of CDFW. CDFW is responsible for any damage that may be caused to property of the United States by CDFW activities and shall exercise due diligences in the protection of all property located on the premises against fire or damage from any and all other causes.

The proposed action includes continued administration of the license to CDFW to operate the VAKI Riverwatcher infrared and photogrammetric system in the fish ladders at Daguerre Point Dam.

(4) Administration of a License Issued to Cordua Irrigation District for Flashboard Installation, Removal and Maintenance at Daguerre Point Dam

To benefit listed fish species by improving the ability of the fish to locate the fish ladders and migrate upstream to spawning and rearing habitats the Corps, in coordination with CDFW and NMFS, developed and implemented a Daguerre Point Dam Flashboard Management Plan in 2011. The Plan addresses the use, placement, monitoring and removal of flashboards at Daguerre Point Dam. To improve management of the flashboards at Daguerre Point Dam on a long-term basis, the Flashboard Management Plan was incorporated into the September 27, 2011 license amendment issued by the Corps to Cordua Irrigation District. The proposed action includes continued administration of the license issued to Cordua Irrigation District which incorporates the Flashboard Management Plan, until the license expires in 2016.

Installation of these flashboards directs some sheet flow from over the top of Daguerre Point Dam into the fish ladders. In accordance with the terms of the 2011 amended license, which will continue to be administered by the Corps as part of the proposed action, Cordua Irrigation District will install, remove, monitor and maintain the anchoring system, supporting brackets and flashboards and must coordinate its activities with the Corps, NMFS, and CDFW. These agencies will work with Cordua Irrigation District to direct the placement, timing and configuration of the flashboards to best manage flows to benefit fish (Grothe 2011). The long-term flashboard operations plan developed by the Corps includes the following.

(a) Conditions of Placement. Flashboards will be used in periods of low flow to direct water toward the fish ladders to provide optimal flow conditions. Because there is no recorded flow information at this time to set a flow-based trigger, the flashboards will be set in place when the flows recede to a point that only part of the dam has water flowing over it. Flows will be recorded at the time of placement to determine the flow rate trigger for future placement.

(b) Period of Placement. Flashboards and brackets will be installed as described above, but only after April 15 and will be removed before November 1 of each year. Further, flashboards will be removed within 24 hours, if directed by the Corps, NMFS or CDFW.

(c) Flashboard Adjustments. Flashboards will be closely monitored in accordance with monitoring and inspection activities (see below) to ensure they have been placed in a manner that leads to actual improvement in fish passage and will be adjusted accordingly based on such monitoring. All adjustments will be coordinated with NMFS and CDFW. Any recommended adjustments will be made within 24 hours of notification unless flow conditions prohibit them. In that case, the adjustments will be made as soon as conditions allow.

(d) Method of Placement. Flashboards will be installed using metal brackets that are attached to the dam with anchor bolts. The brackets will be fabricated of material that is light enough that it will break away if the flows increase too rapidly before the brackets can be removed.

(e) Location of Placement. When flashboard placement is required, they will be placed in the center portion of the dam in such a way that the flows are directed toward both fish ladders. This will ensure adequate flows through the fish ladders to promote optimal flow conditions and attraction flows to the fish ladders. The number of boards placed and the exact location will be determined based upon flow conditions and channel position. Adjustments will be made as necessary to provide optimal fish attraction and passage. All adjustments will be coordinated with NMFS and CDFW.

(f) Flashboard Material. Flashboard material will be 2” x 10” Douglas Fir or equal material. Material will be free of preservatives and other contaminants – no pressure treated material will be used.

(g) Monitoring and Inspection. Once the flashboards have been placed, fish passage will be closely monitored for the first week after placement to confirm that the flashboard installation improves fish passage. This monitoring will be conducted via the VAKI in coordination with the RMT. Additionally, during the period that flashboards are installed in accordance with this plan, the flashboards will be monitored at least once per week to make sure that the flashboards have not collected debris that might contribute to juvenile fish mortality. The flashboards will be cleared within 24 hours of finding a blockage, or as soon as it is safe to clear them.

(h) Updates. The Corps will update and adjust this plan as required based upon new information generated through monitoring efforts.

As part of future Cordua Irrigation District license renewal and approval processes after 2016, the Corps will refine the description of specific operations addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam and incorporate changes to the Flashboard Management Plan into the terms and conditions for the Corps license to be re-issued to Cordua Irrigation District (Grothe 2011), and Cordua Irrigation District will remain responsible for implementing the flashboard operations.

In addition to the aforementioned description of the long-term flashboard operations developed by the Corps, additional refinements for the license may include the following.

(i) The flow conditions in the lower Yuba River flow that will prompt the placement and removal of the flashboards.

(j) The responsibility of Cordua Irrigation District for monitoring the flashboards at least once a week to make sure that they have not collected debris that might contribute to juvenile fish mortality.

(k) The responsibility of Cordua Irrigation District for monitoring the effects of the flashboards on juvenile salmonids and the potential for direct mortality due to entrainment or concentrating juveniles in a manner that promotes predation.

If the Corps does not renew the license to Cordua Irrigation District or another entity when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan on a long-term basis.

(5) Protective Conservation Measures

ESA section 7(a) states: “The Secretary shall review other programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act.”

The Corps has committed to incorporate several conservation measures into its activities for this proposed action. These measures are intended to improve conditions for listed salmonids in the lower Yuba River. The Corps will implement the following protective conservation measures under the Corps' obligation to section 7(a)(1) of the ESA for the conservation of threatened and endangered species.

(a) Implementation of the Daguerre Point Dam Fish Passage Sediment Management Plan

The proposed action includes continued implementation of the 2009 Fish Passage Sediment Management Plan. The Corps considers the Fish Passage Sediment Management Plan to be a protective conservation measure because it includes activities beyond those specified in the Daguerre Point Dam O&M Manual (Corps 2013b).

(b) Management of a Long-term Flashboard Program at Daguerre Point Dam

The proposed action includes implementation of the Flashboard Management Plan through the administration of a license issued to Cordua Irrigation District. If the Corps does not renew the license to Cordua Irrigation District, or another entity, when it expires in 2016, then the Corps will assume responsibility for implementing the operations and maintenance activities addressing the placement, timing and configuration of the flashboards at Daguerre Point Dam that are described in the Flashboard Management Plan on a long-term basis.

(c) Implementation of a Debris Monitoring and Maintenance Plan at Daguerre Point Dam

Through coordination with CDFW and NMFS, the Corps will implement the Debris Monitoring and Maintenance Plan for clearing accumulated debris and blockages in the fish ladders at Daguerre Point Dam. This plan specifies that CDFW is responsible for inspecting and clearing the portion of the ladders containing the VAKI device, and that the Corps is responsible for all other parts of the ladders. Inspections will include sub-surface inspections of the ladders. The Corps will conduct weekly inspections of the Daguerre Point Dam fish ladders for surface and subsurface debris. The Corps also will routinely inspect the fish ladder gates to ensure that no third parties close them. Routine inspections shall occur at least weekly, and may be conducted under agreement with CDFW. This plan also specifies that routine inspection and clearing of debris from the two fish ladders at Daguerre Point Dam may be conducted by CDFW pursuant to agreement with the Corps, or by other parties (*e.g.*, PSMFC) under CDFW direction. Routine inspections and debris clearing will occur weekly, although more frequent inspections and debris clearing activities may be conducted by CDFW, or other parties (*e.g.*, PSMFC) under CDFW direction.

When river flows are 4,200 cfs or greater, the Corps or other designated parties as described above, will conduct daily manual inspections of the Daguerre Point

Dam fish ladders. Upon discovering debris in the ladders, the debris will be removed within twelve hours, even if the Corps or CDFW determines that flow levels are adequate for fish passage. If conditions do not allow for safe immediate removal of the debris, the debris will be removed within twelve hours after flows have returned to safe levels.

The Corps will reconsider the need for specific provisions, and may modify the Debris Monitoring and Maintenance Plan upon issuance by NMFS of a BiOp for the proposed action.

(6) Corps' Voluntary Conservation Program

With respect to the conservation of federally-listed endangered and threatened species on existing Corps' project lands, the Corps' Environmental Stewardship and Maintenance Guidance and Procedures (Corps 2013b) states that identified conservation activities will be accomplished when funds are available through the budget priority process presented in the Annual O&M Budget Guidance. Therefore, conservation measures contained within the Corps' Voluntary Conservation Program are subject to the availability of funding. Limited financial resources are presently available for the Corps to proceed with implementing the Voluntary Conservation Program measures described below. In the past, the Corps has been successful in obtaining the additional funding as it places a high priority on these measures. The Corps will continue to diligently seek opportunities for future implementation, subject to available funding.

(a) Gravel Injection in the Englebright Dam Reach of the Lower Yuba River

The Corps has been injecting a mixture of coarse sediment in the gravel (2-64 mm) and cobble (64-256 mm) size ranges into the lower Yuba River below Englebright Dam, as part of their voluntary conservation measures associated with ESA consultations regarding Daguerre Point Dam. Four separate gravel injection efforts have been undertaken from 2007-2013, with approximately 15,500 tons of gravel/cobble placed into the Englebright Dam Reach.

Future gravel injections are anticipated as one of the Corps voluntary conservation measures associated with the current ESA consultation. The Corps' Gravel Augmentation Implementation Plan (GAIP) provides guidance for a long-term gravel injection program to provide CV Chinook salmon spawning habitat in the bedrock canyon downstream of Englebright Dam. The Corps has contracted bathymetric survey monitoring to compare volumetric differences between pre- and post- gravel injection distributions, to further evaluate the disposition of the injected gravels. Additionally, the Corps has funded PSMFC to conduct redd surveys in the Englebright Dam Reach to investigate whether CV Chinook salmon and CCV steelhead are utilizing areas where gravel placement occurred. If the monitoring suggests alterative locations or gravel injection methods, then the Corps will continue the long-term gravel injection program accordingly. In addition, the frequency of gravel injection will be dependent upon annual monitoring results.

The GAIP (Pasternack 2010) describes present and proposed future gravel injection efforts, based on information available in 2010. The long-term plan calls for continuing gravel/cobble injection into the Englebright Dam Reach until the estimated coarse sediment storage deficit for the reach is eradicated, and then it calls for subsequent injections as needed to maintain the sediment storage volume in the event that floods export material downstream of the reach. The Corps does not currently have the authority to completely eradicate the deficit created by various causes in one placement, nor is that the intent of the Corps gravel injection program.

(b) Large Woody Material Management Program

The Corps has prepared the Large Woody Material Management Plan (LWMMP), which includes the implementation of a Pilot Study in order to enhance rearing conditions for CV spring-run Chinook salmon and CCV steelhead (Corps 2012d). The Corps proposed to initiate a pilot study to determine an effective method of replenishing the supply of large woody material (LWM) back into the lower Yuba River. As described in the LWMMP, the Pilot Study will use LWM from existing stockpiles at New Bullards Bar Reservoir for placement at selected sites along the lower Yuba River. The Pilot Study would include monitoring of placed materials, and used to assess the effectiveness of LWM placement in the lower Yuba River in order to develop a long-term program (Corps 2012b).

As part of this conservation measure, the Corps will: (1) refine the draft plan that was prepared for management of LWM, consistent with recreation safety needs, (2) conduct a pilot project to identify suitable locations and evaluate the efficacy of placing large in-stream woody material to modify local flow dynamics to increase cover and diversity of instream habitat for the primary purpose of benefitting juvenile salmonid rearing, and (3) based upon the outcomes of the pilot program, develop and implement a long-term large woody material management plan for the lower Yuba River, anticipated to occur within one year following completion of the pilot program, and subject to available funding.

(B) Interrelated Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification (50 C.F.R. 402.02). The Corps has determined there are no anticipated interrelated actions associated with the proposed action.

(C) Interdependent Actions

Interdependent actions are those that have no independent utility apart from the action under consideration (50 C.F.R. 402.02). The Corps has determined that there are no anticipated interdependent actions associated with the proposed action.

In the 2012 BiOp, NMFS identified several additional actions as interrelated and interdependent actions associated with the project description in the Corps 2012 BA (Corps 2012a). Due to modifications in the proposed action, and new information regarding Corps discretion and authority, those actions are no longer identified in this BiOp as interrelated and interdependent actions.

(V) DESCRIPTION OF ACTION AREA

The action area is defined in 50 CFR 402.02 as all areas to be affected directly or indirectly by the Federal action, and not merely the immediate area involved in the action. Direct effects include those resulting from interdependent or interrelated actions. Indirect effects are defined as those effects that are caused by or will result from the proposed action and are later in time, but still reasonably certain to occur (50 CFR §402.02). The action area is not the same as the project boundary area because the action area must delineate all areas to be affected by the implementation of the proposed action.

Based on the scope of the BA (Corps 2013b), the Action Area for the proposed action includes the lower Yuba River starting at a point approximately 135 feet upstream of the downstream of the Narrows II powerhouse and approximately 415 feet downstream of Englebright Dam, downstream to the confluence of the Yuba and Feather rivers. The Action Area is based on the geographic extent of potential direct and indirect effects of the proposed action on ESA listed species and critical habitat. The proposed action has potential activities upstream as far the Narrows II powerhouse as ESA listed anadromous fish species have the potential to be attracted to this area, due to the spawning gravel augmentation.

Under certain flow conditions fish could move upstream of the Action Area. When CV spring-run Chinook salmon are present, the upstream migration of CV spring-run Chinook samon is limited by the inadequate flow between Englebright Dam and the pool adjacent to the Narrows II powerhouse and bypass valve. If spring-run Chinook salmon were to move upstream of the Action Area, it would not be due to the proposed action. While CCV steelhead may move further upstream, up to the base of Englebright Dam, movement upstream of the Action Area would most likely be possible when spill associated with Englebright Dam occurs, and not associated with the proposed project.

The effects of the operations and maintenance of Daguerre Point Dam for which the Corps has requested consultation are:

1. Fish passage facilities,
2. Staff gage,
3. Flashboard (dam) management,
4. Debris monitoring,
5. Sediment management,
6. Gravel augmentation (subject to funding), and
7. Large Woody Material Management Program (subject to funding).

While water storage and diversions affect habitat within the Action Area, the Corps has limited the scope of its BA (Corps 2013b) and this consultation to its discretionary actions associated with operation and maintenance of Daguerre Point Dam.

(VI) ANALYTICAL FRAMEWORK

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts on the conservation value of designated critical habitat. This biological opinion 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 following analysis with respect to critical habitat.[1]

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach conclusions regarding jeopardy and adverse modification determinations.
- If necessary, define a reasonable and prudent alternative to the proposed action.

[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

(VII) STATUS OF THE SPECIES AND CRITICAL HABITAT

(A) CV spring-run Chinook Salmon

Central Valley spring-run Chinook salmon ESU
Listed as threatened September 16, 1999 (64 FR 50394).
Final listing determination (threatened, June 28, 2005 (FR 37160)

Central Valley spring-run Chinook salmon designated critical habitat
Designated September 2, 2005 (70 FR 52488

(1) Species Listing History

CV spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). On June 14, 2004, following a five-year species status review, NMFS proposed that CV spring-run Chinook salmon remain listed as a threatened species based on the Biological Review Team strong majority opinion that the Central Valley spring-run Chinook salmon ESU is ‘‘likely to become endangered within the foreseeable future’’ due to the greatly reduced distribution of Central Valley spring-run Chinook salmon and hatchery influences on the natural population. On June 28, 2005, NMFS reaffirmed the threatened status of CV spring-run Chinook salmon ESU, and included the FRFH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU (70 FR 37160).

Section 4(c)(2) of the ESA requires that NMFS review the status of listed species under its authority at least every five years and determine whether any species should be removed from the list or have its listing status changed. In August 2011, NMFS completed a second 5-year status review of CV spring-run Chinook salmon ESU. Prior to making a determination on whether the listing status of the ESU should be uplisted (*i.e.*, threatened to endangered), downlisted, or remain unchanged, NMFS considered: (1) new scientific information that has become available since the 2005 status review (Good *et al*. 2005), (2) an updated biological status summary report (Williams *et al*. 2011) intended to determine whether or not the biological status of CV spring-run Chinook salmon has changed since the 2005 status review was conducted (referred to as the “viability report”), (3) the current threats to the species, and (4) relevant ongoing and future conservation measures and programs.

Based on a review of the available information, NMFS (2011a) recommended that the CV spring-run Chinook salmon ESU remain classified as a threatened species. NMFS’ review also indicates that the biological status of the ESU has declined since the previous status review in 2005 and, therefore, NMFS recommended that the ESU’s status be reassessed in 2 to 3 years if it does not respond positively to improvements in environmental conditions and management actions. As part of the 5-year review, NMFS also re-evaluated the status of the FRFH stock and concluded that it still should be considered part of the CV spring-run Chinook salmon ESU.

(2) Critical Habitat Designation and Primary Constituent Elements for CV Spring-run Chinook Salmon

Critical habitat was designated for the Central Valley spring-run Chinook salmon ESU on September 2, 2005 (70 FR 52488), and includes stream reaches of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, and portions of the northern Delta (NMFS 2009a). On the lower Yuba River, critical habitat is designated from the confluence with the Feather River upstream to Englebright Dam. This critical habitat includes the stream channels in the designated stream reaches and their lateral extents, 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, 70 FR 52488, September 2, 2005).

In designating critical habitat, NMFS (2009a) 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 key physical and biological features within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. Specifically, primary constituent elements (PCEs) of critical habitat are those physical and biological features essential to the conservation of a species for which its designated or proposed critical habitat is based on.

Within the range of the CV spring-run Chinook salmon ESU, the PCEs of the designated critical habitat include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore and offshore marine areas. The following summary descriptions of the current conditions of the freshwater PCEs for the CV spring-run Chinook salmon ESU were taken from NMFS (2009a), with the exception of new or updated information regarding current habitat conditions.

<u>Spawning Habitat</u>

Freshwater spawning sites are those with sufficient water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the CV for Chinook salmon is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for CV spring-run Chinook salmon occurs on the mainstem Sacramento River between the Red Bluff Diversion Dam (RBDD) and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks, as well as the Feather and Yuba rivers, Big Chico, Battle, Antelope, and Clear creeks. Even in degraded reaches, spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile salmonid 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 piscivorous fish and birds. Freshwater rearing habitat also has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

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 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 stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

Estuarine Areas

Estuarine areas, such as the San Francisco Bay and the downstream portions of the Sacramento-San Joaquin Delta, free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging.

The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

Nearshore Coastal Marine and Offshore Marine Areas

CV Spring-run Chinook salmon reside in the Pacific Ocean from one to four years. The first few months of a salmon's ocean life has been identified as the period of critical climatic influences on survival which, in turn, suggests that coastal and estuarine environments are key areas of biophysical interaction (NMFS 2009). Juvenile salmon grow rapidly as they feed in the highly productive currents along the continental shelf (Barnhart 1986).

Most climate factors affect the entire West Coast complex of salmonids. This is particularly true in their marine phase, because the California populations are believed to range fairly broadly along the coast and intermingle, and climate impacts in the ocean occur over large spatial scales (Schwing and Lindley 2009). Salmon and steelhead residing in coastal areas where upwelling is the dominant process are more sensitive to climate-driven changes in the strength and timing of upwelling (NMFS 2009).

Oceanic and climate conditions such as sea surface temperatures, air temperatures, strength of upwelling, El Niño events, salinity, ocean currents, wind speed, and primary and secondary productivity affect all facets of the physical, biological and chemical processes in the marine environment. Some of the conditions associated with El Niño events include warmer water temperatures, weak upwelling, low primary productivity (which leads to decreased zooplankton biomass), decreased southward transport of subarctic water, and increased sea levels (Pearcy 1997 as cited in NMFS 2009). Strong upwelling is probably beneficial because it causes greater transport of smolts offshore, beyond major concentrations of inshore predators (Pearcy 1997 as cited in NMFS 2009).

The California Current Ecosystem (CCE) is designated by NMFS as one of eight large marine ecosystems within the United States Exclusive Economic Zone. The California Current begins at the northern tip of Vancouver Island, Canada and ends somewhere between Punta Eugenia and the tip of Baja California, Mexico (NMFS 2009). The northern end of the current is dominated by strong seasonal variability in winds, temperature, upwelling, plankton production and the spawning times of many fishes, whereas the southern end of the current has much less seasonal variability (NMFS 2009). The primary issue for the CCE is the onset and length of the upwelling season, that is when upwelling begins and ends (*i.e.*, the "spring" and "fall" transitions). The biological transition date provides an estimate of when seasonal cycles of significant plankton and euphausiid production are initiated (NMFS 2009).

(3) Historical Abundance and Distribution

CV Spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley and were found in both the Sacramento and San Joaquin drainages. The Central Valley drainage as a whole is estimated to have supported annual runs of CV spring-run Chinook salmon as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). More than 500,000 CV spring-run Chinook salmon were reportedly caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama *et al*. 1998). Before the construction of Friant Dam (completed in 1942), nearly 50,000 adults were counted in the San Joaquin River (Fry 1961). The San Joaquin populations were essentially extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Hallock and Van Woert 1959, Yoshiyama *et al*. 1998).

Annual run sizes of CV spring-run Chinook salmon are reported in “GrandTab”, a database administered by CDFW for the Central Valley that includes reported run size estimates from 1960 through 2012, although mainstem Sacramento River estimates are not available for years before 1969 (CDFW 2013). The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance. Estimates of CV spring-run Chinook salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather rivers because GrandTab does not distinguish between fall-run and CV spring-run Chinook salmon in-river spawners, and not including the FRFH) have ranged from 1,404 in 1993 to 25,890 in 1982.
The average abundance for the Sacramento River and its tributaries (excluding the lower Yuba and Feather rivers – see above) was 11,646 for the period extending from 1970 through 1979, 14,240 for the period 1980 through 1989, 5,825 for the period 1990 through 1999, and 14,055 for the period 2000 through 2009. Since 1995, CV spring-run Chinook salmon annual run size estimates have been dominated by Butte Creek returns. Since carcass survey estimates have been available in Butte Creek in 2001 through 2012, Butte Creek returns have averaged 10,874 fish. The estimated CV spring-run Chinook salmon run size was 18,511 for 2012, of which Butte Creek returns (based on the carcass survey) accounted for 16,140 fish (CDFW 2013).

Historically, CV spring-run Chinook salmon occurred in the headwaters of all major river systems in the Central Valley where natural barriers to migration were absent, and occupied the middle and upper elevation reaches (1,000 to 6,000 feet) of most streams and rivers with sufficient habitat for over summering adults (Clark 1929). Excluding the lower stream reaches that were used as adult migration corridors (and, to a lesser degree, for juvenile rearing), it has been estimated that at least 72 percent of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer available due to the construction of non-passable dams (Yoshiyama *et al*. 2001). Adult migrations to the upper reaches of the Sacramento, Feather, and Yuba rivers were eliminated with the construction of major dams during the 1940s, 1950s and 1960s. Naturally spawning populations of CV spring-run Chinook salmon have been reported to be restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

(4) Species Life History

Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River beginning in March (Yoshiyama 1998). CV spring-run Chinook salmon move into tributaries of the Sacramento River (*e.g.*, Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley *et al.* 2004). CV spring-run Chinook salmon rely on suitable water temperatures, and adequate flows to provide migrating adults with olfactory and other cues needed to locate their spawning reaches (CDFG 1998). Typically, CV spring-run Chinook salmon 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).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows 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^{o}F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70^{o}F, and that fish can become stressed as temperatures approach 70^{o}F. Reclamation reports that CV spring-run Chinook salmon 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 (Williams 2006).

Adult Spawning

In the Central Valley, spawning has been reported to primarily occur from September to November, with spawning peaking in mid- September (DWR 2004a, Moyle 2002, Vogel and Marine 1991). Within the ESU, CV spring-run Chinook salmon spawn in accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). In the CV they mature primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Fisher 1994).

In general, CV spring-run Chinook salmon have been reported to spawn at the tails of holding pools (Moyle 2002, NMFS 2007, USFWS 1995a). Redd sites are apparently chosen in part by the presence of subsurface flow. 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 usually seek a mixture of gravel and small cobbles with low silt content to build their redds. Characteristics of spawning habitats that are directly related to flow include water depth and velocity. Chinook salmon spawning reportedly occurs in water velocities ranging from 1.2 feet/sec to 3.5 feet/sec, and spawning typically occurs at water depths greater than 0.5 feet (YCWA *et al*. 2007). The upper preferred water temperature for spawning Chinook salmon is 55°F to 57°F (Smith 1973, Bjornn and Reiser 1991, and Snider 2001). Chinook salmon are semelparous (die after spawning).

<u>Embryo Incubation</u>

The CV spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sacs prior to emergence.

The length of time for CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intragravel environs where water temperatures range from about 41ºF to 55.4°F embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2009). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence 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 (NMFS 1997, 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 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. The newly emerged 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 small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 mm to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. 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).

Newly emergent fry seek nearshore habitats containing beneficial aspects such as riparian vegetation and adjacent substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996a). The benefits of floodplain habitat and shallow water habitat 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).

Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially 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).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters. Migration 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 when they have reached the appropriate stage of development (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 primarily crepuscular. The daily migration of juveniles passing Red Bluff Diversion Dam (RBDD) is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 mile up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smolt 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).

CV Spring-run Chinook salmon 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, or as juveniles, or yearlings. The modal size of fry migrants at approximately 40 millimeters between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of CV spring-run Chinook salmon migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run Chinook salmon were observed to remain 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 young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). California Department of Fish and Game (1998) observed the emigration period for CV spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run Chinook salmon 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).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run Chinook salmon 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). 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). 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).

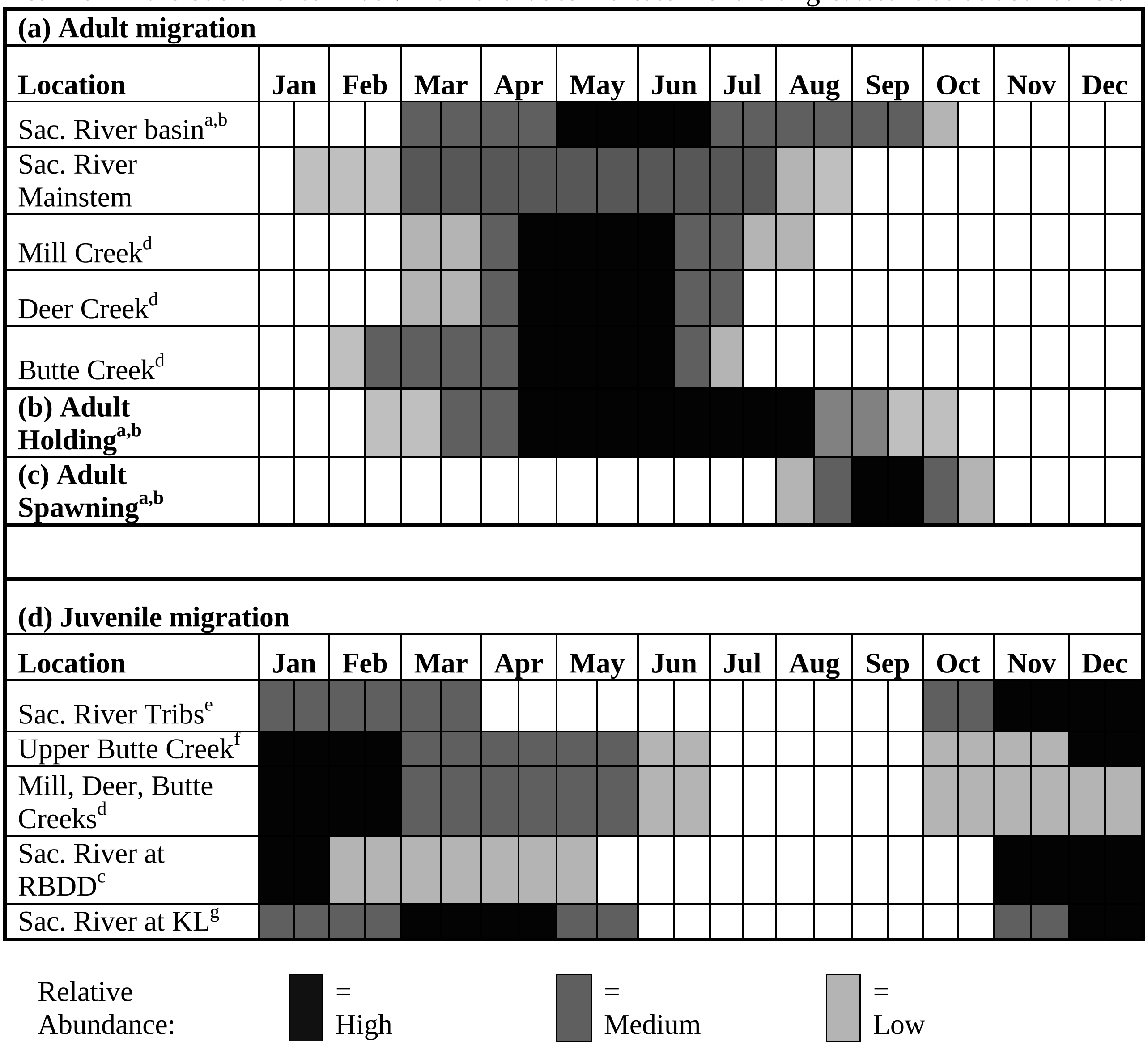
Estuarine Rearing

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 (Levy and Northcote 1982, Levings 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, Herbold *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.

Ocean Rearing and Behavior

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California Current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002). After entering the ocean, juveniles become voracious predators on small fish, crustaceans, and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic planktivore is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The ocean stage of the Chinook salmon life cycle lasts one to five years.

Table VII-1. The temporal occurrence of adult (a) and juvenile (b) CV spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.



Sources: [a]Yoshiyama *et al.* (1998); [b]Moyle (2002); [c]Myers *et al.* (1998); [d]Lindley *et al.* (2004); [e]CDFG (1998); [f]McReynolds *et al.* (2007), Ward *et al.* (2003); [g]Snider and Titus (2000)

Note: Yearling CV spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year CV spring-run Chinook salmon emigrate during the first spring after they hatch.

(5) Factors Affecting the Species and Critical Habitat

California's robust agricultural economy and rapidly increasing urban growth create a high demand for water in the Sacramento and San Joaquin river basins and out of basin. The demand for water from the Central Valley has significantly altered the natural morphology and hydrology of the Sacramento and San Joaquin rivers and their major tributaries. Agricultural lands and urban areas have flourished on historic floodplains. An extensive flood management system of dams, levees, and bypass channels restricts the river's natural sinuosity, volume, and reduces the transit time of water flowing through the system. An impressive network of water delivery systems has transformed Central Valley rivers into a series of lined conveyance channels and reservoirs that are highly managed. Flood management and water delivery systems, in addition to agricultural, grazing, and urban land uses, are the main anthropogenic factors affecting watersheds in the action area.

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon species in the Central Valley (*e.g.*, Busby *et al.* 1996, Myers *et al.* 1998, Good *et al.* 2005, CALFED 2000). NMFS has also assessed the factors contributing to Chinook salmon decline in supplemental documents and Federal Register notices. The foremost reason for the decline in these anadromous salmonid populations is habitat blockage by dams and the degradation and destruction of habitat. Additional factors contributing to the decline of these populations include: over-utilization from fisheries, disease or predation, the inadequacy of existing regulatory mechanisms, and other natural and manmade factors such as global climate change. All of these factors have contributed to the federal listing of Central Valley salmonid populations under the ESA and the deterioration of their critical habitats. However, it is widely recognized in numerous species accounts in the peer-reviewed literature that the modification and curtailment of habitat and range have had the most substantial impacts on the abundance, distribution, population growth, and diversity of salmonid populations. Although habitat and ecosystem restoration has contributed to recent improvements in habitat conditions throughout the range of the ESU, global climate change remains a looming threat. The following general description of the factors affecting the viability of CV spring-run Chinook salmon is based on a summarization of these documents.

ESU Considerations

Threats to CV spring-run Chinook salmon are in three broad categories: (1) loss of historical spawning habitat, (2) degradation of remaining habitat, and (3) threats to the genetic integrity of the wild spawning populations from the FRFH spring-run Chinook salmon production program. The CV spring-run Chinook salmon ESU continues to be threatened by habitat loss, degradation and modification, small hydropower dams and water diversions that reduce or eliminate instream flows during migration, unscreened or inadequately screened water diversions, excessively high water temperatures, and predation by non-native species. The potential effects of long-term climate change also may adversely affect CV spring-run Chinook salmon and their recovery. The current status of the species is defined by habitat blockage, water development and diversion dams, water conveyance and flood control, land use activities, water quality, hatchery operations and practices, over-utilization (*e.g.*, ocean commercial and sport harvest, inland sport harvest), disease and predation, environmental variation (*e.g.*, natural environmental cycles, ocean productivity, global climate change), and non-native invasive species.

Habitat Loss

Hydropower, flood control, and water supply dams of the Central Valley Project (CVP), State Water Project (SWP), navigation/sediment dams, 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.

Juvenile downstream migration patterns have been altered by the presence of dams. Juvenile CV spring-run Chinook salmon (as well as winter-run) on the mainstem Sacramento River generally outmigrate earlier than they did historically because they are hatched considerably farther downstream and now have less distance to travel. Therefore, smolts in the Sacramento River under present conditions must rear for a longer period of time in order to reach sizes comparable to those of smolts that historically reared in upstream reaches above the dams. However, for several months of the year, habitat conditions in the mainstem Sacramento River do not provide the necessary features for listed anadromous fish species, especially for an extended period of time.

As a result of manmade migrational barriers, especially the construction of major dams, CV spring-run Chinook salmon have been confined to lower elevation river mainstems that historically only were used for migration. The greatly reduced spawning and rearing habitat has resulted in declines in population abundances in these streams. Additionally, the remaining habitat is of lower quality, in particular because of higher water temperatures in late summer and fall, reduced gravel recruitment, and lack of instream large woody material (LWM). According to Lindley *et al.* (2004), of the 18 independent populations of CV spring-run Chinook salmon that occurred historically, only three independent populations remain in Deer, Mill, and Butte creeks. Dependent populations of CV spring-run Chinook salmon continue to occur in Big Chico, Antelope, Battle, Clear, Thomes, Beegum, and Stony creeks, but rely on the three extant independent populations for their continued survival.

Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have altered the natural hydrologic cycles on which juvenile and adult salmonids historically based their migration patterns upon (NMFS 2009a). As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Dams have contributed to lower flows, higher water temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and LWM. More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands exist throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, its tributaries and the Delta. 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 have the potential to entrain many lifestages of aquatic species, including juvenile salmonids.

The Anderson-Cottonwood Irrigation District (ACID) operates a diversion dam across the Sacramento River about 5 miles downstream of Keswick Dam, which is one of the three largest diversions on the Sacramento River. Operated from April through October, the installation and removal of the diversion dam flashboards requires close coordination between Reclamation and ACID. Because substantial reductions (limited to 15 percent in a 24-hour period and 2.5 percent in any 1 hour) in Keswick Dam releases are necessary to install or remove the flashboards, the ACID diversion dam operations have the potential to impact various lifestages of Chinook salmon (*e.g.*, redd dewatering, juvenile stranding and exposure to elevated water temperatures). Redd dewatering primarily affects CV spring- and fall-run Chinook salmon during October. Although flow reductions are usually of a short-term duration (*i.e.*, lasting less than 8 hours), these short-term flow reductions may cause mortality through desiccation of incubating eggs and loss of stranded juveniles.

Located 59 miles downstream of Keswick Dam, RBDD is owned and operated by Reclamation. Historically, RBDD impeded 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 were not very efficient at passing fish because it was difficult for fish to locate the entrances to the ladders. Water released from RBDD flows through a small opening under each of the 11 gates in the dam cause turbulent flows that confused fish and keep them from finding the ladders. The effects resulting from upstream migrational delays at RBDD ranged from delayed but eventually successful spawning, to pre-spawn mortality and the complete loss of spawning potential in that fraction of the population. The fish ladders are not designed to allow a sufficient amount of flow through them to attract adult salmonids, and previous studies have shown that salmon could be delayed up to 20 days in passing the dam. These delays had the potential to reduce the fitness of adults that expend their energy reserves fighting the flows beneath the gates, and increase the chance of pre-spawn mortality. Passage delays of a few days up to a week were believed to prevent timely movement of adult CV spring-run Chinook salmon upstream to enter the lower reaches of Sacramento River tributaries (*e.g.*, Cottonwood Creek, Cow Creek) above the RBDD, which dry up or warm up during the spring. These passage delays prevented adult CV spring-run Chinook salmon from accessing summer holding pools in the upper reaches of these tributaries. The RBDD gates were permanently raised in September 2011 and, thus, many of the migration-related stressors associated with this location have likely been eliminated due to the improved fish passage conditions.

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 diversions from the mainstem

Sacramento River into the Central Delta through the Delta Cross Channel (DCC), (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways, (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay, and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.) within the waterways of
the Delta.

Water Conveyance and Flood Control

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase 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 2007). These changes affect the quantity and quality of near shore 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 near shore 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 material. 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 (McLain and Castillo 2010).

Prior to the 1970s, there was so much woody material 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 material thought to be a barrier to fish migration (NMFS 1996b). However, it is now recognized that too much LWM was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody material 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 LWM are still limited in the recovery of salmonid stocks, this limitation could be expected to persist for 50 to 100 years following removal of woody material.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996b). LWM 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.

<u>Hatchery Operations and Practices</u>

Five hatcheries currently produce Chinook salmon in the Central Valley and hatchery origin Chinook salmon make up a substantial percentage of Central Valley salmon runs (Yoshiyama *et al*. 2000) and spawning escapement to some major streams, such as the Feather and Yuba rivers, is now dominated by hatchery-origin fish (California HSRG 2012). 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 (USDOI 1999, as cited in NMFS 2009a).

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between CV spring- and fall-run Chinook salmon 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 Chinook salmon from the FRFH have been documented as straying throughout the Central Valley for many years (CDFG 1998), and may have contributed to hybridization. In the Feather River, the lack of physical separation has led to hybridization of CV spring- and fall-run Chinook salmon.

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 by-catch (McEwan 2001). Hatcheries also can have some positive effects on salmonid populations. CV spring-run Chinook salmon produced in the FRFH are considered part of the CV spring-run Chinook salmon 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 (IMST 2001, as cited in NMFS 2004).

In 2000, Congress established and funded a hatchery review process because it recognized that, while hatcheries have a necessary role to play in meeting harvest and conservation goals, many populations of salmon and steelhead are listed under the ESA, and face significant genetic risks from hatchery programs. Comprehensive hatchery reform is needed to conserve these listed stocks (California HSRG 2012). The California Hatchery Science Review Group reviewed the practices of Central Valley salmon and steelhead hatcheries and issued a report in 2012 and made recommendations for all hatchery programs. Some of the key recommendations include:

- Transporting and releasing juveniles to areas outside of the Feather River and near or downstream of the confluence of the Yuba River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Feather River from the confluence of the Yuba River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery.
- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.
- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (*e.g.*, fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).
- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.
- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (*e.g.*, seining or trapping).

In order to meet the recommendations described above, the FRFH has undergone various operational changes in recent years. Rigorous selection procedures allow the FRFH to better separate spring- and fall-run Chinook salmon broodstock, further improving the genetic distinction between the two races. Genetic analysis is conducted annually to better inform future broodstock selection with regard to both origin (hatchery vs. natural) and relatedness. Egg culling procedures will further the separation of spring- and fall-run Chinook salmon broodstock by eliminating the “tails” of each run at the hatchery. The use of size assortative mating procedures, where feasible, should provide more “natural” mate pairings, thereby reducing unforeseen selection effects from standard hatchery practices.

In addition to maintaining best hatchery practices for adult broodstock collection (as defined by the HSRG), the FRFH has made some substantial changes to their juvenile release strategies. At least half of the spring-run Chinook salmon produced at the FRFH are released in the Feather River in order to reduce straying into other watersheds. Various release sites within the Feather River have been utilized in order to determine which sites maximize survival for emigrating juveniles. The FRFH plans to release all juvenile spring-run Chinook salmon production in-river in subsequent years.

Another key recommendation to be addressed in future years will be the addition of a segregation weir. Not only will this help to segregate spring- and fall-run Chinook salmon on the spawning grounds, thereby reducing redd superimposition and genetic introgression, the addition of the weir will also serve as an auxiliary adult collection facility allowing for increased levels of natural-origin Chinook salmon in the broodstock.

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 LWM input needed to form and maintain stream habitat that salmon depend on in their various life stages. In addition to this loss of LWM sources, removal of snags and obstructions from the active river channel for navigational safety has further reduced the presence of LWM 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 stream bank 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 LWM, and removal of riparian vegetation, resulting in increased stream bank 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 material 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, Goals Project 1999). Prior to 1850, approximately 1,400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999). Even more extensive losses of wetland marshes occurred in the Sacramento and San Joaquin river basins. Little of the extensive tracts of wetland marshes that existed prior to 1850 along the valley's river systems and within the natural flood basins exist today. Most has been "reclaimed" for agricultural purposes, leaving only small remnant patches.

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley. Starting in the mid-1800s, the Corps and private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bed load 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 LWM from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Urban storm water 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 potentially 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. Past mining practices included 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 conducive to invasive plant and aquatic species that impact 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 water withdrawals, reservoir operations, the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by CDWR 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.

<u>Water Quality</u>

Over the past 150 years, the water quality of the Delta has been adversely affected by increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads, which have degraded the quality of the aquatic habitat for the rearing and migration of salmonids.

Historic and ongoing point and nonpoint source discharges impact surface waters, and portions of major rivers and the Delta are impaired, to some degree, by discharges from agriculture, mines, urban areas and industries (California RWQCB 1998). Pollutants include effluents from wastewater treatment plants and chemical discharges (*e.g.*, dioxin from San Francisco Bay petroleum refineries) (McEwan and Jackson 1996). Agricultural drain water, another possible source of contaminants, can contribute up to 30 percent of the total inflow into the Sacramento River during drier conditions (Reclamation 2008a).

According to NMFS (2009a), the California RWQCB (1998, 2001) has identified the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, mercury, Group A pesticides (*e.g.*, aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan and toxaphene), organic enrichment, as well as low DO. 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 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 as cited in NMFS 2009a). Direct exposure to contaminated sediments may cause deleterious effects if a fish swims through a plume of the re-suspended sediments or rests on contaminated substrate and absorbs the toxic compounds via dermal contact, ingestion, or uptake across the gills. Although sediment contaminant levels can be significantly higher than the overlying water column concentrations (EPA 1994), the more likely means of exposure is through the food chain when 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 consumed. Salmonid biological responses to contaminated sediments are similar to those resulting from waterborne exposures once a contaminant has entered the body of the fish.

Over Utilization

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 CV for Chinook salmon. Ocean harvest of CV 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 (adult spawner populations that have “escaped” the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

Ocean fisheries have affected the age structure of CV spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of four- and five-year-old fish (CDFG 1998). As a result of very low returns of fall-run Chinook salmon to the Central Valley in 2007 and 2008, there was a complete closure of commercial and recreational ocean Chinook salmon fishery in 2008 and 2009, respectively. Salmon fisheries were again restricted in 2010 with a limited fishing season due to poor returns of fall-run Chinook salmon in 2009. However, contrary to expectations, even with the two years of ocean fishery closures, the CV spring-run Chinook salmon population declined while the fall-run population increased. Ocean harvest rates of CV spring-run Chinook salmon are thought to be a function of the CVI (Good *et al.* 2005). Harvest rates of CV spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 to 0.27 as a result of high fall-run escapement also reduced harvest of CV spring-run Chinook salmon.

Historically in California, almost half of the river sport fishing effort has occurred in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al*. 1991). In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, adult spring-run Chinook salmon are targeted by anglers when the fish congregate and hold in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate. However, the significance of poaching on the adult population is unknown (NMFS 2009a). Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks and the lower Yuba River have been added to the CDFW regulations.

Disease and Predation

Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996, 1996a, 1998a), and infectious disease is one of many factors that influence adult and juvenile salmonid survival. Specific diseases such as bacterial kidney disease, Ceratomyxosis shasta, columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect Chinook salmon and steelhead (NMFS 1996a, 1996b, 1998a). 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 (NMFS 2009a). 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.

As described in NMFS (2005a), accelerated predation is also a significant factor affecting critical habitat for spring-run Chinook salmon. Although predation is a natural component of spring-run Chinook salmon life ecology, the rate of predation likely has greatly increased through the introduction of non-native predatory species such as striped bass and largemouth bass, and through the alteration of natural flow regimes and the development of structures that attract predators, including dams, bank revetment, bridges, diversions, piers, and wharfs (Stevens 1961, Vogel *et al*. 1988 as cited in NMFS 2009, Garcia 1989 as cited in Reclamation 2008, Decato 1978 as cited in Reclamation 2008). The 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). On the mainstem Sacramento River, high rates of predation are known to occur at RBDD, ACID, GCID, and at south Delta water diversion structures (CDFG 1998). From October 1976 to November 1993, CDFW conducted ten mark/recapture experiments at the SWP's Clifton Court Forebay to estimate prescreen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 to 99 percent. Predation from striped bass is thought to be the primary cause of the loss (CDFG 1998, 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. As juvenile salmonids pass the Sacramento River system dams, fish are subject to conditions that can disorient them, making them highly susceptible to predation by fish or birds. Striped bass and Sacramento pikeminnow (*Ptychocheilus grandis*), a species native to the Sacramento River Basin that co-evolved with anadromous salmonids, congregate below dams and prey on juvenile salmon in the tail waters. Tucker *et al*. (1998) reported that: (1) striped bass exhibit a strong preference for juvenile salmonids, (2) during the summer months, juvenile salmonids increased to 66 percent of the total weight of Sacramento pikeminnow stomach contents, and (3) the percent frequency of occurrence for juvenile salmonids nearly equaled other fish species in the stomach contents of the predatory fish. Additionally, Tucker *et al*. (2003) showed the temporal distribution for these two predatory species in the RBDD area were directly related to RBDD operations (*i.e.*, predators congregated when the dam gates were in, and dispersed when the dam gates were removed).

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 Suisun Marsh Salinity Control Gates (SMSCG). 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 1997a). 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. From October 1976 to November 1993, CDFW 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 to 99 percent, and predation by striped bass is thought to be the primary cause of the loss (Gingras 1997). More recent studies by DWR (2008) have verified this level of predation also exists for steelhead smolts within Clifton Court Forebay, indicating that these predators were efficient at removing salmonids over a wide range of body sizes.

Avian predation on fish contributes to the loss of migrating juvenile salmonids (NMFS 2009a). Fish-eating birds [*e.g.*, great blue herons (*Ardea herodias*), black-crowned night herons (*Nycticorax nycticorax*), gulls (*Larus* spp), osprey (*Pandion haliactus*)] in the Central Valley 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. These animals, especially river otters (*Lontra canadensis*), are capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993 as cited in NMFS 2009a). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. In the marine environment, Southern Resident killer whales (*Orcinus orca*) target Chinook salmon as their preferred prey (96 percent of prey consumed during spring, summer and fall, from long-term study of resident killer whale diet, Ford and Ellis 2006).

Non-Native Invasive Species

Non-native invasive species are of concern throughout the ESU and DPSs and can result in numerous deleterious effects to native species. For example, introduction of non-native invasive species can alter the natural food webs that existed prior to their introduction, as illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis* in the Delta. Cohen and Moyle (2004) report that the arrival of these two clam species disrupted the normal benthic community structure, and depressed phytoplankton levels in the Delta due to the highly efficient filter feeding of the introduced clams. Declines in phytoplankton levels have consequently resulted in reduced populations of zooplankton that feed upon them, thereby reducing the forage base available to salmonids transiting through the Delta and the San Francisco estuary on their ocean migrations. The lack of forage base can adversely affect the health and physiological condition of salmonids as they migrate to the Pacific Ocean.

Attempts to control non-native invasive plant species also can adversely affect the health and habitat suitability of salmonids within affected water systems, through either direct exposure to toxic chemicals or reductions in DO levels associated with the decomposition of vegetative matter in the water. As an example, control programs for the invasive water hyacinth (*Eichhornia crassipes*) and Brazilian waterweed (*Egeria densa)* plants in the Delta must balance the toxicity of the herbicides applied to control the plants against the probability of exposure to listed salmonids during herbicide application period.

Environmental Variation

The scientific basis for understanding the processes and sources of climate variability has grown significantly in recent years, and our ability to forecast human and natural contributions to climate change has improved dramatically. With consensus on the reality of climate change now established (Oreskes 2004, IPCC 2007), the scientific, political, and public priorities are evolving toward determining its ecosystem impacts, and developing strategies for adapting to those impacts. Global climate change is playing an increasingly important role in scientific and policy debates related to effective water management. The most considerable impacts of climate change on water resources in the United States are believed to occur in the mid-latitudes of the West, where the runoff cycle is largely determined by snow accumulation and subsequent melt patterns. Evidence is continuing to accumulate to indicate global climate change will have a marked effect on water resources in California. Numerous peer-reviewed scientific articles on climate and water issues in California have been published to date, with many more in preparation, addressing a range of considerations from proposed improvements in the downscaling of general circulation models to understanding how reservoir operations might be adapted to new conditions (Kiparsky and Gleick 2003).

NMFS (2009) states that the potential effects of long-term climate change may adversely affect spring-run Chinook salmon and steelhead, and the recovery of both species. Current climate change information suggests that the Central Valley climate will become warmer, a challenging prospect for Chinook salmon and steelhead – both of which are coldwater fish at the southern end of their distribution. According to NMFS (2009a), 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 how climate-related factors influence salmon survival in the ocean. Consistent with the approach taken in recent NMFS BOs (NMFS 2010, NMFS 2010a, b, NMFS 2011b, c), the discussion below describes the potential climate-related threats anticipated to affect the status of listed species, including inter-annual climatic variations (*e.g.* El Niño and La Niña), the Wells Ocean Productivity Index, and longer term cycles in ocean conditions pertinent to salmonid survival (*e.g.*, Pacific Decadal Oscillation).

Natural Environmental Cycles

Natural climate variability in freshwater and marine environments has the potential to substantially affect salmonid abundance, particularly during early lifestages (NMFS 2008). Sources of variability include inter-annual climatic variations (*e.g.*, El Niño and La Niña), longer-term cycles in ocean conditions (e.g., Pacific Decadal Oscillation, Mantua *et al*. 1997), and ongoing global climate change. Climate variability can affect ocean productivity in the marine environment, as well as water storage (*e.g.*, snow pack) and in-stream flow in the freshwater environment. Early lifestage growth and survival of salmon can be negatively affected when climate variability results in conditions that hinder ocean productivity (*e.g.*, Scheuerell and Williams 2005) and water storage (*e.g.*, Independent Scientific Advisory Board 2007) in marine and freshwater systems, respectively.

Fisheries scientists have shown that ocean climate varies strongly at decadal scales (*e.g.*, Beamish 1993, Beamish and Bouillon 1993, Graham 1994, Miller *et al*. 1994, Hare and Francis 1995, Mantua *et al*. 1997, Mueter *et al*. 2002). In particular, the identification of the Pacific Decadal Oscillation (PDO) (Mantua *et al*. 1997) has led to the belief that decadal-scale variation may be cyclical, and thus predictable (Lindley *et al*. 2007). Evidence also 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 as cited in NMFS 2009a, Mantua and Hare 2002). In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996b). El Niño is an unusual warming of the Pacific Ocean off South

America and is caused by atmospheric changes in the tropical Pacific Ocean (El Niño Southern Oscillation [ENSO]) resulting in reductions or reversals of the normal trade wind circulation patterns. El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes to coastal currents and upwelling patterns. Principal ecosystem alterations include decreased primary and secondary productivity in affected regions and changes in prey and predator species distributions. Cold-water species are displaced towards higher latitudes or move into deeper, cooler water, and their habitat niches are occupied by species tolerant of warmer water that move upwards from the lower latitudes with the warm water tongue.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival of Chinook salmon in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult lifestage. 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 Chinook salmon spawning population in 2007 (Oppenheim 2008 as cited in NMFS 2009a). Lindley *et al*. (2009) reviewed the possible causes for the decline in Sacramento River fall-run Chinook salmon in 2007 and 2008 for which reliable data were available. They concluded that a broad body of evidence suggested that anomalous conditions in the coastal ocean in 2005 and 2006 resulted in unusually poor survival of the 2004 and 2005 broods of fall-run Chinook salmon. However, Lindley *et al*. (2009) recognize that the rapid and likely temporary deterioration in ocean conditions acted on top of a long-term, steady degradation of the freshwater and estuarine environment.

As suggested by Rudnick and Davis (2003) and Hsieh *et al*. (2005), apparent regime shifts need not be cyclical or predictable, but rather may be the expression of a stochastic process. If this interpretation is correct, then we should expect future ocean climate conditions to be different than those observed over the past few decades (Lindley *et al*. 2007).

Lindley *et al*. (2007) further state that Central Valley salmonid ESUs and DPSs are capable of surviving the kinds of climate extremes observed over the past few thousand years if they have functional habitats, because these lineages are on order of a thousand years old or older. There is growing concern, however, that the future climate will be unlike that seen before, due to global warming in response to anthropogenic greenhouse gas emissions (Lindley *et al*. 2007).

<u>Ocean Productivity</u>

The time when juvenile salmonids enter the marine environment marks a critical point 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 as cited in NMFS 2009a, MacFarlane *et al*. 2008 as cited in NMFS 2009a). Emigration periods and ocean entry can vary substantially among, and even within, runs in the

Central Valley. Winter-run Chinook salmon typically rear in freshwater for 5 to 9 months and exhibit a peak emigration period in March and April. CV spring-run Chinook salmon 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, Reclamation 2008).

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 (Reclamation 2008). While still acknowledging this variability in emigration patterns, a general statement can be made that Chinook salmon typically rear in freshwater environments for less than a year and enter the marine environment as sub-yearlings in late spring to early summer (NMFS 2009a). Similarly, although steelhead life histories are more elastic, they typically enter the ocean in approximately the same time frame. The 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 as cited in NMFS 2009a). 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.

Variations in salmon marine survival correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm regimes 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 System (CCS) off the Pacific Northwest can be linked to fluctuations in ocean conditions. The CCS extends up to 1000 km offshore from Oregon to Baja California and encompasses a southward meandering surface current, a pole-ward undercurrent and surface countercurrents that exhibit high biological productivity, diverse regional characteristics, and intricate eddy motions that have mystified oceanographers for decades.

An evaluation of conditions in the CCS since the late 1970s reveals that a generally warm, unproductive regime persisted until the late 1990s. This regime was 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, the brief cold cycle was immediately succeeded by a 4-year period of predominantly warm ocean conditions beginning in late 2002, which appeared to negatively impact salmon populations in the CCS (Peterson *et al*. 2006). 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 PDO and the Multivariate ENSO Index], (2) local observations of physical and biological ocean conditions off northern Oregon (*e.g.*, upwelling, water temperature, plankton species compositions, etc.), and (3) biological sampling of juvenile salmon, plankton, forage fish, and Pacific hake (which prey on salmon). When used collectively, this information can provide a general assessment of ocean conditions in the northern California Current that pertain to multi-year warm or cold phases. It can also be used to develop a qualitative evaluation for a particular year of the effect these ocean conditions have on juvenile salmon when they enter the marine environment and the potential impact to returning adults in subsequent years (NMFS 2009a).

The generally warmer ocean conditions in the California Current that began to prevail in late 2002 have resulted in coastal ocean temperatures remaining 1°C to 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 (NMFS 2009a). 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 since 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).

Peterson *et al*. (2006) shows the transition to colder ocean conditions, which began in 2007 and persisted through 2008. For juvenile salmon that entered the ocean in 2008, ocean indicators suggested a highly favorable marine environment (NMFS 2009a). 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, when sea surface temperatures also remained cold. Because coastal upwelling was initiated early and the larger, energy-rich, coldwater plankton species were present in large numbers during 2007 and 2008, ocean conditions in the broader California Current appear to have been favorable for salmon survival in 2007 and to a greater extent in 2008. 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 general ocean conditions in the North Pacific Ocean. 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 (*Sebastes jordani*), and common murre (*Uria aalge*) production along the California coast (MacFarlane *et al*. 2008 as cited in NMFS 2009a). In addition to its use as an indicator of general ocean productivity, the index may also relate to salmon dynamics due to their heavy reliance on krill and rockfish as prey items during early and later lifestages. 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 as cited in NMFS 2009a).

Available information suggests ocean conditions in 2007 and 2008 improved substantially over those observed in 2005 and 2006. The spring transition, which marks the beginning of the upwelling season and typically occurs between March and June, was earlier in 2007 and 2008, relative 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 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 (a mathematical representation of the vertical component of wind shear which represents the rotation of the vector field), which are negatively correlated with ocean productivity, were both poor (Wells and Mohr 2008).

Therefore, during the spring of 2007 and 2008, ocean conditions off California were indicative of a productive marine environment favorable for ocean salmon survival (and much improved over 2005 and 2006). However, those conditions did not persist throughout the year, as Wells *et al*. (2008) index values observed in the summer of 2007 and 2008 were similar to those experienced in the summer of 2005 and 2006, two years marked by extremely low productivity of salmon off the central California coast.

Changes in the state of the California Current since spring 2009 reflected a transition from cool La Niña conditions into and through a short-lived relatively weak El Niño event (Bjorkstedt *et al*. 2010). Weaker than normal upwelling and several extended relaxation events contributed to warming over much of the California Current during summer 2009, especially in the north. Moderation of La Niña conditions in the California Current coincided with the development of El Niño conditions in the equatorial Pacific, yet manifested well in advance of any evidence for direct effects of El Niño on the California Current. Responses to El Niño in fall 2009 and winter 2009–2010 appear to have varied substantially with latitude - conditions off southern California returned to near climatological values with the decline of La Niña, and did not indicate any subsequent response to El Niño, yet the northern California Current warmed substantially following the decline of La Niña and was strongly affected by intense downwelling during winter 2009–2010. The 2009–2010 El Niño diminished rapidly in early 2010, and upwelling off central and southern California resumed unusually early and strongly for a spring following an El Niño, but recovery from El Niño in early 2010 appears to be less robust in the northern California Current. Thus, despite dynamic changes in the overall state of the California Current, 2009–2010 continued the recent pattern of strong regional variability across the California Current (Bjorkstedt *et al*. 2010).

Responses to this climate sequence exhibited some consistent patterns across the California Current, but regional differences noted in recent State of the California Current reports appear to have persisted along the west coast of North America (Goericke *et al*. 2007, McClatchie *et al*. 2009). The transition from La Niña conditions appears to have unfolded well in advance of the arrival of direct effects of El Niño in the California Current in late 2009. Cool conditions related to the 2007–2008 La Niña abated in summer 2009, and, in general terms, hydrographic and ecological conditions from southern California north approached climatological values during summer 2009 (Bjorkstedt *et al*. 2010).

Warmer than usual conditions had already developed off Baja California in 2008 and persisted into the current year, but showed similar directional responses to climate variability as did regions to the north (Bjorkstedt *et al*. 2010). Overall, changes in the state of the California Current during 2009 coincided with the decay of La Niña conditions in the tropical Pacific Ocean. In the context of the general pattern of transition from La Niña to El Niño, differences between the northern and southern regions of the California Current are readily apparent. Off southern California, the general trend was for mean hydrographic, chemical, and biological properties of the system to return to long-term average conditions during summer 2009. In contrast, the northern California Current experienced anomalous warming of coastal waters and associated ecosystem responses, presumably as a consequence of anomalously weak and intermittent upwelling during 2009.

Likewise, regional differences and similarities are apparent from late fall 2009 through spring 2010, the period during which El Niño conditions propagated into the California Current and subsequently diminished. Off southern California, the arrival of El Niño was clearly indicated by anomalously high sea level, but responses to El Niño were limited to changes in isopyncnal depth—presumably related to the passage of poleward-propagating Kelvin waves and their lingering consequences (Bjorkstedt *et al*. 2010).

Coastal waters off Oregon and northern California were affected by unusually strong downwelling during winter 2009–2010. In neither case, however, was there any evidence for intrusion of unusual water masses such as had been observed during the strong 1997–1998 El

Niño. Relatively strong positive anomalies in temperature and salinity off southern Baja California suggest that the 2009–2010 El Niño influenced the southern extent of the California Current, but these changes appear to have been a consequence of local circulation patterns rather than anomalous poleward flows (Bjorkstedt *et al*. 2010).

Copepod assemblages observed at mid-shelf stations off northern California and Oregon continued to show marked seasonal variation, with high abundances developing over the summer and into the fall and subsequently declining over the winter (Bjorkstedt *et al*. 2010). Total abundance of copepods over the shelf appears to have been lower or later in developing in summer 2009 than in 2008 in sampled areas of the northern California Current. Patterns in assemblage structure, as indicated by the abundance of species particular biogeographic affinities [*e.g.*, southern (warm) v. northern (cold), neritic v. oceanic, (Hooff and Peterson 2006)], show a substantial degree of coherence since 2008, particularly at stations north of Cape Mendocino. Compared to winter 2009, the composition of copepod assemblages off Oregon and northern California shifted strongly towards being dominated by southern and oceanic species by winter 2010. Southern taxa were abundant off Bodega Bay in late 2008, coincident with warm temperatures, but largely disappeared from mid-shelf waters in early 2009, possibly as a consequence of intense transport. Although warm water and reduced flows were observed in summer 2009 off Bodega, total copepod abundance did not reach high abundances and southern taxa did not assume a dominant place in the assemblage until winter 2010 (Bjorkstedt *et al*. 2010).

Catches of juvenile salmonids in pelagic surface trawl surveys were unusually low during September 2009 (Bjorkstedt *et al*. 2010). The fewest juvenile coho salmon (*O. kisutch)*, 2 compared to maximum catch of 158 in 1999) and sub-yearling Chinook salmon (2 versus 465 in 2001) were caught since the beginning of the time series in 1998. Overall spring 2009 appeared to be relatively good for salmon marine survival but oceanographic conditions appear to have deteriorated for salmon by late summer 2009 (Bjorkstedt *et al*. 2010).

In 2008 and 2009, poor Sacramento returns, primarily supported by Sacramento River fall-run Chinook salmon, led to the largest fishery closure on record. In 2009, adult spawning escapement for Sacramento River fall Chinook salmon failed to meet the escapement goal (122,000-180,000 adults) for the third year in a row, leading to the formal declaration of an overfishing concern (although fishing is not considered one of the major causes of the stock’s decline). The forecast for the index of ocean abundance in 2010 was 245,500 adults, which provided adequate numbers for limited fisheries (PFMC 2011).

Ecosystem observations offer further suggestion of regional variation in responses to El Niño, but it must be noted that such comparisons are limited by disparity in available data sets (Bjorkstedt *et al*. 2010). Off southern California, estimates of nutrient concentrations, chlorophyll a standing stock, primary productivity, and zooplankton displacement volumes returned to “normal” levels, and did not show evidence for any decline associated with El Niño. In contrast, anomalies in chlorophyll a concentration shifted from positive to negative off Baja California, especially north of Point Eugenia, despite the lack of concomitantly strong changes in hydrographic conditions. Responses at higher trophic levels are much more difficult to connect to simple indices of climate variability, but provide insight to the potential magnitude of ecosystem responses to conditions leading into spring 2009 and the consequences of the 2009–2010 El Niño relative to previous El Niños.

Positive shifts in indices of abundance for the juvenile groundfish assemblage off central California and breeding success of Cassin's Auklet (*Ptychorampus aleuticus*) in 2009 are consistent with the persistence of cool conditions into spring 2009. Interestingly, the pelagic juvenile groundfish assemblage did not appear to collapse in 2010, suggesting that El Niño conditions did not substantially diminish productivity available to these taxa during critical lifestages during winter and early spring. In contrast, juvenile salmonids at sea in the northern region of the California Current appear to have fared poorly during the warmer than usual conditions of summer and fall 2009. Changes in the copepod assemblage off Oregon were consistent with warmer conditions that do not favor salmon production (Peterson and Schwing 2003, Peterson *et al*. 2010).

In summary, the significant changes in the state of the California Current during 2009 and early 2010 appear to have been more closely associated with diminishment of La Niña conditions than direct effects of El Niño (Bjorkstedt *et al*. 2010). The signature of the 2009–2010 El Niño throughout much of the California Current was substantially weaker than that of the strong 1997–1998 El Niño when influxes of more tropical waters were observed throughout the California Current. While the 2009–2010 El Niño is perhaps most comparable to the mild 2002–2003 El Niño, direct comparisons between the two events are confounded by the interaction of the 2002–2003 El Niño with a coincident intrusion of subarctic water that affected much of the California Current (Venrick *et al*. 2003). The more dramatic changes observed during 2009–2010 in the northern California Current might reflect responses to atmospheric forcing favoring coastal warming absent countervailing subarctic influences. Because a transition to moderate La Niña conditions was forecast for summer 2010, the past year might represent a temporary interruption of an otherwise cool period in the California Current (Bjorkstedt *et al*. 2010).

NMFS (2009a) suggests that 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) state that climate patterns would not likely be the sole cause but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans. Thus, the efforts to try and gain a greater understanding of the role ocean conditions play in salmon productivity will continue to provide valuable information that can be incorporated into the management of these species and should continue to be pursued. However, the highly variable nature of these environmental factors makes it very difficult, if not impossible, to accurately predict what they will be like in the future. Because the potential for poor ocean conditions exists in any given year, and because 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 (NMFS 2009a).

Global Climate Change

Warming over this century is projected to be considerably greater than over the last century (Thomas *et al*. 2009). Since 1900, the global average temperature has risen by about 1.5°F. By about 2100, it is projected to rise between 2°F and 10.5°F, but could increase up to 11.5°F (Thomas *et al*. 2009, California Climate Change Center 2006). In the United States, the average temperature has risen by a comparable amount and is very likely to rise more than the global average over this century, with some variation according to location. Regarding climate change impacts already being observed, the Sierra Nevada Alliance (2008) reports that seven of the largest Sierra glaciers have retreated by 30 to 70 percent in the past 100 years. Changes observed over the past several decades also have shown that the earth is warming, and scientific evidence suggests that increasing greenhouse gas emissions are changing the earth's climate (Moser *et al*. 2009). Accumulating greenhouse gas concentrations in the earth's atmosphere have been linked to global warming, and projected future trends of increasing atmospheric greenhouse gas concentrations suggest global warming will continue (National Research Council 2001). Several factors will determine future temperature increases. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are substantially reduced. If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range (NMFS 2009).

Global climate change has the potential to impact numerous environmental resources in California through potential, though uncertain, impacts related to future air temperatures and precipitation patterns, and the resulting implications to stream runoff rate and timing, water temperatures, reservoir operations, and sea levels. Although current models are broadly consistent in predicting increases in probable global air temperatures and increasing levels of greenhouse gasses resulting from human activities, there are considerable uncertainties about precipitation estimates. For example, many regional modeling analyses conducted for the western United States indicate that overall precipitation will increase, but uncertainties remain due to differences among larger-scale General Circulation Models (GCMs) (Kiparsky and Gleick 2003). Some researchers believe that climate warming might push the storm track on the West Coast further north, which would result in drier conditions in California. At the same time, relatively newer GCMs, including those used in the National Water Assessment, predict increases in California precipitation (DWR 2005). Similarly, two popular climate models, including HadCM2 developed by the U.K. Hadley Center and PCM developed by the U.S. National Center for Atmospheric Research, also predict very different future scenarios. The HadCM2 predicts wetter conditions while the PCM predicts drier conditions (Brekke *et al*. 2004).

While much variation exists in projections related to future precipitation patterns, all available climate models predict a warming trend resulting from the influence of rising levels of greenhouse gasses in the atmosphere (Barnett *et al*. 2005). The potential effects of a warmer climate on the seasonality of runoff from snowmelt in the Central Valley have been well-studied and results suggest that melt runoff will likely shift from spring and summer to earlier periods in the water year (Vanrheenen *et al*. 2001). Presently, snow accumulation in the Sierra Nevada acts as a natural reservoir for California by delaying runoff from winter months when precipitation is high (Kiparsky and Gleick 2003). However, compared to present water resources development, Null *et al*. (2010) report that watersheds in the Northern Sierra Nevada are most vulnerable to decreased mean annual flow, southern-central watersheds are most susceptible to runoff timing changes, and the central portion of the range is most affected by longer periods with low flow conditions. Despite the uncertainties about future changes in precipitation rates, it is generally believed that higher temperatures will lead to changes in snowfall and snowmelt dynamics. Higher atmospheric temperatures will likely increase the ratio of rain to snow, shorten and delay the onset of the snowfall season, and accelerate the rate of spring snowmelt, which would lead to more rapid and earlier seasonal runoff relative to current conditions (Kiparsky and Gleick 2003). Studies suggest that the spring stream flow maximum could occur about one month earlier by 2050 (Barnett *et al*. 2005).

If air temperatures in California rise significantly, it will become increasingly difficult to maintain appropriate water temperatures in order to manage coldwater fisheries, including salmonids. A reduction in snowmelt and increased evaporation could lead to decreases in reservoir levels and, perhaps more importantly, coldwater pool reserves (California Energy Commission 2003). As a result, increasing air temperatures, particularly during the summer, lead to rising water temperatures in rivers and streams, which increase stress on coldwater fish. Projected temperatures for the 2020s and 2040s under a higher emissions scenario suggest that the habitat for these fish is likely to decrease dramatically (Mote *et al*. 2008, Salathé 2005, Keleher and Rahel 1996, McCullough *et al*. 2001). Reduced summer flows and warmer water temperatures will create less favorable instream habitat conditions for coldwater fish species. In the Central Valley, by 2100 mean summer temperatures may increase by 2 to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern Sierra Nevada mountains (NMFS 2009). Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley. As with their ocean phase, Chinook salmon and steelhead will be more thermally stressed by stream warming at the southern ends of their ranges (*e.g.*, Central Valley Domain). For example, warming at the lower end of the predicted range (about 2°C) may allow CV spring-run Chinook salmon to persist in some streams, while making some currently utilized habitat inhospitable (Lindley *et al*. 2007). At the upper end of the range of predicted warming, very little CV spring-run Chinook salmon habitat is expected to remain suitable (Lindley *et al*. 2007).

Under the expected warming of around 5°C, substantial amounts of habitat would be lost, with significant amounts of habitat remaining primarily in the Feather and Yuba rivers, and remnants of habitat in the upper Sacramento, McCloud, and Pit rivers, Battle and Mill creeks, and the Stanislaus River (Lindley *et al*. 2007). Under the less likely but still possible scenario of an 8°C warming, CV spring-run Chinook salmon habitat would be found only in the upper-most reaches of the north fork Feather River, Battle Creek, and Mill Creek. This simple analysis suggests that CV salmonids are vulnerable to warming, but more research is needed to evaluate the details of how warming would influence individual populations and subbasins.

As summarized by Lindley *et al*. (2007), climate change may pose new threats to Central Valley salmonids by reducing the quantity and quality of freshwater habitat. Under the worst case scenario, CV spring-run Chinook salmon may be driven extinct by warming in this century, while the best-case scenario may allow them to persist in some streams, although prediction of the future status of Central Valley salmonids associated with long-term climate change is fraught with uncertainty.

Ocean Acidification

Ocean acidification has been called a “sister” or co-equal problem to climate change because it is caused by the same human-caused production of large amounts of CO_2. Its impacts are additional to, and may exacerbate, the effects of climate change (Alaska Marine Conservation Council 2011).

Seawater pH is a critical variable in marine systems. Today’s surface ocean water is slightly alkaline, with a pH ranging from 7.5 to 8.5 and it is saturated with calcium carbonate, a very important organic molecule for organisms like corals, mollusks and crustaceans that make shells. As CO_2 reacts with the seawater, it lowers the pH and releases hydrogen ions. These ions bind strongly with carbonate, preventing it from forming the important calcium carbonate molecules. If the pH of the global oceans drops 0.4 by the end of the century as predicted, the levels of calcium carbonate available for use by marine organisms will decrease by 50 percent (Alaska Marine Conservation Council 2011).

Ocean acidification is likely to alter the biodiversity of the world’s marine ecosystems and may affect the total productivity of the oceans. Previously it was thought that these changes would take centuries, but new findings indicate that an increasingly acidic environment could cause problems in high-latitude marine ecosystems within just a few decades (Alaska Marine Conservation Council 2011).

Currently, the oceans’ surface water layers have sufficient amounts of calcium carbonate for organisms to use (known as saturated conditions). This calcium carbonate rich layer is deeper in warmer regions and closer to the surface in colder regions. Because calcium carbonate is less stable in colder waters, marine life in the polar oceans will be affected by calcium carbonate loss first. A study published in Nature by 27 U.S. and international scientists stated, “*Some polar and sub-polar waters will become under-saturated [at twice the pre-industrial level of* CO_2*, 560 ppm], probably within the next 50 years*” (Orr *et al*. 2005). Under-saturated refers to conditions in which the seawater has some calcium carbonate remaining, but it does not have enough available for the organisms to build strong shells (Alaska Marine Conservation Council 2011). Research has shown that lowered ocean pH will affect the processes by which animals such as corals, mollusks and crustaceans make their support structures. Because these organisms depend on calcium carbonate, increasing acidity threatens their survival. At higher levels of acidity (lower pH levels), any organism that forms a shell through calcification — from clams to pteropods — could be adversely affected. These species use the naturally occurring carbonate minerals calcite and aragonite for the calcification process.

Pteropods are small planktonic mollusks that are at the bottom of the food chain and because of their dependence on calcium carbonate, they will be one of the first casualties of increasing acidity in Alaska's marine waters. In recent experiments exposing live pteropods to the conditions predicted by “business-as-usual” carbon emission scenarios – the pteropod shells showed evidence of dissolution and damage within only 48 hours. Pteropods are a key food source for salmon and other species (Alaska Marine Conservation Council 2011). Increased research into ocean acidification caused by the saturation of water with carbon dioxide suggests that a 10 percent decline in pteropod production can lead to a 20 percent reduction in the body weight of mature salmon (Climate Solutions 2011). A decrease in these mineral levels to food web base species like pteropods, also known as sea butterflies, which make up 45 percent of the diet for juvenile pink salmon, can cause cascading waves of disruption up the food chain (Climate Solutions 2011).

Ecosystem Restoration

Restoration efforts in the Central Valley are mainly funded by State and Federal agencies through the ERP. This program (formerly started under CALFED) was created to improve conditions for fish, including listed salmonids (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 (listed above) affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for steelhead and CV spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fish monitoring and evaluation programs

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), The B2 Water Program. 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 spawning gravel replenishment. The AFRP 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 B2 Program sets aside 800 TAF of CVP water annually for improving instream flows for salmonids and meeting water quality objectives in the Delta.

Summary of Factors Affecting the Species and Critical Habitat

For CV spring-run Chinook salmon, the construction of impassable dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent), 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 CV spring-run Chinook salmon 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 rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species.

CV spring-run Chinook salmon spawning in lower elevation habitats also exposes CV spring-run Chinook salmon to effects associated the presence of fall-run Chinook salmon. These effects can included genetic influences and redd super imposition.

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 CV spring-run Chinook salmon. 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 completed and benefits to listed salmonids from the EWA have been less than anticipated.

(6) Description of Viable Salmonid Population (VSP) Parameters

The “Viable Salmonid Population” (VSP) concept was developed by McElhany *et al*. (2000) to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. Four key parameters were identified by McElhany *et al*. (2000) as the key to evaluating population viability status: (1) abundance, (2) productivity, (3) diversity, and (4) spatial structure. McElhany *et al*. (2000) interchangeably use the term population growth rate (*i.e.,* productivity over the entire life cycle) and productivity. Good *et al*. (2007) used the term productivity when describing this VSP parameter, which also is the term used for this parameter in this BA. The following discussion regarding the four population viability population parameters was taken directly from NMFS (2009).

Abundance is an important determinant of risk, both by itself and in relationship to other factors (McElhany *et al*. 2000). Small populations are at a greater risk for extinction than larger populations because risks that affect the population dynamics operate differently on small populations than in large populations. A variety of risks are associated with the dynamics of small populations, including directional effects (*i.e.*, density dependence - compensatory and depensatory), and random effects (*i.e.*, demographic stochasticity, environmental stochasticity, and catastrophic events).

The parameter of productivity and factors that affect productivity provide information on how well a population is “performing” in the habitats it occupies during the life cycle (McElhany *et al*. 2000). Productivity and related attributes are indicators of a population’s performance in response to its environment and environmental change and variability. Intrinsic productivity (the maximum production expected for a population sufficiently small relative to its resource supply not to experience density dependence), the intensity of density dependence, and stage-specific productivity (productivity realized over a particular part of the life cycle) are useful in assessing productivity of a population.

Diversity refers to the distribution of traits within and among populations, and these traits range in scale from DNA sequence variation at single genes to complex life-history traits (McElhany *et al*. 2000). Traits can be completely genetic or vary due to a combination of genetics and environmental factors. Diversity in traits is an important parameter because: (1) diversity allows a species to use a wide array of environments, (2) diversity protects a species against short-term spatial and temporal changes in its environment, and (3) genetic diversity provides the raw material for surviving long-term environmental changes (McElhany *et al*. 2000). Some of the varying traits include run timing, spawning timing, age structure, outmigration timing, etc. Straying and gene flow strongly influence patterns of diversity within and among populations (McElhany *et al*. 2000).

Spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure encompasses the geographic distribution of that population, as well as the processes that generate or affect that distribution (McElhany *et al*. 2000). A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics as well as the dispersal characteristics of individuals in the population. Potentially suitable but unused habitat is an indication of the potential for population growth.

To determine the current viability of the CV spring-run Chinook salmon ESU, NMFS (2009a) used the historical population structure of CV spring-run Chinook salmon presented in Lindley *et al*. (2007) and the concept of VSP for evaluating populations described by McElhany *et al*. (2000). Lindley *et al*. (2004) identified 26 historical populations within the spring-run ESU; 19 were independent populations, and 7 were dependent populations. Of the 19 independent populations of spring-run that occurred historically, only three remain, in Deer, Mill, and Butte creeks. Extant dependent populations occur in Battle, Antelope, Big Chico, Clear, Beegum, and Thomes creeks, as well as in the Yuba River, the Feather River below Oroville Dam, and in the mainstem Sacramento River below Keswick Dam (NMFS 2009a).

Lindley *et al*. (2007) provide criteria to assess the level of risk of extinction of Pacific salmonids based on population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. Although these criteria were developed for application to specific populations, insight to the viability of the CV spring-run Chinook salmon ESU can be obtained by examining population trends within the context of these criteria.

<u>Abundance</u>

Historically CV spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast. These fish occupied the upper and middle elevation 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 1872, Rutter 1904, Clark 1929).

The Central Valley drainage as a whole is estimated to have supported CV spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of CV spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually. Construction of Friant Dam began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH spring-run Chinook salmon population has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of CV spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (CDWR 2001).

However, after 1981, CDFG (now California Department of Fish and Wildlife (CDFW)) ceased to estimate in-river spawning CV spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. CV spring-run Chinook salmon estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,783 fish in 2011 (CDFW 2013). Genetic testing has indicated that substantial introgression has occurred between fall-run and CV spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (CDWR 2001).

Because Chinook salmon have not always been spatially separated in the FRFH, CV spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock (Good *et al.* 2005, CDWR and CDFG 2012). In addition, coded-wire tag (CWT) information from these hatchery returns has indicated that fall-run and CV spring-run Chinook salmon have overlapped (CDWR 2001). For the reasons discussed above, the FRFH spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

In addition, monitoring of the Sacramento River mainstem during CV spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of CV spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon has made identification of CV spring-run Chinook salmon in the mainstem very difficult to determine, and there is speculation as to whether a true CV spring-run Chinook salmon population still exists in the Sacramento River downstream of Keswick Dam. Although the physical habitat conditions downstream of Keswick Dam are capable of supporting CV spring-run Chinook salmon, higher than normal water temperatures in some years have led to substantial levels of egg mortality. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam (RBDD), ranging from 3 to 105 redds. Zero redds were observed in 2012; and in 2013 57 redds were observe in September (Corps 2013b). This is typically when spring-run spawn, however, these redds also could be early spawning fall-run Chinook salmon. Therefore, even though physical habitat conditions may be suitable for spawning and incubation, CV spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With fall-run Chinook salmon spawning occurring in the same time and place as potential CV spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occured (CDFG 1998). For these reasons, Sacramento River mainstem CV spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table VII-2). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000. During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish and just over 1,000 fish, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remained 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 (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a 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 Chinook salmon in Butte Creek due to the diseases.

From 2005 through 2011, abundance numbers in most of the tributaries have declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011b). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 is nearly sufficient to classify it as a high extinction risk based on this criteria. Some other tributaries to the

Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. Year 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased in most tributary populations, which resulted in the second highest number of CV spring-run Chinook salmon returning to the tributaries since 1960.

Table VII-2. CV Spring-run Chinook salmon population estimates from CDFW Grand Tab (CDFW 2013) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.54	4,795	1.63	1.36
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,534	6,746	23,788	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24
2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,869	4,135	12,734	9,917	0.54	2.09	14,301	0.55	1.30
2002	17,224	4,189	13,035	12,242	2.13	2.35	16,733	1.75	1.46
2003	17,691	8,662	9,029	9,290	1.63	2.17	14,165	1.92	1.43
2004	13,612	4,212	9,400	9,948	0.74	1.79	14,919	0.81	1.37
2005	16,096	1,774	14,322	11,704	1.10	1.23	16,298	0.93	1.19
2006	10,948	2,181	8,767	10,911	0.97	1.31	15,114	0.62	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,615	0.71	1.00
2008	6,368	1,624	4,744	8,857	0.33	0.78	11,350	0.40	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,388	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.54	6,927	0.39	0.49
2011	4,967	1,969	3,067	3,961	0.65	0.47	5,731	0.78	0.53
2012	18,275	7,465	10,810	4,713	3.84	1.09	7,441	4.81	1.34
2013	38,556	20,057	18,499	7,464	8.68	2.76	13,878	2.00	0.86
Median	10,962	4,456	6,508	6,324	2.08	1.83	10,258	1.00	1.29

[a] NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.
[b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

Productivity

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). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation.

The CV spring-run Chinook salmon run size estimate for the Sacramento River system (not including the FRFH or the lower Yuba River) over the past three consecutive years totaled 26,912 fish, thereby exceeding both the minimum total escapement value of 2,500 (Lindley *et al*. 2007), as well as the mean value of 833 fish per year identified by NMFS (2011a).

From 1983 through 2012, the annual contribution of CV spring-run Chinook salmon from the FRFH to the total annual run size in the Sacramento River system has ranged from a high of 76.9 percent (4,672 fish) in 1993 to a low of 5.6 percent (1,433 fish) in 1986. As an indicator of the FRFH influence on CV spring-run Chinook salmon in the Sacramento River system, the average annual percent contribution of FRFH spring-run Chinook salmon relative to the total annual run in the Sacramento River system was 31.2 percent over the entire 30-year period (1983-2012), and was 20.7 percent over the last 10 years (2003-2012). The percent contribution of FRFH to the total population of CV spring-run Chinook salmon does not represent straying *per se*. The guidelines presented in Figure 1 in Lindley *et al*. (2007) present extinction risk levels corresponding to different amount, duration and source of hatchery strays, taking into consideration whether hatchery strays are from within the ESU, the diversity group, and from a "best management practices" hatchery. These criteria indicate a high extinction risk if hatchery straying represents more than 20 percent hatchery contribution for one generation or more than 10 percent for four generations from a hatchery within a given diversity group, or more than 50 percent hatchery contribution for one generation or more than 15 percent for four generations from a best management practices hatchery within a given diversity group. Although not technically representing straying, the average contribution of CV spring-run Chinook salmon from the FRFH to the total annual run size in the Sacramento River system has been 26.4 percent over the most recent generation, 21.6 percent over the two most recent generations, 19.8 percent over the three most recent generations, and 19.9 percent over the four most recent generations assuming a three-year life cycle. According to NMFS (2011a), recent anomalous conditions in the coastal ocean, along with consecutive dry years affecting inland freshwater conditions, have contributed to statewide escapement declines.

From 1993 to 2007 the 5-year moving average of the tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011. The CRR for the 2012 combined tributary population was 3.84, due to increases in abundance for most populations.

Spatial Structure

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure VII-1) (Lindley *et al.* 2004). Of these 18 populations, only three extant populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995. The northwestern California diversity group did not historically contain independent populations, and currently contains two or three populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Construction of low elevation dams in the foothills of the Sierras on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers, has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps naturally-occurring populations may still persist in the Stanislaus and Tuolumne rivers (Corps 2013b). Naturally-spawning populations of CV spring-run Chinook salmon are currently 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 the Yuba River (CDFG 1998).

Spatial structure refers to the arrangement of populations across the landscape, the distribution of spawners within a population, and the processes that produce these patterns. Species with a restricted spatial distribution and few spawning areas are at a higher risk of extinction from catastrophic environmental events (*e.g.*, a single landslide) than are species with more widespread and complex spatial structure. Species or population diversity concerns the phenotypic (morphology, behavior, and life-history traits) and genotypic (DNA) characteristics of populations. Phenotypic diversity allows more populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genotypic diversity (DNA), on the other hand, provides populations with the ability to survive long-term changes in the environment. To meet the objective of representation and redundancy, diversity groups need to contain multiple populations to survive in a dynamic ecosystem subject to unpredictable stochastic events, such as pyroclastic events or wild fires.

With only one of four diversity groups currently containing viable independent populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon adult returns are currently utilizing all available habitat in the creek, and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration projects completed and more underway, are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the CV spring-run Chinook salmon

ESU would still be lacking due to the extirpation of all San Joaquin River basin CV spring-run Chinook salmon populations, however recent information suggests that perhaps a self-sustaining (capable of reproducing without hatchery influence) population of CV spring-run Chinook is occurring in some of the San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne rivers.

Snorkel surveys (Kennedy T. and T. Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate CV spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult CV spring-run Chinook salmon (Anderson *et al.* 2007). Genetic testing is needed to confirm that these fish are CV spring-run Chinook salmon, to determine which strain they are. Finally, rotary screw trap (RST) data provided by Stockton USFWS corroborates the CV spring-run Chinook salmon adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration (Corps 2013b). Plans are underway to re-establish a CV spring-run Chinook salmon population in the San Joaquin River downstream of Friant Dam, as part of the San Joaquin River Restoration Program. Interim flows for this began in 2009 and CV spring-run Chinook salmon are expected to be released in 2013. The San Joaquin River Restoration Programs' future long-term contribution to the CV spring-run Chinook salmon ESU is uncertain.

Recovery criteria for each diversity group have been specifically laid out in the draft Central Valley Salmon and Steelhead Recovery Plan (NMFS 2009b). According to the criteria, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, are needed for recovery. It is clear that further efforts will need to involve more than restoration of currently accessible watersheds to make the ESU viable. The draft Central Valley Salmon and Steelhead Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams, such as the reintroduction of a population upstream of Shasta Dam, and to facilitate passage of fish upstream of Englebright Dam on the Yuba River (NMFS 2009b).

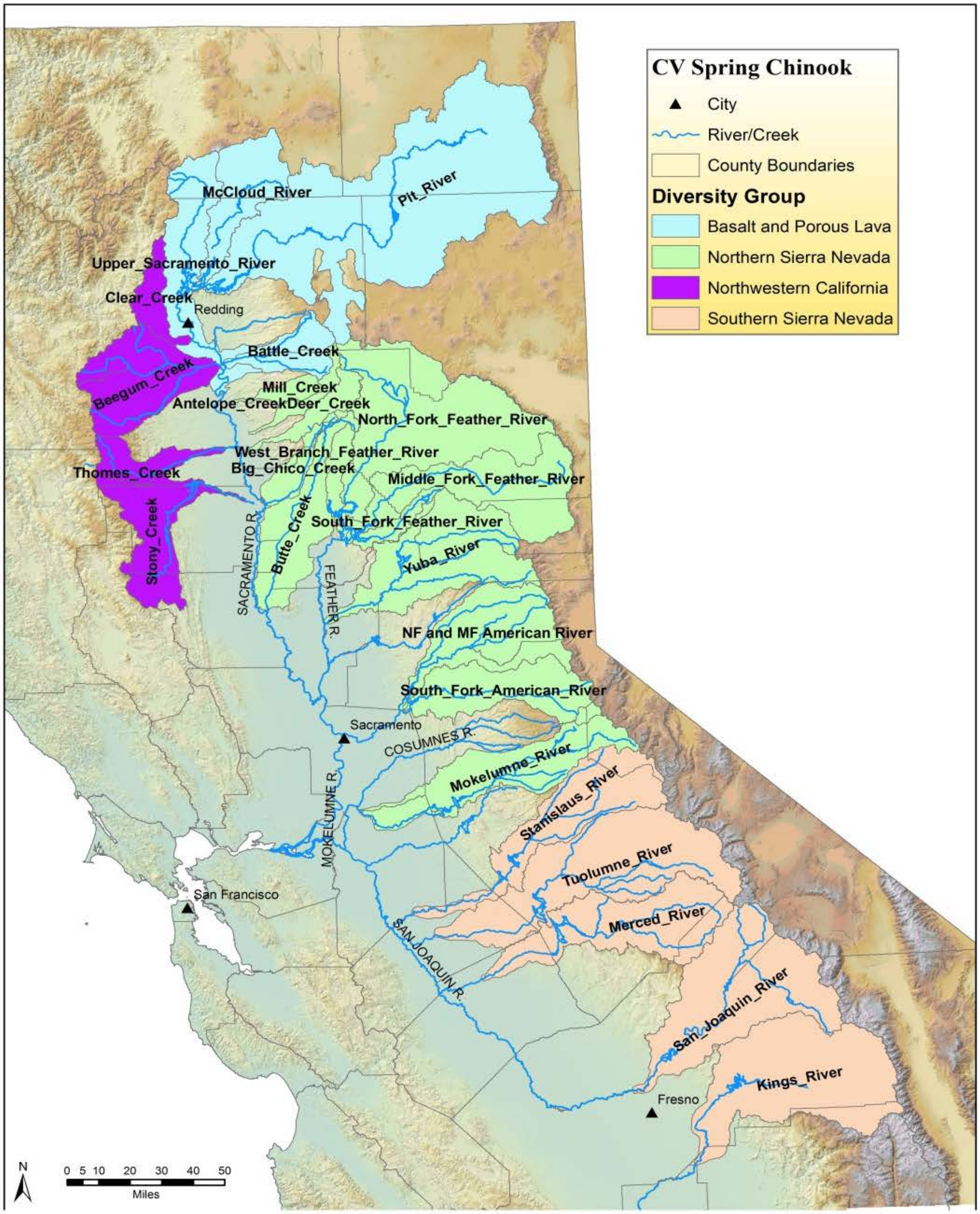


Figure VII-1. Diversity Groups for the CV spring-run Chinook salmon ESU.

Diversity

As discussed in NMFS (2009a), 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. CV spring-run Chinook salmon reserve some genetic and behavioral variation in that in any given year, at least two cohorts are in the marine environment and, therefore, are not exposed to the same environmental stressors as their freshwater cohorts (NMFS 2009a).

Analysis of natural and hatchery CV spring-run Chinook salmon stocks indicates that the northern Sierra Nevada diversity group CV spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retains genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised through introgresesion. Despite the introgression, spring-run produced at the FRFH display some unique characteristics that may be part of the historic Sierra Nevada genetics and because of this they are included as part of the CV spring-run Chinook salmon ESU (70 FR 37160, June 28, 2005), although current hatchery practices compromises their genetic diversity of naturally-spawned CV spring-run Chinook salmon (California HSRG 2012).

The CV spring-run Chinook salmon ESU fails to meet the "representation and redundancy rule," since the northern Sierra Nevada is the only diversity group in the CV spring-run Chinook salmon ESU that contains demonstrably viable populations out of at least three diversity groups that historically contained them. The Northwestern California diversity group contains a few smaller populations of CV spring-run Chinook salmon that are likely currently dependent on the northern Sierra Nevada populations for their continued existence. The CV spring-run Chinook salmon populations that historically occurred in the basalt and porous lava, and southern Sierra Nevada diversity groups have been extirpated, although a small population in Battle Creek has been reestablished and has persisted over the last 15 years.

Summary of ESU Viability

Lindley *et al.* (2007) indicated that the spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run Chinook salmon population failed to meet the "representation and redundancy rule" since there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them. Over the long term, these remaining 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 CV spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other.

In the 2011 California CV status review for spring-run Chinook salmon, NMFS identified the status of CV spring-run Chinook salmon ESU as having declined since the 2005 status review and Lindley *et al.*'s (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of CV spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk.

In the 2011, status review for CV spring-run Chinook salmon, the ESU as a whole could not be considered viable because there were no extant viable populations in the three other diversity groups. Since 2011, the abundance of several populations has increased and the extinction risk of Sacramento tributary populations generally has improved from high to moderate.

(B) CCV Steelhead

CCV Steelhead DPS
Listed as threatened on March 19, 1998 (63 FR 13347)
Reaffirmed as threatened January 5, 2006 (71 FR 834), and August 15, 2011 (76 FR 157)

California Central Valley Steelhead designated critical habitat
Designated September 2, 2005 (70 FR 52488)

(1) Species Listing History

California Central Valley (CCV) steelhead were originally listed as threatened on March 19, 1998, (63 FR 13347). Following a new status review (Good *et al.* 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the Feather River Hatchery and Coleman National Fish Hatchery stocks as part of the DPS in 2006 (71 FR 834). In June 2004, after a complete status review of 27 west coast salmonid evolutionarily significant units (ESUs) and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS (71 FR 834). On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011c). Critical habitat was designated for CCV steelhead on September 2, 2005, (70 FR 52488).

(2) Critical Habitat Designation

On February 16, 2000, (65 FR 7764), NMFS published a final rule designating critical habitat for CCV steelhead. This critical habitat includes all river reaches accessible to listed steelhead in the Sacramento and San Joaquin rivers and their tributaries in California, including the lower Yuba River upstream to Englebright Dam. NMFS proposed new Critical Habitat for CV spring-run Chinook salmon and CCV steelhead on December 10, 2004, (69 FR 71880) and published a final rule designating critical habitat for these species on September 2, 2005.

Critical habitat for CCV 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 San Joaquin River, including its tributaries, and the waterways of the Delta (Figure VII-2). Currently the CCV steelhead DPS and critical habitat extends up the San Joaquin River up to the confluence with the Merced River. 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 bank full 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, 70 FR 52488). Critical habitat for CCV steelhead is defined as specific areas that contain the primary constituent elements (PCEs) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CCV steelhead:

<u>Spawning Habitat</u>

On February 16, 2000 (65 FR 7764), NMFS published a final rule designating critical habitat for CCV steelhead. This critical habitat includes all river reaches accessible to listed steelhead in the Sacramento and San Joaquin rivers and their tributaries in California, including the lower Yuba River upstream to Englebright Dam. NMFS proposed new Critical Habitat for CV spring-run Chinook salmon and CCV steelhead on December 10, 2004 (69 FR 71880) and published a final rule designating critical habitat for these species on September 2, 2005.

<u>Freshwater Rearing Habitat</u>

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile salmonid 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 piscivorous fish and birds. Freshwater rearing habitat also has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

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 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 stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

Estuarine Areas

Estuarine areas, such as the San Francisco Bay and the downstream portions of the Sacramento-San Joaquin Delta, free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large woody material, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging.

The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

Nearshore Coastal Marine and Offshore Marine Areas

The most recent discussion of PCEs for the CCV steelhead DPS (NMFS 2009a) did not include the PCEs of nearshore coastal marine and offshore marine areas. Although relatively little is known about steelhead utilization of nearshore coastal marine and offshore marine areas, it is reasonable to assume that the discussion of these PCEs previously provided for spring-run Chinook salmon in Section 4.1 of this BA generally is applicable to steelhead.

(3) Historical Distribution and Abundance

CCV steelhead historically occurred naturally throughout the Sacramento and San Joaquin River basins, although stocks have been extirpated from large areas in both basins. The California Advisory Committee on Salmon and Steelhead (CDFG 1988) reported a reduction in freshwater CCV steelhead habitat from 6,000 linear miles historically to 300 linear miles of stream habitat.

NMFS (2009) reported that prior to dam construction, water development and watershed perturbations, CCV steelhead were distributed throughout the Sacramento and San Joaquin rivers (Busby *et al*. 1996, McEwan 2001). CCV steelhead were found from the upper Sacramento and Pit rivers (now inaccessible due to Shasta and Keswick dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al*. 1996). Lindley *et al*. (2006) estimated that historically there were at least 81 independent CCV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers. Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006). Existing wild steelhead stocks in the California Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope Creek, Deer Creek, and Mill Creek, 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 2001).

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, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001).

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, as cited in NMFS 2009). Incidental catches and observations of steelhead juveniles 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). Naturally spawning populations of CCV steelhead also occur in the Feather, Yuba, American, and Mokelumne rivers, but these populations have had substantial hatchery influence and their ancestries are not clear (Busby *et al*. 1996). CCV steelhead runs in the Feather and American rivers are sustained largely by the FRFH and Nimbus Hatchery (McEwan and Jackson 1996). CCV steelhead also currently occur in the Stanislaus, Calaveras, Merced, and Tuolumne rivers (NMFS 2009).

Historic CCV steelhead run sizes are difficult to estimate because of the lack of data, but McEwan (2001) suggested that CCV steelhead run sizes may have approached one to two million adults annually. McEwan and Jackson (1996) suggested that by the early 1960s, the CCV steelhead run size had declined to about 40,000. Over the last 30 years the CCV steelhead populations in the upper Sacramento River have declined substantially (NMFS 2009). In 1996, NMFS estimated the Central Valley total run size based on dam counts, hatchery returns, and past spawning surveys was probably fewer than 10,000 fish. Both natural and hatchery runs have declined since the 1960s. Counts at RBDD averaged 1,400 fish from 1991 to 1996, compared to counts in excess of 10,000 fish in the late 1960s (McEwan and Jackson 1996). American River redd surveys and associated monitoring from 2002 through 2007 indicate that only a few hundred CCV steelhead spawn in the river and a portion of those spawners originated from Nimbus Hatchery (Hannon and Deason 2008).

Specific information regarding CCV steelhead spawning within the mainstem Sacramento River is limited due to lack of monitoring (NMFS 2004). Currently, the number of CCV steelhead spawning in the Sacramento River is unknown because redds cannot be distinguished from a large resident rainbow trout population that has developed as a result of managing the upper Sacramento River for coldwater species.

The lack of sustained monitoring programs for steelhead throughout most of the California Central Valley persists to the present time. There is a paucity of reliable data to estimate run sizes of steelhead in the Central Valley, particularly wild stocks. However, some steelhead escapement monitoring surveys have been initiated in upper Sacramento River tributaries (*e.g.*, Beegum, Deer, and Antelope creeks) using snorkel methods similar to CV spring-run Chinook salmon escapement surveys (NMFS 2009a).

There is a general lack of steelhead population monitoring in most of the Central Valley (NMFS 2009a). Lindley *et al*. (2007) stated that there are almost no data with which to assess the status of any of the CCV steelhead populations. They further stated that CCV steelhead populations are classified as data deficient, with the exceptions restricted to streams with long-running hatchery programs including Battle Creek and the Feather, American and Mokelumne rivers.

According to NMFS (2007a), in the *Updated Status Review of West Coast Salmon and Steelhead* (Good *et al*. 2005), the Biological Review Team made the following conclusion based on steelhead Chipps Island trawl 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."

(4) Species Life History

Steelhead exhibits perhaps the most complex suite of life-history traits of any species of Pacific salmonid. Members of this species can be anadromous or freshwater residents and, under some circumstances, members of one form can yield offspring of another form.

<u>Adult Migration and Holding</u>

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter. CCV steelhead are known to use the Sacramento River as a migration corridor to spawning areas in upstream tributaries. Historically, steelhead likely did not utilize the mainstem Sacramento River downstream from the present location of Shasta Dam, except as a migration corridor to and from headwater streams (NMFS 2009).

Spawning

Central Valley adult steelhead generally begin spawning in late December and spawning extends through March, but also can range from November through April. Steelhead adults typically spawn from December through April with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock *et al*. 1961, McEwan 2001). Based on all available information collected to date, the RMT (2013) recently identified the steelhead spawning period as extending from January through April.
CCV steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer creeks, steelhead still have access to historical spawning areas (NMFS 2009a).

The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them (NMFS 2009). Spawning occurs mainly in gravel substrates (particle size range of about 0.2−4.0 inches). Sand-gravel and gravel-cobble substrates are also used, but these must be highly permeable and contain less than 5 percent sand and silt for the water to be able to provide sufficient oxygen to the incubating eggs. Adults tend to spawn in shallow areas (6−24 inches deep) with moderate water velocities (about 1 to 3.6 ft/s) (Bovee 1978 as cited in McEwan and Jackson 1996, Hannon and Deason 2007 as cited in Reclamation 2008). The optimal temperature range for spawning has been reported to range from 39 to 52°F (Bovee 1978, Reiser and Bjornn 1979, Bell 1986 all as cited in McEwan and Jackson 1996). Egg mortality begins to occur at 56°F (McEwan and Jackson 1996).

Unlike Chinook salmon, CCV steelhead may not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for two or three years. The percentage of adults surviving spawning is generally thought to be low for CCV steelhead, but varies annually and between stocks. Acoustic tagging of CCV steelhead kelts from the Coleman Hatchery indicates survival rates can be high, especially for CCV steelhead reconditioned by holding and feeding at the hatchery prior to release. Some return immediately to the ocean and some remain and rear in the Sacramento River (NMFS 2009a).

Kelts

Post-spawning steelhead (kelts) may migrate downstream to the ocean immediately after spawning, or they may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Recent studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo *et al.* 2011), but that most return to the ocean (Null *et al.* 2013).

Table VII-3. The temporal occurrence of (a) adult and (b) juvenile California CCV steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult migration																								
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1]Sacramento River near Fremont Weir	Low	Low	Low	Low	Low							Low	Low	Low	Low	Medium	High	High	High	Medium	Low	Low	Low	Low
[2]Sacramento R. at Red Bluff	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Medium	Medium	High	Medium	Low	Low	Low	Low
[3]Mill and Deer Creeks	Medium	Medium	High	Medium	Medium	Low	Low	Low	Low	Low	Low	Low							Medium	High	High	Low	Low	Low
[4]Mill Creek at Clough Dam	Low	Low	Medium	High	Medium	Medium	Low	Low										Low	Medium	High	High	High	Medium	Medium
[5]San Joaquin River	High	High	Medium	Medium	Low	Low							Low	Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	High	High

(b) Juvenile migration																								
Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,2]Sacramento River near Fremont Weir	Low	Low	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	Low	Low	Low	Medium	Medium	Medium	Medium	Low	Low
[6]Sacramento River at Knights Landing	High	High	High	High	Medium	Medium	Medium	Medium	Low	Low	Low	Low									Low	Low	Low	Low
[7]Mill and Deer Creeks (silvery parr/smolts)	Low	Low	Low	Low	Medium	High	High	High	High	High	Low	Low							Low	Low	Low	Low	Low	Low
[7]Mill and Deer Creeks (fry/parr)	Low	Low	Low	Low	Low	Low	Medium	Medium	High	High	High	High							Medium	Medium	Medium	Medium	Medium	Medium
[8]Chipps Island (clipped)	Medium	Medium	High	High	Medium	Medium	Low	Low	Low	Low													Low	Low
[8]Chipps Island (unclipped)	Medium	Medium	Medium	Medium	High	High	High	High	High	High	Medium	Medium	Low	Low									Low	Low
[9]Mossdale on San Joaquin River			Low	Low	Medium	Medium	High	High	High	High	Low	Low							Low	Low				
[10]Mokelumne R. (silvery parr/smolts)	Low	Low	Medium	Medium	Medium	Medium	High	High	High	High	Medium	Medium	Medium	Medium										
[10]Mokelumne R. (fry/parr)			Low	Low	Low	Low	Low	Low	Medium	Medium	High	High	Medium	Medium										
[11]Stanislaus R. at Caswell	Low	Low	Medium	Medium	High	High	Medium	Medium	Medium	Medium	Low	Low												
[12]Sacramento R. at Hood	Low	Low	High	High	High	High	High	High	High	High	High										Low	Low	Low	Low

Relative Abundance: = High = Medium = Low

Sources: [1](Hallock *et al.* 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998-2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998-2011 USFWS data; [9]NMFS analysis of 2003-2011 USFWS data; [10]unpublished EBMUD RST data for 2008-2013; [11]Oakdale RST data (collected by Fishbio) summarized by John Hannon (Reclamation) ; [12](Schaffter 1980).

Embryo Incubation

California Central Valley adult steelhead eggs incubate within the gravel and hatch from approximately 19 to 80 days at water temperatures ranging from 60°F to 40°F, respectively (NMFS 2009). After hatching, the young fish (alevins) remain in the gravel for an extra two to six weeks before emerging from the gravel and taking up residence in the shallow margins of the stream.

Steelhead embryo incubation generally occurs from December through June in the Central Valley. The RMT (2013) identified the period of January through May as encompassing the majority of the steelhead embryo incubation period in the lower Yuba River. Following deposition of fertilized eggs in the redd, they are covered with loose gravel. CCV steelhead eggs can reportedly survive at water temperature ranges of 35.6°F to 59°F (Myrick and Cech 2001). Steelhead eggs reportedly have the highest survival rates at water temperature ranges of 44.6°F to 50.0°F (Myrick and Cech 2001). Studies conducted at or near 54.0°F report high survival and normal development of steelhead incubating embryos, a relatively low mortality of incubating steelhead embryos is reported to occur at 57.2°F, and a sharp decrease in survival has been reported for *O. mykiss* embryos incubated above 57.2°F (RMT 2010b).

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in three to four weeks at 10°C (50°F) to 15°C (59°F) (Moyle 2002). After hatching, alevins remain in the gravel for an additional two to five weeks while absorbing their yolk sacs, and emerge in spring or early summer (Barnhart 1986). Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986, NMFS 1996).

Juvenile Rearing and Outmigration

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965, Everest and Chapman 1972).

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or bolders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Juvenile steelhead have been reported to occupy a wide range of habitats, preferring deep pools as well as higher velocity rapid and cascade habitats (Bisson *et al*. 1982, 1988). During the winter period of inactivity, steelhead prefer low velocity pool habitats with large rocky substrate or woody debris for cover (Hartman 1965, Swales *et al*. 1986, Raleigh *et al*. 1984). During periods of low temperatures and high flows associated with the winter months, juvenile steelhead seek refuge in interstitial spaces in cobble and boulder substrates (Bustard and Narver 1975, Everest *et al*. 1986).

Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart 1986 as cited in McEwan and Jackson 1996). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995).

Optimal water temperatures for growth range from 15°C (59°F) to 20°C (68°F) (McCullough *et al.* 2001, Spina 2006). Cherry *et al.* (1975) found preferred temperatures for rainbow trout ranged from 11°C (51.8°F) to 21°C (69.8°F) depending on acclimation temperatures (cited in Myrick and Cech 2001). CCV steelhead can show mortality at constant temperatures of 77°F although they can tolerate 85°F for short periods (Myrick and Cech 2001). Juvenile steelhead in northern California rivers reportedly exhibited increased physiological stress, increased agonistic activity, and a decrease in forage activity after ambient stream temperatures exceeded 71.6°F (Nielsen *et al*. 1994). Hatchery reared steelhead in thermal gradients selected temperatures of 64-66°F while wild caught steelhead selected temperatures around 63°F (Myrick and Cech 2001). An upper water temperature limit of 65°F is preferred for growth and development of Sacramento River and American River juvenile steelhead (NMFS 2002a).

Smolt Migration

Most juvenile steelhead spend one to three years in fresh water before emigrating to the ocean as smolts (Shapovalov and Taft 1954). During their downstream migration, juvenile steelhead undergo a process referred to as smoltification, which is a physiologic transformation and osmoregulatory pre-adaptation to residence in saline environs. Physiologic expressions of smoltification include increased gill ATPase and thyroxin levels, and more slender body form which is silvery in appearance. The primary period of steelhead smolt outmigration from rivers and creeks to the ocean generally occurs from January to June (NMFS 2009).

In the Sacramento River, juvenile steelhead migrate to the ocean in spring and early summer at 1 to 3 years of age with peak migration through the Delta in March and April (Reynolds *et al*. 1993 as cited in NMFS 2009). Hallock *et al*. (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak emigration period occurred in the spring, with a much smaller peak in the fall (NMFS 2009).

Steelhead are present at Chipps Island between at least October and July, according to catch data from the USFWS Chipps Island Trawl (NMFS 2009a). It appears that adipose fin-clipped steelhead have a different emigration pattern than unclipped steelhead. Adipose fin-clipped steelhead showed distinct peaks in catch between January and March corresponding with time of release, whereas unclipped steelhead were more evenly distributed over a period of six months or more. These differences are likely an artifact of the method and timing of hatchery releases (NMFS 2009a).

Steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech 2001). The optimum water temperature range for successful smoltification in young steelhead has been reported as 44.0°F to 52.3°F (Rich 1987). Wagner (1974) reported smolting ceased rather abruptly when water temperatures increased to 57°F-64°F.

Ocean Rearing and Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that California steelhead may not migrate to the Gulf of Alaska region of the north Pacific as commonly as more northern populations such as those in Washington and British Colombia. (Burgner, et al. 1993) reported that no coded-wire tagged steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of CCV steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

Pearcy et al. (1990) found that the diets of juvenile steelhead caught in coastal waters of Oregon and Washington were highly diverse and included many species of insects, copepods, and amphipods, but by biomass the dominant prey items were small fishes (including rockfish (*Sebastes* spp. and greenling (*Hexagrammos* spp.) and euphausids .

There are no commercial fisheries for steelhead in California, Oregon, or Washington, with the exception of some tribal fisheries in Washington waters.

(5) Factors Affecting the Species and Critical Habitat

The factors affecting the survival and recovery of CCV steelhead and their habitat are similar to those affecting CV spring-run Chinook salmon and are primarily associated with habitat loss (McEwan 2001). McEwan and Jackson (1996) attribute this habitat loss and other impacts to steelhead habitat primarily to water development resulting in inadequate flows, flow fluctuations, blockages, and entrainment into diversions. Other effects on critical habitat related to land use practices and urbanization have also contributed to steelhead declines (Busby *et al*. 1996). Although many of the factors affecting CV spring-run Chinook salmon habitat are common to steelhead, some stressors, especially summer water temperatures, cause greater effects to steelhead because juvenile steelhead rear in freshwater for more than one year. Because most suitable habitat has been lost to dam construction, juvenile steelhead rearing is generally confined to lower elevation stream reaches, where water temperatures during late summer and early fall can be sub-optimal (NMFS 2005b).

Many of the improvements to critical habitat that have benefited CV spring-run Chinook salmon, including water management through the CVPIA Section 3406(b)(2) water supply and the CALFED Environmental Water Account, improved screening conditions at water diversions, and changes in inland fishing regulations (there is no ocean steelhead fishery) also benefit CCV steelhead (NMFS 2005b). However, many dams and reservoirs in the Central Valley do not have water storage capacity or release mechanisms necessary to maintain suitable water temperatures for steelhead rearing through the critical summer and fall periods, especially during critically dry years (McEwan 2001).

Threats to CCV steelhead are similar to those for CV spring-run Chinook salmon and fall into three broad categories: (1) loss of historical spawning habitat, (2) degradation of remaining habitat, and (3) threats to the genetic integrity of the wild spawning populations from hatchery steelhead production programs in the Central Valley. Also, as for spring-run Chinook salmon, the potential effects of long-term climate change also may adversely affect steelhead and their recovery.

In 1998, NMFS concluded that the risks to CCV steelhead had diminished, based on a review of existing and recently implemented state conservation efforts and federal management programs (*e.g.*, CVPIA, AFRP, CALFED) that address key factors for the decline of this species (NMFS 2009). NMFS stated that CCV steelhead were benefiting from two major conservation initiatives, being simultaneously implemented: (1) the CVPIA, which was passed by Congress in 1992 and (2) the CALFED Program, a joint state/federal effort implemented in 1995. The following discussion of these two programs was taken directly from NMFS (2009).
The CVPIA is specifically intended to remedy habitat and other problems associated with the construction and operation of the CVP. The CVPIA has two key features related to steelhead. First, it directs the Secretary of the Interior to develop and implement a program that makes all reasonable efforts to double natural production of anadromous fish in Central Valley streams (Section 3406(b)(1)) by the year 2002. The AFRP was initially drafted in 1995 and subsequently revised in 1997. Funding has been appropriated since 1995 to implement restoration projects identified in the AFRP planning process. Second, the CVPIA dedicates up to 800,000 acre-feet of water annually for fish, wildlife, and habitat restoration purposes (Section 3406(b)(2)) and provides for the acquisition of additional water to supplement the 800,000 acre-feet (Section 3406(b)(3)). USFWS, in consultation with other federal and state agencies, has directed the use of this dedicated water yield since 1993.

The CALFED Program, which began in June 1995, was charged with the responsibility of developing a long-term Bay-Delta solution. A major element of the CALFED Program is the Ecosystem Restoration Program (ERP), which was intended to provide the foundation for long-term ecosystem and water quality restoration and protection throughout the region. Among the non-flow factors causing decline that have been targeted by the program are unscreened diversions, waste discharges and water pollution, impacts due to poaching, land derived salts, exotic species, fish barriers, channel alterations, loss of riparian wetlands, and other causes of estuarine habitat degradation. The level of risk faced by the CCV steelhead DPS may have diminished since the 1996 listing proposal as a result of habitat restoration and other measures that have recently been implemented through the CALFED and CVPIA programs. Although most restoration measures designed to recover Chinook salmon stocks can benefit steelhead, focusing restoration solely on Chinook salmon may lead to inadequate measures to restore steelhead because of their different life histories and resource requirements, particularly for rearing juveniles (McEwan 2001). Additional actions that benefit CCV steelhead include efforts to enhance fisheries monitoring, such as the CCV steelhead Monitoring Plan, and conservation actions to address artificial propagation.

In spite of the benefits derived from implementation of these two programs, NMFS (2009) identified several major stressors presently applicable to the entire CCV steelhead DPS. Many of the most important stressors specific to the steelhead DPS correspond to the stressors described for the CV spring-run Chinook salmon ESU. As previously stated, the 2009 NMFS OCAP BO (2009a) identified factors leading to the current status of the CV spring-run Chinook salmon ESU, which also are applicable to the steelhead DPS, including habitat blockage, water development and diversion dams, water conveyance and flood control, land use activities, water quality, hatchery operations and practices, over-utilization (*e.g.*, ocean commercial and sport harvest, inland sport harvest), disease and predation, environmental variation (*e.g.*, natural environmental cycles, ocean productivity, climate change), and non-native invasive species. The previous discussions in this BA addressing limiting factors and threats for the CV spring-run Chinook salmon ESU and their specific geographic influences, including the Sacramento River and the Delta, are not repeated in this section of this BA. Stressors that are unique to the steelhead DPS, or substantially differ in the severity from the stressor for the previously described CV spring-run Chinook salmon ESU, are described below.

Threats and stressors for the CCV steelhead DPS identified in Appendix B (Threats Assessment) of the NMFS Draft Recovery Plan (NMFS 2009) include: (1) destruction, modification, or curtailment of habitat or range, (2) overutilization for commercial, recreational, scientific or education purposes, (3) disease or predation, (4) inadequacy of existing regulatory mechanisms, including federal and non-federal efforts, (5) other natural and man-made factors affecting its continued existence, and (6) non-lifestage specific threats and stressors including artificial propagation programs, small population size, genetic integrity and long-term climate change. The following summarization of threats and stressors for the CCV steelhead DPS is taken directly from Appendix B (Threats Assessment) of the NMFS Draft Recovery Plan (NMFS 2009).

<u>Habitat Loss</u>

The spawning habitat for CCV steelhead has been greatly reduced from its historical range (NMFS 2009). The vast majority of historical spawning habitat for CCV steelhead has been eliminated by fish passage impediments associated with water storage, withdrawal, conveyance, and diversions for agriculture, flood control, and domestic and hydropower purposes (NMFS 2009). Modification of natural flow regimes has resulted in increased water temperatures, changes in fish community structures, depleted flow necessary for migration, spawning, rearing, and flushing of sediments from spawning gravels. These changes in flow regimes may be driving a shift in the frequencies of various life history strategies, especially a decline in the proportion of the population migrating to the ocean. Land use activities, such as those associated with agriculture and urban development, have altered steelhead habitat quantity and quality. Although many historically harmful practices have been halted, much of the historical damage to habitats limiting steelhead remains to be addressed, and the necessary restoration activities will likely require decades.

Hydropower, flood control, and water supply dams of the Central Valley Project (CVP) and State Water Project (SWP), and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds. 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. Lindley *et al.* (2006) estimated that 80 percent of historically available steelhead habitat has been lost to impassable dams. CCV 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.

As a result of migration barriers, steelhead populations have been confined to lower elevation mainstems that historically were used only for migration. 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 summer and fall are also a major stressor to adult and juvenile salmonids.

Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta have been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and LWM. More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slowed regeneration of riparian vegetation. Dams have reduced bed load movement (Mount 1995, Ayres and Associates 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 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 or spring snow melt, 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.

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 the following: (1) water diversion from the main stem 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 extremely low survival in Clifton Court Forebay, and (4) increased exposure to introduced, non-native predators such as striped bass, largemouth bass, and smallmouth bass (*Micropterus dolomieu*). On June 4, 2009, NMFS issued a biological and conference opinion on the long-term operations of the CVP and SWP (NMFS 2009). As a result of the jeopardy and adverse modification determinations, NMFS provided a reasonable and prudent alternative (RPA) that reduces many of the adverse effects of the CVP and SWP resulting from the stressors described above. Several of the actions required by the RPA have been challenged in Federal court and their implementation is uncertain, thus rendering the improvements to the ecosystem tenuous and forestalling benefits to the affected salmonid populations.

<u>Water Conveyance and Flood Control</u>

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

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 near shore habitat for juvenile salmonids (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al.* 2002). Simple slopes protected with rock revetment generally create near shore 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 diversity of habitat conditions that would be found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refugia from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, many streams had so much debris from poor logging practices that many were completely clogged and were thought to be 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 LWM 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 LWM are still limited in the recovery of salmonid stocks, this limitation could be expected to persist for many years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996b). LWM 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.

Hatchery Operations and Practices

Hatcheries have come under scrutiny for their potential effects on wild salmonid populations (Bisson *et al*. 2002, Araki *et al*. 2007). The concern with hatchery operations is two-fold. First, they may result in unintentional, but maladaptive genetic changes in wild steelhead stocks (McEwan and Jackson 1996). CDFW believes its hatcheries take eggs and sperm from enough individuals to avoid loss of genetic diversity through inbreeding depression and genetic drift. However, artificial selection for traits that improve hatchery success (*e.g.*, fast growth, tolerance of crowding) are not avoidable and may reduce genetic diversity and population fitness (Araki *et al*. 2007). Past and present hatchery practices represent the major threat to the genetic integrity of CCV steelhead (NMFS 2009). Overlap of spawning hatchery and natural fish within the steelhead DPS exists, resulting in genetic introgression. Also, a substantial problem with straying of hatchery fish exists within this DPS (Hallock 1989). Habitat fragmentation and population declines resulting in small, isolated populations also pose genetic risk from inbreeding, loss of rare alleles, and genetic drift (NMFS 2009).

The second concern with hatchery operations revolves around the potential for undesirable competitive interactions between hatchery and wild stocks. Intraspecific competition between wild and artificially produced stocks can result in wild fish declines (McMichael *et al*. 1997, 1999). Although wild fish are presumably more adept at foraging for natural foods than hatchery-reared fish, this advantage can be negated by density-dependent effects resulting from large numbers of hatchery fish released at a specific locale, as well as the larger size and more aggressive behavior of the hatchery fish (Reclamation 2008).

Currently, four hatcheries in the Central Valley produce steelhead to supplement the Central Valley wild steelhead population. These four CCV steelhead hatcheries (Mokelumne River, FRFH, Coleman, and Nimbus hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually when all four hatcheries reach production goals (CMARP 1998). The hatchery steelhead programs originated as mitigation for the habitat lost by construction of dams. Steelhead are released at downstream locations in January and February at about four fish per pound, generally corresponding to the initiation of the peak of outmigration (Reclamation 2008). In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (USDOI 1999, as cited in NMFS 2009a).

According to Reclamation (2008), the hatchery runs in the American and Mokelumne rivers are probably highly introgressed mixtures of many exotic stocks introduced in the early days of the hatcheries (McEwan and Jackson 1996, NMFS 1998b). Beginning in 1962, steelhead eggs were imported into Nimbus Hatchery from the Eel, Mad, upper Sacramento, and Russian rivers and from the Washougal and Siletz Rivers in Washington and Oregon, respectively (McEwan and Nelson 1991, as cited in McEwan and Jackson 1996). Egg importation has also occurred at other Central Valley hatcheries (McEwan and Jackson 1996).

Reclamation (2008) further states that stock introductions began at the FRFH in 1967, when steelhead eggs were imported from Nimbus Hatchery to be raised as broodstock. In 1971, the first release of Nimbus origin fish occurred. From 1975 to 1982, steelhead eggs or juveniles were imported from the American, Mad, and Klamath rivers and the Washougal River in Washington. The last year that Nimbus-origin fish were released into the Feather River was 1988. Based on preliminary genetic assessments of CCV steelhead, NMFS (1998b) concluded the FRFH steelhead were part of the CCV DPS despite an egg importation history similar to the Nimbus Hatchery stock, which NMFS did not consider part of the CCV DPS.

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 (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 (Reclamation 2008).

In addition, harvest impacts associated with hatchery-wild population interactions have been identified as a stressor to wild CCV steelhead stocks (NMFS 2009). 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). According to CDFW creel census surveys, the majority (93 percent) of steelhead catches occur on the American and Feather rivers, sites of steelhead hatcheries (CDFG 2001d, as cited in NMFS 2009). Creel census surveys conducted during 2000 indicated that 1,800 steelhead were retained, and 14,300 were caught and released. The total number of steelhead contacted might be a significant fraction of basin-wide escapement, so even low catch-and-release mortality may pose a problem for wild populations.

In 2000, Congress established and funded a hatchery review process because it recognized that, while hatcheries have a necessary role to play in meeting harvest and conservation goals, many populations of salmon and steelhead are listed under the ESA, and face significant genetic risks from hatchery programs. Comprehensive hatchery reform is needed to conserve these listed stocks (California HSRG 2012). The California Hatchery Science Review Group reviewed the practices of Central Valley salmon and steelhead hatcheries and issued a report in 2012 and made recommendations for all hatchery programs. Some of the key recommendations include:

- The number of eggs taken annually should be reduced to a level appropriate to produce 450,000 juveniles and the transfer of eggs to other programs terminated. Collection of excess eggs is permissible to increase effective population size as long as culling is done representatively.
- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.
- Non-anadromous (resident) fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.
- Attempts should be made to utilize extended reconditioning for adult steelhead brought into the hatchery. All steelhead should be released after reconditioning.

Currently, adult CCV steelhead that are trapped during the early part of the run are not retained for hatchery broodstock because of the difficulties associated with holding sexually immature fish. These sexually immature fish are returned to the river via a metal discharge tube that enters the river approximately 0.5 miles downstream from the ladder entrance. Only sexually mature steelhead are retained for spawning, with timing ranging from late October to the first week of January. If it appears that the run is small and difficulties may be encountered collecting enough eggs to meet mitigation goals, sexually immature adult steelhead may be held in one of four round tanks and sorted weekly for eventual spawning. All post-spawn adults (kelts) are returned to the river without reconditioning.

Hatchery personnel attempt to distinguish steelhead from resident rainbow trout through physical characteristics such as size, coloration, and body conformation. All CCV steelhead that enter the trap and gathering tank are sorted a minimum of once each week during the run, examined for marks, and the degree of sexual maturity determined. Fish smaller than 16 inches are returned to the river in order to reduce the number of non-anadromous *O. mykiss* used as broodstock.

In order to maintain the genetic integrity of CCV steelhead within each watershed, out of basin egg transfers ceased in the Central Valley in 2008. For many Central Valley steelhead hatcheries, this change led to an inability to meet production goals. According to the HSRG, runs of both natural- and hatchery-origin steelhead in the Central Valley are at record lows when compared to historical numbers both before and after construction of numerous water projects.

This statement holds true for the Feather River. As a result, egg take goals have not been met since 2005.

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 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 LWM input needed to form and maintain stream habitat that salmon depend on in their various life stages. In addition to this loss of LWM sources, removal of snags and obstructions from the active river channel for navigational safety has further reduced the presence of LWM 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 1996b). 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, 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 stream bank 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 LWM, and removal of riparian vegetation, resulting in increased stream bank erosion (Meehan 1991). Urban storm water 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, 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 riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bed load 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 LWM from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Urban storm water 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 potentially destroy aquatic life necessary for salmonid survival (NMFS 1996b). 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). 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 from past and present mining activities can 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 on water quality in the Delta show an increase in the clarity of the water, likely due to a reduction in phytoplankton abundance (Jassby 2008), the increased abundance of submerged aquatic vegetation (Santos *et al*. 2009), and from lower sediment inputs as mining era debris has been pushed down the system (Schoellhamer 2011). These conditions likely have contributed to increased mortality of juvenile steelhead as they move through the Delta, as the higher visibility makes juvenile fish more vulnerable to sight predators.

Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO concentrations, altered turbidity levels and increased contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The California Regional Water Quality Control 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 (CRWQCB 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 et al. 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. This may occur if a fish swims through a plume of the re-suspended 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 (U.S. Environmental Protection Agency 1998). However, the more likely route of exposure to salmonids 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.

Low DO levels frequently are observed in the portion of the Stockton deep water ship channel (DWSC) extending from Channel Point, downstream to Turner and Columbia Cuts. Starting in 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of the 5-year time period between 2000 and 2005, there were 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 occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center (CDEC) files indicate that DO depressions occured during all migratory months, with significant events occurring from November through March when listed CCV steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor.

Potential factors that contribute to these DO depressions are reduced river flows through the DWSC, 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 between 2000 and 2005, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowered the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Actions have been taken to remedy this source of ammonia by modifying the treatment train at the wastewater facility.

Likewise, adult fish migrating upstream will potentially 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. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970). There is insufficient flow to adequately mix the water mass and maintain the necessary level of DO. To help reduce the incidence of seasonally low DO concentrations in this reach of the DWSC, DWR has constructed a demonstration aeration facility, operational plans call for it to be activated when DO in the DWSC approaches 5.0 mg/L. This should help reduce or potentially eliminate passage issues caused by low DO, but it is unclear if the aeration facility will continue operating indefinitely.

<u>Over Utilization</u>

An inland recreational fishery exists in the Central Valley for steelhead and essentially no ocean harvest exists. 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 and it appears that even hatchery steelhead are rarely kept, as CDFW creel surveys and steelhead report cards indicate that only about 1-2 percent of hatchery steelhead caught by anglers in the Central Valley are harvested. Overall, this regulation has greatly increased protection of naturally produced adult steelhead, however, the total number of CCV steelhead caught 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).

<u>Disease and Predation</u>

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 1996b, 1998a). Specific diseases such as bacterial kidney disease, *Ceratomyxosis 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 steelhead (NMFS 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.

Temperature stress can also increase susceptibility to disease, and may result from a variety of factors, including seasonal changes, water management activities, handling practices, and climate change. Water temperature is critical to fish physiological reaction rates and metabolic processes. As body temperature increases, biochemical reaction rates generally increase for enzyme reactions and membrane transport flux dynamics (Elliott 1981). Thermal stress occurs when the water temperature exceeds the optimal temperature range, thus initiating changes that disrupt normal physiological functions resulting in energy expended towards stress responses, potentially decreasing survivorship (Brett et al. 1958, Fry 1971, Elliott 1981).

An increased risk of predation may also be a factor in the decline of CCV 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 concentrate juvenile salmonids and attract predators (Stevens 1961, Decoto 1978, Vogel *et al.* 1988).

Predation on juvenile salmonids has increased as a result of water development activities which have created ideal habitats for predators. 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, release sites for salmonids salvaged at the CVP and SWP Fish Facilities, and the Suisun Marsh Salinity Control Gates. Predation on salmon by striped bass and pikeminnow 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.

Predation on juvenile steelhead can be seasonally and locally significant. Changes in predator and prey populations along with changes in the environment, both related and unrelated to development, have been shown to reshape the role of predation. Of the aquatic fish predators, Sacramento pikeminnow and striped bass have the greatest potential to negatively affect the abundance of juvenile salmonids in the Central Valley. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Catfish (Order Siluriformes) also have the potential to significantly affect the abundance of juvenile salmonids. Prickly sculpin (*Cottus asper*) and riffle sculpin (*C. gulosus*), and larger salmonids also prey on juvenile salmonids (Hunter 1959, Patten 1962, 1971a, b, Garcia 1989).

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, gulls, osprey, 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, 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 (*Lontra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonids include: badger (*Taxidea taxus*), bobcat (*Lynx rufus*), 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*). River otters are capable of removing large numbers of *O. mykiss* from the aquatic habitat (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids. 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.

Environmental Variation

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. A three year period of reduced precipitation from 2007 to 2009 is thought to have been a contributing factor to reduced salmonid populations in the Central Valley.

"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. The 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.

Ecosystem Restoration

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 this 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 CV spring-run Chinook salmon and steelhead by maintaining or increasing instream flows in Butte and Mill creeks and the San Joaquin River at critical times.

San Joaquin River Restoration Program (SJRRP)

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the CVP Friant Division Contractors. After more than 18 years of litigation of this lawsuit, known as *NRDC, et al. v. Kirk Rodgers, et al.*, a settlement was reached. On September 13, 2006, the Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, filed a stipulation of the terms and conditions of the settlement, which was subsequently approved by the U.S. District Court, Eastern District of California, on October 23, 2006. The settlement establishes restoration and water management goals. The Restoration Goal is to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence with the Merced River, including naturally reproducing and self-sustaining of Chinook salmon and other fish. The Water Management Goal is to reduce or avoid water supply impacts to all of the Friant Division long-term contractors that may result from the Interim and Restoration Flows provided for in the Settlement. President Obama signed the San Joaquin River Restoration

Settlement Act (Act) on March 30, 2009, which authorized implementation of the settlement, as part of the Omnibus Public Land Management Act of 2009. Pub. L. No. 111-11, 123 Stat. 991. To achieve the Restoration Goal, the Settlement calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of CV spring-run and fall-run Chinook salmon prior to December 31, 2012. Title X, section 10011(b) of the Act states that CV spring-run Chinook salmon shall be reintroduced in the San Joaquin River below Friant Dam pursuant to section 10(j) of the ESA, provided that a permit for the reintroduction may be issued pursuant to section 10(a)(1)(A) of the ESA. In addition, Title X, section 10011(c)(2) of the Act states that the Secretary of Commerce shall issue a final rule pursuant to section 4(d) of the ESA governing the incidental take of reintroduced CV spring-run Chinook salmon prior to the reintroduction. Furthermore, Title X, section 10011(c)(3) of the Act states that the rule issued under paragraph 2 shall provide that the reintroduction will not impose more than de minimus: water supply reductions, additional storage releases, or bypass flows on unwilling third parties due to such reintroduction.

Battle Creek Salmon and Steelhead Restoration Project

This restoration project will eventually remove five dams on Battle Creek, install fish screens and ladders on three dams, and end the diversion of water from the North Fork to the South Fork. When the program is complete, a total of 42 miles of mainstem habitat and six miles of tributary habitat will be opened up to anadromous salmonids. Phases lA (North Fork Battle Creek actions) and 1B (a tailrace connector project) have been funded, Phase 2 (South Fork Battle Creek actions) has not been completely funded. Wildcat Diversion Dam on the North Fork of Battle Creek was removed in 2010. Phase 2 is scheduled to be completed between 2012 and 2014. Improved habitat conditions in Battle Creek should support returning steelhead that are currently being passed above the Coleman National Fish Hatchery weir.

Invasive Species

As currently seen in the San Francisco estuary, invasive species can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by 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 invasive species 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 Brazilian waterweed 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.

<u>Summary of Factors Affecting the Species and Critical Habitat</u>

The construction of 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 caused precipitous declines in abundance, life history diversity, and productivity of CCV steelhead. The reduced populations of steelhead that remain below Central Valley dams are forced to spawn in lower elevation reaches of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is often 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. These dams also block access to small tributary habitat similar to what they historically used for spawning, habitat that is largely unavailable to them under the current water management scenario. Many salmonid species have been adversely 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*.). (Kostow *et al.* 2003, McLean *et al.* 2003, Araki *et al*. 2008 and 2009, Seamons *et al.* 2012).

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 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 LWM, gravel, 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 concentrate 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.*, gravel enhancement). However, some important restoration activities (*e.g.*, Battle Creek Restoration Project) have not yet been completed.

(6) Description of Viable Salmonid Population (VSP) Parameters

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a viable salmonid population (VSP). The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany *et al*., 2000). The VSP concept measures population performance in term of four key parameters: abundance, population growth rate, spatial structure, and diversity.

As described by NMFS (2009), there are few data with which to assess the status of CCV steelhead populations. Lindley *et al*. (2007) stated that, with the few exceptions of streams with long-running hatchery programs such as Battle Creek and the Feather, American and Mokelumne rivers, CCV steelhead populations are classified as data deficient. In all cases, hatchery-origin fish likely comprise the majority of the natural spawning run, placing the natural populations at high risk of extinction (Lindley *et al*. 2007). As of 2009, NMFS (2009) reinforced the conclusion that the CCV steelhead DPS is data deficient, with the exception of these hatchery programs.

From 1967-1993, steelhead run-size estimates were generated from fish counts in the fish ladder at RBDD (CDFG 2010). From these counts, estimates of the natural spawner escapement upstream of RBDD were generated. Because RBDD impacted winter-run Chinook salmon by delaying their upstream migration, dam operations were changed in 1993 so that dam gates were raised earlier in the season, which eliminated the need for fish to navigate fish ladders, but also eliminated the ability to generate accurate run-size estimates for the upper Sacramento River Basin (CDFG 2010).

Presently, little information is available regarding the abundance of steelhead in the Central Valley (CDFG 2010). Currently there is virtually no coordinated, comprehensive, or consistent monitoring of steelhead in the Central Valley. In 2004, the Interagency Ecological Program Steelhead Project Work Team developed a proposal to develop a comprehensive monitoring plan for CCV steelhead. In 2007, development of this steelhead monitoring plan was funded by the CALFED Ecosystem Restoration Program. In 2010, a document titled “A Comprehensive Monitoring Plan for Steelhead in the California Central Valley” was completed by CDFG (2010a), which recommended steelhead monitoring activities in the Central Valley. The objectives of the plan include: (1) estimate steelhead population abundance with levels of precision, (2) examine trends in steelhead abundance, and (3) identify the spatial distribution of steelhead in the Central Valley to assess their current range and observe changes in their range that may occur over time. However, for the most part, recommendations in the plan remain to be implemented.

According to NMFS (2009), data are lacking to suggest that the CCV steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Conversely, there is evidence to suggest that the CCV steelhead DPS is at moderate or high risk of extinction (McEwan 2001, Good *et al*. 2005). Most of the historical habitat once available to steelhead has been lost (Yoshiyama *et al*. 1996, McEwan 2001, Lindley *et al*. 2006). Furthermore, the observation that anadromous *O. mykiss* are becoming rare in areas where they were probably once abundant indicates that an important component of life history diversity is being suppressed or lost (NMFS 2009). Habitat fragmentation, degradation, and loss are likely having a strong negative impact on many resident as well as anadromous *O. mykiss* populations (Hopelain 2003 as cited in NMFS 2009).

Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of 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). 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 Red Bluff Diversion Dam (RBDD) declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, 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, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers *et al.* 2010).

Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable, as redd surveys for steelhead are often made difficult by the high flows and turbid water often present during the winter-spring spawning period.

Coleman National Fish Hatchery (Coleman) operates a weir on Battle Creek, where all upstream fish movement is blocked. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the CCV steelhead DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman stopped transferring all clipped steelhead above the weir, resulting in a large decrease in the overall numbers in recent years (Figure VII-3). In addition, in 2003, Coleman transferred about 1,000 clipped adult steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

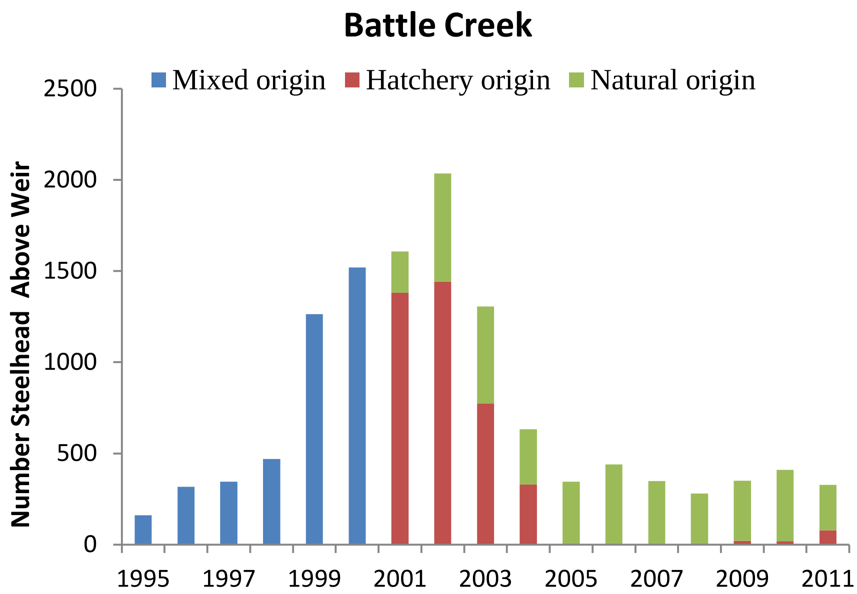


Figure VII-3. Steelhead enumerated passing upstream of the hatchery weir on Battle Creek from 1995-2009. Starting in 2001, fish were classified as either wild (unclipped) or hatchery produced (clipped). Includes fish passed above the weir during broodstock collection and fish passing through the fish ladder (enumerated with a camera) March 1 to August 31. Data are from USFWS.

Steelhead returns to Coleman NFH decreased over the last few years, especially from 2008 to 2010 (Figure VII-4). Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200-300 fish each year. Numbers of hatchery produced adults have ranged from 624 to 2,968.

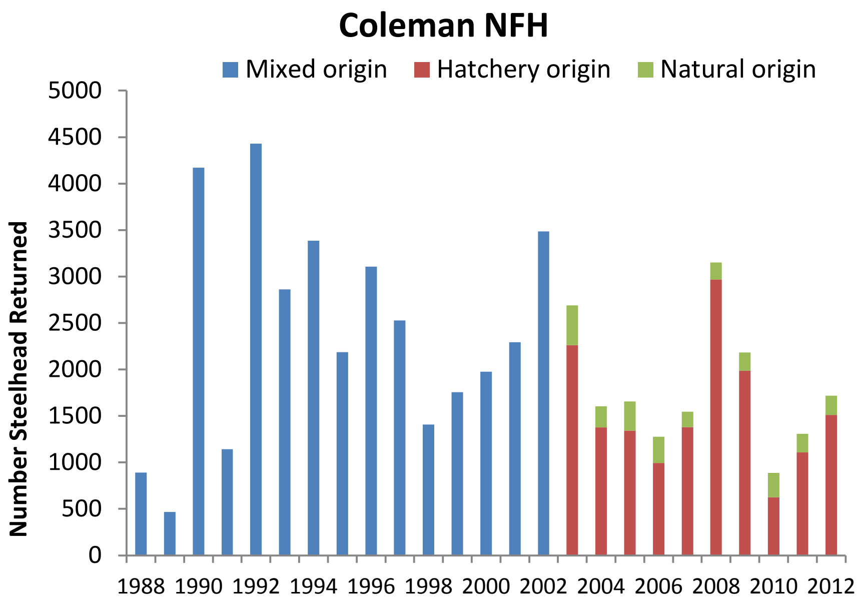


Figure VII-4. Number of steelhead that returned to the Coleman National Fish Hatchery annually. Adipose fin-clipping of hatchery smolts started in1998, and since 2003 all returning steelhead have been categorized by origin. Some of the steelhead are released upstream of the weir, Figure VII-3.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 151 redds have been counted in Clear Creek from 2001 to 2010 (Figure VII-6, data from USFW), and an average of 154 redds have been counted on the American River from 2002-2010 (Figure VII-5, data from Hannon and Deason 2008, Hannon *et al*. 2003, Chase 2010).

The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season, and the overall trend is a slight increase. However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite *et al*. 2010), which are not part of the CCV steelhead DPS.

The returns of steelhead to the Feather River Hatchery have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure VII-7). This is despite the fact that almost all of these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. However, preliminary return data for 2011(CDFG) shows a slight rebound in numbers, with 712 adults returning to the hatchery through April 5th, 2011.

The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USF&W has steadily increased since 2001 (Figure VII-6). The average redd index from 2001 to

2011 is 157, representing somewhere between 128 and 255 spawning adult steelhead on average each year. The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the production of wild steelhead relative to hatchery steelhead (CDFG, ftp.delta.dfg.ca.gov/salvage). The overall catch of steelhead at these facilities has been highly variable since 1993 (Figure VII-9). The percentage of unclipped steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of stocked hatchery steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

The years 2009 and 2010 showed poor returns of steelhead to the Feather River Hatchery and Coleman Hatchery, probably due to three consecutive drought years in 2007-2009, which would have impacted parr and smolt growth and survival in the rivers, and possibly due to poor coastal upwelling conditions in 2005 and 2006, which strongly impacted fall-run Chinook salmon post-smolt survival (Lindley *et al*. 2009). Wild (unclipped) adult counts appear not to have decreased as greatly in those same years, based on returns to the hatcheries and redd counts conducted on Clear Creek, and the American and Mokelumne Rivers. This may reflect greater fitness of naturally produced steelhead relative to hatchery fish, and certainly merits further study.

Overall, steelhead returns to hatcheries have fluctuated so much from 2001 to 2011 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960's and 70's, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small though perhaps not as variable from year to year as the hatchery returns.

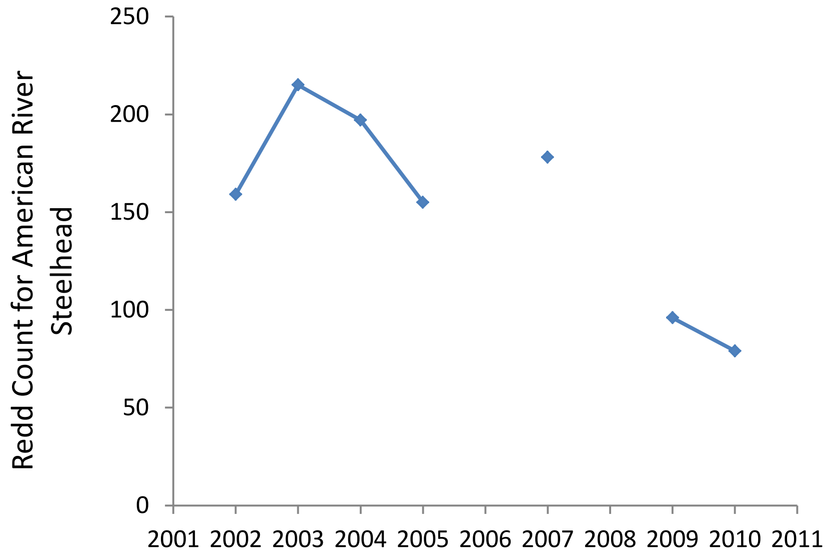


Figure VII-5. Steelhead redd counts from USBR surveys on the American River from 2002-2010. Surveys could not be conducted in some years due to high flows and low visibility.

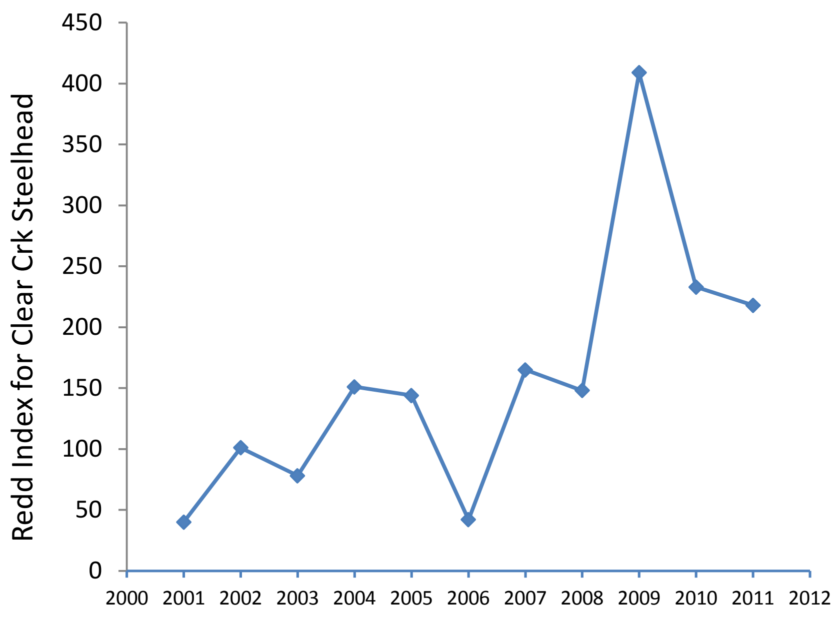


Figure VII-6. Redd counts from USF&W surveys on Clear Creek from 2001-2011.

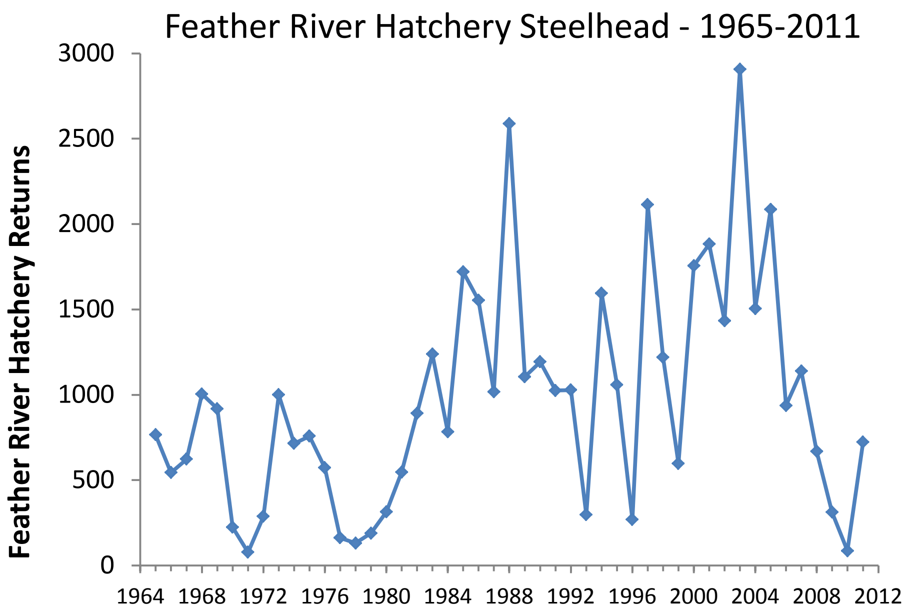


Figure VII-7. Number of steelhead that returned to the Feather River Fish Hatchery each year. Almost all fish are hatchery origin.

Productivity

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFG and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams *et al.* 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts 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".

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (NMFS 2011c). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite *et al.* (2010), it is likely that most of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead. The Mokelumne River steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). However, this practice was discontinued for Nimbus stock after 1991, and discontinued for Feather River stock after 2008. Recent results show that the Mokelumne River Hatchery steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock (Garza and Pearse, in prep).

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural steelhead production has continued to decline, and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Beginning in 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (Ad-clipped). Since that time, the trawl data indicates that the proportion of Ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. The proportion of hatchery fish exceeded 90 percent in 2007, 2010, and 2011 (Figure VII-8). Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley.

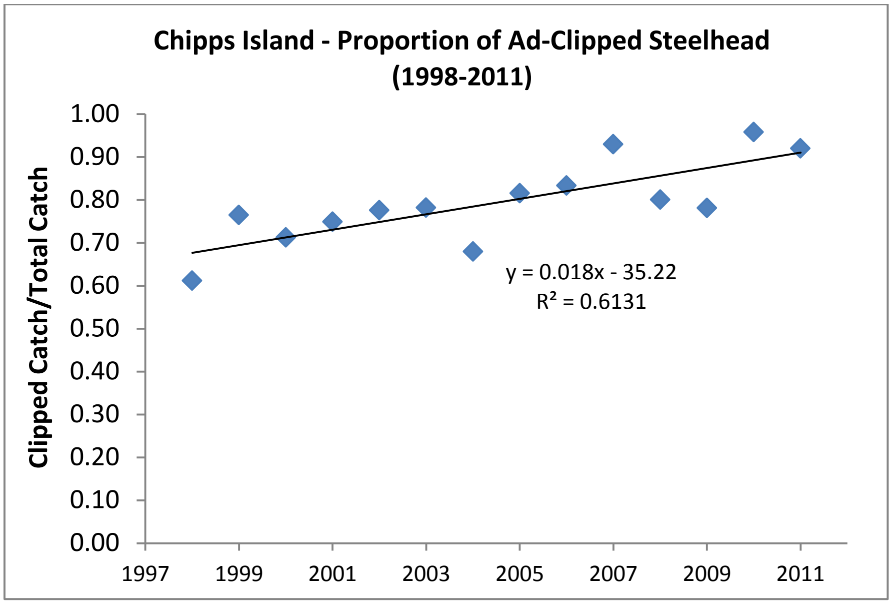


Figure VII-8. Catch of steelhead at Chipps Island by the USFWS midwater trawl survey from 1998 to 2011. Fraction of the catch bearing an adipose fin clip. All hatchery steelhead have been marked starting in 1998.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities also indicates a reduction in the natural production of steelhead (Figure VII-9). The percentage of unclipped juvenile steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (NMFS 2011c).

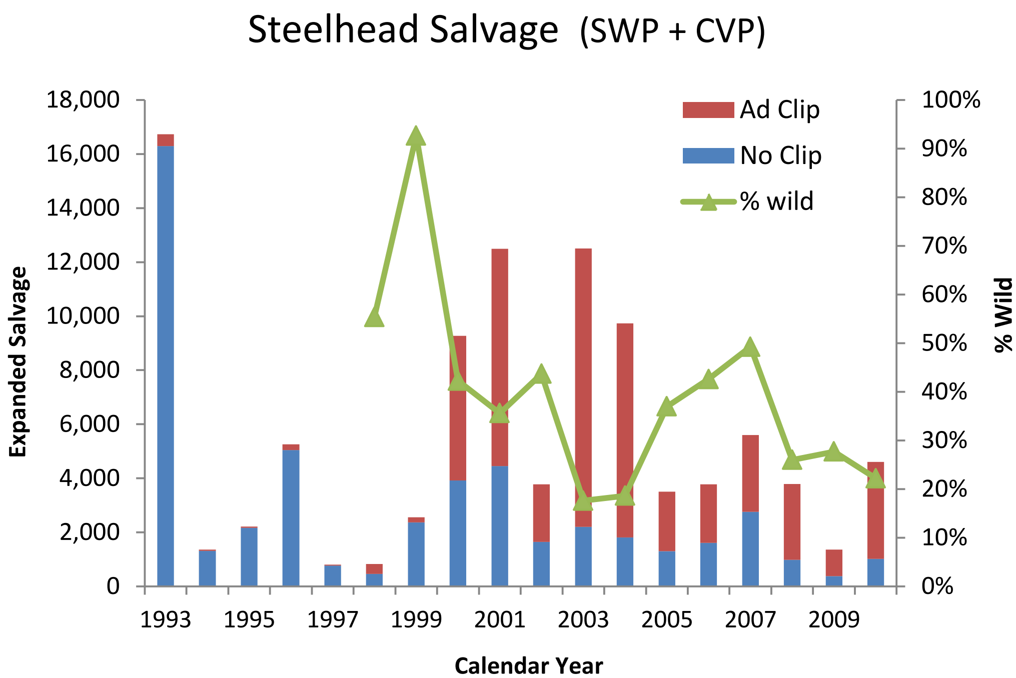


Figure VII-9. Steelhead salvaged in the Delta fish collection facilities from 1993 to 2010. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFG, at: ftp.delta.dfg.ca.gov/salvage.

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011c). Since 2003, fish returning to the Coleman National Fish Hatchery have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely, ranging from 624 to 2,968 fish per year.

In summary, available information indicates that CCV wild steelhead are overall in decline. However there are some areas in which populations of CCV steelhead are improving, or not showing a decline.

Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley *et al.* 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama *et al.* 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001).

Steelhead appear to be well-distributed throughout the Central Valley below the major rim dams (Good *et al.* 2005, NMFS 2011c). Zimmerman *et al.* (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers 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. A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon, these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir, and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO 2012, 2013a). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FISHBIO 2013c). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24 hour period. Annual Kodiak trawl surverys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of CV spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for CV spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011c).

<u>Diversity</u>

Genetic Diversity: California CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the diversity of habitats available to these populations (Lindley *et al.* 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen *et al.* 2003). Garza and Pearse (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). There are four hatcheries (Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 600,000 yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

Life-History Diversity: Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning.

Between 1944 and 1947, annual counts of summer-run steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish (Gerstung 1971). After 1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead were no longer able to access their historic spawning areas, and perished in the warm water downstream of Old Folsom Dam.

Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002, McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as coldwater pools in the headwaters of CV streams, presently located above impassible dams (Lindley *et al.* 2006).

Juvenile steelhead (parr) rear in freshwater for one to three years before migrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater is inversely related to their growth rate, with faster-growing members of a cohort smolting at an earlier age but a smaller size (Peven *et al.* 1994, Seelbach 1993). Hallock *et al.* (1961) aged 100 adult steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954, and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most steelhead return to their natal streams as adults at a total age of two to four years (Hallock 1961, McEwan and Jackson 1996).

Deer and Mill creeks were monitored from 1994 to 2010 by the CDFW using rotary screw traps to capture emigrating juvenile steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm in Deer and Mill creeks, while smolts averaged 210 mm and 204 mm. Most silvery parr and smolts were caught in the spring months from March through May, while fry and parr peaked later in the spring (May and June) and were fairly common in the fall (October through December) as well.

In contrast to the upper Sacramento River tributaries, Lower American River juvenile steelhead have been shown to smolt at a very large size (270 to 350 mm FL), and nearly all smolt at age-1 (Sogard *et al.* 2012).

<u>Summary of CCV Steelhead DPS Viability</u>

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005, NMFS 2011c), the long-term trend remains negative. Hatchery production and returns are dominant over natural fish and include significant numbers of non-DPS-origin Eel/Mad River steelhead stock. Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show a decline, an overall low abundance, and fluctuating return rates. Lindley *et al.* (2007) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley *et al.* (2007) found that data were insufficient to determine the status of any of the naturally-spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The widespread distribution of wild steelhead in the Central Valley provides the spatial distribution necessary for the DPS to survive and avoid localized catastrophes. However, these populations are frequently very small, and lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011c).

The most recent status review of the CCV steelhead DPS (NMFS 2011c) found that the status of the population appears to have worsened since the 2005 status review (Good *et al.* 2005), when it was considered to be in danger of extinction.

(C) Green Sturgeon

Southern DPS Green Sturgeon
Listed as threatened on June 6, 2006 (71 FR 17757)

Southern DPS Green Sturgeon designated critical habitat
Designated October 9, 2009 (74 FR 52300)

(1) Species Listing History

The Southern DPS of green sturgeon (*Acipenser medirostrus*) was listed as a federally threatened species on April 7, 2006 (71 FR 17757) and includes the green sturgeon population spawning in the Sacramento River and utilizing the Sacramento-San Joaquin River Delta, and San Francisco Estuary.

Green sturgeon are divided into two distinct population segments (DPSs), a Northern DPS and a Southern DPS. The Southern DPS was listed as threatened under the Endangered Species Act on June 6, 2006. The Northern DPS is currently not listed under the ESA, but NMFS notes it as a "species of concern" In its 2006 final decision to list Southern DPS green sturgeon as a threatened species, the NMFS cited concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats with regard to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities.

NMFS conducts 5-year status reviews upon all species listed under the ESA to determine if new information is available that might influence the listing designation. Since the original 2006 determination for Southern DPS green sturgeon, new information has become available. This new information has revealed that Southern DPS green sturgeon still face substantial threats, challenging their recovery. A 5-year status review is expected to be published for Southern DPS green sturgeon in 2014.

(2) Critical Habitat Designation

Critical habitat for Southern DPS green sturgeon was designated on October 9, 2009 (74 FR 52300). Generally, critical habitat includes: (1) the Sacramento River from the I-Street Bridge to Keswick Dam, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge (2) the Feather River up to the Fish Barrier Dam, (3) the Yuba River up to Daguerre Point Dam, (4) the Sacramento-San Joaquin Delta (as defined by California Water Code section

12220), but with many exclusions, (5) San Francisco Bay, San Pablo Bay, and Suisun Bay, but with many exclusions, and (6) coastal marine areas to the 60 fathom depth bathymetry line, from Monterey Bay, California to the Strait of Juan de Fuca, Washington. Figure VII-10 provides a map of the California Southern DPS green sturgeon critical habitat.

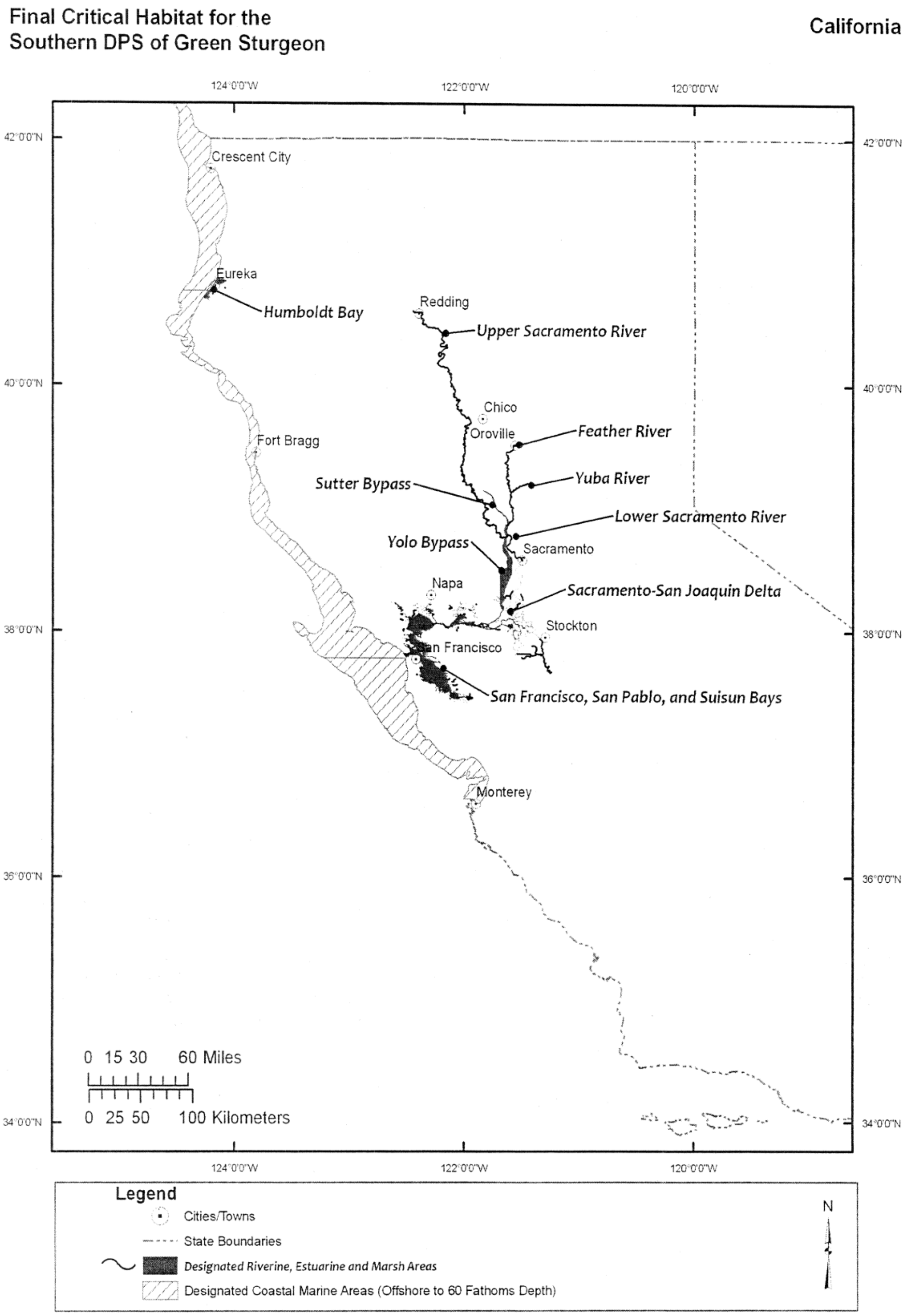


Figure VII-10. Green sturgeon critical habitat in California. Source: 50 CFR 226.219

Critical Habitat and Primary Constituent Elements (PCEs)

Critical habitat for the Southern DPS of green sturgeon includes principal biological or physical constituent elements (hereafter referred to as PCEs) within the defined areas that are essential to the conservation of the species. PCEs for Southern DPS green sturgeon have been designated for freshwater riverine systems, estuarine habitats, and nearshore coastal areas. Essential physical and biological habitat features identified for the Southern DPS of green sturgeon include food resources (*e.g.*, benthic invertebrates and small fish), substrate types (*i.e.*, appropriate spawning substrates within freshwater rivers), water flow (particularly in freshwater rivers), water quality, water depth, migratory corridors, and sediment quality.

<u>Freshwater Riverine Systems</u>

***Food Resources* -** Abundant food items for larval, juvenile, subadult, and adult life stages for Southern DPS green sturgeon should be present in sufficient amounts to sustain growth, development, and support basic metabolism. Although specific information on food resources for green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey as other sturgeons (Israel and Klimley 2008). Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items of shovelnose and pallid sturgeon in the Missouri River (Wanner *et al*. 2007), lake sturgeon in the St. Lawrence River (Nilo *et al*. 2006), and white sturgeon in the lower Columbia River (Muir *et al.* 2000). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of lake sturgeon (Nilo *et al*. 2006), pallid sturgeon (Gerrity *et al*. 2006), and white sturgeon (Muir *et al.* 2000).

***Substrate Type or Size* -** Suitable freshwater riverine system habitat includes substrates suitable for egg deposition and development (*e.g.*, cobble, gravel, or bedrock sills and shelves with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (*e.g.*, substrates with interstices or voids providing refuge from predators and from high flow conditions), and sub-adults and adult lifestages (*e.g.*, substrates for holding and spawning). Stream surveys by USFWS and Reclamation biologists have identified approximately 54 suitable holes and pools between Keswick Dam and the GCID diversion that would support spawning or holding activities for green sturgeon, based on identified physical criteria. Many of these locations are at the confluences of tributaries with the mainstem Sacramento River or at bend pools. Observations of channel type and substrate compositions during these surveys indicate that appropriate substrate is available in the Sacramento River between Keswick Dam and the GCID diversion. Ongoing surveys are anticipated to further identify river reaches in the upper river with suitable substrate characteristics and their utilization by green sturgeon.

***Water Flow* -** An adequate flow regime is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (11 - 19°C) (Mayfield and Cech 2004, Van Eenennaam *et al*. 2005, Allen *et al*. 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cubic feet per second (cfs) [average daily water flow during spawning months: 6,900 – 10,800 cfs, Brown (2007)]. In

Oregon's Rogue River, the Northern DPS green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 10° C and flows increased (Erickson *et al*. 2002). On the Klamath River, the fall outmigration of the Northern DPS green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al*. 2007). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon Southern DPS green sturgeon habitat.

Water Quality - Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all green sturgeon lifestages, is required for the proper functioning of the freshwater habitat. Suitable water temperatures include: (1) stable water temperatures within spawning reaches (wide fluctuations could increase egg mortality or deformities in developing embryos), (2) water temperatures within 51.8-62.6°F (optimal range = 57.2-60.8°F) in spawning reaches for egg incubation (March-August) (Van Eenennaam *et al*. 2005), (3) water temperatures below 68°F for larval development (Werner *et al*. 2007 as cited in NMFS 2009a), and (4) water temperatures below 75.2°F for juveniles (Mayfield and Cech 2004, Allen *et al*. 2006). Due to the temperature management of the releases from Keswick Dam for winter-run Chinook salmon in the upper Sacramento River, water temperatures in the river reaches utilized currently by green sturgeon appear to be suitable for proper egg development and larval and juvenile rearing. Suitable salinity levels range from fresh water [<3 parts per thousand (ppt)] for larvae and early juveniles [to about 100 days post hatch (dph)] to brackish water (10 ppt) for juveniles prior to their transition to salt water. Prolonged exposure to higher salinities may result in decreased growth and activity levels and even mortality (Allen and Cech 2007). Salinity levels are suitable for green sturgeon in the Sacramento River and freshwater portions of the Delta for early lifestages. Adequate levels of DO are needed to support oxygen consumption by early lifestages (Allen and Cech 2007). Current DO levels in the mainstem Sacramento River are suitable to support the growth and migration of green sturgeon. Suitable water quality also includes water free of contaminants (*i.e.*, pesticides, organochlorines, elevated levels of heavy metals, etc.) that may disrupt normal development of embryonic, larval, and juvenile lifestages of green sturgeon. Legacy contaminants such as mercury still persist in the watershed and pulses of pesticides have been identified in winter storm discharges throughout the Sacramento River Basin.

***Migratory Corridor* -** Unobstructed migratory pathways are necessary for passage within riverine habitats and between riverine and estuarine habitats (*e.g.*, an unobstructed river or dammed river that still allows for passage). Unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. Unobstructed passage throughout the Sacramento River up to Keswick Dam (RM 302) is important, because optimal spawning habitats for green sturgeon are believed to be located upstream of the RBDD (RM 242).

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

Closure of the gates at RBDD from May 15 through September 15 previously precluded all access to spawning grounds above the dam during that time period. However, as previously discussed, the RBDD gates were permanently raised in September 2011.

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

Depth **-** Deep pools of more than five m depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River above the Glen Colusa Irrigation District (GCID) diversion. The significance and purpose of these aggregations are unknown at the present time, but may be a behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al*. 2002, Benson *et al*. 2007). Approximately 54 pools with adequate depth have been identified in the Sacramento River above the GCID location.

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

<u>Estuarine Habitats</u>

Food Resources –Abundant food items within estuarine habitats and substrates for juvenile, subadult, and adult life stages are required for the proper functioning of this PCE for green sturgeon. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries.

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 inflow to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract adult green sturgeon to the Sacramento River from the bay and to initiate the upstream spawning migration into the upper river. Currently, flows provide the necessary attraction to green sturgeon to enter the Sacramento River. Nevertheless, these flows are substantially less than those that historically occurred and stimulated the spawning migration.

Water Quality - Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all lifestages. Suitable water temperatures for juvenile green sturgeon should be below 75^{o}F. At temperatures above 75.2°F, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen *et al*. 2006). Suitable salinities in the estuary range from brackish water (10 ppt) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas sub-adults and adults tolerate a wide range of salinities (Kelly *et al*. 2007 as cited in Reclamation 2008). Sub-adult and adult green sturgeon occupy a wide range of DO levels, but may need a minimum DO level of at least 6.54 mg O2/l (Kelly *et al*. 2007 as cited in Reclamation 2008, Moser and Lindley 2007 as cited in Reclamation 2008). Suitable water quality also includes water free of contaminants, as described above. In general, water quality in the Delta and estuary meets these criteria, but local areas of the Delta and downstream bays have been identified as having deficiencies. Water quality in the areas such as the Stockton turning basin and Port of Stockton routinely have depletions of DO and episodes of first flush contaminants from the surrounding industrial and urban watershed. Discharges of agricultural drain water have also been implicated in local elevations of pesticides and other related agricultural compounds within the Delta and the tributaries and sloughs feeding into the Delta. Discharges from petroleum refineries in Suisun and San Pablo Bay have been identified as sources of selenium to the local aquatic ecosystem (Linville *et al*. 2002).

Migratory Corridor **-** Safe and unobstructed migratory pathways are necessary for the successful and timely passage of adult, sub-adult, and juvenile fish within estuarine habitats and between estuarine and riverine or marine habitats. Fish need the ability to freely migrate from the river through the estuarine waterways of the delta and bays and eventually out into the ocean. Southern DPS green sturgeon use the Sacramento River and the Sacramento-San Joaquin Delta as a migratory corridor. Additionally, certain bays and harbors throughout Oregon and Washington and into Canada are also utilized for rearing and holding, and these areas too must offer safe and unobstructed migratory corridors.

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

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

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

Coastal Marine Areas

The PCE’s for coastal marine areas are omitted from this document as the focus here is upon the California Central Valley and the Sacramento-San Joaquin Delta. A full description of all PCE’s, including those for coastal marine areas, may be found in 74 FR 52300.

Green Sturgeon Critical Habitat Summary

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

(3) Historical Abundance and Distribution

Green sturgeon are widely distributed along the Pacific Coast, have been documented offshore from Ensenada, Mexico, to the Bering Sea, and are found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, the Southern DPS green sturgeon are anadromous, however, they are the most marine-oriented of the sturgeon species (Moyle 2002).

The historical distribution of green sturgeon in the Sacramento-San Joaquin river basins is poorly documented, but Adams *et al*. (2007) summarizes information that suggests that green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers (Mora *et al*. 2009). Historical records from the 1930s indicate that green sturgeon were not listed as either "known to occur" or "presumed to occur" in the Yuba or American Rivers (Sumner and Smith 1939, Evermann and Clark 1931).

Spawning populations of green sturgeon in North America are currently found in only three river systems: the Sacramento and Klamath rivers in California and the Rogue River in southern Oregon. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy ocean waters down to the 110 meter contour (Erickson and Hightower 2007). During the late summer and early fall, sub-adults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al*. 1991, Moser and Lindley 2007 as cited in Reclamation 2008). Particularly large concentrations of green sturgeon from both the northern and southern populations occur in the Columbia River estuary, Willapa Bay, Grays Harbor and Winchester Bay, with smaller aggregations in Humboldt Bay, Tillamook Bay, Nehalem Bay, and San Francisco and San Pablo bays (Emmett *et al*. 1991, Moyle *et al*. 1992 as cited in Reclamation 2008, Beamesderfer *et al*. 2007). Lindley *et al*. (2008) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska.

Individual fish from the Southern DPS of green sturgeon have been detected in these seasonal aggregations. Information regarding the migration and habitat use of green sturgeon has recently emerged. Lindley (2006 as cited in NMFS 2009a) presented preliminary results of large-scale green sturgeon migration studies, and verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. This work was further expanded by recent tagging studies of green sturgeon conducted by Erickson and Hightower (2007) and Lindley *et al*. (2008). To date, the data indicate that green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River estuary. This information also agrees with the results of previous green sturgeon tagging studies (CDFG 2002), where CDFW tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 commercial fisheries recoveries were in the Columbia River estuary (CDFG 2002).

In the lower Feather River, green sturgeon have intermittently been observed (Beamesderfer *et al*. 2007). NMFS (2008b) states that the presence of adult, and possibly sub-adult, green sturgeon within the lower Feather River has been confirmed by photographs, anglers' descriptions of fish catches (P. Foley, pers. comm. cited in CDFG 2002), incidental sightings (DWR 2005), and occasional catches of green sturgeon reported by fishing guides (Beamesderfer *et al*. 2004).

In the mid-1970s, green sturgeon were caught each year on the Feather River, with the majority of catches occurring from March to May and a few additional catches occurring in July and August (USFWS 1995). In 1993, seven adult green sturgeon were captured at the Thermalito Afterbay Outlet, ranging in size from 60.9 to more than 73.2 inches (USFWS 1995). In a broad scale survey from 1999 to 2001, green sturgeon were infrequently observed within the area downstream of the Thermalito Afterbay Outlet and none observed upstream (DWR 2003a). In 2006, four green sturgeon were positively identified by DWR biologist near the Thermalito Afterbay Outlet. Eight additional sturgeon were also observed in the same area but could not be positively identified as green sturgeon (DWR 2007a as cited in Reclamation 2008).

Although adult green sturgeon occurrence in the Feather River has been previously documented, larval and juvenile green sturgeon have not been collected despite attempts to collect larval and juvenile sturgeon during early spring through summer using rotary screw traps, artificial substrates, and larval nets deployed at multiple locations (Seesholtz *et al*. 2003). Moreover, unspecific past reports of green sturgeon spawning (Wang, 1986, USFWS 1995, CDFG 2002) have not been corroborated by observations of young fish or significant numbers of adults in focused sampling efforts (Niggemyer and Duster 2003, Seesholz *et al*. 2003, Beamesderfer *et al*. 2004). Based on these results, in 2006, NMFS concluded that an effective population of spawning green sturgeon did not exist in the lower Feather River (71 FR 17757). However, four fertilized green sturgeon eggs were collected near the Thermalito Afterbay Outlet on June 14, 2011, thus providing the first documentation of at least some successful spawning in the Feather River (Corps 2013b).

Historical accounts of sturgeon in the Yuba River have been reported by anglers, but these accounts do not specify whether the fish were white or green sturgeon (Beamesderfer *et al*. 2004). Since the 1970s, numerous surveys of the lower Yuba River downstream of Englebright Dam have been conducted, including annual salmon carcass surveys, snorkel surveys, beach seining, electrofishing, rotary screw trapping, redd surveys, and other monitoring and evaluation activities. Over the years of these surveys and monitoring of the lower Yuba River, one confirmed observation of an adult green sturgeon has occurred prior to 2011.

As part of ongoing sturgeon monitoring efforts in the Feather River Basin under the AFRP, Cramer Fish Sciences conducted roving underwater video surveys in the lower Feather and lower Yuba rivers using a drop-down camera suspended from a motorized boat. On May 24, 25 and 26, 2011, underwater videographic monitoring was conducted in the lower Yuba River downstream of Daguerre Point Dam. Although results are preliminary, a memorandum dated June 7, 2011, Cramer Fish Sciences (2011) stated that they observed what they believed were 4-5 green sturgeon near the center of the channel at the edge of the bubble curtain below Daguerre Point Dam. The sturgeon were observed either on a gravel bar approximately 1.5 m deep, and in a pool approximately 4 m deep immediately adjacent to the gravel bar. Photographs taken by Cramer Fish Sciences (2011) were forwarded to green sturgeon experts. Olaf P. Langness, Sturgeon and Smelt Projects, Washington Department of Fish and Wildlife Region 5, expressed the opinion that the photographs were of green (rather than white) sturgeon. Also, David Woodbury, NMFS Sturgeon Recovery Coordinator, expressed his opinion that the fish in the photographs were green sturgeon.

During 2012, underwater videography also was used in an attempt to document the presence of green sturgeon downstream of Daguerre Point Dam, but no observations of green sturgeon were made.

YCWA (2013a) examined the potential occurrence of green sturgeon in the lowermost 24 miles of the Yuba River based on detections of acoustically-tagged green sturgeon in the Yuba River. The examination included coordination with agencies and organizations involved with green sturgeon research in the Central Valley, and collection of available information and data regarding the presence and use of the Yuba River by green sturgeon. YCWA collaborated with DWR's Feather River Program, the California Fish Tracking Consortium (CFTC), and CDFW's Heritage and Wild Trout and Steelhead Management and Recovery Programs to examine whether any of the acoustically-tagged green sturgeon were found in the lower Yuba River. The CFTC is tracking 217 green sturgeon acoustically tagged in the Central Valley, and DWR's Feather River Program has acoustically tagged 2 green sturgeon in the lower Feather River.

(4) Species Life History

Information about larval Southern DPS green sturgeon in the wild is developing since the species was listed as threatened. The U.S. Fish and Wildlife Service (USFWS), conducts annual sampling for egg an larvae in the mainstem Sacramento River, above an below RBDD. Their data reveals some limited information about green sturgeon larvae, such as time and date of capture, and corresponding river conditions such as temperature and flow parameters. Unfortunately, there is little information on diet, distribution, travel time, and estuary rearing. However, laboratory studies have provided some information about this initial life stage.

Adult Immigration, Holding and Emigration

Green sturgeon in the Sacramento River have been documented and studied more widely than they have in either the Feather or the Yuba rivers. Green sturgeon adults in the Sacramento River are reported to begin their upstream spawning migrations into freshwater during late February, before spawning between March and July, with peak spawning believed to occur between April and June (Adams *et al*. 2002). NMFS (2009) reports that based on recent data gathered from acoustically tagged adult green sturgeon, these fish migrate upstream during May as far as the mouth of Cow Creek, near Bend Bridge on the Sacramento River.

Adult green sturgeon prefer deep holes (≥ 5 m depth) at the mouths of tributary streams, where they spawn and rest on the bottom (NMFS 2009). After spawning, the adults hold over in the upper Sacramento River between RBDD and the GCID diversion until November (Klimley 2007). Heublein *et al*. (2006, 2009) reported the presence of adults in the Sacramento River during the spring through the fall into the early winter months, holding in upstream locations before their emigration from the system later in the year. Green sturgeon downstream migration appears to be triggered by increased flows and decreasing water temperatures, and occurs rapidly once initiated (NMFS 2009). Some adult green sturgeon rapidly leave the system following their suspected spawning activity and re-enter the ocean in early summer (Heublein 2006). NMFS (2009) states that green sturgeon larvae and juveniles are routinely observed in rotary screw traps at RBDD and the GCID diversion, indicating that spawning occurs upstream of both these sites. Before the studies conducted by UC Davis, there were few empirical observations of green sturgeon movement in the Sacramento River (Heublein *et al*. 2009). The study by Heublein *et al*. (2009) is reportedly the first to describe the characteristics of the adult green sturgeon migration in the Sacramento River, and to identify putative regions of spawning habitat, based on the recorded movements of free-swimming adults.

The Sacramento River adjacent to the GCID diversion routinely contains a large aggregation of green sturgeon during summer and fall months, although the GCID aggregation site is atypical of over-summering habitats in other systems, being an area of high water velocity (Heublein *et al*. 2009). The GCID site is over five meters deep, with structural current refuges and eddy formations. It is possible that green sturgeon occupy lower-velocity subsections of the site, although observations of green sturgeon capture, and manual tracking estimates, indicate that green sturgeon are found in, or in very close proximity to, high velocity areas (Heublein *et al*. 2009).

<u>Adult Spawning</u>

Adult green sturgeon are believed to spawn every two to five years (Beamesderfer *et al*. 2007). Upon maturation of their gonadal tissue, but prior to ovulation or spermiation, the adult fish enter freshwater and migrate upriver to their spawning grounds (NMFS 2009a). Heublein *et al*. (2009) observed that green sturgeon enter San Francisco Bay in March and April and migrate rapidly up the Sacramento River to the region between GCID and Cow Creek. The fish lingered at these regions at the apex of their migration for 14 to 51 days, presumably engaged in spawning behavior, before moving back downriver (Heublein *et al*. 2009).

To investigate adult immigration, spawning or juvenile nursery habits of green sturgeon in the upper Sacramento River, Brown (2007) developed a study to identify green sturgeon spawning locations and dates in the upper Sacramento River. Using a depth finder, study sites were selected at locations upstream of deeper holes in higher velocity water in the Sacramento River (Brown 2007). The study was originally designed in 1997 using the prevalent methodology at the time (*e.g.*, artificial substrate mats) for the capture of eggs and larvae of white sturgeon. Brown (2007) reports that later findings from artificial spawning and larval rearing of green sturgeon (Van Eenennaam *et al*. 2001) indicate that green sturgeon eggs may be less adhesive than eggs from other acipenserids, possibly reducing the effectiveness of artificial substrate sampling.

Brown (2007) suggested that spawning in the Sacramento River may occur from April to June, and that the potential spawning period may extend from late April through July, as indicated by the rotary screw trap data at the RBDD from 1994 to 2000. Heublein *et al*. (2009) stated that, in contrast to the behavior of green sturgeon observed during 2004–2005, the majority of out-migrants detected in 2006 displayed an entirely different movement strategy. Nine of the ten tagged fish detected that year exited the system with no extended hold-over period and with no apparent relation to flow increases, eight leaving before July 4th and the last on August 22nd. Heublein *et al*. (2009) suggested that the rapid out-migration of green sturgeon in 2006, and the reduced aggregation period at the GCID site could be a result of consistently higher flows and lower temperatures than in previous study years. Alternatively, this could be an unusual behavior, related to unknown cues, that has not been documented in green sturgeon before this study (Heublein *et al*. 2009).

The apex detections of individual fish indicate reaches and dates when spawning might have occurred during the study conducted by Heublein *et al*. (2009). They reported that spawning may have occurred between May and July, and that high water velocities and extensive bedrock habitat were found in all of the apex detection reaches. Furthermore, water temperatures did not exceed 62.6°F in these reaches during this study, which would have permitted normal green sturgeon larval development (Van Eenennaam *et al*. 2005 as cited in Heublein *et al*. 2009). During 2009, four spawning sites of green sturgeon were confirmed in the upper Sacramento River (Poytress *et al*. 2010). Three confirmed sites from 2008 surveys were reconfirmed and one of three newly sampled sites in 2009 was confirmed by the presence of green sturgeon eggs on artificial substrate mats.

During 2010, five spawning sites of green sturgeon were confirmed within a 60 river kilometer reach of the upper Sacramento River, California (Poytress *et al*. 2011). As stated by Poytress *et al*. (2010), spawning events occurred several river kilometers upstream and downstream of the RBDD before and after the June 15th seasonal dam gate closure. Spawning occurred directly below RBDD within two weeks after the gate closure. The temporal distribution pattern suggested by 2009 sampling results indicates spawning of Sacramento River green sturgeon occurs from early April through late June (Poytress *et al*. 2010). Sampling conducted during 2010 suggested that spawning of Sacramento River green sturgeon occurs from early April through mid-June (Poytress *et al*. 2011). During 2010 sampling, depths for eggs collected from all of the sites combined ranged from 2.4 to 10.9 m (7.9 to 35.8 ft) with an average of 6.9 m (22.6 ft). Sacramento River flows and water temperatures at sites located above RBDD during the estimated spawning period ranged from 166 to 459 m^3/s (5,862 cfs to 16,209 cfs), with an average of 293 m^3/s (10,347 cfs), and 52.0°F to 57.9°F during the estimated spawning period. Sacramento River flows and temperatures at sites located below RBDD during the estimated spawning period ranged from 268 to 509 m^3/s (9,464 cfs to 17,975 cfs), with an average of 349 m^3/s (12,324 cfs), and 52.9°F to 60.1°F during the estimated spawning period (Poytress *et al*. 2011).

The habitat requirements of green sturgeon are not well known. Eggs are likely broadcast and externally fertilized in relatively fast water and probably in depths greater than three meters (Moyle 2002). Preferred spawning substrate is likely large cobble where eggs settle into cracks, but spawning substrate can range from clean sand to bedrock (Moyle 2002). Spawning is believed to occur over substrates ranging from clean sand to bedrock, with preferences for cobble (Emmett *et al*. 1991, Moyle *et al*. 1995). Eggs likely adhere to substrates, or settle into crevices between substrates (Van Eenennaam *et al*. 2001, Deng *et al*. 2002). Both embryos and larvae exhibited a strong affinity for benthic structure during laboratory studies (Van Eenennaam *et al*. 2001, Deng *et al*. 2002, Kynard *et al*. 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2007).

Embryo Incubation

Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15^{o}C (59^{o}F) (Van Eenennaam *et al*. 2001, Deng *et al*. 2002). Studies conducted at the University of California, Davis by Van Eenennaam *et al*. (2005) using the Northern DPS green sturgeon juveniles indicated that an optimum range of water temperature for egg development ranged between 14^{o}C (57.2^{o}F) and 17^{o}C (62.6^{o}F). Temperatures over 23^{o}C (73.4^{o}F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5^{o}C (63.5^{o}F) and 22^{o} C (71.6^{o}F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch.

At incubation temperatures below 14^{o}C (57.2^{o}F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam *et al*. 2005).

Newly hatched green sturgeon are approximately 12.5 to 14.5 mm long. After approximately 10 days, larvae begin feeding and growing rapidly. Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other Acipenseridae. They 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 six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al*. 2005). Exogenous feeding starts at approximately 14 days (23 to 25 mm) (Van Eenennaam *et al*. 2001).

Juvenile Rearing and Emigration

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other Acipenseridae. They are strongly oriented to the bottom and exhibit nocturnal activity patterns (NMFS 2009a). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al*. 2005). Juvenile fish continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages (NMFS 2009a). Observations made during nocturnal sampling in the Sacramento River indicate a possible preference of larvae for mid-channel environments or swift water velocity areas (Poytress *et al*. 2010). When ambient water temperatures reached 8^{o}C (46.4^{o}F), downstream migrational behavior diminished and holding behavior increased (Kynard *et al*. 2005). This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds (NMFS 2009a).

Growth is rapid as juveniles move downstream and reach up to 300 mm the first year and over 600 mm in the first 2 to 3 years (Nakamoto *et al*. 1995). Juvenile Southern DPS green sturgeon have been salvaged at the Federal and State pumping facilities (which are located in the southern region of the Delta), and collected in sampling studies by CDFW during all months of the year (CDFG 2002). The majority of juveniles that were captured in the Delta were between 200 and 500 mm indicating they were from 2 to 3 years of age, based on studies from the Klamath River Nakamoto *et al*. (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates juvenile green sturgeon likely hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard *et al*. (2005). Both Northern DPS and Southern DPS green sturgeon juveniles tested under laboratory conditions, with either full or reduced rations, had optimal bioenergetic performance (*i.e.,* growth, food conversion, swimming ability) between 15^{o} C (59^{o} F) and 19^{o} C (66.2^{o} F) , thus providing a temperature related habitat target for conservation of this rare species (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed.

Radtke (1966) inspected the stomach contents of juvenile green sturgeon in the Delta and found food items to include a mysid shrimp species (*Neomysis awatschensis)*, amphipods (*Corophium* spp*.)*, and other unidentified shrimp. In the northern estuaries of Willapa Bay, Grays Harbor, and the Columbia River, where both Southern DPS and Northern DPS green sturgeon exist, green sturgeon have been found to feed on a diet consisting primarily of benthic prey and fish common to the estuary. For example, burrowing thalassinid shrimp (mostly *Neotrypaea californiensis*) were important food items for green sturgeon taken in Willapa Bay, Washington (Dumbauld *et al*. 2008).

There is a fair amount of variability (1.5 – 4 years) in the estimates of the time spent by juvenile green sturgeon in freshwater before making their first migration to sea. Nakamoto *et al*. (1995) found that Northern DPS green sturgeon on the Klamath River migrated to sea, on average by age three and no later than by age four. Moyle (2002) suggests juveniles migrate out to sea before the end of their second year, and perhaps as yearlings. Laboratory experiments indicate that both Northrn DPS and Southern DPS green sturgeon juveniles may occupy fresh to brackish water at any age, but they are physiologically able to completely transition to saltwater at around 1.5 years in age (Allen and Cech 2007). In studying Northern DPS green sturgeon on the Klamath River, Allen *et al.* (2009) devised a technique to estimate the timing of transition from fresh water to brackish water to seawater by taking a bone sample from the leading edge of the pectoral fin and anlyzing the ratios of stontium and barium to calcium. The results of this study indicate that green sturgeon move from freshwater to brackish water (such as the estuary) at ages 0.5–1.5 years and then move into seawater at ages 2.5-3.5 years. Table VII-4 shows the migration timing of various life stages throughout the Central Valley, Delta, San Francisco Bay, and into the Pacific Ocean.

Ocean Growth

Once green sturgeon juveniles make their first entry into sea, they may spend a number of years migrating up and down the coast. While they may enter river mouths and coastal bays throughout their years in the sub-adult phase, they do not return to their natal freshwater environments before they are mature. In the summer months, multiple rivers and estuaries throughout the Southern DPS range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley *et al*. 2011). Some of these aggregations are mixtures of both the

Southern DPS and the Northern DPS green sturgeon, and there is considerable overlap in their ranges. However, Northern DPS green sturgeon do not appear to migrate into San Francisco Bay. Genetic studies on green sturgeon stocks indicate that the green sturgeon in the San Francisco Bay ecosystem belong to the Southern DPS (Israel *et al*. 2009). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly *et al*. 2007, Heublein *et al*. 2009, Lindley *et al*. 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean, and why they aggregate episodically (Lindley *et al*. 2008, Lindley *et al*. 2011).

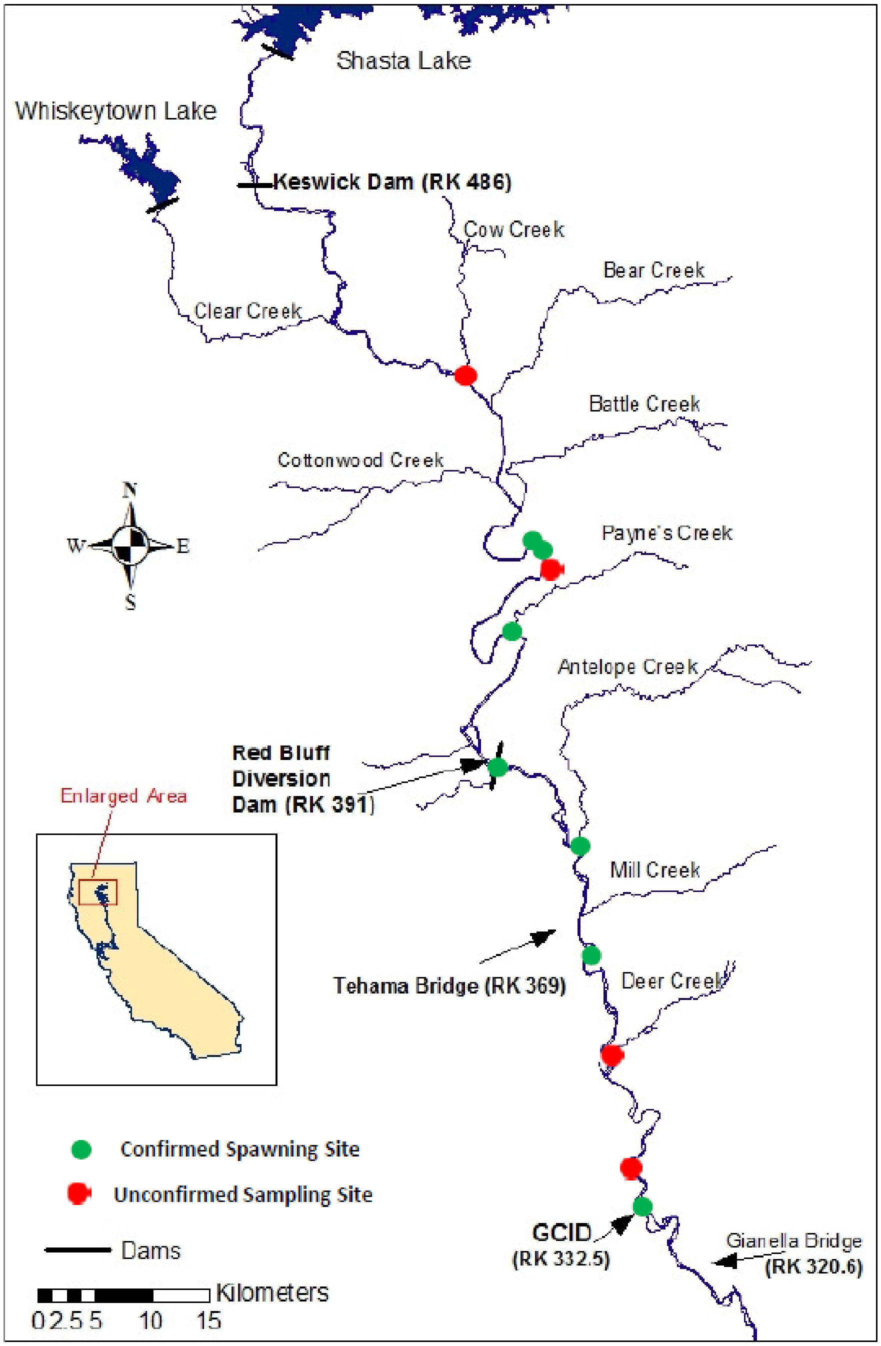


Figure VII-11. Green sturgeon known spawning locations on the upper Sacramento River, as identified by USFWS during the 2008-2012 field sampling seasons. Source: Poytress *et al.* (2012). An uncomfirmed sampling site indicates an area where sturgeon have been known to congregate but where evidence of spawning was not able to be obtained in the study.

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

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

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

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

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

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

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

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

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

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

* Fish Facility salvage operations

Sources: [a]USFWS (2002); [b]Moyle *et al*. (1992); [c]Adams *et al*. (2002) and NMFS (2005); [d]Kelly *et al*. (2007); [e]CDFG (2002); [f]IEP Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [g]Nakamoto *et al*. (1995); [h]Heublein (2006); [i]CDFG Draft Sturgeon Report Card (2007), [j]Poytress *et al* (2011, 2012), [k]Alicia Seesholtz, DWR, personal communication

(5) Factors Affecting the Species and Critical Habitat

Population Size

Population(s) should be large enough to survive environmental variations, catastrophes, and anthropogenic perturbations. Also, the population(s) should be sufficiently large to maintain long term genetic diversity (McElhany *et al*. 2000). The draft Southern DPS green sturgeon Recovery Plan (NMFS, unpublished) suggests 500 adult spawners per year would be needed for a viable population that is able to counter the effects of genetic drift. Estimates of the annual Southern DPS green sturgeon adult spawning population size range from a low of 10-28 individuals (Israel and May 2010) to a high of (refer to Yolo Bypass population estimate in Thomas *et al*. (2013). Ethan Mora, (unpublished data) conducted abundance surveys in the upper Sacramento in 2010-2012 and detected 164 to 245 individuals annually, which provides preliminary abundance data for the Sacramento River spawning population. Neither of these estimates approach the spawning population size identified in the NMFS draft Recovery Plan (NMFS 2014).

Stranding Events

Flood control, through the construction of engineered floodplains and associated control structures such as weirs, have helped to protect urban areas from flooding around the Sacramento River and the Delta. The two largest of these are the Yolo Bypass, which is controlled primarily by the Fremont Weir, and the Sutter Bypass, controlled by the Tisdale Weir. While the anthropogenic benefits of flood control are incredibly valuable to the protection of life and property, there are unintended consequences to Southern DPS green sturgeon, green sturgeon find their way into these floodplains and become stranded. The mechanism by which these strandings occur is not clear, they may enter the floodplain and encounter impassable weirs; they may wash over the top of the weir but be unable to fight their way back; or they may linger in the floodplain until water levels recede, effectively cutting off any possible exit point.

Stranding events are a concern, as was highlighted in 2011 when green sturgeon (and other species of fish) were detected in the Yolo and Sutter Bypasses and required rescue and return to the Sacramento River. Thomas *et al.* (2013) described the 2011 stranding event, and proposed a Population Viability Analysis (PVA) model to quantify the effects of stranding events on the long-term viability of Southern DPS green sturgeon. The authors stated: "Our analysis of green sturgeon population viability in the Sacramento River suggests that stranding could have a biologically significant impact if it is a recurring event. Furthermore, it appears that monitoring and rescue will substantially reduce, though not completely offset, that impact. While our analysis indicated that the single stranding event in 2011 was, by itself, a small risk to population viability, it has since emerged that similar events have occurred at least four times over the last decade."

The PVA model analysis by Thomas *et al.* (2013) indicates two things; first, a need to find better solutions to green sturgeon stranding events such as a fish ladder designed to accommodate green sturgeon, and second, and more generally, better information about Southern DPS green sturgeon to help improve the various parameters and assumptions the PVA model was forced to make. Currently, there is a Yolo Bypass Implementation Plan that has been written in response to the stranding issues in the Yolo Bypass, see actions required in the NMFS 2009 biological and conference opinion on the long-term operations of the CVP and SWP (NMFS 2009). (USBR/CADWR Yolo Bypass Implementation Plan 2012).

Loss of Habitat

Access to historical spawning habitat has been reduced by construction of migration barriers, such as major dams, that block or impede access to the spawning habitat. The principal factor for the decline of green sturgeon reportedly comes from the reduction of green sturgeon spawning habitat to a limited area of the Sacramento River (70 FR 17391). Although existing water storage dams only block access to about 9 percent of historically available green sturgeon habitat, Mora *et al*. (2009) suggest that the blocked areas historically contained relatively high amounts of spawning habitat because of their upstream position in the river system. Adams *et al*. (2007) hypothesized that significant amounts of historically-utilized spawning habitat may be blocked by Shasta Dam and Oroville Dam on the Feather River, reducing the productive capacity and simplifying the spatial structure of the Sacramento River green sturgeon population.

Keswick Dam is an impassible barrier blocking green sturgeon access to what are thought to have been historic spawning grounds upstream (70 FR 17386). In addition, a substantial amount of what may have been historical spawning and rearing habitat in the Feather River upstream of Oroville Dam has also been lost (70 FR 17386). Southern DPS green sturgeon are observed at the base of impassable dams such as the Fish Barrier Dam (Corps 2013b) on the Feather River and at Daguerre Point Dam on the Yuba River (Bergman *et al.* 2013), suggesting the possibility that adult green sturgeon would migrate further upstream, if possible. Loss of habitat is widely implicated in the decline of many if not most federally listed species, and habitat loss is likely a major factor affecting Southern DPS green sturgeon.

Alteration of Habitat

Green sturgeon habitat in the mainstem Sacramento River and the Delta has been greatly modified since the mid-1800s. Based on NMFS (2010d), the following examples illustrate relationships between threats to green sturgeon and specific types of habitat alteration:

- Hydraulic gold mining resulted in the removal of gravel and the deposition of mercury-laced fine sediment within streams, rivers, and the Bay/Delta estuary.
- Agricultural practices have converted tidal and seasonal marshlands and continue to release contaminants into Central Valley waterways.
- Levees have been created extensively along the Sacramento River and the Delta, resulting in the removal of riparian vegetation and the reduction of channel complexity.

- Historical reclamation of wetlands and islands, channelization and hardening of levees with riprap have reduced and degraded in- and off-channel intertidal and sub-tidal rearing habitat for green sturgeon.
- The hydrographs of the Sacramento River and its tributaries have been substantially altered from unimpaired conditions, and may no longer favorably correspond with green sturgeon lifestage periodicities.
- In-river water diversions alter flow and potentially entrain larval/juvenile green sturgeon.
- Introduced and invasive species have likely modified trophic relationships in both freshwater and estuarine habitats, which may have resulted in increased predation on young green sturgeon, as well as reduced growth and fitness as a result of feeding on non-optimal prey resources.

Flows

NMFS (2005c) and USFWS (1995) found a strong correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength in the Sacramento-San Joaquin Estuary (these studies primarily involve the more abundant white sturgeon, however, the threats to green sturgeon are thought to be similar), indicating that insufficient flow rates are likely to pose a significant threat to green sturgeon (71 FR 17757). Low flow rates affect adult migration and may cause fish to stop their upstream migration or may delay access to spawning habitats. Also, it was posited that low flow rates could dampen survival by hampering the dispersal of larvae to areas of greater food availability, hampering the dispersal of larvae to all available habitat, delaying the transportation of larvae downstream of water diversions in the Delta, or decreasing nutrient supply to the nursery, thus stifling productivity (NMFS 2005c). Very little information is available on the habitat requirements and utilization patterns for early lifestages of green sturgeon (Mora *et al*. 2009).

Stranding due to flow reduction also may pose a threat to green sturgeon in the Sacramento River system. Green sturgeon that are attracted by high flows in the Yolo Bypass move onto the floodplain and eventually concentrate behind Fremont Weir, where they are blocked from further upstream migration (DWR 2005). As the Yolo Bypass recedes, these sturgeon become stranded behind the flashboards of the weir and can be subjected to heavy illegal fishing pressure. Sturgeon can also be attracted to small pulse flows and trapped during the descending hydrograph (Harrell and Sommer 2003).

Water Temperature

The installation of the Shasta Dam temperature control device in 1997 is thought to have reduced the previous problems related to high water temperatures in the upper Sacramento River, although Shasta Dam has a limited storage capacity and cold water reserves could be depleted in long droughts (NMFS 2007). Water temperatures at RBDD have not been higher than 62°F since 1995 (NMFS 2007) and have been within the green sturgeon egg and larvae optimum range for growth and survival of 59 to 66°F (Mayfield and Cech 2004). According to Reclamation (2008), water temperatures in the Feather River appear adequate for spawning and egg incubation, contrary to previous concerns that releases of warmed water from Thermalito

Afterbay are one reason neither green nor white sturgeon are found in the river in low-flow years (CDFG 2002, SWRI 2003). In some years, water temperatures downstream of the Thermalito Outlet are inadequate for spawning and egg incubation, which has been suggested as a reason why green sturgeon are not found in the river during low flow years (DWR 2007). However, post-Oroville Dam water temperatures are cooler than historic river temperatures during the summer months when early lifestages are likely to be present in the lower Feather River (DWR 2005a in Reclamation 2008). Prior to the construction of the Oroville Dam, water temperatures in the Feather River at Oroville averaged 65-71°F from June through August for the period of 1958-1968 (DWR 2004b). After Oroville Dam construction, water temperatures in the Feather River at the Thermalito Afterbay averaged 60-65°F from June through August for the period of 1993-2002 (DWR 2004b). It is likely that high water temperatures (greater than 63°F) may deleteriously affect sturgeon egg and larval development, especially for late-spawning fish in drier water years (70 FR 17386). The table below represents the range of temperatures to which green sturgeon are best suited, at various life stages.

Table VII-5. Temperature tolerance range by life stage.

Green Sturgeon Temperature Tolerance by Life Stage

temperature °C	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
temperature °F	41.0	42.8	44.6	46.4	48.2	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4
egg							b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
larvae													c	i	i	i	i	i	i	i	c,i	i	i	i
juvenile							a	a	a	a	a	a	a	a	a,d	a	a	a	a	a,d	a	a	a	a
sub-adult or adult, SF estuary										h	h	h	h	h	h	h	h							
adult (>152 cm), spawning						e	e	e,f	e,f	e,f	e,f	f												
sub-adult or adult, ocean			g	g	g	g	g	g	g	g	g													

optimal temperature	a = Mayfield and Cech, 2004
acceptable temperature	b = Van Eenennaam *et al*, 2005
impaired fitness; avoid prolonged exposure; increasing chance of lethal effects	c = Werner *et al*, 2007
likely lethal	d = Allen et al, 2006
lethal	e = Poytress *et al*, 2012
unknown effect upon survival and fitness	f = Poytress *et al*, 2013
NOTES: a, b, c, d, i used green sturgeon sourced from the Klamath River. E and f indicate water temperature during estimated spawning period on the upper Sacramento River. G used green strugeon captured in the Rogue River. H involved tracking acoustically tagged green sturgeon captured in San Pablo Bay	g = Erickson and Hightower, 2007 h= Kelly *et al*, 2007 i = Linares-Casenave *et al*, 2013

NOTES on variability of individual's fitness and varibality of themal stress effects: Linares-Casenave *et al* (2013) found varying levels of temperature tolerance by broodstock collected at different times of the year when river temperatures were different. Wener *et al* (2007) found that detrimental thermal stress efects (notochord deformity and impaired swimming) were reversible in 50% of larvae returned to cool water (17° C) after 3 days exposure to 26° C. Thus it is important to note that thermal stress effects are sometimes reversible and can also affect individuals differently.

Delayed or Blocked Migration

It has been suggested that the primary effect of construction of large water-storage reservoirs in the Sacramento–San Joaquin river basin has been to curtail the distribution of green sturgeon within the DPS (Mora *et al*. 2009). For example, water storage dams are hypothesized to be a major factor in the decline of green sturgeon in the Sacramento River (Adams *et al*. 2007). The existence and ongoing effects of these dams may have reduced the amount and altered the spatial distribution of spawning, rearing and holding habitat available and by restriction to the mainstem

Sacramento River, resulting in green sturgeon becoming more vulnerable to environmental catastrophes (Mora *et al*. 2009).

Other potential adult migration barriers to green sturgeon have been reported to include the Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and the DCC Gates on the Sacramento River, and Shanghai Bench and Sunset Pumps on the Feather River (71 FR 17757).

DWR (2005) reported that the lock connecting the Sacramento River Deep Water Ship Channel with the Sacramento River blocks the migration of all fish from the deep water ship channel back to the Sacramento River. Thus, if green sturgeon enter the Sacramento River Deep Water Ship Channel, they will be unable to continue their migration upstream in the Sacramento River. Green sturgeon are attracted by high floodwater flows into the Yolo Bypass, but are restricted from entering the Sacramento River by the Fremont Weir (DWR 2005). Sturgeon also may be attracted to small pulse flows into the Yolo Bypass, and isolated during the descending hydrograph (Harrell and Sommer 2003).

Green sturgeon can become entrained in the Sutter Bypass during storm flow events. During April 2011, several sturgeon (green and white) were stranded behind the Tisdale Weir on the Sutter Bypass when storm flows receded. CDFW, in collaboration with UC Davis, organized a fish rescue operation and returned the sturgeon to the Sacramento River.

The DCC, located near Walnut Grove, California, was constructed in 1951 to facilitate the transfer of fresh water from the Sacramento River to the federal and state pumps located in the south Delta. Flow from the Sacramento River into the DCC is controlled by two radial arm gates that can be opened or closed depending on water quality, flood protection, and fish protection requirements. When the gates are open, Sacramento River water is diverted into the Mokelumne and San Joaquin rivers. The gates are closed in fall to protect migrating salmonids, then are opened the following spring. Thirty-percent of the tagged adult green sturgeon migrating down the Sacramento River after spawning entered the DCC (Israel *et al*. 2010). Most of these fish were able to successfully negotiate their way through the Delta and reach the Pacific Ocean. However, four fish were detected in the south Delta, with only one surviving to reach the Pacific Ocean. Juvenile green sturgeon may also be entrained into the interior delta during the summer when the DCC is open. Further studies are necessary to investigate the threat this alternative route through the Delta poses for these fish (NMFS 2010c).

Potential physical barriers to adult green sturgeon migration in the Feather River are located at Shanghai Bench (RM 25) and at the Sutter Extension Water District's Sunset Pumps (RM 39). Although Shanghai Bench was breached during 2011, it is uncertain whether or not it still imposes a migration barrier or impediment to adult green sturgeon. Each of these barriers could impede adult upstream migration during low flows (USFWS 1995a). Impediments to migration may cause fish to stop their natural upstream migration or may delay access to spawning habitats (Moser and Ross 1995). Natural (Shanghai Bench) and man-made (Sunset Pumps) impediments to upstream movements in the Feather River during low flow years might also limit significant spawning activities of green sturgeon above these obstacles to wet, high flow water years when they are most likely to be able to pass these obstacles (Beamesderfer *et al*. 2004).

Impaired Water Quality

Exposure of green sturgeon to toxics has been identified as a factor that can lower reproductive success, decrease early lifestage survival, and cause abnormal development, even at low concentrations (USFWS 1995). Contamination of the Sacramento River increased substantially in the mid-1970s when application of rice pesticides increased (70 FR 17386). Additionally, water discharges containing metals from Iron Mountain Mine, located adjacent to the Sacramento River, have been identified as a factor affecting survival of sturgeon downstream of Keswick Dam. However, treatment processes and improved drainage management in recent years have reduced the toxicity of runoff from Iron Mountain Mine to acceptable levels. It has been reported that white sturgeon may accumulate PCBs and selenium (White *et al*. 1989 as cited in Reclamation 2008). While green sturgeon spend more time in the marine environment than white sturgeon and, therefore, may have less exposure, the NMFS BRT for green sturgeon concluded that contaminants also pose some risk for green sturgeon. However, this risk has not been quantified or estimated (NMFS 2007). Additionally, events such as toxic oil or chemical spills in the upper Sacramento River could result in the loss of both spawning adults and their progeny, and lead to year-class failure (BRT 2005).

Dredging and Ship Traffic

Hydraulic suction dredging is conducted in the Sacramento and San Joaquin rivers, navigation channels within the Delta, and Suisun, San Pablo, and San Francisco bays. Juvenile green sturgeon residing within the Delta and the San Francisco Bay Estuary may be entrained during hydraulic suction dredging, which is conducted to maintain adequate depth within navigation areas or to mine sand for commercial use (NMFS 2010c). Additionally, the disposal of dredged material at aquatic sites within the estuary might bury green sturgeon or their prey, and expose green sturgeon to elevated levels of contaminated sediments (NMFS 2010c).

Harvest

Commercial harvest of white sturgeon results in the incidental bycatch of green sturgeon primarily along the Oregon and Washington coasts and within their coastal estuaries. Oregon and Washington have recently prohibited the retention of green sturgeon in their waters for commercial and recreational fisheries. Adams *et al*. (2002) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that averages of 4.7 tons to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appeared to be dropping through the years, however, this could be related to changing fishing regulations. Adams *et al*. (2002) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are caught by sport fishermen targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). Sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time, however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by Israel (2007) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS geen sturgeon. This indicates a potential threat to the Southern DPS green sturgeon population. Beamesderfer *et al.* (2007) estimated that green sturgeon will be vulnerable to slot limits (outside of California) for approximately 14 years of their life span. Fishing gear mortality presents an additional risk to the long-lived sturgeon species such as the green sturgeon (Boreman 1997). Although sturgeon are relatively hardy and generally survive being hooked, their long life makes them vulnerable to repeated hooking encounters, which leads to an overall significant hooking mortality rate over their lifetime. An adult green sturgeon may not become sexually mature until they are 13 to 18 years of age for males (152-185cm), and 16 to 27 years of age for females (165-202 cm, Van Eenennaam 2006). Even though slot limits "protect" a significant proportion of the life history of green sturgeon from harvest, they do not protect them from fishing pressure.

Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. New regulations which went into effect in March 2007, reduced the slot limit of sturgeon from 72 inches to 66 inches, and limit the retention of white sturgeon to one fish per day with a total of three fish retained per year. In addition, a non-transferable sturgeon punch card with tags must be obtained by each angler fishing for sturgeon. All sturgeon caught must be recorded on the card, including those released. All green sturgeon must be released unharmed and recorded on the sturgeon punch card by the angler. In 2010, further restrictions to fishing for sturgeon in the upper Sacramento River were enacted between Keswick Dam and the Highway 162 Bridge over the Sacramento River near the towns of Cordora and Butte City. These regulations are designed to protect green sturgeon in the upper Sacramento River from unnecessary harm due to fishing pressure (CDFG 2011, freshwater fishing regulations 2010-2011).

Poaching rates of green sturgeon in the Central Valley are unknown, however, catches of sturgeon occur during all years, especially during wet years. Unfortunately, there is no catch, effort, and stock size data for this fishery which precludes making exploitation estimates (USFWS 1995a). Areas just downstream of Thermalito Afterbay outlet and Cox's Spillway, and several barriers impeding migration on the Feather River may be areas of high adult mortality from increased fishing effort and poaching. The small population of sturgeon inhabiting the San Joaquin River (believed to be currently composed of only white sturgeon) experiences heavy fishing pressure, particularly regarding illegal snagging and it may be more than the population can support (USFWS 1995a).

Disease and Predation

A number of viral and bacterial infections have been reported for sturgeon in general (Mims *et al*. 2002), however specific issues related to diseases of green sturgeon have not been studied or reported. Therefore, it is not known if disease has played a role in the decline of the Southern DPS of green sturgeon.

The significance of predation on each lifestage of green sturgeon has not been determined. There has been an increasing prevalence of nonnative species in the Sacramento and San Joaquin rivers and the Delta (CDFG 2002) and this may pose a significant threat (NMFS 2010c). Striped bass, an introduced species, may affect the population viability of Chinook salmon (Lindley *et al*. 2004), and probably preys on other species, such as sturgeon (Blackwell and Juanes 1998). It is likely that sea lions consume green sturgeon in the San Francisco Bay estuary, but the extent to which this occurs is unknown (NMFS 2010c).

(6) Viability Factors for Southern DPS green sturgeon

As an approach to determining the conservation status of salmonids, NMFS has developed a framework for identifying attributes of a viable salmonid population (VSP). The intent of this framework is to provide parties with the ability to assess the effects of management and conservation actions and ensure their actions promote the listed species' survival and recovery. This framework is known as the VSP concept (McElhany *et al*. 2000). The VSP concept measures population performance in term of four key parameters: abundance, population growth rate, spatial structure, and diversity. Although the VSP concept was developed for Pacific salmonids, the underlying parameters are general principles of conservation biology and can therefore be applied more broadly; here we adopt the VSP parameters for analysing the Southern DPS of green sturgeon viability.

<u>Abundance</u>

Abundance is one of the most basic principles of conservation biology, and from this measurement other parameters can be related. In applying the VSP concept, abundance is examined at the population level, and therefore population size is perhaps a more appropriate term. Historically, abundance and population trends of Southern DPS green sturgeon has been inferred in two ways, first by analyzing salvage numbers at the State and Federal pumping facilities (see below), and second, by incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Both methods of estimating Southern DPS green sturgeon abundance are problematic, nevertheless this has been the best data available. Only recently has more rigorous scientific inquiry begun with Israel and May (2010) and Ethan Mora (UC Davis, 2013, ongoing PhD thesis, unpublished).

A decrease in Southern DPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities, the Skinner Delta Fish Protection Facility (SDFPF) and the Tracy Fish Collection Facility (TFCF). However, this data should be interpreted with some caution, operations and practices at the facilities have changed over the decades, which may affect the salvage data shown below. (Figure VII-12).

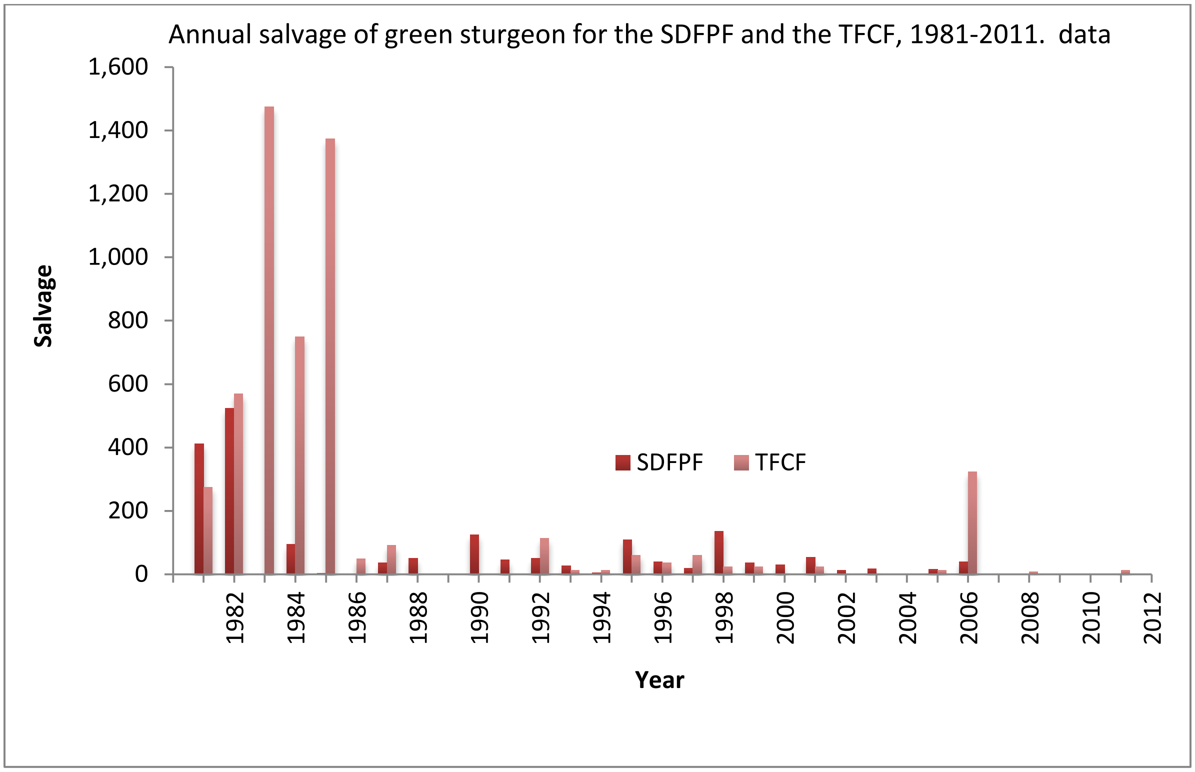


Figure VII-12. Annual salvage of green sturgeon for the SDFPF and the TFCF from 1981 to 2012. Data source: ftp://ftp.delta.dfg.ca.gov/salvage

Despite the potential pitfalls of using salvage data to estimate an abundance trendline for Southern DPS green sturgeon, the above chart shows what appears to be a very steep decline in abundance, and potentially great cause for concern.

Green sturgeon in the Sacramento River have been documented and studied more widely than those in either the Feather River or the Yuba River. In general, sturgeon year class strength appears to be episodic with overall abundance and dependent on a few successful spawning events. Genetic techniques were used to estimate the number of green sturgeon spawners contributing to juvenile production between 2002 and 2006 in the upper segment of spawning habitat above RBDD. Based upon these techniques, it was estimated that between 10 and 28 individuals contributed to juvenile production (Israel and May 2010). Because populations appear to be not in equilibrium, conclusions regarding equilibrium dynamics are uncertain given the lack of information (NMFS 2010c). Green sturgeon occasionally range into the Feather and Yuba Rivers, but numbers are low.

Productivity

Productivity and recruitment information for the Southern DPS of green sturgeon is an area that requires additional research.. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green sturgeon at the south Delta pumping facilities suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al*. 2007, Lindley *et al*. 2007). In general, the Southern DPS green sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010). It is unclear if the population is able to consistently replace itself. This is significant because the VSP concept requires that a population meeting or exceeding the abundance criteria for viability should, on average, be able to replace itself (McElhany *et al*. 2000). More research is needed to establish Southern DPS of green sturgeon productivity, however, green sturgeon are iteroparous and long-lived, so that spawning failure in any one year may be rectified in a succeeding spawning year (NMFS 2009a).

The table below summarizes data from 11 years of USFWS sampling for larval green sturgeon at the RBDD. Caution is needed in interpreting this data as the catch counts have not been corrected for sampling effort or volume of water (catch per unit volume, or CPUV, would be the preferred standard). Furthermore, the raising or lowering of the gates at RBDD could have produced profound impacts to the catch counts, but this variable is not quantified nor even qualified. Starting in 2012, the RBDD gates have remained permanently open, allowing anadromous fish such as green sturgeon unrestricted passage at Red Bluff all year long, and it may be reasonably expected that this should bolster the population's productivity by removing a major barrier to migration/passage. In 2011, a wet year, vastly more larval green sturgeon caught than in any other year. A preliminary conclusion might be that the Southern DPS of green sturgeon population productivity is highly variable, and recruitment is dependent upon banner years such as 2011.

Table VII-6. Green Sturgeon Capture Data at Red Bluff Diversion Dam.

The following Data is preliminary and will be included in this or a different summary within a forthcoming Draft compendium report, in preparation. 11/1

RBDD RST Green Sturgeon Capture Data

	Catch	Sampling	Dates of Capture				Temperature (F)			Discharge (cfs)			Turbidity (NTU)		
Year	Count	Effort (%)	Initial	Final	Range (Days)		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
2002	35	23%	7-May	16-Jul	70		54.3	58.6	57.3	9,203	14,762	12,005	1.0	1.7	1.4
2003	360	92%	13-Jun	9-Aug	151		51.7	59.9	57.2	6,920	15,049	10,079	0.8	35.4	1.6
2004	265	84%	4-May	29-Jul	86		54.3	58.6	57.2	8,716	15,641	12,929	1.6	3.0	2.3
2005	271	74%	7-May	13-Aug	98		52.2	59.7	52.2	9,817	60,867	9,817	1.4	20.3	2.9
2006	193	61%	10-Jun	25-Aug	76		54.9	57.9	56.8	11,716	14,608	13,371	2.8	6.9	3.3
2007	19	83%	11-May	24-Jul	74		54.0	59.4	57.1	8,943	14,807	11,708	0.8	4.7	1.5
2008*	0	64%	-	-	-		-	-	-	-	-	-	-	-	-
2009	32	71%	11-May	16-Jul	66		56.0	60.8	59.2	9,228	12,642	10,588	2.4	8.0	3.8
2010	70	68%	26-May	29-Aug	95		54.6	59.3	57.6	9,018	17,971	12,132	1.3	7.2	2.3
2011	3,701	63%	16-May	27-Aug	103		52.1	59.6	57.0	10,027	24,363	12,913	3.3	19.0	4.9
2012	288	78%	1-May	26-Jun	56		54.3	60.3	57.4	7,851	14,118	10,475	1.4	3.8	2.4
Ave	**476**	**69%**	**16-May**	**2-Aug**	**78**	**Ave**	**53.8**	**59.4**	**56.9**	**9,144**	**20,483**	**11,602**	**1.7**	**11.0**	**2.7**

Table 1. Enviromental data readings observed during periods when larval Green Sturgeon were collected via rotary screw traps at the Red Bluff Diversion Dam (RBDD) from calendar years 2002 through 2012 (Total Count = 5,234). Sampling effort (%) represents rotary trap sampling effort between the intial and final capture dates and is standardized to four traps sampling at 100% capacity. Range (days) represents number of days between first and last capture for each year. Minimum, maximum and average environmental data values correspond with dates of capture for each calendar year. RBDD water temperature (F) was obtained from the RBDD CDEC gauging station. Discharge (cfs) is calculated by subtracting mean daily water diversions from the Red Bluff Diversion Site (RM 243) from the mean daily discharge observed at the Bend Bridge USGS gauging station. Turbidity was collected on site via daily grab samples. *Note: Zero Green Sturgeon were collected in 2008 and sampling effort was calculated from an estimated capture period from May 1, 2008 to August 31, 2008.

While this table includes data that needs to be standardized, and is therefore preliminary, it is included here because at the present time this is the best information available, NMFS is directed by the ESA to use the best information available.

Spatial Structure

Historical green sturgeon spawning habitat may have extended up into the three major branches of the upper Sacramento River above the current location of Shasta Dam - the Little Sacramento River, the Pit River, and the McCloud River (NMFS 2009a, NMFS 2009d). Additional spawning habitat is believed to have once existed above the current location of Oroville Dam on the Feather River (NMFS 2009a). The Southern DPS of green sturgeon population has been relegated to a single spawning area, which is, for the most part, outside of its historical spawning area.

According to NMFS (2009a), the reduction of green sturgeon spawning habitat into one reach on the Sacramento River between Keswick Dam and Hamilton City has increased the vulnerability of this spawning population to catastrophic events. One spill of toxic materials into this reach of river, similar to the Cantara Loop spill of herbicides on the upper Sacramento River, could remove a significant proportion of the adult spawning broodstock from the population, as well as reduce the recruitment of the exposed year class of juvenile fish. Additionally, extended drought conditions could imperil the spawning success for green sturgeon, particularly those that are restricted to the river reaches below RBDD (NMFS 2009a).

Diversity

The VSP concept identifies a variety of traits that exhibit diversity within and among populations, and this variation has important effects on population viability (McElhany *et al*, 2000). For the Southern DPS of green sturgeon, such traits include, but are not limited to fecundity, age at maturity, physiology, and genetic characteristics. Within the Southern DPS of, diversity is not well documented. Little is known about how current levels of diversity (*e.g.*, genetic, life history) compare with historical levels. Further inquiry is needed to determine what, if any, genetic separation exists between those fish spawning within the Sacramento River, and those spawning elsewhere.

Summary of the Green Sturgeon Southern DPS Viability

The Southern DPS of green sturgeon is at substantial risk of future population declines (Adams *et al*. 2007). The principal threat to green sturgeon in the Southern DPS is the reduction in available spawning habitat due to the construction of barriers on Central Valley rivers (NMFS 2009d). According to NMFS (2009a), the potential threats faced by the green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and the Delta, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult lifestages. In summary, NMFS (2009d) concluded that the Southern DPS of green sturgeon remains at a moderate to high risk of extinction.

A recent study (Thomas *et al*. 2013) provided additional analysis regarding population-level impacts due to stranding of green sturgeon. During April 2011, 24 green sturgeon were rescued that had been stranded behind two weirs (Fremont and Tisdale) along the Sacramento River. Those 24 green sturgeon were acoustically tagged and their survival and migration success to their spawning grounds was analyzed. Additionally, population viability modeling and analysis was conducted to show the potential impacts of stranding and the benefits of conducting rescues at the population level. Population viability analyses of rescue predicted a 7 percent decrease below the population baseline model over 50 years as opposed to 33 percent without rescue (Thomas *et al*. 2013).

The current extent of scientific knowledge of the Southern DPS of green sturgeon is sufficient only to make coarse statements about the viability of the DPS. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (NMFS 2010). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany *et al.* 2000). The best available scientific information does not indicate that the extinction risk facing the Southern DPS of green sturgeon is negligible over a long term time horizon, therefore the viability of the the Southern DPS of is is at moderate risk of extinction. To support this statement, the population viability analysis (PVA) that was done for the Southern DPS of green sturgeon in relation to stranding events (Thomas *et al*. 2013) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, the modelling showed the DPS declining over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

(VIII) ENVIRONMENTAL BASELINE

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

The Environmental Baseline analysis in this BiOp:

- Provides information on past, present and future state, local, private, or tribal activities in the action area – specifically, the positive or negative impacts those activities have had on the species or habitat in the area in terms of abundance, reproduction, distribution, diversity, and habitat quality or function,
- Current extinction risk for each listed species within the Yuba River,
- Condition of critical habitat for each population,
- Provides a species status,
- Includes the impacts of past and present Federal actions,
- Describes the impacts of the past existence and operation of the action under consultation (for continuing actions),
- Presents all known and relative effects on the population (*e.g.*, fish stocking, fishing, hunting, other recreation, illegal collecting, private wells, development, grazing, local trust programs), and
- Includes impacts to the listed and proposed species in the action area that are occurring, and that are unrelated to the Proposed Action (*e.g.*, poaching, road kills from off-road vehicle use, trespass).

Distinguishing differences between the proposed action and the environmental baseline requires careful consideration of an agency's discretion and lack of discretion. To help inform the distinctions NMFS applied the following key analytic considerations:

(1) In general, effects attributable to the existence of a dam over which the action agency has no discretion, such as Daguerre Point Dam, or to non-discretionary operations and maintenance should be included in the environmental baseline rather than attributable to the proposed action. The environmental baseline includes, not only the past and present impacts of existing structures over which the Corps lacks discretion, but also continuing effects into the future.

(2) Areas of discretion and non-discretion must be clearly described by the Corps in BAs.

(3) Where the scope of the Corps' discretion is not clear, NMFS will assume that the Corps has discretion and will attribute effects to the proposed action.

The Environmental Baseline is characterized by the existing physical features and habitat conditions in the Action Area. Because the construction and the continued existence of Daguerre Point Dam have resulted in effects that have contributed to the current status of the species within the Action Area, these effects are considered to be part of the Environmental Baseline.

(A) Background

(1) Environmental Setting

Hydraulic mining in the Yuba River watershed during the mid-1800s contributed large quantities of sediment to the river. About 600 million cubic yards of material exposed by hydraulic mining had entered the Yuba River between 1849 and 1909 (Hagwood 1981). The sediment deposited in the channel raised the channel bed to the point that in 1868 it was higher than the streets in Marysville. Subsequent flooding of Marysville in the late 1800s led to attempts to mitigate the adverse effects of hydraulic mining (Corps 2005).

Efforts to control sediment came together with a project known as the “1898 Project”. This project involved controlling sediment with several small dams and building gravel berms to confine the low-water channel (Ayers 1997 as cited in DWR and Corps 2003a). In 1901, the California Debris Commission approved a plan to construct four barrier dams, build a settling basin, and build training walls. The plan was authorized by the Rivers and Harbor Act of 1902 (Hagwood 1981).

The major features of the "1898 Project" included: (1) storage of the mining debris within the bed of the Yuba River, (2) control of the low water channel within well-defined limits, and (3) the erection of several barriers of modest size across the bed of the river, specifically: (a) Barriers No. 1 and No. 2 to be located about 3 miles east of the mouth of Dry Creek, (b) a barrier to be built just below the mouth of Dry Creek, (c) a barrier to be placed at Daguerre Point, (d) construction of a settling basin about 3 miles by 1½ miles wide on the south side of the river, and (e) the building of gravel berms below the basin to confine the river channel within well-defined limits (Hagwood 1981).

The first attempt to constrain mine tailings and debris in the lower Yuba River was made using a structure referred to as Barrier No. 1, located about 1 mile downstream of the Parks Bar Bridge and 4.5 miles upstream of Daguerre Point (Hunerlack *et al*. 2004, Sumner and Smith 1939 as cited in Hagwood 1981). Work on Barrier No. 2, located about a half mile above Barrier No. 1, was initiated during September 1903, and work on Barrier No. 1 commenced shortly thereafter (Hagwood 1981). Unusually high water came down the Yuba River in November 1903, and destroyed much of the work completed. Barrier No. 1, re-constructed in 1905, was 14 feet high and constrained 1,690,000 cubic yards of gravel that were transported in the river channel during the winter and spring of 1906 (Gilbert 1917 as cited in Yoshiyama *et al*. 2001). Of this total, 920,000 cubic yards were constrained upstream of the barrier during the January 1906 flood alone. Barrier No. 1 probably hindered salmon upstream movement until it failed the following year when floods destroyed it during March 1907 (Sumner and Smith 1939 as cited in Hagwood 1981). Many acres of farmlands were repeatedly destroyed by flooding and silting in the Yuba River watershed, and properties in the cities of Marysville were threatened frequently by the rise of the riverbed (Hunerlack *et al*. 2004). When the flood subsided, the engineers decided to cease construction at the Barrier No. 1 site, and instead proposed to complete a barrier at Daguerre Point (the fourth dam of the original proposal) and the settling basin immediately below. The gravel berms below the Daguerre Point cut also were to be completed. The gravel berms built on the south side of the river were completed by the Yuba Consolidated Gold Fields and the Marysville Gold Dredging Company as part of their gold dredging operations. Finally, the Yuba Consolidated Gold Fields Company also built a rock levee which took the place of Barriers No. 1 and No. 2 (Hagwood 1981). In other words, the "1898 Project" was revised so as to concentrate the Commission's effort at and near Daguerre Point (Hagwood 1981).

The California Debris Commission constructed the original Daguerre Point Dam in 1906 as part of the later Yuba River Debris Control Project (Corps 2001). Daguerre Point Dam was constructed in a cut above and to the north of the original Yuba River channel. The bedrock under Daguerre Point Dam is a portion of the Daguerre Point Terrace, a feature that facilitated the construction of a low dam at a relatively low cost. Over the next few years, the cut through Daguerre Point was completed and a concrete inlet wall, or spillway, was constructed. Gravel berms extending about 12,000 feet on each side of the river below the cut were built. The entrance gates to the settling basin were constructed, most of its enclosing levees were built, and the outlet works were practically completed when this part of the project was found no longer necessary and was abandoned under authority of the River and Harbor Act of June 25, 1910. The settling basin itself was never constructed. The land acquired for the settling basin, together with the intake and outlet works, was then sold (Hagwood 1981).

Daguerre Point Dam was completed in May of 1906, but the river was not diverted over the dam until 1910 (Corps 2007). Daguerre Point Dam rapidly filled to capacity with sediment and debris that moved downstream during flooding in 1911 (Hunerlach *et al*. 2004). The "1898 Project", as modified, was completed in 1935 (Hagwood 1981). By that time, three gravel berms existed, having a total length of approximately 85,100 feet which provided two 500-foot channels. The result of the work on the Yuba River in and around Daguerre Point has held back millions of cubic yards of mining debris in the Yuba River which would otherwise have passed into the navigable channels of the Feather and Sacramento Rivers (Hagwood 1981).

After its construction, Daguerre Point Dam was reported to be a partial or complete barrier to salmon and steelhead for many years because of the lack of functional fish ladders (Mitchell 2010). Although the dam made it difficult for spawning Chinook salmon and steelhead to migrate upstream, salmon reportedly did surmount that dam in occasional years because they were observed in large numbers in the North Yuba River at Bullards Bar during the early 1920s (Yoshiyama *et al*. 2001). Two fishways, one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928 (Clark 1929, CDFG 1991a), the fish ladders were destroyed, and were not replaced until 1938, leaving a 10-year period when upstream fish passage at Daguerre Point Dam was blocked (CDFG 1991). That 10-year period coincided with the drought of 1928 through 1934, which raised water temperatures below Daguerre Point Dam much higher than those tolerated by Chinook salmon (Mitchell 1992 as cited in NMFS 2012). These conditions probably caused the extirpation of CV spring-run Chinook salmon from the lower Yuba River (Mitchell 1992 as cited in NMFS 2012). On the southern end of the dam, a fish ladder was constructed in 1938 and consisted of 8- by 10-foot bays arranged in steps with about 1 foot of difference in elevation between steps. However, it was generally ineffective (Sumner and Smith 1939). Two functional fish ladders were installed in 1951 by the State of California and it was stated that "*With ladders at both ends, the fish have no difficulty negotiating this barrier at any water stage*" (CDFG 1953).

Precipitation regimes in the region are highly variable in timing and quantity, with unpredictable autumn rainfall and occasional winter deluges producing a considerable part of the average annual runoff (USGS gage data 1858-2009). The flood of February 1963, estimated at about 120,000 cfs, washed out a section of Daguerre Point Dam between the mid-stream stations. During the summer of 1964, the Corps met with the USFWS and CDFG to develop criteria for the reconstruction and modification of the existing fishways at Daguerre Point Dam. Repairs were made in 1964 to Daguerre Point Dam and to the southern fish ladder, but before modifications could be made to the northern ladder, the flood of December 1964 washed out a portion of the dam that had not been reconstructed and eroded the underlying rock foundation to an estimated depth of 15 to 25 feet (Corps 2007a). The floods of 1964 also washed out nearly all of the sediments and debris that had accumulated behind the dam up to that time. The flood of December 1964, estimated at about 180,000 cfs, also washed out the retaining walls of the Hallwood-Cordua diversion structure, completely destroyed the fish ladder headwork on the north as well as a large part of the original fish ladder, but the portion of the fish ladder completed with the rehabilitation from the 1963 floods of the dam was still intact (Corps 2013b). Temporary repairs of the damage were made in February and March 1965. Extensions to the fish ladders were added, and slide gates, which also permit the passage of fish, were added to both upstream ends of the ladders in 1965 (Corps 2007a). "*Permanent repair of Daguerre Point Dam abutment and fish facilities was completed in October 1965 at a cost of $447,808 with Federal and required State contributed funds on a matching basis*." (ERDC 2008).

At the time that the Daguerre Point Dam fish ladders were reconstructed in 1965, the fish passage facility and ladder design were developed following USFWS and CDFG provided criteria. If the ladders were to be reconstructed today, the Corps anticipates that the design would be much different, given the advances in fisheries biology, engineering, and technology that have occurred over the past 48 years, as well as changes in fisheries management objectives resulting from new species listings (*e.g.*, green sturgeon) under the ESA.

(2) Summary of Past and Ongoing Fisheries Studies on the Lower Yuba River

As stated in YCWA (2010), the Yuba River downstream of Englebright Dam is one of the more thoroughly studied rivers in the Central Valley of California. A description of existing information regarding salmonid populations in the lower Yuba River downstream of Englebright Dam is contained in Attachment 1 to YCWA (2010), which is in Appendix E of the BA. Appendix E summarizes the available literature for CV spring-run Chinook salmon where specifically identified, Chinook salmon in general where runs are not specifically identified, and *O. mykiss*. Much of the referenced information discusses both runs of Chinook salmon and *O. mykiss,* and therefore is presented in its entirety in Appendix E of the BA. The appendix describes available field studies and data collection reports, other relevant documents, and ongoing data collection, monitoring and evaluation activities including the Yuba River Accord Monitoring and Evaluation Program (M&E Program) and other data collection and monitoring programs. Appendix E of the BA summarily describes 21 available field studies and data collection reports, 20 other relevant documents (*e.g.*, plans, policies, historical accounts and regulatory compliance), 14 ongoing data collection, monitoring and evaluation activities for the M&E Program, and 4 other data collection and monitoring programs.

(3) Physical Habitat

During the period of hydraulic gold mining in the 1800s, vast quantities of sand, gravel, and cobble entered the Yuba River (Gilbert 1917 as cited in Yoshiyama *et al*. 2001) and deposited throughout the system. This human impact completely transformed the river. Daguerre Point Dam was constructed at the downstream end of an enormous gravel deposit, and about 16 miles of “gravel berms” were erected to channelize the river by piling gravel on both the north and south banks, as well as down the center of the river in some places to create two channels. These activities were two of the major features of the “1898 Project”, which was completed in 1935 (Hagwood 1981). By that time, three gravel berms existed, having a total length of 85,100 feet which provided two 500-foot-wide channels. In 1944, the California Debris Commission issued a permit to the Yuba Consolidated Gold Fields to dredge a 600-foot-wide channel and build gravel berms to take the place of the pair of 500-foot-wide channels completed in 1935 (Hagwood 1981). The effect of the gravel berms was to keep the river from spreading in its floodplain and to turn this stretch of the lower Yuba River into a channel that conveys water downstream to serve agricultural and municipal users (Gustaitis 2009). Downstream of Daguerre Point Dam, the Yuba River has resumed a meandering course through the fluvial tailings. Down-cutting of the streambed downstream of Daguerre Point Dam has exposed the bedrock of Daguerre Point (Hunerlach *et al*. 2004).

The Corps has not issued any permits, licenses, or easements to other parties, and does not conduct inspection or maintenance activities associated with the gravel berms (Corps 2013b). The Corps has concluded it is not responsible for operations and maintenance of the gravel berms along the lower Yuba River. Because the Corps does not have the ability to lessen any effects on listed species habitat availability associated with dynamic fluvial/geomorphologic processes in the floodplain of the lower Yuba River located between the gravel berms, and because the Corps is not proposing any actions pertaining to the gravel berms, any such effects are appropriately considered part of the Environmental Baseline and not the proposed action.

Fluvial Geomorphology

Fluvial geomorphologic processes in the lower Yuba River downstream of Englebright Dam continue to represent adjustments to the tremendous influx of hydraulic mining debris, and the construction of Englebright Dam. Since the construction of Englebright Dam, the lower Yuba River continues to incise and landform adjustments continue to occur - as illustrated by Pasternack (2008), who estimated that about 605,000 yds^3 of sediment (primarily gravel and cobble) were exported out of Timbuctoo Bend from 1999 to 2006. The lower Yuba River is adjusting toward its historical geomorphic condition, by going back to the pre-existing state prior to hydraulic gold mining (Pasternack 2010).

The lower Yuba River has been subjected to additional in-channel human activities such as: (1) the formation of the approximately 10,000-acre Yuba Goldfields in the ancestral migration belt, (2) the relocation of the river to the Yuba Goldfield’s northern edge and its isolation from most of the Goldfields by large “gravel berms” of piled-up dredger spoils, (3) mechanized gold mining facilitated by bulldozers beginning in about 1960 in the vicinity of the confluence with Deer Creek, changing the lower Yuba River geomorphology (Pasternack *et al*. 2010a), (4) bulldozer debris constricting the channel significantly and inducing abrupt hydraulic transitioning, and (5) mining operations combined with the 1997 flood which caused angular hillside rocks and “shot rock” debris to be deposited on top of the hydraulic-mining alluvium in the canyon (Pasternack 2010).

All of these activities have influenced physical habitat conditions in the lower Yuba River downstream of Englebright Dam. Physical conditions related to fisheries habitat in the lower Yuba River have been studied over many years. With respect to the spawning lifestage, Fulton (2008) found spawning habitat conditions to be very poor to nonexistent in the Englebright Dam Reach. *Spring-run Chinook salmon individuals immigrating into the Yuba River each year attempt to spawn in the Englebright Dam Reach, which historically was characterized by a paucity of suitable spawning gravels.* However, gravel augmentation funded by the Corps in the Englebright Dam Reach over the past several years has spurred spawning activity and Chinook salmon redd construction in this reach (see Corps 2013b for additional discussion). The net result is an increase in the spatial distribution of spawning habitat availability in the river, particularly for early spawning (presumably spring-run) Chinook salmon (RMT 2013). Farther downstream, spawning habitat does not appear to be limited by an inadequate supply of gravel in the lower Yuba River due to ample storage of mining sediments in the banks, bars, and dredger-spoil gravel berms (RMT 2013).

According to NMFS (2009), river channelization and confinement has led to a decrease in riverine habitat complexity and a decrease in the quantity and quality of juvenile rearing habitat. Also according to NMFS (2009), attenuated peak flows and controlled flow regimes have altered the lower Yuba River's geomorphology and have affected the natural meandering of the river downstream of Englebright Dam.

As reported by RMT (2013), the Yuba River downstream of Englebright Dam has complex river morphological characteristics. Evaluation of the morphological units in the Yuba River as part of the spatial structure analyses indicates that, in general, the sequence and organization of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (RMT 2013). In addition, the Yuba River downstream of Englebright Dam exhibits: (1) lateral variability in its form-process associations, (2) complex channel geomorphology, and (3) a complex and diverse suite of morphological units. The complexity in the landforms creates diversity in the flow hydraulics which, in turn, contributes to diversity in habitats available for all riverine lifestages of anadromous salmonids in the Yuba River downstream of Englebright Dam (RMT 2013). NMFS (2009) further stated that in the lower Yuba River, controlled flows and decreases in peak flows has reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. However, as reported by RMT (2013), despite some flow regulation the channel and floodplain in the lower Yuba River are highly connected, with floods spilling out onto the floodplain more frequently than commonly occurs for unregulated semi-arid rivers. Some locations exhibit overbank flow well below 5,000 cfs, while others require somewhat more than that. In any given year, there is an 82 percent chance the river will spill out of its bankfull channel and a 40 percent chance that the floodway will be fully inundated. These results demonstrate that floodplain inundation occurs with a relatively high frequency in the lower Yuba River compared to other Central Valley streams which, in turn, contributes to a diversity in habitats available for anadromous salmonids (RMT 2013).

Loss of Natural River Morphology and Function

According to NMFS (2009), "Loss of Natural River Morphology and Function" is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity, and thus, a decrease in the quantity and quality of juvenile rearing habitat. Additionally, this primary stressor category includes the effect that dams have on the aquatic invertebrate species composition and distribution, which may have an effect on the quality and quantity of food resources available to juvenile salmonids. According to NMFS (2009), attenuated peak flows and controlled flow regimes have altered the lower Yuba River's geomorphology and have affected the natural meandering of the river downstream of Englebright Dam. This is a stressor affecting juvenile anadromous salmonid rearing habitat availability.

As reported by RMT (2013), preliminary evaluation of available data collected to date related to Yuba River fluvial geomorphology indicates that the Yuba River downstream of Englebright Dam has complex river morphological characteristics. Evaluation of the morphological units in the Yuba River as part of the spatial structure analyses indicates that, in general, the sequence and organization of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (RMT 2013).

The Yuba River downstream of Englebright Dam exhibits lateral variability in its form-process associations (RMT 2013). In the Yuba River, morphological unit organization highlights the complexity of the channel geomorphology, as well as the complex and diverse suite of morphological units. The complexity in the landforms creates diversity in the flow hydraulics which, in turn, contributes to a diversity of habitat types available for all riverine lifestages of anadromous salmonids in the Yuba River downstream of Englebright Dam (RMT 2013).

From a floodplain meander perspective, braided channels, side channels, and channel sinuosity are created through complex hydraulic-geomorphic interactions. Attenuated peak flows and controlled flow regimes emanating from the upper Yuba River watershed, and the influence of gravel berms along portions of the lower Yuba River have affected the natural meandering of the lower Yuba River in the Action Area. As stated by UC Davis Professor Greg Pasternack (see Corps 2013b, Appendix B, Attachment 3) "… *the morphology of the LYR is self-determined, dynamic, and increasing habitat complexity over time due to the restorative role of Englebright Dam relative to the vast reservoir and continuing influx of hydraulic mining waste upstream of that barrier. It is true that the LYR's morphology is altering, but all the evidence indicates that the alterations are beneficial, not harmful, and are driven by understandable and beneficial natural processes*".

As reported by RMT (2013), preliminary evaluation of available data collected to date related to Yuba River fluvial geomorphology indicates that the Yuba River downstream of Englebright Dam has complex river morphological characteristics. Evaluation of the morphological units in the Yuba River as part of the spatial structure analyses indicates that, in general, the sequence and organization of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (RMT 2013).

The Yuba River downstream of Englebright Dam exhibits lateral variability in its form-process associations (RMT 2013). In the Yuba River, morphological unit organization highlights the complexity of the channel geomorphology, as well as the complex and diverse suite of morphological units. The complexity in the landforms creates diversity in the flow hydraulics which, in turn, contributes to a diversity of habitat types available for all riverine lifestages of anadromous salmonids in the Yuba River downstream of Englebright Dam (RMT 2013).

In the lower Yuba River, anadromous salmonids spawn in mean substrate sizes ranging from about 50 to 150 mm, and most of the lower Yuba River from Englebright Dam to the confluence with the Feather River is characterized by average substrate particle sizes within this size range (RMT 2013). The exceptions are sand/silt areas near the confluence with the Feather River, and the boulder/bedrock regions in the upper sections of Timbuctoo Bend and most of the Englebright Dam Reach. However, gravel augmentation funded by the Corps in the Englebright Dam Reach over the past several years has spurred spawning activity and Chinook salmon redd construction in this reach. The net result is an increase in the spatial distribution of spawning habitat availability in the river, particularly for early spawning (presumably spring-run) Chinook salmon (RMT 2013).

The loss of natural river morphology and function presently continues to represent a relatively high stressor to Yuba River spring-run Chinook salmon under the environmental baseline.

<u>Loss of Floodplain Habitat</u>

Off-channel habitats such as floodplains, riparian, and wetland habitats have been suggested to be of major importance for the growth and survival of juvenile salmon (Moyle 2002). These habitats also promote extended rearing and expression of the stream-type rearing characteristic of spring-run Chinook salmon. Within the Yuba Goldfields area (RM 8–14), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat (DWR and PG&E 2010). For this BiOp, a distinction is made between floodplain habitat and the previously discussed stressors of physical habitat alteration and loss of natural morphology and function, both of which focused on habitat and complexity in the lower Yuba River. Considerations of those stressors included adult and juvenile lifestages. Floodplain habitat, as considered in this section of the BiOp, is more narrowly focused on the inundation of floodplain habitat and associated effects on juvenile rearing.

NMFS (2009) listed the loss of floodplain habitat in the lower Yuba River as one of the key stressors affecting anadromous salmonids (including spring-run Chinook salmon). NMFS (2009) stated …"*Historically, the Yuba River was connected to vast floodplains and included a complex network of channels, backwaters and woody material. The legacy of hydraulic and dredger mining is still evident on the lower Yuba River where, for much of the river, dredger piles confine the river to an unnaturally narrow channel. The consequences of this unusual and artificial geomorphic condition include reduced floodplain and riparian habitat and resultant limitations in fish habitat, particularly for rearing juvenile salmonids.*"

NMFS (2009) further stated that in the lower Yuba River, controlled flows and decreases in peak flows has reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. Within the Yuba Goldfields area (RM 8–14), confinement of the river by massive deposits of cobble and gravel derived from hydraulic and dredge mining activities resulted in a relatively simple river corridor dominated by a single main channel and large cobble-dominated bars, with little riparian and floodplain habitat (DWR and PG&E 2010).

Loss of off-channel habitats such as floodplains, riparian, and wetland habitats has substantially reduced the productive capacity of the Central Valley for many native fish and wildlife species, and evidence is growing that such habitats were once of major importance for the growth and survival of juvenile salmon (Moyle 2002). Recent observations on the lower Yuba River indicate that remnant side channels and associated riparian vegetation play a similar role by providing flood refugia, protection from predators, and abundant food for young salmonids and other native fishes. These habitats also promote extended rearing and expression of the stream-type rearing characteristic of spring-run Chinook salmon (DWR and PG&E 2010).

As reported by RMT (2013), despite some flow regulation, the channel and floodplain in the lower Yuba River are highly connected, with floods spilling out onto the floodplain more frequently than commonly occurs for unregulated semiarid rivers. Some locations exhibit overbank flow well below 5,000 cfs, while others require somewhat more than that. In any given year, there is an 82 percent chance the river will spill out of its bankfull channel and a 40 percent chance that the floodway will be fully inundated. These results demonstrate that floodplain inundation occurs with a relatively high frequency in the lower Yuba River compared to other Central Valley streams which, in turn, contributes to a diversity in habitats available for anadromous salmonids (RMT 2013).

RMT (2013) conducted a flood-frequency analysis of the annual peak discharges recorded at the USGS stream gage near Marysville (#11421000) that showed average annual return periods of 1.25 years and 2.5 years for the bankfull and flood discharges, respectively. Bankfull flows for similar rivers are generally assumed to occur with return periods of 1.5-2 years. The fact that the lower Yuba River is less than this implies that the channel is naturally undersized relative to generalized expectations and flows spill into the floodplain at a more frequent rate (RMT 2013).

In consideration that this stressor primarily addresses one lifestage, that inundation of floodplain habitat occurs relatively frequently compared to other Central Valley streams, that inundation of floodplain habitat would not necessarily occur each year even under unaltered hydrologic conditions, and that the lower Yuba River floodplain is comprised of unconsolidated alluvium without an abundance of characteristics associated with increased juvenile salmonid growth, loss of floodplain habitat availability likely represents a medium stressor to Yuba River juvenile spring-run Chinook salmon.

Riparian Vegetation

Most of the original plant communities along the lower Yuba River have been significantly altered from pristine conditions (Corps 1977 as cited in CDFG 1991). Although little has been written specifically about the ancestral riparian forests of the lower Yuba River, it is believed that the banks of the lower Yuba River and its adjacent natural levees once were covered by riparian forest of considerable width. It has been suggested that most riverine floodplains in the Central Valley supported riparian vegetation to the 100-year floodplain, and it is likely that the Yuba River was no exception (CDFG 1991).

In its *Final Biological and Conference Opinion for the Yuba River Development Project License Amendment (FERC No. 2246)*, NMFS (2005b) reports that "*The deposition of hydraulic mining debris, subsequent dredge mining, and loss/confinement of the active river corridor and floodplain of the lower Yuba River which started in the mid-1800's and continues to a lesser extent today, has eliminated much of the riparian vegetation along the lower Yuba River. In addition, the large quantities of cobble and gravel that remained generally provided poor conditions for re-establishment and growth of riparian vegetation. Construction of Englebright Dam also inhibited regeneration of riparian vegetation by preventing the transport of any new fine sediment, woody debris, and nutrients from upstream sources to the lower river. Subsequently, mature riparian vegetation is sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded and lacking in large woody debris.*"

To determine the cumulative change over time in total vegetative cover and riparian vegetation cover in the lower Yuba River, YCWA compared aerial photographs from 1937 and 2010. Over this time period, riparian vegetation cover in the Englebright Dam site decreased over time, and the Narrows study site exhibited little detectable change over time. For the remaining study sites distributed throughout the lower Yuba River, riparian vegetation cover increased over time. Dramatic increases in riparian vegetation cover were observed for the Dry Creek and Parks Bar study sites.

Riparian habitats support the greatest diversity of wildlife species of any habitat in California, including many species of fish within channel edge habitats (CALFED 2000a as cited in RMT 2013). Furthermore, more extensive and continuous riparian forest canopy on the banks of estuaries and rivers can stabilize channels, provide structure for submerged aquatic habitat, contribute shade, overhead canopy, and instream cover for fish, and reduce water temperatures (CALFED 2000a as cited in RMT 2013).

Although fish species do not directly utilize terrestrial aspects of riparian habitat, they are directly and indirectly supported by the habitat services and food sources provided by the highly productive riparian ecosystem. Riparian communities provide habitat and food for species fundamental to the aquatic and terrestrial food web, from insects to top predators. As stated in CALFED and YCWA (2005), riparian vegetation, an important habitat component for anadromous fish, is known to provide:

(1) bank stabilization and sediment load reduction,
(2) shade that results in lower instream water temperatures,
(3) overhead cover,
(4) streamside habitat for aquatic and terrestrial insects, which are important food sources for rearing juvenile fishes,
(5) a source of instream cover in the form of woody material, and

(6) allochthonous nutrient input.

Riparian vegetation on floodplains can provide additional benefits to fish when the floodplain is inundated, by providing velocity and predator refugia.

In 2012, YCWA conducted a riparian habitat study in the Yuba River from Englebright Dam to the confluence with the Feather River (YCWA 2013). Field efforts included descriptive observations of woody and riparian vegetation, cottonwood inventory and coring, and a LWM survey. The RMT contracted Watershed Sciences Inc. to use existing LiDAR to produce a map of riparian vegetation stands by type. The resulting data was subject to a field validation and briefly summarized in WSI (2010 as cited in RMT 2013) and the data were also utilized in YCWA (2013).

Based on field observations, YCWA (2013) reported that all reaches supported woody species in various lifestages - mature trees, recruits, and seedlings were observed within all reaches. Where individuals or groups of trees were less vigorous, beaver (*Castor canadensis*) activity was the main cause, although some trees in the Marysville Reach appeared to be damaged by human camping.

The structure and composition of riparian vegetation was largely associated with four landforms. Cobble-dominated banks primarily supported bands of willow shrubs with scattered hardwood trees. Areas with saturated soils or sands supported the most complex riparian areas and tended to be associated with backwater ponds. Scarps and levees supported lines of mature cottonwood and other hardwood species, typically with a simple understory of Himalayan blackberry (*Rubus discolor*) or blue elderberry shrubs (*Sambucus nigra* ssp. *cerula*). Bedrock dominated reaches had limited riparian complexity and supported mostly willow shrubs (*Salix* spp.) and cottonwoods (*Populus* spp.).

The longitudinal distribution of riparian species in the lower Yuba River downstream of the Englebright Dam shows a trend of limited vegetation in the confined, bedrock areas, with increased vegetation in the less-confined, alluvial areas downstream, which is within expected parameters (Naiman *et al*. 2005 as cited in YCWA 2013). The increase in hardwood diversity and cover downstream of Daguerre Point Dam may be associated with sediment, as reaches above the Daguerre Point Dam have greater scour, while the downstream reaches have more deposition (YCWA 2012).

Cottonwoods are one of the most abundant woody species in the Action Area, and the most likely source of locally-derived large instream woody material due to rapid growth rates and size of individual stems commonly exceeding 2 feet in diameter and 50 feet in length. Cottonwoods exist in all lifestages including as mature trees, recruits, or saplings, and as seedlings. Cottonwoods are more abundant in downstream areas of the Action Area relative to upstream. Of the estimated 18,540 cottonwood individuals/stands, 12 percent are within the bankfull channel (flows of 5,000 cfs or less), and 39 percent are within the floodway inundation zone (flows between 5,000 and 21,100 cfs).

The RMT conducted a LiDAR survey of the lower Yuba River from Highway 20 to the confluence, and digitized the patches of vegetation in recent aerial imagery of Timbuctoo Bend and the Englebright Dam Reach (Pasternack 2012). With respect to having sufficient riparian vegetation to provide ecological functionality, the RMT conducted paired hydrodynamic modeling of the lower Yuba River in which one set of models lacks vegetation and the other represents the actual lower Yuba River vegetation pattern and height as best as possible. As shown at the 2011 Lower Yuba River Symposium and in RMT meeting presentations, vegetation was found to significantly affect the hydraulics of the lower Yuba River and, thus, may be deemed present in a significant quantity relative to that functionality (Pasternack 2012).

YCWA (2013) assessed the riparian communities in the Yuba River downstream of the Englebright Dam as healthy and recovering from historical disturbance. Historical aerial photograph analysis indicates that vegetation cover has increased over time, with short-term decreases associated with stochastic flow events, which are normal for riparian systems, and anthropogenic channel changes. Although the riparian vegetation is healthy (plants have high vigor and are present in all age classes), the vegetation communities tend to be simplistic in structure. Riparian communities are seral, establishing first with simplistic herb and shrub layers, then canopies of hardwood trees, and becoming more complex over time. Indicative of early seral stages, the assessed riparian communities tended to be simplistic in both lateral and horizontal stratification, with limited pockets of diverse and well-stratified riparian forests (YCWA 2013). As an example, bands of willows on the floodplains, with some alder and cottonwood recruits, are early in the seral process and still capturing sediment or developing soils to support more productive systems. However, these areas on the floodplains may not become more complex, as they are likely to be scoured during peak flow events (YCWA 2013). Areas dominated by cottonwood trees with only herbaceous understories (*e.g.*, those found on levees), are likely a sign of interrupted riparian development, and maintenance of the levees may have prevented the natural stages of the riparian community to develop.

<u>Large Woody Material</u>

LWM creates both micro- and macro-habitat heterogeneity by forming pools, back eddies and side channels and by creating channel sinuosity and hydraulic complexity. Instream object cover provides structure, which promotes hydraulic complexity, diversity and microhabitats for juvenile salmonids, as well as escape cover from predators. The extent and quality of suitable rearing habitat and cover, including SRA, generally has a strong effect on juvenile salmonid production in rivers (Healey 1991 as cited in CALFED and YCWA 2005). LWM also contributes to the productivity of invertebrate food sources, and micro-habitat complexity for juvenile salmonids (NMFS 2007). Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with LWM (JSA 1992).

LWM mapping was conducted from the fall 2011 through the fall of 2012 as part of YCWA's FERC relicensing efforts. YCWA also conducted field surveys in the spring of 2013 to collect LWM data for pieces found exclusively within bankfull widths. The LWM observed in study sites tended to accumulate in one of three distributions within the active channel: (1) in the bands of willow (*Salix* spp.) shrubs near the wetted edge, (2) dispersed across open cobble bars, and (3) stranded above normal high-flow indicators (YCWA 2012). Bands of woody vegetation, dominated by willow shrubs, were present along the cobble bars and floodplains at various distances from the wetted channel. The shrubs acted as a capture point for much of the LWM, creating tall piles of small woody debris and LWM against the upstream side of the vegetation and around the base of the shrubs. On open cobbles of bars in the alluvial reaches, YCWA observed LWM and smaller woody debris deposited at high flow lines (Figure VIII-1), this distribution comprised the smallest number of LWM pieces. A great deal of LWM was observed at flood heights, either far from the wetted channel in depressions, in stands of riparian forests, or in areas with reduced floodplains. Piles accumulated on top of boulders or rip-rap at flood flow levels. The majority of the wood surveyed at flood flow levels was highly degraded (YCWA 2012). Most pieces of LWM were found to be mobile (not stabilized to resist high flows) and few pieces were observed to have channel forming influences (greater than one square meter) including the capture of other woody debris (Figure VIII-2).

The majority of the LWM located within bankfull areas appeared to have floated in, with less LWM appearing to have fallen from the bank. The largest pieces of LWM were cottonwoods that fell from erosional banks.

Pasternack (2012) states that because the lower Yuba River floodway is so wide that on the falling limb of a flood, the LWM gets scattered over a vast area, with disproportionate concentrations racked behind flow obstructions, racked throughout vegetation patches, and lining the water's edge demarking peak flood stages. Pasternack (2012) further states that there is ample roughness along the fringe to catch very large pieces of wood, but the lower Yuba River is so wide and deep during flood conditions that LWM cannot produce log jams relative to the scale of the system. Piles of LWM (Figures VIII-17 and VIII-18) also were found to accumulate on top of boulders or rip-rap at flood flow levels (YCWA 2013).

Figure VIII-1. LWM and smaller woody debris deposited downstream from Englebright Dam at a high flow line in the Timbuctoo Bend study site, looking downstream on the south side of the lower Yuba River (YCWA 2013).

Figure VIII-2. Example of mobile LWM downstream from Englebright Dam at a mid-channel bar looking downstream at the Hallwood study site in the lower Yuba River (YCWA 2013).


Figure VIII-3. LWM accumulated downstream from Englebright Dam against the lower portion of the gravel berms that line the north side of the lower Yuba River in the Dry Creek study site at flood flow levels (YCWA 2013).

Figure VIII-4. LWM and smaller woody debris accumulated downstream from Englebright Dam on rip-rap at flood flow heights in the Parks Bar study site on the lower Yuba River (YCWA 2013).

Loss of Riparian Habitat and Instream Cover (Riparian Vegetation, Instream Woody Material)

The loss of riparian habitat and large woody material (LWM) are discussed together, because LWM is recruited from large riparian vegetation, such as large trees. Large trees that grow adjacent to the river improve fish habitat, and when the tree falls and enters the river it improves habitat for fish.

Mature riparian vegetation is relatively sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded. It has previously been reported that relatively low amounts of LWM occur in the lower Yuba River because of the general paucity of riparian vegetation throughout much of the lower Yuba River, and because some of the upstream dams in the upper Yuba River watershed reduce the downstream transport of LWM (cbec and McBain & Trush 2010).

Instream woody material provides escape cover and relief from high current velocities for juvenile salmonids and other fishes. LWM also contributes to the contribution of invertebrate food sources, and micro-habitat complexity for juvenile salmonids (NMFS 2007). Snorkeling observations in the lower Yuba River have indicated that juvenile Chinook salmon had a strong preference for near-shore habitats with instream woody material (JSA 1992).

SRA cover generally occurs in the lower Yuba River as scattered, short strips of low-growing woody species (*e.g.*, willows) adjacent to the shoreline. Beak (1989) reported that the most extensive and continuous segments of SRA cover occur along bars where [then] recent channel migrations or avulsions had cut new channels through relatively large, dense stands of riparian vegetation. SRA cover consists of instream object cover and overhanging cover. Instream object cover provides structure, which promotes hydraulic complexity, diversity and microhabitats for juvenile salmonids, as well as escape cover from predators. The extent and quality of suitable rearing habitat and cover, including SRA, generally has a strong effect on juvenile salmonid production in rivers (Healey 1991 as cited in CALFED and YCWA 2005).

Since completion of New Bullards Bar Reservoir, the riparian community (in the lower Yuba River) has expanded under summer and fall streamflow conditions that have generally been higher than those that previously occurred (SWRCB 2003). However, the riparian habitat is not pristine. NMFS (2005b) reports …"*The deposition of hydraulic mining debris, subsequent dredge mining, and loss/confinement of the active river corridor and floodplain of the lower Yuba River which started in the mid-1800's and continues to a lesser extent today, has eliminated much of the riparian vegetation along the lower Yuba River. In addition, the large quantities of cobble and gravel that remained generally provided poor conditions for re-establishment and growth of riparian vegetation. Construction of Englebright Dam also inhibited regeneration of riparian vegetation by preventing the transport of any new fine sediment, woody debris, and nutrients from upstream sources to the lower river. Subsequently, mature riparian vegetation is sparse and intermittent along the lower Yuba River, leaving much of the bank areas unshaded and lacking in large woody debris. This loss of riparian cover has greatly diminished the value of the habitat in this area*."

Where hydrologic conditions are supportive, riparian and wetland vegetative communities are found adjacent to the lower Yuba River and on the river sides of retaining levees. These communities are dynamic and have changed over the years as the river meanders. The plant communities along the river are a combination of remnant Central Valley riparian forests, foothill oak/pine woodlands, agricultural grasslands, and orchards (Beak 1989).

According to CALFED and YCWA (2005), the lower Yuba River, especially in the vicinity of Daguerre Point Dam and the Yuba Goldfields, is largely devoid of sufficient riparian vegetation to derive the benefits (to anadromous salmonids) discussed above (Figure VIII-5).

In 2012, YCWA conducted a riparian habitat study in the Yuba River from Englebright Dam to the confluence with the Feather River (see Technical Memorandum 6-2 in YCWA 2013). Field efforts included descriptive observations of woody and riparian vegetation, cottonwood inventory and coring, and a large woody material (LWM) survey. The study was performed by establishing eight LWM study sites and seven riparian habitat study sites. One LWM study site was established within each of eight distinct reaches (*i.e.*, Marysville, Hallwood, Daguerre Point Dam, Dry Creek, Parks Bar, Timbuctoo Bend, Narrows, and Englebright Dam). Riparian habitat sites were established in the same locations as the LWM study sites, with the exception of the Marysville study site. Riparian information regarding the Marysville Reach was developed, but no analysis was performed because of backwater effects of the Feather River.

In the lower Yuba River, although woody material was found to be relatively ubiquitous, it was generally found in bands of willow shrubs near the wetted edge, dispersed across open cobble bars, and stranded above normal high-flow indicators. Most (77-96 percent) pieces of wood found in each reach surveyed were smaller than 25 feet in length and smaller than 24 inches in diameter, which is the definition of LWM used by the RMT (RMT 2013). The largest size classes of LWM (*i.e.*, longer than 50 feet and greater than 24 inches in diameter) were rare or uncommon (*i.e.*, fewer than 20 pieces total) with no discernible distribution. Pieces of this larger size class were counted as "key pieces", as were any pieces exceeding 25 inches in diameter and 25 feet in length and showing any morphological influence (*e.g.*, trapping sediment or altering flow patterns). A total of 15 key pieces of LWM were found in all study sites, including six in the Marysville study site. Few of the key pieces were found in the active channel or exhibiting channel forming processes.

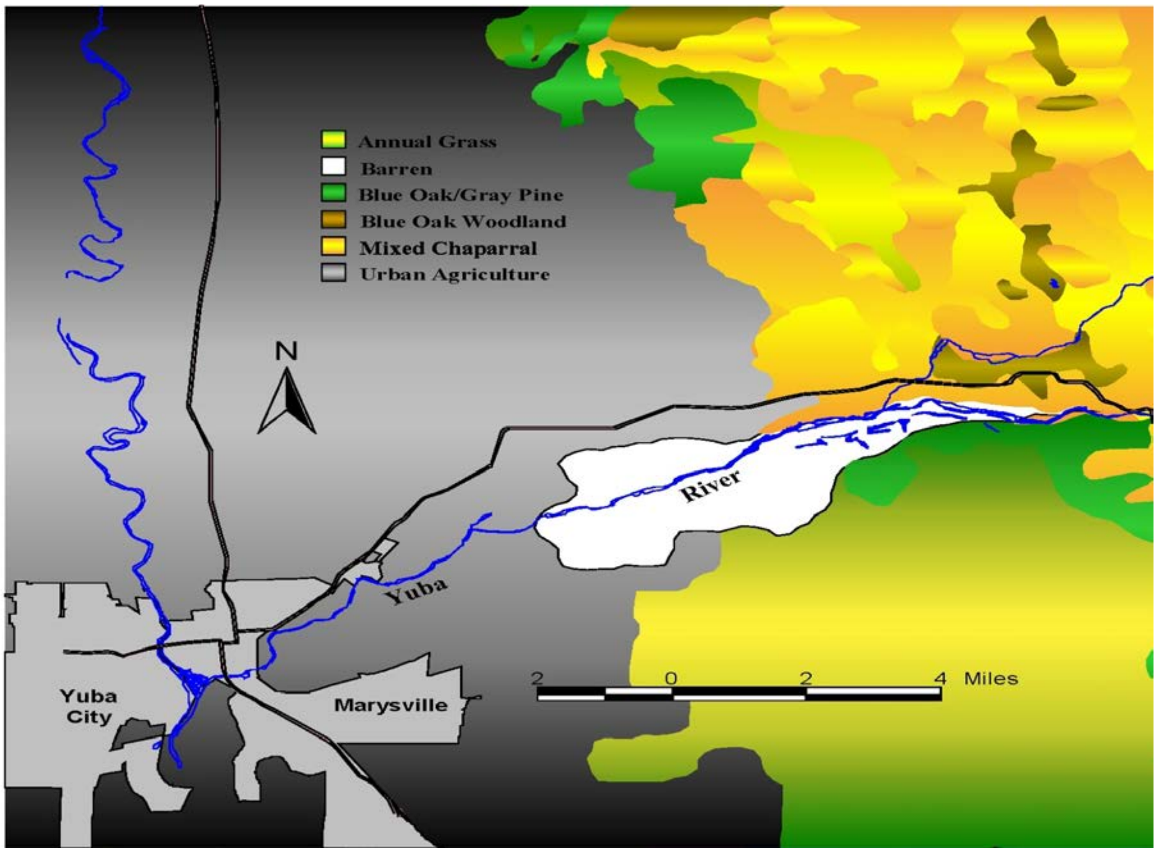


Figure VIII-5. Vegetation communities in the lower Yuba River vicinity (Source: CALFED and YCWA 2005).

The RMT contracted Watershed Sciences Inc. to use existing LiDAR to produce a map of riparian vegetation stands by type. The resulting data was subject to a field validation and briefly summarized in WSI (2010 as cited by Corps 2013) and the data were also utilized in YCWA's Riparian Study Technical Memorandum 6-2 (YCWA 2013).

Based on field observations, YCWA (2013) reported that all reaches supported woody species in various lifestages - mature trees, recruits, and seedlings were observed within all reaches. Where individuals or groups of trees were less vigorous, beaver activity was the main cause, although some trees in the Marysville Reach appeared to be damaged by human camping.

The structure and composition of riparian vegetation was largely associated with four landforms. Cobble-dominated banks primarily supported bands of willow shrubs with scattered hardwood trees. Areas with saturated soils or sands supported the most complex riparian areas and tended to be associated with backwater ponds. Scarps and levees supported lines of mature cottonwood and other hardwood species, typically with a simple understory of Himalayan blackberry or blue elderberry shrubs. Bedrock dominated reaches had limited riparian complexity and supported mostly willow shrubs and cottonwoods (YCWA 2013).

Based on analysis of the mapping data, RMT (2013) reported that the majority of the woody species present in the river valley include, in order of most to least number of individuals:

various willow species (*Cephalanthus occidentalis*), Fremont cottonwood (*P. fremontii*), blue elderberry, black walnut (*Juglans hindsii*), Western sycamore (*Platanus racemosa*), Oregon ash (*Fraxinus latifolia*), white alder (*Alnus rhombifolia*), tree of heaven (*Ailanthus altissima*), and grey pine (*Pinus sabiniana*). Willow species could not be differentiated by species using remote sensing information. Willow on the lower Yuba River are dominated by dusky sandbar willow (*S. melanopsis*) and narrow leaf willow (*S. exigua*), and relative dominance of the two species shifts respectively in the downstream direction (WSI 2010 as cited in Corps 2013b). Other species occurring are arundo willow (*S. lasiolepsis*), Goodings willow (*S. goodingii*) and red willow (*S. laevigata*). Goodings and red willow comprise 6.4 percent of the willow according to a limited field validation survey (WSI 2010 as cited in Corps 2013b).

Cottonwoods are one of the most abundant woody species in the study area, and the most likely source of locally-derived large instream woody material due to rapid growth rates and size of individual stems commonly exceeding 2 feet in diameter and 50 feet in length. Cottonwoods exist in all lifestages including as mature trees, recruits, or saplings, and as seedlings. Cottonwoods are more abundant in downstream areas of the study area relative to upstream. Cottonwoods are distributed laterally across the valley floor. Of the estimated 18,540 cottonwood individuals/stands, 12 percent are within the bankfull channel (flows of 5,000 cfs or less), and 39 percent are within the floodway inundation zone (flows between 5,000 and 21,100 cfs). However, recruitment patterns of cottonwood have not been analyzed with respect to time or with any more detail regarding channel location (YCWA 2013).

A total of 97 cottonwood trees were cored to estimate age. Age estimates ranged from 11 to 87 years. The cottonwood tree age analysis resulted in age estimates that place the year of establishment for trees in a range of years from ±7 to 16 years, which is too wide to allow for linking the establishment of trees to any year's specific conditions (YCWA 2013).

YCWA conducted a historical aerial photograph analysis to describe changes over time to total vegetation delineated within the valley walls, riparian vegetation delineated within 50 feet of the active river channel,[2] and channel alignment (see Technical Memorandum 6-2 in YCWA 2013). To determine the cumulative change over time[3] in total vegetative cover and riparian vegetation cover for the Marysville, Timbuctoo Bend, Narrows, and Englebright Dam study sites, YCWA compared the aerial photographs from 1937 and 2010.

Cumulative changes in vegetative cover in the Englebright Dam and Narrows study sites decreased. For the remaining study sites, including Marysville, Hallwood, Daguerre Point Dam, Dry Creek, Parks Bar, and Timbuctoo Bend study sites, the cumulative change in vegetative cover increased. The least amount of vegetation change over time was observed in the Englebright Dam, Narrows and Marysville sites. The Dry Creek, Daguerre Point Dam and Hallwood sites had the greatest vegetated area, and YCWA identified those sites as the most

---

2 Total vegetation is inclusive of riparian vegetation.

3 Cumulative change describes the changes to observable area for either total vegetation or riparian vegetation from the earliest photo date to the most recent photo date.

dynamic (*i.e.*, both decreased in vegetative cover through 1970 and then increased through 2010).

Cumulative changes in riparian vegetation cover in the Englebright Dam and Narrows study sites decreased with very little detectable change for the Narrows study site. For the remaining study sites, the cumulative change in riparian vegetation cover increased. The observed changes for the Englebright Dam, Narrows and Marysville study sites were very small. For the Dry Creek and Parks Bar study sites, the greatest changes were observed, with dramatic increases in riparian vegetation cover. The magnitude of change of riparian vegetation between photoset years (in a stepwise comparison) was greater than that seen in the cumulative riparian vegetation cover change.

There is currently a lack of consensus regarding the amount of instream woody material occuring in the lower Yuba River (Corps 2012d). It has been suggested (CALFED and YCWA 2005) that the presence of Englebright Dam has resulted in decreased recruitment of LWM to the lower Yuba River, although no surveys or studies were cited to support these statements. Some woody material may not reach the lower Yuba River due to collecting on the shoreline and sinking in Englebright Reservoir (Corps 2012d). However, Englebright Dam operations do not block woody material from reaching the lower Yuba River because there is no woody material removal program implemented for Englebright Reservoir, and accumulated woody material therefore spills over the dam during uncontrolled flood events (R. Olsen, Corps, pers. comm. 2011, as cited in Corps 2012d).

About 8.7 miles of the lower Yuba River downstream of Englebright Dam, distributed among study sites per reach, were surveyed and evaluated for pieces of wood (YCWA 2013). The number of pieces of wood was relatively similar above and below Daguerre Point Dam (*i.e.*, about 5,100 and 5,750 pieces, respectively). Woody material was generally found in bands of willow shrubs near the wetted edge, dispersed across open cobble bars, and stranded above normal high-flow indicators. Most of the woody material was diffuse and located on floodplains and high floodplains, with only about a quarter of the material in heavy concentrations (YCWA 2013).

Most (77-96 percent) pieces of wood found in each reach were smaller than 25 feet in length and smaller than 24 inches in diameter, which is the definition of large woody material (LWM). These pieces would be typically floated by flood flows and trapped within willows and alders above the 21,100 cfs line, which is defined as the flow delineating the floodway boundary (YCWA 2013).

Instream woody material was not evenly distributed throughout the reaches. For the smaller size classes (*i.e.*, shorter than 50 feet, less than 24 inches in diameter), the greatest abundance of pieces was found in the Hallwood or Daguerre Point Dam reaches, with lower abundances above and below these reaches (YCWA 2013).

The largest size classes of LWM (*i.e.*, longer than 50 feet and greater than 24 inches in diameter) were rare or uncommon (*i.e.*, fewer than 20 pieces total) with no discernible distribution. Pieces of this larger size class were counted as “key pieces”, as were any pieces exceeding 25 inches in diameter and 25 feet in length and showing any morphological influence (*e.g.*, trapping sediment or altering flow patterns). A total of 15 key pieces of LWM were found in all study sites, including six in the Marysville study site. Few of the key pieces were found in the active channel or exhibiting channel forming processes (YCWA 2013).

In consideration of the importance that riparian vegetation and LWM play in the habitat complexity and diversity which potentially limits the productivity of juvenile salmonids, the abundance and distribution of these physical habitat characteristics in the lower Yuba River, and the fact that the present availability of riparian habitat and instream cover (in the form of LWM) is a stressor that is manifested every year, it represents a stressor of relatively high magnitude to Yuba River juvenile spring-run Chinook salmon.

<u>Habitat complexity and diversity</u>

Habitat complexity and diversity refer to the quality of instream physical habitat including, but not necessarily limited to, the following physical habitat characteristics:

• Escape cover • Feeding cover • Allochthonous material contribution • Alternating point-bar sequences	• Pool-to-riffle ratios • Sinuosity • Instream object cover • Overhanging riparian vegetation

The physical structure of rivers plays a significant role in determining the suitability of aquatic habitats for juvenile salmonids, as well as for other organisms upon which salmonids depend for food. These structural elements are created through complex interactions among natural geomorphic features, the power of flowing water, sediment delivery and movement, and riparian vegetation, which provides bank stability and inputs of large woody debris (Spence *et al*. 1996). The geomorphic conditions caused by hydraulic and dredge mining since the mid-1800s, and the construction of Englebright Dam, which affects the transport of nutrients, fine and course sediments and, to a lesser degree, woody material from upstream sources to the lower river, continue to limit habitat complexity and diversity in the lower Yuba River.

LWM creates both micro- and macro-habitat heterogeneity by forming pools, back eddies and side channels and by creating channel sinuosity and hydraulic complexity. This habitat complexity provides juvenile salmonids numerous refugia from predators and water velocity, and provides efficient locations from which to feed. LWM also functions to retain coarse sediments and organic matter in addition to providing substrate for numerous aquatic invertebrates (Spence *et al*. 1996).

In the lower Yuba River, mature riparian vegetation is scattered intermittently, leaving much of the banks devoid of LWM and unshaded – affecting components that are essential to the health and survival of the freshwater lifestages of salmonids (NMFS 2002). Although the ability of the lower Yuba River to support riparian vegetation has been substantially reduced by the historic impacts from mining activities, the dynamic nature of the river channel results in periodic creation of high-value shaded riverine aquatic (SRA) cover for fish and wildlife (Beak 1989).

Other important components of habitat structure at the micro-scale include large boulders, coarse substrate, undercut banks and overhanging vegetation. These habitat elements offer juvenile salmonids concealment from predators, shelter from fast current, feeding stations and nutrient inputs. At the macro-scale, streams and rivers with high channel sinuosity, multiple channels and sloughs, beaver impoundments or backwaters typically provide high-quality rearing and refugia habitats (Spence *et al*. 1996). The lower Yuba River can be generally characterized as lacking an abundance of such features.

(4) Flows

Instream flow requirements are specified for the lower Yuba River at the Smartsville Gage (RM 23.6), located approximately 2,000 feet downstream from Englebright Dam, and at the Marysville Gage (RM 6.2). Downstream of the Smartsville Gage, accretions, local inflow, and runoff contribute, on average, approximately 200 TAF per year to the lower Yuba River (JSA 2008).

The two major tributaries to the lower Yuba River are Deer Creek and Dry Creek. Located about 1.2 miles downstream of Englebright Dam, Deer Creek flows into the lower Yuba River at approximately RM 22.7. A significant falls exists approximately 500 feet upstream of the mouth of Deer Creek, which is likely impassable during drier years, but steelhead have been found above the falls during wetter years with high runoff (CDFG 1991). Deer Creek flows are regulated at Lake Wildwood (CALFED and YCWA 2005).

Located about 10.3 miles downstream of Englebright Dam, Dry Creek flows into the lower Yuba River at RM 13.6, approximately two miles upstream of Daguerre Point Dam (JSA 2008). The flow in Dry Creek is regulated by BVID's operation of Merle Collins Reservoir, located on Dry Creek about 8 miles upstream from its confluence with the Yuba River.

<u>Lower Yuba River flows</u>

Flow releases through the power plants at Englebright Dam are subject to provisions of various permits, licenses and contracts, including water rights permits and licenses administered by the SWRCB, PG&E's FERC License for Project No. 1403, YCWA's FERC License for Project No. 2246, YCWA's 1966 Power Purchase Contract with PG&E, a 1965 contract between YCWA and CDFW concerning instream flows, and a 1966 contract between YCWA and DWR under the Davis-Grunsky Act (NMFS 2007).

In 1962 and 1965, YCWA entered into agreements with CDFW to provide the following minimum instream flows for normal water years for preserving and enhancing the fish resources in the lower Yuba River downstream of Daguerre Point Dam:

- October through December – 400 cfs,
- January through June – 245 cfs, and
- July through September – 70 cfs.

Minimum flows required by the agreements were subject to reductions in critical dry years. However, in no event were flows to be reduced to less than 70 cfs. YCWA's FERC license also contains these requirements. In most years, YCWA voluntarily exceeded the 1962 and 1965 agreements' minimum flow requirements. However, when these minimum flows were implemented they often produced water temperatures and habitat conditions that were well outside the optimal preferred ranges for salmonids (NMFS 2007).

On February 23, 1988, the SWRCB received a complaint filed by a coalition of fishery groups referred to as the United Groups regarding fishery protection and water rights issues on the lower Yuba River. In 1992 and 2000, the SWRCB held hearings to receive testimony and other evidence regarding fishery issues in the lower Yuba River and other issues raised in the United Groups complaint. The SWRCB held supplemental hearings in 2003.

On July 16, 2003, the SWRCB issued a decision (RD-1644) regarding the protection of fishery resources and other issues relating to diversion and use of water from the lower Yuba River. Among other requirements, RD-1644 specified new minimum flow requirements and flow fluctuation criteria for the lower Yuba River. Although these minimum flow requirements did not provide the level of flow protection recommended by CDFW or NMFS, according to RD-1644 these flows were developed to attempt to enhance habitat for adult attraction and passage, spawning, egg incubation, juvenile rearing, and emigration of Chinook salmon, CCV steelhead, and American shad (*Alosa sapidissima*) in the lower Yuba River (NMFS 2007).

Conflicts among fisheries resources, water supply reliability, flood concerns, and surface and groundwater management associated with the lower Yuba River resulted in litigation between environmental and water supply interests regarding RD-1644. The Yuba Accord was developed as an alternative to litigation over the flow requirements specified in RD-1644.

<u>Lower Yuba River Accord</u>

The Lower Yuba River Accord (Yuba Accord) includes three separate but related agreements that protect and enhance fisheries resources in the lower Yuba River, increase local supply reliability, and provide Reclamation and DWR with increased operational flexibility for protection of Delta fisheries resources through the Environmental Water Account (EWA) Program, and provision of supplemental dry-year water supplies to State and Federal water contractors (YCWA *et al*. 2007). These agreements are:

- *Lower Yuba River Fisheries Agreement* (Fisheries Agreement),
- *Conjunctive Use Agreements* (Conjunctive Use Agreements), and
- *Long-term Water Purchase Agreement* (Water Purchase Agreement).

The development of the Yuba Accord was a collaborative process, which led to a comprehensive settlement of 20 years of litigation over lower Yuba River instream flow requirements and related issues. Stakeholders that participated in the development of the Yuba Accord include NMFS, CDFW, USFWS, YCWA, SYRCL, Trout Unlimited (TU), FOR, and the Bay Institute.

The Fisheries Agreement is the cornerstone of the Yuba Accord. The Fisheries Agreement contains new instream flow requirements for the lower Yuba River, developed to increase protection of the river's fisheries resources. In addition to the best available science and data, the interests of the participating State, Federal, and local fisheries biologists, fisheries advocates, and policy representatives were considered during development of the Fisheries Agreement. The Fisheries Agreement provides for minimum instream flows during specified periods of the year that are higher than the corresponding flow requirements of RD-1644. Besides the new minimum instream flows, the Fisheries Agreement also contains provisions for a monitoring and evaluation program to oversee the success of the flow schedules and a funding mechanism to pay for monitoring and study activities.

The Yuba Accord Technical Team, tasked with flow schedule development, pursued a variety of analytic techniques and tools, and performed numerous evaluations to develop minimum flow requirements, referred to as "flow schedules" for the lower Yuba River. Additionally, the development of a new Yuba Basin water availability index was required to allow a more precise determination of which flow schedule to use in the lower Yuba River under each of several hydrological conditions.

Several steps were taken to develop to the Yuba Accord flow schedules:

(1) Development of a stressor matrix for key fisheries species in the lower Yuba River,
(2) Focusing on key fish species,but also considering general aquatic habitat conditions and health in the lower Yuba River,
(3) Defining general fisheries goals (*e.g.*, maintenance, recovery, enhancement, etc.),
(4) Defining specific fisheries-related goals of the new flow regime in terms of flow, temperature, habitat, etc.,
(5) Developing a comprehensive understanding of the hydrology and range of variability in hydrology for the Yuba Basin,
(6) Developing a comprehensive understanding of the operational constraints (regulatory, contractual, and physical) of the YRDP and lower Yuba River, as well as an understanding of the flexibilities and inflexibilities of those constraints, and
(7) Developing flow regimes based on specific fisheries-related goals and water availability (as defined by operational constraints and hydrologic conditions).

The Technical Team recognized that a new flow regime for the lower Yuba River would need to achieve several objectives, including:

(1) Maximize the occurrence of "optimal" flows and minimize the occurrence of sub-optimal flows, within the bounds of hydrologic constraints,
(2) Maximize occurrence of appropriate flows for Chinook salmon and steelhead immigration spawning, rearing, and emigration,
(3) Provide month-to-month flow sequencing in consideration of Chinook salmon and CCV steelhead life history periodicities,

(4) Provide appropriate water temperatures for Chinook salmon and CCV steelhead immigration and holding, spawning, embryo incubation, rearing and emigration,
(5) Promote a dynamic, resilient, and diverse fish assemblage,
(6) Minimize potential stressors to fish species and lifestages, and
(7) Develop flow regimes that consider all freshwater lifestages of salmonids and allocate flows accordingly.

To build a scientific basis for crafting a flow regime that would meet these objectives, the Technical Team needed a tool to prioritize impacts on and benefits to the lower Yuba River aquatic resources. To meet this need, the Technical Team undertook development of a matrix of the primary "stressors" that affect anadromous salmonids in the lower Yuba River.

While the Technical Team recognized the critical importance of having a dynamic and resilient aquatic community, the Technical Team also realized that developing a flow regime that considered the environmental and biotic requirements of each species in the entire aquatic community would not only be exceedingly complex and difficult, but probably also impossible, given the myriad constraints (time, operations, finite water availability, water rights, conflicting requirements of aquatic species, etc.) confronting the process. The Technical Team decided that, to meet its goals, efforts would be focused on addressing "keystone" lower Yuba River species. The Technical Team agreed that a flow regime that supported key fish species such as CCV steelhead and Central Valley Chinook salmon would generally benefit other native fish species, recreationally important fish species such as American shad and striped bass, aquatic macroinvertebrates, and other aquatic and riparian resources. The Technical Team also realized that, above all else, the developed flow regime would be evaluated primarily on its perceived value or benefit to State and Federally listed species, namely CCV steelhead and CV spring-run Chinook salmon, and also to fall-run Chinook salmon. For this reason, the lower Yuba River stressor prioritization process principally considered steelhead, CV spring-run Chinook salmon, and fall-run Chinook salmon. Other fish species considered, but ultimately not included in the stressor prioritization process, were American shad, striped bass, and green sturgeon. At the time of development, green sturgeon were neither listed nor proposed for listing under the Federal ESA. The primary purpose of the stressor prioritization process was to provide specific input and rationale for seasonal flow regime development as well as to provide overall guidance for other management and potential restoration actions.

For the purpose of developing the lower Yuba River Anadromous Salmonid Stressor Matrix – the ultimate product of the stressor prioritization process – each species' or race's freshwater lifecycle was broken up into six commonly acknowledged lifestages. These lifestages are: (1) adult immigration and holding, (2) spawning and egg incubation, (3) post-emergent fry outmigration (referred to as young-of-year downstream movement/outmigration for steelhead), (4) fry rearing, (5) juvenile rearing, and (6) smolt outmigration (referred to as yearling (+) outmigration for steelhead and Chinook salmon). Each of the lifestages was then assigned a temporal component reflecting the best available knowledge of the timing and duration of that lifestage in the lower Yuba River.

Potential stressors (also referred to as limiting factors) were then identified for each species' or race's lifestage. Because most potential stressors were limited to a particular geographic reach or extent in the lower Yuba River, a geographical component was assigned to each stressor. The following is a listing of all of the potential stressors considered for the purpose of Stressor Matrix development.

- Water Temperature
- Flow Fluctuations
- Flow Dependent Habitat Availability
- Habitat Complexity and Diversity
- Predation
- Entrainment/Diversion Impacts
- Physical Passage Impediments
- Transport/Pulse Flows
- Poaching
- Spawning Substrate Availability
- Angler Impacts
- Attraction Of Non-Native Chinook Salmon
- Overlapping Habitat
- Physical Passage Impacts
- Lake Wildwood Operations/Deer Creek Flow Fluctuations
- Motor-powered Watercraft

These potential stressors were not necessarily considered to be an exhaustive list of all stressors, but were the major perceived stressors, based on information current at that time. In addition, the list of stressors included some elements that were not necessarily considered to be stressors by all Technical Team members. The stressor prioritization process was intended to serve as a tool to provide context for and assistance in the development of the flow schedules. Geographic and temporal considerations then were assigned to each stressor, further defining the extent of the potential stressor's effect on each species and lifestage. The result was a stressor matrix, which provided the Technical Team with a quantitative context of the relative importance of stressors for each month. The Technical Team members utilized the Stressor Matrix results for each month to help guide flow schedule development.

The first step in developing the flow schedules was the development of an "optimal" flow schedule that was not constrained by water availability limitations. Available information such as the Stressor Matrix results (and the species and lifestage rankings, lifestage periodicities, and geographical considerations developed for the Stressor Matrix), flow-habitat relationships (*i.e.*, WUA) for Chinook salmon and steelhead spawning, and an understanding of the lower Yuba River flow-water temperature relationship was utilized in this process.

The development of the "optimal" flow schedule resulted in a "high" (Schedule 1) and a "low" (Schedule 2) range of ideal flows. The development of the "high" and "low" range of ideal flows was representative of the variety of opinions among the Technical Team biologists. Through extensive discussion and collaboration, the Technical Team biologists and representatives came to a general agreement that the two flow schedules represented the range of the "optimal" flows.

The second step of the flow schedule development process was the development of a "worst case" flow schedule for years with extremely low water availability, targeting hydrologic year classes in the 5 percent of driest years. This flow schedule, which eventually became Schedule 6, was termed the "survival" flow schedule, because the Technical Team sought to develop a flow regime that would permit survival of the year's cohort during very dry hydrological conditions.

Recognizing the year-to-year variations in lower Yuba River water availability, the Technical Team developed three additional flow schedules (Schedules 3, 4, and 5) between the "optimal" flows and the "survival" flows to be used during intermediate hydrological conditions. The step size between each successive flow schedule was adjusted to be large enough to cover the ranges of water availability without excessive jumps between flow schedules. The Technical Team considered utilizing more or fewer than a total of six flow schedules. However, it was ultimately determined that six flow schedules could adequately address nearly the entire spectrum of hydrological occurrences.

Ultimately, six flow schedules, plus conference year provisions, were developed to cover the entire range of Yuba River Basin water availabilities. The flow schedules were developed to maximize fisheries benefits during wetter years, and to maintain fisheries benefits to the greatest extent possible for drier years while taking into account other key considerations such as water supply demands, flood control operations, and hydrologic constraints of the system (NMFS 2007). Conference Years are predicted to occur during the 1 percent driest hydrological conditions. The Yuba Accord contains provisions regarding the minimum flows, reductions in diversions for irrigation and consultations among representatives of interested parties and regulatory agencies that will occur during Conference Years.

The Yuba Accord flow schedules were developed between 2001 and 2004, and formalized in a set of proposed agreements in 2005. In April of 2005, a statement of support for the proposed Fisheries Agreement was signed by YCWA, CDFW, NMFS, USFWS, SYRCL, FOR, TU, and the Bay Institute. NMFS played a vital role in the development, and subsequent implementation, of the Yuba Accord.

In January 2006, the parties to the Proposed Yuba Accord signed the 2006 Pilot Program Fisheries Agreement, which contained minimum instream flow requirements for the lower Yuba River for the period of April 1, 2006, through February 28, 2007, (YCWA 2006). On April 5, 2006, the SWRCB issued Order WR 2006-0009, which granted YCWA's petition to extend the effective date of the RD-1644 interim instream flow requirements from April 21, 2006, to March 1, 2007. On April 10, 2006, the SWRCB's Division of Water Rights issued WR-2006-0010-DWR, which approved YCWA's petition for the 2006 Pilot Program water transfer. Due to hydrologic conditions in the Delta (*e.g.*, unbalanced conditions), YCWA was not able to transfer water to DWR for use in the EWA Program in 2006. However, the 2006 Pilot Program Fisheries Agreement flow schedules remained in effect through February 28, 2007, (YCWA 2006).
In August 2006, YCWA also filed two petitions to temporarily amend its water right permits so that YCWA could implement the 2007 Pilot Program. The first petition (the Extension Petition) requested a change in the effective date of the SWRCB RD-1644 long-term instream flow requirements from March 1, 2007, to April 1, 2008. The second petition (the Transfer Petition), filed pursuant to Water Code Section 1725, requested approval of the temporary changes in YCWA's water right permits that were necessary for a one-year water transfer from YCWA to DWR. The SWRCB approved these petitions in February 2007.

The 2006 and 2007 Pilot Programs closely followed the proposed Yuba Accord flow regimes, accounting rules, management framework and other aspects of the Yuba Accord. Additionally, implementation of the 2006 and 2007 Pilot Programs allowed real-world tests of several of the principal elements of the Yuba Accord, including the proposed lower Yuba River flow schedules, transfer accounting rules, and compliance provisions (YCWA *et al*. 2007).

In 2008, the SWRCB approved the water-rights petitions necessary to implement the Yuba Accord on a long-term basis. The six flow schedules for specific types of water years are based on hydrologic conditions represented by the North Yuba Index (NYI). The NYI is an indicator of the amount of water available in the North Yuba River at New Bullards Bar Reservoir that is used to achieve the flow schedules on the lower Yuba River through operations of the reservoir. The estimated frequencies of occurrence of year-type designations under the NYI are shown below.

Flow Schedule	**North Yuba Index (TAF)**	**Percent Occurrence (Percent)**	**Cumulative (Percentage)**
1	≥ 1,400	56	56
2	1,040 – 1,399	22	78
3	920 – 1,039	7	85
4	820 – 919	5	90
5	693 – 819	5	95
6	500 – 692	4	99
Conference	< 500	1	100

In addition to the six types of water years for the flow schedules, Conference Years are predicted to occur at a frequency of 1 percent or less (during the driest years). Conference Years are defined as water years for which the NYI is less than 500 TAF.

As part of the Yuba Accord, YCWA operates the YRDP and manages lower Yuba River instream flows according to the revised instream flow requirements, and according to specific flow schedules, numbered 1 through 6 (measured at the Marysville Gage) and lettered A and B (measured at the Smartsville Gage), based on water availability (see Table VIII-1 for Schedules 1 through 6 and Table VIII-2 for Schedules A and B). The specific flow schedule that is in effect at any time is determined by the value of the NYI and the rules described in the Fisheries Agreement.

Table VIII-1. Yuba Accord lower Yuba River minimum instream flows (cfs) for Schedules 1 through 6, measured at the Marysville Gage.

Schedule[a]	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-31	Aug 1-31	Sep 1-30
1	500	500	500	500	500	700	1,000	1,000	2,000	2,000	1,500	1,500	700	600	500
2	500	500	500	500	500	700	700	800	1,000	1,000	800	500	500	500	500
3	500	500	500	500	500	500	700	700	900	900	500	500	500	500	500
4	400	500	500	500	500	500	600	900	900	600	400	400	400	400	400
5	400	500	500	500	500	500	500	600	600	400	400	400	400	400	400
6 [b, c]	350	350	350	350	350	350	350	500	500	400	300	150	150	150	350

[a] For the Yuba Accord Alternative (using the NYI): Schedule 1 years are years with the NYI ≥ 1,400 TAF, Schedule 2 are years with NYI 1,040 to 1,399 TAF, Schedule 3 are years with NYI 920 to 1,039 TAF, Schedule 4 are years with NYI 820 to 919 TAF, Schedule 5 are years with NYI 693 to 819 TAF, Schedule 6 are years with NYI 500 to 692 TAF, and Conference Years are years with NYI < 500 TAF.

[b] Indicated flows represent the average flow rate at the Marysville Gage for the specified time periods listed above. Actual flows may vary from the indicated flows according to established criteria.

[c] Indicated Schedule 6 flows do not include an additional 30 TAF available from groundwater substitution to be allocated according to the criteria established in the Fisheries Agreement.

Table VIII-2. Yuba Accord lower Yuba River minimum instream flows (cfs) for Schedules A and B, measured at the Smartsville Gage.

Schedule [a]	Oct 1-31	Nov 1-30	Dec 1-31	Jan 1-31	Feb 1-29	Mar 1-31	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun 1-15	Jun 16-30	Jul 1-31	Aug 1-31	Sep 1-30
A[a]	700	700	700	700	700	700	700	c	c	c	c	c	c	c	700
B[b]	600	600	550	550	550	550	600	c	c	c	c	c	c	c	500

[a] Schedule A flows are to be used concurrently with Schedules 1, 2, 3, and 4 at Marysville.

[b] Schedule B flows are to be used concurrently with Schedules 5 and 6 at Marysville.

[c] During the summer months, flow requirements at the downstream Marysville Gage always will control, and thus, Schedule A and Schedule B flows were not developed for the May through August period. Flows at the Smartsville Gage will equal or exceed flows at Marysville.

Implementation of the flow schedules contained in the Yuba Accord has addressed many of the flow-related stressors that existed previously, and represents relatively recent improvement to Environmental Baseline conditions. The NMFS (2009) Draft Recovery Plan states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*.

The Yuba Accord had not been approved or implemented on a long-term basis at the time that the 2007 NMFS BiOp was prepared. The 2007 NMFS BiOp generally treated effects resulting from flow regime changes on the lower Yuba River as part of the Environmental Baseline, but also discussed flow- and water temperature-related effects on critical habitat as part of the proposed action.

In the future the effects of the Yuba Accord flows on ESA listed anadromous fish species will likely be addressed through the Federal Energy Regulatory Commission relicensing process for the Yuba River Development Project. The license for that project expires in 2016, and the licensing process is currently in progress.

Juvenile Stranding and Redd Dewatering

In the California State Water Resources Control Board's (SWRCB) 2001 Decision (D)-1644, the SWRCB directed YCWA to submit a plan that described the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (YCWA 1992). The monitoring and evaluation plan contained the following objectives (JSA 2003):

- Determine the potential magnitude of redd dewatering in relation to the timing and magnitude of flow fluctuations and reductions
- Determine the potential magnitude of fry stranding in relation to the timing, magnitude, and rate of flow fluctuations and reductions
- Evaluate the effectiveness of the D-1644 flow fluctuation and reduction criteria in protecting redds and fry
- Recommend additional measures to protect redds and fry from flow fluctuations and reductions if warranted

The studies combined habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead fry. Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Report* (JSA 2008) to the SWRCB, and results from an additional study were reported in a progress report in 2010 (ICF Jones & Stokes 2010). A preliminary draft report providing the results of all survey activities conducted during 2007 through 2011 was produced in 2012 (ICF Jones & Stokes 2012), although additional evaluation and reporting of the data is ongoing.

The first *Lower Yuba River Redd Dewatering and Fry Stranding Study* was conducted in April 2007 to evaluate bar and off-channel stranding of juvenile salmonids associated with a flow reduction of 1,300-900 cfs at Smartsville at a ramping rate of 100 cfs per hour. Bar stranding was again evaluated in June with a temporary flow reduction of 1,600-1,300 cfs at a rate of 100 cfs per hour. Snorkel surveys were conducted between Rose Bar, located ~2.5 miles downstream of Englebright Dam, and the Highway 20 Bridge, located ~5.7 miles downstream of Englebright Dam.

During the April 5, 2007, drawdown, field crews observed eight stranded salmon fry in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 0.5 to 5.5 percent in slope. No stranded fish were observed during surveys conducted on June 18, 2007.

The presence of both juvenile Chinook salmon and *O. mykiss* were confirmed in shallow, near-shore areas adjacent to the study sites, suggesting that the risk of bar stranding is greatly reduced by June. Following the April 5, 2007, flow reductions, juvenile salmon were found in 16 of the 24 disconnected off-channel sites (ICF Jones & Stokes 2012). Most of the fish that had become isolated in off-channel sites were 30-50 mm fry. Out of the 16 sites where isolation of fry was observed, 70 percent of the fish were found in the four largest sites, which accounted for nearly 60 percent of the total wetted area that had become disconnected from the main river. According to ICF Jones & Stokes (2012), these four sites were unique in that they were all associated with man-made features within or adjacent to the main river channel (*e.g.*, diversion channels, ponds and bridge piers).

An updated *Lower Yuba River Redd Dewatering and Fry Stranding Study* was subsequently conducted from May 29, 2008, through June 4, 2008, with a scheduled flow reduction on June 1, 2008. A total of seven stranded trout fry ranging between 30-35 mm were observed in the interstitial spaces of substrates on bar slopes ranging from 2.0 to 5.7 percent in slope.

Juvenile salmon were found isolated in seven of the 12 off-channel sites that had become disconnected from the main river by the June 1, 2008, event. One site accounted for only about 7 percent of the total wetted area that had been disconnected from the main river, but nearly 80 percent of the total number of juvenile salmon that had been isolated by the June 1, 2008, event. A total of 13 steelhead fry were found isolated in 2 of the 12 off-channel sites that had become disconnected from the main river by the June 1, 2008, event. Nearly all of these fish were 30-50 mm fry that had been isolated in a single backwater pool adjacent to the main river in the Timbuctoo Reach (ICF Jones & Stokes 2012).

JSA (2008) suggested that the preliminary findings indicated that juvenile *O. mykiss* fry may be less vulnerable to off-channel stranding than juvenile Chinook salmon because of their more restricted distribution and inability to access off-channel areas under late spring flow conditions. Long-term monitoring of several isolated off-channel sites confirmed that some sites can support juvenile salmonids for long periods and even produce favorable summer rearing conditions.

A 2010 study was conducted from June 21, 2010, through July 1, 2010, with a scheduled flow reduction between June 28 and June 30 from approximately 4,000 cfs to 3,200 cfs as measured at the Smartsville Gage. As reported by ICF Jones & Stokes (2010), fish stranding surveys were conducted on June 21, 22, and 23 to identify potential stranding areas and document habitat conditions and fish presence before the flow reduction, and were repeated on June 29, June 30, and July 1 to document the incidence of fish stranding and habitat conditions after the flow reduction.

After the June flow reduction, a total of six juvenile salmon and 46 juvenile trout was observed in seven of the 26 off-channel sites that had become fully or nearly disconnected (≤0.1 foot deep) from the main river. Most of the stranded fish were juvenile trout 30-70 mm in length that had become isolated in five off-channel sites above Daguerre Point Dam. Below Daguerre Point Dam, observations of stranded fish were limited to six juvenile salmon and two juvenile trout at two study sites (ICF Jones & Stokes 2010).

Hydrologic and operating conditions in January and February 2011 provided the first opportunity to evaluate the effect of a winter flow reduction on the incidence of bar stranding. A series of three successive flow reductions were evaluated. Following a 3-week period of relatively stable flows, Englebright Dam releases were reduced from 3,000-2,600 cfs on January 31, 2,600-2,200 cfs on February 7, and 2,200-2,000 cfs on February 11.

The first event was a 400-cfs flow reduction (3,000–2,600 cfs) conducted from 8:00 AM to 10:00 AM at a target rate of 200 cfs per hour on January 31, 2011. This event resulted in a 2.1–2.5 inch drop in water surface elevation and a rate of change of 0.6–0.8 inch per hour at the three study sites. Field crews searched a total of 764 square feet of dewatered shoreline and found a total of 20 stranded salmon fry (30-40 mm long) and six stranded steelhead (50-90 mm long) (ICF Jones & Stokes 2012).

During the second event on February 7, 2011, flows were again reduced by 400 cfs (2,600–2,200 cfs) from 8:00 AM to 10:00 AM, but at a target rate of 100 cfs per hour. This event resulted in a 1.8–2.1 inch drop in water surface elevation and a rate of change of 0.4–0.5 inch per hour at the three study sites. Field crews searched a total of 560 square feet of dewatered shoreline and found a total of 10 stranded salmon fry (30-40 mm long) and no steelhead (ICF Jones & Stokes 2012).

During the third event on February 11, 2011, flows were reduced by 200 cfs (2,200–2,000 cfs) from 2:00 AM to 4:00 AM at a target rate of 100 cfs per hour. This event resulted in a 0.8–1.3 inch drop in water surface elevation and a rate of change of 0.4–0.7 inch per hour at the three study sites. Field crews searched a total of 248 square feet of dewatered shoreline and found a total of four stranded salmon fry (30-40 mm long) and no steelhead (ICF Jones & Stokes 2012).

(5) Global Climate Change

By contrast to the conditions for other Central Valley floor rivers, climate change may not be likely to have such impacts on salmonids in the lower Yuba River downstream of Englebright Reservoir (YCWA 2010a). Presently, the lower Yuba River is one of the few Central Valley tributaries that consistently has suitable water temperatures for salmonids throughout the year. Lower Yuba River water temperatures generally remain below 58°F year-round at the Smartsville Gage (downstream of Englebright Dam), and below 60°F year-round at Daguerre Point Dam (YCWA *et al*. 2007). At Marysville, water temperatures generally remain below 60°F from October through May, and below 65°F from June through September (YCWA *et al*. 2007). However, in dry years temperatures may become warmer than the optimum range for salmonids.

According to YCWA (2010), because of specific physical and hydrologic factors, the lower Yuba River is expected to continue to provide the most suitable water temperature conditions for anadromous salmonids of all Central Valley floor rivers, even if there are long-term climate changes. This is because New Bullards Bar Reservoir is a deep, steep-sloped reservoir with ample cold water pool reserves. Throughout the period of operations of New Bullards Bar Reservoir (1969 through present), which encompasses the most extreme critically dry year on record (1977), the cold water pool in New Bullards Bar Reservoir never was depleted. Since 1993, cold water pool availability in New Bullards Bar Reservoir has been sufficient to accommodate year-round utilization of the reservoir's lower level outlets to provide cold water to the lower Yuba River. Even if climate conditions change, New Bullards Bar Reservoir still will have a very substantial cold water pool each year that will continue to be available to provide sustained, relatively cold flows of water into the lower Yuba River during the late spring, summer and fall of each year (YCWA 2010).

(6) BiOp for the Central Valley Project/State Water Project

The BiOp for the Central Valley Project/State Water Project (CVP/SWP) consultation (NMFS 2009a) covered CVP and SWP facilities and potentially affected water bodies. The lower Yuba River is not included in the CVP or SWP, and CV spring-run Chinook salmon would not be affected by CVP/SWP operations while in the lower Yuba River. However, the Yuba River CV spring-run Chinook salmon population would be subject to CVP/SWP operational and ESU-wide effects associated with the Environmental Baseline while in their migratory lifestages in the lower Feather River, lower Sacramento River, and the Delta, as well as in the Pacific Ocean. The NMFS (2009a) CVP/SWP BiOp, therefore, is used in this BiOp for an assessment of the entire CV spring-run Chinook salmon ESU.

NMFS' evaluation of potential effects of the CVP/SWP OCAP (NMFS 2009a) included an assessment of the VSP parameters of abundance, productivity, spatial structure, and diversity. Regarding abundance, NMFS (2009a) stated that long-term CVP/SWP system-wide operations are expected to result in substantial mortality to juvenile CV spring-run Chinook salmon, and that CVP/SWP-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. NMFS (2009a) also stated that population growth rate of CV spring-run Chinook salmon would be expected to decline in the future.

According to NMFS (2009a), operations of the CVP and SWP reduce the population's current spatial structure (by reducing habitat quantity and quality) and negatively affect the diversity of CV spring-run Chinook salmon in the mainstem Sacramento River. CVP/SWP operations are expected to continue these effects. The operations of the DCC, and historical operations of RBDD have affected the temporal distribution of adult spring-run on their spawning migration to mainstem Sacramento River spawning grounds, and potentially result in introgression with fall-run Chinook salmon and continues the pattern of genetic introgression and hybridization that has occurred since RBDD was built in the late 1960s (CDFG 1988, NMFS 2004b, TCCA 2008 as cited in NMFS 2009a). In addition, the FRFH program has affected the diversity of the CV spring-run Chinook salmon and, together with the loss of the San Joaquin River Basin spring-run populations, the diversity of the CV spring-run Chinook salmon ESU has been reduced (NMFS 2004).

According to NMFS (2009a), all of the above factors, which reduce the spatial structure, diversity, and abundance, compromise the capacity for the CV spring-run Chinook salmon ESU to respond and adapt to environmental changes. NMFS' VSP analysis at the population and diversity group scales showed reduced viability of extant CVspring-run Chinook salmon populations and diversity groups. Additionally, high quality critical habitat containing spawning sites with adequate water and substrate conditions, or rearing sites with adequate floodplain connectivity, cover, and water conditions (*i.e.*, key PCEs of critical habitat that contribute to its conservation value) is considered to be limited. Future projections over the duration of evaluated long-term CVP/SWP operations (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks to the CV spring-run Chinook salmon ESU. NMFS (2009a) stated that the CV spring-run Chinook salmon ESU is at moderate risk of extinction.

NMFS (2009a) concluded that long-term CVP/SWP operations are likely to jeopardize the continued existence of Central Valley spring-run Chinook salmon, and are likely to destroy or adversely modify critical habitat for CV spring-run Chinook salmon.

NMFS (2009a) initially attempted to devise a RPA for CV spring-run Chinook salmon and its critical habitat by modifying CVP/SWP project operations (*e.g.*, timing/magnitude of releases from dams, closure of operable gates and barriers, and reductions in negative flows). In some cases, however, altering CVP/SWP project operations was not sufficient to ensure that the CVP and SWP projects would be likely to avoid jeopardizing the species or adversely modifying critical habitat. Consequently, NMFS (2009a) developed focused actions designed to compensate for particular stressors, considering the full range of authorities that Reclamation and DWR may use to implement these actions. NMFS concentrated on actions that have the highest likelihood of alleviating the stressors with the most significant effects on the species, rather than attempting to address every project stressor for each species or every PCE for critical habitat.

The NMFS (2009a) RPA is composed of numerous elements for each of the various CVP/SWP project divisions and associated stressors. NMFS recognized that the RPA must be an alternative that is likely to avoid jeopardizing listed species or adversely modifying their critical habitats, rather than a plan that will achieve recovery. Short-term actions are presented in NMFS (2009a) for each division of the CVP/SWP, and are summarized for each species to ensure that the likelihood of survival and recovery is not appreciably reduced in the short term (*i.e.*, one to five years). In addition, because evaluated long-term CVP/SWP system-wide operations extend until 2030, the consultation also included long-term actions that NMFS identified as being necessary to address CVP/SWP project-related adverse effects on the likelihood of survival and recovery of the species over the next two decades. However, the District Court for the Eastern District of California largely held that the jeopardy conclusions of the 2009 NMFS BiOp was correct, but that the RPA actions were not adequately justified or supported by the record. The NMFS 2009 BiOp was remanded (Consol. Salmonid Cases, 791 F. Supp. 2d 802 (E.D. Cal. 2011)).

For the ESU-wide Environmental Baseline effects assessment of the CV spring-run Chinook salmon, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline result in an unstable ESU at moderate risk of extinction.

(B) Physical Features

(1) Daguerre Point Dam

The Rivers and Harbor Act of June 13, 1902, (32 Stat. 331) authorized the construction of the Yuba River Debris Control Project, of which Daguerre Point Dam is a part (Corps 2001). Construction of Daguerre Point Dam was funded through a 50/50 cost share between the California Debris Commission and the State of California.

The original purpose of the Daguerre Point Dam was to create a basin for the storage of debris originating from the operation of hydraulic equipment for gold mining in the Yuba River watershed. Since the cessation of hydraulic mining operations, Daguerre Point Dam has retained the debris stored behind the dam and prevented it from being washed into the Feather and Sacramento Rivers to the detriment of associated navigation and flood control facilities. The dam was not intended for, nor does it provide for, the control of floods (Corps 2001).

Past, present, and future effects associated with the physical presence of the existing facilities at Daguerre Point Dam are included in the Environmental Baseline. With the exception of potential effects related to fish ladder performance associated with authorized discretionary operations and maintenance activities at Daguerre Point Dam, the Corps does not have the authority or discretion to lessen other stressors associated with these facilities. Therefore, it is appropriate that the ongoing impacts from the stressors associated with the continued existence of Daguerre Point Dam are included in the Environmental Baseline.

<u>Physical Facilities Description</u>

The current configuration of Daguerre Point Dam is a reinforced, overflow concrete ogee ("s-shaped") spillway with concrete apron and concrete abutments. The ogee spillway section is 575 feet wide and 25 feet tall (NMFS 2007).

There is no reservoir associated with Daguerre Point Dam. The dam is a low-head dam across the Yuba River. In addition to the dam structure, there are two fish ladders, each with a control gate. The two fish ladders utilize the hydraulic head created by the dam due to the influence of the dam preventing additional channel incision above the dam. The purpose of these two fish ladders is to permit salmon and steelhead access upriver to the seasonal spawning areas. There are no recreation facilities located at Daguerre Point Dam.

Daguerre Point Dam is the primary diversion point for water entering the Hallwood-Cordua Canal and the South Yuba Canal, which supply the water districts located north and south of the lower Yuba River, respectively. Water levels in the Hallwood-Cordua and South canals are manually controlled year-round using board weirs. Minimum water levels are maintained to ensure there is enough pressure for any user to divert water when needed (R. McDaniel, pers. comm. 2006 in YCWA et. al. 2007). While water elevations in these primary conveyances remain constant, the flow rates through these conveyances may change with changes in agricultural demands. The amounts of groundwater pumping by farmers have no effects on surface water levels in the primary conveyances. Even during seasons when farmers are implementing groundwater conjunctive use measures, water levels are maintained in the primary conveyances for those districts or farmers that are not participating in the conjunctive use programs.

Fish Ladders and Fish Passage

Under the Environmental Baseline, there are numerous issues associated with anadromous fish passage at Daguerre Point Dam. NMFS (2007) stated that passage conditions at Daguerre Point Dam are considered to be inadequate for Chinook salmon and steelhead throughout much of the year due to the design of the existing ladders. When high flow conditions occur during winter and spring, adult CV spring-run Chinook salmon and steelhead reportedly can experience difficulty in finding the entrances to the ladders because of the relatively low amount of attraction flows exiting the fish ladders, compared to the magnitude of the sheet-flow spilling over the top of Daguerre Point Dam. In addition, the NMFS (2007) stated that the angles of the fish ladder entrance orifices and their proximities to the plunge pool also increase the difficulty for fish to find the entrances to the ladders.

Other configuration and design features of the fish ladders and passage facilities that reportedly could either delay or impede anadromous salmonid access to spawning and rearing areas above the dam include: (1) the control gate, acting as a submerged orifice, is only passable at low flows (actual flow data are unavailable) during the summer and fall; (2) the ladders become clogged with debris; (3) insufficient attraction flows during non-overflow operational conditions; (4) unfavorable within-bay hydraulic characteristics, particularly associated with debris collection; (5) unfavorable fish ladder geometric configurations; and (6) sedimentation and unfavorable habitat conditions associated with egress from the fish ladders.

The Corps installed locking metal grates on 33 unscreened bays of the Daguerre Point Dam fish ladders in response to the Interim Remedy Order issued by the Court on July 25, 2011. Because the fish ladder bays are not uniformly sized, each metal grate needed to be custom fabricated by hand (Figure VIII-6). Due to concerns expressed by both NMFS and CDFW, the Court then reconsidered the requirement to put grates over the bays on the lowermost section of the south fish ladder at Daguerre Point Dam. Consequently, grates were not installed over the lower eight bays of the south fish ladder at Daguerre Point Dam.

NMFS (2007) suggested that the biological consequences to anadromous salmonids of blockage or passage delays include changes in spawning distribution, increased adult prespawning mortality, and decreased egg viability, which may result in the reduction of the abundance and productivity of the listed species.

DWR and the Corps (2003) stated that there is no direct evidence that holding below the dam when the fish ladders are not fully functional affects the condition of salmon during their migration, except that repeated attempts to pass over the dam probably result in injury from contact with the rough concrete surface of the dam face. Moreover, short-term delays in spawning migration are not inherently problematic, and salmon and steelhead health and/or egg viability may not be adversely affected by short- term delays (DWR and Corps 2003). It has been suggested that water temperatures in the pool below Daguerre Point Dam may be higher than optimum for all salmonids during the warmer parts of the year, especially during low flow conditions in late summer, and that water temperature effects may adversely impact egg viability (DWR and Corps 2003).

The RMT recently evaluated the potential effects of water temperatures on CV spring-run Chinook salmon, fall-run Chinook salmon and steelhead, by lifestage, using the mean monthly water temperature modeling conducted for the 2007 Lower Yuba River Accord EIR/EIS and water temperature monitoring data conducted from 2006 - 2012. The RMT (2013) included evaluation of water temperatures at Daguerre Point Dam during the CV spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability, characterized as extending from April through August, and concluded that water temperatures were suitable.

Concern has been expressed that if emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam (DWR and Corps 2003). However, this concern was raised prior to implementation of the Yuba Accord minimum flow schedules and associated water temperatures (initiated as Pilot Programs in 2006 and 2007, and now being implemented through the permanent changes made to YCWA's water-right permits in 2008). The RMT (2013) also included an evaluation of water temperatures at Daguerre Point Dam and at the Marysville Gage on the lower Yuba River during the year-round juvenile rearing period for CV spring-run Chinook salmon and CCV steelhead, and found that water temperatures remained at suitable levels. Low flow conditions, during hot weather have the potential to result in undesirable temperatures in part of the reach between the Feather River and Daguerre Point Dam.

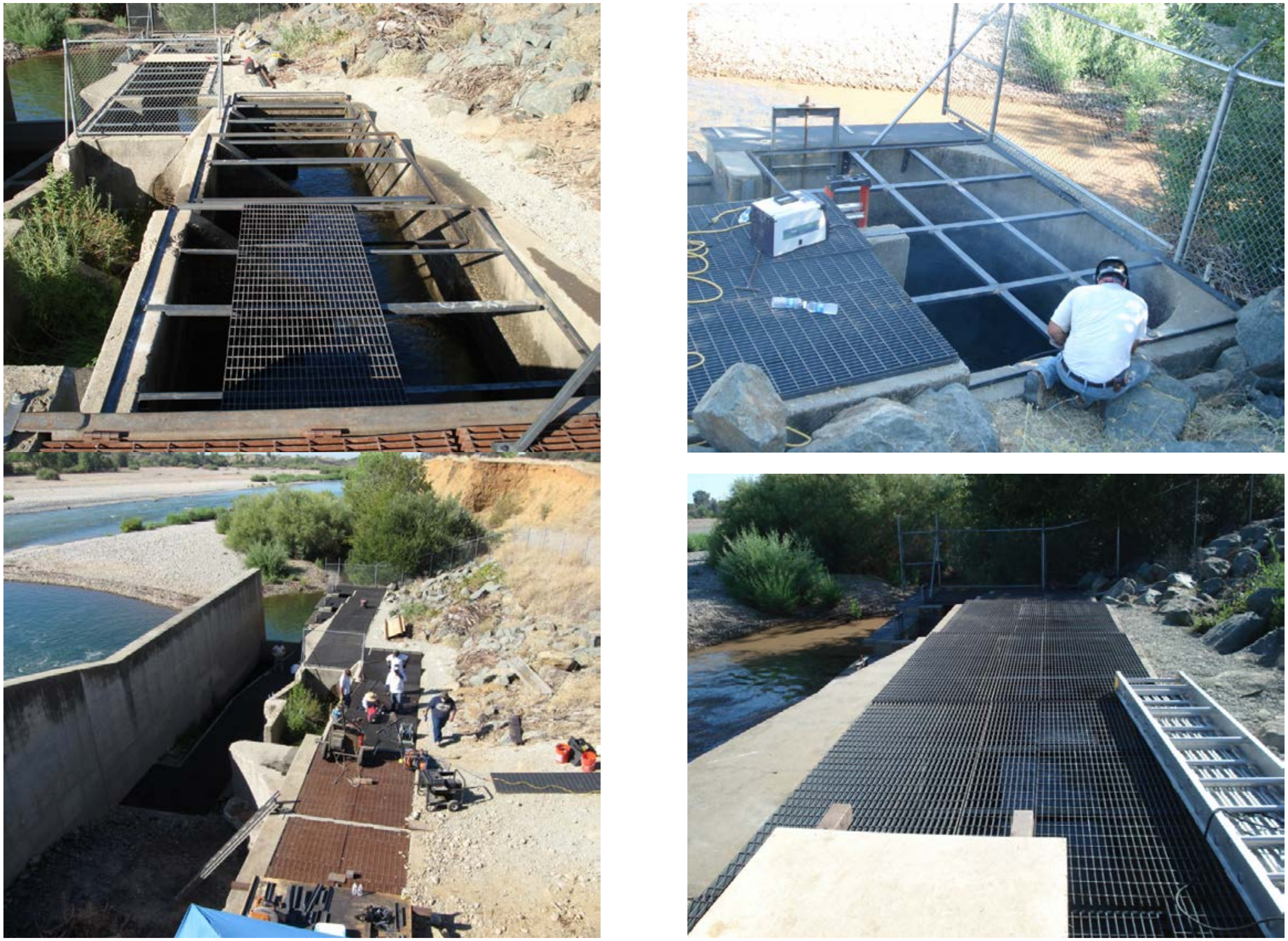


Figure VIII-6. Installation of metal grates on the Daguerre Point Dam fish ladder bays during August 2011 (Corps 2011).

NMFS (2007) and other documents (NMFS 2002, CALFED and YCWA 2005) suggest that juvenile salmonids may be adversely affected by Daguerre Point Dam on their downstream migrations, because Daguerre Point Dam creates a large plunge pool at its base, which provides ambush habitat for predatory fish in an area where emigrating juvenile salmonids may be disoriented after plunging over the face of the dam into the deep pool below. The introduced predatory striped bass and American shad have been observed in this pool (CALFED and YCWA 2005). It has been suggested that the rates of predation of juvenile salmonids passing over dams in general, and Daguerre Point Dam in particular, may be unnaturally high (NMFS 2007). However, DWR and Corps (2003) stated that there is no substantial evidence of predation on emigrating juvenile salmon by warmwater fish, and that temperature and habitat conditions in the lower Yuba River are not conducive to the establishment of significant populations of warmwater fish, except perhaps in the Marysville area. Daguerre Point Dam may influence predation rates on emigrant juvenile anadromous salmonids, although DWR and Corps (2003) stated that there are no data indicating that such predation is significant, whether predation at the dam is offset by lower predation rates downstream, or even what percentage of juvenile salmonids are taken by predators. Presently, there are limited studies or data regarding predation rates on juvenile anadromous salmonids in the vicinity of Daguerre Point Dam relative to elsewhere in the lower Yuba River.

An additional issue associated with fish passage at Daguerre Point Dam relates to the abundance and distribution of rearing juvenile anadromous salmonids relative to predators. Most juvenile Chinook salmon and steelhead rearing has been reported to occur above Daguerre Point Dam (Beak 1989, CDFG 1991, SWRI *et al*. 2000). Kozlowski (2004) observed age-0 *O. mykiss* throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance downstream from the Narrows. Approximately 82 percent of juvenile *O. mykiss* were observed upstream of Daguerre Point Dam. Kozlowski (2004) suggested that the distribution of age-0 *O. mykiss* appeared to be related to the distribution of spawning adults. The higher abundance of juvenile salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam (YCWA *et al*. 2007). It is uncertain the extent to which the design, operational and maintenance activities have incrementally contributed to the current status of the species, including their viabilities and extinction risks.

Daguerre Point Dam was not designed for green sturgeon and is therefore a complete barrier to upstream passage because green sturgeon are unable to ascend the fish ladders on the dam, or otherwise pass over or around the structure. The scarcity of information on green sturgeon in the lower Yuba River makes it difficult to determine how these fish are utilizing the habitat in the river, or for what purpose green sturgeon are entering the river.

According to NMFS (2007), it is possible that the plunge pool below Daguerre Point Dam or other deep holes downstream of the dam provide suitable habitat for green sturgeon spawning. It is unlikely that any green sturgeon alive today could have been spawned above Daguerre Point Dam, and are attempting to return to their natal spawning habitat above the dam, because the dam has been in place longer than the expected maximum life span [60 to 70 years (Moyle 2002)] of green sturgeon.

In this BiOp, a distinction is made between effects on listed species attributable to designs of facilities that have been operational since 1965 and before, and effects associated with the Corps authorized activities associated with the fish ladders. The Corps has the authority and discretion to lessen adverse effects associated with operation and maintenance of the fish ladders and sediment removal upstream of Daguerre Point Dam, removal of sediment and woody debris from the fish ladders themselves, and minor adjustments to the hydraulic performance of the ladders. Further, the Corps has determined that they do not currently have authorization or discretion to make modifications to the fish ladders. Therefore, effects to listed species associated specifically with these activities are characterized as effects of the proposed action. All other effects associated with design of the ladders and the facilities are part of the Environmental Baseline.

Operations and Maintenance Activities

The Corps past operational criteria required that the fish ladders be physically closed when water elevations reached 130 feet, or when flows were slightly less than 10,000 cfs (SWRCB 2003), and to keep them closed until the water receded to an elevation of 127 feet (CALFED and YCWA 2005). However, current operation of the fish ladder gates differs from past operations in that the Corps coordinates with NMFS and CDFW to keep the gates open at all flow levels.

In 2003, the Corps first installed a log boom at the north ladder exit to divert debris away from the ladder. In June 2010, CDFW installed flashboards in the lower bays of the south fish ladder in an effort to improve attraction flows to the south ladder (Grothe 2011). Upon completing this work, CDFW reported that the number of fish moving through the south ladder increased compared to numbers recorded prior to installation of the flashboards.

On October 20, 2010, CDFW advised the Corps that staff from the Pacific States Marine Fisheries Commission (PSMFC) had documented as many as a dozen fall-run Chinook salmon that had jumped out of the south fish ladder over the previous 4 to 6 weeks. That same day, Corps staff placed plywood boards over the bay from which the fish reportedly jumped as a temporary measure to prevent any more fish from escaping the ladder. By email dated November 5, 2010, Duane Massa, a project manager for PSMFC, provided additional information to the Corps regarding the incident. According to Mr. Massa, PSMFC maintenance logs indicated that six fall-run Chinook salmon carcasses were observed outside the south fish ladder over a period of four weeks (September 27, 2010 – October 26, 2010) rather than one dozen as initially reported. No further incidences of fish escaping the ladder were reported during 2010 (D. Massa, PSMFC, pers. comm. 2010 as cited in Corps 2013b). More recently, in response to the Interim Remedy Order issued by the Court on July 25, 2011, during the summer of 2011, the Corps proceeded with installation of locking metal grates on 33 unscreened bays. Due to concerns expressed by both NMFS and CDFW, the Court then reconsidered the requirement to put grates over the bays on the lowermost section of the south fish ladder at Daguerre Point Dam (Figure VIII-7 and Figure VIII-8). Consequently, grates were not installed over the lower eight bays of the south fish ladder at Daguerre Point Dam.

The upstream exit of the fish ladder periodically becomes ineffective due to sediment buildup in the channel, which acts as a barrier that prevents upstream fish migration. As an example of the maintenance activities typically conducted, CDFW observed fall-run Chinook salmon migration problems resulting from a clogged channel at the north fish ladder upstream exit during fall of 1999. The Corps, in co-operation with CDFW, excavated the entire area just upstream from the ogee spillway, as well as two deeper channels running diagonally from each ladder upstream toward the middle of the river channel. The gravel bar that blocked access from the south ladder also was cleared to allow access to the river channel (Corps 2001). During 2009, the Corps dredged the upstream side of Daguerre Point Dam to provide egress from the fish ladders and continued fish passage opportunity.

Gravel buildup can itself block fish passage, as well as further reduce attraction flows in the fish ladders at Daguerre Point Dam. As discussed in the July 8, 2010 Order of the United States District Court, Eastern District of California, in Case No. Civ. S-06-2845 LKK/JFM, the Corps has implemented a plan to ensure that a minimum 30 foot wide by 3 foot deep channel remains open to facilitate fish passage and avoid blocking attraction flows.

Figure VIII-7. North fish ladders at Daguerre Point Dam (Corps 2012c).


Figure VIII-8. South fish ladders at Daguerre Point Dam (Corps 2012c).

In late August 2010, the Corps removed sediment that had accumulated on the north side of the channel upstream of Daguerre Point Dam (Grothe 2011), and the material that was removed was disposed of above the ordinary high water mark. Again during August 2011, the Corps removed sediment that had accumulated upstream of Daguerre Point Dam and placed that excavated material above the ordinary high water mark. The Corps also inspected the sediment depth upstream from Daguerre Point Dam and cleared sediment and gravel from the channels upstream of the dam and along the upstream face of the dam on August 7, 2012. Because the Yuba River was too deep at that time, the gravel was moved to the downstream gravel bar in late October 2012 (D. Grothe, Corps, pers. comm. 2013, as cited in Corps 2013b).

Daguerre Point Dam Fish Passage Improvement Studies

In 1994, the Yuba River Technical Working Group and the USFWS identified fish passage issues at Daguerre Point Dam (DWR and Corps 2003). As a result, a preliminary evaluation of measures and alternative concepts to improve fish passage was conducted by the Corps and others.

Initiated by the State Legislature and the California Bay-Delta Program agencies in 1999, the Fish Passage Improvement Program (FPIP), an element of the ERP, is a partnership-building effort to improve and enhance fish passage in Central Valley rivers and streams (DWR 2005a). The program works with other local, State, and Federal agencies and stakeholders to plan and implement projects to remove barriers that impede migration and spawning of anadromous fish. FPIP does not provide for screening diversions.

In 1999, CALFED established the Upper Yuba River Studies Program, a stakeholder-driven collaborative process to discuss fish passage. Also in 1999, the AFRP funded a project to develop fish screen and diversion bypass feasibility alternatives at the Hallwood-Cordura Irrigation District Diversion.

In 1999, USFWS funded a Corps Preliminary Fish Passage Improvement Study of fish passage alternatives at Daguerre Point Dam (Corps 2001). Initiated in 2001, DWR and the Corps undertook the preparation of a joint Draft EIR/EIS to evaluate the Daguerre Point Dam Fish Passage Improvement Project on the Yuba River.

According to CALFED and YCWA (2005), the USFWS Fish Passage Improvement Study identified the following concerns with Daguerre Point Dam's fishways for upstream migration of adult fish:

- The fish ladder control gate entrance, acting as a submerged orifice, is more passable at low flows during summer and fall rather than at high flows during winter and spring.
- The fish ladder exit sometimes becomes unusable due to clogging by woody and non-woody debris.
- Fish may have difficulty finding the orifice during high flows.
- The fish ladders are narrow and have low flow capacities.

The passage study also identified the following concerns for emigration of juvenile anadromous fish:

- Emigration may be impeded during low flows.
- Pools immediately upstream and downstream harbor piscivorous fish.
- Fish may be injured or killed by passing over the dam.
- Water diversion operations may trap fish.

The Daguerre Point Dam Fish Passage Improvement Project aims to improve upstream and downstream passage for all lifestages of native anadromous fish, while keeping water interests whole and with no increase in downstream flood risks (DWR 2011).

Historically, DWR has had a cost sharing agreement with the Corps on any fish passage improvement or studies regarding Daguerre Point Dam. Stakeholders and partner agencies were developing a restoration prioritization plan, and implementing other actions to improve habitat conditions in the lower Yuba, including separate actions implemented through the Lower Yuba River Accord.

Several documents related to the Daguerre Point Dam Fish Passage Improvement Project have been completed. These documents include:

(1) a draft of the Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation, released in September 2003,
(2) a stakeholder review draft of the Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam released in March 2003, and
(3) a stakeholder review draft of the Daguerre Point Dam Fish Passage Improvement Project 2002 Water Resources Study for DWR and the Corps, released in June 2003 (DWR 2011).

In 2008, NMFS awarded a contract to evaluate options for fish passage in the Yuba River (DWR 2011). The main goal of that study was to identify and describe potential fish passage facilities for the reintroduction of CV spring-run Chinook salmon and steelhead in the upper Yuba River watershed. The study included fish passage option considerations at Daguerre Point Dam (NMFS 2010).

(2) Diversions in the Vicinity of Daguerre Point Dam

As development intensified within the Yuba River Basin during the early 1950s, the lower Yuba River and Daguerre Point Dam took on a new purpose. The people of Yuba and Sutter counties recognized the demand for securing, utilizing, and distributing available water resources for the impending domestic and agricultural development. The function of Daguerre Point Dam subsequently evolved to provide additional benefits for water supply purposes (DWR and Corps 2003b). There are three water diversions associated with Daguerre Point Dam, which utilize the elevated head[4] created by the dam, or the influence of the dam in the prevention of additional river channel incision, to gravity-feed their canals. The three diversions are the Hallwood-Cordua diversion, the South Yuba/Brophy diversion, and the Browns Valley Irrigation District (BVID) diversion (Figure VIII-9).

[4] The "elevated head" at Daguerre Point Dam is created by the hydraulic conditions associated with water being impounded behind (*i.e.*, upstream) of the dam. The Corps has no control over the in-river flows, and has no discretionay control over the "head" for local water users in the vicinity of Daguerre Point Dam.

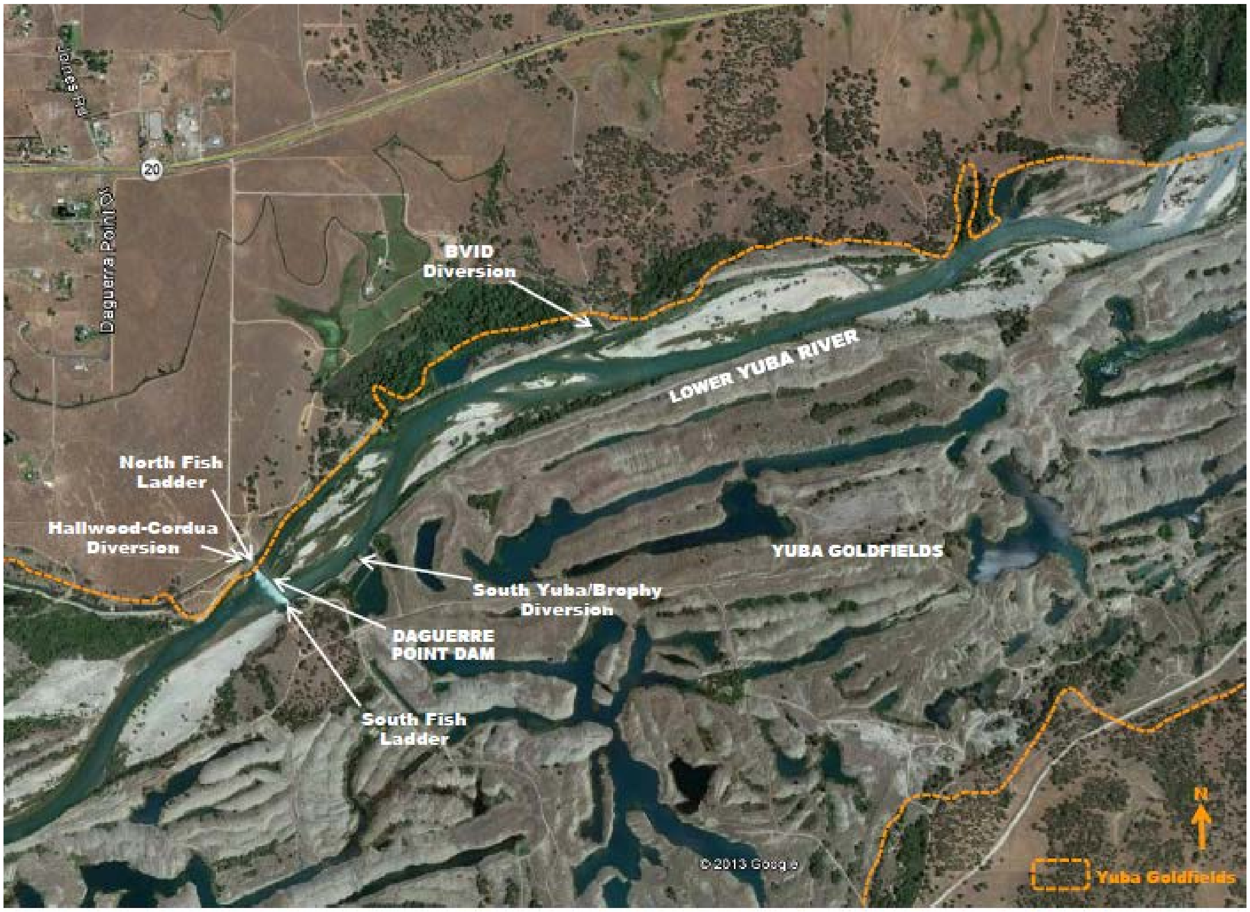


Figure VIII-9. Non-Federal water diversion facilities in the vicinity of Daguerre Point Dam on the lower Yuba River.

Diverters using these facilities divert water under their own water rights, purchase water from YCWA, or do both. YCWA has contractual agreements to deliver water to these irrigation districts, and the three diversions have a combined capacity of 1,085 cfs. As with the Yuba River Development Project, the Corps does not regulate water right diversions or control: (1) whether or not water is diverted from the lower Yuba River through the three agricultural diversions near Daguerre Point Dam (*i.e.*, Hallwood-Cordua, South Yuba-Brophy, and BVID), (2) the quantity and timing of those diversions, or (3) the ultimate use of the water once diverted (Corps 2012b). From the primary conveyances, the irrigation districts use smaller ditches to supply water to their customers according to the following seasonal considerations:

- Irrigation Season, April 1 through October 15
- Waterfowl/Straw Management Season, October 15 through January 31
- Maintenance Season, January 31 through April 1

Hallwood-Cordua North Canal

Hallwood Irrigation Company and Cordua Irrigation District divert water from the Hallwood-Cordua Diversion (also referred to as the “North Canal”) under pre-1914 and post-1914 appropriative water rights and contracts with YCWA. The license issued by the Secretary of War to the Hallwood Irrigation Company and the Cordua Irrigation District (formerly the Stall Ditch Company) in 1911 allow Hallwood and Cordua to continue their diversions of water from the Yuba River, which pre-dated the construction of Daguerre Point Dam.

Cordua Irrigation District is located in an area covering approximately 11,400 acres. Cordua Irrigation District’s first surface water deliveries from the lower Yuba River began in the late 1890s, with receipt of water deliveries under the YCWA contract beginning in October 1971 (YCWA 2008). Rice is the primary crop, which is irrigated primarily by surface water diverted under a combination of water rights (totaling 60,000 acre-feet per year) and under a contract with YCWA (for 12,000 acre-feet per year), for an annual surface water supply of up to 72,000 acre-feet.

The Hallwood-Cordua Diversion (Figure VIII-10), a gravity flow diversion facility located on the north bank of the lower Yuba River at Daguerre Point Dam, has a diversion capacity of 625 cfs (SWRCB 2001). The diversion was originally screened in 1972, and later modified in 1977 (CALFED and YCWA 2005). The Hallwood-Cordua fish screen located in the North Canal utilized a V-shaped perforated plate screen constructed, operated and maintained by CDFW. A bypass system diverted fish captured by the screen into a collection tank, and collected fish were returned to the river either through a pipeline or by truck (SWRCB 2001). CDFW initially operated the fish screen in the North Canal, located approximately one-quarter mile down the canal from the river, for intermittent periods during the Chinook salmon juvenile emigration period of April through June (SWRI *et al*. 2000).

The original design and operation of the Hallwood-Cordua fish screen resulted in the losses of significant numbers of fish (SWRCB 2001). During some years, the fish screen was not operated at all, which resulted in occasions when reportedly up to a million juvenile salmonids were entrained in the diversion (CALFED and YCWA 2005). When operational, the CDFW screen was reported to be effective in preventing the entrainment and impingement of juvenile salmonids, but salmonid losses reportedly did occur as a result of predation in the intake channel between Daguerre Point Dam and the CDFW fish screen. In addition, predation resulted from the removal of the screen by CDFW during the emigration period of juvenile steelhead (YCWA *et al*. 2000).

Figure VIII-10. Hallwood-Cordua Diversion. Image on the left shows the control gate headworks on the north abutment of Daguerre Point Dam. Image on the right shows the current v-shaped screen (Source: YCWA 2013b).

According to SWRCB (2001), the number of Chinook salmon entrained at a diversion facility is related to the percent of river flow that is diverted. SWRCB (2001) reported that an analysis of the daily North Canal fish screen trap records for 1972 to 1991 by the USFWS showed that the number of juvenile salmonids entering the trap was directly related to the percent of river flow diverted. Fish losses also occurred at the fish trapping facility that returned fish from the diversion canal to the river. The long distance between the diversion channel intake and the fish screen, low bypass flows, and excessive handling of the fish stopped by the screen all contributed to the loss of salmonids at the Hallwood-Cordua fish screen (SWRCB 2001).

In 1999, CDFW began an outmigration study of juvenile salmonids using a rotary screw trap located in the lower Yuba River near Hallwood Boulevard. CDFW reported that significant numbers of juvenile Chinook salmon, including CV spring-run Chinook salmon, were captured in the traps, and recently emerged steelhead also were present throughout the summer months (SWRCB 2001). Steelhead as small as 24 mm were observed in July, with 27 and 37 mm fish observed during August and September. Based on the size and numbers of juvenile steelhead and Chinook salmon present throughout the year, it was determined that large numbers of fish were vulnerable to entrainment at the Hallwood-Cordua Diversion. In addition, CDFW stated that the 5/32 inch mesh size of the Hallwood-Cordua fish screen was much larger than the 3/32 inch mesh recommended by CDFW and NMFS (SWRCB 2001). The ineffectiveness of the screen in salvaging fry-size fish was evident when comparing catches at the screen with catches in the rotary screw trap during the same period. During periods when catches of fry-size fish were still high in the rotary screw trap, the fish screen was capturing no fish in that size range. In addition, the approach velocities at approximately 25 percent of the screen area exceeded approach velocities that were, and still are, recommended by NMFS and CDFW. CDFW recommended installation of a fish screen at the Hallwood-Cordua diversion that meets the criteria established by NMFS and CDFW for protection of juvenile Chinook salmon and steelhead (SWRCB 2001).

Consequently, the Hallwood-Cordua fish screen was replaced with a screen that more closely conforms to CDFW and NMFS criteria in 2001. This screen is at the same location, but has appropriate openings and sweeping and approach velocities to facilitate direct return of screened fish back to the river below Daguerre Point Dam. Additionally, the fish screen is operated for the entire diversion season (NMFS 2002). Although this fish screen does not meet all of CDFW and NMFS criteria, the rehabilitation efforts included the installation of the proper-sized screening material and have allowed continuous operation of the screen throughout the irrigation season along with the direct return of screened fish back to the river below the dam (NMFS 2007). The Corps was not involved in the 2001 Hallwood-Cordua fish screen replacement, nor does the Corps operate or maintain the fish screen facility or have discretionary control over it. Therefore, the Corps has determined that the effects of operation and maintenance of the fish screen facility at the Hallwood-Cordua diversion location at Daguerre Point Dam is not part of the proposed action and is therefore included as part of the Environmental Baseline.

<u>South Yuba/Brophy Diversion Canal and Facilities</u>

Approximately 1,000 feet upstream of Daguerre Point Dam on the south side of the river, the South Yuba/Brophy Diversion Canal and Facilities divert water through an excavated channel from the Yuba River's south bank. The South Yuba/Brophy diversion facility includes a 450-foot long porous rock weir fitted with a fine-mesh barrier (geotextile cloth) within the weir, intended to protect juvenile fish from becoming entrained into the canal (Corps 2007).

The South Yuba/Brophy Diversion Canal and Facilities was constructed in the mid-1980s. Prior to construction of the diversion headworks, the rate at which water could be diverted was limited by flows in the lower Yuba River and the percolation rate through the dredge spoil gravel mounds (USFWS 1990).

The South Yuba Water District encompasses about 9,800 acres of land, with the primary crops consisting of rice and pasture (YCWA 2008). The South Yuba Water District began receiving surface water jointly with Brophy Water District in 1983.

Brophy Water District serves approximately 17,200 acres of land, with rice being the dominant irrigated crop, distantly followed by pasture and field crops (YCWA 2008). Since 1985, all water from the lower Yuba River used by the Brophy Water District has been delivered through the South Canal under contract with YCWA.

The South Yuba/Brophy diversion headworks are located above Daguerre Point Dam on the Yuba River, adjacent to the Yuba Goldfields, roughly 9 miles northeast of Marysville, California (Demko and Cramer 2000). The diversion headworks consist of an intake channel and bypass channel (collectively called the diversion channel), a porous rock gabion, a diversion pond behind the rock gabion and an irrigation canal existing at the diversion pond (Figure VIII-11). The South Yuba/Brophy Diversion Canal and Facilities (or the South Canal) is a gravity flow diversion with a current diversion capacity of 380 cfs (SWRCB 2001), and it is authorized to divert water at a rate of up to 600 cfs (DWR and Corps 2003).

Water flows from the mainstem of the lower Yuba River into the diversion channel (side channel of the Yuba River) where it percolates through the porous rock gabion and surrounding gravel deposits into the diversion pond (Corps 2001).

Figure VIII-11. Diversion headworks area for the South Yuba/Brophy Diversion Canal and Facilities.

The pond has a surface area of about 3 acres. The rock gabion consists of cobble size rock, and is roughly 400 feet long, ranging in width from roughly 30 feet at the base to 10 feet at the top. A fine-meshed, geotextile fabric was placed a few feet inside the river-side of the rock gabion during construction to prevent juvenile salmonids from passing through the rock gabion (Corps 2001).

At the far south end of the pond into which water percolates (approximately 300 feet away from the rock gabion) three 5-feet diameter pipes withdraw water from the pond to the main irrigation canal (Demko and Cramer 2000a).

Gates at the entrance of each pipe allow the flow of water to be controlled manually (Corps 2001). The pipes extend underground approximately 450 feet from the southwest corner of the diversion pond to the head of the main irrigation canal. Water can also enter the main irrigation canal by natural seepage. At times when water demand in the irrigation districts is low, the demand can be met entirely from seepage (around 100 cfs) into the canal (Demko and Cramer 2000). The diversion channel and the head control structure require regular maintenance to remove accumulated gravel and debris deposited during high flows (USFWS 1990).

Some of the water that enters the diversion channel remains in the channel as it passes the rock gabion and flows back to the lower Yuba River through a lower portion of the diversion channel referred to as the bypass channel. The bypass channel extends roughly 450 feet from the downstream end of the rock gabion to the box culvert, which is located about 270 feet upstream of Daguerre Point Dam.

The diversion system and the percolation water outfall system are directly connected at an eight foot culvert and check structure located in a dredge pond near the river diversion facility (USFWS 1990). During the irrigation season (April-November), headboards are placed in the check structure to increase pond storage and capture percolation flows for conveyance. The headboards are pulled during the non-irrigation season to reduce pond storage and allow percolation water to return to the river via the culvert and outfall. The Corps has no involvement in these activities. As of 1990, USFWS (1990) reported that a seasonal dam located near the culvert protects the culvert structure during high winter flow conditions. When percolation flows exceed the capacity of the culvert, the seasonal dam was designed to blow-out and allow the high flows to bypass the culvert and return to the lower Yuba River via the outfall channel. This seasonal dam and blow-out feature also provided for winter-time flood protection of the various structures and activities occurring in the Goldfields Area (USFWS 1990).

Although the diversion structure addressed CDFW fish screening requirements at the time of construction in 1985, fish screening requirements have changed over time and the diversion structure does not meet current NMFS and CDFW screening criteria. Screening criteria issues associated with the diversion structure include potential non-compliance with: (1) screen space size (*i.e.*, 3/32 inch mesh size), (2) screen porosity, (3) uniformity of approach velocity, (4) sweeping flow, and (5) cleaning frequency. Additional issues associated with the diversion structure include predation in the channel that leads to the diversion and at the face of the rock weir, and overtopping of the weir and subsequent entrainment of juvenile salmonids behind the weir.

The interstitial spaces between the rocks of the levee are larger than the maximum 3/32 inches required by NMFS fish screening criteria (CALFED and YCWA 2005). The fine mesh barrier imbedded within the rock gabion was designed to prevent fry or juvenile salmonids from passing through the gabion. However, it has been suggested that flows, at times, reportedly are not sufficient to sweep fry along the face of the rock gabion and, as a result, fry may become impinged or entrained into the diversion (CALFED and YCWA 2005).

NMFS (2007) also discussed the effects on salmonids of the South Yuba/Brophy Diversion Canal and Facilities, and stated that the fine-meshed, geotextile fabric buried within the rock gabion weir at this diversion "*may meet the opening size criteria (if it is still intact) but there is obviously no sweeping flow along the face of this fabric inside of the weir and therefore any fry which encounter this mesh, instead of being swept along the face of the fabric, would be more likely to become impinged on the fabric and perish*." NMFS (2007) also noted that several studies have suggested that the structure does not exclude juvenile salmonids from being entrained into this diversion.

By agreement with CDFW, at least 10 percent of the water diverted into the diversion channel is required to bypass the rock gabion and flow back to the river, to allow migrant fish entering the diversion channel to return to the river. However, it has been reported that the 10 percent bypass flow has not always been met historically (NMFS 2002). In September 2010, YCWA replaced the two 48-inch culverts located at the downstream terminus of the bypass channel with a concrete box culvert and then restored the site. YCWA undertook the project to improve water flow at various river stages, reduce debris loading, and reduce maintenance. Installation of the concrete box culvert also was necessary to efficiently accommodate new flow metering equipment to measure the flow returning to the Yuba River from the diversion channel. YCWA installed a downlooking acoustic Doppler flow meter in the access port in the box culvert, and the flow meter was connected to the data monitoring and communication equipment located in the concrete building at the south abutment of Daguerre Point Dam. These improvements were made to ensure that the 10 percent return flows occur in the future pursuant to the stipulated settlement and order in the SYRCL v. NMFS case. High flows during the winter and spring of 2010/2011 resulted in the deposition of sediment and debris requiring clearance and maintenance of the box culvert, prior to the installation of the flow monitoring equipment.

In addition, predation of juvenile anadromous salmonids in the pool located within the diversion channel in front of the porous rock gabion has been raised as an issue by CDFW and NMFS. Construction of the porous rock gabion has resulted in a relatively wide, deep pool directly in front of the rock gabion characterized by reduced water velocities, which potentially could delay the continued downstream migration of juvenile salmonids (NMFS 2002). The pool also reportedly provides holding and ambush habitat for predatory fish such as Sacramento pikeminnow (NMFS 2002).

The issues of predation, impingement, and entrainment at the South Yuba/Brophy Diversion Canal and Facilities have been the subject of numerous evaluations over the past many years. A brief summary of the various studies and resultant findings is presented in chronological order hereas follows.

Pursuant to the 1984 Agreements between the South Yuba Water District and the Brophy Water District and CDFW, South Yuba/Brophy built Alternative No. 4, which stipulated additional criteria including "*c. A return diversion will provide for returning at least 10% of the quantity diverted back into the river*." In 1988, CDFG (1988a) conducted a mark-recapture study to: (1) evaluate the effectiveness of the rock gabion, and (2) determine whether bypass flows were at least 10 percent of the diverted quantity.

The mark-recapture survey was conducted using a fyke net located in the upstream portion of the diversion channel, and two additional fyke nets located near the downstream terminous of the bypass channel. During the first treatment period, which began on May 11, 1988, a total of 4,746 salmon were captured in the upstream fyke net, whereas a total of 2,684 salmon were captured during the second treatment period (CDFG 1988a). The recapture rate at the downstream fyke nets after 72 hours approached zero. According to CDFG (1988a), the results of this mark-recapture study showed that less than 95 percent of the marked fish made it through the bypass canal, potentially because of the large predator (Sacramento pikeminnow) populations that existed in the diversion channel. CDFG (1988a) suggested that losses of juvenile salmonids at the South Yuba/Brophy diversion were between 40 and 60 percent. However, Cramer (1992) used the observed capture efficiency estimates to expand the number of marked fish recovered by CDFG (1988a) and found that estimated survival from the mouth of the diversion channel all of the way to the bypass exit was substantially higher than the estimates given by CDFG (1988a) and likely exceeded the 95 percent survival criterion stipulated by CDFW. During this study, Sacramento pikeminnow were observed feeding on juvenile salmonids as they attempted to migrate out of the diversion channel (CDFG 1988a). Flow measurements were taken by a SWRCB engineer, with assistance from CDFW and USFWS, at the following locations: (1) the inflow to South Yuba/Brophy Diversion Canal and Facilities (downstream of the intake fyke), and (2) the return flow to the lower Yuba River in the bypass canal (just downstream of the upper bypass fyke). Bypass flows exceeded 10 percent of the diverted flows of water during both treatment periods (CDFG 1988a).

Juvenile salmonids have been collected behind the rock gabion. These fish either passed through the gabion and mesh barrier or were washed over the top of the rock gabion during high flows (NMFS 2002). Juvenile sampling surveys have had mixed results in capturing salmon behind the rock gabion fish screen (USFWS 1990). An electrofishing survey of the diversion pond was conducted by CDFW in March 1987. Although juvenile salmonids were found in the pond behind the rock gabion prior to this study, salmonids were not captured when the pond was electrofished (CDFG 1988a). However, Preston (1987 as cited in CDFG 1988a) stated that three juvenile Chinook salmon were captured behind the gabion prior to diversions from the river. In that year, flows in the lower Yuba River reportedly did not exceed 2,000 cfs that could over-top the present height of the gabion, and allow for fish to pass over the gabion (USFWS 1990).
In April 1989, USFWS seined 31 juvenile Chinook salmon ranging in size from 46 to 70 mm fork length in the diversion pond area behind the rock gabion (USFWS 1990, SWRCB 2001). These fish reportedly had become trapped in the pond prior to any diversion. Although this was the only date USFWS seined the diversion pond, USFWS also observed several hundred juvenile salmonids feeding in the same area on May 5, 1989. After diversions began about May 10, 1989, USFWS (1990) did not observe any Chinook salmon in the diversion pond.

The entire back side of the rock gabion fish screen was observed during a scuba dive survey on May 11, 1989 (USFWS 1990). Water depth at the base of the gabion was approximately 20 feet with water visibility about 6 feet. The rock material was consistent in size and placement along the entire screen face. USFWS (1990) did not observe any unusually large sized openings that would allow for unimpeded flow through the gabion. An unknown amount of water was being diverted from the river through the gabion, and this diversion did not create any noticeable head differential between the pool in front of the gabion and the pool behind. The gabion appeared to be fairly fish tight (USFWS 1990). USFWS (1990) concluded that the salmon collected in 1989 behind the gabion most likely were washed into the pond during early March when river flows exceeded 20,000 cfs and over-topped the gabion structure. Although USFWS (1990) did not directly observe the flooding of the gabion, based on the accumulation of woody debris and dead leaves in small shrubs along the top of the gabion, it appeared that about 1 to 2 feet of water flowed over the north end of the structure. Flow measurements at Marysville from 1969 to 1989 indicate that flows that overtop the levee (exceeding 20,000 cfs) have occurred numerous times in eight of those 20 years (SWRCB 2001).

To determine whether juvenile fish were passing through the rock gabion, Demko and Cramer (1992 as cited in Corps 2001) installed a fyke net on the outfall of the diversion pipe that enters the South Yuba/ Brophy irrigation canal. They sampled continuously whenever water was diverted, from the day water diversions began on May 7 through July 22, and captured 17 juvenile Chinook salmon and 2 steelhead fry during the sampling period. However, all Chinook salmon caught in the irrigation canal were substantially larger than those migrating down the river at the same time, and Demko and Cramer (1993) concluded that the large juvenile Chinook salmon could not have passed through the interstitial spaces in the rock gabion at the time they were captured. They deduced, as did the USFWS in the 1988 study (USFWS 1990), that fish were not passing through the porous dyke, but rather that a small number of fish passed into the diversion pond during winter during times of high flows that over-topped the rock gabion (Corps 2001). However, CDFW suggested that the fyke net, constructed of 1/8 inch mesh, used in the study may not have been efficient for small salmonids and SWRCB (2001) suggested that the number of small juvenile steelhead entering the irrigation canal, therefore, may have been significantly underestimated. Regardless of the manner in which fish entered the diversion pond, SWRCB (2001) suggested that fish, including listed species, continued to be lost from the lower Yuba River fishery at the rock gabion.

In August 1993, Demko and Cramer (1993) observed nineteen 20 cm and larger pikeminnow in the diversion channel that were large enough to be predators of juvenile Chinook salmon. However, Cramer (2000 as cited in Corps 2001) reviewed all studies performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFW or fisheries consultants had indicated that juvenile Chinook salmon became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred in the diversion channel.

SWRCB (2001) stated that during the 2000 SWRCB hearing, USFWS presented data showing that bypass flows in the return channel were at times less than 10 percent of the water diverted, and recommended that higher bypass flows be maintained. SWRCB (2001) also stated that because there was no way to prevent water from entering the diversion channel when water was not being diverted into the South Canal for irrigation, losses at the diversion facilities due to predation and other factors occur even when no water is being diverted for beneficial use (SWRCB 2001). USFWS presented evidence to the SWRCB that deposition and accumulation of gravel and debris in the diversion channel as a result of floods or other events can adversely affect flow and migration of juvenile salmon through the diversion facility (SWRCB 2001).

On July 8, 2004, representatives of CDFW and NMFS made a series of water velocity measurements along the face of the permeable rock gabion that separates the lower Yuba River from the headgates for the South Yuba/Brophy diversion. The purpose of the flow measurements was to characterize the flow conditions along the upstream face of the rock gabion. The flow along the upstream face of the rock gabion appeared to be irregular and complex in all three components of the velocity measurements (NAFWB 2004). According to NAFWB (2004), this was probably due to roughness of the gravel/cobble surface, irregularities in the rock gabion profile, differences in the permeability along the length of the rock gabion, and variations in the plugging of the upstream face of the rock gabion. Approach velocities varied from -0.054 feet per second (fps) to 0.686 fps with mean velocity of 0.052 fps. One approach velocity measurement exceeded 0.33 fps. Sweeping velocities varied from -0.167 fps to 1.034 fps with mean velocity of 0.260 fps. Two sweeping velocity measurements exceeded 0.67 fps. The head loss across the rock gabion was approximately 0.9 feet on the day of the measurements (NAFWB 2004).

On August 30, 2011, PSFMC personnel and YCWA representatives conducted a reconnaissance survey to investigate the presence/absence of predatory fish in the South Yuba/Brophy diversion channel. A jet boat was used to navigate through the diversion channel, initially entering from the upstream point of the diversion channel and drifting downstream to the box culvert at the lower end of the diversion channel (Figure VIII-11). During the first pass, six fish, preliminarily identified as pikeminnow, ranging from approximately 16 to 20 inches in length were observed at about the mid-way point of the diversion channel. Three additional pikeminnow also approximately 16 to 20 inches in length were observed during a second pass, which was taken in an upstream direction from the box culvert crossing to the upstream point of the diversion channel. The jet boat then drifted down to the lower portion of the diversion channel and then slowly powered upstream. At approximately the mid-point of the diversion channel, pikeminnow were observed darting ahead of the boat and continued to do so until 13 pikeminnow were observed darting ahead of the boat into a relatively deep, fast flowing section at the upstream end of the diversion channel.

During May and June of 2012, field studies were conducted to investigate potential sources of juvenile Chinook salmon and steelhead mortality associated with the South Yuba/Brophy Diversion Canal and Facilities, including: (1) predation due to a concentration of predators in the diversion canal, and (2) entrainment or impingement caused by fish becoming trapped in the permeable rock gabion.

The data suggest that the diversion channel does not support a unique concentration of predators (Bergman *et al*. 2013). Adult pikeminnow densities were not significantly different between the diversion channel and the mainstem lower Yuba River adjacent to the diversion. Similarly, previous snorkeling surveys conducted in the diversion channel found relatively low abundances of adult Sacramento pikeminnow, with only 12 fish observed in 1988 (CDFG 1988a) and 19 in 1993 (Demko and Cramer 1993).

According to Bergman *et al*. (2013), approach velocities (perpendicular) and sweeping velocities (parallel) varied along the upstream side of the permeable rock gabion, and ranged from -0.15 to 0.17 meters per second (m/s) and -0.15 to 0.31 m/s, respectively (Figure VIII-12). Although variable along the face of the rock gabion, approach velocities were relatively low, with only 15 of 147 locations having approach velocities above 0.06 m/s, and 0.17 m/s being the highest velocity observed. Sweeping velocities were lower at the up-river and down-river ends of the rock gabion (-0.14 to 0 m/s) and consistently higher in the middle of the gabion. The observed variability is likely due to the roughness of the gravel/cobble substrate, irregularities in the gabion profile, and differences in the permeability along the rock gabion, as was previously concluded by CDFG (2004, as cited in Bergman *et al*. 2013).

Bergman *et al*. (2013) concluded that present operations at the diversion facility provide adequate bypass flows to create positive sweeping velocities along the rock gabion, and measured approach velocities satisfied NMFS approach velocity standards except at a

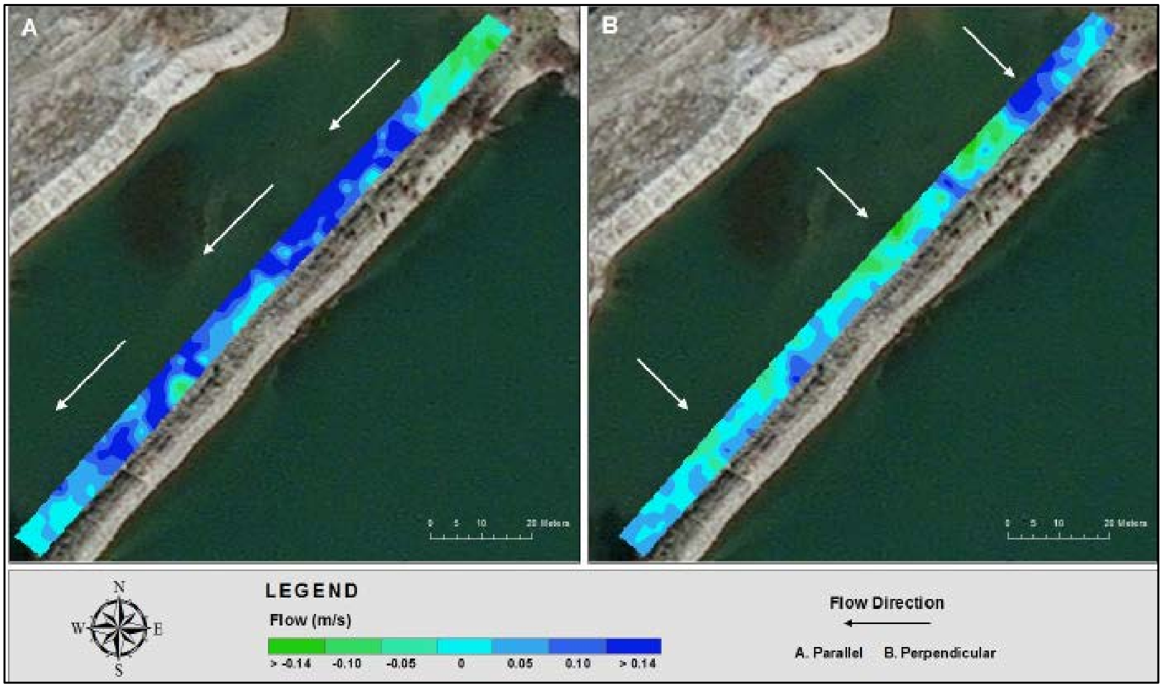


Figure VIII-12. Gradient of sweeping velocities (parallel to the rock gabion) and approach velocities (perpendicular to the rock gabion) measured along the permeable face of the gabion on June 28, 2012 (Bergman *et al*. 2013).

bend at the upstream end of the rock gabion, where an eddy draws water up-river (Bergman *et al*. 2013). The end of the gabion where an eddy draws water up-river was identified because this anomalous area of higher approach velocities did not meet the NMFS (2011d) criteria of providing "nearly uniform" flow distribution along the face of a screen and, thus, may increase susceptibility of juvenile salmonids to impingement or entrainment. To improve these conditions, Bergman *et al*. (2013) state that re-grading the upstream entry into the diversion channel by "smoothing out" the pronounced bend could provide more uniform flow distribution along the face of the rock gabion.

Underwater video showed no evidence for impingement or entrainment risk to juvenile salmonids along the permeable rock gabion, and little risk even to larval fish much smaller than the juvenile samonids. The interstitial spaces along the rock gabion and the back side of cobbles were used as temporary cover by juvenile salmonids. Bergman *et al*. (2013) also observed that juvenile salmonids moved freely along the river bottom between cobbles, without indication of being drawn into the interstices within the rock gabion.

Daily bypass flows measured during 2012 were consistently above 10 percent of the diverted flow, and bypass flows ranged from 40 to 80 cfs (Bergman *et al*. 2013). According to Bergman *et al*. (2013), present operations provide adequate bypass flows to create positive sweeping velocities along the rock gabion.

Wheatland Project

The Wheatland Water District (WWD) is located in Yuba County in the southeastern portion of the South Yuba Basin, with much of the district located between Best Slough and Dry Creek, east of Highway 65 (YCWA 2008). Wheatland's service area contains about 10,400 acres, which are dominated by orchards, pasture, and rice. Historically, agricultural water demands were met with groundwater. The intense groundwater use in this area resulted in declining groundwater levels and deteriorating groundwater quality, forcing the abandonment of several wells. The project was jointly financed by YCWA, WWD and a grant from DWR. Completed in 2010, a canal was built to enable YCWA to provide water from the South Canal to WWD. Providing surface water in-lieu of groundwater pumping is intended to improve local groundwater conditions within the district and the surrounding areas, including the City of Wheatland, which is currently entirely dependent on groundwater (YCWA 2008).

The Yuba Wheatland In-Lieu Groundwater Recharge and Storage Project (Wheatland Project) supplies surface water from the YCWA South Canal to agricultural lands within the WWD and the Brophy Water District in southern Yuba County (YCWA 2012). This surface water supply is intended to improve the water quality and water supply reliability to farmers who mainly rely on groundwater to grow crops such as fruit, nuts, rice and pasture for cattle. The project also is intended to recharge depleted groundwater aquifers and provide opportunities for conjunctive use of surface and groundwater supplies to enhance the reliability of YCWA's water system (YCWA 2012).

YCWA diverts water from the lower Yuba River through the South Yuba/Brophy diversion structure located near Daguerre Point Dam and conveyed via the South Canal to the WWD's service area in southern Yuba County. Many of the ongoing effects associated with the existence of the South Yuba/Brophy Diversion Canal and Facilities may appropriately be considered stressors under the Environmental Baseline. Updated demand projections indicate that annual water deliveries to the Wheatland Project in the future are projected to increase up to about 35,000 to 36,000 acre-feet, depending on water year type. Projected future Wheatland Project demands are represented in modeling simulations for future Cumulative Conditions (for additional detail, see the BA).

Through a separate environmental process, YCWA is developing a fisheries improvement project at the South Yuba/Brophy Diversion Canal and Facilities that is investigating and addressing potential NMFS and CDFG fisheries compliance issues. Potential construction-related effects to listed species and their critical habitats in the lower Yuba River associated with YCWA's proposed fisheries improvement project at the South Yuba/Brophy Diversion Canal and Facilities will be evaluated and addressed through a separate ESA consultation process. The Corps has determined that it is not responsible for the operations or maintenance of the diversion facility or any appurtenant facilities, and the Corps will not be responsible for these activities in the future. Therefore, all activities by YCWA with respect to these diversions are excluded from the proposed action and coverage in the incidental take state.

Browns Valley Irrigation District Diversion

Formed in 1888, BVID is an agricultural water purveyor that delivers water to over 1,300 agricultural water users encompassing about 55,000 acres of land along the Sierra Nevada foothills and the eastern edge of the Sacramento Valley floor (YCWA 2008). In addition to other water sources, BVID has a contract with YCWA authorizing diversions of 9,500 acre-feet per year from the lower Yuba River at BVID's Pumpline Diversion Facility (Pumpline Facility) to supplement BVID's water rights diversions. BVID has received deliveries from YCWA since October 1971 (YCWA 2008). BVID may divert up to 25,687 acre-feet annually.

In 1964, BVID built the Pumpline Facility (Figure VIII-13) on the north bank of the lower Yuba River about 0.75 mile upstream (*i.e.*, 4,200 feet) of Daguerre Point Dam (SWRI 2003). The Pumpline Facility has a diversion capacity of 80.2 cfs (CALFED and YCWA 2005). In 1990, BVID ceased diversions from the Yuba River at locations other than the Pumpline Facility. For many years, the (Pumpline Facility) was unscreened until a new fish screen was completed in 1999.

Figure VIII-13. BVID diversion facility, including the fish screen and diversion forebay (Source: YCWA 2013b).

Inflow to the canal depends on sufficient head at the point of diversion. The presence of Daguerre Point Dam serves to prevent additional down-cutting, or incision, of the Yuba River and therefore contributes to the maintenance of sufficient head at the BVID point of diversion. Diverted water enters an excavated side channel, passes through the fish screen described in the following paragraph and is then pumped up into the canal supplying the BVID service area. The Pumpline Facility diversion uses pumps located on the north bank of the river to divert water through an excavated side channel and up into the canal at rates estimated up to 100 cfs. Water bypassing the fish screen continues through the side channel and reenters the lower Yuba River upstream of Daguerre Point Dam.

In 1999, a new state-of-the-art fish screen was installed at the Pumpline Facility that meets NMFS and CDFW screening criteria (SWRCB 2001, NMFS 2002, CALFED and YCWA 2005). Funding for design and construction of the screen was obtained from DWR, the Reclamation's CVPIA Anadromous Fish Screen Program, the California Urban Water Agencies Category III Account, PG&E, and YCWA. BVID contributed manpower and equipment to the construction and assumed the obligation to operate and maintain the fish screen (SWRCB 2001). The SWRCB (2001) determined that the new fish screen at the Browns Valley Pumpline Diversion Facility provided adequate protection for juvenile salmonids under state law standards, and that BVID should continue to operate and maintain the new fish screen in compliance with NMFS and CDFW criteria.

The BVID diversion is not licensed by the Corps, and it has no direct physical link to Corps property. Although there is no apparent nexus with the Corps, BVID's Browns Valley Pumpline Diversion Facility was either included in the project description or discussed under effects of the proposed action in the 2000 Corps BA, 2002 NMFS BiOp, 2007 Corps BA, and 2007 NFMS BiOp. However, because the BVID diversion is not licensed by the Corps and it has no direct physical link to Corps property, there are no permits, licenses, or easements associated with the Corps' operation and maintenance of Daguerre Point Dam. The Corps has determined that the Browns Valley Pumpline Diversion Facility and associated effects of diversion on the listed species and their habitat in the lower Yuba River are included in the Environmental Baseline, and not in the proposed action. Because the Corps exercises no discretionary authority over the BVID diversion and activities, any take caused by BVID activities is not covered by the incidental take statement in this BiOp.

(3) Waterway 13 and the Yuba Goldfields Fish Barrier Project

Located along the Yuba River near Daguerre Point Dam, the Yuba Goldfields consist of more than 8,000 acres of dredged landscape and represent one of the largest tracts of mining debris in northern California (Hunerlach *et al*. 2004). Historical records from the Yuba Goldfields indicate that dredging near Daguerre Point Dam took place on a nearly continuous basis from 1904 through 1968. Since 1904, dredging has been the principal form of mining in the Yuba Goldfields. Mining company records indicate that extensive areas were re-dredged as technology improved, allowing deeper digging. The area of the present Yuba River channel upstream of Daguerre Point Dam was dredged primarily during 1916-1934. Water flowing through the gravels creates large tracts of ponds throughout the mined landscape (Hunerlach *et al*. 2004). As a result of the high permeability of the Goldfield's rocky soil, water from the Yuba River freely migrates into and through the Goldfields, forming interconnected ponds and canals throughout the undulating terrain (DWR 1999). This high permeability causes water levels in the ponds and canals to rise and fall according to the stage of the Yuba River. Generally, water from the Yuba River enters the Goldfield area from above Daguerre Point Dam, then migrates down-gradient through the Yuba Goldfields. A portion of this migrating water eventually returns to the Yuba River approximately one mile downstream of Daguerre Point Dam via an outlet canal, referred to as Waterway 13, the origin of which is uncertain. This outlet canal helps to drain water out of the Goldfields to the Yuba River, which prevents high water levels from adversely impacting current mining and aggregate operations (DWR 1999).

During the fall of 1988 and the winter and spring of 1989, adult fall/late fall-run Chinook salmon and American shad were observed in the area of the Yuba Goldfields (USFWS 1990). It was suggested that these fish were attracted into the area via the outfall channel referred to as Waterway 13. In 1989, the Red Bluff Fisheries Assistance Office conducted a fishery investigation in the Yuba Goldfields area near Daguerre Point Dam on the lower Yuba River. Several hundred fall-run Chinook salmon were observed spawning in the open access channel in December 1988. In the 1980s, it was discovered that adult anadromous fish (Chinook salmon, American shad, and steelhead) had migrated into the interconnected ponds and canals of the Yuba Goldfields via the area's outlet canal. USFWS (1990) also observed a pair of spawning late fall-run Chinook salmon during March 1989.

Salmon spawning habitat in the Yuba Goldfields was observed in several interconnecting stream channels between ponds, and numerous fall-run Chinook salmon redds were observed (USFWS 1990). From February through April 1989, USFWS (1990) captured 241 juvenile Chinook salmon in the Yuba Goldfields ponds with beach seines at five sample sites located in ponds downstream of the spawning area. In May 1989, juvenile sampling was terminated when reduced flows through the ponds prevented access to the sampling sites. The juveniles ranged in size from about 30 to 65 mm, with the average fork length about 40 mm (USFWS 1990). It was suggested that these small individuals would have a poor chance of survival because increasing water temperatures during May would likely increase predation rates from the numerous adult squawfish and bass observed in the ponds (USFWS 1990).

SWRCB (2000) reported that on various occasions CDFW staff also observed from a few fish to several hundred adult fall-run Chinook salmon attracted up through the outfall into the Yuba Goldfields in the late 1990s. Attraction of adult fall-run Chinook salmon was of concern because there is a general lack of spawning habitat in the Yuba Goldfields, and water temperatures in the Yuba Goldfields can be unsuitable, especially in the lower ends where water discharges into the lower Yuba River (SWRCB 2000). Additionally, fish habitat within the ponds and canals is not conducive to anadromous fish survival because food supply is limited, predator habitat is extensive, and water quality conditions, especially water temperature, are poor (DWR 1999). There have been several past attempts at taking actions to preclude anadromous salmonids from entering the Yuba Goldfields (SWRCB 2000). In the early 1980s, a large grate was placed on the outfall of Waterway 13 to preclude fish from entering the Yuba Goldfields. However, no one maintained the grate and it was damaged by debris. Thus, adult salmon and steelhead continued to access the Yuba Goldfields. During the January 1997 floods, flows through the Yuba Goldfields became so high that they washed out the structure (SWRCB 2000). The entry point remained open for several years. Realizing that adult fish were once again entering the Yuba Goldfields, CDFW worked with a local aggregate company to install a temporary aggregate berm to exclude adult fish, which was effective for several years. However, any time there is high water in the Yuba Goldfields, the barrier can be breached and activities to replace that barrier cannot begin until the summer or late spring (SWRCB 2000).

The USFWS provided funding for an investigation through the AFRP, and engineering design and environmental evaluation of an adult fish barrier in Waterway 13 that would meet the resource needs of CDFW, USFWS, and NMFS, as well as the needs of the Goldfields' owners - Western Aggregates and Cal-Sierra Development was conducted (SWRCB 2000). Design objectives for a fish barrier located in the Yuba Goldfields outlet canal included the following: (1) prevent adult anadromous fish from entering the Yuba Goldfields, (2) not increase water elevations within the Yuba Goldfields, (3) require minimal maintenance, and (4) allow for passage or removal of debris (DWR 1999). The primary project objective was to prevent adult anadromous fish from entering the Yuba Goldfields through the outlet canal. The outlet canal is especially important during periods of high flows, when the outlet canal must be able to pass high flows in order to prevent flooding in nearby low-lying areas. It is also important that flows not be greatly restricted during non-flood conditions. If flows during these periods are restricted, water elevations within the Yuba Goldfields rise, adversely affecting Yuba Goldfields mining operations. Consequently, a project needed to be designed to accommodate high flows exiting the Yuba Goldfields. In addition, this project needed to be low maintenance and allow for the passage or removal of debris (DWR 1999). Outlet canal flows during summer and fall months were estimated to range from five to 50 cfs, whereas canal flows during winter and spring months can exceed 1,000 cfs (DWR 1999).

In 2002, the BLM signed a Finding of No Significant Impact for the Yuba Goldfields Fish Barrier Replacement Project. The BLM approved the replacement of the original structure in the same location as the previous structure. The construction of a temporary rock embankment was completed in September 2003 (Figure VIII-13). In May 2005, heavy rains and subsequent flooding breached the structure at the east (upstream facing) end. AFRP funding was available to repair the “plug” (*i.e.*, temporary aggregate berm) but, because there was no project proponent to do the necessary work, YCWA facilitated the effort but did not accept any responsibility for construction, operation or maintenance (C. Aikens, YCWA, pers. comm. 2011, as cited in Corps 2013b). A "leaky-dike" barrier (Figure VIII-14) intended to serve as an exclusion device for upstream migrating adult salmonids was constructed at the outfall of Waterway 13 (AFRP 2010).

Although most of the area encompassing the Yuba Goldfields is located on private land, it has been determined that the rock weir plug on Waterway 13 is located on Corps property. However, the Corps does not have any operations or maintenance responsibilities for the earthen “plug” and Waterway 13, nor has it issued any permits or licenses for it. Thus, the Corps has determined that operation and maintenance of Waterway 13 is part of the Environmental Baseline, and is not part of the proposed action. As such, any take caused by the operation and maintenance of Waterway 13 is excluded from take covered by the incidental take statement.

Figure VIII-13. Yuba Goldfields barrier located at the outfall of Waterway 13 (Source: AFRP 2011).

Figure VIII-14. Location of the Waterway 13 "leaky-dike" barrier prior to it washing out during the spring of 2011 due to high flows through the Yuba Goldfields.

During the spring of 2011, high flows (~30,000 cfs) in the lower Yuba River and high flows through the Yuba Goldfields once again caused the "leaky-dike" barrier at the entrance to Waterway 13 to wash out. In response to this recent loss of the "leaky-dike" barrier at Waterway 13, the Corps conducted a real estate investigation and determined that Waterway 13 is located on lands that are under the Corps' jurisdiction. As a separate action unrelated to this ESA consultation, the Corps will work with local stakeholders and resource agencies to identify potential biological concerns associated with Waterway 13 and will support the development of measures to repair the barrier. If needed in the future, the Corps will collaborate with the stakeholders involved to develop a shared agreement (*e.g.*, a right-of-way or easement) that would provide access to those parties that would conduct future maintenance activities that may become necessary if and when the fish barrier at Waterway 13 washes out again in the future. However, because these activities would occur in the future, and a project has not been proposed at this time, Waterway 13 activities are not part of the proposed action. The Corps does not have any operations or maintenance responsibilities for the earthen "plug" and Waterway 13, nor has it issued any permits or licenses for it. Nonetheless, until a more permanent solution is implemented, ongoing issues associated with attraction of upstream migrating adult salmonids into Waterway 13 are considered to remain a stressor to spring-run Chinook salmon and steelhead.

(4) Barriers Upstream of the Action Area (including Englebright Dam)

Englebright Dam, built in 1941 to retain hydraulic mining debris from the Yuba River watershed, blocks upstream migration of fish in the lower Yuba River and, in particular, blocks the migration of steelhead and CV spring-run Chinook salmon to their historic spawning grounds (NMFS 2002).

Although located upstream of the Action Area, NMFS (2007, 2009) reports that the greatest impact to listed anadromous salmonids in the Yuba River watershed is the complete blockage of access for these species to their historical spawning and rearing habitat above Englebright Dam. Because this historic habitat is no longer accessible, CV spring-run Chinook salmon and steelhead are relegated to the 24 miles of the lower Yuba River from Englebright Dam to the confluence with the lower Feather River. Since construction of Englebright Dam in 1941, these species are required to complete all of their riverine lifestages in the 24 miles of the lower Yuba River, which previously served primarily as a migratory corridor to upstream spawning and rearing habitats.

The long-standing effects of Englebright Dam on the status of CV spring-run Chinook salmon and steelhead have affected the viability of these populations in the Yuba River. The lack of access to historic habitats upstream of Englebright Dam has reduced all four VSP parameters (abundance, productivity, spatial structure and genetic diversity) for CV spring-run Chinook salmon (and CCV steelhead). Although the effects of the presence of Englebright Dam persist and continue to affect the status of the species in the Action Area, recent actions have ameliorated some of the stressors on these populations, which now are restricted to the lower Yuba River.

The NMFS (2009) Draft Recovery Plan states that, for currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support viable independent populations of CV spring-run Chinook salmon and steelhead can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Flow schedules specified in the Fisheries Agreement of the Yuba Accord were first implemented on a pilot program basis in 2006 and 2007, and then were implemented on a long-term basis in 2008, after the SWRCB made the necessary changes to YCWA's water right permits. Continued implementation of the Yuba Accord addresses flow-related major stressors, including flow-dependent habitat availability, flow-related habitat complexity and diversity, and water temperatures, and considerably improves conditions in the lower Yuba River (NMFS 2009).

Related to external influences in the upper Yuba River watershed that have the potential to affect the status of listed species present in the Action Area, NMFS (2007) identified the following non-flow related stressors associated with Englebright Dam: (1) blocking access of listed salmonids to the habitat above the dam, (2) forcing overlapping use of the same spawning areas by spring and fall-run Chinook salmon below the dam, (3) forcing fish to spawn in a limited area without the benefit of smaller tributaries, which can provide some level of refuge in the event of catastrophic events, and (4) preventing the recruitment of spawning gravel and LWM from upstream of the dam into the lower river.

Information developed since 2007 provides clarification regarding the fourth component in the foregoing list of stressors, as well as the influence of fluvial geomorphological processes affecting PCEs in the Action Area of the lower Yuba River.

The fluvial geomorphology of the Yuba River is unique and therefore it is crucial to evaluate it on its own terms and not to apply simple generalizations and concepts from other rivers with dams (Pasternack 2010). First, unlike most other rivers below dams, lack of spawning gravel is not limiting in the lower Yuba River, with the localized exception of the Englebright Dam Reach of the river, which extends from immediately downstream of Englebright Dam to the vicinity of the confluence with Deer Creek. In this reach, no rounded river gravels/cobbles, suitable for spawning, were present until a small amount (about 500 tons) of gravel was injected artificially by the Corps in the Narrows II pool area of the Englebright Dam Reach during November 2007 and the subsequent injections by the Corps of: (1) 5,000 tons of suitable spawning substrate downstream of the Narrows I powerhouse during the fall of 2010 extending to January 2011, (2) 5,000 tons of suitable spawning substrate downstream of the Narrows I powerhouse during July and August of 2012, and (3) 5,000 tons in the Englebright Dam Reach during July and August of 2013.

In the Timbuctoo Bend area of the lower Yuba River, Pasternack (2008) reported that there is adequate physical habitat to support spawning of Chinook salmon and CCV steelhead. Farther downstream, spawning habitat does not appear to be limited by an inadequate supply of gravel within the Parks Bar and Hammon Bar reaches of the lower Yuba River, due to ample storage of mining sediments in the banks, bars, and training walls (cbec and McBain & Trush 2010). For the remainder of the lower Yuba River, Beak Consultants, Inc (1989) stated that the spawning gravel resources in the river are considered to be excellent based on the abundance of suitable gravels, and that the tremendous volumes of gravel remaining in the river as a result of hydraulic mining make it unlikely that spawning gravel will be in short supply in the foreseeable future. Pasternack (2010) concluded that because of the pre-existing, unnatural condition of the river corridor influenced by mining debris, Englebright Dam… "*is actually contributing to the restoration of the river toward its historical geomorphic condition, in the truest meaning of the term - going back to the pre-existing state prior to hydraulic gold mining*." He further concluded that most of the lower Yuba River is still geomorphically dynamic and the river has a diversity of in-channel physical habitats, and that because Englebright Dam prevents residual mining wastes from moving downstream into the Action Area, channel complexity and habitat diversity in the lower Yuba River have been re-emerging, and that process continues.

Regarding the recruitment of woody material, some woody material may not reach the lower Yuba River due to collecting on the shoreline and sinking in Englebright Reservoir, or due to New Bullard's Bar Dam blocking natural downstream migration. However, Englebright Dam does not functionally block woody material from reaching the lower Yuba River because any accumulated woody material either spills over the dam during uncontrolled flood events or otherwise is pushed over the dam by the Corps.

In conclusion, the lack of spawning gravel (or recruitment thereof) is not a significant stressor to CV spring-run Chinook salmon in the lower Yuba River, with the exception of the Englebright Dam Reach. Moreover, the abundance of LWM in the lower Yuba River is not substantively attributable to the presence of Englebright Dam. Ongoing effects associated with Englebright Dam include the loss of historical spawning and rearing habitat above Englebright Dam, resultant loss of reproductive isolation and subsequent hybridization with fall-run Chinook salmon, restriction of spatial structure and associated vulnerability to catastrophic events. Although the genesis of these stressors emanate upstream of the Action Area at Englebright Dam, the manifestation of these stressors affect the current status of the species in the Action Area in the lower Yuba River.

(5) Deer Creek

Another physical habitat alternation stressor is Lake Wildwood operations and resultant Deer Creek flow fluctuations (according to the SWRCB's Revised Decision 1644, Lake Wildwood is operated by the Lake Wildwood Association — a gated community in Penn Valley, California). This stressor refers to the potential for stranding or isolation events to occur in Deer Creek, near its confluence with the lower Yuba River. Observational evidence suggests that, in the past, adult Chinook salmon entered Deer Creek during relatively high flow periods, presumably for holding or spawning purposes, only to subsequently become stranded in the creek when flows receded due to changes in Lake Wildwood operations. Stranding may delay or prevent adult Chinook salmon from spawning, or cause decreased spawning success due to increased energy expenditure or stress due to delayed spawning (CALFED and YCWA 2005).

The Sierra Streams Institute (SSI) is in the process of implementing the Deer Creek Spawning Bed Enhancement Project, which is located on a tributary to the lower Yuba River. From September 4-7, 2012, 250 tons of spawning gravel (~180 cubic yards) was placed in the creek.

Chinook salmon redd surveys were conducted after the initial placement to document the number and characteristics of salmon redds created in Deer Creek during the 2012 spawning season. On November 27, 2012, more than 51 salmon redds were observed in Deer Creek, compared to 15 redds in 2011, and 9 redds in 2003 (SSI 2013). Approximately 75 percent of spawning activity during 2012 occurred in the newly created spawning areas, with the remaining spawning activity occurring in locations where spawning was observed in 2011. Gravel transport also was monitored to understand the effects of higher stream flows on gravel movement, and to evaluate transport of spawning gravels in Deer Creek. Tracer gravel surveys were conducted during February, March, and April 2013. Based on these and other visual observations of substrate deposition in Deer Creek, SSI (2013) reports that it is likely that some of the placed gravels remain in Deer Creek providing spawning habitat, and that some of the gravels were mobilized downstream into the Yuba River to provide habitat for anadromous salmonids. To supplement existing available spawning habitat, SSI planned to place an additional 250 tons of spawning gravel in Deer Creek from September
3-13, 2013.

Physical habitat alteration stressors also address habitat complexity and diversity. The concepts of habitat complexity and diversity pertinent to the lower Yuba River were described by CALFED and YCWA (2005), as discussed below.

(C) CV Spring-run Chinook Samon ESU

(1) CV Spring-run Chinook Salmon Historical Abundance and Distribution

Historically, the Yuba River watershed reportedly was one of the most productive habitats for runs of Chinook salmon and steelhead (Yoshiyama *et al*. 1996). Although it is not possible to estimate the numbers of spawning fish from historical data, CDFG (1993) suggested that the Yuba River "*historically supported up to 15 percent of the annual run of fall-run Chinook salmon in the Sacramento River system*" (Yoshiyama *et al*. 1996).

By the late 1800s, anadromous fish populations were experiencing significant declines, primarily because of mining activities and resultant extreme sedimentation following flood events (McEwan 2001, Yoshiyama *et al*. 2001). As an example, the flood of 1861–1862 buried much of the bottomlands along the lower Yuba River under sand deposits averaging two to seven feet deep (Kelley 1989). By 1876 the channel of the lower Yuba River reportedly had become completely filled, and what remained of the adjoining agricultural lands was covered with sand and gravel (Kelley 1989, CDFG 1993) — a marked deterioration of the river as salmon habitat (Yoshiyama *et al*. 2001).

To control flooding and the downstream movement of sediment, construction of several man-made instream structures on the Yuba River occurred during the early 1900s. A structure referred to as Barrier No. 1, built in 1904 and 1905, was located 1 mile below Parks Bar Bridge near Smartsville and was destroyed by flood waters in March 1907 (Sumner and Smith 1939). This barrier probably hindered salmon upstream movement (Sumner and Smith 1939). In 1906, the California Debris Commission, a partnership between the Federal Government and the State of California, constructed Daguerre Point Dam, specifically to hold back mining debris. In 1910, the Yuba River was diverted over the new dam. This approximately 24-foot high dam retained the debris, but made it difficult for spawning fish to migrate upstream, although salmon reportedly did surmount the dam in occasional years because they were reportedly observed in large numbers in the North Yuba River at Bullards Bar during the early 1920s (Yoshiyama *et al*. 2001). Two fishways, one for low water and the other for high water, were constructed at Daguerre Point Dam prior to the floods of 1927-1928 (Clark 1929), when the fish ladders were destroyed, and were not replaced until 1938, leaving a 10-year period when upstream fish passage at Daguerre Point Dam was blocked (CDFG 1991). A fish ladder was constructed at the south end of Daguerre Point Dam in 1938 and was generally ineffective (CDFG 1991), but during the fall of 1938, *"several salmon were reported seen below the Colgate Head Dam on the North Fork of the Yuba, 35 miles above Daguerre Point Dam."* (Sumner and Smith 1939).

Upstream of Daguerre Point Dam, the 260-foot-high Englebright Dam was authorized in 1935 to hold back hydraulic mining debris, and was constructed in 1941 by the California Debris Commission. Englebright Dam has no fish ladders and blocks anadromous fish access to all areas upstream of the dam (Eilers 2008, PG&E 2008, DWR 2009). The dam restricts anadromous fish to the lower 24 miles of the Yuba River.

There is limited information on the historical population size of CV spring-run Chinook salmon in the Yuba River. Historical accounts indicate that "large numbers" of Chinook salmon may have been present as far upstream as Downieville on the North Fork Yuba River (Yoshiyama *et al*. 1996). Due to their presence high in the watershed, Yoshiyama *et al*. (1996) concluded that these fish were CV spring-run Chinook salmon.

For the Middle Fork Yuba River, Yoshiyama *et al*. (2001) concluded that direct information was lacking on historic abundance and distribution of salmon, and they conservatively considered the 10-foot falls located 1.5 miles above the mouth of the Middle Fork Yuba River was the upstream limit of salmon distribution.

Yoshiyama *et al*. (2001) report that little is known of the original distribution of salmon in the South Fork Yuba River where the Chinook salmon population was severely depressed and upstream access was obstructed by dams when CDFW began surveys in the 1930s. Sumner and Smith (1939) stated that the "*South Fork of the Yuba is not considered an angling stream in its 24 miles below the mouth of Poorman Creek, where slickens* (pulverized rock) from the Spanish Mine turns the river a muddy grey*." They also reported that in "*Poorman Creek, cyanide poisoning may have done more harm than the slickens… It was evident that some strong poison was entering the stream with the tailings. An occasional heavy dose of cyanide would kill off fish and fish food…"* Yoshiyama *et al*. (2001) consider the cascade, with at least a 12-foot drop, located 0.5 mile below the juncture of Humbug Creek, which was as essentially the historical upstream limit of salmon during most years of natural streamflows.

Clark (1929) reported that the salmon spawning grounds extended from the mouth of the lower Yuba River upstream to the town of Smartsville, but that very few salmon (evidently spring-run) went farther upstream past that point. Sumner and Smith (1940) report that salmon ascended in considerable numbers up to Bullard's Bar Dam on the North Fork Yuba River while it was being constructed (1921-1924). In their 1938 survey of Yuba River salmon populations, Sumner and

Smith (1940) stated that the height of the dams in the Yuba River blocked all potential salmon and steelhead runs upstream of the barriers (Sumner and Smith 1940). However, Sumner and Smith (1940) describe the ladders as "*a rather ineffectual fishway... That few fish have been able to use it...is testified to by the almost universal belief among local residents that at present no fish ever come above the dam*." In addition, the fall-run Chinook salmon run was reportedly destroyed at least temporarily, and many miles of streams rendered unfit for trout (Sumner and Smith 1939).

In 1951, two functional fish ladders were installed at Daguerre Point Dam by the State of California and it was stated that *"With ladders at both ends, the fish have no difficulty negotiating this barrier at any water stage."* (CDFG 1953).

CDFG (1991) reports that a small CV spring-run Chinook salmon population historically occurred in the lower Yuba River but the run virtually disappeared by 1959, presumably due to the effects of water diversion and hydraulic developments on the river (Fry 1961). As of 1991, a remnant CV spring-run Chinook salmon population reportedly persisted in the lower Yuba River downstream of Englebright Dam, maintained by fish produced in the lower Yuba River, fish straying from the Feather River, or fish previously and infrequently stocked from the FRFH (CDFG 1991).

In the 1990s, relatively small numbers of Chinook salmon that exhibit spring-run phenotypic characteristics were observed in the lower Yuba River (CDFG 1998). Although precise escapement estimates are not available, the USFWS testified at the 1992 SWRCB lower Yuba River hearing that "*…a population of about 1,000 adult spring-run Chinook salmon now exists in the lower Yuba River*" (San Francisco Bay RWQCB 2006 as cited in NMFS 2009).

(2) CV Spring-run Chinook Salmon General Life History and Habitat Requirements

This section presents a general overview of lifestage-specific information (*e.g.*, adult immigration and holding, adult spawning, embryo incubation, juvenile rearing and outmigration) for the Central Valley spring-run Chinook salmon ESU. Then, this section specifically focuses and provides information on lifestage specific temporal and spatial distributions for CV spring-run Chinook salmon in the lower Yuba River. Recently, the RMT developed representative temporal distributions for specific CV spring-run Chinook salmon lifestages through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program (Table VIII-3). The resultant lifestage periodicities encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population (RMT 2010; RMT 2013).

Four distinct runs of Chinook salmon spawn in the Sacramento-San Joaquin River system, with each run named for the season when the majority of the run enters freshwater as adults. The primary characteristic distinguishing CV spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon enter their natal streams during the spring, and hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning.

Table VIII-3. Lifestage-specific periodicities for CV spring-run Chinook salmon in the lower Yuba River (Source: RMT 2013).

Lifestage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Spring-run Chinook Salmon																								
Adult Immigration and Holding							■	■	■	■	■	■	■	■	■	■	■	■						
Spawning																	■	■	■					
Embryo Incubation																	■	■	■	■	■	■	■	■
Fry Rearing	■	■	■																			■	■	■
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Downstream Movement	■	■	■	■	■	■	■	■	■	■	■	■										■	■	■
Smolt (Yearling+) Emigration	■	■	■	■	■	■	■	■	■										■	■	■	■	■	■

(3) Spring-run Chinook Salmon Adult Immigration and Holding

For the lower Yuba River, adult CV spring-run Chinook salmon immigration and holding has previously been reported to primarily occur from March through October (Vogel and Marine 1991, YCWA *et al*. 2007), with upstream migration generally peaking in May. The RMT's examination of preliminary data obtained since the VAKI Riverwatcher infrared and videographic sampling system has been operated (2003 – present) found variable temporal modalities of Chinook salmon ascending the fish ladders at Daguerre Point Dam. The RMT (2013) identified the CV spring-run Chinook salmon adult immigration and holding period as extending from April through September.

Previously, it has been reported that CV spring-run Chinook salmon in the lower Yuba River hold over during the summer in the deep pools and cool water downstream of the Narrows I and Narrows II powerhouses, or further downstream in the Narrows Reach (CDFG 1991, SWRCB 2003), where water depths can exceed 40 feet (YCWA *et al*. 2007). Congregations of adult Chinook salmon (approximately 30 to 100 fish) have been observed in the outlet pool at the base of the Narrows II Powerhouse, generally during late August or September when the powerhouse is shut down for maintenance. During this time period, the pool becomes clear enough to see the fish [(M. Tucker, NMFS, pers. comm. 2003 S. Onken, YCWA, pers. comm. 2004) as cited in Corps 2013b]. While it is difficult to visually distinguish spring-run from fall-run Chinook salmon in this situation, the fact that these fish are congregated this far up the river at this time of year indicates that some of them are likely to be CV spring-run Chinook salmon (NMFS 2007).

Past characterizations of CV spring-run Chinook salmon distributions from available literature on the lower Yuba River have provided some anecdotal references to behavioral run details (such as migration timing and areas of holding and spawning), but the referenced information has not provided or referenced the basis for these descriptions. CV spring-run Chinook salmon have been reported to migrate immediately to areas upstream of the Highway 20 Bridge after entering the lower Yuba River from March through October (Vogel and Marine 1991, YCWA *et al*. 2007), and then over-summer in deep pools located downstream of the Narrows 1 and 2 powerhouses, or further downstream in the Narrows Reach through the reported spawning period of September through November (CDFG 1991, SWRCB 2003).

The RMT's (2013) examination of preliminary data obtained since the VAKI Riverwatcher infrared and videographic sampling system has been operated (2003 – present) found variable temporal modalities of Chinook salmon ascending the fish ladders at Daguerre Point Dam. The RMT's 3-year acoustic telemetry study of adult CV spring-run Chinook salmon tagged downstream of Daguerre Point Dam during the phenotypic adult upstream migration period has provided new information to better understand adult CV spring-run Chinook salmon temporal and spatial distributions in the lower Yuba River. The results from the Vaki Riverwatcher monitoring, and particularly from the acoustic telemetry study found past characterizations of temporal and spatial distributions to be largely unsupported, as phenotypic adult CV spring-run Chinook salmon were observed to exhibit a much more diverse pattern of movement, and holding locations in the lower Yuba River were more expansive than has been previously reported (RMT 2013).

Although some of the acoustically-tagged CV spring-run Chinook salmon were observed to adhere to other previously reported characterizations, observations from the telemetry study also identified that a large longitudinal extent of the lower Yuba River was occupied by the tagged phenotypic adult CV spring-run Chinook salmon during immigration and holding periods (Figure VIII-15). Figure VIII-15 displays all individual fish detections obtained during the RMT's mobile acoustic tracking surveys conducted from May 2009 until November 2011 (RMT 2013).

Also, temporal migrations to areas upstream of Daguerre Point Dam occurred over an extended period of time (Figure VIII-16). The tagged phenotypic adult CV spring-run Chinook salmon in the lower Yuba River actually migrated upstream of Daguerre Point Dam from May through September, and utilized a broad expanse of the lower Yuba River during the summer holding period, including areas as far downstream as Simpson Lane Bridge (*i.e.*, ~RM 3.2), and as far upstream as the area just below Englebright Dam. A longitudinal analysis of acoustic tag detection data indicated that distributions were non-random, and that the tagged CV spring-run Chinook salmon were selecting locations for holding.

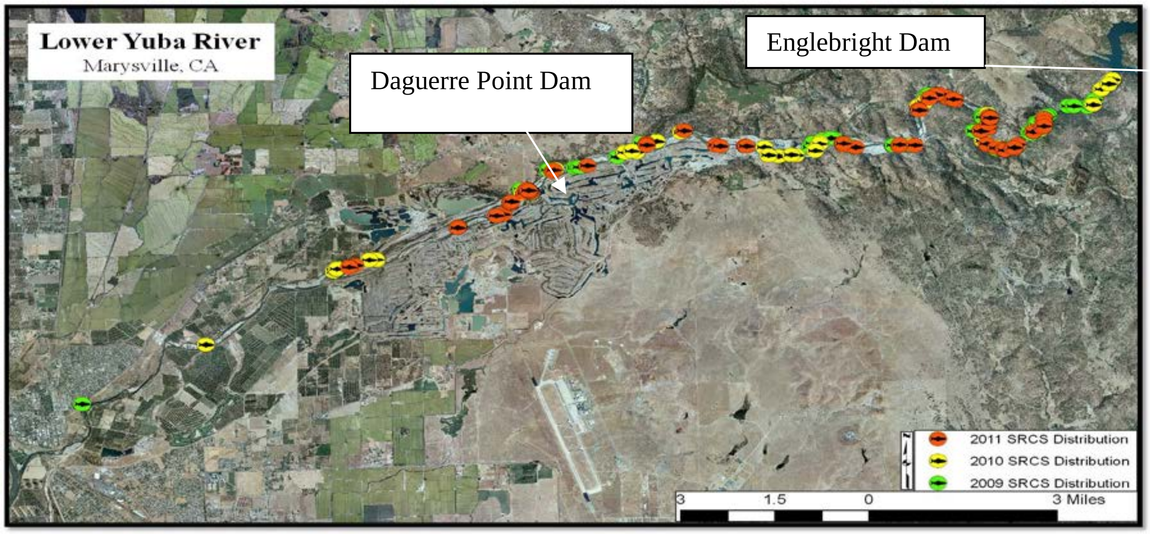


Figure VIII-15. Spatial distribution of all individual acoustically-tagged adult phenotypic CV spring-run Chinook salmon detections obtained from the mobile tracking surveys conducted during 2009, 2010 and 2011 (Source: RMT 2013).

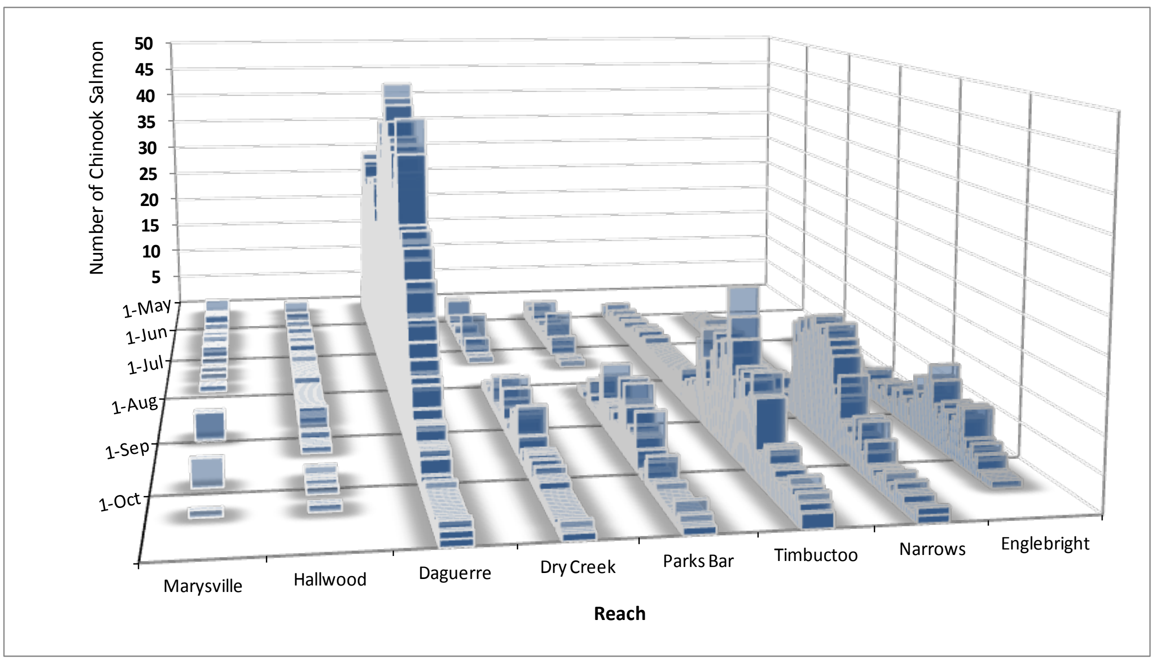


Figure VIII-16. Spatial and temporal distribution of all individual acoustically-tagged adult phenotypic CV spring-run Chinook salmon detected from the mobile tracking surveys conducted during 2009, 2010 and 2011 in the lower Yuba River (Source: RMT 2013).

The area of the river between Daguerre Point Dam and the Highway 20 Bridge was largely used as a migratory corridor by the tagged adult CV spring-run Chinook salmon during all three years of the study (RMT 2013). Telemetry data in this area demonstrated relatively brief periods of occupation, characterized by sequential upstream detections as individually-tagged fish migrated through this area. By contrast, frequent and sustained detections were observed from the Highway 20 Bridge upstream to Englebright Dam (RMT 2013).

Examination of individual detection data indicated that tagged phenotypic adult CV spring-run Chinook salmon that moved upstream of Daguerre Point Dam had generally passed through the Daguerre Point Dam fish ladders by the end of September during all three years (RMT 2013). Acoustic tag detection data were used to discern tagged CV spring-run Chinook salmon residing in holding areas during June, July and August, and shifting to spawning areas during September into early October. This observation was repeated during all three years of the study, and in all occupied reaches. Telemetry data demonstrated that the majority of tagged phenotypic adult CV spring-run Chinook salmon that ascended the ladders at Daguerre Point Dam also continued to move farther upstream to the Timbuctoo, Narrows, and Englebright Dam reaches during September, coincident with the initiation of spawning activity (RMT 2013).

YCWA (2013) used the RMT's 2009-2011 acoustic tagging study data to evaluate movements of the individual acoustically-tagged CV spring-run Chinook salmon and potential relationships between changes in flow. Visual examination of the time series plots of daily locations of individual acoustically-tagged Chinook salmon and mean daily flows at the Smartsville Gage showed highly variable behavior among individuals on a daily basis within and among years. However, several general patterns of fish movement in relationship to flow are apparent.

- Abrupt upstream movement coinciding with an increase in flow.
- Abrupt upstream movement coinciding with a decrease in flow.
- Abrupt downstream movement coinciding with a decrease in flow.
- Abrupt upstream movement occurring after an increase in flow.

YCWA (2013) found that most of the individual movements of acoustically-tagged CV spring-run Chinook salmon potentially associated with a change in Smartsville flow were abrupt upstream movements occurring concurrently with a noticeable decrease in flow. Additional notable observations included some individuals that abruptly moved upstream in the days following a reduction in flow.

Observed movements of individual CV spring-run Chinook salmon identified during 2009 generally occurred within the time period from about mid-May to early September, and generally occurred over a period ranging from one to nine days. Most of the observed movements identified during 2010 occurred during early to mid-June, with a few movements occurring during August, and generally occurred over a period ranging from about one to seven days. The identified movements during 2011 generally occurred during late August into early September, and generally occurred over a period ranging from about one to five days. Because CV spring-running Chinook salmon immigrated into the lower Yuba River later in 2011 than during 2009 and 2010, and were not captured and acoustically-tagged until July, no potential relationships between fish movement and flow reductions during the spring months could be evaluated for 2011.

More than half (40 out of 60) of the identified movements of Chinook salmon over the three years that were potentially associated with a concurrent change in flow consisted of upstream movements coinciding with a large decrease in flow (measured at the Smartsville Gage). Most of the identified upstream movements occurring coincident to a decrease in flow occurred when flow decreased substantially during a 1 to 2 week period in late August to early September and/or during a 1 to 2 week period during May or June, depending on the year. In other words, the most common potential relationship identified between CV spring-run Chinook salmon movement and flow was an abrupt and continued movement upstream to the upper reaches during a large reduction in mean daily Smartsville flow (38 to 68 percent reduction in flow) occurring over about 1 to 2 weeks.

<u>CV Spring-run Chinook Salmon Adult Spawning</u>

For the lower Yuba River, the CV spring-run Chinook salmon spawning period has been reported to extend from September through November (CDFG 1991, YCWA *et al*. 2007). Limited reconnaissance-level redd surveys conducted by CDFW since 2000 during late August and September have detected spawning activities beginning during the first or second week of September. They have not detected a bimodal distribution of spawning activities (*i.e.*, a distinct spring-run spawning period followed by a distinct fall-run Chinook salmon spawning period), and instead have detected a slow build-up of spawning activities starting in early September and transitioning into the main fall-run spawning period.

The RMT's (2013) examination of the 2009, 2010 and 2011 acoustically-tagged CV spring-run Chinook salmon data revealed a consistent pattern in fish movement. In general, acoustically-tagged CV spring-run Chinook salmon exhibited an extended holding period, followed by a rapid movement into upstream areas (upper Timbuctoo Reach, Narrows Reach, and Englebright Reach) during September. Then, a period encompassing approximately one week was observed when fish held at one specific location, followed by rapid downstream movement. The approximate one-week period appeared to be indicative of spawning events, which ended by the first week in October. These observations, combined with early redd detections and initial carcasses appearing in the carcass surveys (see below), suggest that the CV spring-run Chinook salmon spawning period in the lower Yuba River may be of shorter duration than previously reported, extending from September 1 through mid-October (RMT 2013).

The earliest spawning (presumed to be CV spring-run Chinook salmon) generally occurs in the upper reaches of the highest quality spawning habitat (*i.e.*, below the Narrows pool) and progressively moves downstream throughout the fall-run Chinook salmon spawning season (NMFS 2007). CV spring-run Chinook salmon spawning in the lower Yuba River is believed to occur upstream of Daguerre Point Dam. USFWS (2007) collected data from 168 Chinook salmon redds in the lower Yuba River on September 16-17, 2002 and September 23-26, 2002, considered to be CV spring-run Chinook salmon redds. The redds were all located above Daguerre Point Dam. During the pilot redd survey conducted from the fall of 2008 through spring of 2009, the RMT (2010a) report that the vast majority (96 percent) of fresh Chinook salmon redds constructed by the first week of October 2008, potentially representing spring-run Chinook salmon, were observed upstream of Daguerre Point Dam. Similar distributions were observed during the 2010 and 2011 redd surveys, when weekly redd surveys were conducted.

About 97 and 96 percent of the fresh Chinook salmon redds constructed by the first week of October were observed upstream of Daguerre Point Dam during 2009 and 2010, respectively (RMT 2013).

CV Spring-run Chinook Salmon Embryo Incubation

The CV spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sacs prior to emergence.

The length of time for CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intragravel environs where water temperatures range from about 41ºF to 55.4°F embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2009). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002).

In the lower Yuba River, the RMT (2013) concluded that CV spring-run Chinook salmon embryo incubation period generally extends from September through December.

Spring-run Chinook Salmon Juvenile Rearing and Outmigration

In general, juvenile Chinook salmon have been collected by electrofishing and observed by snorkeling throughout the lower Yuba River, but with higher abundances above Daguerre Point Dam (Beak 1989, CDFG 1991, Kozlowski 2004). This may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are restricted to areas below the dam (YCWA *et al*. 2007). During juvenile rearing and outmigration, salmonids prefer stream margin habitats with sufficient depths and velocities to provide suitable cover and foraging opportunities. Juvenile Chinook salmon reportedly utilize river channel depths ranging from 0.9 feet to 2.0 feet, and most frequently are in water with velocities ranging from 0 feet/sec to 1.3 feet/sec (Raleigh *et al*. 1986).

Juvenile snorkeling surveys conducted in the lower Yuba River during 2012 indicate that juvenile Chinook salmon in the lower Yuba River initially prefer slower, shallower habitat, and move into faster and deeper water as they grow. The RMT (2013) reported that the vast majority of observations of juvenile Chinook salmon in the lower Yuba River occurred in water velocities and depths indicative of slackwater and slow glide mesohabitats. Juvenile Chinook salmon are known to prefer slower water habitats than many other members of *Oncorhynchus* (Quinn 2005), and have been previously reported to actively seek out slow backwaters, pools, or floodplain habitat for rearing (Sommer *et al*. 2001, Jeffres *et al*. 2008). The snorkeling data collected by the RMT during 2012 are generally consistent with other data available for multiple rivers (Bjornn and Reiser 1991). Juvenile Chinook salmon in the 30-50 mm size class tended to occupy shallower habitats than larger (and presumably older) individuals, which is consistent with other observations of salmonids (*e.g.*, Bjornn and Reiser 1991). Similarly, juvenile Chinook salmon showed a clear preference for faster water (up to an average of about 1.8 ft/s) as they grew, consistent with trends found with salmonids in other rivers (Bjornn and Reiser 1991).

Based upon review of available information, the RMT (2010b) recently identified the CV spring-run Chinook salmon fry rearing period as extending from mid-November through March, the juvenile rearing period extending year-round, and the young-of-year emigration period extending from November through mid-July. Associated with the previously described shortened duration of CV spring-run Chinook salmon spawning, the fry rearing period is estimated to extend from mid-November through mid-February (RMT 2013). Updated characterization of the juvenile young-of-year emigration (*i.e.*, downstream movement) period extends from mid-November through June (RMT 2013).

In the lower Yuba River, CDFW has conducted juvenile salmonid outmigration monitoring by operating rotary screw traps (RSTs) near Hallwood Boulevard, located approximately 6 RM upstream from the city of Marysville. CDFW's RST monitoring efforts generally extended from fall (October or November) through winter, and either into spring (June) or through the summer (September) annually from 1999 to 2006. The RMT took over operation of the year-round RST effort in the fall of 2006, and continued operations through August 2009 (RMT 2013).

Analyses of CDFW RST data indicate that most Chinook salmon juveniles move downstream past the Hallwood Boulevard location prior to May of each year. For the 5 years of data included in the analyses, 97.5 to 99.2 percent of the total numbers of juvenile Chinook salmon were captured by May 1 of each year. The percentage of the total juvenile Chinook salmon catch moving downstream past the Hallwood Boulevard location each year ranged from 0.4 to 1.3 percent during May, and 0 to 1.2 percent during June (YCWA *et al*. 2007). During the 2007/2008 sampling period, 95 percent of all juvenile Chinook salmon were captured by June 2, 2008 (Campos and Massa 2010a). Analysis of the fitted distribution of weekly juvenile Chinook salmon catch at the Hallwood Boulevard RST site from survey year 1999 through 2008 revealed that most emigration occurred from late-December through late-April in each survey year (RMT 2013). Approximately 95 percent of the observed catch across all years based on the fitted distribution occurred by April 30 (RMT 2013).

Overall, most (about 84 percent) of the juvenile Chinook salmon were captured at the Hallwood Boulevard RSTs soon after emergence from November through February, with relatively small numbers continuing to be captured through June. Although not numerous, captures of (oversummer) holdover juvenile Chinook salmon ranging from about 70 to 140 mm FL, primarily occurred from October through January with a few individuals captured into March (Massa 2005, Massa and McKibbin 2005). These fish likely reared in the river over the previous summer, representing an extended juvenile rearing strategy characteristic of CV spring-run Chinook salmon. During the 2007/2008 sampling period, 33 Chinook salmon that met this criterion were observed at the Hallwood Boulevard RST site from mid-December through January. Juvenile Chinook salmon captured during the fall and early winter (October-January) larger than 70 mm are likely exhibiting an extended rearing strategy in the lower Yuba River (Campos and Massa 2010a).

For the sampling periods extending from 2001 to 2005, CDFW identified specific runs based on sub-samples of lengths of all juvenile Chinook salmon captured in the RSTs by using the length-at-time tables developed by Fisher (1992), as modified by S. Greene (DWR 2003b). Although the veracity of utilization of the length-at-time tables for determining the run type of Chinook salmon in the Yuba River has not been ascertained, based on the examination of run-specific determinations, in the lower Yuba River the vast majority (approximately 94 percent) of spring-run Chinook salmon were captured as post-emergent fry during November and December, with a relatively small percentage (nearly 6 percent) of individuals remaining in the lower Yuba River and captured as YOY from January through March. Only 0.6 percentof the juvenile Chinook salmon identified as spring-run was captured during April, and only 0.1 percent during May, and none were captured during June (YCWA *et al*. 2007). The above summary of juvenile Chinook salmon emigration monitoring studies in the Yuba River is most consistent with the temporal trends of CV spring-run Chinook salmon young-of-year outmigration reported for Butte and Big Chico creeks (YCWA *et al*. 2007).

<u>Spring-run Chinook Smolt Emigration</u>

For the Central Valley, it has been reported that while some spring-run Chinook salmon emigrate from natal streams soon after emergence during the winter and early-spring (NMFS 2004a), some may spend as long as 18 months in freshwater and move downstream as smolts during the first high flows of the winter, which typically occur from November through January (CDFG 1998, USFWS 1995). In the Sacramento River drainage, CV spring-run Chinook salmon smolt emigration reportedly occurs from October through March (CDFG 1998). In Butte Creek, some juvenile CV spring-run Chinook salmon rear through the summer and emigrate as yearlings from October to February, with peak yearling emigration occurring in November and December (CDFG 1998). In the Feather River, some CV spring-run Chinook salmon smolts reportedly emigrate from the Feather River system from October through June (B. Cavallo, DWR, pers. comm. 2004, as cited in Corps 2013b).

Although it has been previously suggested that CV spring-run Chinook salmon smolt emigration generally occurs from November through June in the lower Yuba River (CALFED and YCWA 2005, CDFG 1998), recent (1999-2005), CDFW monitoring data indicate that the vast majority of CV spring-run Chinook salmon emigrate as post-emergent fry during November and December. There were some captures of (over-summer) holdover juvenile Chinook salmon ranging from about 70 to 140 mm FL, which primarily occurred from October through January with a few individuals captured into March (Massa 2005, Massa and McKibbin 2005). These fish likely reared in the river over the previous summer, representing an extended juvenile rearing strategy characteristic of CV spring-run Chinook salmon. During the 2007/2008 sampling period, 33 Chinook salmon that met this criterion were observed at the Hallwood Boulevard RST site from mid-December through January. Juvenile Chinook salmon captured during the fall and early winter (October-January) larger than 70 mm are likely exhibiting an extended rearing strategy in the lower Yuba River (Campos and Massa 2010a).

Based upon review of available information, the RMT (2013) recently identified the CV spring-run Chinook salmon smolt (yearling+) outmigration period as extending from October through mid-May.

Spring-run Chinook Salmon Lifestage-Specific Water Temperature Suitabilities

During November 2010, the RMT prepared a technical memorandum (RMT 2010b) to review the appropriateness of the water temperature regime associated with implementation of the Yuba Accord using previously available data and information, updated in consideration of recent and ongoing monitoring activities conducted by the RMT since the pilot programs were initiated in 2006. The RMT's objectives for that memorandum were to review and update the lifestage periodicities of target species in the lower Yuba River, identify the appropriate thermal regime for target fish species taking into account individual species and lifestage water temperature requirements, identify water temperature index values, assess the probability of occurrence that those water temperature index values would be achieved with implementation of the Yuba Accord, and to evaluate whether alternative water temperature regimes are warranted.

Since November 2010, additional water temperature monitoring and life history investigations of anadromous salmonids in the lower Yuba River have been conducted by the RMT. An update to the water temperature suitability evaluation in RMT (2010) was recently conducted by RMT (2013). The water temperature suitability evaluation conducted for this BA incorporates additional water temperature monitoring data from what was presented in RMT (2013).

Through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program, the RMT (2013) developed the following representative lifestage-specific periodicities and primary locations for water temperature suitability evaluations. The locations used for water temperature evaluations correspond to Smartsville, Daguerre Point Dam, and Marysville.

- Adult Immigration and Holding (April through September) – Smartsville, Daguerre Point Dam, and Marysville,
- Spawning (September through mid-October) – Smartsville,
- Embryo Incubation (September through December) – Smartsville,
- Juvenile Rearing and Outmigration (Year-round) – Daguerre Point Dam and Marysville, and
- Smolt (Yearling+) Emigration (October through mid-May) – Daguerre Point Dam and Marysville

Lifestage-specific water temperature index values used as evaluation guidelines for CV spring-run Chinook salmon were developed based on the information described in Attachment A to RMT (2010b), as well as additional updated information provided in Bratovich *et al*. (2012). These documents present the results of literature reviews that were conducted to: (1) interpret the literature on the effects of water temperature on the various lifestages of Chinook salmon and steelhead, (2) consider the effects of short-term and long-term exposure to constant or fluctuating temperatures, and (3) establish water temperature index (WTI) values to be used as guidelines for evaluation. Specifically, the RMT (2013) evaluation adopted the approach established by Bratovich *et al*. (2012) which uses the lifestage and species-specific upper tolerance WTI values. These WTI values were not meant to be significance thresholds, but instead provide a mechanism by which to compare the suitability of the water temperature regimes associated with implementation of the Yuba Accord. CV spring-run Chinook salmon lifestage-specific WTI values are provided in Table VIII-4. The lifestages and periodicities presented in Table VIII-4 differ from those presented in Table VIII-3 due to specific lifestages that have the same or distinct upper tolerable WTI values.

Table VIII-4. CV spring-run Chinook salmon lifestage-specific upper tolerance WTI values.

Lifestage	Upper Tolerance WTI	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	68°F							■	■	■	■	■	■	■	■	■	■	■	■						
Adult Holding	65°F							■	■	■	■	■	■	■	■	■	■	■	■						
Spawning	58°F																	■	■	■					
Embryo Incubation	58°F																	■	■	■	■	■	■	■	■
Juvenile Rearing and Downstream Movement	65°F	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Smolt (Yearling+) Emigration	68°F	■	■	■	■	■	■	■	■	■										■	■	■	■	■	■

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. In general, the lowest water temperatures in the lower Yuba River are observed during January and February, and water temperatures steadily increase until mid-June or July, remain at relatively high values through September and steadily decrease thereafter. The coldest water temperatures are observed upstream at the Smartsville Gage, intermediate water temperatures occur at Daguerre Point Dam, and the warmest temperatures are observed downstream at the Marysville Gage for most months of the year. The least amount of spatial variation in water temperature is observed during late fall through winter months (*i.e.*, late November through February), when water temperatures are similar at the three monitoring locations.

Figure VIII-17 displays daily water temperature monitoring results from October 2006 through late June 2013 at the Smartsville, Daguerre Point Dam, and Marysville water temperature gages, superimposed with CV spring-run Chinook salmon lifestage-specific

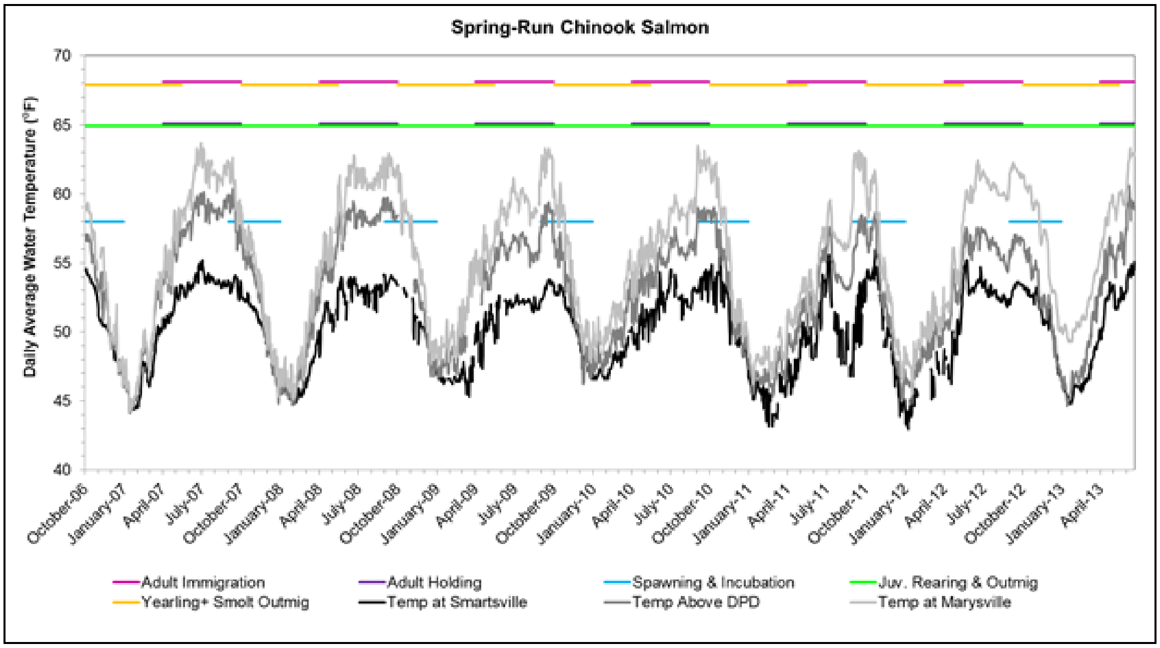


Figure VIII-17. Monitored lower Yuba River water temperatures and CV spring-run Chinook salmon upper tolerance WTI values.

upper tolerance WTI values. Water temperatures at all three gages during the period evaluated are always below the upper tolerance WTI values for smolt (yearling+) outmigration, juvenile rearing and outmigration, and adult immigration and holding. The upper tolerance spawning and embryo incubation WTI value is never exceeded at Smartsville, which is the only location evaluated for CV spring-run Chinook salmon spawning and embryo incubation.

(4) CV Spring-run Chinook Salmon Limiting Factors, Threats and Stressors

The key limiting factors, threats and stressors associated with the environmental baseline affecting the CV spring-run Chinook salmon ESU include the following:

- Habitat Blockage,
- Water Conveyance and Flood Control,
- Water Quality,
- Hatchery Operations and Practices,
- Overutilization (ocean commercial and sport harvest, inland sport harvest),
- Environmental Variation (natural environmental cycles, ocean productivity, global climate change, ocean acidification),
- Water Development,
- Land Use Activities,
- Non-Native Invasive Species, and
- Disease and Predation.

The CV spring-run Chinook salmon ESU continues to display broad fluctuations in abundance. According to NMFS (2011a), recent anomalous conditions in the coastal ocean, along with consecutive dry years affecting inland freshwater conditions, have contributed to statewide CV spring-run Chinook salmon escapement declines. As a species' abundance decreases, and spatial structure of the ESU is reduced, a species has less flexibility to withstand changes in the environment.

Critical habitat for CV spring-run Chinook salmon is composed of PCEs that are essential for the conservation of the species, including but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Most of the historic spawning and rearing habitat for the CV spring-run Chinook salmon ESU is above impassable dams. According to NMFS (2009a), substantial habitat degradation and alteration also has affected the rearing, migratory, and estuarine areas used by CV spring-run Chinook salmon. Some general examples of how CV spring-run Chinook salmon critical habitat has been degraded include the loss of natural river function and floodplain connectivity through levee construction, and direct losses of floodplain and riparian habitat, effects to water quality associated with agricultural, urban, and industrial land use, and substantial changes to Delta estuarine habitat (NMFS 2009a).

Due to past and ongoing effects, the current condition of CV spring-run Chinook salmon critical habitat is considered to be highly degraded, and does not provide the conservation value necessary for the survival and recovery of the species (NMFS 2009a). In addition, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley *et al*. 2007).

Limiting factors, threats and stressors specifically addressing CV spring-run Chinook salmon in the lower Yuba River are discussed in the NMFS Draft Recovery Plan (NMFS 2009). This document is incorporated by reference into this BiOp.

The phenotypic lower Yuba River CV spring-run Chinook salmon population is exposed and subject to the myriad of limiting factors, threats and stressors described above for the Central Valley ESU. Lower Yuba River phenotypic CV spring-run Chinook salmon generally spend a few months (with some individuals remaining up to several months, or a year) in the lower Yuba River prior to migrating downstream through the lower Feather River, the lower Sacramento River, the Delta, and San Francisco Bay to the Pacific Ocean, where they spend from two to four years growing and maturing. Following their ocean residency, these fish then undertake an upstream migration through this same system, and are again exposed to the associated limiting factors, threats and stressors, prior to spending a few additional months in the lower Yuba River holding and subsequently spawning.

Three separate efforts have been undertaken over the past few years to identify, characterize and prioritize limiting factors (*i.e.*, "stressors") for anadromous salmonids (including CV spring-run Chinook salmon) in the lower Yuba River. The Lower Yuba River Fisheries Technical Working Group, a multi-party stakeholder group including the Corps and YCWA, established a process to rank stressors as part of the "*Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration*" (CALFED and YCWA 2005). The Yuba Accord Technical Team built upon these efforts and utilized a stressor analysis in the development of the Yuba Accord minimum flow requirements (*i.e.*, "flow schedules") (YCWA *et al*. 2007).

Most recently, NMFS (2009) conducted a comprehensive assessment of stressors affecting CV spring-run Chinook salmon both within the lower Yuba River, and affecting lower Yuba River populations as they migrate downstream (as juveniles) and upstream (as adults) through the lower Feather River, the lower Sacramento River, and the Bay-Delta system.

As stated by NMFS (2009), stressor matrices, which structured hierarchically related tiers in order to prioritize stressors, were developed. After all of the variables in the matrix were identified and weighted, stressors within the matrices were sorted in descending order (from the highest to the lowest biological impact). Although the resultant sorted matrices provide a pseudo-quantitative means of comparatively ranking individual stressors, to avoid attributing unwarranted specificity to the prioritized stressor list, it was distributed into four separate quartiles ("Very High", "High", "Medium", and "Low"). The ranking and quartile characterization of stressors were organized such that stressors affecting the individual lifestages also could be ascertained.

According to NMFS (2009a), for the lower Yuba River population of CV spring-run Chinook salmon, the number of stressors according to the categories of "Very High", "High", "Medium", and "Low" that occur in the lower Yuba River or occur out of basin are presented below by lifestage (Table VIII-5).

Table VIII-5. The number of stressors according to the categories of "Very High", "High", "Medium", and "Low" that occur in the lower Yuba River, or occur out-of-basin, by lifestage for the lower Yuba River population of CV spring-run Chinook salmon (Source: NMFS 2009a).

Lifestage	**Location**	**Stressor Categories**			
		Very High	**High**	**Medium**	**Low**
Adult Immigration and Holding					
	Lower Yuba River	2	1	3	1
	Out of Basin	1	5	8	6
Spawning					
	Lower Yuba River	3	2	0	2
	Out of Basin	N/A*	N/A	N/A	N/A
Embryo Incubation					
	Lower Yuba River	1	0	4	0
	Out of Basin	N/A	N/A	N/A	N/A
Juvenile Rearing and Outmigration					
	Lower Yuba River	5	1	1	5
	Out of Basin	12	16	6	9
* Not Applicable. These lifestages for this population only occur in the lower Yuba River.					

As shown by the numbers in Table VIII-5, of the total number of 94 stressors affecting all identified lifestages of the lower Yuba River populations of CV spring-run Chinook salmon, 31 are within the lower Yuba River and 63 are out-of-basin. Because spawning and incubation occurs only in the lower Yuba River, all of the stressors associated with these lifestages occur in the lower Yuba River. Therefore, for the adult immigration and holding, and the juvenile rearing and outmigration lifestages combined, a total of 49 "Very High" and "High" stressors were identified, with 15 of those occurring in the lower Yuba River and 34 occurring out-of-basin.

The NMFS (2009) Draft Recovery Plan states that "*The lower Yuba River, below Englebright Dam, is characterized as having a high potential to support a viable independent population of spring-run Chinook salmon, primarily because: (1) flow and water temperature conditions are generally suitable to support all lifestage requirements, (2) the river does not have a hatchery on it, (3) spawning habitat availability is believed not to be limiting, and (4) high habitat restoration potential*".

The NMFS (2009) Draft Recovery Plan further states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate* *instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*."

The key limiting factors, threats and stressors associated with the Environmental Baseline affecting the CV spring-run Chinook salmon in the lower Yuba River include the following.

- Passage Impediments/Barriers,
- Poaching,
- Entrainment,
- Loss of Natural River Morphology and Function,
- Loss of Riparian Habitat and Instream Cover (riparian vegetation, instream woody material),
- Harvest/Angling Impacts,
- Loss of Floodplain Habitat,
- Predation,
- Physical Habitat Alteration (including Waterway 13), and
- Hatchery Effects (FRFH genetic considerations, straying into the lower Yuba River) and other genetic considerations.

Passage impediments/barriers

Englebright Dam presents an impassable barrier to the upstream migration of anadromous salmonids, and marks the upstream extent of currently accessible CV spring-run Chinook salmon habitat in the lower Yuba River, whereas Daguerre Point Dam presents an impediment to upstream migration in the Action Area.

Adult CV Chinook salmon migration within the Action Area

The RMT (2013) further evaluated whether adult Chinook salmon upstream passage through the ladders at Daguerre Point Dam is associated with specific flow levels. They reported that Chinook salmon upstream passage through the ladders at Daguerre Point Dam not only occurs over a wide range of flows but that, at least to some degree, passage occurs during the upstream migration period irrespective of flow rates (over the range of flows examined). In other words, passage occurs at higher flows during "wetter" years characterized by high flows from spring into summer, and at lower flows during "drier" years characterized by low flows from spring into summer. Flow thresholds prohibiting passage of Chinook salmon through the ladders at Daguerre Point Dam were not apparent in the data.

The RMT's 3-year acoustic telemetry study of adult Chinook salmon tagged during the phenotypic adult CV spring-run Chinook salmon upstream migration period has provided new information to better understand adult CV spring-run Chinook salmon temporal and spatial distributions in the Yuba River. The results from the acoustic telemetry study found past characterizations of temporal and spatial distributions to be largely unsupported, as adult CV spring-run Chinook salmon were observed to exhibit a much more diverse pattern of movement, and holding locations in the lower Yuba River were more expansive than has been previously reported (RMT 2013). Observations from the telemetry study identified that a large longitudinal extent of the lower Yuba River was occupied by the tagged CV spring-run Chinook salmon during immigration and holding periods. Also, temporal migrations to areas upstream of Daguerre Point Dam occurred over an extended period of time. A longitudinal analysis of acoustic tag detection data indicated that distributions were non-random, and that the tagged CV spring-run Chinook salmon were selecting locations for holding.

Flows under the Yuba Accord have provided adult CV spring-running Chinook salmon migratory access to areas located throughout the lower Yuba River, as well as a broad expanse of longitudinally distributed areas selected for holding. In general, acoustically-tagged CV spring-run Chinook salmon exhibited an extended holding period, followed by a rapid movement into upstream areas (*i.e.*, the upper Timbuctoo Reach, Narrows Reach, and Englebright Dam Reach) during September (RMT 2013).

Regarding potential changes in spawning distribution, it is not possible to assess if, or the manner in which, extended duration of holding below Daguerre Point Dam could potentially change spawning distribution, because no base data are available for conditions without the presence of Daguerre Point Dam.

Distribution of CV Chinook Salmon Spawning in the Action Area

During the RMT's pilot redd survey conducted from the fall of 2008 through spring of 2009, the vast majority (*i.e.*, 96 percent) of fresh Chinook salmon redds constructed by the first week of October 2008, potentially representing CV spring-run Chinook salmon, were observed upstream of Daguerre Point Dam. Similar distributions were observed during the other two years of redd surveys, when weekly redd surveys were conducted. About 97 percent and 96 percent of the fresh Chinook salmon redds constructed by the first week of October were observed upstream of Daguerre Point Dam during 2009 and 2010, respectively.

The similar percentage distribution of Chinook salmon redds, potentially representing CV spring-run Chinook salmon, located upstream of Daguerre Point Dam occurred despite considerable differences in flow (monthly average cfs) that occurred from late spring into fall prior to each of the redd survey periods, as indicated below.

	June	**July**	**August**	**September**
Marysville Gage				
2008	597	866	882	622
2009	1,846	1,737	1,715	768
2010	4,067	2,698	1,991	768
Smartsville Gage				
2008	1,334	1,621	1,490	868
2009	2,065	1,992	1,866	832
2010	4,516	3,104	2,273	896

Regarding increased adult prespawning mortality, one way that adult prespawning mortality could occur is the potential for fish to jump out of the fish ladders. Because this phenomenon has rarely been observed or reported historically, and potential effects have been further eliminated/reduced following the installation of locking metal grates over 25 of the 33 unscreened bays of the fish ladders during the summer of 2011, it has likely represented a low impact to Yuba River CV spring-run Chinook salmon, but nonetheless has been identified as a stressor that could harm adult fish. Another way that adult prespawning mortality could occur is associated with anecdotal reported observations of Chinook salmon (run unspecified) leaping into the downstream face of Daguerre Point Dam, although no information is available regarding the potential extent or frequency of this reported phenomenon. It is possible that prespawning adult mortality could occur from repeated attempts to pass over the dam and injuries resulting from contact with the rough concrete surface of the dam face. However, it is unlikely that this represents a significant source of mortality to CV spring-run Chinook salmon.

Adult prespawning acute or latent mortality also could occur due to exposure to elevated water temperatures, which could also affect egg viability. The RMT (2013) included evaluation of water temperatures during the CV spring-run Chinook salmon adult upstream immigration and holding lifestage, which addressed considerations regarding both water temperature effects to pre-spawning adults and egg viability. They found that available water temperature monitoring data at all three gages (*i.e.*, Smartsville, Daguerre Point Dam, Marysville) were always below the upper tolerance WTI values for adult immigration and holding. Thus, it is unlikely that this represents a significant source of mortality to CV spring-run Chinook salmon.

Juvenile CV Chinook Downstream Migration in the Action Area

Concern has been expressed that if emigrating salmon and steelhead juveniles encounter high water temperatures in the reach below Daguerre Point Dam, they cannot return to the lower-temperature habitat upstream because their passage is blocked by the dam (DWR and Corps 2003). However, this concern was raised prior to implementation of the Yuba Accord minimum flow schedules and associated water temperatures (initiated as a Pilot Program in 2006 and continuing to present). The RMT (2013) also included evaluation of water temperatures in the lower Yuba River during the year-round juvenile rearing period for CV spring-run Chinook salmon (and CCV steelhead), and found that water temperatures at all three gages (*i.e.*, Smartsville, Daguerre Point Dam, Marysville) were always below the upper tolerance WTI values for the juvenile rearing and outmigration lifestage. Thus, it is unlikely that this represents a significant source of mortality to CV spring-run Chinook salmon.

Daguerre Point Dam may influence predation rates on emigrant juvenile anadromous salmonids. Although it is recognized that there is a paucity of information regarding predation rates on juvenile salmonids in the lower Yuba River, predation likely represents a stressor of relatively high magnitude to the juvenile rearing lifestage of Yuba River CV spring-run Chinook salmon. The presence of Daguerre Point Dam may influence predation rates above Daguerre Point Dam compared to below Daguerre Point Dam. The higher abundance of juvenile anadromous salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam due to their limited ability to pass through the fish ladders, relative to anadromous salmonids (YCWA *et al*. 2007). Daguerre Point Dam also may influence localized predation rates by increased predation of juveniles in the plunge pool located immediately downstream of the dam.

Passage Summary

Given the entire suite of considerations associated with the design configuration and features of Daguerre Point Dam and its associated fish ladders that reportedly could either delay or impede adult upstream migration, as well as issues identified regarding juvenile downstream passage, the effects associated with the presence of Daguerre Point Dam likely represent a medium to high stressor to Yuba River CV spring-run Chinook salmon under the environmental baseline.

Harvest/Angling Impacts

Angling regulations on the lower Yuba River are intended to protect sensitive species, in particular CV spring-run Chinook salmon (and wild steelhead). Fishing for Chinook salmon on the lower Yuba River is regulated by CDFW. CDFW angling regulations 2013-2014 (CDFW 2013a) state that the lower Yuba River from its confluence with the lower Feather River up to Englebright Dam is closed year-round to salmon fishing, and no take or possession of salmon is allowed. Angling regulations on the lower Yuba River are intended to protect sensitive species, in particular CV spring-run Chinook salmon (and wild steelhead). Although harvest/angler impacts were previously listed as a stressor, the magnitude of this potential stressor has been reduced associated with changes in fishing regulations over time.

Fishing for hatchery trout or hatchery steelhead is allowed on the lower Yuba River from its confluence with the lower Feather River up to the Highway 20 Bridge year-round. Incidental impacts have the potential to occur to CV spring-run Chinook salmon through physical disturbance of salmonid redds, and incidental hooking and catch-and-release stress or mortality. However, the lower Yuba River, between the Highway 20 Bridge and Englebright Dam, is closed to fishing from September through November to protect CV spring-run Chinook salmon spawning activity and egg incubation. Although these regulations are intended to specifically protect CV spring-run Chinook salmon, anglers can potentially harass, harm and kill listed species (CV spring-run Chinook salmon and wild steelhead) through incidental actions while targeting non-listed species.

Examples of potential angler impacts may include, but are not necessarily limited to, angler harvest, physical disturbance of salmonid redds, hooking and catch-and-release stress or mortality, including that which results from incidental hooking (CALFED and YCWA 2005).

Harvest/angling likely represents a negligible impact to Yuba River adult CV spring-run Chinook salmon. Hence, harvest/angling is characterized as a stressor of low magnitude to spring-run Chinook salmon.

Poaching of CV Spring-run Chinook Salmon

Poaching of adult Chinook salmon at the fish ladders and at the base of Daguerre Point Dam has been previously suggested to represent a stressor to CV spring-run Chinook salmon. NMFS' Draft Recovery Plan (NMFS 2009) identified poaching as a stressor of "low" importance to CV spring-run Chinook salmon in the lower Yuba River. The only actual account of documented poaching was provided in a declaration by Nelson (2009) in which he stated that during his tenure at CDFW (which extended until 2006) he personally observed people fishing illegally in the ladders, and further observed gear around the ladders used for poaching. It is not clear regarding the time period to which he was referring, although it may have been referring to the period prior to 2000. The VAKI Riverwatcher infrared and videographic sampling system began operations in 2003. CDFW monitored VAKI Riverwatcher operations at Daguerre Point Dam seasonally from 2003 through 2005, and CDFW and/or PSMFC have monitored the system on an approximate every other day basis, year-round, since 2006. Over this 10-year period, neither CDFW nor PSMFC staff has reported poaching in the ladders, or immediately downstream of Daguerre Point Dam.

More recently, in a July 2011 Court Order, the Federal Court of the Eastern District of California concluded that "*installation of locked metal grates over the Daguerre fish ladders is necessary to prevent irreparable harm to the survival and recovery of the species during the interim period*". In response to the Court's Order, the Corps installed locking metal grates over the Daguerre Point Dam fish ladder bays[5] in August/September 2011 to prevent fish from jumping out of the ladders and to prevent poaching in the fish ladders.

Whether poaching represents a stressor, or the extent to which CV spring-run Chinook salmon are targeted for poaching in the lower Yuba River is unknown. Poaching of adult Chinook salmon at the fish ladders and at the base of Daguerre Point Dam has been previously reported in several documents. Poaching has been previously reported as a "chronic problem" (Falxa 1994 as cited in CALFED and YCWA 2005). The CV spring-run Chinook salmon status report (CDFG 1998) stated that poaching was an "ongoing problem" at Daguerre Point Dam. Poaching of salmon has been reported as a "long-standing problem" on the Yuba River, particularly at Daguerre Point Dam (John Nelson, CDFG, pers. comm., November 2000, as cited in NMFS 2005a). The Corps (2001) and NMFS (2009) both refer to poaching of adult salmon at the Daguerre Point Dam.

The extent to which CV spring-run Chinook salmon are targeted for poaching in the lower Yuba River is unknown, and it is unclear whether the previous reports of poaching were directed toward spring-run or fall-run Chinook salmon. With the installation of the metal grates over the Daguerre Point Dam fish ladders, poaching likely represents a low (or negligible) stressor to Yuba River adult CV spring-run Chinook salmon.

5 Excluding the eight bays on the lowermost section of the south fish ladder at Daguerre Point Dam so that CDFW can maintain continued access to the flow modification equipment that is located in the fish ladder and designed to improve fish passage conditions.

Predation

The extent of predation on juvenile Chinook salmon in the lower Yuba River is not well documented (NMFS 2009). Although predation is a natural component of salmonid ecology, it has been suggested that the rate of predation of salmonids in the lower Yuba River has potentially increased through the introduction of non-native predatory species such as striped bass, largemouth bass and American shad, and through the alteration of natural flow regimes and the development of structures that attract predators (NMFS 2009).

Daguerre Point Dam creates a large plunge pool at its base, which may provide ambush habitat for predatory fish in an area where emigrating juvenile salmonids may be disoriented after plunging over the face of the dam into the deep pool below (NMFS 2002). It has been suggested that the rate of predation of juvenile salmonids passing over dams in general, and Daguerre Point Dam in particular, may be unnaturally high (NMFS 2007). It also has been suggested that unnaturally high predation rates may also occur in the diversion channel associated with the South Yuba/Brophy diversion (NMFS 2007). Demko and Cramer (2000) reviewed all studies previously performed at the South Yuba/Brophy diversion, and found that none of the research by USFWS, CDFW, or fisheries consultants had indicated that juvenile Chinook became disoriented upon entering the diversion channel, or that abnormally high predation on juvenile Chinook salmon occurred. Nonetheless, SWRCB (2001) stated that there was no way to prevent water from entering the diversion channel when water was not being diverted into the South Canal for irrigation, and that therefore losses due to predation occur even when no water is being diverted for beneficial use.

Other structure-related predation issues in the environmental baseline include the potential for increased rates of predation of juvenile salmonids: (1) in the entryway of the Hallwood-Cordua diversion canal upstream of the fish screen, and (2) at the point of return of fish from the bypass pipe of the Hallwood-Cordua diversion canal into the lower Yuba River. The relatively recent fish screen constructed at the Hallwood-Cordua diversion is considered a notable improvement over the previous design, but the configuration of the bypass return pipe and predation losses of emigrating fry and juvenile Chinook salmon, including spring-run Chinook salmon, remain a concern.

As previously discussed, most juvenile Chinook salmon and steelhead rearing has been reported to occur above Daguerre Point Dam. The higher abundance of juvenile salmonids above Daguerre Point Dam may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are generally restricted to areas below the dam (YCWA *et al*. 2007).
For the purpose of stressor identification in this BA, predation includes the predation associated with increases in predator habitat and predation opportunities for piscivorous species created by major structures and diversions, and predation resulting from limited amounts of prey escape cover in the lower Yuba River. Consequently, predation of juvenile salmonids by introduced and native piscivorous fishes occurs throughout the lower Yuba River potentially at relatively high rates. Therefore, predation likely represents a high stressor to the juvenile lifestage of Yuba River spring-run Chinook salmon.

Hatchery Effects (FRFH Genetic Considerations, Straying into the Lower Yuba River) and other Genetic Considerations

Although no fish hatcheries are located on the lower Yuba River, and the river continues to support a persistent population of spring-run Chinook salmon that spawn downstream of Englebright Dam, the genetic integrity of the fish expressing the phenotypic characteristics of spring-run Chinook salmon is presently uncertain. CDFG (1998) suggested that spring-run Chinook salmon populations may be hybridized to some degree with fall-run Chinook salmon due to lack of spatial separation of spawning habitat. Also, the observation of adipose fin clips on adult Chinook salmon passing upstream through the VAKI system at Daguerre Point Dam during the spring demonstrates that hatchery straying into the lower Yuba River has and continues to occur, most likely from the FRFH (NMFS 2009, RMT 2013).

The FRFH is the only hatchery in the Central Valley that currently produces spring-run Chinook salmon. The FRFH was constructed in 1967 to compensate for anadromous salmonid spawning habitat lost with construction of the Oroville Dam. The FRFH has a goal of releasing 2,000,000 spring-run Chinook salmon smolts annually (DWR 2004b).

From 1962 to 1966, spring-run Chinook salmon were trapped and trucked above Oroville Dam. Beginning in 1967, spring-run Chinook salmon were collected for artificial propagation at FRFH as the construction of Oroville Dam was completed. The program is funded by the DWR and managed by CDFW (NMFS 2004).

Spring-run Chinook salmon from the FRFH were planted in the lower Yuba River during 1980 (CDFG 1991). In addition, it is possible that some hatchery-reared juvenile Chinook salmon from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned spring-run Chinook salmon could occur as a result (YCWA *et al*. 2007). The remainder of this discussion pertains to hatchery effects associated with the straying of adult Chinook salmon into the lower Yuba River.

The FRFH spring-run Chinook salmon program was founded with local native stock collected at the FRFH. Early attempts to over-summer spring-run at the hatchery resulted in high mortality and the decision to allow the run to hold in the river until September 1. Prior to 2004, FRFH hatchery staff differentiated spring-run Chinook salmon from fall-run Chinook salmon by opening the ladder to the hatchery on September 1 (NMFS 2009). Those fish ascending the ladder from September 1 through September 15 were assumed to be spring-run Chinook salmon while those ascending the ladder after September 15 were assumed to be fall-run (Kastner 2003 as cited in NMFS 2009). This practice led to considerable hybridization between spring- and fall-run Chinook salmon (DWR 2004b). Since 2004, the FRFH fish ladder remains open during the spring months, closing on June 30, and those fish ascending the ladder are marked with an external floy tag and returned to the river. This practice allows FRFH staff to identify those previously marked fish as spring-run when they re-enter the ladder in September. Only floy-tagged fish are spawned with floy-tagged fish in the month of September. No other fish are spawned during this time, as part of an effort to prevent hybridization with fall-run, and to introduce a temporal separation between stocks in the hatchery. During the FRFH spring-run spawning season, all heads from adipose fin-clipped fish are taken and sent to CDFW's laboratory in Santa Rosa for tag extraction and decoding. The tag information will be used to test the hypothesis that early spring-run spawners will produce progeny that maintain that run fidelity.

Regardless of recent improved FRFH practices, previous practices appear to have resulted in hybridization between "spring-run" and "fall-run" Chinook salmon. The following discussion was taken from Garza *et al*. (2008).

Evaluation of the FRFH "spring-run" stock found that it is genetically most similar to the FRFH fall-run stock, as indicated both by clustering on the phylogeographic trees and by comparison of the [standardized variance in allele frequencies between the sample years] (F_{ST}) values, and is nested within the fall-run group of populations in all analyses (Garza *et al*. 2008). F_{ST} values between the FRFH "spring-run" and naturally-spawned spring-run are in the low end of the range of values for fall-run populations to spring-run populations, but not the lowest. In addition, they are the essentially the same as those of FRFH fall-run to spring-run populations. This demonstrates that the FRFH "spring-run" stock is dominated by fall-run ancestry. However, Garza *et al*. (2008) also found very slight, but significant, differentiation between the two FRFH stocks, which is concordant with the results of Hedgecock *et al*. (unpublished study as cited in Garza *et al*. 2008) on these stocks. In addition, Garza *et al*. (2008) found a strong signal of linkage (gametic phase) disequilbrium, absent in all other population samples, in the FRFH "spring-run" stock. Garza *et al*. (2008) interpreted this as evidence that the FRFH "spring" run retains remnants of the phenotype and ancestry of the Feather River spring-run Chinook salmon that existed prior to the dam and hatchery (as opposed to representing a hatchery selection-created and maintained phenotypic variant), but that has been heavily introgressed by fall-run Chinook salmon through some combination of hatchery practices and natural hybridization, induced by habitat concentration due to lack of access to spring-run Chinook salmon habitat above the dam. This suggests that it may be possible to preserve some additional component of the ancestral Central Valley spring-run Chinook salmon genomic variation through careful management of this stock that can contribute to the recovery of the ESA-listed Central Valley spring-run Chinook salmon ESU, although it will not be possible to reconstitute a "pure" spring-run stock from these fish.

Although the FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU, concern has been expressed that straying of FRFH fish into the lower Yuba River may represent an adverse impact due to the potential influence of previous hatchery management practices on the genetic integrity of FRFH spring-run Chinook salmon.

More recently, NMFS Southwest Fisheries Science Center conducted a preliminary genetic analysis of tissues collected from adult Chinook salmon downstream of Daguerre Point Dam in the lower Yuba River during May 2009 (*i.e.*, phenotypic spring-run Chinook salmon). Of the 43 samples, 28 were positively identified as Feather River spring-run Chinook salmon. The remaining 15 samples were all identified as Central Valley fall-run Chinook salmon, primarily from the Feather River. These preliminary results are presented with the strong cautionary note that the genetic analyses have somewhat limited ability to distinguish Central Valley fall-run Chinook salmon from Feather River spring-run Chinook salmon due to past introgression, and due to incomplete databases for some Central Valley populations.

Straying

FRFH hatchery spring-run Chinook salmon straying into the lower Yuba River and interbreeding with naturally-spawning Yuba River spring-run Chinook salmon has been suggested to represent a threat to the genetic integrity of the naturally-spawning spring-run Chinook salmon population in the lower Yuba River. This suggested threat raises the question of the present genetic integrity of the fish expressing phenotypic characteristics of spring-run Chinook salmon in the lower Yuba River.

The FRFH "spring-run" stock is dominated by fall-run ancestry (Garza *et al*. 2008). However, the FRFH "spring" run retains remnants of the phenotype and ancestry of the Feather River spring-run Chinook salmon that existed prior to the Oroville Dam and the FRFH, but has been heavily introgressed by fall-run Chinook salmon through some combination of hatchery practices and hybridization induced by lack of access to spring-run Chinook salmon habitat above Oroville Dam. This suggests that it may be possible to preserve some additional component of the ancestral Central Valley spring-run Chinook salmon genomic variation through careful management of this stock, although it will not be possible to reconstitute a "pure" spring-run stock from these fish (Garza *et al*. 2008).

Straying of FRFH "spring-run" Chinook salmon into the lower Yuba River has oftentimes been suggested to represent an adverse impact on lower Yuba River "spring-run" Chinook salmon stocks. It is reasonable to assume that such straying would represent an impact if the lower Yuba River stocks represented a genetically distinct, independent population. However, given the foregoing available information, spring-run Chinook salmon on the lower Yuba River do not represent a "pure" ancestral genome.

The RMT (2013) reported that substantially higher amounts of straying of adipose fin-clipped Chinook salmon into the lower Yuba River occur than that which was previously believed. Although no quantitative analyses or data were presented, NMFS (2007) stated that some hatchery fish stray into the lower Yuba River and that these fish likely come from the FRFH.

Some information indicating the extent to which adipose-clipped Chinook salmon originating from the FRFH return to the lower Yuba River is available from coded wire tag analysis. During the October through December 2010 carcass survey period in the lower Yuba River, the RMT collected heads from fresh Chinook salmon carcasses with adipose fin clips, and sent the heads to the CDFW coded wire tag (CWT) interpretive center. In April of 2011, the results of the interpretation of the CWTs became available. Of the 333 Chinook salmon heads sent to the CDFW interpretive center, 11 did not contain a CWT, 8 were fall-run Chinook salmon from the Coleman National Fish Hatchery, 2 were from the RST captured and tagged juveniles in the lower Yuba River, 1 was a naturally-spawned fall-run Chinook salmon from the Feather River, 1 was a fall-run Chinook salmon from the Mokelumne River Hatchery, and 310 were Chinook salmon from the FRFH (234 spring-run and 76 fall-run Chinook salmon). Thus, for all CWT hatchery-origin fish returning to the Yuba River from out-of-basin sources, 97 percent were from the FRFH. However, this information does not indicate the percentage of hatchery contribution from the FRFH to the phenotypic spring-run Chinook salmon run in the lower Yuba River, because, among other reasons, all of these heads were collected during the fall and represent a mixture of phenotypic spring- and fall-run Chinook salmon spawning in the lower Yuba River (RMT 2013).

Additional information that can be used to assess the amount of straying of FRFH Chinook salmon into the lower Yuba River is provided from VAKI Riverwatcher data collected from 2004 through 2011 (RMT 2013). The estimated numbers of adipose fin-clipped spring-run Chinook salmon that passed upstream of Daguerre Point Dam from 2004 through 2011 that were derived from the VAKI Riverwatcher data are an indicator of the minimum number of Chinook salmon of hatchery origin (most likely of FRFH origin) that strayed into the lower Yuba River. The following discussion of adipose fin-clipped spring-run Chinook salmon is from RMT (2013).

Because the VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam can record both silhouettes and electronic images of each fish passage event, the systems were able to differentiate Chinook salmon with adipose fins clipped or absent from Chinook salmon with their adipose fins intact. Thus, annual series of daily counts of Chinook salmon with adipose fins clipped (*i.e.*, ad-clipped fish) and with adipose fins intact (*i.e.*, not ad-clipped fish) that passed upstream of Daguerre Point Dam from March 1, 2004, through February 29, 2012, were obtained. The estimated numbers of spring-run Chinook salmon of hatchery (*i.e.*, ad-clipped fish) and potentially non-hatchery origin (*i.e.*, not ad-clipped fish) passing upstream of Daguerre Point Dam for the last eight years of available VAKI Riverwatcher data are presented in Table VIII-6.

<u>Relationships between Spring-run Chinook Salmon Straying into the lower Yuba River and Attraction Flows and Water Temperatures</u>

As reported by RMT (2013), to evaluate the influence of "attraction" flows and water temperatures on the straying of adipose fin-clipped adult phenotypic spring-run Chinook salmon into the lower Yuba River, variables related to flows and water temperatures in the lower Yuba River and the lower Feather River were developed and statistically related to the weekly proportions of adipose fin-clipped phenotypic spring-run Chinook salmon (relative to all spring-run Chinook salmon) passing upstream of Daguerre Point Dam during each of the 8 years when annual VAKI Riverwatcher counts at Daguerre Point Dam are available. Details of this analytical evaluation are provided in the RMT (2013) Monitoring and Evaluation report.

Table VIII-6. Estimated numbers of Chinook salmon, ad-clipped and not ad-clipped phenotypic spring-run Chinook salmon that passed upstream of Daguerre Point Dam annually from 2004 through 2011 (Source: RMT 2013).

Year	Demarcation Date	Chinook Salmon Passage Upstream of Daguerre Point Dam				
		All Chinook Salmon	Spring-run Chinook Salmon			
			Total	Ad-Clipped	Not Ad-Clipped	% Ad-Clipped
2004	8/1/04	5,927	738	72	666	10
2005	8/24/05	11,374	3,592	676	2,916	19
2006	9/6/06	5,203	1,326	81	1,245	6
2007	9/4/07	1,394	372	38	334	10
2008	8/10/08	2,533	521	15	506	3
2009	7/9/09	5,378	723	213	510	29
2010	7/6/10	6,469	2,886	1,774	1,112	61
2011	9/7/11	7,785	1,159	323	836	28

Results of the RMT (2013) analysis suggest that there is a moderately strong (R^2=0.72) and highly significant ($P < 0.000001$) relationship between the percentage of adipose fin-clipped spring-run Chinook salmon contribution to the weekly spring-run Chinook salmon total counts at Daguerre Point Dam and the attraction flow and water temperature indices four weeks prior. The attraction flow index explained 20.4 percent of the data variability, the attraction water temperature index explained 27.5 percent of the variability, and the interaction term explained 24.4 percent of the variability in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing Daguerre Point Dam weekly (RMT 2013). Figure VIII-18 displays the 3-D response surface produced by the fitted logistic model.

The analysis described above showed that an estimated 72 percent of the variation in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing upstream of Daguerre Point Dam can be accounted for by the ratio of lower Yuba River flow relative to lower Feather River flow, and the ratio of lower Yuba River water temperature relative to lower Feather River water temperature, four weeks prior to the

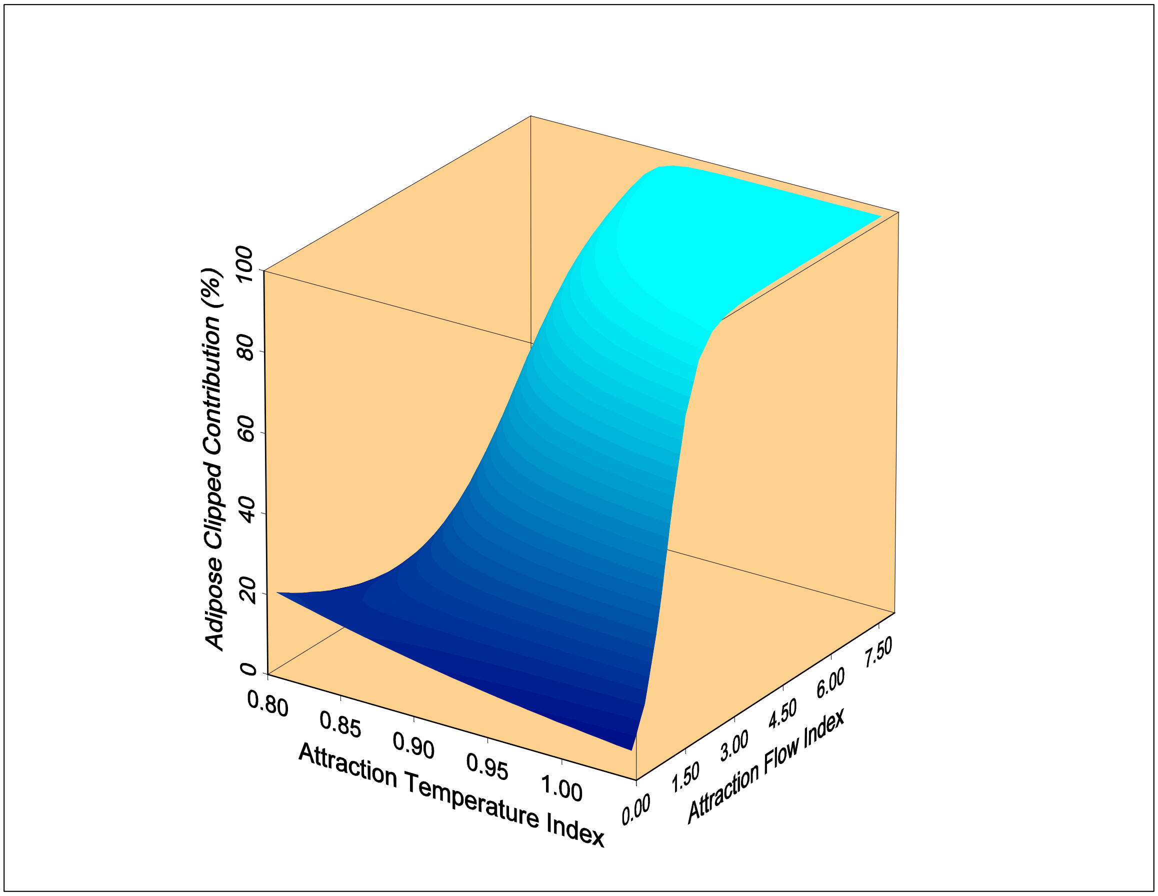


Figure VIII-18. Relationship of the weekly percentage of adipose fin-clipped contribution to the weekly phenotypic spring-run Chinook salmon count at Daguerre Point Dam as function of the weekly attraction flow and water temperature indices calculated four weeks prior to the week of passage at Daguerre Point Dam (Source: RMT 2013).

time of passage at Daguerre Point Dam. In other words, the higher the Yuba River flows relative to Feather River flows, combined with the lower the Yuba River water temperatures relative to Feather River water temperatures, the higher the percentage of fin-clipped Chinook salmon passing upstream of Daguerre Point Dam four weeks later (RMT 2013).

As described in RMT (2013), the acoustically-tagged phenotypic spring-run Chinook salmon spent variable and extended periods of time holding below Daguerre Point Dam after being tagged and prior to passing upstream of Daguerre Point Dam, with a range of 0 to 116 days. Based on all 67 acoustically-tagged spring-run Chinook salmon that passed upstream of Daguerre Point Dam, the average holding time before passing upstream of Daguerre Point Dam was about 50 days. For the phenotypic acoustically-tagged spring-run Chinook salmon that passed upstream of Daguerre Point Dam by the annual spring-run Chinook salmon demarcation date for each year, the average holding periods before passing upstream of Daguerre Point Dam were approximately 51, 41, and 57 days during 2009, 2010 and 2011, respectively. Therefore, it would be expected that attraction of adipose fin-clipped fish to the lower Yuba River associated with flows and water temperatures in the lower Yuba River relative to the lower Feather River would occur at least several weeks prior to passage of phenotypic spring-run Chinook salmon upstream of Daguerre Point Dam (RMT 2013).

While the variation in the proportion of adipose fin-clipped phenotypic spring-run Chinook salmon passing Daguerre Point Dam was best explained with ratios of flows and water temperatures in the lower Yuba and Feather rivers four weeks prior to passage at Daguerre Point Dam, the acoustically-tagged individuals exhibited a somewhat longer duration of holding on average. However, due to the relatively small sample size of acoustically-tagged spring-run Chinook salmon passing upstream of Daguerre Point Dam (N=67), the short duration of the study, and based on the highly variable holding duration (*i.e.*, 0-116 days), the average holding time calculated for the acoustically-tagged spring-run Chinook salmon is considered to be a general approximation of holding duration downstream of Daguerre Point Dam (RMT 2013). Therefore, consideration of holding duration downstream of Daguerre Point Dam supports the observation that the ratios of flows and water temperatures in the lower Yuba River relative to the lower Feather River four weeks prior to passage of spring-run Chinook salmon at Daguerre Point Dam may be influencing the attraction of adipose fin-clipped spring-run Chinook salmon of FRFH-origin into the lower Yuba River (RMT 2013).

Lower Yuba River Genetic Considerations

Spring-run Chinook salmon historically acquired and maintained genetic integrity through reproductive (spatial-temporal) isolation from other Central Valley Chinook salmon runs. However, construction of dams has prevented access to headwater areas and much of this historical reproductive isolation has been compromised, resulting in intermixed life history traits in many remaining habitats (YCWA 2010).

CDFG (1991) reported that a small spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959. As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River downstream of Englebright Dam maintained by fish produced in the lower Yuba River, fish straying from the Feather River, or fish previously and infrequently stocked from the FRFH (CDFG 1991). In the 1990s, relatively small numbers of Chinook salmon that exhibit spring-run phenotypic characteristics were reported to have been observed in the lower Yuba River (CDFG 1998). Although precise escapement estimates are not available, the USFWS testified at the 1992 SWRCB lower Yuba River hearing that "…*a population of about 1,000 adult spring-run Chinook salmon now exists in the lower Yuba River*" (San Francisco Bay RWQCB 2006).

If spring-run Chinook salmon were extirpated from the lower Yuba River in 1959 (Fry 1961) and, as reported by CDFG (1991), a population of spring-run Chinook salmon became reestablished since the 1970s due to improved habitat conditions and fish straying from the Feather River or stocked and straying from the FRFH, then it is likely that spring-run Chinook salmon on the lower Yuba river do not represent a "pure" ancestral genome.

There also is concern that the existing spring-run Chinook salmon population has interbred with fall-run Chinook salmon and, as a result, it is a hybrid species and not a true spring-run species (Corps 2001). In addition to the effects of hatchery straying, an additional issue regarding the genetic integrity of phenotypic spring-run Chinook salmon in the lower Yuba River pertains to the loss or reduction of reproductive isolation.

Spring-run Chinook salmon acquired and maintained genetic integrity through spatial-temporal isolation from other Central Valley Chinook salmon runs. Historically, spring-run Chinook salmon were temporally and geographically largely isolated in both time and space from the fall-run. Much of this historical spatial-temporal integrity has broken down, resulting in intermixed life history traits in many remaining habitats. Consequently, the present self-sustaining, persistent populations of spring-run Chinook salmon in the upper Sacramento, lower Yuba, and lower Feather rivers may be hybridized to some degree with fall-run Chinook salmon (YCWA et. al 2007).

The presence of Englebright Dam has necessitated that spring-run Chinook salmon spawn in areas that were believed to formerly represent fall-run Chinook salmon spawning areas. Although the lower Yuba River continues to support a persistent population of spring-run Chinook salmon that now are restricted to spawning downstream of Englebright Dam, the genetic integrity of the fish expressing the phenotypic characteristics of spring-run Chinook salmon is presently uncertain. For example, CDFG (1998) suggests that spring-run populations may be hybridized to some degree with fall-run populations due to lack of spatial separation of spawning habitat for the two runs of Chinook salmon in the lower Yuba River.

In the report titled *Salmonid Hatchery Inventory and Effects Evaluation* (NMFS 2004), through an analysis of Yuba River Chinook salmon tissues, NMFS genetically linked the spring-run and fall-run populations, which exhibit a merged run timing similar to that found in the Feather River.

The Corps conclude (as cited in Corps 2013b) that the available information indicates that: (1) the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations, and (2) straying from FRFH origin "spring-run" Chinook salmon into the lower Yuba River occurs, and that this rate of straying is associated with the relative proportion of lower Yuba River flows and water temperatures to lower Feather River flows and water temperatures ("attraction flows and water temperatures"), and (3) the FRFH spring-run Chinook salmon is included in the ESU, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (70 FR 37160). Although straying of FRFH "spring-run" Chinook salmon into the lower Yuba River has oftentimes been suggested to represent an adverse impact on lower Yuba River spring-run Chinook salmon stocks, it is questionable whether the phenotypic spring-run Chinook salmon in the lower Yuba River represents an independent population. The RMT (2013) recently reported that data obtained through the course of implementing the RMT's M&E Program demonstrate that phenotypically "spring-running" Chinook salmon in the lower Yuba River do not represent an independent population – rather, they represent an introgressive hybridization of the larger Feather-Yuba river regional population.

If spring-run Chinook salmon were extirpated from the lower Yuba River in 1959 and, as reported by CDFG (1991), a population of spring-run Chinook salmon became reestablished in the 1970s due to improved habitat conditions and fish straying from the Feather River or stocked and straying from the FRFH, then it is likely that spring-run Chinook salmon on the lower Yuba River do not represent a "pure" ancestral genome. Available information indicates that the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations (RMT 2013).

The FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU (NMFS 2005d) and, therefore, is protected by the applicable provisions of the ESA. At the time of issuance of the final rule regarding the listing status of the Central Valley ESU of spring-run Chinook salmon, NMFS (2005d) recognized that naturally spawning spring-run Chinook in the Feather River are genetically similar to the FRFH spring-run Chinook stock, and that the hatchery stock shows evidence of introgression with Central Valley fall-run Chinook salmon. However, NMFS also stated that FRFH stock should be included in the ESU because the FRFH spring-run Chinook salmon stock may play an important role in the recovery of spring-run Chinook salmon in the Feather River Basin, as efforts progress to restore natural spring-run populations in the Feather and Yuba Rivers (NMFS 2005d).

The FRFH spring-run Chinook salmon population is part of the Central Valley spring-run Chinook salmon ESU (70 FR 37160). At the time of issuance of the final rule regarding the listing status of the Central Valley ESU of spring-run Chinook salmon, NMFS (70 FR 37160) recognized that naturally spawning spring-run Chinook salmon in the Feather River are genetically similar to the FRFH spring-run Chinook salmon stock, and that the hatchery stock shows evidence of introgression with Central Valley fall-run Chinook salmon. NMFS also stated that FRFH stock should be included in the ESU because the FRFH spring-run Chinook salmon stock may play an important role in the recovery of CV spring-run Chinook salmon in the Feather River Basin, as efforts progress to restore natural spring-run populations in the Feather and Yuba Rivers (70 FR 37160).

The Corps concluded that the continued and ongoing influx of FRFH-origin fish under the Environmental Baseline would represent a relatively high stressor if the management goal is to reestablish a viable population of spring-run Chinook salmon in the lower Yuba River. However, data obtained through the course of implementing the RMT M&E Program demonstrate that phenotypically spring-run Chinook salmon in the lower Yuba River do not represent an independent population – rather, they represent an introgressive hybridization of the larger Feather-Yuba river regional population (RMT 2013). Continued influx of FRFH-origin spring-run Chinook salmon into the lower Yuba River contributes to the abundance of the phenotypic spring-run Chinook salmon population in the lower Yuba River, but straying decrease the populations viability and precludes it from meeting recovery criteria.

It is NMFS' opinion that it is important for recovery of the CV spring-run Chinook salmon to have a viable population of CV spring-run Chinook salmon in the Yuba River (NMFS 2014).

We agree that the phenotypic spring-run Chinook salmon population in the Yuba River represent a genetic blending of different groups of Chinook salmon. Genetically the Yuba River spring-run Chinook salmon population is mixed. Phenotypically we have a group of CV spring-run Chinook salmon in the Yuba River that annually have varying levels of genetic influence from Feather River Chinook salmon. Current information indicates that not all of the CV spring-run Chinook salmon in the Yuba River are from the Feather River. For evaluating whether hatchery fish and straying are stressors to Yuba River spring-run Chinook samon it is not important whether the Yuba River spring-run Chinook salmon are an independent population or part of the natural spawning Feather River spring-run Chinook salmon. Both Feather River Chinook salmon populations are included in the CV spring-run Chinook salmon ESU ESA listing. Based on the best available scientific information, it is NMFS' opinion that past hatchery practices and the ongoing straying of FRFH fish into the lower Yuba River have resulted in stressors of high magnitude regarding the population viability of CV spring-run Chinook salmon in the lower Yuba River.

CV Spring-run Chinook Salmon Genetic Summary

In summary, available information about CV spring-run Chinook salmon indicates the following.

- Modication of the river system (*e.g.* dams, mining, diversions) has altered the river system and affected the Yuba River population of spring-run Chinook salmon.
- A CV spring-run Chinook salmon population historically occurred in the lower Yuba River, but the run virtually disappeared by 1959.
- By 1991, a small spring-run Chinook salmon population became reestablished in the lower Yuba River due to improved habitat conditions and due to recolonization by fish straying from the Feather River, fish previously and infrequently stocked from the FRFH, and/or possible production from a remnant population in the lower Yuba River.
- The phenotypic spring-run Chinook salmon in the lower Yuba River actually represents introgression between spring- and fall-run Chinook salmon in the lower Yuba River, and introgression with Feather River stocks including the FRFH spring-run Chinook salmon stock.
- The FRFH spring-run Chinook salmon stock itself represents a hybrid stock of Feather River fall- and spring-run Chinook salmon parentage.
- Straying from FRFH origin "spring-run" Chinook salmon into the lower Yuba River has and continues to occur, and this rate of straying is associated with "attraction flows" – the relative proportion of lower Yuba River flows to lower Feather River flows.
- The FRFH spring-run Chinook salmon is included in the ESU (NMFS 2005d).
- Although the FRFH spring-run Chinook salmon population is part of the CV spring-run Chinook salmon ESU, straying of FRFH fish into the lower Yuba River may represent an adverse impact to the genetic integrity of lower Yuba River spring-run Chinook salmon.

(5) Viability of CV Spring-run Chinook Salmon

<u>Lower Yuba River</u>

As previously discussed, the VSP concept was developed by McElhany *et al*. (2000) in order to facilitate establishment of ESU-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. The four parameters established by McElhany *et al*. (2000) included abundance, productivity, spatial structure and genetic and life-history diversity, although McElhany *et al*. (2000) did not provide quantitative criteria that would allow assessment of whether particular populations or ESUs/DPSs are viable.

Lindley *et al*. (2007) characterized the spring-run Chinook salmon population in the lower Yuba River as data deficient, and therefore did not characterize its viability. In 2007, there was limited information on the current population size of spring-run Chinook salmon in the lower Yuba River, although NMFS (2009) stated that ongoing monitoring is providing additional information.

<u>Abundance and Productivity – Spring-run Chinook</u>

Run Differentiation (Spring-run vs. Fall-run Chinook Salmon)

Prior to application of VSP performance indicators or the extinction risk criteria, it is necessary to differentiate between annually returning spring-run and fall-run Chinook salmon in the lower Yuba River.

However, as reported by RMT (2013), there is no discernible genetic differentiation available to determine spring-run Chinook salmon, only phenotypic differentiation. The phenotypic expression is often obscure, requiring application of advanced statistical techniques to VAKI Riverwatcher and other datasets in order to identify the phenotypic differences in run timing. The following discussion of differentiating phenotypic spring-run from phenotypic fall-run Chinook salmon in the lower Yuba River is generally taken from RMT (2013).

Infrared-imaging technology has been used to monitor fish passage at Daguerre Point Dam in the lower Yuba River since 2003 using VAKI Riverwatcher systems to document specific observations used to address VSP parameters of adult abundance and diversity. The VAKI Riverwatcher infrared systems produced by VAKI Aquaculture Systems Ltd., of Iceland, provided a tool for monitoring fish passage year-round. The VAKI Riverwatcher system records both silhouettes and electronic images of each fish passage event in both of the Daguerre Point Dam fish ladders. By capturing silhouettes and images, fish passage can be accurately monitored even under turbid conditions.

The VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam were able to record and identify the timing and magnitude of passage for Chinook salmon at Daguerre Point Dam during most temporal periods of a given year.

Prior to applying any analysis of temporal modalities to the eight annual time series of Chinook salmon daily VAKI counts, the annual daily count series at each ladder were adjusted to account for days when the VAKI Riverwatcher systems were not fully operational. The procedure used to obtain complete annual daily count series of Chinook salmon migrating upstream of Daguerre Point Dam is provided in RMT (2013).

The daily time series of Chinook salmon moving upstream of Daguerre Point Dam resulting from the previous step were further analyzed and temporal modalities were explored to differentiate spring-run from fall-run Chinook salmon each year. For a full description of the run differentiation process, see RMT (2013).

Figure VIII-19 and Figure VIII-20 display the daily number of Chinook salmon that passed upstream of Daguerre Point Dam during the 2004 to the 2011 biological years (March 1 through February 28) and the fitted generalized logistic functions describing the distributions of spring-run and fall-run Chinook salmon resulting from the application of the annually variable temporal demarcation procedure. Finally, Table VIII-21 summarizes the total number of spring-run and fall-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam annually, and the estimated annual percentage of spring-run Chinook salmon relative to all Chinook salmon each year.

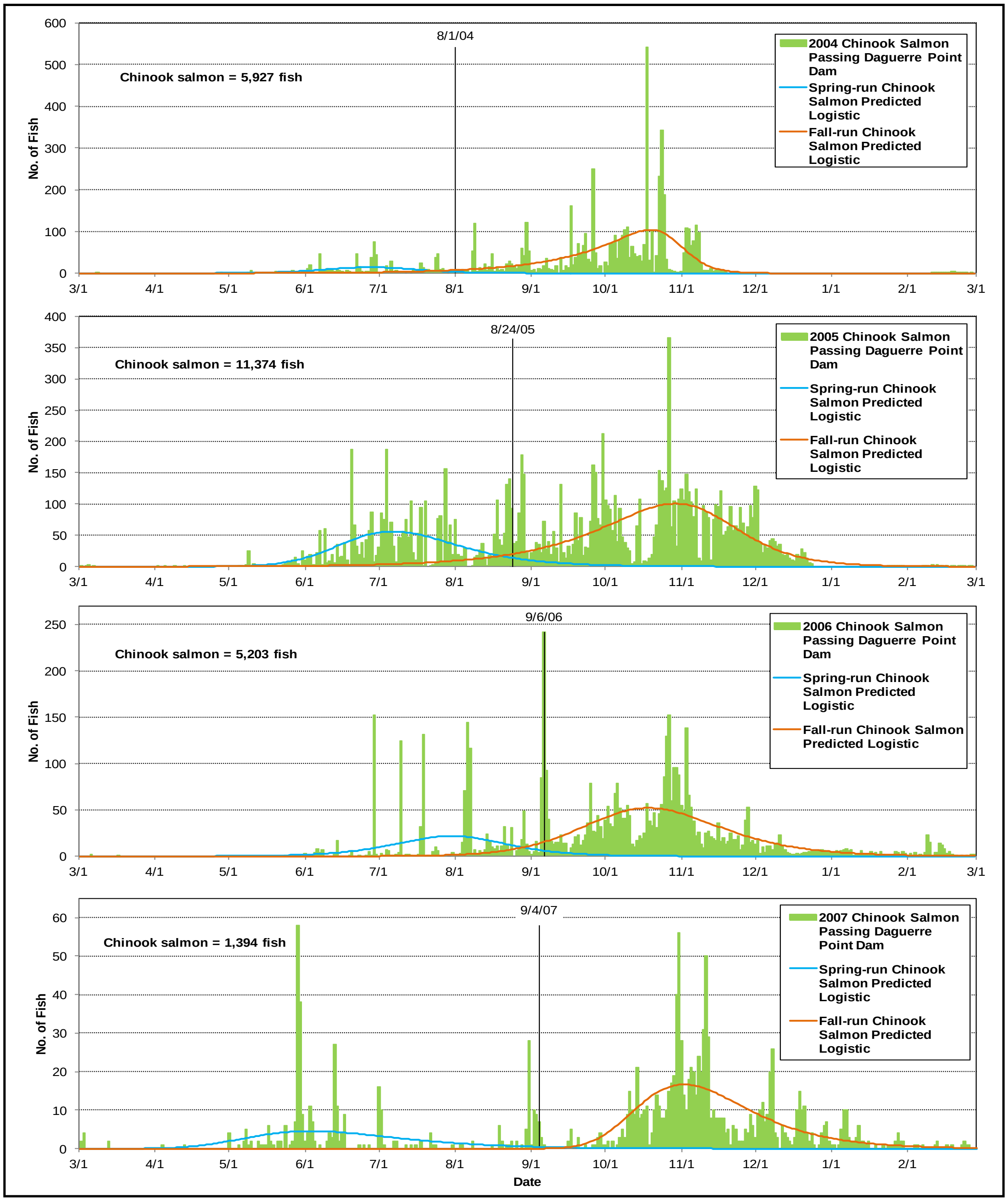


Figure VIII-19. Daily number of Chinook salmon passing upstream of Daguerre Point Dam during the 2004 to 2007 biological years. Bars indicate the VAKI Riverwatcher daily counts and lines indicate the predicted daily distributions of spring-run (blue line) and fall-run (orange line) Chinook salmon based on the fitting of two generalized logistic functions to the data. The demarcation date differentiating the two runs of Chinook salmon is indicated for each year (Source: RMT 2013).

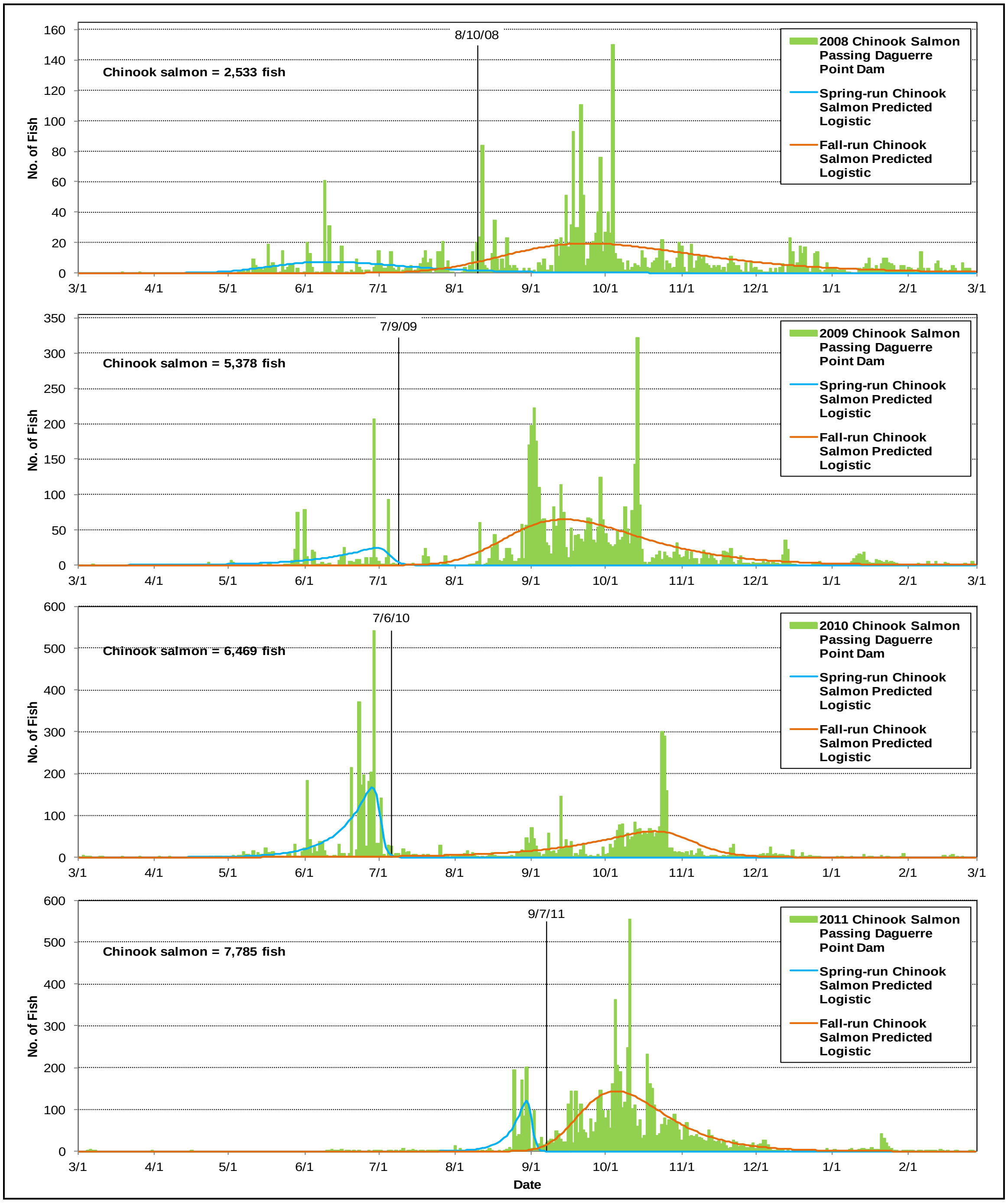


Figure VIII-20. Daily number of Chinook salmon passing upstream of Daguerre Point Dam during the 2008 to 2011 biological years. Bars indicate the VAKI Riverwatcher daily counts and lines indicate the predicted daily distributions of spring-run (blue line) and fall-run (orange line) Chinook salmon based on the fitting of two generalized logistic functions to the data. The demarcation date differentiating the two runs of Chinook salmon is indicated for each year. (Source: RMT 2013)

Table VIII-7. Annual number of spring-run and fall-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam, and the estimated annual percentage of spring-run Chinook salmon relative to all Chinook salmon each year. (Source: RMT 2013)

Run	**Biological Year**							
	2004	**2005**						
	738	3,592	1,326	372	521	723	2,886	1,159
	12.5%	31.6%	25.5%	26.7%	20.6%	13.4%	44.6%	14.9%
Fall-run Chinook Salmon	5,189	7,782	3,877	1,022	2,012	4,655	3,583	6,626
	87.5%	68.4%	74.5%	73.3%	79.4%	86.6%	55.4%	85.1%

Annual Abundance of Spring-run Chinook Salmon

For the period (2004-2011) during which VAKI Riverwatcher data are available, the annual number of spring-run Chinook salmon estimated to have passed upstream of Daguerre Point Dam ranged from 372 in 2007 to 3,592 in 2005, with an average of 1,415 (RMT 2013). The abundance of spring-run Chinook salmon during the past two years has been substantially higher than the three years prior (RMT 2013).

As previously described by NMFS (2011a), populations with a low risk of extinction (less than 5 percent chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year). For the last three consecutive years, an estimated total of 4,768 spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 1,589 fish per year (RMT 2013). However, as further discussed below, the annual abundances of phenotypic spring-run Chinook salmon in the lower Yuba River are strongly influenced by hatchery fish (RMT 2013).

Trends in the Annual Abundance of Spring-run Chinook Salmon

The statistical approach recommended by Lindley *et al.* (2007) was followed by RMT (2013) to examine whether the abundance of lower Yuba River spring-run Chinook salmon exhibited a statistically significant linear trend over time during the eight most recent years for which VAKI Riverwatcher data are available. The natural logarithms of the abundance estimates of lower Yuba River spring-run Chinook salmon for the eight most recent years (2004-2011) were linearly regressed against time (year) using a simple least-squares approach (RMT 2013). The estimated slope of the resulting line is a measure of the average rate of change of the abundance in the population over time.

Figure VIII-21 displays the antilogarithmic transformation of the estimated annual number of spring-run Chinook salmon passing upstream of Daguerre Point Dam from 2004-2011 (RMT 2013). Figure VIII-21 demonstrates that the abundance of spring-run Chinook salmon in the lower Yuba River has exhibited a very slight increase over the eight years examined. However, the coefficient of determination is very weak ($r^2 = 0.0005$) and the slope is not statistically significantly different from zero ($P = 0.96$), indicating that the positive trend is not significant (RMT 2013). The relationship indicates that the phenotypic spring-run Chinook salmon annual abundance over this time period is stable, and is not exhibiting a significant declining trend (RMT 2013). These abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley *et al*. 2007). However, the RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because they presumably apply to independent populations and, as previously discussed, lower Yuba River anadromous salmonids

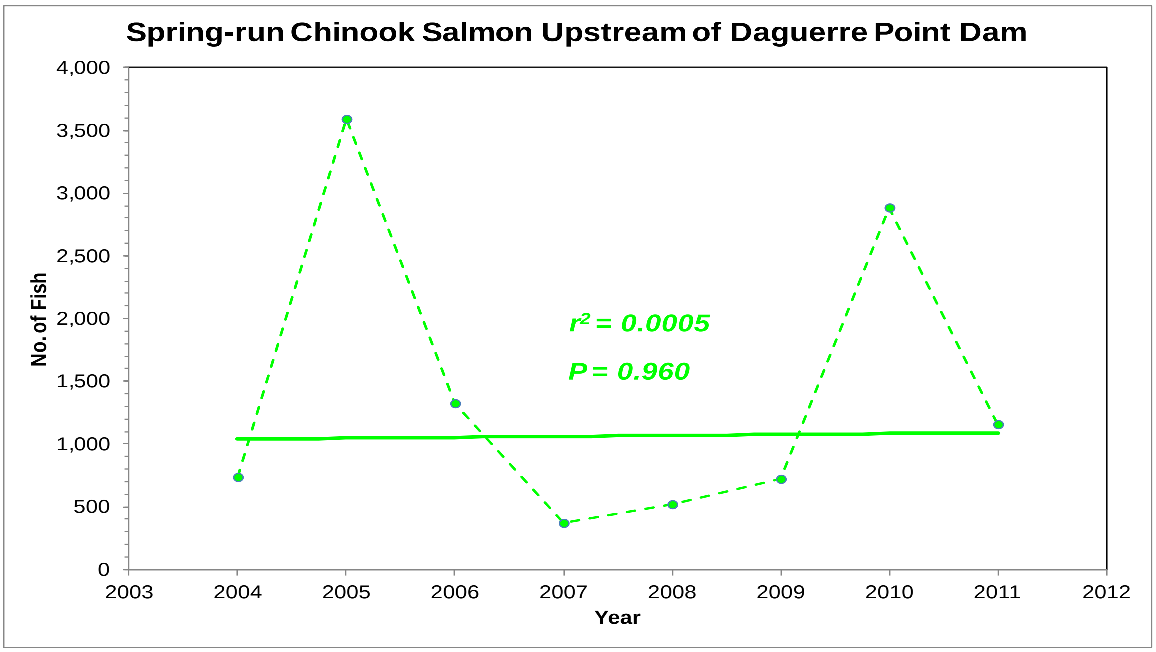


Figure VIII-21. Temporal trend and estimated annual number of phenotypic adult spring-run Chinook salmon passing upstream of Daguerre Point Dam from 2004 through 2011. (Source: RMT 2013)

represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs. As previously mentioned, the annual abundances of phenotypic spring-run Chinook salmon in the lower Yuba River are strongly influenced by hatchery fish, as discussed below.

Annual Abundance of Adipose Fin-clipped and Non Adipose Fin-Clipped Spring-run Chinook Salmon

Because the VAKI Riverwatcher systems located at both the north and south ladder of Daguerre Point Dam can record both silhouettes and electronic images of each fish passage event, the systems were able to differentiate Chinook salmon with adipose fins clipped or absent from Chinook salmon with their adipose fins intact. Thus, annual series of daily counts of Chinook salmon with adipose fins clipped (*i.e.*, ad-clipped fish) and with adipose fins intact (*i.e.*, not ad-clipped fish) that passed upstream of Daguerre Point Dam from March 1, 2004 through February 29, 2012 were obtained by RMT (2013).

The estimated numbers of spring-run Chinook salmon of hatchery (*i.e.*, ad-clipped fish) and potentially non-hatchery origin (*i.e.*, not ad-clipped fish) passing upstream of Daguerre Point Dam for the last eight years of available VAKI Riverwatcher data are presented in Table VIII-8. Examination of Table VIII-8 demonstrates a sharp increase in the annual percent contribution of ad-clipped phenotypic spring-run Chinook salmon to the total estimated annual run beginning in 2009 and extending through 2011 (RMT 2013). This may be due, in part, to the fact that FRFH-origin spring-run Chinook salmon were fractionally marked prior to 2005 and 100 percent marked thereafter. These fish would have returned as age-3 fish during 2008. Also, fractional marking of fall-run hatchery fish at the FRFH started during 2006, and these fish may return, to some extent, as phenotypic spring-run Chinook salmon. Age 3 fish would have returned during 2009. The first full year (age 3 and age 4) of recovery data from the CFM program occurred during 2010. Evaluation of the lower Yuba River carcass survey data indicated that hatchery-origin Chinook salmon comprised an estimated 71 percent of the total 2010 Chinook salmon run (Kormos *et al*. 2012, as cited in RMT 2013), although it was not possible to differentiate between phenotypic spring- and fall-run Chinook salmon in the lower Yuba River carcass surveys (RMT 2013).

Table VIII-8. Estimated numbers of Chinook salmon, ad-clipped and non ad-clipped phenotypic spring-run Chinook salmon that passed upstream of Daguerre Point Dam annually from 2004 through 2011. (Source: RMT 2013)

Year	Demarcation Date	Chinook Salmon Passage Upstream of Daguerre Point Dam				
		All Chinook Salmon	Spring-run Chinook Salmon			
			Total	Ad-Clipped	Not Ad-Clipped	% Ad-Clipped
2004	8/1/04	5,927	738	72	666	10
2005	8/24/05	11,374	3,592	676	2,916	19
2006	9/6/06	5,203	1,326	81	1,245	6
2007	9/4/07	1,394	372	38	334	10
2008	8/10/08	2,533	521	15	506	3
2009	7/9/09	5,378	723	213	510	29
2010	7/6/10	6,469	2,886	1,774	1,112	61
2011	9/7/11	7,785	1,159	323	836	28

The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size in the lower Yuba River, as implied by the percentage of adipose fin-clipped fish passing upstream of Daguerre Point Dam during the annual defined phenotypic period, has been 20.8 percent over the eight years of available data and, assuming a 3-year generation, the four most recent 3-year running averages of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size have been 39.6 percent, 31.3 percent, 14.2 percent, and 6.4 percent, respectively. The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run sizes of these four generations is 22.9 percent. The RMT (2013) recognized that there are limitations to simply using percent adipose fin-clipped spring-run Chinook salmon passing through the VAKI Riverwatcher systems as an estimate of total hatchery influence, and that resulting estimates should be considered as minimum estimates. It is important to note that the adipose fin-clipped phenotypic spring-run Chinook salmon abundance represents a minimum indicator of hatchery-origin individuals due to fractional marking of spring-run hatchery fish prior to 2005, and constant fractional marking (CFM) of fall-run hatchery fish at the FRFH since 2006 which may return as phenotypic spring-run Chinook salmon.

It also is recognized that the hatchery influence criterion presumably is applicable to an independent, genetically distinct population. However, as previously discussed, the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.

Applicability of Additional VSP Parameters and Extinction Risk Criteria

The M&E Program Framework developed by the RMT (2010) utilized VSP performance indicators that were identified based on the precept that the lower Yuba River anadromous salmonid populations represented independent populations. However, the RMT has identified a substantial amount of reproductive interaction between lower Yuba River and lower Feather River anadromous salmonid stocks. As described in RMT (2013), phenotypic spring-run Chinook salmon in the lower Yuba River likely represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, hybridization with Feather River fall- and spring-run Chinook salmon stocks, and hybridization with the FRFH spring-run Chinook salmon stock, which itself represents hybridization between Feather River fall- and spring-run Chinook salmon populations. Additionally, it is likely that anadromous *O. mykiss* stocks are similarly hybridized, with fluid intermixing of lower Feather River and lower Yuba River fish.

The recognition of the extent of hybridization and lack of reproductive isolation of lower Yuba River and lower Feather River anadromous salmonid stocks logically constrains the manner in which the VSP concept can be applied to the lower Yuba River, because many of the VSP metrics are designed to evaluate the viability of discrete, independent populations. Even the simplified approach suggested by Lindley *et al*. (2007) to evaluate 'extinction risk' is of limited applicability in the evaluation of highly introgressed populations whose evaluation metrics are directly influenced by other stocks, and out-of-basin factors.

Lindley *et al*. (2007) provide criteria to assess the level of risk of extinction of Pacific salmonids based on population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. Populations with a low risk of extinction (less than 5 percent chance of extinction in 100 years) are those with a minimum total escapement of 2,500 spawners in 3 consecutive years (mean of 833 fish per year), no apparent decline in escapement, no catastrophic declines within the last 10 years, and a low hatchery influence (NMFS 2011b). The overall estimated risk of extinction for the population is determined by the highest risk score for any category Lindley *et al*. (2007). While more detailed population viability assessment (PVA) models could be constructed to assess Chinook salmon populations, Lindley *et al*. (2007) suggest any PVA results should be compared with the results of applying their simpler criteria to estimate status (NMFS 2011b).

Only some of the VSP performance indicators identified in the RMT (2010) M&E Program framework and some of the extinction risk criteria provided by Lindley *et al*. (2007) are appropriate for application specifically to lower Yuba River anadromous salmonids. VSP performance indicators regarding spatial structure are applicable to the habitat conditions in the lower Yuba River. Similarly, the catastrophe occurrence extinction risk criterion also is applicable to the lower Yuba River. The extinction risk criteria including abundance, and trends in abundance are of limited applicability and serve as illustrative comparative measures in consideration of the non-independent salmonid populations in the lower Yuba River. The hatchery risk extinction criterion does not appear to be applicable to the non-independent lower Yuba River salmonid populations. Considerations regarding each of these applicabilities are discussed below.

Spatial Structure

According to McElhany *et al*. (2000), spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics, as well as on the dispersal characteristics of individuals in the population.

Performance indicators and analytics addressing spatial structure include spatial organization of morphological units (*e.g.*, lateral variability/diversity, adjacency, randomness, and abundance), persistence of morphological units through time, and the quality, number, size and distribution of morphological units available for spawning Chinook salmon. Additional considerations include floodplain connectivity, entrenchment, channel sinuosity, substrate size, changes in topographic depth, scour and fill processes, bankfull and flood flow recurrence interval, and maintenance of watershed processes to maintain suitable habitat for anadromous salmonid lifestages.

As stated in the M&E Plan (RMT 2010a), the spatial structure evaluation includes examination of maintenance of watershed processes and regulatory management practices to create and maintain suitable habitat for all freshwater lifestages of spring-run and fall-run Chinook salmon, and steelhead. As discussed in RMT (2013), one of the performance indicators preliminarily evaluated by Wyrick and Pasternack (2012) is whether the sequence of morphological units in the lower Yuba River is non-random. Highly disturbed systems often degrade into homogeneity or randomness.

Of the 12 major near-bankfull morphological units, the most uniformly distributed (*i.e.*, randomly located) units are slackwater, slow glide, and lateral bar. As an example of non-uniform distribution, pool units were predominantly found in the upstream reaches (*i.e.*, Englebright and Timbuctoo Bend) and the downstream reach (*i.e.*, Marysville), but were less abundant in the middle, wider reaches (*i.e.*, Daguerre Point Dam and Dry Creek). Consequently, evaluation of the morphological units in the lower Yuba River as part of the spatial structure analyses indicates that, in general, the sequence of morphological units is non-random, indicating that the channel has been self-sustaining of sufficient duration to establish an ordered spatial structure (refer to RMT 2013 for additional discussion).

Another new method for analyzing the morphological unit organization that Wyrick and Pasternack (2012) developed is an adjacency probability analysis, which evaluates the frequency at which each morphological unit is adjacent to every other unit, and compares that against random adjacency expectations. Results of this analysis indicate that the in-channel units near the thalweg typically exhibit low adjacency probabilities to the bar units, although they do exhibit higher-than-random probabilities to other in-channel units.

Wide, diverse rivers should also exhibit lateral variability in its form-process associations. In the lower Yuba River, morphological unit organization highlights the complexity of the channel geomorphology, as well as the complex and diverse suite of potential habitat at any given location in the Yuba River. The above summary (described in more detail in RMT 2013) illustrates that spatial structure of morphological units in the lower Yuba River is complex, diverse, and persistent.

<u>Catastrophe Occurrence</u>

According to Lindley *et al*. (2007), the catastrophe criteria trace back to Mace and Lande (1991), and the underlying theory is further developed by Lande (1993). The following discussion was taken from Lindley *et al*. (2007). The overall goal of the catastrophe criteria is to capture a sudden shift from a low risk state to a higher one. Catastrophes are defined as instantaneous declines in population size due to stochastic events that occur randomly in time, in contrast to regular environmental variation, which occurs constantly and can have both positive and negative effects on the population. Lindley *et al*. (2007) view catastrophes as singular events with an identifiable cause and only negative immediate consequences, as opposed to normal environmental variation which can produce very good as well as very bad conditions. Some examples of catastrophes include disease outbreaks, toxic spills, or volcanic eruptions. A high risk situation is created by a 90 percent decline in population size over one generation. A moderate risk event is one that is smaller but biologically significant, such as a year-class failure.

<u>Extinction Risk Criteria and Application</u>

Lindley *et al*. (2007) characterized the spring-run Chinook salmon population in the lower Yuba River as data deficient, and therefore did not characterize its viability. In 2007, there was limited information on the current population size of spring-run Chinook salmon in the lower Yuba River. NMFS' 5 Year Status Review for the Central Valley Spring-run Chinook Salmon ESU (NMFS 2011b) reported that the annual spawning run size of spring-run Chinook salmon in the lower Yuba River generally ranges from a few hundred to a few thousand fish with the annual trend closely following the annual abundance trend of the Feather River Hatchery spring-run Chinook salmon population. NMFS (2011a) concluded that the Yuba River spring-run Chinook salmon population satisfies the moderate extinction risk criteria for abundance, but likely falls into the high risk category for hatchery influence.

Criteria to assess extinction risk of Pacific salmonids are based on population size, recent population decline, occurrences of catastrophes within the last 10 years, and the impacts of hatchery influence (Lindley *et al*. 2007). As previously discussed, for the last three consecutive years, an estimated total of 4,768 phenotypic spring-run Chinook salmon have passed upstream of Daguerre Point Dam, with an average of 1,589 fish per year. Catastrophes have not occurred in the Yuba River Basin, nor have catastrophic declines been observed within the phenotypic spring-run Chinook salmon abundance estimates within the last ten years. The abundance of phenotypic spring-run Chinook salmon in the lower Yuba River has exhibited a very slight increase over the eight years examined, although the positive trend is not statistically significant. These abundance and trend considerations would correspond to low extinction risk according to NMFS criteria (Lindley *et al*. 2007). However, RMT (2013) questions the applicability of any of these criteria addressing extinction risk, because they presumably apply to independent populations and, as previously discussed, lower Yuba River anadromous salmonids represent introgressive hybridization of larger Feather-Yuba river populations, with substantial contributions of hatchery-origin fish to the annual runs. For additional discussion, see RMT (2013).

The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size in the lower Yuba River, as inferred by the percentage of adipose fin-clipped fish passing upstream of Daguerre Point Dam during the annual defined phenotypic period, has been 20.8 percent over the eight years of available data and, assuming a 3-year generation, the four most recent 3-year running averages of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run size have been 39.6 percent, 31.3 percent, 14.2 percent, and 6.4 percent, respectively. The average contribution of adipose fin-clipped phenotypic spring-run Chinook salmon to the total annual run sizes of these four generations is 22.9 percent. RMT (2013) recognized that there are limitations to simply using percent adipose fin-clipped spring-run Chinook salmon passing through the VAKI Riverwatcher systems as an estimate of total hatchery influence, and that resulting estimates should be considered as minimum estimates. As previously discussed, it is important to note that the adipose fin-clipped phenotypic spring-run Chinook salmon abundance represents a minimum indicator of hatchery-origin individuals due to fractional marking of spring-run hatchery fish prior to 2006, and constant fractional marking (CFM) of fall-run hatchery fish at the FRFH which may return as phenotypic spring-run Chinook salmon.

It also is recognized that the hatchery influence criterion presumably is applicable to an independent, genetically distinct population (RMT 2013). However, as previously discussed, the phenotypic spring-run Chinook salmon in the lower Yuba River actually represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents a hybridization between Feather River fall- and spring-run Chinook salmon populations.

Although straying of FRFH-origin Chinook salmon into the lower Yuba River occurs, available information indicates that: (1) the FRFH spring-run Chinook salmon is included in the ESU, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (70 FR 37160), (2) the spring-run

Chinook program at FRFH is an Integrated Recovery Program which seeks to aid in the recovery and conservation of Central Valley spring-run Chinook salmon (DWR 2009a), and (3) fish produced at FRFH are intended to spawn in the wild or be genetically integrated with the targeted natural population as FRFH broodstock (DWR 2009a).

Public Review Draft Recovery Plan Considerations

According to NMFS (2005) *Recommendations for the Contents of Biological Assessments and Biological Evaluations* pertaining to status of the species in the action area, a BA should:

> Identify any recovery plan implementation that is occurring in the action area, especially priority one action items from recovery plans.

The NMFS Draft Recovery Plan establishes three population levels to help guide recovery efforts for existing populations, referred to as Core 1, 2, and 3 populations. The NMFS Draft Recovery Plan (pg. 65) identifies lower Yuba River spring-run Chinook salmon [and steelhead] populations as Core 1 populations. Core 1 populations form the foundation of the recovery strategy, and Core 1 populations should be the first focus of an overall recovery effort (NMFS 2009).

To meet recovery objectives for the diversity groups, the conceptual recovery scenarios for the spring-run Chinook salmon ESU (pg. 99) [and the steelhead DPS (pg. 123)] include: (1) securing extant populations by implementing key habitat restoration actions, particularly in the near term, and (2) establishment of additional viable independent populations.

The NMFS Draft Recovery Plan states, that in order to secure a viable independent population of spring-run Chinook salmon (pg. 116), [and to secure the extant population and promote a viable population of steelhead (pg. 140)], in the lower Yuba River, several key near-term and long-term habitat restoration actions were identified, including the following:

- Continued implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all lifestages,
- Improvements to adult salmonid upstream passage at Daguerre Point Dam,
- Improvements to juvenile salmonid downstream passage at Daguerre Point Dam,
- Implementation of a spawning gravel augmentation program in the uppermost reach (*i.e.*, Englebright Dam to the Narrows) of the lower Yuba River,
- Improvements to riparian habitats for juvenile salmonid rearing,
- Creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas, and
- Implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing

The NMFS Draft Recovery Plan includes Priority 1, Priority 2, and Priority 3 recovery actions. The NMFS Draft Recovery Plan Appendix C (pgs. 2, 3) states *"According to NMFS' 1990 Endangered and Threatened Species Listing and Recovery Priority Guidelines (55 FR 24296), recovery actions identified in a Recovery Plan are to be assigned priorities of 1 to 3, as follows:*

Priority 1 – An action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction
Priority 2 – An action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction
Priority 3 – All other actions necessary to provide for full recovery of the species."

The NMFS Draft Recovery Plan (pg. 161)(NMFS 2009) identifies the following proposed action as a Priority 1 recovery action for the Yuba River:

> **Recovery Action 1.9.6.1.** Develop and implement a phased approach to salmon reintroduction planning to recolonize historic habitats above Englebright Dam. Implement actions to: (1) enhance habitat conditions including providing flows and suitable water temperatures for successful upstream and downstream passage, holding, spawning and rearing, and (2) improve access within the area above Englebright Dam, including increasing minimum flows, providing passage at Our House, New Bullards Bar, and Log Cabin dams, and assessing feasibility of passage improvement at natural barriers. The phased approach should include the following measures:
>
> - Conduct feasibility studies,
> - Conduct habitat evaluations,
> - Conduct 3-5 year pilot testing program, and
> - Implement long-term fish passage program

The spring-run Chinook salmon conceptual recovery scenario also includes reintroduction of spring-run Chinook salmon to the candidate areas of the North Fork, Middle Fork, and South Fork Yuba rivers. Reintroduction of anadromous salmonids above Englebright Dam has been the subject of recent and current investigations. Evaluation of habitat suitability for anadromous salmonids upstream of Englebright Dam was recently undertaken (DWR 2007), but those evaluations have yet to be finalized as part of the Upper Yuba River Watershed Studies Program. Currently, NMFS is evaluating the feasibility of providing passage for anadromous salmonids at Englebright Dam. Hence, the conceptual recovery scenario does not further discuss specific restoration actions associated with reintroduction.

The NMFS Draft Recovery Plan (pg. 161) identifies the following proposed action as a Priority 1 recovery action for the Yuba River:

> **Recovery Action 1.9.6.2.** Improve spawning habitat in the lower river by gravel restoration program below Englebright Dam and improve rearing habitat by increasing floodplain habitat availability.
>
> Also, a gravel restoration program below Englebright Dam is discussed as a Priority 2 action on pg. 73, and lower Yuba River floodplain habitat availability considerations are discussed as Priority 2 actions on pgs. 73, 74, 76, and 92 of Appendix C in NMFS (2009).

Proposed recovery action 1.9.6.2 actually includes two separate proposed actions: (1) improve spawning habitat in the lower river by gravel restoration program below Englebright Dam, and (2) improve rearing habitat by increasing floodplain habitat availability. Each of these is discussed separately, below.

(1) Improve spawning habitat in the lower river by gravel restoration program below Englebright Dam. The Corps completed the injection of 500 tons of gravel approximately 200 yards downstream of Englebright on November 30, 2007, (Grothe 2011). The Corps completed additional injections of 5,000 tons of gravel on January 13, 2011, August 21, 2012, and August 14, 2013.

(2) Improve rearing habitat by increasing floodplain habitat availability. Since the NMFS Draft Recovery Plan was noticed in the Federal Register on October 6, 2009, substantial efforts have been undertaken to identify, develop and consider the relative merits of habitat restoration actions in the lower Yuba River. The need for restoration actions, identification of the specific actions themselves, and the relative merits of the actions to expand habitat and accomplish the goals of the Oroville FERC Relicensing Habitat Expansion Agreement (HEA) were presented in a report submitted to the HEA Steering Committee during early November 2009 (YCWA *et al*. 2009). This report represents a comprehensive consideration of such restoration actions developed for the lower Yuba River. The YCWA *et al*. (2009) report identified several factors that continue to limit juvenile spring-run Chinook salmon [and steelhead] rearing habitat suitability in the lower Yuba River, including: (1) sparse and restricted amounts of riparian vegetation and associated instream object and overhanging object cover, (2) limited aquatic habitat complexity and diversity, and (3) altered natural river function and morphology in the lower Yuba River. Shaded Riverine Aquatic (SRA) habitat generally occurs in the lower Yuba River as scattered, short strips, with the most extensive and continuous segments of SRA habitat occurring along bars where recent channel migrations or avulsions have cut new channels through stands of riparian vegetation.

Regarding juvenile salmonid rearing habitat, the NMFS Draft Recovery Plan states that, in order to secure a viable independent population of spring-run Chinook salmon (pg. 116), [and to secure the extant population and promote a viable population of steelhead (pg.140)] in the lower Yuba River, the following key near-term and long-term habitat restoration actions should be implemented: (1) the creation and restoration of side channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas, (2) improvements to riparian habitats for juvenile salmonid rearing, and (3) implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing. Of the proposed actions regarding juvenile rearing, the actions that would be most beneficial and cost-effective for juvenile rearing habitat, and the actions that would yield the most immediate benefits, are the creation of new side-channel habitats associated with existing stands of riparian vegetation that are not presently hydraulically connected to the river channel (YCWA 2010). Specifically, new side-channel habitats would: (1) increase and maintain existing riparian vegetation, (2) provide instream object and overhanging object cover, (3) provide new SRA, and associated allochthonous food sources for rearing juveniles, (4) increase aquatic habitat complexity and diversity, (5) provide habitats more consistent with those previously available in the upper watershed, and (6) provide predator escape cover, and overall increased survival of juvenile spring-run Chinook salmon and steelhead.

(D) CCV steelhead DPS

(1) Steelhead General Life History and Habitat Requirements

Steelhead exhibits perhaps the most complex suite of life-history traits of any species of Pacific salmonid. Members of this species can be anadromous or freshwater residents and, under some circumstances, members of one form can apparently yield offspring of another form (YCWA 2010). Unlike salmon steelhead can make more than one migration to the ocean and spawn more than once.

“Steelhead” is the name commonly applied to the anadromous form of the biological species *O. mykiss*. The physical appearance of *O. mykiss* adults and the presence of seasonal runs and year-round residents indicate that both anadromous (steelhead) and resident rainbow trout exist in the lower Yuba River downstream of Englebright Dam, although no definitive visual characteristics have been identified to distinguish young steelhead from resident trout (SWRI *et al*. 2000). Zimmerman *et al*. (2009) analyzed otolith strontium:calcium (Sr:Ca) ratios in 964 otolith samples comprised of young-of-year, age-1, age-2, age-3, and age-4+ fish to determine maternal origin and migratory history (anadromous vs. non-anadromous) of *O. mykiss* collected in Central Valley rivers between 2001 and 2007, including the lower Yuba River. The proportion of steelhead progeny in the lower Yuba River (about 13 percent) was intermediate to the other rivers examined (Sacramento, Deer Creek, Calaveras, Stanislaus, Tuolumne, and Merced), which ranged from about 4 percent in the Merced River to 74 percent in Deer Creek (Zimmerman *et al*. 2009). Results from Mitchell (2010) indicate *O. mykiss* in the lower Yuba River are exhibiting a predominately residential life history pattern. He found that 14 percent of scale samples gathered from 71 *O. mykiss* moving upstream and trapped in the fish ladder at Daguerre Point Dam from November 1, 2000, through March 28, 2001, exhibited an anadromous life history. Thus, it is recognized that both anadromous and resident life history strategies of *O. mykiss* have been and continue to be present in the lower Yuba River**.**

The RMT (2013) developed representative temporal distributions for specific steelhead lifestages in the lower Yuba River through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program. As with spring-run Chinook salmon, the resultant lifestage periodicities are intended to encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population. The lifestage-specific periodicities for steelhead in the lower Yuba River are summarized in Table VIII-9, and are discussed below.

Steelhead Adult Immigration and Holding

Table VIII-9. Lifestage-specific periodicities for steelhead in the lower Yuba River (Source: RMT 2013).

Lifestage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Steelhead																								
Adult Immigration & Holding	■	■	■	■	■	■									■	■	■	■	■	■	■	■	■	■
Spawning	■	■	■	■	■	■	■	■																
Embryo Incubation	■	■	■	■	■	■	■	■	■	■														
Fry Rearing							■	■	■	■	■	■	■	■										
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Juvenile Downstream Movement							■	■	■	■	■	■	■	■	■	■	■	■						
Smolt (Yearling+) Emigration	■	■	■	■	■	■	■												■	■	■	■	■	■

The immigration of adult steelhead in the lower Yuba River has been reported to occur from August through March, with peak immigration from October through February (CALFED and YCWA 2005, McEwan and Jackson 1996). CDFG (1984a) reported that during the drought years of 1976-1977, two steelhead immigration peaks were observed – one in October and one in February. CDFG (1991a) reported that steelhead enter the lower Yuba River as early as August, migration peaks in October through February, and may extend through March. In addition, they report that a run of “half-pounder” steelhead occurred from late-June through the winter months.

The RMT (2010b) examined preliminary data and identified variable annual timing of *O. mykiss* ascending the fish ladders at Daguerre Point Dam since the VAKI Riverwatcher infrared and videographic sampling system began operations in 2003. For example, Massa *et al*. (2010) state that peak passage of steelhead at Daguerre Point Dam occurred from April through June during 2007. They also suggest that the apparent disparity between the preliminary data and other reports of steelhead adult immigration periodicity may be explained by the previously reported (Zimmerman *et al*. 2009, Mitchell 2010) relatively high proportion of resident (vs. anadromous) *O. mykiss* occurring in the lower Yuba River, because the VAKI Riverwatcher system did document larger (>40.6 cm) *O. mykiss* ascending the fish ladders at Daguerre Point Dam during the winter months (December through February). The observed timing of larger *O. mykiss* ascending the fish ladders at Daguerre Point Dam more closely corresponds with previously reported adult steelhead immigration periodicities. The RMT (2010b, 2013) identified the period extending from August through March as encompassing the majority of the upstream migration and holding of adult steelhead in the lower Yuba River.

Steelhead Adult Spawning

Steelhead spawning has been reported to generally extend from January through April in the lower Yuba River (CALFED and YCWA 2005, CDFG 1991a, YCWA *et al*. 2007). The RMT conducted a pilot redd survey from September 2008 through April 2009 (RMT 2010a). Surveys were not conducted during March, which is a known time for steelhead spawning in other Central Valley rivers, due to high flows and turbidity. An extensive area redd survey was conducted by surveyors kayaking from the downstream end of the Narrows pool to the Simpson Lane Bridge. During the extensive area redd survey, redds that were categorized as steelhead based on redd size criteria were reportedly observed from October through April. However, some of those redds categorized as steelhead, particularly during October, may actually have been small Chinook salmon redds because the size criteria used to identify steelhead redds was found to be 53 percent accurate for identifying steelhead redds in the Feather River (USFWS 2008).

Campos and Massa (2010b and 2011) synthesized results of near-census redd surveys conducted on the lower Yuba River during the 2009 and 2010 survey periods. During both annual survey efforts, a substantial proportion of the weekly strata in the January through April time periods were not sampled due to elevated flows and associated turbidity levels. Nonetheless, RMT (2013) demonstrated that based upon cumulative temporal distribution curves, the steelhead spawning period in the lower Yuba River is generally characterized to extend from January through April.

Steelhead spawning has been reported to primarily occur in the lower Yuba River upstream of Daguerre Point Dam (SWRI *et al*. 2000, YCWA *et al*. 2007). Kozlowski (2004) states that field observations during winter and spring 2000 (YCWA unpublished data, as cited in Corps 2013b) indicated that the majority of steelhead spawning in the lower Yuba River occurred from Long Bar upstream to the Narrows, with the highest concentration of redds observed upstream of the Highway 20 Bridge. USFWS (2007) data were collected on *O. mykiss* redds in the lower Yuba River during 2002, 2003, and 2004, with approximately 98 percent of the redds located upstream of Daguerre Point Dam. During the pilot redd survey conducted from the fall of 2008 through spring of 2009, the RMT (2010) report that most (65 percent) of the steelhead redds were observed upstream of Daguerre Point Dam. Female steelhead construct redds within a range of depths and velocities in suitable gravels, oftentimes in pool tailouts and heads of riffles. In the lower Yuba River, steelhead have also been observed to spawn in side channel areas (YCWA unpublished data, as cited in Corps 2013b).

Steelhead Embryo Incubation

The RMT (2013) identified the period of January through May as encompassing the majority of the steelhead embryo incubation period in the lower Yuba River. Following deposition of fertilized eggs in the redd, they are covered with loose gravel.

Steelhead Juvenile Rearing and Outmigration

In the lower Yuba River, juvenile steelhead exhibit variable durations of rearing. The RMT (2010b) distinguished fry, juvenile, and yearling+ lifestages through evaluation of bi-weekly length-frequency distributions of *O. mykiss* captured in rotary screw traps in the lower Yuba River, and other studies that report length-frequency estimates (Mitchell 2010, CDFG 1984a). Some juvenile *O. mykiss* may rear in the lower Yuba River for short periods (up to a few months) and others may spend from one to three years rearing in the river.

Some age-0 *O. mykiss* disperse downstream soon after emerging and this continues throughout the year (Kozlowski 2004). Thus, the steelhead fry (individuals less than about 45 mm) lifestage generally extends from the time of initial emergence (based upon accumulated thermal units from the time of egg deposition through hatching and alevin incubation) until three months following the end of the spawning period. YCWA (2010) identified the fry rearing lifestage as generally extending from mid-March through July, and identified the juvenile rearing lifestage as extending year-round. Based on all information collected to date, the RMT (2013) identified the steelhead fry rearing period as extending from April through July.

Juvenile steelhead have been reported to rear in the lower Yuba River for up to 1 year or more. CDFG (1991a) reported that juvenile steelhead rear throughout the year in the lower Yuba River, and may spend from 1 to 3 years rearing in the river. Scale analysis conducted by Mitchell (2010) indicates the presence of at least four age categories for *O. mykiss* in the lower Yuba River that spent 1, 2, or 3 years in freshwater and 1 year at sea before returning to the lower Yuba River to spawn.

Based on the combined results from electrofishing and snorkeling surveys conducted during the late 1980s, CDFG (1991a) reported that juvenile steelhead were observed in all river reaches downstream of the Englebright Dam and, in addition to Chinook salmon, were the only fish species observed in the Narrows Reach. They also indicated that most juvenile steelhead rearing occurred above Daguerre Point Dam. SWRI *et al*. (2000) summarized data collection in the lower Yuba River obtained from 1992 through 2000. Since 1992, Jones and Stokes Associates (JSA) biologists have conducted fish population surveys in the lower Yuba River using snorkel surveys to determine annual and seasonal patterns of abundance and distribution of juvenile *O. mykiss* (and Chinook salmon) during the spring and summer rearing periods. The primary rearing habitat for juvenile *O. mykiss* is upstream of Daguerre Point Dam. In 1993 and 1994, snorkeling surveys indicated that the population densities and overall abundance of juvenile *O. mykiss* (age 0 and 1+) were substantially higher upstream of Daguerre Point Dam, with decreasing abundance downstream of Daguerre Point Dam.

Similarly, Kozlowski (2004) found higher abundances of juvenile *O. mykiss* above Daguerre Point Dam, relative to downstream of Daguerre Point Dam. Kozlowski (2004) observed age-0 *O. mykiss* throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance from the Narrows. Approximately 82 percent of juvenile *O. mykiss* were observed upstream of Daguerre Point Dam. Kozlowski (2004) suggested that the distribution of age-0 *O. mykiss* appeared to be related to the distribution of spawning adults. SWRI *et al*. (2000) suggested that higher abundances of juvenile *O. mykiss* above Daguerre Point Dam may have been due to larger numbers of spawners, greater amounts of more complex, high quality cover, and lower densities of predators such as striped bass and American shad, which reportedly were restricted to areas below Daguerre Point Dam.

In the lower Yuba River, Kozlowski (2004) reports that juvenile *O. mykiss* were observed in greater numbers in pool habitats than in run habitats. He suggests that results of his study indicated a relatively higher degree of habitat complexity, suitable for various lifestages, in the reaches just below the Narrows compared to farther downstream. The Narrows reach includes greater occurrence of pool-type microhabitat suitable for juvenile *O. mykiss* rearing, as well as small boulders and cobbles preferred by the age-0 emerging lifestage (Kozlowski 2004).

Juvenile *O. mykiss* apparently demonstrate a proclivity for near-bank areas, rather than open-channel habitats, in the lower Yuba River. USFWS (2008a) reports 258 observations of juvenile *O. mykiss* and 244 observations of juvenile Chinook salmon, all but 8 of them made near the river banks in the lower Yuba River.

A broad range of *O. mykiss* size classes have been observed in the lower Yuba River during spring and summer snorkeling, electrofishing, and angling surveys (SWRI *et al*. 2000). Juvenile *O. mykiss* ranging in size from 40-150 mm were commonly observed upstream of Daguerre Point Dam. Numerous larger juveniles and resident trout up to 18 inches long were also commonly observed in the mainstem upstream and downstream of Daguerre Point Dam (SWRI *et al*. 2000). Age 0 (young-of-the-year) *O. mykiss* were clearly shown by the distinct mode in lengths of fish caught by electrofishing (40-100 mm fork length). A preliminary examination of scales indicated that most yearling (age 1+) and older *O. mykiss* were represented by fish greater than 110 mm long, including most if not all of the fish caught by hook and line. The sizes of age 0 and 1+ *O. mykiss* indicated substantial annual growth of *O. mykiss* in the lower Yuba River. Seasonal growth of age 0 *O. mykiss* was evident from repeated sampling in 1992 and 1999, but actual growth rates could not be estimated because of continued recruitment of fry (newly emerged juveniles) or insufficient sample sizes (SWRI *et al*. 2000).

Mitchell (2010) reports that analysis of scale growth patterns of juvenile *O. mykiss* in the lower Yuba River indicates a period of accelerated growth during the spring peaking during the summer months, followed by decelerated growth during the fall and winter. Following the second winter, juvenile *O. mykiss* in the lower Yuba River exhibit reduced annual growth in length with continued growth in mass until reaching reproductive age. Additionally, more rapid juvenile and adult *O. mykiss* growth occurred in the lower Yuba River compared to the lower Sacramento River and Klamath River *O. mykiss*, with comparable growth rates to *O. mykiss* in the upper Sacramento River (Mitchell 2010).

CDFG (1991a) reports that juvenile steelhead in the lower Yuba River rear throughout the year, and may spend from one to three years in the river before emigrating primarily from March to June. Salvage data at the Hallwood-Cordua fish screen suggest that most juvenile fish initiated their downstream movements immediately preceding and following a new moon, indicating the presence of lunar periodicity in the timing or outmigration patterns in the lower Yuba River (Kozlowski 2004).

Based on all information collected to date, the RMT (2013) identified the steelhead juvenile rearing period as extending year-round, and the steelhead juvenile downstream movement period as extending from April through September.

In the lower Yuba River, some young-of-year *O. mykiss* were captured in rotary screw traps (RSTs) located downstream of Daguerre Point Dam during late-spring and summer, indicating movement downstream. However, at least some of this downstream movement may be associated with the pattern of flows in the river. Water transfer monitoring in 2001, 2002, and 2004 (YCWA and SWRCB 2001, YCWA 2003, YCWA 2005), generally from about mid-June through September, indicated that the character of the initiation of the water transfers could potentially affect juvenile *O. mykiss* downstream movement. Based upon the substantial differences in juvenile *O. mykiss* downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it was apparent that the increases in juvenile *O. mykiss* downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004 (YCWA *et al*. 2007).

<u>Steelhead Smolt Emigration</u>

In the lower Yuba River, the steelhead smolt emigration period has been reported to extend from October through May (CALFED and YCWA 2005, YCWA *et al*. 2007). The RMT's (2010b, 2013) review of all available data indicate that yearling+ steelhead smolt emigration may extend from October through mid-April.

For the purposes of impact assessment, the RMT (2010b) developed separate water temperature index values for the yearling+ smolt emigration lifestages distinct from values for juvenile steelhead rearing and/or outmigration as juveniles from the lower Yuba River. They assumed that juvenile steelhead that exhibit extended rearing in the lower Yuba River undergo the smoltification process and volitionally emigrate from the river as yearling+ individuals.

<u>Steelhead Lifestage-Specific Water Temperature Suitabilities</u>

Since the RMT prepared its November 2010 water temperature objectives memorandum, additional water temperature monitoring and life history investigations of anadromous salmonids in the lower Yuba River have been conducted by the RMT. Through review of previously conducted studies, as well as recent and currently ongoing data collection activities of the M&E Program, the RMT (2013) developed the following representative steelhead lifestage-specific periodicities and primary locations for water temperature suitability evaluations. The locations used for water temperature evaluations correspond to Smartsville, Daguerre Point Dam, and Marysville.

- Adult Immigration and Holding (August through March) – Smartsville, Daguerre Point Dam, and Marysville,
- Spawning (January through April) – Smartsville and Daguerre Point Dam,
- Embryo Incubation (January through May) – Smartsville and Daguerre Point Dam,

- Juvenile Rearing and Downstream Movement (Year-round) – Daguerre Point Dam and Marysville, and
- Smolt (Yearling+) emigration (October through mid-April) – Daguerre Point Dam and Marysville.

Steelhead lifestage-specific WTI values are provided in Table VIII-10. The lifestages and periodicities presented in Table VIII-10 differ from those presented in Table VIII-9 due to specific lifestages that have the same or distinct upper tolerable WTI values.

Table VIII-10. Steelhead lifestage-specific upper tolerance WTI values.

Lifestage	**Upper Tolerance WTI**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adult Migration	68°F	■■	■■	■■	□□	□□	□□	□□	■■	■■	■■	■■	■■
Adult Holding	65°F	■■	■■	■■	□□	□□	□□	□□	■■	■■	■■	■■	■■
Spawning	57°F	■■	■■	■■	■■	□□	□□	□□	□□	□□	□□	□□	□□
Embryo Incubation	57°F	■■	■■	■■	■■	■■	□□	□□	□□	□□	□□	□□	□□
Juvenile Rearing and Downstream Movement	68°F	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■	■■
Smolt (Yearling+) Emigration	55°F	■■	■■	■■	■□	□□	□□	□□	□□	□□	■■	■■	■■

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. Figure VIII-22 displays daily water temperature monitoring results from October 2006 through June 2013 at Smartsville, Daguerre Point Dam, and Marysville water temperature gages, with steelhead lifestage-specific upper tolerance WTI values. Water temperatures at all three gages are always below the upper tolerance WTI values for juvenile rearing and downstream movement, and adult immigration and holding. The upper tolerance spawning and embryo incubation WTI value is never exceeded at Smartsville, and is generally not exceeded at Daguerre Point Dam with the exception of the end of May of some years. The smolt (yearling+) emigration upper tolerance WTI value generally is not exceeded at the Smartsville Gage, and is not exceeded at the Daguerre Point Dam and Marysville gages after mid-November.

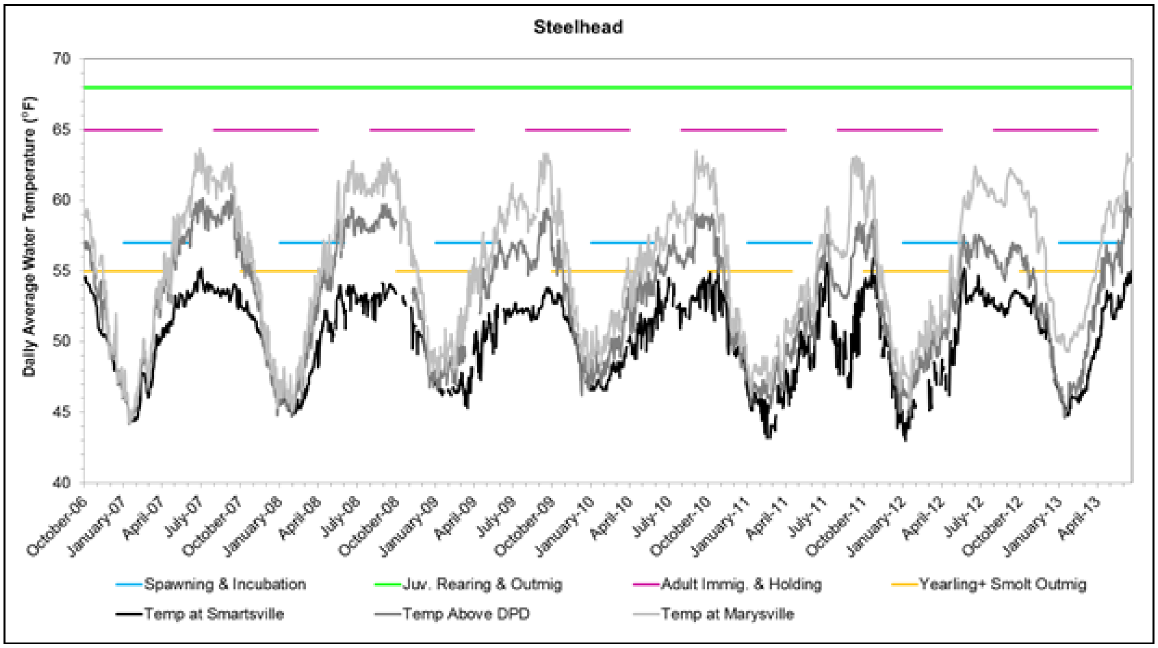


Figure VIII-22. Lower Yuba River monitored water temperatures and steelhead upper tolerance WTI values.

(2) Steelhead Limiting Factors, Threats and Stressors

Lower Yuba River Steelhead

The aforementioned list of limiting factors and stressors pertinent to the spring-run Chinook salmon ESU also pertain to the steelhead DPS. Stressors that are unique to the steelhead DPS, or substantially differ in the severity from the stressor for the previously described spring-run Chinook salmon ESU, include the following.

- Destruction, Modification, or Curtailment of Habitat or Range,
- Overutilization for Commercial, Recreational, Scientific or Education Purposes (inland sport harvest),
- Disease and/or Predation,
- Inadequacy of Existing Regulatory Mechanisms (Federal efforts, non-Federal efforts),
- Other Natural and Man-Made Factors Affecting the Continued Existence of the DPS, and
- Non-Lifestage Specific Threats and Stressors for the DPS (artificial propagation programs, small population size, genetic integrity and long-term climate change).

The Central Valley spring-run Chinook salmon ESU, the BiOp for the CVP/SWP OCAP consultation (NMFS 2009a) covered CVP and SWP facilities and potentially affected waterbodies, which did not include the lower Yuba River. NMFS (2009a) stated that CVP/SWP system-wide operations are expected to result in direct mortality to steelhead, including: (1) increased predation of juveniles when the RBDD gates are down, (2) entrainment of juveniles into the Central and South Delta, (3) entrainment and impingement of juveniles at the CVP/SWP pumps in the South Delta (both direct and indirect loss), and (4) loss associated with the collection, handling, trucking and release program.

According to NMFS (2009a), steelhead habitat conditions in the mainstem Sacramento River and the Delta have been adversely affected by long-term CVP/SWP system-wide operations in several ways, including but not limited to: (1) delaying the upstream migration of adult steelhead through RBDD operations, (2) reducing the availability of quality rearing habitat through the seasonal creation of Lake Red Bluff, and (3) creating improved feeding opportunities at RBDD for predators such as pikeminnow and striped bass. In these ways, the CVP/SWP system-wide operations reduced the population's spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the mainstem Sacramento River steelhead population (NMFS 2009a). Beginning in September 2011 and implemented in response to the NMFS OCAP BiOp (2009a), the RBDD gates were permanently raised, which has likely improved fish passage conditions at the RBDD. The Red Bluff Fish Passage Improvement Project, which included construction of a pumping plant to allow for diversion of water from the Sacramento River without closing the RBDD gates, was completed in 2012 (Tehama-Colusa Canal Authority 2012).

NMFS (2009a) stated that the diversity of mainstem Sacramento River steelhead also may be affected by CVP/SWP system-wide operations due to changed thermal regimes and food web structures in the Sacramento River such that a resident life history strategy may have fitness advantages over anadromous forms, although little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the roles that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on the Sacramento River, which may favor residency, are detrimental to the anadromous population in the Sacramento River or not (Lindley *et al*. 2007). In addition, widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks (Corps 2007). According to NMFS (2009a), critical habitat for steelhead is composed of PCEs that are essential for the conservation of the species including, but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of steelhead critical habitat is degraded, and does not provide the conservation values necessary for the survival and recovery of the species (NMFS 2009a).

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to place critical habitat for mainstem Sacramento River steelhead at considerable risk. The status of steelhead critical habitat, within the mainstem Sacramento River is suggested by NMFS (2009a) to be substantially degraded due to factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use. Additionally, NMFS (2009a) stated that climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions. Estuarine habitats also have been substantially degraded (*e.g.*, Sommer *et al*. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes.

As described by NMFS (2009a), there are few data with which to assess the status of CCV steelhead populations. According to NMFS (2009a), data are lacking to suggest that the CCV steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Conversely, NMFS (2009a) states that there is evidence to suggest that the CCV steelhead DPS is at moderate or high risk of extinction. Most of the historical habitat once available to steelhead has been lost, and the observation that anadromous *O. mykiss* are becoming rare in areas where they were probably once abundant indicates that an important component of life history diversity is being suppressed or lost (NMFS 2009a). Lindley *et al*. (2007) stated that even if there were adequate data on the distribution and abundance of steelhead in the Central Valley, approaches for assessing steelhead population and DPS viability might be problematic because the effect of resident *O. mykiss* on the viability of steelhead populations and the DPS is unknown.

NMFS (2009a) concluded that long-term CVP/SWP operations as proposed were likely to jeopardize the continued existence of CCV steelhead and are likely to destroy or adversely modify critical habitat for CCV steelhead.

NMFS (2009a) developed RPA actions for each of the various CVP/SWP project divisions and associated waterbodies to avoid jeopardy and adverse modification of critical habitat. However, as previously discussed, the Federal Court for the Eastern District of California held that the jeopardy conclusion of the 2009 NMFS BO was correct, but that the RPA actions were not adequately justified or supported by the record. The NMFS 2009 BiOp was remanded (Consol. Salmonid Cases, 791 F. Supp. 2d 802 (E.D. Cal. 2011)). That decision was appealed; oral argument before the 9th Circuit is currently scheduled for September 2014.

For the DPS-wide Environmental Baseline effects assessment of steelhead, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the Environmental Baseline result in an unstable DPS at moderate or high risk of extinction.

The lower Yuba River steelhead population is exposed and subject to the myriad of limiting factors, threats and stressors (see Status of the Species). Concurrently with the effort conducted for spring-run Chinook salmon, NMFS (2009) recently conducted a comprehensive assessment of stressors affecting both steelhead within the lower Yuba River, and lower Yuba River steelhead populations as they migrate downstream (as juveniles) and upstream (as adults) through the lower Feather River, the lower Sacramento River, and the Bay-Delta system. For the lower Yuba River population of steelhead, the number of stressors according to the categories of “Very High”, “High”, “Medium”, and “Low” that occur in the lower Yuba River or occur out of basin are presented below by lifestage (Table VIII-11).

As shown by the numbers in Table VIII-11, of the total number of 94 stressors affecting all identified lifestages of lower Yuba River populations or steelhead, 31 are within the lower Yuba River and 63 are out-of-basin. Because spawning and incubation occurs only in the lower Yuba River, all of the stressors associated with these lifestages occur in the lower Yuba River. For the adult immigration and holding, and the juvenile rearing and outmigration lifestages combined, a total of 49 “Very High” and “High” stressors were identified, with 15 of those occurring in the lower Yuba River and 34 occurring out-of-basin.

Table VIII-11. The number of stressors according to the categories of "Very High", "High", "Medium", and "Low" that occur in the lower Yuba River, or occur out-of-basin, by lifestage for the lower Yuba River population of steelhead (Source: NMFS 2009).

Lifestage	**Location**	**Stressor Categories**			
		Very High	**High**	**Medium**	**Low**
Adult Immigration and Holding					
	Lower Yuba River	2	1	3	1
	Out of Basin	1	5	10	4
Spawning					
	Lower Yuba River	3	2	0	2
	Out of Basin	N/A*	N/A	N/A	N/A
Embryo Incubation					
	Lower Yuba River	1	0	4	0
	Out of Basin	N/A	N/A	N/A	N/A
Juvenile Rearing and Outmigration					
	Lower Yuba River	5	1	1	5
	Out of Basin	12	16	6	9
* N/A – Not Applicable.					

The NMFS (2009) Draft Recovery Plan states that "*The lower Yuba River, below Englebright Dam, is characterized as having a high potential to support a viable population of steelhead, primarily because: (1) the river supports a persistent population of steelhead and historically supported the largest, naturally reproducing population of steelhead in the Central Valley (McEwan and Jackson 1996), (2) flow and water temperature conditions are generally suitable to support all lifestage requirements, (3) the river does not have a hatchery on it, (4) spawning habitat availability does not appear to be limited, and (5) high habitat restoration potential*".

Similar to the statement for spring-run Chinook salmon, the NMFS (2009) Draft Recovery Plan further states that "*For currently occupied habitats below Englebright Dam, it is unlikely that habitats can be restored to pre-dam conditions, but many of the processes and conditions that are necessary to support a population of steelhead can be improved with improvements to instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River.*"

Many of the most important stressors specific to steelhead in the lower Yuba River correspond to the stressors described for spring-run Chinook salmon in the lower Yuba River, which included passage impediments and barriers, harvest and angling impacts, poaching, physical habitat alteration, loss of riparian habitat and instream cover (*e.g.*, riparian vegetation, instream woody material), loss of natural river morphology and function, loss of floodplain habitat, entrainment, predation, and hatchery effects.

The previous discussions in this BiOp addressing limiting factors and threats for the spring-run Chinook salmon population in the lower Yuba River that are pertinent to the steelhead population in the lower Yuba River are not repeated in this section of the BA. Stressors that are unique to steelhead in the lower Yuba River, and stressors that substantially differ in severity for steelhead, are described below.

<u>Harvest/Angling Impacts - Steelhead</u>

Fishing for steelhead on the lower Yuba River is regulated by CDFW. Angling regulations on the lower Yuba River are intended to protect sensitive species, including wild steelhead. CDFW angling regulations (2013/2014) permit fishing for steelhead from the mouth of the Yuba River to the Highway 20 Bridge with only artificial lures with barbless hooks all year-round. The regulations include a daily bag limit of two hatchery trout or hatchery steelhead (identified by an adipose fin clip), and a possession limit of four hatchery trout or hatchery steelhead. From the Highway 20 Bridge to Englebright Dam, fishing for steelhead is permitted from December 1 through August 31 only, with only artificial lures with barbless hooks. For this time period, the regulations include a daily bag limit of two hatchery trout or hatchery steelhead (identified by an adipose fin clip), and a possession limit of four hatchery trout or hatchery steelhead.

<u>Poaching - Steelhead</u>

By contrast to the previous discussion regarding the potential for poaching to be a stressor to spring-run Chinook salmon, no references have been reported regarding the potential poaching of steelhead at the fish ladders, or at the base of Daguerre Point Dam. In addition, no reference has been located regarding the occurrence of steelhead jumping out of the fish ladders at Daguerre Point Dam.

<u>Steelhead Hatchery Effects</u>

The discussion in this BiOp addressing limiting factors, threats and stressors resulting from straying and other hatchery effects on the steelhead DPS that are pertinent to steelhead in the lower Yuba River are not repeated in this section of the BiOp. Hatchery-related stressors that are unique to steelhead in the lower Yuba River, or substantially differ in severity for Yuba River steelhead, are described below.

Although it has been oft-repeated that hatcheries historically have not been located on the Yuba River, that does not appear to be the case. According to a document titled "*A History of California's Fish Hatcheries 1870–1960*" (Leitritz 1970), an experimental fish hatchery station (*i.e.*, the Yuba River Hatchery) was established in 1928 by the California Department of Natural Resources, Division of Fish and Game. The site was on Fiddle Creek, a tributary of the North Fork Yuba River about 34 miles north of Nevada City, near Camptonville. Fish rearing began at the station in 1929. Over the years, improvements were made to the hatchery. No reference could be found regarding salmon, but the hatchery was reported to hatch and rear trout, including steelhead (CDNR 1931). The hatchery continued operations until storms during November 1950 caused such extensive damage that repairs could not be made and it was permanently closed (Leitritz 1970).

Since that time, no fish hatcheries have been located on the lower Yuba River, and the river continues to support a persistent population of steelhead. According to the NMFS Draft Recovery Plan (NMFS 2009), the major threat to the genetic integrity of CCV steelhead results from past and present hatchery practices. These practices include the planting of non-natal fish, overlap of spawning hatchery and natural fish, and straying of hatchery fish.

<u>Steelhead Genetic Considerations</u>

From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchable steelhead from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991a). CDFW stopped stocking steelhead into the lower Yuba River in 1979. In addition, it is possible that some hatchery-reared juvenile steelhead from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned steelhead could occur as a result.

<u>Steelhead Straying into the Lower Yuba River</u>

The observation of adipose fin clips on adult steelhead passing upstream through the VAKI Riverwatcher system at Daguerre Point Dam demonstrates that hatchery straying into the lower Yuba River has, and continues, to occur. Although no information is presently available regarding the origin of adipose-clipped steelhead observed at the VAKI Riverwatcher system at Daguerre Point Dam, it is reasonable to surmise that they most likely originate from the FRFH. The remainder of this discussion pertains to hatchery effects associated with the straying of adult steelhead into the lower Yuba River.

If hatchery-origin steelhead stray into the lower Yuba River and interbreed with naturally-spawning Yuba River steelhead, then such interbreeding has been suggested to represent a threat to the genetic diversity and integrity of the naturally-spawning steelhead population in the lower Yuba River. No previously conducted quantitative analyses or data addressing the extent of hatchery-origin steelhead straying into the lower Yuba River is available. However, some information is presently available to assess the amount of straying of hatchery-origin (adipose fin-clipped) steelhead into the lower Yuba River from VAKI Riverwatcher data.

In the lower Yuba River, attempts were made to differentiate adult steelhead from other *O. mykiss* (*i.e.*, juvenile steelhead and resident rainbow trout) recorded passing Daguerre Point Dam utilizing daily VAKI Riverwatcher data. However, only two years of data (2010/2011 and 2011/2012) are available identifying adipose fin-clipped *O. mykiss* passing through the VAKI Riverwatcher system, during which extensive inoperable periods did not occur during the adult steelhead upstream migration period.

Analysis of the VAKI Riverwatcher data indicates that the percent contribution of hatchery-origin adult upstream migrating fish (represented by the percentage of adipose fin-clipped adult steelhead relative to the total number of adult upstream migrating steelhead, because 100 percent of FRFH-origin steelhead have been marked since 1996) was approximately 43 percent for the 2010/2011 biological year, and about 63 percent for the 2011/2012 biological year (RMT 2013).

(3) Viability of the CCV Steelhead

CCV Steelhead DPS viability

The aforementioned list of limiting factors and stressors pertinent to the spring-run Chinook salmon ESU also pertain to the steelhead DPS. Stressors that are unique to the steelhead DPS, or substantially differ in the severity from the stressor for the previously described spring-run Chinook salmon ESU, and include the following.

- Destruction, Modification, or Curtailment of Habitat or Range,
- Overutilization for Commercial, Recreational, Scientific or Education Purposes (inland sport harvest),
- Disease and/or Predation,
- Inadequacy of Existing Regulatory Mechanisms (Federal efforts, non-Federal efforts),
- Other Natural and Man-Made Factors Affecting the Continued Existence of the DPS, and
- Non-Lifestage Specific Threats and Stressors for the DPS (artificial propagation programs, small population size, genetic integrity and long-term climate change).

As previously discussed for the Central Valley spring-run Chinook salmon ESU, the BiOp for the CVP/SWP OCAP consultation (NMFS 2009a) covered CVP and SWP facilities and potentially affected waterbodies, which did not include the lower Yuba River.

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to result in direct mortality to steelhead, including: (1) increased predation of juveniles when the RBDD gates are down, (2) entrainment of juveniles into the Central and South Delta, (3) entrainment and impingement of juveniles at the CVP/SWP pumps in the South Delta (both direct and indirect loss), and (4) loss associated with the collection, handling, trucking and release program.

According to NMFS (2009a), steelhead habitat conditions in the mainstem Sacramento River and the Delta have been adversely affected by long-term CVP/SWP system-wide operations in several ways, including but not limited to: (1) delaying the upstream migration of adult steelhead through RBDD operations, (2) reducing the availability of quality rearing habitat through the seasonal creation of Lake Red Bluff, and (3) creating improved feeding opportunities at RBDD for predators such as pikeminnow and striped bass. In these ways, the CVP/SWP system-wide operations reduced the population's spatial structure (by reducing habitat quantity and quality), which increases the risk of extinction of the mainstem Sacramento River steelhead population (NMFS 2009a). Beginning in September 2011 and implemented in response to the NMFS OCAP BiOp (2009a), the RBDD gates were permanently raised, which has likely improved fish passage conditions at the RBDD. The Red Bluff Fish Passage Improvement Project, which included construction of a pumping plant to allow for diversion of water from the Sacramento River without closing the RBDD gates, was completed in 2012 (Tehama-Colusa Canal Authority 2012).

NMFS (2009a) stated that the diversity of mainstem Sacramento River steelhead also may be affected by CVP/SWP system-wide operations due to changed thermal regimes and food web structures in the Sacramento River such that a resident life history strategy may have fitness advantages over anadromous forms, although little is known about the relationship of resident and anadromous forms of *O. mykiss*. Without knowing the roles that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on the Sacramento River, which may favor residency, are detrimental to the anadromous population in the Sacramento River or not (Lindley *et al*. 2007). In addition, widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks (Corps 2007). According to NMFS (2009a), critical habitat for steelhead is composed of PCEs that are essential for the conservation of the species including, but not limited to, spawning habitat, rearing habitat, migratory corridors, and estuarine areas. Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of steelhead critical habitat is degraded, and does not provide the conservation values necessary for the survival and recovery of the species (NMFS 2009a).

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to place critical habitat for mainstem Sacramento River steelhead at considerable risk. The status of steelhead critical habitat, within the mainstem Sacramento River is suggested by NMFS (2009a) to be substantially degraded due to factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, a collapsed pelagic community in the Delta, and poor water quality associated with agricultural, urban, and industrial land use. Additionally, NMFS (2009a) stated that climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions. Estuarine habitats also have been substantially degraded (*e.g.*, Sommer *et al*. 2007) and climate change is expected to further alter these habitats through sea level rise and hydrological changes.

As described by NMFS (2009a), there are few data with which to assess the status of CCV steelhead populations. According to NMFS (2009a), data are lacking to suggest that the CCV steelhead DPS is at low risk of extinction, or that there are viable populations of steelhead anywhere in the DPS. Conversely, NMFS (2009a) states that there is evidence to suggest that the CCV steelhead DPS is at moderate or high risk of extinction. Most of the historical habitat once available to steelhead has been lost, and the observation that anadromous *O. mykiss* are becoming rare in areas where they were probably once abundant indicates that an important component of life history diversity is being suppressed or lost (NMFS 2009a). Lindley *et al*. (2007) stated that even if there were adequate data on the distribution and abundance of steelhead in the Central Valley, approaches for assessing steelhead population and DPS viability might be problematic because the effect of resident *O. mykiss* on the viability of steelhead populations and the DPS is unknown.

NMFS (2009a) concluded that long-term CVP/SWP operations as proposed were likely to jeopardize the continued existence of CCV steelhead and were likely to destroy or adversely modify critical habitat for CCV steelhead.

NMFS (2009a) developed RPA actions for each of the various CVP/SWP project divisions and associated water bodies to avoid jeopardy and adverse modification of critical habitat. However, as previously discussed, the Federal Court for the Eastern District of California held that the jeopardy conclusion of the 2009 NMFS BO was correct, but that the RPA actions were not adequately justified or supported by the record. The NMFS 2009 BiOp was remanded (Consol. Salmonid Cases, 791 F. Supp. 2d 802 (E.D. Cal. 2011)). As noted *supra*, that decision has been appealed.

Lower Yuba River Steelhead Viability

As with all naturally-spawning populations of steelhead in the Central Valley, Lindley *et al*. (2007) characterized the steelhead population in the lower Yuba River as data deficient, and therefore did not characterize its viability. Data limitations, particularly regarding abundance and productivity, continue to render problematic quantitative estimation procedures to assess the viability of the steelhead population in the lower Yuba River. Continued monitoring of adult steelhead in the lower Yuba River is providing additional information that is needed to assess extinction risk based on Lindley *et al*. (2007) criteria regarding population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence. The VSP parameters of abundance, productivity, spatial structure and diversity for the steelhead population in the lower Yuba River are discussed below.

Steelhead Abundance and Productivity

VAKI Riverwatcher Data - Steelhead

Ongoing monitoring of the adult steelhead population in the lower Yuba River has been conducted since 2003 with VAKI Riverwatcher systems at Daguerre Point Dam. By contrast to Chinook salmon, escapement surveys involving carcass mark-recovery experiments are not performed on steelhead/*O. mykiss*.

In the lower Yuba River, silhouettes and corresponding photographs were examined for species identification and categorization using methodology similar to that which is described for spring-run Chinook salmon. However, the accurate identification of *O. mykiss* in the VAKI Riverwatcher is more difficult than it is for Chinook salmon.

By contrast to the identification of Chinook salmon which may be conducted with a single attribute, the identification of steelhead becomes more problematic with the absence of a defining silhouette or a clear digital photograph. Additionally, the silhouettes of steelhead cannot reliably be differentiated from resident rainbow trout, and photo documentation of an individual is problematic because adult steelhead typically immigrate during periods of high flow and associated high turbidity and low visibility. The VAKI Riverwatcher systems cannot differentiate an individual as a resident form of the species (*i.e.*, rainbow trout) or as anadromous (*i.e.*, steelhead). Additionally, the VAKI Riverwatcher systems cannot directly distinguish between an adult or juvenile *O. mykiss* (RMT 2013).

Differentiation of Adult Steelhead VAKI Riverwatcher Counts

The silhouettes and/or electronic images of each fish passage event that was identified as an *O. mykiss* fish passage event allow the VAKI Riverwatcher systems to calculate an approximate length (in centimeters) for the observed fish.

As reported by the RMT (2013), as an initial step in the differentiation of adult steelhead passing upstream of Daguerre Point Dam, the length distribution of all fish identified as *O. mykiss* passing through both the north and south ladders at Daguerre Point Dam over the entire data availability period (January 1, 2004, through February 29, 2012) was plotted and visually examined (Figure VIII-23). This figure indicates the possible presence of at least six length groups. These groups represent the potential combination of juvenile and adult anadromous *O. mykiss* (steelhead), as well as juvenile and adult resident *O. mykiss* (rainbow trout). However, this length-frequency distribution does not provide information necessary to differentiate between steelhead and rainbow trout.

Beginning March 1, 2009, VAKI Riverwatcher fish identified as *O. mykiss* also were classified as fish with or without clipped adipose fins, based on the inspection of the fish silhouette and photogrammetric representation (digital photographs and/or video imagery). The analysis of the length-frequency distribution of all adipose fin-clipped *O. mykiss* provides a means of differentiating adult steelhead passing upstream of Daguerre Point Dam from all other *O. mykiss*, because all adipose fin-clipped *O. mykiss* are steelhead that were released by a Central Valley hatchery.

The lengths of all fish passing upstream at Daguerre Point Dam that were identified as *O. mykiss* with clipped adipose fins (*i.e.*, all hatchery steelhead) between March 1, 2009 through February 29, 2012 are presented in Figure VIII-24. Visual examination of the observed length distribution in Figure VIII-24 indicates the possible presence of up to five groups of fish. Two of the length categories demarcating the first two possible groups of fish occur at 20 cm (7.9 inches) and 29 cm (11.4 inches).

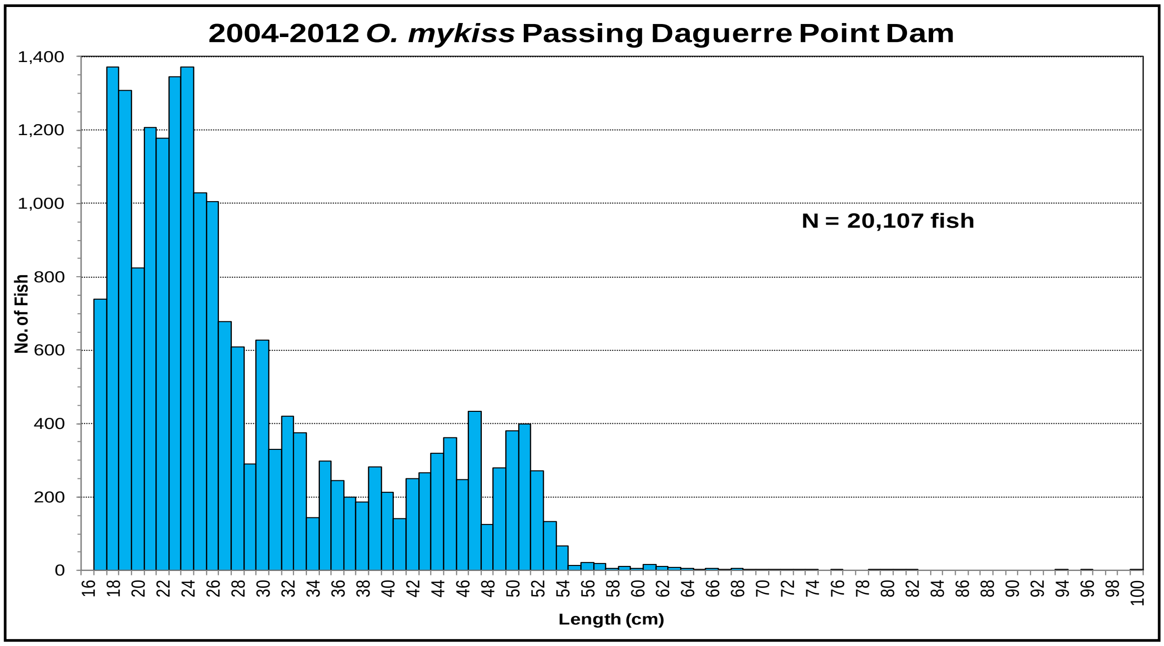


Figure VIII-23. Length distribution of all fish identified by the VAKI Riverwatcher systems as *O. mykiss* passing upstream through the north and south ladders of Daguerre Point Dam from January 1, 2004 through February 29, 2012 (Source: RMT 2013).

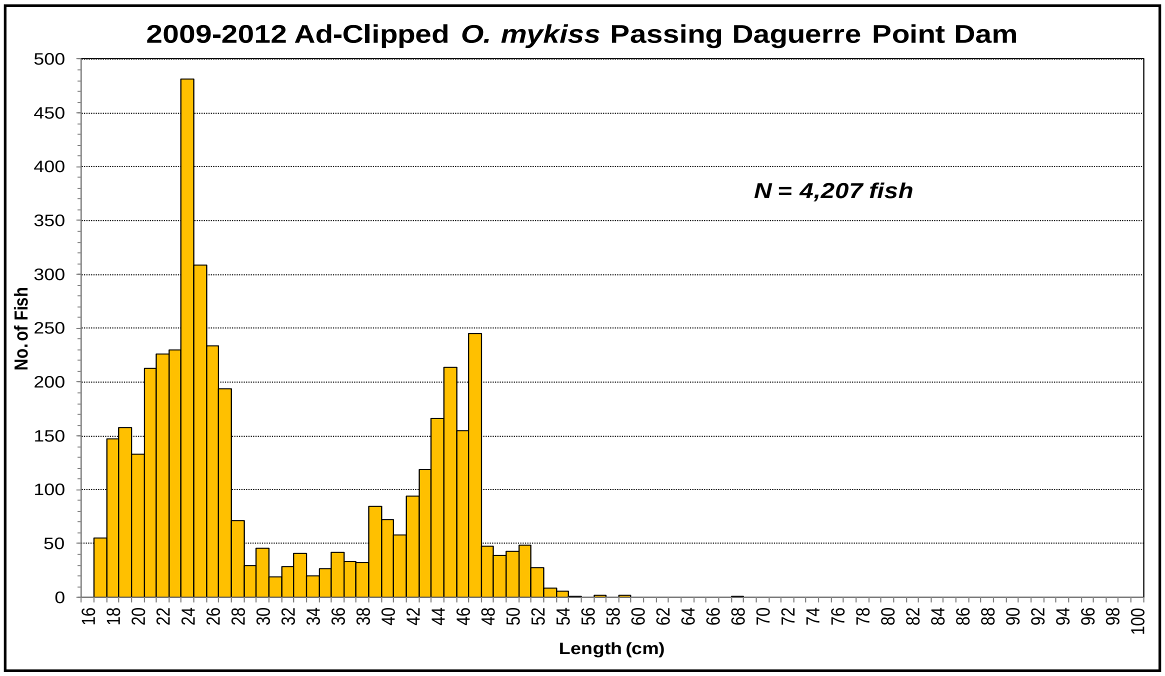


Figure VIII-24. Length distribution of all fish identified by the VAKI Riverwatcher systems as adipose clipped *O. mykiss* passing upstream through the north and south ladders of Daguerre Point Dam from March 1, 2009 through February 29, 2012 (Source: RMT 2013).

According to CDFG and USFWS (2010), the normal FRFH release schedule includes the release of steelhead yearlings, from January to February, released in the Feather River near Gridley at four fish per pound. Although not readily available from CDFW, other sources indicate that steelhead smolts averaging 4 to 5 fish per pound range in length from approximately 8-9 inches (20-23 cm) (IDFG 1992). The presence of small, adipose fin-clipped steelhead in the lower Yuba River as displayed in Figure VIII-24 may be related to releases of yearling FRFH-produced steelhead on the Feather River.

Since 2007, the FRFH has only been releasing steelhead yearlings at various sites along the Feather River, as well as in the Sacramento River at Sutter Slough, and in Butte Creek (Table VIII-12). To determine whether fish planted in the lower Feather River may have been detected in the lower Yuba River, an examination of the VAKI Riverwatcher data was conducted for adipose fin-clipped steelhead consistent with the observed potential length-mode demarcation length of 29 cm (11.4 in) (RMT 2013).

Table VIII-12. Recent releases of hatchery steelhead by the Feather River Fish Hatchery (Source: Regional Mark Information System (RMIS) of the Regional Mark Processing Center, RMT 2013).

Release Dates		Brood Year	Numbers Released		Release Stage[2]	Study Type[3]	Release Location	Agency	
Start	End		Tagged[1] Adclipped	Untagged Adclipped				Reporting	Release
01/08/07	02/05/07	2006	0	10,036	Y	E	Feather River Thermalito Bypass	CDFG	CDWR
02/05/07	02/21/07	2006	0	488,043	Y	E	Feather River	CDFG	CDWR
05/29/07	05/29/07	2006	0	1,643	Y	E	Feather River	CDFG	CDWR
05/30/08	05/30/08	2007	0	1,109	Y	E	Feather River	CDFG	CDWR
02/01/08	02/14/08	2007	0	307,986	Y	P	Feather River Boyds Pump Ramp	CDFG	CDWR
02/03/09	02/03/09	2008	0	2,750	Y	P	Feather River at Live Oak	CDFG	CDFG
02/03/09	02/17/09	2008	0	398,148	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG
02/01/10	02/11/10	2009	0	272,798	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG
02/02/11	02/15/11	2010	0	49,800	Y	P	Feather River Boyds Pump Ramp	CDFG	CDFG

[1] Tagged releases refer to releases with coded wire tags

[2] Release stage Y indicates yearling releases.

[3] Study type E stands for experimental releases, and study type P indicates a production releases.

From February 1, 2010, to February 2, 2011, (*i.e.*, the starting date for the last reported release of adipose fin-clipped juvenile steelhead from the FRFH), 104 adipose fin-clipped juvenile steelhead with lengths less than or equal to 29 cm (11.4 in) were recorded passing upstream of Daguerre Point Dam. Most of these individuals were observed in the VAKI Riverwatcher system during February through April of 2010. Additionally, from February 2, 2011, through January 31, 2012, a total of 1,702 adipose fin-clipped steelhead with lengths less than or equal to 29 cm

(11.4 in) were recorded passing upstream of Daguerre Point Dam. While these individuals were observed in the VAKI Riverwatcher system throughout calendar year 2011, they were most frequently observed during April and May of 2011. In other words, most of the observed adipose fin-clipped juvenile steelhead less than or equal to 29 cm (11.4 in) passing upstream of Daguerre Point Dam occurred within a few months after plantings of juvenile steelhead in the Feather River from the FRFH. Additionally, between February 2011 and January 2012, approximately 676 adipose fin-clipped steelhead with lengths less than or equal to 29 cm were recorded passing downstream of Daguerre Point Dam, with the majority of these individuals passing downstream during April through June. Therefore, approximately one-third of the presumed FRFH steelhead that migrated upstream of Daguerre Point Dam during 2011 apparently turned around and migrated back downstream of Daguerre Point Dam shortly after passing upstream of Daguerre Point Dam (RMT 2013).

If the observation of adipose fin-clipped juvenile steelhead passing upstream at Daguerre Point Dam is associated with the release of yearling steelhead from the FRFH into the lower Feather River, then it logically follows that the planted FRFH yearling steelhead would have had to swim 6 miles upstream from the planting location at Boyds Pump Ramp to the mouth of the lower Yuba River, and then an additional nearly 12 miles upstream to reach Daguerre Point Dam. Although this phenomenon may seem somewhat illogical, it has been reported elsewhere (Steiner Environmental Consulting 1987, as cited in RMT 2013) and is an explanation for the observation of adipose fin-clipped juvenile steelhead passing upstream at Daguerre Point Dam, because no marked juvenile steelhead have been reported to be released over this time frame into the lower Yuba River.

The length-frequency distribution of all adipose fin-clipped steelhead observed at Daguerre Point Dam from March 1, 2009, through February 29, 2012, was used to differentiate between "juvenile" and "adult" steelhead. The second step in the separation of "juvenile" and "adult" steelhead was to fit modeled length-frequency distributions to the observed data to determine a threshold length to separate both fish groups. A detailed description of the analytical processes is provided in RMT (2013).

Unlike the methodology employed for Chinook salmon, the daily counts of adult steelhead passing upstream of Daguerre Point Dam were not corrected for days when the VAKI Riverwatcher systems were not fully operational. The RMT determined it would be inappropriate to attempt to correct the adult steelhead counts due to: (1) the relatively low numbers of adult steelhead recorded during most of the steelhead biological years, and (2) the frequently extended durations when the VAKI Riverwatcher systems were not fully operational during the steelhead immigration season. Instead, the daily counts of adult steelhead passing upstream at Daguerre Point Dam were used to represent the abundance of steelhead, with the understanding that the resultant estimates are minimum numbers, and most of the survey years considerably underestimate the potential number of steelhead because the annual estimates do not include periods of VAKI Riverwatcher system non-operation, and do not consider the fact that not all steelhead migrate past Daguerre Point Dam, due to some spawning occurring downstream Daguerre Point Dam.

Assessment of Available VAKI Riverwatcher Data - Steelhead

For assessment purposes, a "steelhead biological year" was identified as extending from August 1 through July 31 each year, because: (1) preliminary review of the VAKI Riverwatcher data indicated a general paucity of upstream migrant *O. mykiss* during early summer, (2) the immigration of adult steelhead in the lower Yuba River has been reported to occur beginning during August (CALFED and YCWA 2005, McEwan and Jackson 1996), and (3) the RMT (2010b) identified the steelhead upstream migration period as beginning during August in the lower Yuba River (RMT 2013).

Annual Time Series of Steelhead Passing Upstream of Daguerre Point Dam

Figures VIII-25 through VIII-29 illustrate the daily counts of adult steelhead passing upstream at Daguerre Point Dam through both the North and South ladders combined, and the percentage of the daily number of hours when the VAKI Riverwatcher systems were operational at both ladders, during the eight steelhead biological years.

Examination of Figures VIII-25 through VIII-29 demonstrates that although the VAKI Riverwatcher systems have been in place since June of 2003, reliable estimates of the number of adult steelhead passing upstream at Daguerre Point Dam are essentially restricted to the last two years of available data (2010/2011 and 2011/2012).

Due to system failures, including equipment malfunctions and operationally detrimental environmental conditions (heavy overcast and foggy conditions resulting in lack of photovoltaic charging of the system), the VAKI Riverwatcher systems were partially operational or completely non-operational during several months each year of sampling. Additionally, high flows and turbidities reduced the ability of the system to identify, or prevented the system from identifying, adult steelhead oftentimes when the systems were operational. Although improvements to the system have been made over time, it was not until the most recent system improvements were implemented during the 2010/2011 sampling season that the system began demonstrating sustained reliability in the documentation of steelhead passing upstream of Daguerre Point Dam, over a range of environmental conditions.

Since June 2003, numerous improvements have been implemented to improve the reliability of the VAKI Riverwatcher systems, and particularly their ability to document passage during the steelhead upstream migration season. A chronology of the VAKI Riverwatcher system improvements that have occurred over time are described in RMT (2013).

This suite of improvements to the VAKI Riverwatcher systems at Daguerre Point Dam have resulted in much more reliable estimates of steelhead passing the dam. Correspondingly, the largest number of steelhead recorded immigrating past Daguerre Point Dam occurred during the 2010/2011 sampling season. As a result, it is not reasonable to consider data gathered prior to 2010/2011 to be reliable estimates of the annual number of adult steelhead passing upstream of Daguerre Point Dam (RMT 2013).

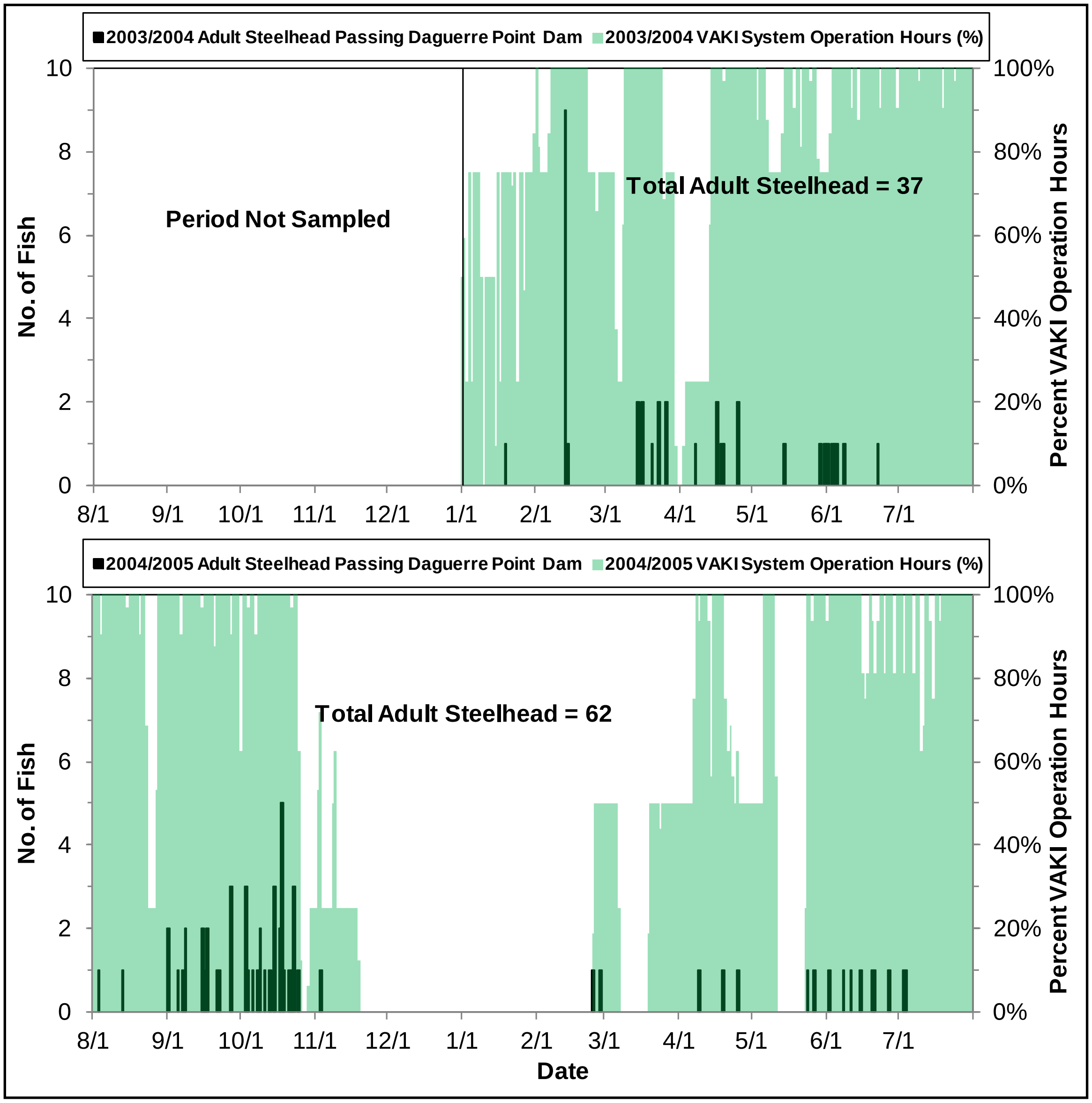


Figure VIII-25. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2003/2004 and 2004/2005 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

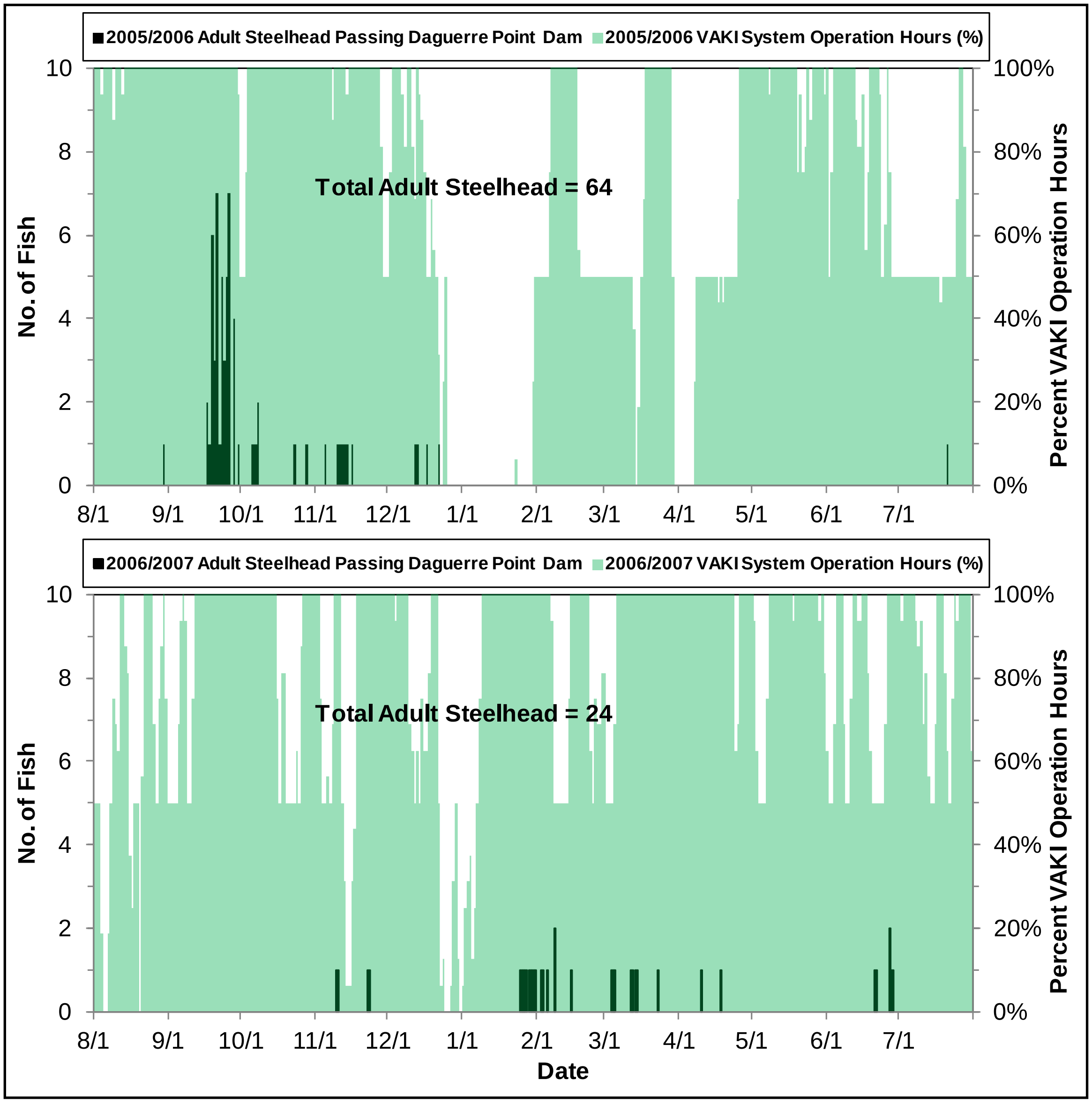


Figure VIII-26. Daily counts of adult steelhead passing upstream Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2005/2006 and 2006/2007 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

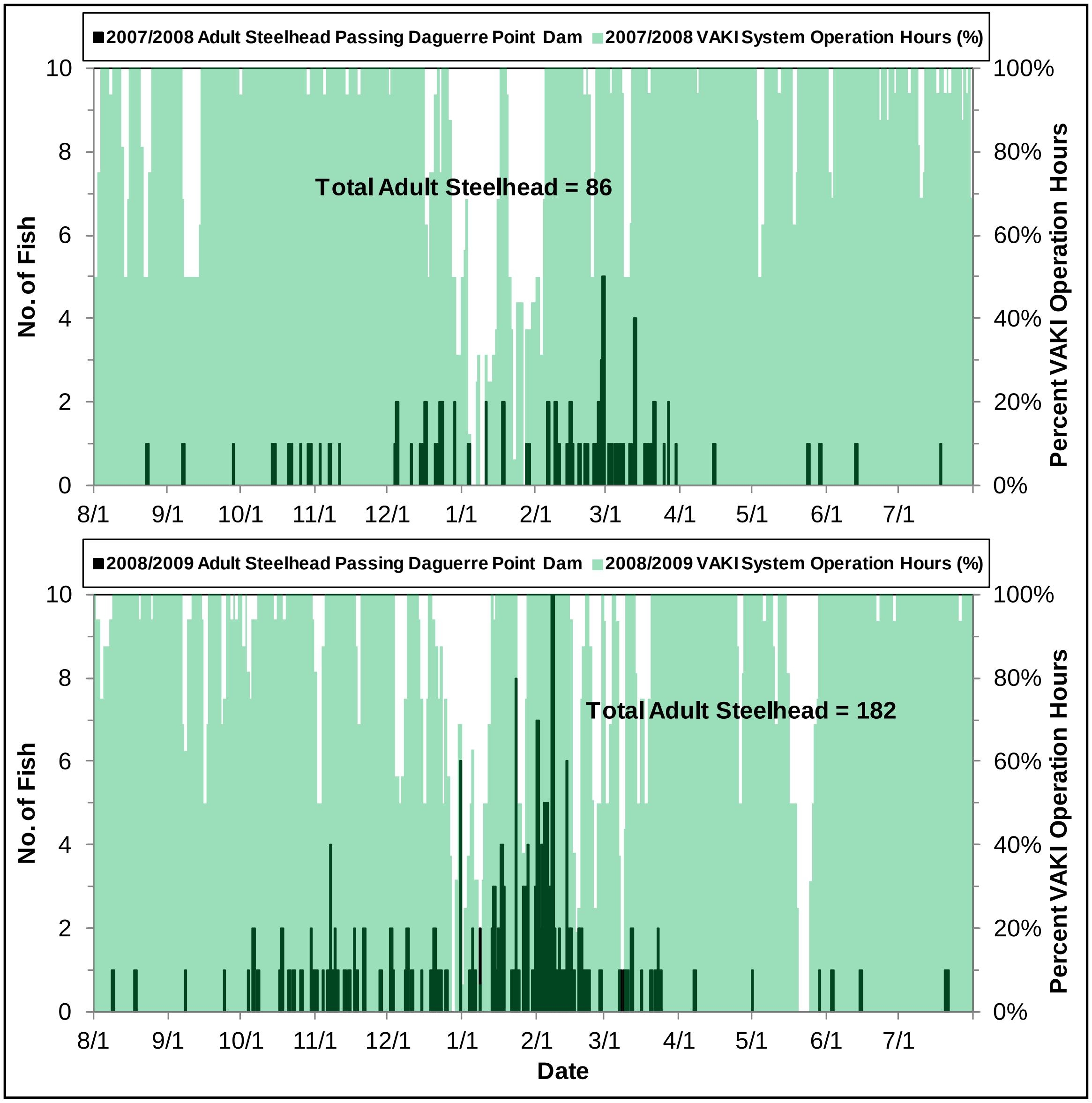


Figure VIII-27. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2007/2008 and 2008/2009 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

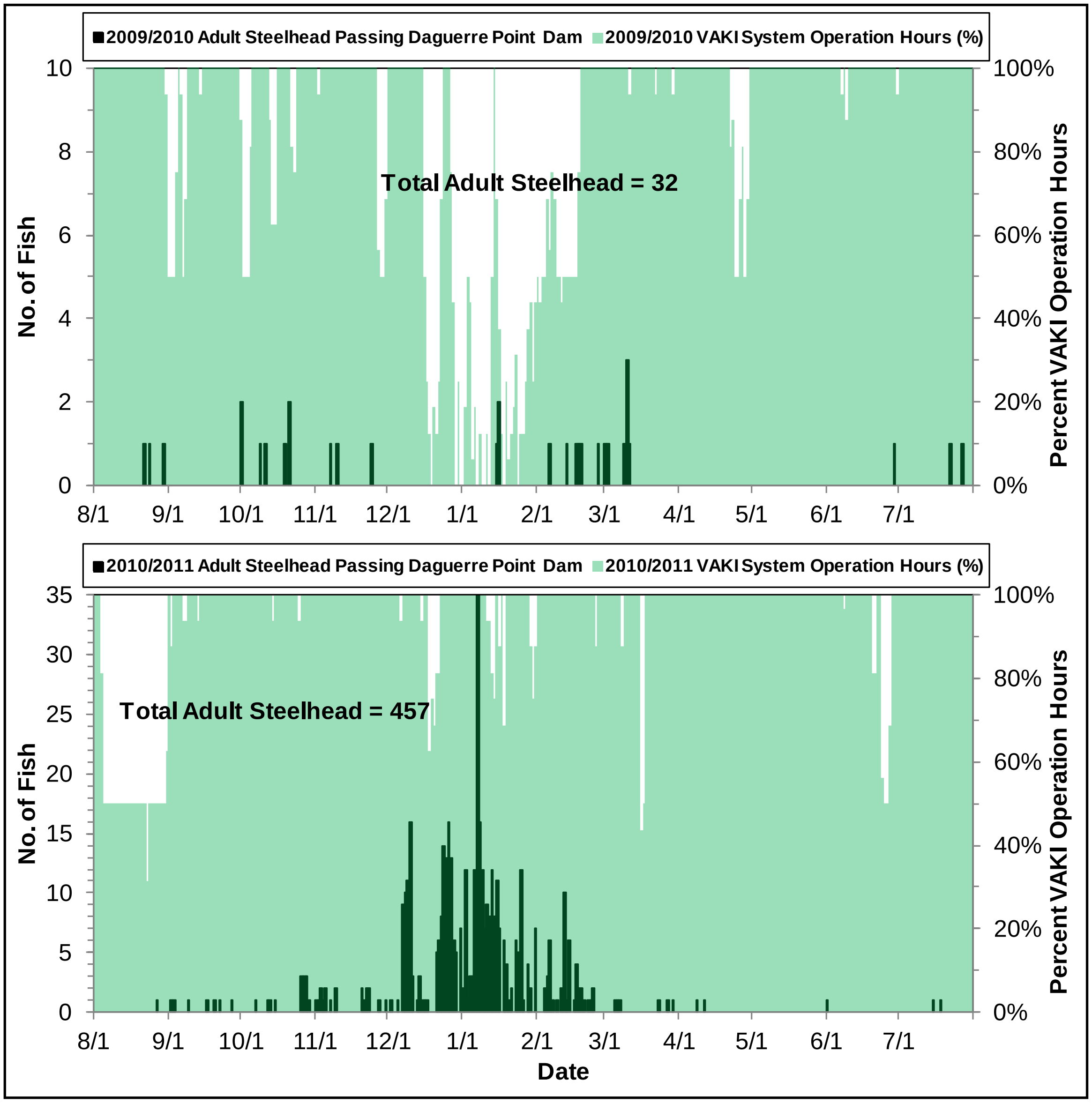


Figure VIII-28. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2009/2010 and 2010/2011 steelhead biological years (August 1 through July 31) (Source: RMT 2013).

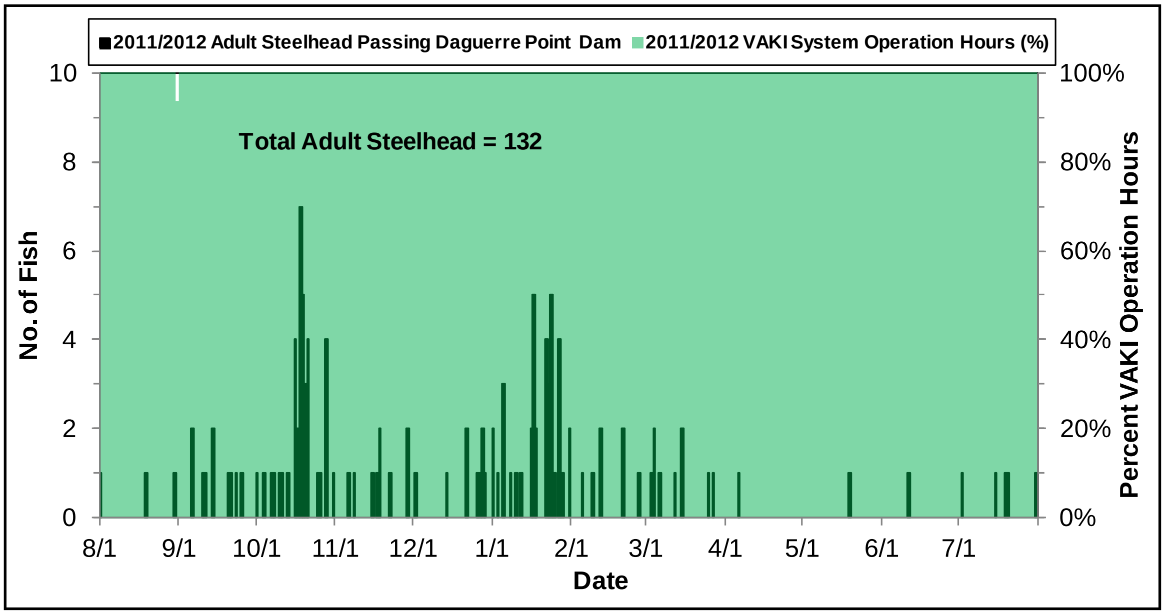


Figure VIII-29. Daily counts of adult steelhead passing upstream of Daguerre Point Dam (dark green bars), and daily number of hours when the VAKI Riverwatcher systems were operational (light green bars), during the 2011/2012 steelhead biological year (August 1 through July 31) (Source: RMT 2013).

The relatively short time period encompassed by the reporting of reliable abundance estimates, and in consideration that steelhead may have returned to the lower Yuba River but remained and spawned in the river downstream of Daguerre Point Dam, currently render problematic the determination of abundance or trends in the productivity of the steelhead over recent years (RMT 2013). Continued implementation of the improved VAKI Riverwatcher systems at Daguerre Point Dam is likely to obtain some of the data necessary to allow abundance estimation and productivity evaluation of steelhead in the lower Yuba River. However, presently the lack of multi-year abundance data precludes the provision of quantitative values associated with extinction risk assessment, addressing abundance and productivity (RMT 2013).

Steelhead Spatial Structure

Spatial structure and considerations regarding anadromous salmonid viability was presented for spring-run Chinook salmon previously in this BA. The spatial structure considerations, as one of the four VSP parameters, for steelhead are analogous to those for spring-run Chinook salmon previously presented. Namely, spatial structure of morphological units in the lower Yuba River is complex, diverse, and persistent.

Steelhead Diversity

Steelhead Phenotypic Considerations

O. mykiss in the lower Yuba River exhibit a high amount of diversity in phenotypic expression and life history strategy. As demonstrated in Figures VIII-25 through VIII-29, *O. mykiss* categorized as adult steelhead exhibit a broad temporal distribution in passing upstream of Daguerre Point Dam. *O. mykiss* (including steelhead) exhibit highly diverse spatial and temporal distributions in patterns of spawning, and juvenile outmigration (RMT 2013). Moreover, *O. mykiss* in the lower Yuba River exhibit polyphenism, or the occurrence of several phenotypes in a population which may not be due to different genetic types, including expressions of anadromy or residency. A thorough discussion of anadromy vs. residency of *O. mykiss* in the lower Yuba River is provided in RMT (2013). A polymorphic *O. mykiss* population structure may be necessary for the long-term persistence in highly variable environments such as the Central Valley (McEwan 2001). Resident fish may reduce extinction risk through the production of anadromous individuals that can enhance weak steelhead populations (Lindley *et al*. 2007). Such considerations may be applicable to the *O. mykiss* populations in the lower Yuba River.

Steelhead Genetic Considerations

Although no fish hatcheries have been located on the Yuba River since 1950, and the lower Yuba River continues to support a persistent population of steelhead, the genetic integrity of these fish is presently uncertain. According to the NMFS Draft Recovery Plan (NMFS 2009a), the major threat to the genetic integrity of CCV steelhead results from past and present hatchery practices. These practices include the planting of non-natal fish, overlap of spawning hatchery and natural fish, and straying of hatchery fish.

The observation of adipose fin clips on adult steelhead passing upstream through the VAKI Riverwatcher system at Daguerre Point Dam demonstrates that hatchery straying into the lower Yuba River occurs. Although no information is presently available regarding the origin of adipose-clipped steelhead observed at the VAKI Riverwatcher system at Daguerre Point Dam, it is reasonable to surmise that they most likely originate from the FRFH.

Analysis of the VAKI Riverwatcher data indicates that the percent contribution of hatchery-origin adult upstream migrating fish (represented by the percentage of adipose fin-clipped adult steelhead relative to the total number of adult upstream migrating steelhead, because 100 percent of FRFH-origin steelhead have been marked since 1996) was approximately 43 percent for the 2010/2011 biological year, and about 63 percent for the 2011/2012 biological year (RMT 2013). If hatchery-origin steelhead stray into the lower Yuba River and interbreed with naturally-spawning Yuba River steelhead, then such interbreeding has been suggested to represent a threat to the genetic diversity and integrity of the naturally-spawning steelhead population in the lower Yuba River. Nonetheless, the question remains regarding the implication of straying of hatchery-origin adult steelhead into the lower Yuba River, given past management practices. From 1970 to 1979, CDFW annually stocked 27,270–217,378 fingerlings, yearlings, and sub-catchable steelhead from Coleman National Fish Hatchery into the lower Yuba River (CDFG 1991a). CDFW stopped stocking steelhead into the lower Yuba River in 1979. In addition, as previously discussed, it is possible that some hatchery-reared juvenile steelhead from the FRFH may move into the lower Yuba River in search of rearing habitat. Some competition for resources with naturally spawned steelhead could occur as a result.

The information above indicates that the steelhead in the lower Yuba River (particularly in consideration of historic plantings and documented straying) likely do not accurately represent the ancestral population genetic structure. In other words, the current steelhead population in the lower Yuba River likely does not represent a “pure” ancestral genome (RMT 2013).

Extinction Risk

For the lower Yuba River, the data limitations previously discussed preclude multi-year abundance and trend analyses (RMT 2013). However, continued implementation of the improved VAKI Riverwatcher systems at Daguerre Point Dam is likely to obtain some of the data necessary to allow abundance estimation and productivity evaluation of steelhead in the lower Yuba River (RMT 2013). For additional discussion, see RMT (2013).

Public Review Draft Recovery Plan Considerations

The discussion regarding recovery plan implementation provided for spring-run Chinook salmon also directly pertains to steelhead in the Yuba River Basin. Therefore, it is not repeated in this section of this BA.

(4) Future Needs

While the steelhead data for the Yuba River is better than many locations in the Central Valley, the lack of steelhead data in Central Valley and in the Yuba points to the need for more information.

(E) Southern DPS of Green Sturgeon

(1) Historical Distribution and Abundance

Historical accounts of sturgeon in the Yuba River have been reported by anglers, but these accounts do not specify whether the fish were white or green sturgeon (Beamesderfer *et al*. 2004). Since the 1970s, numerous surveys of the lower Yuba River downstream of Englebright Dam have been conducted, including annual salmon carcass surveys, snorkel surveys, beach seining, electrofishing, rotary screw trapping, redd surveys, and other monitoring and evaluation activities. Over the many years of these surveys and monitoring of the lower Yuba River, only one confirmed observation of an adult green sturgeon has occurred prior to 2011. The NMFS September 2008 *Draft Biological Report, Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon* (NMFS 2008a) states that of the three adult or sub-adult sturgeon observed in the Yuba River below Daguerre Point Dam during 2006, only one was confirmed to be a green sturgeon (for the other two sturgeon, it was not determined whether they were green or white sturgeon), and that "*Spawning is possible in the river, but has not been confirmed and is less likely to occur in the Yuba River than in the Feather River. No green sturgeon juveniles, larvae, or eggs have been observed in the lower Yuba River to date.*"

As part of ongoing sturgeon monitoring efforts in the Feather River Basin under the AFRP, Cramer Fish Sciences conducted roving underwater video surveys in the lower Feather and lower Yuba rivers using a drop-down camera suspended from a motorized boat. On May 24, 25 and 26, 2011, underwater videographic monitoring was conducted in the lower Yuba River downstream of Daguerre Point Dam. A memorandum dated June 7, 2011 Cramer Fish Sciences (2011) stated that they observed what they believed were 4-5 green sturgeon near the center of the channel at the edge of the bubble curtain below Daguerre Point Dam. The sturgeon were observed either on a gravel bar approximately 1.5 m deep, or in a pool approximately 4 m deep immediately adjacent to the gravel bar. Photographs taken by Cramer Fish Sciences (2011) were forwarded to green sturgeon experts. Olaf P. Langness, Sturgeon and Smelt Projects, Washington Department of Fish and Wildlife Region 5, expressed the opinion that the photographs were of green (rather than white) sturgeon. Also, David Woodbury, NMFS Sturgeon Recovery Coordinator, expressed his opinion that the fish in the photographs were green sturgeon.

During 2012, underwater videography also was used in an attempt to document the presence of green sturgeon downstream of Daguerre Point Dam, but no observations of green sturgeon were made.

YCWA (2013) examined the potential occurrence of green sturgeon in the lowermost 24 miles of the Yuba River based on detections of acoustically-tagged green sturgeon in the Yuba River. The examination included coordination with agencies and organizations involved with green sturgeon research in the Central Valley, and collection of available information and data regarding the presence and use of the Yuba River by green sturgeon. YCWA collaborated with DWR's Feather River Program, the California Fish Tracking Consortium (CFTC), and CDFW's Heritage and Wild Trout and Steelhead Management and Recovery Programs to examine whether any of the acoustically-tagged green sturgeon were found in the lower Yuba River. The CFTC is tracking 217 green sturgeon acoustically tagged in the Central Valley, and DWR's Feather River Program has acoustically tagged 2 green sturgeon in the lower Feather River.

None of the 217 green sturgeon acoustically-tagged in the Central Valley were detected in the Yuba River, with the exception of one fish tagged by DWR in the Feather River. This individual fish was detected once on September 6, 2011 in the Yuba River by the CDFW’s lowermost acoustic receiver located at the confluence of the Yuba and Feather rivers. That fish also was detected upstream in the Feather River earlier on the same day and downstream in the Sacramento River on the evening of September 6, 2011. Therefore, the fish apparently only entered the mouth of the lower Yuba River for a very brief period of time before continuing its downstream migration in the Feather and Sacramento rivers.

(2) Green Sturgeon General Life History and Habitat Requirements

Green Sturgeon Adult Immigration, Holding and Emigration

Green sturgeon in the Sacramento River have been documented and studied more widely than they have in either the Feather or the Yuba rivers. See the Status of the Species for Green Sturgeon for more information.

Green Sturgeon Lifestage-Specific Water Temperature Suitabilities

Since the RMT prepared its November 2010 water temperature objectives memorandum, additional water temperature monitoring in the lower Yuba River has been conducted by the RMT. The RMT (2013) developed the following representative green sturgeon lifestage-specific periodicities and primary locations for water temperature suitability evaluations.

- Adult Immigration and Holding (mid-February through April) – Daguerre Point Dam and Marysville,

- Spawning and Embryo Incubation (March through July) – Daguerre Point Dam and Marysville,
- Post-Spawning Holding (March through November) – Daguerre Point Dam and Marysville, and
- Juvenile Rearing and Outmigration (Year-round) – Daguerre Point Dam and Marysville.

Green sturgeon lifestage-specific WTI values are provided in Table VIII-13.

Table VIII-13. Green sturgeon lifestage-specific WTI value ranges and associated periodicities.

Lifestage	**Water Temperature Range**	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Adult Immigration and Holding	44°F – 61°F				■	■	■	■	■																
Spawning and Embryo Incubation	46°F – 63°F					■	■	■	■	■	■	■	■	■	■										
Post-Spawning Holding	44°F – 61°F					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Juvenile Rearing and Outmigration	52°F – 66°F	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Recent water temperature monitoring data in the lower Yuba River are available for the period extending from 2006 into June 2013, during which time operations have complied with the Yuba Accord. Figure VIII-30 displays water temperature monitoring results from October 2006 through June 2013 at Daguerre Point Dam and Marysville water temperature gages, with the upper end of the green sturgeon lifestage-specific water temperature index value ranges. Water temperature monitoring over the past six years demonstrated that water temperatures remain below the upper WTI values for all lifestages of green sturgeon at Daguerre Point Dam, and for most lifestages at the Marysville Gage. The upper end of the WTI value range for post-spawning adult holding (*i.e.*, 61°F) was exceeded at the Marysville Gage during a portion of this lifestage evaluation period, and the upper end of the WTI range for spawning and incubation was exceeded slightly for a very brief period of time during 2007 and 2013.

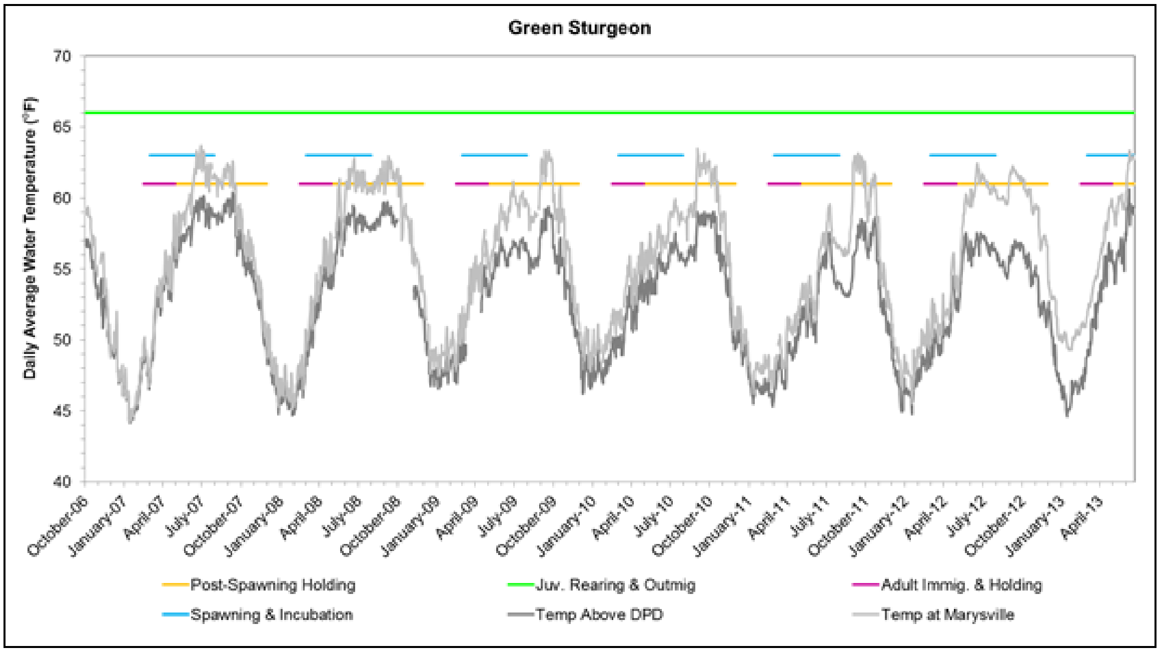


Figure VIII-30. Lower Yuba River monitored water temperatures and green sturgeon upper tolerance water temperature index values.

Daguerre Point Dam was not constructed for green sturgeon passage, and it is a complete barrier to the upstream migration of green sturgeon because they are unable to ascend the fish ladders on the dam, or otherwise pass over or around the structure. The existing fish ladders at Daguerre Point Dam were constructed to provide passage for Chinook salmon and steelhead.

Moreover, in 1938, a biological study was financed by the U.S. Army Corps of Engineers, under the supervision of the U.S. Bureau of Fisheries, to determine the effects of mining debris dams and hydraulic mining on fish life in the Yuba and American rivers. The survey was conducted by F.H. Sumner, Assistant Aquatic Biologist with the U.S. Army Corps of Engineers and Osgood R. Smith, Assistant Aquatic Biologist with the U.S. Bureau of Fisheries, in accordance with methods used by the U.S. Bureau of Fisheries. The 1939 survey report included a list of native and introduced fishes known or presumed to occur in the Yuba and American River basins at that time - which did not list the green sturgeon (Sumner and Smith 1939).

The scarcity of information on green sturgeon in the lower Yuba River makes it difficult to determine how these fish are utilizing the habitat in the river, or for what purpose green sturgeon are entering the river (NMFS 2007). However, because the ongoing stressors associated with Daguerre Point Dam's blockage of green sturgeon are due to the presence of the dam and configuration of the fish ladders, the Corps maintains it does not have the legal authority or discretion to lessen the potential passage/blockage stressors, and therefore they are part of the Environmental Baseline.

Despite the fact that historical accounts of fish species known or presumed to occur in the lower Yuba River do not include reference to green sturgeon (Sumner and Smith 1939), NMFS (2007) suggested that the abundance, productivity, spatial structure and diversity of the green sturgeon population in the lower Yuba River could be improved if green sturgeon had access to areas upstream of Daguerre Point Dam. Mora *et al.* (2009) suggest that Daguerre Point Dam blocks approximately 4 ± 2 km (~2.5 miles ± 1.2 miles) of potential green sturgeon habitat in the lower Yuba River. Regardless, designated critical habitat for green sturgeon does not extend upstream of Daguerre Point Dam.

Over the many years of sampling and monitoring in the lower Yuba River, only one sighting of an adult green sturgeon was confirmed before 2011, although studies specifically designed to search for green sturgeon in the lower Yuba River have not been implemented until the past few years. Sampling conducted during May 2011 with underwater videography indicated the presence of four or five adult green sturgeon just downstream of Daguerre Point Dam (Cramer Fish Sciences 2011). During 2012, underwater videography also was used in an attempt to document the presence of green sturgeon downstream of Daguerre Point Dam, although no green sturgeon were observed.

Under the Environmental Baseline, a total of 26 general pool locations exhibiting deepwater pool habitat potentially available to green sturgeon (*i.e.*, greater than 10.0 feet in depth) was identified within the Yuba River downstream of Daguerre Point Dam (YCWA 2013a). Table VIII-14 shows: (1) the total wetted area of the pool habitats for each flow, and (2) the incremental increase in the wetted pool area compared to the previous flow value.

The period of February through November represents the months when adult green sturgeon may potentially be holding, including the pre-spawning holding, spawning, and post-spawning periods (Adams *et al*. 2002, Klimley *et al*. 2007). Examination of Table VIII-14 demonstrates that a Marysville flow of 500 cfs would provide about 295,218 square

Table VIII-14. Areal extent of deepwater pool habitat availability in the Yuba River downstream of Daguerre Point Dam (YCWA 2013a).

Marysville Flow (cfs)	**Wetted Pool Area (sq. ft.)**	**Incremental Increase in Pool Area (percent)**
300	249,453	--
350	261,441	4.8%
400	274,005	4.8%
450	284,508	3.8%
530	301,644	6.0%
600	316,044	4.8%
622	320,400	1.4%
700	335,484	4.7%
800	354,501	5.7%
880	370,296	4.5%
930	380,070	2.6%
1,000	395,181	4.0%
1,300	456,930	15.6%
1,500	499,626	9.3%
1,700	548,487	9.8%
2,000	634,266	15.6%
2,500	804,861	26.9%
3,000	1,000,071	24.3%
4,000	1,400,292	40.0%
5,000	1,579,815	12.8%
7,500	1,859,247	17.7%
10,000	1,920,357	3.3%
15,000	1,936,989	0.9%
21,100	1,938,600	0.1%
30,000	1,938,465	0.0%
42,200	1,938,600	0.0%

feet of deepwater pool habitat downstream of Daguerre Point Dam. Modeled mean monthly flows under the Environmental Baseline simulation for each individual month from February through November (over the entire simulation period from WY 1922 through WY 2008) demonstrates that mean monthly flows at the Marysville Gage exceed 500 cfs nearly all of the time from February through June, and equal or exceed 500 cfs about 85-90 percent of the time from July through November (see the Cumulative Condition analysis, below). Consequently, a substantial amount of deepwater pool habitat is generally available for the relatively low numbers of green sturgeon that may be present downstream of Daguerre Point Dam under the Environmental Baseline. According to NMFS (2009a), the current population status of the Southern DPS of green sturgeon is unknown. For the Central Valley Domain, currently there are limited data on population sizes, population trends, or productivity of green sturgeon (NMFS 2009e). No information regarding these topics is available for the lower Yuba River, due to the rarity of even sighting green sturgeon in the river.

Hence, it is not practicable to attempt to apply the VSP concepts developed for salmonids to green sturgeon in the lower Yuba River. Moreover, the lack of information pertaining to abundance, productivity, habitat utilization, life history and behavioral patterns in the lower Yuba River, due to infrequent sightings over the past several decades, does not provide the opportunity for reliable alternative methods of viability assessment of green sturgeon in the lower Yuba River. Data limitations preclude application of the extinction risk criteria to green sturgeon in the lower Yuba River. Consequently, green sturgeon in the lower Yuba River cannot be concluded to represent a stable population, or at a specific risk of extinction.

The foregoing discussion indicates that the potential stressor of flow-related habitat availability is low or negligible for green sturgeon in the Action Area below Daguerre Point Dam in the lower Yuba River.

The other potential flow-related stressor to green sturgeon in the Action Area below Daguerre Point Dam in the lower Yuba River is water temperature suitability. Water temperature monitoring over the past six years demonstrated that water temperatures remain below the upper WTI values for all lifestages of green sturgeon at Daguerre Point Dam, and for most lifestages at the Marysville Gage. The upper end of the WTI value range for post-spawning adult holding (*i.e.*, 61°F) was exceeded at the Marysville Gage during a portion of this lifestage evaluation period.

Water temperature modeling demonstrated similar results as water temperature monitoring. Modeled mean monthly water temperatures under the Environmental Baseline (*i.e.*, current conditions simulation) for each individual month from February through November (over the entire simulation period from WY 1922 through WY 2008) demonstrates that mean monthly water temperatures at Daguerre Point Dam always remain below the upper WTI value range for all lifestages of green sturgeon. Modeled water temperatures at the Marysville Gage also remained below the upper WTI value range for all lifestages of green sturgeon with the exception of post-spawning holding. The upper end of the WTI value range for post-spawning adult holding (*i.e.*, 61°F) was exceeded at the Marysville Gage during variable portions of time from June through September.

(3) Summary of the Current Viability of the Southern DPS of Green Sturgeon

For the DPS-wide environmental baseline effects assessment of steelhead, NMFS (2009a) found that the entire suite of limiting factors, threats and stressors associated with the environmental baseline result in an unstable DPS at moderate or high risk of extinction.

The key limiting factors, threats and stressors associated with the environmental baseline affecting the Southern DPS of green sturgeon, include the following.

- Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range (reduction in spawning habitat, alteration of habitat – flows, water temperatures, delayed or blocked migration, impaired water quality, dredging and ship traffic, ocean energy projects),
- Commercial, Recreational, Scientific or Educational Overutilization,
- Disease and Predation,
- Inadequacy of Existing Regulatory Mechanisms, and

- Other Natural and Man-Made Factors Affecting the Species' Continued Existence (non-native invasive species, entrainment).

About 217 green sturgeon have been acoustically-tagged in the Central Valley (CFTC 2012 as cited in YCWA 2013a). However, the current status of the Southern DPS of green sturgeon abundance and productivity is unknown (NMFS 2009a). CVP/SWP system-wide operations, including closures of the ACID dam and the RBDD gates historically resulted in increased loss of individual fish and reduced abundance of adult fish in the green sturgeon population (NMFS 2009a). Closure of the gates at RBDD from May 15 through September 15 previously precluded all access to green sturgeon spawning grounds above the dam during that time period. However, as previously discussed, the RBDD gates were permanently raised during September 2011. With the RBDD gates raised, Vogel (2011) reports that green sturgeon have unimpeded access to upstream reaches as far as the ACID dam near Redding, CA.

Larval and juvenile green sturgeon entrainment or impingement from screened and unscreened agricultural, municipal, and industrial water diversions along the Sacramento River and within the Delta also are considered important threats (71 FR 17757).

The Southern DPS of green sturgeon is at substantial risk of future population declines (NMFS 2009a). The potential threats faced by green sturgeon include increased vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River, lack of good empirical population data, vulnerability of long-term cold water supply for egg incubation and larval survival, loss of juvenile green sturgeon due to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and Delta systems, alterations of food resources due to changes in the Sacramento River and Delta habitats, and exposure to various sources of contaminants throughout the basin to juvenile, sub-adult, and adult lifestages (NMFS 2009a).

According to NMFS (2009a), past RBDD gate closures blocking access to upstream spawning areas decreased the productivity and spatial structure of the green sturgeon population. Fish forced to spawn below RBDD were believed to have a lower rate of spawning success compared to those fish that spawned above the RBDD. Furthermore, NMFS (2009a) stated that reductions in genetic diversity may occur due to the separation of upstream and downstream populations created anthropogenically by the closure of the RBDD. When the gates were down, RBDD precluded access to 53 miles of spawning habitat for 35-40 percent of the spawning population of green sturgeon. NMFS (2009a) mandated an RPA action for RBDD that required the gates to be raised year-round by 2012. As previously discussed, the Red Bluff Diversion Dam Fish Passage Improvement Project was completed in 2012. At the time that NMFS conducted the consultation for the CVP/SWP OCAP, green sturgeon critical habitat had been proposed but a final rule designating critical habitat had not yet been adopted. NMFS (2009a) therefore referred to "proposed" green sturgeon critical habitat in its evaluations.

According to NMFS (2009a), the proposed critical habitat at that time for the Southern DPS of green sturgeon is degraded over its historical conditions. It does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat. In particular, passage and water flow PCEs have been impacted by human actions, substantially altering the historical river characteristics in which green sturgeon evolved. In addition, the alterations to the Delta may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon due to the protracted rearing time in the delta and estuary. Loss of individuals during this phase of the life history of green sturgeon represents losses to multiple year classes rearing in the Delta, which can ultimately impact the potential population structure for decades to come (NMFS 2009a).

NMFS (2009a) stated that CVP/SWP system-wide operations are expected to reduce the conservation value of green sturgeon critical habitat. The principal factor for the decline of green sturgeon reportedly comes from the reduction of green sturgeon spawning habitat to a limited area of the Sacramento River (70 FR 17391). The potential for catastrophic events to affect such a limited spawning area increases the risk of the green sturgeon's extirpation. The value of the upstream migration corridor is currently degraded mainly by the installation of the ACID dam (NMFS 2009a). Elevated water temperatures in the spawning and rearing habitat likely also pose threats to this species (70 FR 17391). The effects of future CVP/SWP system-wide operations under climate change scenarios would likely further degrade the water quality PCE.

As described by NMFS (2009a), there are few data with which to assess the status of green sturgeon in the Central Valley domain. NMFS (2009a) stated that the green sturgeon DPS is data deficient. Nonetheless, NMFS (2009a) concluded that the Southern DPS of green sturgeon remains vulnerable to becoming endangered in the future. Key factors upon which this conclusion was based include: (1) the DPS is comprised of only one spawning population, which has been blocked from a considerable portion of its potential spawning range by dams, (2) the DPS has a risk associated with catastrophes and environmental perturbations (*i.e.*, water temperatures from Shasta Dam) affecting current spawning areas, and (3) mortality rates have significant effects on the adult and sub-adult life history phases of this long-lived species (NMFS 2009a).

NMFS (2009a) concluded that continued operations of the CVP/SWP would be expected to have population level consequences for the single extant population in the mainstem Sacramento River, and greatly increase the extinction risk of the species (NMFS 2009a). Additionally, NMFS (2009a) concluded that the conservation value of the critical habitat, as designated for the conservation of green sturgeon, would be reduced.

NMFS (2009a) developed a RPA for green sturgeon in order to avoid jeopardy and adverse modification of critical habitat. The green sturgeon RPA specifies many significant actions that will reduce the adverse effects of the continued operation of the CVP/SWP and bring about the proper functioning of PCEs of its proposed critical habitat (NMFS 2009a).

<u>Lower Yuba River Green Sturgeon</u>

Very few observations of green sturgeon have occurred in the Yuba River historically or in recent years. The few occasions when confirmed observations have occurred, they were downstream of Daguerre Point Dam and consisted of adult green sturgeon. Green sturgeon acoustic tag detections do not indicate substantive use of the Yuba River (YCWA 2013).

Monitoring and studies of green sturgeon in the Delta, the Sacramento River and its tributaries continue to be undertaken by a variety of agencies implementing numerous different programs. The CFTC continues to monitor acoustically tagged green sturgeon throughout the system, and fixed-station acoustic monitors and roving hydrophonic surveys continue to be conducted on the lower Yuba River by both the RMT and CDFW's Heritage and Wild Trout and the Steelhead Management and Recovery Programs. The AFRP is continuing to fund ongoing sturgeon videographic monitoring efforts in the Feather River Basin, including the lower Yuba River. Additionally, the Sturgeon IEP Project Work Team coordinates green sturgeon research, disseminates information and is overseeing the development of a green sturgeon population model, and the Corps' LTMS for the Placement of Dredged Material in the San Francisco Bay Region Program includes green sturgeon tracking, evaluation of susceptibility to suction dredging and development of entrainment models. Available results from these and other programs may provide additional information regarding green sturgeon in the Central Valley and lower Yuba River. However, despite the contribution resulting from these and other studies conducted to date, knowledge of the population biology and dynamics of green sturgeon remains limited.

Limited information regarding green sturgeon abundance, distribution, movement and behavioral patterns, as well as lifestage-specific habitat utilization preferences, is available for the Sacramento and Feather rivers. According to NMFS (2009a), the current population status of the Southern DPS of green sturgeon is unknown. Currently, there are no reliable data on population sizes, and population trends are lacking (NMFS 2009d). There is insufficient information to evaluate the productivity of green sturgeon (NMFS 2009d), and recruitment data for green sturgeon are essentially nonexistent (NMFS 2009a). Essentially no information regarding these topics is available for the lower Yuba River.

Hence, it is not practicable to attempt to apply the VSP concepts developed for salmonids to green sturgeon in the lower Yuba River. Moreover, the lack of information pertaining to abundance, productivity, habitat utilization, life history and behavioral patterns in the lower Yuba River, due to infrequent sightings over the past several decades, does not provide the opportunity for reliable alternative methods of viability assessment of green sturgeon in the lower Yuba River.

<u>Future Needs</u>

It should be noted that there were not regular surveys for green sturgeon in the Yuba River, until after the siting of green sturgeon at Daguerre Point Dam in 2011. The original observation of green sturgeon in 2011 was unexpected. Some underwater camera equipment was being tested when a sturgeon swam past the camera.

Little is known about green sturgeon use of the lower Yuba River. It is clear that in some years they do use the Yuba River. There are currently efforts underway to collect more information about green sturgeon in the Sacramento River system. The lack of information about green sturgeon points to the need to collect more information about green sturgeon in the Yuba River, and throughout the range of green sturgeon.

(IX) EFFECTS OF THE PROPOSED ACTION

Pursuant to section 7(a)(2) of the ESA, Federal agencies are directed to insure 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. To evaluate whether an action is likely to result in jeopardy to a listed species or result in the destruction or adverse modification of designated critical habitat, this BiOp considers the combination of the status of the species and critical habitat, the environmental baseline, the physical conditions baseline, the effects of the action, the cumulative effects of non-Federal actions that are reasonably certain to occur within the action area, and the interrelated or interdependent actions. Regulations that implement section 7 of the ESA provide that the "effects of the action" refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). An action that is not likely to jeopardize the continued existence of the listed species is one that is not reasonably expected to appreciably reduce the likelihood of both the survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution (50 CFR 402.02). This BiOp does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we rely upon the statutory provisions of the ESA and determine the effects of the action on the conservation value of critical habitat designated for listed species.

This BiOp assesses the effects of the proposed action on the listed CV spring-run Chinook ESU, CCV steelhead DPS, and the Southern DPS of green sturgeon, and their designated critical habitats.

In the BA (Corps 2013b) the Corps deconstructed their activities associated with their facilities on the Yuba River. Figure IX-1 is a representation of that deconstruction. The BA (Corps 2013b) identified the following five categories of activities: 1) future actions requiring separate ESA consultation, 2) non-discretionary actions, 3) discretionary actions with no effect, 4) Englebright Dam and reservoir discretionary actions that are not likely to adversely affect listed species, and 5) Daguerre Point Dam fishway facilities that may affect listed species or designated critical habitat. NMFS' understanding of the reasons that the Corps has not included the activities associated with the first three categories in their proposed project is: 1) the future proposed projects for relicensing the hydropower project in proximity to Englebright Dam by the Federal Energy Regulatory Commission are uncertain at this time, 2) non-discretionary actions do not require consultation under the ESA, and 3) the Corps has determined that certain discretionary actions have no effect on ESA listed anadromous fish species or their associated designated critical habitat. As described above in the proposed action section, this same list of activities was also presented by the Corps in a second BA submitted to NMFS on October 22, 2013, for Engelbright Dam (Corps 2013a). Through meetings with the Corps to clarify the scope of the BA for this consultation (Daguerre Point Dam, Corps 2013b), NMFS understands that, while the Corps presented the same list of activities in both BAs submitted on October 22, 2013, this consultation is limited to item (5) Daguerrre Point Dam fishway facilities and associated activities (*e.g.* gravel augmentation and large woody material programs) that may affect listed species or designated critical habitat. As described earlier, the activities for which the Corps requested ESA consultation associated with Englebright Dam and reservoir were submitted to NMFS as a separate consultation (Corps 2013a). The Corps has identified that their activities associated with Englebright Dam are a distinct project, due to discrete authorization and operations.

The following analysis is limited to fish passage facilities at Daguerre Point Dam, which is the only action which the Corps has requested consultation for due to their limited discretion.

THIS PAGE INTENTIONALLY LEFT BLANK

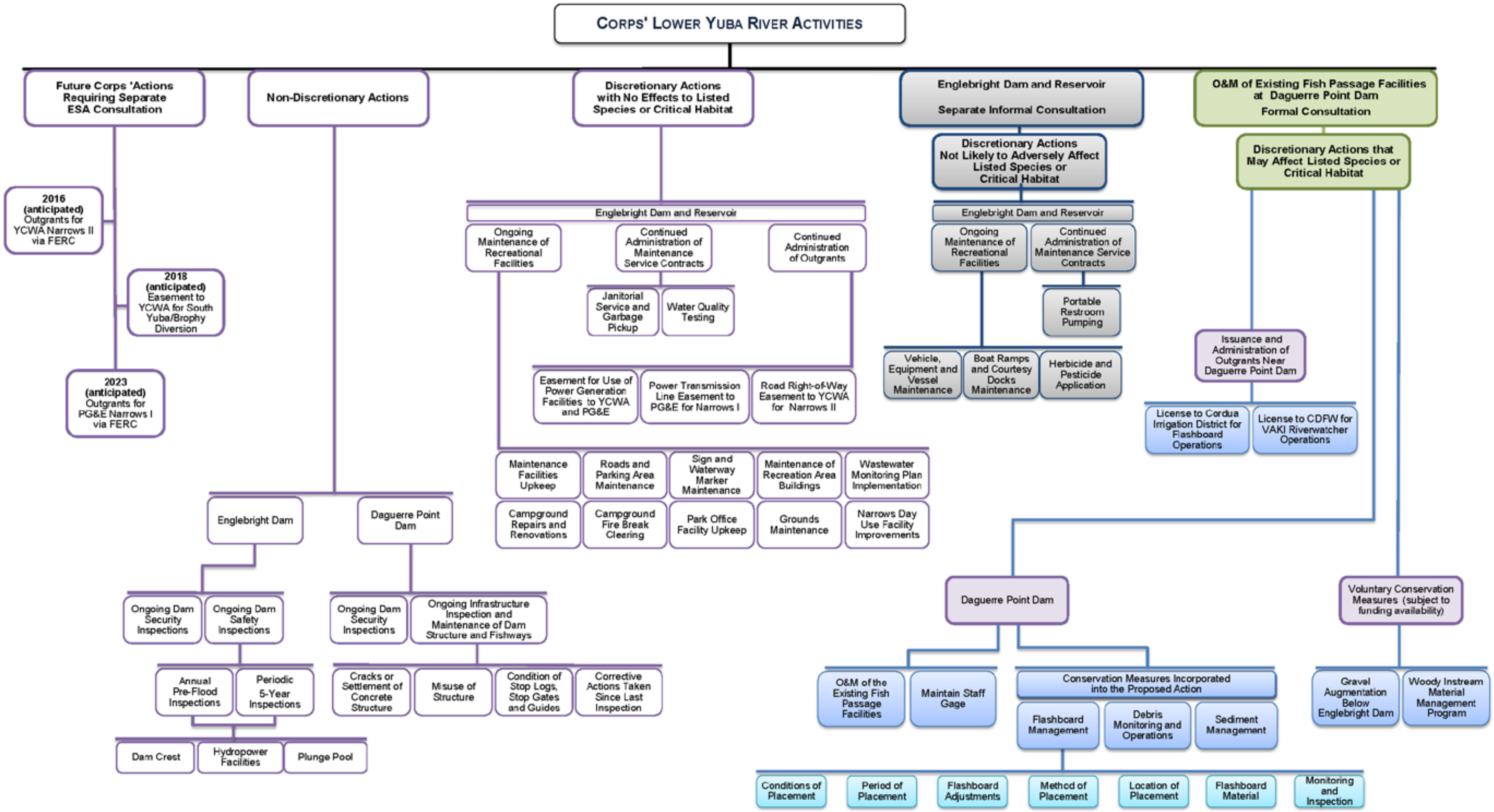


Figure IX-1. Deconstruction of Corps lower Yuba River activities and the Proposed Action (*i.e.* discretionary actions that may affect listed species (Corps 2013b).

(A) Operation and Maintenance of Fish Passage Facilities

The Corps operation and maintenance of the fish passage facilities at Daguerre Point Dam includes:

- Adjusting fishway gates,
- Adjusting within-ladder flashboards,
- Adjusting fish ladder gated orifices,
- Fishway inspections, and
- Cleaning grates covering fishways.

(1) Exposure

The potential exposure of ESA listed anadromous salmonids (spring-run Chinook salmon and steelhead) to these activities is very limited. With the exception of fishway inspections, the activities, at most, usually only occur once or twice a year, and sometime only once every couple of years. Inspections occur more frequently, but are visual inspections that do not involve potential injury or death to ESA listed species.

(2) Response

These activities, with the exception of cleaning debris off of the grates, are beneficial to fish. These activities are intended to improve the operating conditions of the fishways and remove hazards to migrating fish. It is not likely that this activity would be a significant stressor on the CV spring-run Chinook salmon, or CCV steelhead populations. Because green sturgeon do not use the fish ladders, it is unlikely that this activity will adversely affect green sturgeon.

Adjusting fishway gates: Past operations included closing the gates at the upstream end of the fish ladders under certain conditions. Currently, in coordination with CDFW, NMFS and the Yuba River Management Team, these gates are kept open under all flow conditions. Keeping the gates open at the upstream end of the fish ladders will allow fish to move through the fish ladders at all flows. Coordination with CDFW, NMFS, and the Yuba River Management Team and implementation of recommendations will address any issues associated with the fishway gates that may be detrimental to ESA listed anadromous fish species in the fish ladders. Due to the frequent and ongoing inter-agency communication and adaptive management approach of the Yuba River Management Team, if an issue arises, it will be addressed in such a way to minimize effects to listed species. Consistent with the Corps' determination, the operations of the fishway gates as proposed by the Corps are not likely to adversely affect ESA listed anadromous fish species.

Adjusting within-ladder flashboards: Due to changing river water elevations and flows, conditions within the fish ladders can change. Within the south fish ladder, flashboards have been placed to manage flows in such a way as to encourage fish to move into, and up through the fish ladders. Adjusting the boards influences the hydraulics and has been shown to improve attraction of adult salmonids moving upstream. The Corps coordinates with the CDFW regarding the adjustment of the within ladder flashboards to maintain the best possible conditions for migrating salmonids. The fish ladders are not used by green sturgeon, and no response by green sturgeon to changes in the flashboards has been observed, or is expected. Consistent with the Corps' determination, the placement and/or removal, and operations with flashboards within the fish ladders is not likely to adversely affect ESA listed anadromous fish species.

Adjusting fishway gate orifices: As with the within ladder flashboards and fishway gates, the fish ladder gated orifices at the downstream end of the fish ladders are adjusted to provide the best attraction flows to fish that are moving upstream. Changes are made in coordination with CDFW, based on river water elevations. These adjustments are made to improve fish passage for salmonids at Daguerre Point Dam. Consistent with the Corps' determination, adjustments of the fish ladder gated orifices at the downstream end of the fish ladders is not likely to adversely affect ESA listed anadromous fish species.

Fishway inspections: Fishway inspections are visual inspections to determine if sediment or debris has accumulated in the fish ladders. Consistent with the Corps determination, the manner of inspecting the fish ladders is not likely to adversely affect anadromous fish species listed under the ESA.

Cleaning grates covering fishways: Debris can accumulate on top of the fish ladder grates when flows are high. At high flows debris along the shore is picked up by the river and transported downstream. The grates on the tops of the fish ladders have reduced the amount of debris that enters the fish ladders when they are inundated. Floating debris accumulating up on top of the grates is removed by the Corps. Consistent with the Corps' determination, removal of debris from the ladder grates is not likely to adversely affect ESA listed anadromous fish species.

(3) Critical Habitat

PCEs that are relevant to the operation and maintenance of fishway facilities include freshwater migration corridors. Operations and maintenance actions are taken to maintain the connectivity of freshwater migration corridors and therefore do not adversely affect the conservation value of this PCE at the project site or within the action area.

(B) Fishway Debris Removal

(1) Exposure

There is a possibility that juvenile CV spring-run Chinook salmon or CCV steelhead may be within the bays of the fish ladders during debris removal activities and exposed to debris removal equipment and associated noise.

(2) Response

The Corps determined that debris removal component "*may affect, is likely to adversely affect*" because of the possibility of incidental take of CV spring-run Chinook salmon and CCV steelhead. Any fish within the fishways during debris removal Debris maintenance and removal activities performed in the fish ladders at Daguerre Point Dam may temporarily disrupt the upstream migration behavior of adult CV spring-run Chinook salmon and CCV steelhead.

Consequently, there is a possibility that adverse effects such as physical harm or mortality could occur to individual fish.

(3) Critical Habitat

Freshwater migration corridors are the PCEs present at fishway debris removal locations. Debris removal actions are taken to maintain the connectivity of freshwater migration corridors and therefore do not adversely affect the conservation value of this PCE at the project site or within the action area.

(C) Sediment management

The pool upstream of Daguerre Point Dam has been completely filled with sediment through the downstream transport of bedload from the river channel above the dam. This is what the dam was designed and built to do. However, the aggregation of sediment above the dam can create difficulties for migrating fish as they exit the top of the fishways. Fish that have passed through the fish ladders need to migrate from the upstream ends of the ladders at the north and south abutments of Daguerre Point Dam to the main channel of the river before they can continue their upstream migration. As salmonids exiting the fishways move toward the channel, they must swim at right angles to the flow of the river, just upstream of the dam. Where the sediment comes up to the lip of the dam, due to high velocities, a condition is created for fish to potentially be swept over the top of the dam. To address this issue the Corps has, and is proposing to continue, dredging a channel from the exits of both fish ladders, across the upstream side of the dam to the main channel of the river. This channel will allow fish to migrate from the fish ladders to the main river channel in all flows and reduce the risk of the fish being swept over the face of the dam.

(1) Exposure

While the Corps has identified this activity occurring during the first 15 days of August, in some years the flow at that time does not allow for the operation of the equipment. While there is a preference for this work to be done in the first half of August, high flows may require the dredging to be done later in August, but will not change the duration of the activity.

The duration of the increased turbidity will be limited to a short duration and area, and will not occur every year. The duration of this activity is usually for about three to five days. The increased turbidity occurs only for a short distance downstream of Daguerre Point Dam and only usually for a portion of the width of the Daguerre Point Dam pool. The removal of material from the bed of the river could decrease the amount of substrate material moving downstream. The Corps has identified that if the necessary permits can be obtained that they will place the dredged material downstream of Daguerre Point Dam outside of the flowing stream. This will allow this dredged material to be recruited downstream during high flows events. Lacking the permits, the Corps intends to place the material upland.

The work is only conducted in a portion of the river immediately upstream of Daguerre Point Dam at any given time, and there is room for the fish to move to the other side of the river, downstream of the dam.

Mid-August is a period of the year when adult CV spring-run Chinook and to a lesser extent adult CCV steelhead may be present. They would either be migrating through the area, or holding in the pool below the dam. Rearing juvenile CV spring-run Chinook and juvenile CCV steelhead may also be present at the time of the dredging.

Green sturgeon are not present upstream of Daguerre Point Dam, and are not expected to be adversely affected by this activity.

(2) Response

The Corps has determined that this component "*may affect, is likely to adversely affect"* CV spring-run Chinook salmon and CCV steelhead. The Corps (Corps 2013b) determined that there is some potential that sediment excavation activities directly upstream of Daguerre Point Dam may interfere with the egress of adult individuals from the fish ladders, causing temporary behavioral alteration. Sediment excavation also may result in temporary behavioral alteration of CV spring-run Chinook salmon and CCV steelhead juvenile rearing and downstream migration.

Increased turbidity from dredging may result in juvenile and adult CV spring-run Chinook salmon and CCV steelhead moving out of the area of increased turbidity. The plume of increased turbidity is expected to diminish within a short distance downstream (approximately 200 feet), due to dilution from the water flowing over the dam, and the suspended material settling out of the water column. Exposed individuals may be injured or killed through respiratory distress and damage. Although salmonids are expected to avoid areas being dredged, an undetermined number of juvenile salmonids may attempt to find shelter in the substrate and be injured or killed by the dredging equipment. Adult salmonids are expected to avoid the vicinity of the dredging activity.

Additionally, there is the more remote possibility of physical injury or direct mortality to juveniles hiding in the substrate from being contacted by the excavator bucket. Consequently, implementation of the sediment management plan has the limited potential to result to adversely affect adult and juvenile CV spring-run Chinook salmon and CCV steelhead individuals. Therefore, although the sediment management component of the proposed action represents a long-term beneficial effect, there is a possibility that adverse effects such as physical harm or mortality could occur to individual fish

The material that is removed is material that move downstream and filled in the fish channel on the upstream side of the dam. Removing material from the river above the dam improves fish passage and does not decreases the available holding, rearing, or spawning habitat. Placing the material removed below the dam provides for the recruitment of spawning gravel downstream of the dam and constitutes a beneficial effect on critical habitat. Effects from sediment removal will be limited to a small geographical area immediately upstream and downstream of the dam.

(3) Critical Habitat

Critical habitat PCEs that may be affected by the sediment removal include freshwater migration and rearing habitat. Although there may be temporal impacts to PCEs that could result in temporary behavior modifications affecting upstream and downstream migration and rearing, these impacts will be temporary, not occur every year and, ultimately conducted to maintain the connectivity of freshwater migration corridors. For these reasons, the conservation value of freshwater migration corridors and rearing habitat within the action area will not likely be adversely affected.

(D) Staff Gage Maintenance

(1) Exposure

Operation and maintenance of the Daguerre Point Dam staff gage is carried out by the Corps (Corps 2013b). A staff gage is a piece of metal or plastic with elevation measurement marks, similar to a yard stick. A staff gage is attached to a stable structure and is affixed so that it is calibrated to a specific elevation. Operation of a staff gage is the periodic reading of the water level on the staff gage. Maintenance of staff gages involves removing accumulated material adjacent to the gage, and on occasion replacing the gage if it becomes damaged or unreadable.

(2) Response

The Corps determined that the manner and infrequency of replacing the gage is not expected to adversely affect anadromous fish species listed under the ESA. Because reading the gage does not involve any in water activity, the anadromous fish are not exposed to any form of disturbance and the reading of the gage at Daguerre Point Dam is not expected to result in any effect to ESA listed anadromous fish species, or their designated critical habitat. Replacement of the gage occurs on a frequency of once every couple of decades. Replacement is expected to take only a day, and, similar to reading the gage, involves very little in water activity. It is likely that the area would be accessed from the top of the dam and involves the placement of a couple of bolts.

(3) Critical Habitat

Staff gage maintenance requires little to no inwater work and PCEs of critical habitat are not expected to be adversely affected. Therefore, this activity is not expected to affect critical habitat in the action area.

(E) VAKI Riverwatcher

(1) Exposure

There are two VAKI Riverwatcher located at Daguerre Point Dam. One is located in each of the fish ladders at Daguerre Point Dam. The Riverwatchers are devices that record images of fish as they pass through the fish ladder. The Riverwaters are operated by the California Department of Fish and Wildlife, under a license from the Corps. The Riverwatchers include a tunnel in each fish ladder that guides the fish into the area in front of the camera, so that video and other information for each fish can be obtained without handling or disturbing the fish (VAKI: http://www.riverwatcher.is/). Power is supplied to the through solar panels and batteries. The data collection and power systems are located upland from the fish ladders. The VAKI Riverwatchers are inspected daily for any debris that may have accumulated. If debris is present it is removed, to ensure the safe passage of fish.

(2) Response

Based on observations of fish moving through VAKI Riverwatchers, and observations of video taken by VAKI Riverwatchers, it does not appear that the structure or operation of the VAKI Riverwatchers result in significant behavioral effects to ESA listed anadromous fish species. There is the potential that the activity of removing material that accumulates on the VAKI Riverwatchers could disturb fish moving through the fish ladder. Current information is that this activity occurs on less than a daily basis, and the duration is usually only for a few minutes, but can last up to a half hour.

The VAKI reduces the amount and size of debris traveling downstream into the fish ladders. Along with the reduction in debris traveling through the fish ladders, the collection of VAKI data is a beneficial effect of the use of the VAKI Riverwatcher. The level of effect to the behavior of ESA listed individual fish is of such a short duration and frequency as to be considered discountable.

(3) Critical Habitat

The Vaki Riverwatcher is not expected to have any adverse effects on the PCEs of critical habitat at the installation site. As such, the action is not expected to adversely affect the conservation value of critical habitat in the action area.

(F) Dam Flashboard Management

(1) Exposure

During low flow conditions the water flowing over Daguerre Point Dam can recede to the center of the dam, where the dam is evidently slightly lower in elevation than the north and south ends of the crest of the dam. This can result in diminished flows in the fish ladders. During low flow conditions the Corps, through the Cordua Irrigation District, installs flashboards on Daguerre Point Dam to direct flow away from the center of the dam toward the north and south abutments. This redirection of water assists the flow of water into the Cordua Irrigation District's diversion, located in the north abutment of Daguerre Point Dam, and maintains flow into the two fish ladders.

The placement of the dam flashboards is done in accordance with the Flashboard Management Plan, and with the license the Corps has issued to the Cordua Irrigation District. The installation of the flashboards is done in coordination between the Cordua Irrigation District, the Corps, CDFW, and NMFS. The flashboards are attached to Daguerre Point Dam with brackets. The brackets are attached to the dam with anchor bolts. The dam flashboards may be installed after April 15, and will be removed prior to November 1, of each year. The flashboards will be removed within 24 hours, if so directed by the Corps, NMFS, or CDFW. The flashboards are not installed every year, only in the event of low flow conditions that affect flow to the north and south abutments. The flashboards are to be made of 2" x 10" Douglas Fir, or similar material, and be free of preservatives or contaminants. Fish passage will be monitored upon placement of the flashboards. The flashboards will be monitored at least once per week for the accumulation of debris that may contribute to juvenile fish mortality. The Flashboard Management Plan will be updated in 2016. If the Corps' license to the Cordua Irrigation District is not renewed in 2016, the Corps will license another entity or conduct the installation of the flashboards themselves.

(2) Exposure

The installation of flashboards increases the depth of the water flowing over the dam, through decreasing the width of the water flowing over the dam. This reduces the potential for injuries to juvenile salmonids associated with very shallow sheet flow over the dam. Fish moving downstream when the water flowing over the dam is very shallow, may be injured through coming into contact with the concrete of the dam. Thus, during low flow conditions deeper water flowing over the dam as a result of installation/operation of the flashboards would reduce the likelihood of this type of injury.

Installation of the flashboard improves up- and downstream fish passage by increasing flow in the fish ladders through the redirection of flows from the whole width of Daguerre Point Dam to the north and sound ends of the dam, where the entrances to the fish ladders are located. This will improve the attraction flows to the fish ladders, and should reduce the incidence of fish jumping at the face of the dam in attempts to pass upstream.

The Corps (Corps 2013b) identified that there is a potential for the flashboards to collect debris that has an associated potential to entrap downstream migrating juvenile CV spring-run Chinook salmon and CCV steelhead, which may contribute to juvenile fish injury or mortality. However, the plan specifies that the flashboards will be monitored at least once per week, and perhaps as frequently as daily in conjunction with CDFW and/or PSMFC monitoring of the VAKI systems, and that all adjustments to the flashboards will be made as necessary in coordination with NMFS and CDFW. During the period that flashboards are installed, the flashboards will be cleared within 24 hours of finding a blockage, or as soon as it is safe to clear them. Further, flashboards will be removed within 24 hours, if directed by the Corps, NMFS or CDFW.

(3) Response

The dam flashboard management component of the Proposed Action provides a beneficial effect in regards to improved fish passage due to increased attraction flows through the fish ladders and increased depth at the point where water flows over the center of the dam. Due to low flows and low velocities when the dam flashboards are in place, it is not expected that any large amounts of debris will accumulate on the flashboards. With the Corps removal of any accumulation of debris within 24 hours, it is not likely that juvenile or adult CV spring-run Chinook salmon or

CCV steelhead would be directly or indirectly impacted due to interactions with debris on the dam flashboards. While the Corps identified (Corps 2013b) that their activitity “may affect, is likely to adversely affect” Federal ESA listed anadromous salmonids, NMFS’ analysis concluded that the effects of the dam flashboards and associated debris are insignificant and discountable and not likely to adversely affect ESA listed anadromous fish species.

(4) Critical Habitat

PCEs present at and around the dam flashboards include freshwater migration and rearing habitat. Although maintenance actions may result in short-term or temporary impacts to the quality of these PCEs will not be reduced and the conservation value of critical habitat in the action area will not be diminished.

(G) Gravel Augmentation

(1) Exposure

The Corps maintains a program of adding spawning gravel to an anadromous reach of the Yuba River directly downstream of Englebright Dam that was devoid of spawning gravel, prior to the Corps gravel augmentation program (in previous years). The gravel is delivered to the river via a pipe, with water added to move the gravel through the pipe and exposure is caused by the inwater placement of approximately 5,000 tons per year of gravel into the Yuba River from the implementation of the GAIP during the months of July 15 to September 1 (the typical months the Corps has placed gravel in past months). The Corps has identified that the continuation of the gravel augmentation program is subject to funding, but this analysis assumes that gravel placement could occur every year.

While it is expected that the gravel placed in this area will periodically be transported downstream by high flows, the transported gravel is expected to be redeposited in downstream depositional reaches, improving salmonid spawning habitat between the gravel augmentation site and Daguerre Point Dam.

Through habitat improvement, the gravel augmentation is expected to improve designated critical habitat. This represents a beneficial effect to ESA listed anadromous salmonids, as long as the program is continued. If the gravel program is discontinued, the benefits of this program will be lost once the gravel that has been added has moved downstream and out of the action area.

During the act of placing the gravel some individual rearing juveniles may be displaced by the addition of the gravel. Due to the noise associated with the gravel pouring out of the pipe it is expected that any juveniles in the area will move out of the immediate area. At any one time the area disturbed by the gravel and associated turbidity is up to 25 percent of the river width, and about 200 feet downstream of the pipe.

(2) Response

The Corps has determined that the gravel augmentation component "*may affect, is likely to adversely affect*" ESA listed salmonids because of the potential for incidental take of CV spring-run Chinook salmon and CCV steelhead. The Corps (Corps 2013b) determined that gravel injection has the potential to result in harassment of individuals due to noise and vibration. It also may result in physical injury or direct mortality of juvenile CV spring-run Chinook salmon and CCV steelhead, although it is likely that individuals would vacate the area during construction activities. The placement of gravel also increases turbidity within the disturbance footprint described above. Juveniles exposed to the turbidity increases could be injured or killed if turbid water enters their gills and causes respiratory distress. The effect on rearing juvenile salmonids and holding adult salmonids is of short duration and fish can move back into the affected area immediately after gravel augmentation. It is not likely that adults of either species would be directly or indirectly impacted due to natural avoidance behaviors, larger size and associated faster swimming speeds.

Gravel augmentation is not likely to result adverse effects to green sturgeon, because green sturgeon are not present at the gravel augmentation site.

(3) Critical Habitat

Gravel augmentation is expected to benefit CV spring-run Chinook salmon and CCV steelhead designated critical habitat through an increase in both the amount and quality of available spawning and rearing habitat. Although the gravel may have short term adverse effects to individual fish during placement, the gravel augmentation itself will improve the conservation value of freshwater spawning habitat at the project site and within the action area.

(H) Woody Instream Material Management Program

(1) Exposure

There are areas of the lower Yuba River that have very little LWM. LWM is a valuable aspect of salmonid stream habitat. Large wood can break up water velocities and create hydraulics that increase channel complexity, providing holding habitat for salmonids. Bedload is captured by LWM, slowing the transport of spawning gravels through a stream reach and retaining patches of suitable spawning substrate. Large wood can provide cover from predators, and locations from which to forage. In addition, large wood can also provide food through providing habitat for macroinvertebrates. LWM can also benefit stream ecosystems through the snagging of adult salmonid carcasses, allowing carcasses to stay further up in the stream for longer periods. Carcasses provide nutrients directly and indirectly to rearing salmonids.

(2) Response

The Corps has determined that the LWM program "*may affect, is likely to adversely affect*" because of the potential for the injury or mortality of juvenile ESA listed salmonids and the potential harassment of adult listed from the disturbance cause by the operation of heavy equipment close to the river channel. Construction and placement of LWM features have the potential to have adverse effects due to the potential for physical injury or direct mortality of juvenile CV spring-run Chinook salmon and CCV steelhead seeking shelter in substrate gravel and cobble during placement of large LWM. If it is necessary to use heavy equipment close to the river, there is a potential for noise and vibration of short duration to occur during placement of LWM. Adult ESA listed salmonid spawners are expected to exhibit avoidance behavior and leave the area during the disturbance, avoiding direct impacts, but experiencing indirect impacts from being temporarily displaced and harassed.

The placement of LWM is not likely to result in incidental take of green sturgeon, because green sturgeon are not present in the stream reach where construction and placement may occur.

(3) Critical Habitat

Increased amounts of LWM in the Yuba River is expected to benefit CV spring-run Chinook salmon and CCV steelhead designated critical habitat through an increase in both the amount and quality of available spawning and rearing habitat. Although the placement may have short term adverse effects to individual fish during placement, the LWM itself will improve the conservation value of freshwater rearing habitat at the project site and within the action area.

(X) CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

(A) Yuba Goldfields Sand and Gravel Mining Operations

The Yuba Goldfields area is designated and zoned "Extractive Industrial" under the Yuba County General Plan, which allows surface mining as a permitted use. Operators within and adjacent to the Yuba Goldfields currently supply construction materials, including asphaltic concrete, to projects within southern Placer and Yuba counties. These projects are not expected to add incremental adverse effects to listed species or their habitat.

(1) Teichert Aggregates

The Teichert Aggregate's operation mines and processes sand and gravel deposits in addition to hard rock, immediately adjacent to the Yuba Goldfields approximately five miles northeast of Marysville, California, and two miles south of the Yuba River. The mine operates on an approximately 590-acre site and mines to depths of approximately 200 feet (Placer County 2007). Mining operations use a dragline to excavate mined materials in saturated conditions (below groundwater levels). According to Placer County (2007), production is 500,000 tons per year to 1 million tons per year (mty) depending on specific market demands. For purposes of assessing cumulative effects, it was previously assumed that this facility would be operating at its maximum estimated production rate of 1 mty (Placer County 2007). According to SMGB (2010), mineral production at Teichert Aggregate's Marysville facility was curtailed by more than 90 percent of the operation's previous maximum annual mineral production due to economic conditions in 2009. However, the operator submitted an Interim Management Plan (IMP) to the California State Mining and Geology Board (SMGB) for review and approval in 2010, and the operator indicated intent to resume surface mining operations at a future date. The SMGB recommended approval of the IMP for the Teichert Marysville Facility for a period of up to five years (SMGB 2010).

(2) Western Aggregates

The Western Aggregates 180-acre conservation easement (south side of Yuba river from Highway 20 bridge downstream to the Yuba Goldfields) will prohibit development or mining on the encumbered lands (except for disturbance that may be necessary to re-establish floodplains), and will outline a range of potential prescriptions for habitat restoration (YubaNet 2008). The project also will incorporate pedestrian access to the lower Yuba River through several walk-through gates to be established at locations to be agreed upon at a future date.

The parties plan to implement the project in three phases. Initially, the project will protect and conserve land from vehicular damage to habitat. Concurrently, SYRCL will lead design and feasibility studies for physical habitat restoration. In the second phase, habitat for salmon and riparian wildlife will be restored through a series of projects over the encumbered lands. Finally, the project contemplates implementing long-term enhancement and monitoring of these restored habitats. The timing of the completion of the three phases is unknown at this time because of the funding needs of the project (YubaNet 2008). Western has initiated a Yuba Salmon Enhancement Fund through a "challenge grant" to SYRCL of $50,000, and Western has agreed to match SYRCL's fund-raising of the project dollar for dollar for the first $50,000 raised by SYRCL (YubaNet 2008). The four parties to the Agreement in Principle also must obtain the consent of certain third parties who have varying interests in some of the lands contemplated for the conservation easement (YubaNet 2008).

(3) Baldwin Contracting Company and Springer Family Trust Hallwood Aggregate Facility

The Baldwin Contracting Company, Incorporated and Springer Family Trust has proposed to expand its aggregate mining operations in the Hallwood area of east-central Yuba County, just west of the Yuba Goldfields off SR 20 (Placer County 2007). Baldwin Contracting conducts mining operations on 275 acres and is planning a phased expansion of about 200 acres over a period of 14 to 20 years, with expansion occurring 30 acres at a time. The expansion would result in mining of an additional 500,000 tons per year to 1 million tons per year. Applications were submitted to Yuba County for a change of zone, a General Plan amendment, and a Yuba County surface mining permit, and to the California State Office of Mines and Geology for a permit amendment (Placer County 2007). The existing excavation area in the Yuba Goldfields was previously mined for aggregate and gold, and the expansion area is currently in fruit orchards and has not been mined (California RWQCB 2010). Aggregate reserves exist to a depth of approximately 75 feet in both areas (California RWQCB 2010). A Report of Waste Discharge was submitted to the Central Valley Regional Water Quality Control Board for expansion of an existing aggregate facility, which was approved in 2010.

(B) Wheatland Project

YCWA completed an agricultural delivery canal (Wheatland Project) to Wheatland Water District in 2010 (Wheatland Project). The Wheatland Project extended YCWA surface water delivery capabilities to the Wheatland Water District by constructing canal facilities to deliver Yuba River Development Project water to the Wheatland Water District in southern Yuba County. Overall, the project' cumulative effect would generally result in higher flows above Daguerre Point Dam (as measured at the Smartsville Gage) and lower flows below Daguerre Point Dam (as measured at the Marysville Gage), primarily during the summer months of July, August and September.

At the Smartsville gage the Corps (Corps 2013b) analysis demonstrates that over an 87-year simulation period, long-term average monthly flows would increase slightly from May through October (ranging from a 0.6 percent flow increase in May to a 2.4 percent flow increase in July), would decrease slightly from December through April (ranging from a 0.7 percent flow reduction in March to a 1.7 percent flow reduction in December), and would not change during November under the project's cumulative effects, relative to the current conditions.

Below Daguerre Point Dam, at the Marysville gage the Corps found that over an 87-year simulation period, the long-term average monthly flows at the Marysville Gage would be reduced slightly from October through June (ranging from a 0.4 percent flow reduction in April to a 3.2 percent flow reduction in June) under the project's cumulative effects relative to the current conditions. Long-term average monthly flows at the Marysville Gage would be reduced by 7.1 percent, 9.2 percent and 8.7 percent during July, August and September, respectively under the Cumulative Condition relative to the current conditions.

The Corps analysis of water temperature change, with the project, found that the change in temperatures at Smartsville and Daguerre Point Dam would range from a decrease of 0.1˚F to an increase of 0.2˚F. At Marysville the increase in temperature would range from zero to 0.6˚F, depending on the month and water year type.

The evaluation of flow and water temperature changes described in the Corps' BA indicate that changes would be relatively minor, however, any measurable reduction in flow (downstream of the dam) or minor increase in water temperatures represents an incremental effect considered cumulative to the aggregate effects of other factors analyzed in this Biop under "environmental baseline" and "effects of the action."

(C) Agricultural Practices

Agricultural practices will continue to 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 livestock 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. Increased water temperatures can result when agricultural water exposed to warm summer air temperatures is returned to the Yuba River as agricultural return flow. Stormwater and irrigation discharges related to both agricultural and urban activities may contain pesticides and herbicides that may negatively affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000, Daughton 2003). These adverse effects are considered cumulative to the aggregate effects of other factors analyzed in this Biop under "environmental baseline" and "effects of the action."

(D) Browns Valley Irrigation District Agricultural Return Flow Recapturing Project

Browns Valley Irrigation District (BVID) is planning to construct a pumping plant and a pipeline to recapture and recycle irrigation return flows that the district is discharging into Dry Creek (BVID 2011). BVID will convey recycled flows from a pumping plant on Dry Creek to rice fields presently irrigated exclusively by diversions from the lower Yuba River. The warmer reclaimed water will be delivered into BVID's Pipeline Canal and applied by its customers to rice lands where the elevated water temperature benefits rice production. Application of tailwater recaptured from Dry Creek to the agricultural lands within BVID's service area will reduce the district's demand for water diverted directly from the lower Yuba River, thus balancing the reduction in inflow to the river that results from pumping from Dry Creek with an equivalent reduction in diversion. The agricultural return-flow project is of regional significance because it will reduce diversions from the lower Yuba River (Yuba County 2007).

The agricultural return-flow project proposes to recapture up to a maximum of 10 cfs of irrigation return flow from Dry Creek during the irrigation season, which typically runs from April through October (BVID 2011). It is estimated that the influx of tailwater raises Dry Creek's temperature by an average of 4 ºC to 5 ºC and introduces sediment, nutrients, and other constituents into the Dry Creek approximately 1.8 miles upstream of its confluence with the lower Yuba River (BVID 2009). By pumping water from Dry Creek downstream of the confluence with Little Dry Creek when Dry Creek flows are primarily comprised of tailwater from irrigated lands, the agricultural return-flow is expected to improve water quality by removing some of the thermal and pollutant load from Dry Creek before it reaches the lower Yuba River. BVID will continue to meet existing minimum flow requirements with releases of cool, good quality water from Collins Lake. Use of the recaptured tailwater for the rice fields will reduce BVID diversions of cool surface water from the lower Yuba River, and this substitution will retain cool water in the lower Yuba River, which will benefit fisheries resources and aquatic habitat (BVID 2009).

(E) Trust for Public Lands

Excelsior Project

The Excelsior Project is a collaborative conservation effort on the lower Yuba River, featuring 924 acres of wetlands, oak woodlands, gold-rush archeological remnants, and 2 miles of riparian salmon spawning habitat. The Yuba Narrows Ranch will be managed and permanently protected as open space. Additionally, the Trust for Public Land is presently pursuing efforts to acquire a conservation easement for the historic 157-acre Black Swan Ranch portion of the Excelsior property, which is located near the confluence of Deer Creek and overlooks Englebright

Reservoir and the lower Yuba River (Sierra Nevada Conservancy 2010). Protection of open space will benefit listed species and their habitats.

Yuba River Acquisitions

These acquisitions include properties that are part of the Yuba River Wildlife Area Conservation Conceptual Area Protection Plan (CAPP), which coordinates CDFW's acquisition and management activities on more than 81,000 acres of the Yuba River corridor. These acquisitions will benefit listed species through increasing long-term flood control options, protecting and restoring riparian and aquatic habitat and increasing habitat connectivity.

(F) Increased Urbanization and Human Population Growth

Agricultural, residential, and industrial water use and land development result in a cumulative reduction in the extent of riparian habitats in the action area and surrounding region. Increases in urbanization and residential development are expected to impact habitat by altering watershed characteristics, changing both water use and stormwater runoff patterns. 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. It is anticipated that implementation of the Yuba-Sutter Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP) would reduce cumulative biological resources impacts, however future growth will still add incrementally to the aggregate adverse effects of other factors analyzed in this BiOp under "environmental baseline" and "effects of the action."

(XI) INTEGRATION AND SYNTHESIS OF 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 action. In this section, NMFS performs two evaluations: whether, given the environmental baseline and status of the species and critical habitat, as well as future cumulative effects, it is reasonable to expect the proposed action 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 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* described the analyses and tools we have used to complete this analysis. This section is based on analyses provided in the *Status of the Species,* the *Environmental Baseline,* and the *Effects of the Proposed Action*.

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 and present 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 *Environmental Baseline* reviewed the status of the species and the factors that are affecting their survival and recovery in the action area. The *Effects of the Proposed Action* reviewed the exposure of the species and critical habitat to the proposed action and interrelated and interdependent actions, cumulative effects. NMFS then evaluated the likely responses of individuals, populations, and critical habitat. The *Integration and Synthesis* will consider all of these factors to determine the proposed action's influence on the likelihood of both the survival and recovery of the species, and on the conservation value of designated critical habitat.

The criteria recommended for low risk of extinction 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 chance to survive and recover, but that the species faces moderate to high risks from various 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 action are likely to in some way increase the extinction risk each of the species faces.

In order to estimate the risk to CV spring-run Chinook salmon, CCV steelhead, and green sturgeon as a result of the proposed action, NMFS uses a hierarchical approach. The condition of the ESU or DPS is reiterated from the *Status of the Species* section of this BiOp. We then consider how the viability of the population, as described in the *Environmental Baseline*, is affected by the proposed action. Effects to individuals is summarized, and to the consequence of those effects is applied the VSP concept and used to establish risk to the diversity group, ESU, or DPS.

In designating critical habitat, NMFS considers the physical and biological features (essential features) within the designated areas that are essential to the conservation of the species and that may require special management considerations or protection. Such requirements of the species include, but are not limited to: (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; and (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 principal biological or physical constituent elements within the defined area that are essential to the conservation of the species. Primary constituent elements 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.

(A) Impacts on Species

(1) CV Spring-Run Chinook Salmon ESU

Condition of the ESU

The CV spring-run Chinook salmon ESU is at moderate risk of extinction (Lindley *et al.* 2007). The most recent viability assessment of CV spring-run Chinook salmon was conducted during NMFS' 2011 status review (NMFS 2011b). This review found that the biological status of the ESU has worsened since the last status review. In the 2011, the ESU as a whole could not be considered viable because there were no extant viable populations in the three other diversity groups. In addition, Mill, Deer, and Butte creeks are close together geographically, decreasing the independence of their extinction risks due to catastrophic disturbance. These and other conditions covered in the 2011 status review have not changed since 2011. While the abundance for some populations appears to be improving, due to the high variability in abundance, we cannot say based on two years (2012 and 2013) of increased abundance that the risk of extinction for the ESU has improved. The ESU fails all VSP criteria for viability.

Viability at the Population Level

The Yuba River population of the spring-run Chinook has low abundance, low productivity, limited spatial structure, and is potentially a population sink for other populations (NMFS 2011b, Schick and Lindley 2007).

The Yuba River population spring-run Chinook salmon has very high hatchery introgression with FRFH spring- and fall-run run Chinook salmon. The spatial structure of spring-run Chinook salmon spawning is subject to redd superimposition. The lack of access to historical spawning habitat is the primary driver for the stressors of superimposition by fall-run Chinook salmon and low abundance relative to FRFH fish. The population has low viability and a high risk of extinction (NMFS 2011b).

Flow conditions in the Yuba River provide greater attraction flow than the Feather River during some years, causing spring-run Chinook salmon from the Feather River and the FRFH to be preferentially attracted into the Yuba River to spawn. This may exacerbate baseline hatchery effects and genetic introgression, because it results in an increase in genetic mixing of Feather River wild and hatchery spring-run Chinook salmon with natal Yuba River spring-run Chinook salmon.

The phenotypic spring-run Chinook salmon in the lower Yuba River represents hybridization between spring- and fall-run Chinook salmon in the lower Yuba River, and hybridization with

Feather River stocks including the FRFH spring-run Chinook salmon stock, which itself represents hybridization between Feather River fall- and spring-run Chinook salmon populations.

Although straying of FRFH-origin Chinook salmon into the lower Yuba River occurs, available information indicates that: (1) the FRFH spring-run Chinook salmon is included in the ESU, in part because of the important role this stock may play in the recovery of spring-run Chinook salmon in the Feather River Basin, including the Yuba River (70 FR 37160), (2) the spring-run Chinook salmon program at FRFH is an Integrated Recovery Program which seeks to aid in the recovery and conservation of CV spring-run Chinook salmon (DWR 2009a), and (3) fish produced at FRFH are intended to spawn in the wild or be genetically integrated with the targeted natural population as FRFH broodstock (DWR 2009a).

Project Effects on Individual CV Spring-Run Chinook Salmon

Adverse effects to CV spring-run Chinook salmon individuals are expected from five specific project components that are proposed by the Corps as either *Protective Conservation Measures* or *Voluntary Conservation Measures*. The *Protective Conservation Measures* that may result in incidental take of CV spring-run Chinook salmon are as follows:

- Sediment Management,
- Dam Flashboard Management , and
- Operation and Maintenance of Fish Passage Facilities: Maintenance and Debris Removal in the Fish Ladders

The *Voluntary Conservation Measures* that may result in the incidental take of CV spring-run Chinook salmon are as follows:

- Gravel Augmentation, and
- Woody Instream Material Management Program

The intended purpose, and ultimate outcome of the *protective conservation measures* and the *volunteer conservation measures* is to improve fish passage, juvenile rearing and spawning conditions above baseline conditions, which include Corps structures over which the Corps has no existing authority or discretion.

However, during the implementation of these activities, certain adverse effects to CV spring-run Chinook salmon may occur. These adverse effects include the potential for injury or death related to harassment, or other physical disturbances to juvenile fish and in some cases adults for short periods of time that are outside of the occurrence of sensitive life stages of CV spring-run Chinook salmon. While the project may result in the injury or death of CV spring-run Chinook salmon, with the measures the Corps has in place the number of CV spring-run Chinook salmon affected by the project is expected to be very small and do more to improve the survival and productivity of CV spring-run Chinook salmon than it would to harm them.

Risk to Northern Sierra Diversity Group

At the scale of the lower Yuba River, the effects of the proposed action do not add any incremental adverse effects to the effects of the Environmental Baseline. Although some adverse effects are expected during the implementation of protective and voluntary conservation measures, the overall additive effect of the Corps' proposed action is beneficial and an improvement over the Environmental Baseline, and reduce the risk to the Northern Sierra Diversity Group by improving migration conditions, rearing habitat and spawning habitat. However, if the Corps does not implement the *Voluntary Conservation Measures* consistently and year-to-year, as described in the GAIP and the LWM plan, the benefits to the species are diminished and the benefits of *Project Conservation Measures* are diminished.

Risk to ESU

The amount of incremental harm to the species that result from the action, when added to the beneficial effects do not add any incremental adverse effects to the Environmental Baseline. The overall effects are likely to improve the status of CV Chinook salmon in the Yuba River, for the Northern Sierra Diversity Group. Therefore, it is reasonable to conclude that the adverse effects of the Corps discretionary actions are not likely to increase the risk to the ESU.

The effects of the environmental baseline increase the risk of extinction of this population. Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the species are measurably diminished. NMFS' recovery draft plan has identified establishment of additional populations in the Northern Sierra Diversity Group as being important to this species' future viability. The recovery plan has also identified that reintroduction of spring-run Chinook salmon into historic higher elevation habitats upstream of the rim dams is also very important to improving the viability of the CV spring-run Chinook salmon ESU.

Summary of Effects on the Survival and Recovery of the Species

The baseline condition is likely to produce stressors that adversely affect the environment of CV spring-run Chinook salmon by creating delays or blockages of upstream migration to historic spawning habitat related to the operations and maintenance of dams without adequate fish passage, superimposition of spawning habitat due to lack of spawning habitat availability, continued introgression with fall-run Chinook salmon and FRFH salmon downstream from Englebright Dam, and is likely to adversely affect the survival and recovery of CV spring-run Chinook salmon in the Yuba River. The CV spring-run Chinook salmon ESU is currently at a moderate to high risk of extinction, any reduction in the viability to the Yuba River population is likely to reduce the viability and increase the extinction risk of the ESU.

A small number of potential injuries and deaths to CV spring-run Chinook salmon may result from the sediment management activity of the proposed project. The project is also expected to benefit CV spring-run Chinook salmon through additional spawning habitat, increased productivity of rearing habitat, and maintenance of fish passage at Daguerre Point Dam. In NMFS' opinion the potential incremental adverse effects of the proposed project does not increase the extinction risk or jeopardize the recovery of the CV spring-run Chinook salmon ESU.

(2) California Central Valley Steelhead DPS

<u>Condition of the DPS</u>

The CCV steelhead DPS is at high risk of extinction (NMFS 2011c), and the extinction risk is increasing. The most recent viability assessment of CCV steelhead was conducted during NMFS' 2011 status review (NMFS 2011c). This review found that the biological status of the ESU has worsened since the last status review recommend that its status be reassessed in two to three years as opposed to waiting another five years, if it does not respond positively to improvements in environmental conditions and management actions. The ESU fails all VSP criteria for viability.

<u>Viability at the Population Level</u>

The population has very high hatchery introgression. The lack of access to historical spawning habitat is the greatest stressor affecting population viability. The population has low viability and a high risk of extinction.

<u>Project Effects on Individual CCV steelhead</u>

Adverse effects to CCV steelhead individuals are expected from four specific project components that are proposed by the Corps as either *Protective Conservation Measures* or *Voluntary Conservation Measures*. The *Protective Conservation Measures* that may result in incidental take of CCV steelhead are as follows:

- Sediment Management,
- Dam Flashboard Management , and
- Operation and Maintenance of Fish Passage Facilities: Maintenance and Debris Removal in the Fish Ladders

The *Voluntary Conservation Measures* that may result in the incidental take of CCV steelhead are as follows:

- Gravel Augmentation, and
- Woody Instream Material Management Program

The intended purpose, and ultimate outcome of the *protective conservation measures* and the *volunteer conservation measures* is to improve fish passage, juvenile rearing and spawning conditions above baseline conditions, which include Corps structures over which the Corps has no existing authority or discretion.

However, during the implementation of these activities, certain adverse effects to CCV steelhead may occur. These adverse effects include the potential for injury or death related to harassment, or other physical disturbances to juvenile fish and in some cases adults for short periods of time that are outside of the occurrence of sensitive life stages of CCV steelhead. While the project may result in the injury or death of CCV steelhead, with the measures the Corps has in place the number of CCV steelhead affected by the project is expected to be very small and do more to improve the survival and productivity of CCV steelhead than it would to harm them.

Risk to Northern Sierra Diversity Group

At the scale of the lower Yuba River, the effects of the proposed action do not add any incremental adverse effects to the effects of the Environmental Baseline. Although some adverse effects are expected during the implementation of protective and voluntary conservation measures, the overall additive effect of the Corps' proposed action is beneficial and an improvement over the Environmental Baseline, and reduce the risk to the Northern Sierra Diversity Group by improving migration conditions, rearing habitat and spawning habitat. However, if the Corps does not implement the *Voluntary Conservation Measures* consistently and year-to-year, as described in the GAIP and the LWM plan, the benefits to the species are diminished and the benefits of *Project Conservation Measures* are diminished.

Risk to DPS

The amount of incremental harm to the species that result from the action, when added to the beneficial effects do not add any incremental adverse effects to the Environmental Baseline. The overall effects are likely to improve the status of CCV steelhead in the Yuba River, for the Northern Sierra Diversity Group. Therefore, it is reasonable to conclude that the adverse effects of the Corps discretionary actions are not likely to increase the risk to the DPS.

The effects of the environmental baseline increase the risk of extinction of this population. Without any recovery actions to stabilize the Yuba River population and allow it to contribute to the recovery of the species, both the survival and recovery of the species are measurably diminished. NMFS' recovery draft plan has identified establishment of additional populations in the Northern Sierra Diversity Group as being important to this species' future viability. The recovery plan has also identified that reintroduction of CCV steelhead into historic higher elevation habitats upstream of the rim dams is also very important to improving the viability of the CCV steelhead DPS.

Summary of Effects on the Survival and Recovery of the Species

The baseline condition is likely to produce stressors that adversely affect the environment of CCV steelhead by creating delays or blocks upstream migration to historic spawning habitat related to the operations and maintenance of dams without adequate fish passage, and is likely to adversely affect the survival and recovery of CCV steelhead in the Yuba River. The CCV steelhead DPS is currently at a moderate to high risk of extinction, any reduction in the viability to the Yuba River population is likely to reduce the viability and increase the extinction risk of the DPS.

A small number of potential injuries and deaths to CCV steelhead may result from the sediment management activity of the proposed project. The project is also expected to benefit spring-run Chinook salmon through additional spawning habitat, increased productivity of rearing habitat, and maintenance of fish passage at Daguerre Point Dam. In NMFS' opinion the potential incremental adverse effects of the proposed project does not increase the extinction risk or jeopardize the recovery of the CCV steelhead DPS.

(3) Green Sturgeon Southern Population DPS

Condition of the Green Sturgeon Southern DPS

The green sturgeon southern population DPS is at substantial risk of extinction (Adams *et al*. 2007). The DPS is compromised by low abundance, limited distribution, and lack of population redundancy. The DPS has only one viable population, the Sacramento River population, upon which the Yuba River green sturgeon are dependent.

Viability at the Population Level

With only five green sturgeon detected in 2011 and infrequent historical sightings by anglers, the number of green sturgeon in the Yuba River is likely to have been low for some time. Green sturgeon continue to be blocked from suitable spawning habitat by Daguerre Point Dam and its impassable fish ladders. The role of the Yuba River for green sturgeon survival and recovery is unknown, but it is considered to have a high conservation value for the species (74 FR 52300).

Project Effects on Individual Green Sturgeon

There is little specific information regarding green sturgeon in the vicinity of Daguerre Point. No green sturgeon have been observed in the fish ladders. Due to the low potential for interaction between individual and the proposed action, the proposed project is not expected to result in the injury or death of green sturgeon.

Risk to DPS

Because the project is not expected to adversely affect individual sturgeon, and green sturgeon do not appear to occupy the Yuba River every year, the proposed project is not expected to increase the risk to the green sturgeon DPS.

Summary of Effects on the Survival and Recovery of the Species

While Daguerre Point Dam is a blockage to upstream migration of green sturgeon, this is a baseline effect, associated with the structure of the dam and the structure of the fish ladders. Because there are no anticipated effects of the project over which the Corps has discretion that extend downstream of the dam and that might affect green sturgeon are limited, the incremental effects of the project are not expected to increase the extinction risk of the species.

(B) Impacts on Critical Habitat

Adverse effects of the proposed project to the designated critical habitat of CCV steelhead, CCV steelhead, and the Southern DPS of green sturgeon include increased turbidity downstream of Daguerre Point Dam and for a short duration and distance upstream of the dam. The duration of the increased turbidity is expected to be short term (less than ten days a year), and will not occur every year. The suspended sediment is expected to settle out the water column quickly and extend downstream for approximately 200 feet. Project effects are not expected to further impair upstream or downstream passage conditions. Therefore, we do not expect project related impacts to reduce the conservation value of designated critical habitat of CCV steelhead, CCV steelhead, and the Southern DPS of green sturgeon.

(XII) CONCLUSIONS

After reviewing the best available scientific and commercial information, the current status of the species and their designated critical habitat, the environmental baseline for the action area, the expected effects of the proposed action, cumulative effects, and the combined effects of the environmental baseline, the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of federally threatened CCV steelhead, threatened CCV steelhead, or the threatened Southern DPS of green sturgeon. Further, it is NMFS' biological opinion that the proposed project will not destroy, or adversely modify critical habitat for CCV steelhead, CCV steelhead, or the Southern DPS of green sturgeon.

(XIII) INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement (ITS).

The reasonable and prudent measures described below are non-discretionary and must be implemented by the Corps, for the exemption in section 7(o)(2) to apply. If the Corps fails to comply with the terms and conditions of this incidental take statement, they may no longer be in compliance with the ESA. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on each listed species to NMFS, as specified in this incidental take statement [50 CFR 402.14(i)(3)]. The take exemption in section 7(o) applies only to the proposed action and not to non-discretionary activities and other third party activities described in the baseline.

(A) Amount or Extent of Take

Incidental take of CCV steelhead and CV spring-run Chinook individuals is expected from four specific project components that are proposed by the Corps as either *Protective Conservation Measures* or *Voluntary Conservation Measures*. The *Protective Conservation Measures* will be implemented as needed based on the frequency or special conditions described in the *Proposed Action* section of the Corps BA. The *Voluntary Conservation Measures* will be implemented consistent with the description of augmentation triggers described in the GAIP and to the extent funding is made available.

The *Protective Conservation Measures* that may result in incidental take of CV spring-run Chinook salmon and CCV steelhead are as follows:

- Sediment Management, and
- Operation and Maintenance of Fish Passage Facilities: Maintenance and Debris Removal in the Fish Ladders

The *Voluntary Conservation Measures* that may result in the incidental take of CV spring-run Chinook salmon and CCV steelhead are as follows:

- Gravel Augmentation, and
- Woody Instream Material Management Program

In the BiOp, NMFS determined that incidental take would occur through one or more take pathways as described below:

Sediment Removal

1. <u>Take in the form of harassment of juvenile and adult CV spring-run Chinook salmon and CCV steelhead may occur due to temporary behavioral modifications related to sediment removal. Specifically, fish in or near the work area may be exposed to noise and disturbance from heavy equipment used in sediment removal and/or a short-term increase in turbidity within and downstream of the work area. Sediment management work could temporarily interfere with the egress of adults from the fish ladder and could modify the behavior of juvenile if they are in the vicinity of the fish ladders during sediment management activities.</u>

2. <u>Take in the form of injury or death to juvenile CV spring-run Chinook salmon and CCV steelhead may occur due to the use of an excavator bucket in the river to remove sediment upstream of Daguerre Point Dam.</u>

Harassment related to sediment removal on the upstream side of Daguerre Point Dam during the month of August, of any given year, may cause temporary behavioral modifications that result in the injury or death of individuals when the channel is widened for fish passage. Injury or death could occur to adults if they are forced to relocate downstream of Daguerre Point Dam and are exposed to hazards within the fish ladder or expend additional energy migrating back upstream. This is not likely to exceed one adult CCV steelhead and one CCV steelhead per year.

Harassment of juveniles is expected for fish that are within the sediment removal footprint. This is an area that is 45 feet wide, extending laterally along the dam for approximately 600 feet, for a total disturbance area of approximately 27,000 square feet. According to RMT data (RMT 2013), Chinook salmon densities in the Daguerre Point Dam reach are approximately 0.4 fish per 100 square feet, or up to approximately 108 juvenile Chinook salmon present in the sediment removal footprint. Juvenile steelhead densities are expected to be less than half of Chinook salmon densities or no more than 54 juveniles present in the sediment removal footprint. These are a conservatively high estimate because fish densities are expected to be lower than average during the months when sediment removal may occur. The amount of fish that could be injured or killed is not expected to exceed 108 juvenile Chinook salmon, and 54 juvenile steelhead per year.

Maintenance and Debris Removal in the Fish Ladders

1. <u>Take in the form of injury or death of CV spring-run Chinook salmon and CCV steelhead adults during fish ladder debris maintenance and debris removal within the fish ladders.</u>

Injury or death of adult CV spring-run Chinook salmon and CCV steelhead could result if fish are within the bays of the fish ladders during debris maintenance and removal activities. Debris accumulation is expected when flows exceed 4,200 cfs and will be removed within 12 hours of detection. If flows present unsafe conditions, debris will be removed within 12 hours after flows have returned to safe levels. Injury and death of adult CV spring-run Chinook salmon, and adult CCV steelhead may occur when debris is removed. Because no adult Chinook salmon or adult CCV steelhead have not been observed during previous fish ladder debris removal; and currently the removal of debris from the fish ladders is less frequent and of a small magnitude than in the past, due to the installation of grates over the fish ladders; the number of adult CV spring-run Chinook salmon, and adult CCV steelhead that would be affected by fish ladder debris removal is expected to be very low. NMFS estimates that no more than two adult CV spring-run Chinook salmon, and two adult CCV steelhead may be injuried or killed during the removal of debris, during each occurance of debris removal.

Gravel Augmentation

1. <u>Take in the form of injury or death of CV spring-run Chinook salmon and CCV steelhead juveniles resulting from the physical placement of up to 15,000 tons of spawning gravel into the Yuba River from July 15 to September 1 of each year.</u>

Injury or death of juvenile of juvenile CCV steelhead and/or CV Chinook salmon may occur from the placement of up to 15,000 tons per year of gravel into the Yuba River from the implementation of the GAIP during the months of July 15 to September 1 (the typical months the Corps has placed gravel in past months). Gravel augmentation will occur until the deficit is eliminated. The injury or death may result if gravel lands on fish, or if fine sediment from turbidity plumes enters the gills of fish and causes respiratory distress or failure. Based on observations of previous gravel placement actions, the turbidity plumes are expected to extend approximately 200 feet downstream and be up to 50 feet wide, for a total area of 10,000 square feet. Monthly juvenile Chinook salmon density for the Englebright Dam reach is approximately 0.625 fish per 100 square feet (~62.5 fish per 10,000 square feet) (RMT 2013). Therefore, we estimate that the maximum number of Chinook salmon affected by gravel placement and turbidity juveniles (amount of take) will be no more than 62.5 fish per year. There are no data available for juvenile steelhead, but a conservative estimate based on field observations is their density is likely to be less than half of the Chinook salmon density. Therefore we estimate that the maximum number of juvenile steelhead that will be adversely affected by gravel placement juveniles (amount of take) will be no more than 32 fish per year. There is not a stronger estimate based on the information available at this time because it is not possible to quantify the exact numbers of individuals that may be affected.

Woody Instream Material Management

1. Take in the form of injury or death of CV spring-run Chinook salmon and CCV steelhead adults and juveniles from large wood placement that occurs underwater or near the water's edge.

Injury or death of juvenile of juvenile CCV steelhead and CV spring-run Chinook salmon may occur from the placement of large wood into the Yuba River or near the water's edge as a result of fish being crushed by heavy equipment necessary for LWM placement or as a result of activity-related noise and vibration, and/or temporary turbidity increases caused by placing LWM into the Yuba River. On Clear Creek, where similar large wood placements are occurring, the area of impact is approximately 20 by 20 feet. Fish that are within this area during construction may be injured or killed. NMFS expects that no more than 20 of these LWM placements will occur per year. There is not a stronger ecological surrogate based on the information available at this time because it is not possible to quantify the exact numbers of individuals that may be affected.

(B) Effect of the Take

In the BiOp, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to CCV steelhead, CCV steelhead, or the sDPS of North American green sturgeon or destruction or adverse modification of critical habitat for these species.

(C) Reasonable and Prudent Measure

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the amount or extent of incidental take (50 CFR 402.02). Pursuant to section 7(b)(4) of the ESA, the following reasonable and prudent measures are necessary and appropriate to minimize take of CCV steelhead, CCV steelhead and sDPS of North American green sturgeon and therefore should be implemented by the Corps.

1. **Measures shall be taken by the Corps to minimize the effects of sediment removal at Daguerre Point Dam.**

2. **Measures shall be taken by the Corps to minimize the effects of debris maintenance and removal at the Daguerre Point Dam fish ladders.**

3. **Measures shall be taken by the Corps to minimize the effects of gravel injections downstream from Englebright Dam.**

4. **Measures shall be taken by the Corps to minimize the effects of the large wood placement downstream of Englebright Dam.**

5. **Prepare and provide NMFS with plan(s) and report(s) describing how listed species in the action area would be protected and/or monitored and to document the effects of the action on listed species in the action area.**

(D) Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a Term and Condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse

1. The following terms and conditions implement reasonable and prudent measure 1: **Measures shall be taken by the Corps to minimize the effects of sediment removal at Daguerre Point Dam.**

    (a) The Corps shall submit the Sediment Management Plan to the NMFS Central Valley Area Office Assistant Regional Administrator for approval within 60 days of the date of this BiOp.
    (b) Any proposed variance to the implementation of the Sediment Management Plan will require approval from the Assistant Regional Administrator of the Central Valley Office or their designated representative.
    (c) The Corps shall notify NMFS in June, of each year, regarding the need for sediment removal necessary to meet channel measurement criteria (depth and width) described in the Corps' Sediment Management Plan.
    (d) The Corps shall remove sediment by the first half of August, unless otherwise authorized by NMFS.
    (e) The Corps shall monitor water turbidity during each sediment removal action. Water turbidity must remain within any applicable water quality or plans for the Yuba River. If water quality criteria are exceeded, the Corps shall consult with NMFS and the State to determine contingency measures for reducing or

mitigating for such increases to either meet State/Regional criteria, or offset unavoidable impacts.
(f) The Corps shall, by January 31 of each year, report to NMFS the previous year's sediment removal actions and turbidity monitoring.

2. The following terms and conditions implement reasonable and prudent measure 2: **Measures shall be taken by the Corps to minimize the effects of debris maintenance and removal at the Daguerre Point Dam fish ladders.**

(a) The Corps shall submit the Debris Monitoring and Maintenance Plan to the NMFS Central Valley Area Office Assistant Regional Administrator for approval within 60 days of the date of this BiOp.
(b) Any proposed variances to the implementation of the Debris Monitoring and Maintenance Plan shall require the approval of the NMFS Central Valley Area Office Assistant Regional Administrator.
(c) When Yuba River flows exceed 4,200 cfs, the Corps shall provide notifications to NMFS on the status of debris accumulations and fish passage conditions at the Daguerre Point Dam fish ladders.
(d) The Corps shall take action within 24 hours, or as soon as it is safe, to remediate fish passage conditions related to debris maintenance and removal at the Daguerre Point Dam fish ladders.
(e) The Corps shall, by January 31 of each year, report to NMFS an update on previous year's debris maintenance and removal actions, including details on amount of debris removed, the timing of removal and the conditions that triggered debris accumulation.

3. The following terms and conditions implement reasonable and prudent measure 3: **Measures shall be taken by the Corps to minimize the effects of gravel injections downstream from Englebright Dam.**

(a) The Corps shall submit a long-term Gravel Augmentation and Implementation Plan (GAIP) to the NMFS Central Valley Area Office Assistant Regional Administrator for approval within 60 days of the date of this BiOp.
(b) Any proposed variances to the implementation of the short-term or long-term GAIP shall require the approval of the NMFS Central Valley Area Office Assistant Regional Administrator.
(c) The Corps shall, within their existing authorities, pursue annual and long-term funding for implementation of the GAIP.
(d) The Corps shall, by January 31 or each year, report to NMFS the status of annual funding requests for gravel augmentation.
(e) The Corps shall, by January 31 of each year, report to NMFS an update on previous year(s) gravel injection actions, including details on amount of gravel placed, the size distribution of such gravel, and the placement methods and location.
(f) The Corps shall monitor water turbidity during each gravel placement action. Water turbidity must remain within all applicable water quality requirements or

plans for the Yuba River. If water quality criteria are exceeded, the Corps shall consult with NMFS and the State to determine contingency measures for reducing or mitigating for such increases to either meet criteria, or offset unavoidable impacts.

(g) The Corps shall provide notification to NMFS for gravel augmentations that require additional time for placement (*i.e.*, greater than 9,000 tons per year). NMFS will evaluate the notification and will either confirm the notification, or provide an alternative recommendation.

(h) The Corps shall, by January 31 of each year, report to NMFS the results of water quality monitoring conducted for the previous year's gravel injection actions.

4. The following terms and conditions implement reasonable and prudent measure 4: **Measures shall be taken by the Corps to minimize the effects of the large wood placement downstream of Englebright Dam.**

(a) The Corps shall submit a long-term Large Woody Material Management Plan (LWMMP) to the NMFS Central Valley Area Office Assistant Regional Administrator for approval within 60 days of the date of this BiOp.

(b) Any proposed variances to the implementation of the pilot or long-term LWMMP shall require the approval of the NMFS Central Valley Area Office Assistant Regional Administrator.

(b) The Corps shall, within their existing authorities, pursue annual funding for implementation of the LWMMP.

(c) The Corps shall, by January 31 or each year, report to NMFS the status of annual funding requests.

(d) The Corps shall, by January 31 of each year, report to NMFS an update on previous year's LWMMP placement actions, including details on amount of LWM placed, the location, and the placement methods.

Updates and reports required by these terms and conditions shall be submitted to:

Assistant Regional Administrator
California Central Valley Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento CA 95814
FAX: (916) 930-3629
Phone: (916) 930-3600

(XIV) CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the Corps:

(1) The following recommendations should be implemented by the Corps with respect to dam flashboard management at Daguerre Point Dam.

    (a) The Corps should submit the Flashboard Management Plan to the NMFS Central Valley Area Office Assistant Regional Administrator within 60 days of the date of this BiOp..
    (b) Any proposed variance to the implementation of the Flashboard Management Plan should be provided to the NMFS Central Valley Area Office Assistant Regional Administrator.
    (c) The Corps should notify NMFS within 24 to 48 hours of any debris accumulation on the flashboards on the face of Daguerre Point Dam.
    (d) Measures to remove flashboard blockage should be in compliance with the Corps' Flashboard Management Plan.
    (e) The Corps should notify NMFS within 24 hours of any debris accumulation at the Daguerre Point Dam flashboards.
    (f) Measures to removal flashboard blockage should be in compliance with the Flashboard Management Plan.
    (g) The Corps, should within five years, develop the flow-based trigger for installation of the Daguerre Point Dam flashboards.
    (h) The Corps should provide notification after the first week of flashboard installation confirming that the flashboard installation meets the objectives of the Flashboard Management Plan. If the installation is not found to meet objectives, the Corps should coordinate with NMFS to develop alternative actions.
    (i) The Corps should, by January 31 of each year, report to NMFS an update on previous year's flashboard management actions.

(2) The Corps should continue their efforts to complete the Yuba River reconnaissance study by September 30, 2015, in accordance with applicable Engineer Regulations and policies. Improvement of fish passage at Daguerre Point Dam, and development of a fish passage project to restore spring-run Chinook salmon and steelhead to historic habitats in the Yuba River watershed upstream of Englebright Dam would be a significant step toward the recovery of spring-run Chinook salmon and steelhead listed under the ESA (NMFS 2014).

(3) The Corps should coordinate with NMFS and other Yuba watershed stakeholders regarding the reconnaissance study and any subsequent feasibility study if approved. Yuba watershed stakeholders include, but are not limited to; the Federal Energy Regulatory Commission, National Marine Fisheries Service, U.S. Bureau of Reclamation, U.S. Forest Service, U.S. Fish and Wildlife Service, California Department of Fish and

Wildlife, California Department of Water Resources, American Rivers, Friends of the River, Nevada Irrigation District, Pacific Gas & Electric, South Yuba River Citizens League, Yuba County Water Agency, South County Diverters, and participants in the Yuba River Management Team and Yuba Salmon Forum. These stakeholders have developed a significant amount of information that should be useful to the Corps in moving forward with the Corps' reconnaissance study and any feasibility study, if approved.

(4) The Corps should consider predator removal at Daguerre Point Dam.

(XV) REINITIATION NOTICE

This concludes formal consultation on the proposed action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in the incidental take statement 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 action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the BiOp, or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately**.**

Due to the application of ecological surrogates in the *Amount and Extent of Take* section of this BiOp, NMFS has identified the following reinitiation triggers based on their application. Essentially, they identify thresholds that, if exceeded, would represent modifications to the action that could cause an effect to the listed species or critical habitat that was not considered in the BO. These triggers include the following:

(1) Sediment Removal: If the sediment removal program is not implemented as described in the Corps BA or as otherwise conditioned by reasonable and prudent measures and terms and conditions described above.

(2) Flashboard Management: If the flashboard management program is not implemented as described in the Corps BA or as otherwise conditioned by reasonable and prudent measures and terms and conditions described above.

(3) Debris Maintenance and Removal: If the debris maintenance program is not implemented as described in the Corps BA or as otherwise conditioned by reasonable and prudent measures and terms and conditions described above.

(4) Gravel Management: If the Corps does not request annual funding for the GAIP or as otherwise conditioned by reasonable and prudent measures and terms and conditions described above.

(5) LWM Placement: If the Corps does not request annual funding for the LWM installation program or as otherwise conditioned by reasonable and prudent measures and terms and conditions described above.

(XVI) DATA QUALITY ACT DOCUMENTATION AND PRE- DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the U.S Army Corps of Engineers. Other interested users could include the U.S. Fish and Wildlife Service, Pacific States Marine Fisheries Commission, California Department of Fish and Wildlife, California Department of Water Resources, Yuba County Water Agency, Yuba River Management Team, South Yuba River Citizens League, Friends of the River, and American Rivers. Individual copies of this opinion were provided to the U.S. Army Corps of Engineers. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130, the Computer Security Act, and the Government Information Security Reform Act.

Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01, et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

(XVII) REFERENCES CITED

Adams, P. B., B. Churchill, J. E. Grimes, S. T. Hightower, S. T. Lindley, and M. L. Moser. 2002. NMFS Status Review for North American Green Sturgeon. June 2002.

Adams, P. B., C. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley. 2007. Population Status of North American Green Sturgeon, *Acipenser medirostris*. Environmental Biology of Fishes. Volume 79: 339-356.

AFRP. 2010. AFRP Managed Project: Construct an Exclusion Devise to Prevent Yuba River Chinook Salmon from Accessing the Goldfields. Stockton Fish and Wildlife Office, Pacific Southwest Region. Available at www.fws.gov/stockton/afrp.

AFRP. 2011. Yuba River: Goldfields Barrier Post Project. September 2003. Available at http://www.fws.gov/stockton/afrp.

Alaska Marine Conservation Council. 2011. Ocean Acidification. Available at www.akmarine.org/out-work/address-climate-change/ocean-acidification. Accessed on April 18, 2011.

Alderdice, D.F. and F.P.J. Velsen**.** 1978. Relation between temperature and incubation time for eggs of chinook salmon (*Oncorhynchus tshawytscha*). J. Fish. Res. Brd. Can. 35:69-75.

Allen, M.A., and T.J. Hassler. 1986. Species profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) -- Chinook salmon. USFWS Biol. Rep. 82(11.49) . U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Allen, P. J., B. Hodge, I. Werner, and J. J. Cech. 2006. Effects of Ontogeny, Season, and Temperature on the Swimming Performance of Juvenile Green Sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences. Volume 63: 1360-1369.

Allen, P. J. and J. J. Cech. 2007. Age/Size Effects on Juvenile Green Sturgeon, *Acipenser medirostris*, Oxygen Consumption, Growth, and Osmoregulation in Saline Environments. Environmental Biology of Fishes. Volume 79: 211-229.

Anderson, J.J., M. Deas, P.B. Duffy, D.L. Erickson, R. Reisenbichler, K.A. Rose, and P.E. Smith. 2009. Independent Review of a Draft Version of the 2009 NMFS OCAP Biological Opinion. Science Review Panel report. Prepared for the CALFED Science Program. January 23. 31 pages plus 3 appendices.

Anderson, J. T., C. B. Watry, and A. Gray. 2007. Upstream Fish Passage at a Resistance Board Weir Using Infrared and Digital Technology in the Lower Stanislaus River, California: 2006-2007 Annual Data Report**:** 40.

Araki, H., B. Cooper, and M. Blouin. 2007. Genetic Effects of Captive Breeding Cause a Rapid cumulative Fitness Decline in the Wild. Science. Volume 318: 100-103.

Araki, H., B. A. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of Hatchery-Reared Salmonids in the Wild. Evolutionary Applications 1(2):342-355.

Araki, H., B. Cooper, and M. S. Blouin. 2009. Carry-over Effect of Captive Breeding Reduces Reproductive Fitness of Wild-Born Descendants in the Wild. Biology Letters 5(5):621-624.

Ayres Associates. 2001. Two-Dimensional Modeling and Analysis of Spawning Bed Mobilization, Lower American River. Prepared for Sacramento District U.S. Army Corps of Engineers.

Bain, M. B. and N. J. Stevenson. 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, Maryland.

Barnett, T. P., J. C. Adam, and D. P. Lettenmaier. 2005. Potential Impacts of a Warming Climate on Water Availability in Snow-Dominated Regions. Nature. Volume 438: 303-309.

Barnhart, R. A. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest) - Steelhead. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, USFWS Biological Report, 82(11.60); U.S. Army Corps of Engineers, TR EL-82-4, 21 pp.

Beak Consultants, Inc. 1989. Yuba River Fisheries Investigation, 1986-1988. Summary Report of Technical Studies on the Lower Yuba River, California. Prepared for Sate of California Resources Agency Department of Fish and Game.

Beamesderfer, R. C. and M. A. H. Webb. 2002. Green Sturgeon Status Review Information. State Water Contractors, Sacramento.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and Current Information on Green Sturgeon Occurrence in the Sacramento and San Joaquin Rivers and Tributaries. S. P. Cramer & Associates, Inc.

Beamesderfer, R. C. P., M. L. Simpson, and G. J. Kopp. 2007. Use of Life History Information in a Population Model for Sacramento Green Sturgeon. Environ. Biol. Fish. DOI 10.1007/s10641-006-9145-x

Beamish, R. J. 1993. Climate and Exceptional Fish Production off the West Coast of North America. Canadian Journal of Fisheries and Aquatic Sciences. Volume 50: 2270-2291.

Beamish R. J. and D. R. Bouillon. 1993. Pacific Salmon Production Trends in Relation to Climate. Canadian Journal of Fisheries and Aquatic Sciences. Volume 50: 1002-1016.

Behnke, R. J. 1992. Native Trout of Western North America. American Fisheries Society, Monograph 6, Bethesda, Maryland.

Behrenfeld, M. J., R. T. O'Malley, D. A. Siegel, C. R. McClain, J. L. Sarmiento, G. C. Feldman, A. J. Milligan, P. G. Falkowski, R. M. Letelier, and E. S. Boss. 2006. Climate-Driven Trends in Contemporary Ocean Productivity. Nature. Volume 444: 752–755.

Bell, M. C. 1986. Fisheries Handbook of Engineering Requirements and Biological Criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon.

Bell, M. C. 1991. Fisheries Handbook of Engineering Requirements and Biological Criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers, North Pacific Division. Portland, Oregon.

Benson, R. L., S. Turo, and B. W. McCovey. 2007. Migration and Movement Patterns of Green Sturgeon (*Acipenser medirostris*) in the Klamath and Trinity Rivers, California, USA. Environmental Biology of Fishes. Volume 79: 269-279.

Bergman, P., S. Cramer, and J. Melgo. 2013. Summary of 2012 Fish Studies at the South Yuba-Brophy Diversion Headworks, Yuba River. Prepared for the South YubaWater District, BrophyWater District, Dry Creek Mutual Water Company, and the WheatlandWater District. May 2013.

Bilby, R. E. 1984. Removal of Woody Debris May Affect Stream Channel Stability. Journal of Forestry. Volume 82: 609-613.

Bisson, P. A., J. L. Nielsen, R. A. Palmason, and L. E. Gore. 1982. A System of Naming Habitat Types in Small Streams, with Examples of Habitat Utilization by Salmonids During Low Streamflow. Pages 62-73 in Armantrout, N.B., Editor. Acquisition and Utilization of Aquatic Habitat Information, Western Division, AFS, Portland, OR, 1982.

Bisson, P., J. Nielsen, and J. Ward. 1988. Summer Production of Coho Salmon Stocked in Mount St. Helens Streams from Three to Six Years Posteruption. Proceedings of Western

Association of Fish and Wildlife Agencies and Western Division of American Fisheries Society, Albuquerque, NM: 348-370.

Bisson, P. A., C. C. Coutant, D. Goodman, R. Gramling, D. Lettenmaier, J. Lichatowich, W. Liss, E. Loudenslager, L. McDonald, D. Philipp, and B. Riddell. 2002. Hatchery Surpluses in the Pacific Northwest. Fisheries Management Perspective. Fisheries. Volume 27 (12): 16-27.

Bjorkstedt, E. P., R. Goericke, S. McClatchie, E. Weber, W. Watson, N. Lo, B. Peterson, B. Emmett, J. Peterson, R. Durazo, G. Gaxiola-Castro, F. Chavez, J. T. Pennington, C. A. Collins, J. Field, S. Ralston, K. Sakuma, S. J. Bograd, F. B. Schwing, Y. Xue, W. J. Sydeman, S. A. Thompson, J. A. Santora, J. Largier, C. Halle, S. Morgan, S. Y. Kim, K. P. B. Merkens, J. A. Hildebrand, and L. M. Munger. 2010. State of the California Current 2009–2010: Regional Variation Persists through Transition from La Niña to El Niño (and Back?). State of California Current CalCOFI Report, Volume 51, 2010.

Bjornn, T. C. and D. W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. Pages 83-138 in W. R. Meehan (ed.). Influences of Forest and Rangeland Management of Salmonid fishes and Their Habitats, American Fisheries Society Special Publication 19.

Blackwell, B. F. and F. Juanes. 1998. Predation on Atlantic Salmon Smolts by Striped Bass after Dam Passage. North American Journal of Fisheries Management. Volume 18: 936-939.

Boles, G. L.. 1988. Water Temperature Effects on Chinook Salmon with Emphasis on the Sacramento River: A Literature Review. California Department of Water Resources**:** 48.

Boreman, J. 1997. Sensitivity of North American Sturgeons and Paddlefish to Fishing Mortality. Environmental Biology of Fishes 48: 399-405.

Bovee, K. D. 1978. Probability-of-Use Criteria for the Family Salmonidae. Instream Flow Information Paper 4. U.S. Fish and Wildlife Service. FWS/OBS-78/07.

Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. *In*: R.L. Brown, editor. Contributions to the biology of Central Valley salmonids. Volume 2. California Department of Fish and Game Fish Bulletin 179:39-136.

Bratovich, P., C. Addley, D. Simodynes, and H. Bowen. 2012. Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations. Prepared for: Yuba Salmon Forum Technical Working Group. October 2012.

Brekke, L. D., N. L. Miller, K. E. Bashford, N. W. T. Quinn, and J. A. Dracup. 2004. Climate Change Impacts Uncertainty for Water Resources in the San Joaquin River Basin, California. Journal of the American Water Resources Association. Volume 40: 149-164.

Brett, J.R. 1952. Temperature tolerance of young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9: 265-323.

Brett, J.R. M. Hollands, and D.F. Alderdice. 1958. The Effect of Temperature on the Cruising Speed of Young Sockeye and Coho Salmon. J. Fish. Res. Bd. of Canada 15(4):587-605

Brown, L. R. and A. M. Brasher. 1995. Effect of Predation by Sacramento Pikeminnow (*Ptychocheilus grandis*) on Habitat Choice of California Roach (*Lavinia symmetricus*) and Rainbow Trout (*Oncorhynchus mykiss*) in Artificial Streams. Canadian Journal of Fisheries and Aquatic Sciences. Volume 52: 1639-1646.

Brown, K. 2007. Evidence of Spawning by Green Sturgeon, *Acipenser medirostris,* in the Upper Sacramento River, California. Environmental Biology of Fishes. Volume 79: 297-303.

BRT. 2005. Green Sturgeon (*Acipenser medirostris*) Status Review Update. Biological Review Team. NOAA, National Marine Fisheries Service, Southwest Fisheries Service Center, Santa Cruiz, California.

Burgner, R.L., J.T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1993. Distribution and Origins of Steelhead Trout (Onchorhynchus mykiss) in Offshore Waters of the North Pacific Ocean. International North Pacific Fisheries Commission.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. Report Number NMFS-NWFSC-27. U.S. Department of Commerce, NOAA Technical Memorandum.

Bustard, D. R. and D. W. Narver. 1975. Aspects of the Winter Ecology of Juvenile Coho Salmon and Steelhead Trout. Journal of the Fisheries Resource Board of Canada. Volume 32: 667-680.

BVID. 2009. Mitigated Negative Declaration: Dry Creek Recapture Project. Browns Valley Irrigation District. Prepared by Kleinshmidt Associates. December 2009.

BVID. 2011. Dry Creek Recapture. Browns Valley Irrigation District. Available at www.bvid.org.

CALFED. 2000. Final Programmatic Environmental Impact Statement/Environmental Impact Report. CALFED Bay-Delta Program. Prepared by the CALFED Bay-Delta Program for the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Natural Resources Conservation Service, U.S. Army Corps of Engineers, and California Resources Agency. July 2000.

CALFED and YCWA. 2005. Draft Implementation Plan for Lower Yuba River Anadromous Fish Habitat Restoration. Multi-Agency Plan to Direct Near-Term Implementation of Prioritized Restoration and Enhancement Actions and Studies to Achieve Long-Term Ecosystem and Watershed Management Goals. Prepared by Lower Yuba River Fisheries Technical Working Group. October 2005.

California Energy Commission. 2003. Climate Change and California Staff Report. Prepared in Support of the 2003 Integrated Energy Policy Report Proceeding (Docket # 02-IEO-01).

California HSRG. California Hatchery Scientific Review Group. 2012. California Hatchery Review Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 100 pgs.

cbec and McBain & Trush. 2010. Rehabilitation Concepts for the Parks Bar to Hammon Bar Reach of the Lower Yuba River. Prepared for the South Yuba River Citizens League. Project #08-1021. Funding Provided by the U.S. Fish and Wildlife Service – Anadromous Fish Restoration Program. July 2010.

CDFG. 1953. Division of Fish and Game Forty-Second Biennial Report for 1950-1952. California Department of Fish and Game, Sacramento, California.

CDFG. 1984a. Yuba River Steelhead Run During Winter of 1976-77. Technical Memorandum. Prepared by R. Rogers, CDFG Region 2, Rancho Cordova, California.

CDFG. 1988. California Advisory Committee on Salmon and Steelhead. Restoring the Balance.

CDFG. 1988a. Memorandum from Deborah Konoff at CDFG to Fred Meyer Regarding the South-Yuba Brophy Study. November 18, 1988.

CDFG. 1991. Lower Yuba River Fisheries Management Plan. Final Report. Stream Evaluation Report Number 91-1. February 1991.

CDFG. 1991a. Steelhead Restoration Plan for the American River.

CDFG. 1993. Restoring Central Valley Streams: A Plan for Action. November 1993.

CDFG. 1998. Report to the Fish and Game Commission: A Status Review of the Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. Candidate Species Status Report 98-01. June 1998.

CDFG. 2002. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing.

CDFG. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. Prepared by C. D. Eilers and J. Bergman, Pacific States Marine Fisheries Commission and R. Nielson, Western EcoSystems Inc. Fisheries Branch Administrative Report Number 2010-2. October 2010.

CDFG and USFWS. 2010. Final Hatchery and Stocking Program Environmental Impact Report/Environmental Impact Statement. State Clearinghouse No. 2008082025. Prepared by ICF Jones & Stokes. January 2010.

CDFG, 2011. 2010-2011 Freshwater Sport Fishing Regulations. Effective March 1, 2010 – February 28, 2011.

CDFG. 2012. Grandtab Spreadsheet of Adult Chinook Escapement in the Central Valley. http://www.calfish.org/tabid/104/Default.aspx.

CDFW. 2013. California Central Valley Chinook Population Report. GrandTab. Compiled April 18, 2013.

CDFW. 2013a. 2013-2014 Freshwater Sport Fishing Regulations. Effective March 1, 2013 – February 28, 2014.

California Climate Change Center. 2006. Our Changing Climate: Assessing the Risks to California. A Summary Report from the California Climate Change Center. July 2006.

California Resources Agency. 1989. Upper Sacramento River Fisheries and Riparian Habitat Management Plan. Prepared by an Advisory Council Established by SB1086, Authored by State Senator Jim Nielson. January 1989.

California RWQCB. 1998. Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins. Fourth Edition.

California RWQCB. 2001. Draft Staff Report on Recommended Changes to California's Clean Water Act, Section 303(d) List.

California RWQCB. 2010. Waste Discharge Requirements for Baldwin Contracting Company Incorporated and Springer Family Trust Hallwood Aggregate Facility Yuba County. Order No. R5-2010-0124.

Campos, C. and D. Massa. 2010a. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Rotary Screw Trapping Report October 1, 2007 – September 30, 2008. Prepared for the Lower Yuba River Accord Planning Team. September 13, 2010.

Campos, C. and D. Massa. 2010b. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Rotary Screw Trapping Report: October 1, 2008 – August 31, 2009.

Campos, C. and D. Massa. 2011. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Redd Survey Report: August 31, 2009 – April 8, 2010.

Carlisle, D.M, D.M. Wolock, and M.R. Meador, 2010. Alteration of streamflow magnitudes and potential ecological consequences: a multiregional assessment. *Front Ecol Environ* 2010; doi:10.1890/100053

CDNR. 1931. Thirty-First Biennial Report for the Years 1928-1930. State of California Department of Natural Resources.

Chase, R. 2010. Lower American River steelhead (Oncorhynchus mykiss) spawning surveys – 2010. Department of the Interior, US Bureau of Reclamation, September 2010.

Cherry, D. S., K. L. Dickson, and J. Cairns Jr., 1975. Temperatures Selected and Avoided by Fish at Various Acclimation Temperatures. J. Fish. Res. Board Can., Vol. 32(4).

Clark, G. H. 1929. Sacramento-San Joaquin Salmon (*Oncorhynchus tshawytscha*) Fishery of California. California Fish and Game Bulletin 17: 73.

Climate Solutions. 2011. Alaska Researchers to Study Effects of Ocean Acidification. Available at http://climatesolutions.org/news. Accessed on April 18, 2011.

CMARP. 1998. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. Comprehensive Monitoring, Assessment, and Research Program for the CALFED Bay-Delta Program. Draft. November 1, 1998.

Cohen, A. N. and P. B. Moyle. 2004. Summary of Data and Analyses Indicating that Exotic Species Have Impaired the Beneficial Uses of Certain California Waters: A Report Submitted to the State Water Resources Control Board on June 14, 2004.

Conomos, T.J., R.E. Smith and J.W. Gartner. 1985. Environmental Setting of San Francisco Bay. Hydrobiologia 129, 1-12.

Cordone, A. J. and D. W. Kelley. 1961. The Influences of Inorganic Sediment on the Aquatic Life of Streams. California Fish and Game. Volume 47:89-228.

Corps. 1982. Water Resources Policies and Authorities – Modifications to Completed Projects. Engineer Regulation ER 1165-2-119. U.S. Army Corps of Engineers. September 20, 1982.

Corps. 2001. Daguerre Point Dam, Yuba River California Preliminary Fish Passage Improvement Study. Prepared for the U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program. August 2001.

Corps. 2003a. Daguerre Point Dam Fish Passage Improvement Project – Alternative Concepts Evaluation. Prepared for ENTRIX, Inc. by W. Rodgers, Inc. September 2003.

Corps. 2005. Daguerre Point Dam Initial Appraisal Report. August 17, 2005.

Corps. 2007. Harry L. Englebright Lake Operational Management Plan. December 2007.

Corps. 2007a. Biological Assessment for Daguerre Point and Englebright Dam. Sacramento District, U.S. Army Corps of Engineers. March 27, 2007.

Corps. 2009. Daguerre Point Dam Fish Passage Sediment Management Plan. February 2009.

Corps. 2011. Photos: Installation of Metal Grades on the Daguerre Point Dam Fish Ladder Bays During August 2011.

Corps. 2012a. Biological Assessment for the U. S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir, and Daguerre Point Dam on the Lower Yuba River. January 2012.

Corps. 2012b. Attachment 1 (U.S. Army Corps of Engineers, Sacramento District Itemized Comments on the NMFS' February 2012 Final Jeopardy Biological Opinion on the Lower Yuba River) of the Corps Response Letter to NMFS Regarding February 29, 2012 Final Biological Opinion. July 3, 2012.

Corps. 2012c. Photographs of the North and South Fish Ladders at Daguerre Point Dam. Provided by D. Grothe. January 19, 2012.

Corps. 2012d. Lower Yuba River Large Woody Material Management Plan Pilot Study, Yuba County, California. Final Environmental Assessment. August 2012.

Corps. 2013. ESA Guidance. Memorandum for all Counsel, HQ, DIV, DIST, Center, Lab & FOA Offices. June 11, 2013.

Corps. 2013a. Biological Assessment for the U.S. Army Corps of Engineers Ongoing Operation and Maintenance of Englebright Dam and Reservoir on the Yuba River.

Corps. 2013b. Biological Assessment for the U.S. Army Corps of Engineers Authorized Operation and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River.

Cramer Fish Sciences. 2011. Memo: Green Sturgeon Observations at Daguerre Point Dam, Yuba River, CA. Prepared for the USFWS AFRP (Grant No. 813329G011). Prepared by P. Bergman, J. Merz, and B. Rook. June 7, 2011.

Cramer, S. P. 1992. Written Testimony of Steven P. Cramer. Public Hearing of Fishery and Water Right Issues on the Lower Yuba River. Before the State Water Resources Control Board Division of Water Rights. February 10, 11, and 13, 1992.

Decoto, R. J. 1978. 1974 Evaluation of the Glenn-Colusa Irrigation District Fish Screen. California Department of Fish and Game, Anadromous Fisheries Branch, Sacramento, California.

Dolloff, C. A., D.G. Hankin, and G.H. Reeves. 1993. Basinwide Estimations of Habitat and Fish Populations in Streams. US Forest Service. Southeasten Forest Experiment Station. General Technical Report SE-83.

Demko, D. B. and S. P. Cramer. 1993. Evaluation of Juvenile Chinook Entrainment at the South Yuba-Brothy Diversion Headworks. Final Report. Prepared by S.P. Cramer & Associates, Inc. Prepared for South Yuba-Brothy and Yuba County Water Agency.

Demko, D. B. and S. P. Cramer. 2000. Evaluation of Juvenile Chinook Entrainment at the South Yuba-Brothy Diversion Headworks. Final Report. Prepared for South Yuba-Brophy and Yuba County Water Agency.

Deng, X., J. P. Van Eenennaam, and S. I. Doroshov. 2002. Comparison of Early Life Stages and Growth of Green and White Sturgeon. American Fisheries Society Symposium. Volume 28: 237-248.

Dumbauld, B. R., D. L. Holden, and O. P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest Estuaries? Environmental Biology of Fishes 83:283-296.

DWR. 1999. Yuba Goldfields Fish Barrier Project. Preliminary Engineering Report. Yuba County, California. California Department of Water Resources, Central District. November 1999.

DWR. 2001. Feather River Salmon Spawning Escapement: A History and Critique.

DWR and Corps. 2003a. Stakeholder Review Draft Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Studies – Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam. Prepared by Entrix, Inc. and Jud Monroe. March 7, 2003.

DWR and Corps. 2003b. Draft Daguerre Point Dam Fish Passage Improvement Project Alternative Concepts Evaluation. Prepared by Wood-Rogers, Inc. for Entrix, Inc. September 2003.

DWR. 2003a. Final Assessment of Sturgeon Distribution and Habitat Use. SP-F21, Task 2, Draft Report Oroville Facilities Relicensing FERC Project 2010.

DWR. 2003b. Redd Dewatering and Juvenile Steelhead and Chinook Salmon Stranding in the Lower Feather River 2002-2003. Interim report SP-F10, Task 3c. Oroville Facilities Relicensing FERC Project No. 2100. June 17, 2003.

DWR. 2004a. Evaluation of the Feather River Hatchery Effects on Naturally Spawning Salmonids.

DWR. 2004b. Evaluation of the Feather River Hatchery Effects on Naturally Spawning Salmonids.

DWR. 2005. California Water Plan Update 2005. Volume 4 – Reference Guide Accounting for Climate Change. Public Review Draft. Prepared by Maurice Roos.

DWR. 2005a. Fish Passage Improvement – An Element of CALFED's Ecosystem Restoration Program Bulletin 250. Fish Passage Improvement 2005.

DWR. 2007. Upper Yuba River Watershed Chinook Salmon and Steelhead Habitat Assessment Technical Report. Prepared by the Upper Yuba River Studies Program Study Team. November 2007.

DWR. 2008. Quantification of Pre-screen Loss of Juvenile Steelhead Within Clifton Court Forebay. Draft. September 2008.

DWR. 2009. Fish Passage Improvement – Upper Yuba River Studies Program. Available at www.watershedrestoration.water.ca.gov/fishpassage/projects/uppreyuba.cfm. Accessed in May 2009.

DWR. 2009a. Hatchery and Genetic Management Plan for Feather River Hatchery Spring-Run Chinook Salmon Program. Prepared by Fish Sciences. June 2009.

DWR and PG&E. 2010. Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead Final Habitat Expansion Plan. November 2010.

DWR. 2011. Fish Passage Improvement Program. Available at www.water.ca.gov/ fishpassage/projects/daguerre.cfm.

Edwards, G. W., K. A. F. Urquhart, and T. L. Tillman. 1996. Adult Salmon Migration Monitoring, Suisun Marsh Salinity Control Gates, September-November 1994. Technical Report 50. Interagency Ecological Program for the San Francisco Bay/Delta Estuary.

Eilers, C. D. 2008. Review of Present Steelhead Monitoring Programs in the California Central Valley. Pacific States Marine Fisheries Commission, Sacramento, CA, for CDFG, Central Valley Steelhead Monitoring Plan, Agreement No. P0685619. May 2008.

Eilers, C. D., J. Bergman, and R. Nelson. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. The Resources Agency: Department of Fish and Game: Fisheries Branch Administrative Report Number: 2010–2.

Elliott, J. M. 1981. Some Aspects of Thermal Stress on Freshwater Teleosts. Pages 209-245 *in* Stress and Fish, A. D. Pickering, editor. Academic Press, London.

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume II: Species Life History Summaries. ELMR Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

EPA. 1994. Methods for Measuring the Toxicity and Bioaccumulation of Sediment Associated Contaminants with Freshwater Invertebrates. EPA 600-R-94-024. Duluth, Minnesota.

EPA. 1998. Guidelines for Ecological Risk Assessment. Published May 14, 1998, Federal Register 63(93):26846-26924)

ERDC. 2008. Report to the Secretary of the Army on Civil Works for FY 2008. U.S. Army Engineer Research and Development Center.

Erickson, D. L., J. A. North, J. E. Hightower, J. Weber, and L. Lauck. 2002. Movement and Habitat Use of Green Sturgeon *Acipenser medirostris* in the Rogue River, Oregon, USA. Journal of Applied Ichthyology. Volume 18: 565-569.

Erickson, D. L. and J. E. Hightower. 2007. Oceanic Distribution and Behavior of Green Sturgeon. American Fisheries Society Symposium. Volume 56: 197-211.

Everest, F. H., G. H. Reeves, J. R. Sedell, J. Wolfe, D. Hohler, and D. Heller. 1986. Abundance, Behavior, and Habitat Utilization by Coho Salmon and Steelhead Trout in Fish Creek, Oregon, as Influenced by Habitat Enhancement. U.S. Forest Service Annual Report to Bonneville Power Administration. Annual Report 1985.

Everest, F. H. and D. W. Chapman. 1972. Habitat Selection and Spatial Interaction by Juvenile Chinook Salmon and Steelhead Trout in Two Idaho Streams. Journal of the Fisheries Research Board of Canada. Volume 29: 91-100.

Evermann, B. W. and H. W. Clark. 1931. A Distribution List of the Species of Freshwater Fishes Known to Occur in California. Division of Fish and Game of California. Fish Bulletin No. 35.

FISHBIO. 2012. San Joaquin Basin Update. San Joaquin Basin Newsletter, June 19, 2012. V2012, I 19. Oakdale, California.

FISHBIO. 2013a. 4(D) Permit #16822 Annual Report - Tuolumne River Weir (2012 Season). Oakdale, CA.

FISHBIO. 2013b. 4(D) Permit #16825 Annual Report - Tuolumne River Rotary Screw Trap (2012 Season). Oakdale, CA.

FISHBIO. 2013c. 4(d) Permit #16531 Annual Report Merced River Salmonid Monitoring (2012 Season). Oakdale, CA.

Fisher, F. W. 1992. Chinook Salmon (*Oncorhynchus tshawytscha*) Growth and Occurrence in the Sacramento-San Joaquin River System. Inland Fisheries Division, California Department of Fish and Game.

Fisher, F. W. 1994. "Past and Present Status of Central Valley Chinook Salmon." Conservation Biology 8(3): 870-873.

Fry, D. H. 1961. King Salmon Spawning Stocks of the California Central Valley, 1940-1959. California Department of Fish and Game. Volume 47(1): 55-71.

Ford, J. K. B. and G. M. Ellis. 2006. Selective Foraging by Fish-Eating Killer Whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series. Volume 316:185-199.

Francis, R. C. and N. Mantua. 2003. Climatic Influences on Salmon Populations in the Northeast Pacific. In: Assessing Extinction Risk for West Coast Salmon. Proceedings of the Workshop November 13–15, 1996. NOAA Technical Memorandum NMFS-NWFSC-56 (editors A.D. MacCall and T.C. Wainwright), pp. 3–76. Northwest Fisheries Science Center, Seattle, Washington.

Fry, D. H. 1961. King Salmon Spawning Stocks of the California Central Valley, 1940-1959. California Department of Fish and Game. Volume 47(1): 55-71.

Fulton, A. A. 2008. Gravel for Salmon in Bedrock Channels: Elucidating Mitigation Efficacy Through Site Characterization, 2D-Modeling, and Comparison Along the Yuba River, CA. University of California.

Garcia, A. 1989. The Impacts of Squawfish Predation on Juvenile Chinook Salmon at Red Bluff Diversion Dam and Other Locations in the Sacramento River. U.S. Fish and Wildlife Service, Fisheries Assistance Office, Red Bluff, California.

Garland, R. D., K. F. Tiffan, D. W. Rondorf, and L. O. Clark. 2002. Comparison of Subyearling Fall Chinook Salmon's Use of Riprap Revetments and Unaltered Habitats in Lake Wallula of the Columbia River. North American Journal of Fisheries Management. Volume 22: 1283-1289.

Garza, J. C. and D. E. Pearse. 2008. Population Genetic Structure of *Oncorhynchus mykiss* in the California Central Valley. Final Report for California Department of Fish and Game Contract # PO485303 with University of California, Santa Cruz and NOAA Southwest Fisheries Science Center.

Gerrity, P. C., C. S. Guy, and W. M. Gardner. 2006. Juvenile pallid sturgeon are piscivorous: A call for conserving native cyprinids. Transactions of the American Fisheries Society 135:604-609.

Gerstung, E. 1971. Fish and Wildlife Resources of the American River to Be Affected by the Auburn Dam and Reservoir and the Folsom South Canal, and Measures Proposed to Maintain These Resources. California Department of Fish and Game.

Gingras, M. 1997. Mark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-screen Loss of Juvenile Fishes: 1976-1993. Interagency Ecological Program Technical Report No. 55.

Goals Project. 1999. Baylands Ecosystem Habitat Goals: A Report of Habitat Recommendations Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco. San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed Esus of West Coast Salmon and Steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-66, 637 pp.

Good, T. P., T. J. Beechie, P. McElhany, M. M. McClure, and M. H. Ruckelshaus. 2007. Recovery Planning for Endangered Species Act-listed Pacific Salmon: Using Science to Inform Goals and Strategies. Fisheries. Volume 32: 426-440.

Grothe, D. E. 2011. Declaration of Douglas E. Grothe. In the United States District Court for the Eastern District of California, Sacramento Division. Case Number 2:06-cv-0284S-LKK-JFM. South Yuba River Citizens League, et al., Plaintiffs, v. National Marine

Goyer, R.A. and T.W. Clarkson. 1996. Toxic Effects of Metals. Casarett and Doull's Toxicology, the Basic Science of Poisons, Fifth Edition, Chapter 23. McGraw-Hill.

Graham, N. E. 1994. Decadal-Scale Climate Variability in the Tropical and North Pacific during the 1970s and 1980s: Observations and Model Results. Climate Dynamics. Volume 10: 123-162.

Gustaitis, R. 2009. Restoring Life to the Yuba River Goldfields. California Coast and Ocean Volume 25(2).

Hagwood, J. J. 1981. The California Debris Commission: A History of the Hydraulic Mining Industry in the Western Sierra Nevada of California, and of the Government Agency Charged with Its Regulation. Prepared for the U.S. Army Corps of Engineers.

Hallock, R.J., D. H. Fry, Jr., and D. A. LaFaunce. 1957. The Use of Wire Fyke Traps to Estimate the Runs of Adult Salmon and Steelhead in the Sacramento River. California Fish and Game Quarterly. October 1957 Vol 43, No. 4, pages 271-298.

Hallock, R. J. and W. F. Van Woert. 1959. A Survey of Anadromous Fish Losses in Irrigation Diversions from the Sacramento and San Joaquin Rivers. California Fish and Game. Volume 45(4): 227–95.

Hallock, R. I., W. F. Van Woert, and L. Shapovalov. 1961. An Evaluation of Stocking Hatchery-Reared Steelhead Rainbow Trout (*Salrno gairdneri gairdneri*) in the Sacramento River System. California Department of Fish and Game. Fish Bulletin Number 114.

Hallock, R. J., R. F. Elwell, and D. H. Fry Jr. 1970. Migrations of Adult King Salmon (*Oncorhynchus tsawytsha*) in the San Joaquin Delta as Demsonstrated by the Use of Sonic Tags. Fish Bulletin 151.

Hallock, R. J. 1989. Upper Sacramento River Steelhead, *Oncorhynchus mykiss*, 1952-1988. A Report Prepared for the U.S. Fish and Wildlife Service.

Hannon, J., M. Healey, and B. Deason. 2003. American River Steelhead)*Oncorhynchus mykiss)* Spawning 2001-2003.

Hannon, J. and B. Deason. 2008. American River Steelhead *(Oncorhynchus mykiss)* Spawning 2001-2007. U.S. Bureau of Reclamation, Central Valley Project, American River, California Mid-Pacific Region.

Hare, S. R. and R. C. Francis. 1995. Climate Change and Salmon Production in the Northeast Pacific Ocean. In: Beamins, R. J., Editor, Climate Change and Northern Fish Populations. Canadian Special Publications in Fisheries and Aquatic Sciences. Volume 121: 357-372.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse Production Regimes: Alaska and West Coast Pacific Salmon. Fisheries 24(1):6-14.

Harrell, W. C. and T. R. Sommer. 2003. Patterns of Adult Fish Use on California's Yolo Bypass Floodplain. Pages 88-93 in P. M. Faber, Editor. California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration.

Hartman, G. F. 1965. The Role of Behavior in the Ecology and Interaction of Underyearling Coho Salmon (*Oncorhynchus kisutch*) and Steelhead Trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Cananda. Volume 20: 1035-1081.

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia. Pages 203-229 *in* W.J. McNeil and D.C. Himsworth, editors. Salmonid ecosystems of the North Pacific. Oregon State University Press and Oregon State University Sea Grant College Program, Corvallis.

Healey, M. C. 1991. Life History of Chinook Salmon (*Oncorhynchus tshawytscha*). In: Grootand, C. and L. Margolis, Editors. Pacific Salmon Life Histories. UBC Press, Vancouver.

Herbold, B., and P. B. Moyle. 1989. Ecology of the Sacramento-San Joaquin Delta: A community profile. U.S. Fish and Wildlife Service Biological Report 85(7.22) September. 106 pp.

Herren, J. R. and S. S. Kawasaki. 2001. Inventory of Water Diversions in Four Geographic Areas in California's Central Valley. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179(2):343-355.

Heublein, J. C. 2006. Migration of Green Sturgeon *Acipenser medirostris* in the Sacramento River. Master of Science Thesis. California State University, San Francisco. October 2006.

Heublein, J. C., J. T. Kelly, C. E. Crocker, A. P. Klimley, and S. T. Lindley. 2009. Migration of Green Sturgeon, *Acipenser medirostris,* in the Sacramento River. Environmental Biology of Fishes. Volume 84: 245-258.

Hsieh, C. H., S. M. Glaser, and A. J. Sugihara. 2005. Distinguishing Random Environmental Fluctuations from Ecological Catastrophes for the North Pacific Ocean. Nature. Volume 435: 336-340.

Hunerlach, M. P., C. N. Alpers, M. Marvin-DiPasquale, H. E. Taylor, and J. F. De Wild. 2004. Geochemistry of Mercury and Other Trace Elements in Fluvial Tailings Upstream of Daguerre Point Dam, Yuba River, California. August 2001. U.S. Geological Survey Scientific Investigations Report 2004-5165.

Hunter, J. G. 1959. Survival and Production of Pink and Chum Salmon in a Coastal Stream. Journal of the Fisheries Research Board of Canada 16(6):835-886.

ICF Jones & Stokes. 2010. 2010 Progress Report: Yuba River Fish Stranding Surveys. Prepared for Yuba County Water Agency. December 31, 2010.

ICF Jones & Stokes. 2012. Lower Yuba River Redd Dewatering and Fry Stranding Study. Final Report. Prepared for Yuba County Water Agency. Draft.
August 2012.

IDFG. 1992. Potential Impacts of Releases of Hatchery Steelhead Trout "Smolts" on Wild and Natural Juvenile Chinook and Sockeye Salmon. A White Paper. Prepared by D. A. Cannamela. Idaho Department of Fish and Game. March 1992.

IEP Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review Existing Programs, and Assessment Needs. In Comprehensive Monitoring, Assessment, and Research Program Plan, Technical Appendix VII-11.

Independent Scientific Advisory Board. 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. ISAB, Report 2007-2, Portland, Oregon.

Ingersoll, C. G. 1995. Sediment Tests. Pages 231-255 *in* Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment, Second Edition, G. M. Rand, editor. Taylor and Francis, Bristol, Pennsylvania.

IPCC. 2007. Climate change 2007 – The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report on the IPCC. Intergovernmental Panel on Climate Change.

Israel, J. A. and B. May. 2007. Mixed Stock Analysis of Green Sturgeon from Washington State Coastal Aggegations. Genomic Variation Laboratory, U.C. Davis.

Israel, J. A. and A. Klimley. 2008. Life history conceptual model for north american green sturgeon, Acipenser medirostris.

Israel, J. A., K. J. Bando, E. C. Anderson, and B. May. 2009. Polyploid Microsatellite Data Reveal Stock Complexity Among Estuarine North American Green Sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences. Volume 66: 1491-1504.

Israel, J. A. and B. May. 2010. Indirect Genetic Estimates of Breeding Population Size in the Polyploid Green Sturgeon (*Acipenser medirostris*). Molecular Ecology. Volume 19: 1058-1070.

Israel, J. A., M. Thomas, R. Corwin, A. Hearn, R. Chase, and A. P. Klimley. 2010. Implications of Seasonal Migration Impediments on Green Sturgeon in the Sacramento River. Poster Presented at the 6th Biennial Bay-Delta Science Conference.

Jassby, A. 2008. Phytoplankton in the Upper San Francisco Estuary: Recent Biomass Trends, Their Causes and Their Trophic Significance. San Francisco Estuary and Watershed Science 6(1).

Jeffres, C. A., J. J. Opperman, and P. B. Moyle. 2008. Ephemeral Floodplain Habitats Provide Best Growth Conditions for Juvenile Chinook Salmon in a California River. Environmental Biology of Fishes 83: 449-458.

Johnson, M. R. and K. Merrick. 2012. Juvenile Salmonid Monitoring Using Rotary Screw Traps in Deer Creek and Mill Creek, Tehama County, California. Summary Report: 1994-2010. California Department of Fish and Wildlife, Red Bluff Fisheries Office - Red Bluff, California.

JSA. 1992. Expert Testimony on Yuba River Fisheries Issues by Jones & Stoke Associates' Aquatic and Environmental Specialists Representing Yuba County Water Agency. Prepared for California State Water Resources Control Board, Water Rights Hearing on Lower Yuba River, February, 10, 11, and 13, 1992. Prepared January 1992.

JSA. 2003. Freeport Regional Water Project. Volume 1: Draft Environmental Impact Report/Environmental Impact Statement. Prepared for Freeport Regional Water Authority and U.S. Department of Interior, Bureau of Reclamation. July, 2003.

JSA. 2008. Lower Yuba River Redd Dewatering and Fry Stranding Study – 2007 Annual Report. Draft. Prepared for Yuba County Water Agency. February 2008.

Keleher, C. J. and F. J. Rahel. 1996. Thermal Limits to Salmonid Distributions in the Rocky Mountain Region and Potential Habitat Loss Due to Global Warming: A Geographic Information System (GIS) Approach. Transactions of the American Fisheries Society. Volume 125(1): 1-13.

Keller, E. A. and F. J. Swanson. 1979. Effects of Large Organic Material on Channel Form and Fluvial Processes. Earth Surface Processes. Volume 4: 361-380.

Kelley, R. 1989. Battling the Inland Sea. American Political Culture, Public Policy, and the Sacramento Valley 1850-1986.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of Green Sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, CA. Environmental Biology of Fishes. Volume 79(3-4): 281-295.

Kennedy, T. and T. Cannon. 2002. Stanislaus River Salmonid Density and Distribution Survey Report (2000-2001). Fishery Foundation of California.

Kiparsky, M. and P. H. Gleick. 2003. Climate Change and California Water Resources: A Survey and Summary of the Literature. The California Water Plan, Volume 4 - Reference Guide. Oakland, CA: Pacific Institute for Studies in Development, Environment, and Security.

Kjelson, M.A., P.F. Raquel, and F. W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, Pages 393-411 *in* V.S. Kennedy, editor. Estuarine comparisons. Academic Press, New York, NY.

Klimley, A. P., P. J. Allen, J. A. Israel, and J. T. Kelly. 2007. The Green Sturgeon and Its Environment: Past, Present, and Future. Environmental Biology of Fishes. Volume 79: 415-421.

Kostow, K. E., A.R. Marshall, and S.R. Phelps. 2003. Natural Spawning Hatchery Steelhead Contribute to Smolt Production but Experience Low Reproductive Success. Transactions of the American Fisheries Society(132):780-790.

Kozlowski, J. F. 2004. Summer Distribution, Abundance, and Movements of Rainbow Trout (*Oncorhynchus mykiss*) and Other Fishes in the Lower Yuba River, California. Master's Thesis, University of California, Davis.

Kynard, B., E. Parker and T. Parker. 2005. Behavior of Early Life Intervals of Klamath River Green Sturgeon, *Acipenser medirostris*, with a Note on Body Color. Environmental Biology of Fishes. Volume 72: 85-97.

Lande, R. 1993. Risks of Population Extinction from Demographic and Environemntal Stochasticity and Random Catastrophes. American Naturalist 142: 911-927.

Leitritz, E. 1970. A History of California's Fish Hatcheries 1870-1960. California Department of fish and Game Fish Bulletin 150.

Levings, C.D. 1982. Short Term Use Of Low-Tide Refugia in a Sand Flat by Juvenile Chinook, (*Oncorhynchus tshawytscha*), Fraser River Estuary. Canadian Technical Reports of Fisheries and Aquatic Sciences, Number 1111. 7 pages.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43:1386-1397.

Levy, D.A., Northcote, T.G. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westwater Research Center, University of British Columbia, Technical Report 25, 117 pp.

Lindley, S. T., R. S. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population Structure of Threatened and Endangered Chinook Salmon ESUs in California's Central Valley Basin. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-360.

Lindley, S. T., R. S. Schick, A. Agrawal, M. Goslin, T. Pearson, E. Mora, J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. Williams. 2006. Historical Population Structure of Central Valley Steelhead and Its Alteration by Dams. San Francisco Estuary and Watershed Science. Volume 4(1): Article 3.

Lindley, S. T., R .S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science. Volume 5(1):26 Article 4.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. L. Rechisky, J. T. Kelley, J. Heublein, and A. P. Klimley. 2008. Marine Migration of North American Green Sturgeon. Transactions of the American Fisheries Society. Volume 137: 182-194.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, T. H. Williams. 2009. What Caused the Sacramento River Fall Chinook Stock Collapse? Pre-publication Report to the Pacific Fishery Management Council. March 18, 2009.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries. Transactions of the American Fisheries Society 140:108-122.

Linville, R. G., S. N. Luoma, L. Cutter, and G. A. Cutter. 2002. Increased Selenium Threat as a Result of Invasion of the Exotic Bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology. Volume 57: 51-64.

Mace, G. M. and R. Lande. 1991. Assessing Extinction Threats: Toward a Reevaluation of IUCN Threatened Species Categories. Conservation Biology 5(2): 148-157.

MacFarlane, R.B., and E.C. Norton. 2002. Physiological Ecology of juvenile chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallons, California. Fishery Bulletin 100: 244-257.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bulletin of the American Meteorological Society. Volume 78: 1069–1079.

Mantua, N. J. and S. R. Hare. 2002. The Pacific Decadal Oscillation. Journal of Oceanography. Volume 58: 35-44.

Martin, C.D., P.D. Gaines and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U.S. Fish and Wildlife Service, Red Bluff, California.

Maslin, P., M Lennox, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*). California State University, Chico, Department of Biological Sciences. 89 pages.

Massa, D. 2005. Yuba River Juvenile Chinook Salmon, *Oncorhynchus tshawytsha*, and Juvenile Central Valley Steelhead Trout, *Oncorhynchus mykiss*, Life History Survey. Annual Data Report 2003-2004. California Department of Fish and Game.

Massa, D., J. Bergman, and R. Greathouse. 2010. Lower Yuba River Accord Monitoring and Evaluation Plan: Annual Vaki Riverwatcher Report March 1, 2007 – February 29, 2008. April 29, 2010.

Mayfield, R. B. and J. J. Cech. 2004. Temperature Effects on Green Sturgeon Bioenergetics. Transactions of the American Fisheries Society. Volume 133: 961-970.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5: Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. Report EPA-910-D-01-005. Prepared as Part of U.S. EPA Region 10 Temperature Water Quality Criteria Guidance Development Project.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42, 174 pp.

McEwan, D. 2001. Central Valley Steelhead. In: Contributions to the Biology of Central Valley Salmonids, California Fish and Game, Bulletin 179, Volume 1. Salmonid Symposium, Bodega Bay, California. October 22-24, 1997, Randall Brown, Editor.

McEwan, D. and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game. February 1996.

McGill, R. R. and A. Price. 1987. Land Use Changes in the Sacramento River Riparian Zone, Redding to Colusa. A Third Update: 1982-1987. Department of Water Resources, Northern District.

McLain, J. and G. Castillo. 2010. "Nearshore Areas Used by Fry Chinook Salmon, *Oncorhynchus tshawytscha*, in the Northwestern Sacramento-San Joaquin Delta, California." San Francisco Estuary and Watershed Science **7**(2): 1-12.

McLean, J. E., Paul Bentzen, and Thomas P. Quinn. 2003. Differential Reproductive Success of Sympatric, Naturally Spawning Hatchery and Wild Steelhead Trout (Oncorhynchus Mykiss) through the Adult Stage. Can. J. Fish. Aquat. Sci. 60:433-440.

McMichael, G. A., C. S. Sharpe, and T. N. Pearsons. 1997. Effects of Residual Hatchery-Reared Steelhead on Growth of Wild Rainbow Trout and Spring Chinook Salmon. Transactions of the American Fisheries Society. Volume 126: 230-239.

McMichael, G. A., T. N. Pearsons, and S. A. Leider. 1999. Behavioral Interactions Among Hatchery-Reared Steelhead Smolts and Wild *Oncorhynchus mykiss* in Natural Streams. North American Journal of Fisheries Management. Volume 19: 948-956.

McReynolds, T. R., C. E. Garman, P. D. Ward, and S. L. Plemons. 2007. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncoryhnchus tshawytscha*, Life History Investigation 2005-2006. California Department of Fish and Game.

Meehan WR. ed. 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Bethesda (MD): American Fisheries Society. Special Publication 19.

Meehan, W. R. and T. C. Bjornn. 1991. Salmonid distributions and life histories. *In* W. R. Meehan, editor, Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats, pages 47-82. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland. 751 pages.

Merz, J. 2002. Seasonal Feeding Habits, Growth, and Movement of Steelhead Trout in the Lower Mokelumne River, California. California Fish and Game 88(3): 95-111.

Michny, F. and M. Hampton. 1984. Sacramento River Chico Landing to Red Bluff Project, 1984 Juvenile Salmon Study. U.S. Fish and Wildlife Service, Division of Ecological Services.

Miller, A. J., D. R. Cayan, T. P. Barnett, N. E. Graham, and J. M. Oberhuber. 1994. The 1976-77 Climate Shift of the Pacific Ocean. Oceanography. Volume 7: 21-26.

Mims, S. D., A. Lazur, W. L. Shelton, b. Gomelsky, and F. Chapman. 2002. Species Profile: Production of Sturgeon. Southern Regional Aquaculture Center Publication Number 7200. November 2002.

Mitchell, W. T. 2010. Age, Growth, and Life History of Steelhead Rainbow Trout (*Oncorhynchus mykiss*) in the Lower Yuba River, California. March 2010.

Mora, E. A., S. T. Lindley, D. L. Erickson and A. P. Klimley. 2009. Do Impassable Dams and Flow Regulation Constrain the Distribution of Green Sturgeon in the Sacramento River, California? Journal of Applied Ichthyology 25 (Suppl. 2) (2009), 39–47. February 2009.

Moser, M. L. and S. W. Ross. 1995. Habitat Use and Movements of Shortnose and Atlantic Sturgeons in the Lower Cape Fear River, North Carolina. Transactions of the America Fisheries Society. Volume 124(2): 225-234.

Moser, M. L. and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Moser, S., G. Franco, S. Pittiglio, W. Chou, and D. Cayan. 2009. The Future Is Now: An Update on Climate Change Science Impacts and Response Options for California. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-071. May 2009.

Mote, P. W., A. Peterson, S. Reeder, H. Shipman, and L. Whitely Binder. 2008. Sea Level Rise in the Coastal Waters of Washington State. Climate Impacts Group. Joint Institute for the Study of the Atmosphere and Ocean. University of Washington.

Moyle, P.B., and B. Herbold. 1989. Status of the Delta smelt, Hypomesus transpacificus. Final Report U.S. Fish and Wildlife Service.

Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller. 1992. Life History and Status of Delta Smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish Species of Special Concern in California. 2nd Edition. California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles, California.

Mount, J. F. 1995. California Rivers and Streams: The Conflict Between Fluvial Process and Land Use. University California Press, Berkeley, California.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Tech Memo. NMFS-NWFSC-35.

Mueter, F. J., R. M. Peterman, and B. J. Pyper. 2002. Opposite Effects of Ocean Temperature on Survival Rates of 120 Stocks of Pacific Salmon (*Oncorhynchus spp.*) in Northern and Southern Areas. Canadian Journal of Fisheries and Aquatic Sciences. Volume 59: 456-463.

Muir, W.D., McCabe, G.T., Parsley, M.J. and Hinton, S.A. 2000. Diet of First-Feeting Larval and Young-of-the-Year White Sturgeon in the Lower Columbia River. Northwest Science, Vol. 74, No 1.

Myrick, C. A. and J. J. Cech. 2001. Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations. Bay-Delta Modeling Forum Technical Publication 01-1.

NAFWB. 2004. Memorandum from NAFWB to B. Curtis Regarding Water Velocity Measurements at Gravel Dike, South Yuba Brophy Diversion, Yuba River.

Naiman, R.J. and M.G. Turner. 2000. A future perspective on North America's freshwater ecosystems. *Ecological Applications*. 10:958-970.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and Growth of Klamath River Green Sturgeon (*Acipenser medirostris*). U. S. Fish and Wildlife Service, Project Number 93-FP-13, Klamath River Fishery Resource Office, Yreka, CA.

Nelson, J. 2009. Declaration of John Nelson in Support of Plaintiffs' Motion for Preliminary Injunction. United States District Court for the Eastern District of California. Case Number: 06-cv-02845-LKK-JFM. South Yuba River Citizens League and Friends of the River, Plaintiffs, v. National Marine Fisheries Service, United States Army Corps of Engineers and Yuba County Water Agency, Defendants.

Nguyen, R.M. and C.E. Croker. 2007. The Effects of Substrate Composition on Forage Behavior and Growth Rate of Larval Sturgeon, *Acipenser medirostris*. Environ. Biol. Fish 79:231-241.

Nichols, F. H., J. E. Cloern, S. N. Louma, and D. H. Peterson. 1986. The Modification of an Estuary. Science. Volume 231: 567-573.

Nielsen, J. L., T. E. Lisle, and V. Ozaki. 1994. Thermally Stratified Pools and Their Use by Steelhead in Northern California Streams. Transactions of the American Fisheries Society. Volume 123: 613-626.

Nielsen, J. L., S. Pavey, T. Wiacek, G. K. Sage, and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations 1999-2003. U.S.G.S. Alaska Science Center - Final Technical Report Submitted December 8, 2003. California Department of Fish and Game, Sacramento, California and US Fish and Wildlife Service, Red Bluff Fish, California.

Niggemyer, A. and T. Duster. 2003. Final Assessment of Potential Sturgeon Passage Impediments Sp-F3.2 Task 3A. Oroville Facilities Relicensing FERC Project No. 2100. September 2003.

Nilo, P., S. Tremblay, A. Bolon, J. Dodson, P. Dumont, and R. Fortin. 2006. Feeding Ecology of Juvenile Lake Sturgeon in the St, Lawrence River System. Transaction of the American Fisheries Society.

National Research Council. 2001. Climate Change Science: An Analysis of Some Key Questions. Committee on the Science of Climate Change, National Research Council. National Academy Press, Washington, D. C.

NMFS. 1996a. Factors for Decline: A supplement to the Notice of Determination for West Coast Steelhead. Protected Species Branch and Protected Species Management Division. August 1996.

NMFS. 1996b. Making Endangered Species Act Determinations of Effect for Individual or Group Actions at the Watershed Scale. Prepared by NMFS, Environmental and Technical Services Branch, Habitat Conservation Branch. August 1996.

NMFS. 1997. NMFS Proposed Recovery Plan for the Sacramento River Winter-Run Chinook Salmon. Long Beach, CA: National Marine Fisheries Service, Southwest Region. August 1997.

NMFS. 1997a. Status Review Update for Deferred and Candidate ESUs of West Coast Steelhead (Lower Columbia River, Klamath Mountain Province, Northern California, Central Valley, and Middle Columbia River ESUs). Predecisional ESA Document. December 17, 1997.

NMFS. 1998a. Factors Contributing to the Decline of Chinook Salmon: An Addendum to the 1996 West Coast Steelhead Factors for Decline Report. Protected Resources Division, National Marine Fisheries Service. Portland, Oregon. June 1998.

NMFS. 1998b. Final Rule: Notice of Determination. Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California. Federal Register 63: 13347-13371.

NMFS. 2002. Biological Opinion on the Effects of the Corps' Operation of Englebright Dam and Daguerre Point Dam on the Yuba River, in Yuba and Nevada Counties, California, on the Threatened Central Valley Spring-Run Chinook Salmon (*Oncorhynchus tshawtscha*), the Central Valley Steelhead (*0. mykiss*) and Their Respective Designated Critical Habitats. March 27, 2002.

NMFS. 2002a. Biological Opinion on Interim Operations of the Central Valley Project and State Water Project Between April 1, 2002, and March 31, 2004, on Federally Listed Threatened Central Valley Spring-Run Chinook Salmon and Threatened Central Valley Steelhead in Accordance With Section 7 of the Endangered Species Act of 1973, As Amended. National Marine Fisheries Service, Southwest Region.

NMFS. 2004. Salmonid Hatchery Inventory and Effects Evaluation Report. Technical Memorandum NMFS-NWR/SWR. An Evaluation of the Effects of Artificial Propagation on the Status and Likelihood of Extinction of West Coast Salmon and Steelhead under the Federal Endangered Species Act. May 28, 2004.

NMFS. 2004a. Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan. Prepared by National Marine Fisheries Service, Southwest Region. October 2004.

NMFS. 2004b. Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids. June 14, 2004.

NMFS. 2005. Recommendations for the Contents of Biological Assessments and Biological Evaluations. August 11, 2005.

NMFS. 2005a. Biological Opinion Based on Review of the Proposed Yuba River Development Project License Amendment for Federal Energy Regulatory Commission License Number 2246, Located on the Yuba River in Yuba County, California, and Its Effects on Threatened Central Valley Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) and Central Valley Steelhead (*O. mykiss*), in Accordance With Section 7 of the Endangered Species Act of 1973, As Amended.

NMFS. 2005b. Final Biological and Conference Opinion for the Proposed Narrows II Hydropower Facility on the Yuba River and Its Effects on Central Valley Spring-Run Chinook Salmon and Central Valley Steelhead. Yuba River Development Project License Amendment for FERC License Number 2246.

NMFS. 2005c. Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. Federal Register 70: 17386-17401.

NMFS. 2005d. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. Federal Register 70: 37160-37204.

NMFS. 2007. Final Biological Opinion on the Effects of Operation of Englebright and Daguerre Point Dams on the Yuba River, California, on Threatened Central Valley Steelhead, the Respective Designated Critical Habitats for these Salmonid Species, and the Threatened Southern Distinct Population Segment of North American Green Sturgeon. November 2007.

NMFS. 2007a. Biological Opinion on the Operation of Englebright and Daguerre Point Dams on the Yuba River, California, for a 1-Year Period. National Marine Fisheries Service, Southwest Region. April 2007.

NMFS. 2008. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species October 1, 2006 – September 30, 2008. Prepared by the Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration. U.S. Department of Commerce.

NMFS. 2008a. Proposed Designation of Critical Habitat for the Southern Distinct Population Segment of North American Green Sturgeon. Draft Biological Report. September 2008.

NMFS. 2008b. Designation of Critical Habitat for the Southern Distinct Population Segment of Green Sturgeon, Section 4(b)(2) Report. August 2008.

NMFS. 2009. Public Draft Central Valley Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon, and the Distinct Population Segment of California Central Valley Steelhead. Southwest Region Protected Resources Division, 273 pp.

NMFS. 2009a. Biological Opinion and Conference Opinion on the Long-Term Operations of the Cenral Valley Project and State Water Project. Southwest Region Protected Resources Division.

NMFS. 2009b. Draft Environmental Assessment for the Proposed Application of Protective Regulations Under Section 4(D) of the Endangered Species Act for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Prepared by the Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Region. Long Beach, California. May 2009.

NMFS. 2009c. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon; Final Rule.

NMFS. 2009d. Draft Biological and Conference Opinion for the Federal Energy Regulatory Commission’s Relicensing of the California Department of Water Resources Oroville Facilities (FERC Project No. 2100-134). July 2, 2009.

NMFS. 2010. Reinitiation of Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for State Route 529 Ebey Slough Bridge Replacement Project, Snohomish County, Washington. (COE No. NWS-2009-22) (Snohomish River 6th Field HUCs, 171100110201, 171100110202). February 2010.

NMFS. 2010a. U.S. Bureau of Reclamation Operation of the Klamath Project Between 2010 and 2018. March 2010.

NMFS. 2010b. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the State Route 520 Pontoon Construction Project, Grays Harbor County, Washington (Grays Harbor, HUC 17100105). October 2010.

NMFS. 2010c. Federal Recovery Outline North American Green Sturgeon Southern Distinct Population Segment. December 2010.

NMFS. 2011a. NOAA's National Marine Fisheries Service's Requests for Information or Study, Comments on the Applicant's Preliminary Application Document, and Comments on the Commission's Public Scoping Meeting and Scoping Document 1, Yuba River Development Project, Project No. 2246-058. Letter to YCWA.

NMFS. 2011b. 5-Year Review: Summary and Evaluation of Central Valley Spring-Run Chinook Salmon ESU. Central Valley Recovery Domain. National Marine Fisheries Service, Southwest Region.

NMFS. 2011c. 5-Year Review: Summary and Evaluation of Central Valley Steelhead DPS. Central Valley Recovery Domain. National Marine Fisheries Service, Southwest Region.

NMFS. 2011d. Anadromous Salmonid Passage Facility Design. National Marine Fisheries Service, Northwest Region. July 2011.

NMFS. 2012. Final Biological Opinion on the U.S. Army Corps of Engineers' Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir. February 29, 2012.

NMFS. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead. National Marine Fisheries Service, Southwest Regional Office, Sacramento, California. 2014.

NMFS and CDFG. 2001. Final Report on Anadromous Salmon Fish Hatcheries in California. Prepared by Joint Hatchery Review Committee. June 27, 2001.

Nobriga, M. and P. Cadrett. 2001. Differences among Hatchery and Wild Steelhead: Evidence from Delta Fish Monitoring Programs. IEP Newsletter 14(3):30-38.

Nobriga, M. L. and P. Cadrett. 2003. Differences Among Hatchery and Wild Steelhead: Evidence from Delta Fish Monitoring Programs. Interagency Ecological Program for the San Francisco Estuary Newsletter. Volume 14(3): 30-38.

Null, R. E., K.S. Niemela, and S.F. Hamelberg. 2013. Post-Spawn Migrations of Hatchery-Origin Oncorhynchus Mykiss Kelts in the Central Valley of California. Environmental Biology of Fishes(96):341–353.

Null, S. E., J. H. Viers, and J. F. Mount. 2010. Hydrologic Response and Watershed Sensitivity to Climate Warming in California's Sierra Nevada. PLoS ONE. Volume 5(4).

Null, R. E., K. S. Niemela, and S. F. Hamelberg. 2013. Post-spawn Migrations of Hatchery-origin *Onchorhynchus mykiss* Kelts in the Central Valley of California. Environ. Biol. Fish 96:341-353

Oreskes, N. 2004. Beyond the Ivory Tower: The Scientific Consensus on Climate Change. Science. Volume 306: 1686.

Orr, J. C., V. J. Fabry, O. Aumont, L. Bopp, S. C. Doney, R. A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R. M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R. G. Najjar, G. K. Plattner, K. B. Rodgers, C. L. Sabine, J. L. Sarmiento, R. Schlitzer, R. D. Slater, I. J. Totterdell, M. F. Weirig, Y. Yamanaka, and A. Yool. 2005. Anthropogenic Ocean Acidification Over the Twenty-First Century and Its Impact on Calcifying Organisms. Nature. Volume 437: 681-686.

Orsi, J. 1967. Predation Study Report, 1966-1967. California Department of Fish and Game.

Patten, B. G. 1962. Cottid Predation Upon Salmon Fry in a Washington Stream. Transactions of the American Fisheries Society 91(4):427-429.

Patten, B. G. 1971a. Increased Predation by the Torrent Sculpin, Cottus Rhotheus, on Coho Salmon Fry, Oncorhynchus Kisutch, During Moonlight Nights. Journal of the Fisheries Research Board of Canada 28(9):1352-1354.

Patten, B. G. 1971b. Predation by Sculpins on Fall Chinook Salmon, Oncorhynchus Tshawytscha, Fry of Hatchery Origin. U.S. Dept. of Commerce; National Marine Fisheries Service, Washington, D.C.

Phillips, R.W. and H.J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Annual Report to Pacific Marine Fisheries Commission. 14:60-73.

Pickard, A., A. Grover, and F. Hall. 1982. An Evaluation of Predator Composition at Three Locations on the Sacramento River. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report Number 2. September 1982.

Pasternack, G. B. 2008. Spawning Habitat Rehabilitation: Advances in Analysis Tools. In: Sear, D. A, P. DeVries, and S. Greig, Editors. Salmonid Spawning Habitat in Rivers: Physical Controls, Biological Responses, and Approaches to Remediation. Symposium 65, American Fisheries Society, Bethesda, MD.

Pasternack, G. B. 2010. Gravel/Cobble Augmentation Implementation Plan (GAIP) for the Englebright Dam Reach of the Lower Yuba River, CA. Prepared for the U.S. Army Corps of Engineers Sacramento District. September 30, 2010.

Pasternack, G. B., A. A. Fulton, and S. L. Morford. 2010a. Yuba River Analysis Aims to Aid Spring-Run Chinook Salmon Habitat Rehabilitation. California Agriculture. Volume 64(2): 69-77.

Pasternack, G. B. 2012. Assessment of Geomorphology and Habitat Related Statements in the NMFS Biological Opinion of Continued Operation and Maintenance of Englebright Dam and Reservoir, Daguerre Point Dam, and Recreational Facilities On and Around Englebright Reservoir. Prepared for the U.S. Army Corps of Engineers, Sacramento District. May 9, 2012.

Pearcy, W.G., R.D. Brodeur, and J.P. Fisher. 1990. Distribution and Biology of Juvenile Cutthorat Trout *Onchorhynchus clarki clarki* and Steelhead *O. mykiss* in Coastal Water off Oregon and Washington.

Peterson, W. T., C. A. Morgan, E. Casillas, J. O. Peterson, J. L. Fisher, and J. W. Ferguson. 2010. Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current. April 2010.

Peterson, W. T., R. C. Hooff, C. A. Morgan, K. L. Hunter, E. Casillas, and J. W. Ferguson. 2006. Ocean Conditions and Salmon Survival in the Northern California Current. White Paper.

Peterson, W. T. and F. B. Schwing. 2003. A New Climate Regime in Northeast Pacific Ecosystems. Geophysical Research Letters. Volume 30(17).

Peven, C. M., R. R. Whitney, and K. R. Williams. 1994. Age and Length of Steelhead Smolts from the Mid-Columbia River Basin, Washington. North American Journal of Fisheries Management 14(1):77-86.

PFMC. 2011. Preseason Report I: Stock Abundance Analysis and Environmental Assessment Part 1 for 2011 Ocean Salmon Fishery Regulations. (Document Prepared for the Council and Its Advisory Entities). Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Phillips, R.W., H.J. Campbell. 1961 The Embryonic Survival of Coho Salmon and Steelhead Trout as Influenced by some Environmental Conditions in Gravel Beds. Oregon State Game Commission Research Division. Oregon State University.

Placer County. 2007. Patterson Sand and Gravel Mine Expansion Project Final Environmental Impact Report. Part II of II: Revised Draft EIR. Prepared by Resource Design Technology, Inc. Prepared for County of Placer Community Development Resource Agency Planning Department. August 2007.

Poytress, W. R., J. J. Gruber, and J. P. Van Eenennaam. 2010. 2009 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Poytress, W. R., J. J. Gruber, and J. P. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. American Fisheries Society, University of Washington Press, Seattle, Washington. 378 pp.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon, in Ecological studies of the Sacramento-San Joaquin Delta, Part II. (J. L. Turner and D. W. Kelley, comp.). California Department of Fish and Game Fish Bulletin 136:115-129.

Raleigh, R. F., T. Hickman, R. C. Solomon, and P. C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. Department of Interior, U.S. Fish and Wildlife Service, Washington, D. C. FWS/OBS-82/10.60.

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chinook Salmon. U.S. Fish and Wildlife Service.

Reclamation. 2008. Biological Assessment on the Continued Long-Term Operations of the Central Valley Project and the State Water Project. August 2008.

Reiser, D. W. and T. C. Bjornn. 1979. Habitat Requirements of Anadromous Salmonids. USDA, Forest Service, Pacific Northwest and Range Experiment Station, Portland, Oregon. General Technical Report PNW-96.

Reynolds, F., T. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game, 217 pp.

Rich, A.A. 1987. Report on Studies Conducted by Sacramento County to Deterimine the Temperatures which Opimize Growth and Survival in Juvenle Chinook Salmon (*Onchorhynchus tshawytscha*). Prepared for McDonough, Holland & Allen.

RMT. 2010. Lower Yuba River Accord Monitoring and Evaluation Program. Draft. June 28, 2010.

RMT. 2010a. Lower Yuba River Accord Pilot Redd Survey Report: September 15, 2008 – April 27, 2009.

RMT. 2010b. River Management Team Technical Memorandum: Lower Yuba River Water Temperature Objectives. November 2010.

RMT. 2013. Aquatic Resources of the Lower Yuba River – Past, Present & Future, Yuba Accord Monitoring and Evaluation Program, Draft Interim Report. April 2013.

Robison, G. E. and R. L. Beschta. 1990. Identifying Trees in Riparian Areas that Can Provide Coarse Woody Debris to Streams. Forest Service. Volume 36: 790-801.

Rudnick, D. L. and R. E. Davis. 2003. Red Noise and Regime Shifts. Deep Sea Research Part I: Oceanographic Research Papers. Volume 50: 691-699.

Rutter, C. 1904. The Fishes of the Sacramento-San Joaquin Basin, with a Study of Their Distribution and Variation. Pages 103-152 *in* Bill of U.S. Bureau of Fisheries.

Salathé, E.P. 2005. Downscaling Simulations of Future Global Climate with Application to Hydrologic Modeling. International Journal of Climatology. Volume 25(4): 419-436.

San Francisco Bay RWQCB. 2006. Water Quality Control Plan for the San Francisco Bay/Sacramento San-Joaquin Delta Estuary. December 2006.

Santos, M. J., S. Khanna, E. L. Hestir, M. E. Andrew, S. S. Rajapakse, J. A. Greenberg, L. W. J. Anderson, and S. L. Ustin. 2009. Use of Hyperspectral Remote Sensing to Evaluate Efficacy of Aquatic Plant Management. Invasive Plant Science and Management 2(3):216-229.

Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2010. State-Dependent Life History Models in a Changing (and Regulated) Environment: Steelhead in the California Central Valley. Evolutionary Applications 3(3):221-243.

Schmetterling, D. A., C. G. Clancy, and T. M. Brandt. 2001. Effects of riprap bank reinforcement on stream salmonids in the western United States. Fisheries 26(7): 6-23.

Schoellhamer, D. 2011. Sudden Clearing of Estuarine Waters Upon Crossing the Threshold from Transport to Supply Regulation of Sediment Transport as an Erodible Sediment Pool Is Depleted: San Francisco Bay, 1999. Estuaries and Coasts 34(5):885-899.

Seamons TR, H. L., Naish KA, Quinn TP. 2012. Can Interbreeding of Wild and Artificially Propagated Animals Be Prevented by Using Broodstock Selected for a Divergent Life History? Evolutionary Applications 5(7):705-719.

Schwing, F. and S. Lindley. 2009. Climate Change in California: Implications for the Recovery and Protection of Pacific Salmon and Steelhead. U.S. Department of Commerce, NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-451.

Scheuerell, M. D. and J. G. Williams. 2005. Forecasting Climate-Induced Changes in the Survival of Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography. Volume 14(6): 448-457.

Seelbach, P. W. 1993. Population Biology of Steelhead in a Stable-Flow, Low-Gradient Tributary of Lake Michigan. Transactions of the American Fisheries Society 122(2):179-198.

Seesholtz, A., B. Cavallo, J. Kindopp, R. Kurth, and M. Perrone. 2003. Lower Feather River Juvenile Communities: Distribution, Emigration Patterns, and Association With Environmental Variables. In Early Life History of Fishes in the San Francisco Estuary and Watershed: Symposium and Proceedings Volume American Fisheries Society, Larval Fish Conference, August 20-23, 2003, Santa Cruz, California.

Shapovalov, L. and A. C. Taft. 1954. The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*) with Special Reference to Waddell Creek, California, and Recommendations Regarding Their Management. California Department of Fish and Game. Fish Bulletin Number 98.

Shelton, J.M. 1955. The hatching of Chinook salmon eggs under simulated stream conditions. Progressive Fish-Culturist 17:20-35.

Sierra Nevada Alliance. 2008. Programs - Sierra Water & Climate Change Campaign. Available at www.sierranevadaalliance.org/programs. Accessed in 2008.

Slater, D. W. 1963. Winter-Run Chinook Salmon in the Sacramento River, California, with Notes on Water Temperature Requirements at Spawning. U.S. Fish and Wildlife Service, Special Science Report Fisheries 461:9.

SMGB. 2010. Approval of an Interim Management Plan for the Marysville Facility (CA Mine ID #91-58-0019), Teichert Aggregates (Operator), Ms. Lillie Noble (Agent), County of Yuba. Agenda Item Number 3 for Meeting Date: July 8, 2010. State Mining and Geology Board Executive Officer's Report.

Smith, A. K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Trans. Am. Fish. Soc. 102(2):312-316.

Snider, B. 2001. Evaluation of effects of flow fluctuations on the anadromous fish populations in the lower American River. California Department of Fish and Game, Habitat Conservation Division. Stream Evaluation Program. Tech. Reports No. 1 and 2 with appendices 1-3. Sacramento, California.

Snider, B., and R. G. Titus. 2000. Timing, composition, and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996-September 1997. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 00-04.

Sogard, S., J. Merz, W. Satterthwaite, M. Beakes, D. Swank, E. Collins, R. Titus, and M. Mangel. 2012. Contrasts in Habitat Characteristics and Life History Patterns of Oncorhynchus Mykiss in California's Central Coast and Central Valley. Transactions of the American Fisheries Society 141(3):747-760.

Sommer, T. R., M. L. Nobriga, W. C. Harrel, W. Batham, and W. J. Kimmerer. 2001. Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 325-333.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The Collapse of Pelagic Fishes in the Upper San Francisco Estuary. Fisheries 32(6): 270-277.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Report Number TR-4501-96-6057. Corvallis, OR: ManTech Environmental Research Services Corp.

Spina, A. P., M. R. McGoogan, and T. S. Gaffney. 2006. Influence of Surface-water Withdrawal on Juvenile Steelhead and their Habitat in a South-central California Nursery Stream. CDFG 92(2):81-90.

SSI. 2013. Monitoring Report to California Department of Fish and Wildlife: Deer Creek Spawning Bed Enhancement Project. Sierra Streams Institute.

Stevens, D. E. 1961. Food Habits of Striped Bass, *Roccus saxatilis* (Walbaum) in the Sacramento-Rio Vista Area of Sacramento River. Master’s Thesis. University of California. Berkeley, California.

Stephenson, A. E. and D. E. Fast. 2005. Monitoring and Evaluation of Avian Predation on Juvenile Salmonids on the Yakima River, Washington. Annual Report 2004. Prepared for: U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon.

Stillwater Sciences. 2002. Merced River corridor restoration plan. Stillwater Sciences, Berkeley, California. 245 pages.

Stillwater Sciences. 2006. Sacramento River Ecological Flows Study: State of the System Report Public Review Draft. The Nature Conservancy, California.

Stillwater Sciences. 2007. Linking Biological Responses to River Processes: Implications for Conservation and Management of the Sacramento River – A Focal Species Approach. Final Report. Prepared by Stillwater Sciences, Berkeley. Prepared for The Nature Conservancy, Chico, California.

Stillwater Sciences. 2012. Modeling habitat capacity and population productivity for spring-run Chinook salmon and steelhead in the Upper Yuba River watershed. Technical Report. Prepared by Stillwater Sciences, Berkeley, California for National Marine Fisheries Service, Santa Rosa, California.

Stone, L. 1872. Report of Operations During 1872 at the United States Salmon-Hatching Establishment on the McCloud River, and on the California Salmonidae Generally; with a List of Specimens Collected.

Sumner, F. H. and O. R. Smith. 1939. A Biological Study of the Effect of Mining Debris Dams and Hydraulic Mining on Fish Life in the Yuba and American Rivers in California. Stanford University.

Sumner, F. H. and O. R. Smith. 1940. Hydraulic Mining and Debris Dams in Relation to Fish Life in the American and Yuba Rivers of California. California Fish and Game. Volume 26(1): 2 – 22.

Swales, S., R. B. Lauzier, and C. D. Levings. 1986. Winter Habitat Preferences of Juvenile Salmonids in Two Interior Rivers in British Columbia. Canadian Journal of Zoology. Volume 64: 1506-1514.

Sweeney, B. W., T. L. Bott, J. K. Jackson, L. A. Kaplan, J. D. Newbold, L. J. Standley, W. C. Hession, and R. J. Horwitz. 2004. Riparian Deforestation, Stream Narrowing, and Loss of Stream Ecosystem Services. National Academy of Sciences. Volume 101: 14132-14137.

SWRCB. 2000. State Water Resources Control Board Public Hearing. California Department of Fish and Game's Lower Yuba River Fisheries Management Plan and a Complaint by the United Group Against Yuba County Water Agency and Other Diverters of Water from the Lower Yuba River in Yuba County. April 4, 2000.

SWRCB. 2001. Decision Regarding Protection of Fishery Resources and Other Issues Relating to Diversion and Use of Water from the Lower Yuba River.

SWRCB. 2003. Revised Water Right Decision 1644 in the Matter of Fishery Resources and Water Right Issues of the Lower Yuba River.

SWRI, JSA, and Bookman-Edmonston Engineering, Inc. 2000. Hearing Exhibit S-YCWA-19. Expert Testimony on Yuba River Fisheries Issues by Surface Water Resources, Inc., Junes & Stokes Associates, and Bookman-Edmonston Engineering, Inc., Aquatic and Engineering Specialists for Yuba County Water Agency. Prepared for the California State Water Resources Control Board Water Rights Hearing on Lower Yuba River February 22-25 and March 6-9, 2000.

SWRI. 2003. Biological Assessment: Yuba River Development Project (FERC No. 2246) Proposed License Amendment. Prepared for Yuba County Water Agency, Federal Energy Regulatory Commission Office of Energy Projects and the National Marine Fisheries Service. September 2003.

Taylor, E. B. 1991. A review of local adaptation in Salmonidae, with particular reference to Pacific and Atlantic salmon. Aquaculture 98: 185-207.

Tehama-Colusa Canal Authority. 2012. Fish Passage Improvement Project at the Red Bluff Diversion Dam. September 2012.

Teo, S. L. H., P. T. Sandstrom, E. D. Chapman, R. E. Null, K. Brown, A. P. Klimley, and B. A. Block. 2011. Archival and Acoustic Tags Reveal the Post-Spawning Migrations, Diving Behavior, and Thermal Habitat of Hatchery-Origin Sacramento River Steelhead Kelts (*Oncorhynchus mykiss*). Environmental Biology of Fishes(96):175-187.

Thomas, R. K., J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

Thomas, M. J., M. L. Peterson, N. Fridenberg, J. P Van Eenennaam, J. R. Johnson, J. J. Hoover, and A. P. Klimley. 2013. Stranding of Spawning Run Green Sturgeon in the Sacramento River: Post-Rescue Movements and Potential Population-Level Effects. North American Journal of Fisheries Management 33: 287-297.

Tillman, T. L., G. W. Edwards, and K. A. F. Urquhart. 1996. Adult Salmon Migration During the Various Operational Phases of Suisun Marsh Salinity Control Gates in Montezuma Slough: August-October 1993. Agreement to California Department of Water Resources, Ecological Services Office by California Department of Fish and Game, Bay-Delta and Special Water Projects Division.

Tucker, M. E., C. D. Martin, and P. D. Gaines. 2003. Spatial and Temporal Distribution of Sacramento Pikeminnow and Striped Bass at the Red Bluff Diversion Complex, Including the Research Pumping Plant, Sacramento River, CA: January 1997 – August 1998. Red Bluff Research Pumping Plant Report Series, Volume 10. U.S. Fish and Wildlife Service, Red Bluff, California.

Tucker, M. E., C. D. Martin, and P. D. Gaines. 2003. Spatial and Temporal Distribution of Sacramento Pikeminnow and Striped Bass at the Red Bluff Diversion Complex, Including the Research Pumping Plant, Sacramento River, CA: January 1997 – August 1998. Red Bluff Research Pumping Plant Report Series, Volume 10. U.S. Fish and Wildlife Service, Red Bluff, California.

USBR and CDWR, 2012. Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan; Long-Term Operation of the Central Valley Project and State Water Project Biological Opinion. Reasonable and Prudent Alternative Actions I.6.1 and I.7 September 2012. 140 pp.

USFWS. 1990. Fishery Investigations in the Yuba Goldfields Area Near Daguerre Point Dam on the Yuba River in 1989. USFWS Report No. AFFl-FAO-90-9. August 1990.

USFWS. 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS. 1995a. Working Paper on Restoration Needs: Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California. Volume 2. U.S. Fish and Wildlife Service, Stockton, California.

USFWS. 2000. Impacts of Riprapping to Ecosystem Functioning, Lower Sacramento River, California. U.S. Fish and Wildlife Service, Sacramento Field Office, Sacramento, California. Prepared for U.S. Army Corps of Engineers, Sacramento District.

USFWS. 2002. Spawning areas of green sturgeon *Acipenser medirostris* in the upper Sacramento River California. U.S. Fish and Wildlife Service, Red Bluff, California.

USFWS. 2003. Flow-Habitat Relationships for Spring-Run Chinook Salmon Spawning in Butte Creek.

USFWS. 2007. Flow-Habitat Relationships for Spring and Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Spawning in the Yuba River. Prepared by The Energy Planning and Instream Flow Branch. May 31, 2007.

USFWS. 2008. Effects Instream Flow Investigations Yuba River Spring and Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Spawning Habitat.

Van Eenennaam, J. P., M. A .H. Webb, X. Deng, and S. I. Doroshov. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transactions of the American Fisheries Society. Volume 130: 159-165.

Van Eenennaam, J. P., J. Linares-Casenave, X. Deng, and S. I. Doroshov. 2005. Effect of Incubation Temperature on Green Sturgeon Embryos, *Acipenser medirostris*. Environmental Biology of Fishes. Volume 72: 145-154.

VanRheenen, N. T., R. N. Palmer, and M. A. Hahn. 2001. Evaluating Potential Climate Change Impacts on Water Resource Systems Operations: Case Studies of Portland, Oregon and Central Valley, California. Universities Council on Water Resources: 35-50.

Varanasi, U. and N. Bartoo. 2008. Evaluating Causes of Low 2007 Coho and Chinook Salmon Returns. Memorandum to D. Robert Lohn (NMFS-Northwest Region) and Rodney McInnis (NMFS-Southwest Region). February 22, 2008.

Venrick, E., S. J. Bograd, D. Checkley, R. Durazo, G. Gaxiola-Castro, J. Hunter, A. Huyer, K. D. Hyrenbach, B. E. Laveniegos, A. Mantyla, F. B. Schwing, R. L. Smith, W. J. Sydeman, and P. A. Wheeler. 2003. The State of the California Current, 2002–2003: Tropical and Subarctic Influences Vie for Dominance. California Cooperative Oceanic Fisheries Investigations. Report Volume 44:28–60.

Vincik, R.F. and J.R. Johnson 2013. A Report on Fish Rescue Operations at Sacramento and Delevan NWR Areas April 24 through June 5, 2013. CDFG.

Vogel, D. A., K. R. Marine, and J. G. Smith. 1988. Fish Passage Action Program for Red Bluff Diversion Dam, Final Report on Fishery Investigations. U.S. Fish and Wildlife Service, USFWS Report No. FR1/FAO-88-1, 92 pp.

Vogel, D. A. and K. R. Marine. 1991. Guide to Upper Sacramento River Chinook Salmon Life History. U.S. Bureau of Reclamation Central Valley Project. July 1991.

Vogel, D. A. 2011. Insights into the Problems, Progress, and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration. Prepared for the Northern California Water Association and the Sacramento Valley Water Users. April 2011.

Wagner, H. H. 1974. Photoperiod and Temperature Regulation of Smolting in Steelhead Trout (*Salmo gairdneri*). Canadian Journal of Zoology. Volume 52: 219-234.

Wang, J. C. S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. Interagency Ecological Program Technical Report No. 9.

Wanner, G. A., D. A. Shuman, and D. W. Willis. 2007. Food habits of juvenile pallid sturgeon and adult shovelnose sturgeon in the Missouri River downstream of Fort Randall Dam, South Dakota. Journal of Freshwater Ecology 22:81-92.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2003. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncorhynchus tshawytscha*, Life History Investigations 2001-2002. Prepared for California Department of Fish and Game.

Waples, R. S. 1991. Pacific Salmon, *Oncorhynchus spp*., and the Definition of "Species" Under the Endangered Species Act. Marine Fisheries Review. Volume 53(3):11-22.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Wells, B. K., C. B. Grimes, J. C. Field, and C. S. Reiss. 2006. Covariation Between the Average Lengths of Mature Coho (*Oncorhynchus kisutch*) and Chinook Salmon (*O. tshawytscha*) and the Ocean Environment. Fisheries Oceanography. Volume 15(1): 67–79.

Wells, B. K., C. B. Grimes, J. G. Sneva, S. McPherson, and J. B. Waldvogel. 2008. Relationships Between Oceanic Conditions and Growth of Chinook Salmon (*Oncorhynchus tshawytscha*) from California, Washington, and Alaska, USA. Fisheries Oceanography Volume 17(2): 101-125.

Wells, B. K. and M. S. Mohr. 2008. Characterization of 2005-2008 Central California Ocean Conditions. NMFS Southwest Fisheries Science Center, Fisheries Ecology Division. White Paper. November 26, 2008.

Werner, I., J. Linares-Casenave, J. P. Van Eenennaam, and S. I. Doroshov. 2007. The Effect of Temperature Stress on Development and Heat-Shock Protein Expression in Larval Green Sturgeon (*Acipenser madirostris*). Environmental Biology of Fishes. Volume 79: 191-200.

Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): 416.

Williams, J. E., A. L. Hank, N. G. Gillespie, And W. T. Colyer. 2007. The conservation success index: synthesizing and communicating salmonid condition and management needs. Fisheries 32:477-492

Williams, Thomas H., Steven T. Lindley, Brian C. Spence, and David A. Boughton. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. Report to the NMFS Southwest and Northwest Regions, May 20, 2011. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 98 p.

Wright, D.A., and D.J. Phillips. 1988. Chesapeake and San Francisco Bays: A study in contrasts and parallels. Marine Pollution Bulletin 19 (9): 405-413.

Wyrick, J. and G. Pasternack. 2012. Landforms of the Lower Yuba River. Lower Yuba River Accord Monitoring and Evaluation Program. Prepared for the Yuba Accord River Accord Planning Team. University of California, Davis.

YCWA. 1992. 1992 Juvenile Chinook Salmon Monitoring Study in the Yuba River. Prepared by William T. Mitchell.

YCWA and SWRCB. 2001. Environmental Assessment: Proposed Temporary Transfer of Water From Yuba County Water Agency to DWR, Year 2001. Prepared for Yuba County Water Agency and the State Water Resources Control Board by EDAW.

YCWA. 2003. Initial Study/Proposed Mitigated Negative Declaration for the Narrows 2 Powerplant Flow Bypass System Project. Prepared by EDAW, Inc.

YCWA. 2005. Evaluation of the 2004 Yuba River Water Transfers. Draft. Prepared for Yuba County Water Agency by Surface Water Resources, Inc.

YCWA. 2006. Draft Initial Study/Proposed Mitigated Negative Declaration for the Yuba County Water Agency Proposed Extension Petition for the Interim Instream Flow Requirements Under State Water Resources Control Board Revised Water Right Decision 1644.

YCWA, DWR, and Reclamation. 2007. Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord. State Clearinghouse (SCH) No: 2005062111. Prepared by HDR|Surface Water Resources, Inc. June 2007.

YCWA. 2008. Yuba County Integrated Regional Water Management Plan. Project No: 054310. Submitted to the Yuba County IRWM Plan Water Management Group. February 2008.

YCWA, CDFG, USFWS, SYRCL, and PG&E Lower Yuba River Habitat Discussion Group. 2009. Habitat Expansion for Spring-Run Chinook Salmon and Steelhead in the Lower Yuba River. Prepared for the Habitat Expansion Agreement Steering Committee.

YCWA. 2010. Pre-Application Document, Yuba County Water Agency Yuba River Development Project FERC Project No. 2246.

YCWA. 2010a. Yuba County Water Agency's Comments on the Public Review Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Federal Register Doc. E9-24224. Filed 10-6-09 RIN 0648 – XR39. February 2010.

YCWA. 2012. Interim Technical Memorandum 6-2 – Riparian Habitat Downstream of Englebright Dam. Yuba River Development Project FERC Project No. 2246.

YCWA. 2013. Technical Memorandum 6-2 – Riparian Habitat Downstream of Englebright Dam. Yuba River Development Project FERC Project No. 2246. June 2013.

YCWA. 2013a. Technical Memorandum 7-9 – Green Sturgeon Downstream of Englebright Dam. Yuba River Development Project FERC Project No. 2246. April 2013.

YCWA. 2013b. Technical Memorandum 7-12 – Project Effects on Fish Facilities Associated with Daguerre Point Dam. Yuba River Development Project FERC Project No. 2246. May 2013.

Yoshiyama, R. M., E. R. Gertstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. University of California, Davis, Davis, California.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management. Volume 18: 487-521.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. Contributions to the Biology of Central Valley Salmonids. Fish Bulletin 179, Volume 1.

Yuba County. 2007. Project Detail: Browns Valley Irrigation District. Project WQ1 – Agricultural Return Flow Recapturing Project.

YubaNet. 2008. Western Aggregates and SYRCL Announce Agreement for 180-Acre Salmon Habitat Enhancement Along Yuba River. Published on October 10, 2008. Available at yubanet.com.

Zimmerman, C., G. Edwards, and K. Perry. 2009. Maternal Origin and Migratory History of Steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California. Transactions of the American Fisheries Society. Volume 138:280-291.