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

September 18, 2012

In response refer to:
2011/05814:ELS

Ms. Alicia Forsythe
Program Manager
San Joaquin River Restoration Program
U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825-1898

Dear Ms. Forsythe:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the San Joaquin River Restoration Program (SJRRP) in Fresno County, California, and its effects on federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley steelhead, and the North American green sturgeon DPS, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Your request for section 7 consultation on this project was received on November 30, 2011. NMFS sent an insufficiency letter on January 26, 2102, indicating that the initiation package was incomplete and additional information was necessary to initiate consultation. Additional information was received by NMFS on June 25, 2012, and July 10, 2012. NMFS sent a letter informing Reclamation that formal consultation for the SJRRP was initiated on August 1, 2012.

This biological opinion is based on information provided in the April 2011, draft PEIR/S, July 2012, final PEIR/S, the November 30, 2011, final biological assessment, and additional information received on June 25, 2012, and July 10, 2012; and, numerous scientific articles and reports from both the peer reviewed literature and agency "gray literature." A complete administrative record of this consultation is on file at the Central Valley Office of NMFS.

Based on the best available scientific and commercial information, the biological opinion concludes that the SJRRP, as presented by Reclamation, is not likely to jeopardize the continued existence of the listed species or permanently destroy or adversely modify designated critical habitat. Because this consultation is programmatic in nature NMFS has included an incidental take statement with no authorized take, and without reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take associated with the project of listed salmonids. NMFS has however included several conservation recommendations that should be incorporated into the SJRRP to prevent and/or minimize take of listed species and impacts to critical habitat.

This letter also transmits NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha)* and Pacific Coast groundfish as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the SJRRP will adversely affect the EFH of Pacific salmon in the action area and adopts the ESA conservation recommendations of the biological opinion as the EFH conservation recommendations.

Reclamation has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 (j)). If unable to complete a final response within 30 days, Reclamation should provide an interim written response within 30 days before submitting its final response.

Please contact Ms. Erin Strange in our Sacramento Area Office at (916) 930-3653 or via e-mail at Erin.Strange@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

for Chris E. Yates

Rodney R. McInnis
Regional Administrator

Enclosures (2)
1. Biological Opinion with appendices
2. Essential Fish Habitat Conservation Recommendations

cc: Copy to file – ARN# 151422SWR2010SA00360
NMFS-PRD, Long Beach, CA
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Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	U.S. Bureau of Reclamation, Mid-Pacific Region
ACTIVITY:	Formal consultation for the San Joaquin River Restoration Program
CONSULTATION CONDUCTED BY:	Southwest Region, National Marine Fisheries Service
FILE NUMBER:	151422SWR2010SA00360 (2011/05814)
DATE ISSUE:	**September 18, 2012**

I. BACKGROUND and CONSULTATION HISTORY

A. Background

1. Introduction

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement the Stipulation of Settlement in *NDRC, et al., v. Kirk Rodgers, et al.* (Settlement). Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act), including in Public Law 111-11. The five implementing agencies for the SJRRP are the U.S. Bureau of Reclamation (Reclamation), the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the California Department of Fish and Game (CDFG), and the California Department of Water Resources (CDWR). The Settlement establishes two primary goals:

(1) **Restoration Goal** – To restore and maintain fish populations in "good condition" in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish; and (2) **Water Management Goal** – To reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim and Restoration Flows called for in the Settlement.

As part of the restoration goal, Chinook salmon will be re-introduced to the restoration area, once flows, fish migration barriers, and habitat improvements have been made that will sufficiently support fall-run and spring-run Chinook salmon. Improved river conditions will likely improve conditions for steelhead within the restoration area also. The Settlement requires the Department of Commerce to submit a report to Congress by December 2024 evaluating the progress made in reintroducing fall-run and spring-run Chinook salmon and discuss plans for future implementation of the Settlement. Subsequently, the Restoration Flows will be reviewed and revised if necessary by December 2025.

The restoration area encompasses the San Joaquin River from Friant Dam downstream to the Merced River confluence and is divided into five reaches (Appendix B: Figure 1). Each reach of the restoration area as well as the bypass system are described below:

Reach 1 begins at Friant Dam and continues approximately 37 miles downstream to Gravelly Ford. Reclamation makes releases from Friant Dam to maintain continuous flows past Gravelly Ford, providing deliveries to riparian water rights holders in Reach 1 under "holding contracts." The reach is divided into two subreaches, 1A and 1B. Reach 1A extends from Friant Dam to State Route (SR) 99. Reach 1B continues from SR 99 to Gravelly Ford. Reach 1 is the principal area identified for future salmon spawning, but has been extensively mined for instream gravel and is limited for sediment supply.

Reach 2 begins at Gravelly Ford and extends approximately 24 miles downstream to the Mendota Pool, continuing the boundary between Fresno and Madera counties. This reach is a meandering, low-gradient channel. Reach 2 is subdivided at the Chowchilla Bypass Bifurcation Structure into two subreaches. Both Reach 2A and Reach 2B are dry in most months. Reach 2A is subject to extensive seepage losses. Reach 2B is a sandy channel with limited conveyance capacity.

Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam. Reach 3 conveys flows of up to 800 cubic feet per second (cfs) from the Mendota Pool for diversion to the Arroyo Canal at Sack Dam, maintaining year-round flow in a meandering channel with a sandy bed. Flood flows from the Kings River are conveyed to Reach 3 via Fresno Slough and Mendota Dam. This reach continues the boundary between Fresno and Madera counties. The sandy channel meanders through a predominantly agricultural area, and diversion structures are common in this reach.

Reach 4 is approximately 46 miles long, and is subdivided into three distinct subreaches. Reach 4A begins at Sack Dam and extends to the Sand Slough Control Structure. This subreach is dry in most months except under flood conditions. Reach 4B1 begins at the San Slough control structure and continues to the confluence of the San Joaquin River and the Mariposa Bypass. All flows reaching the Sand Slough Control Structure are diverted to the flood bypass system via the

Sand Slough Bypass, leaving Reach 4B1 perennially dry for more than 40 years, with the exception of agricultural return flows. Reach 4B2 begins at the confluence of the Mariposa Bypass, where flood flows in the bypass system rejoin the mainstem San Joaquin River. Reach 4B2 extends to the confluence of the Eastside Bypass.

Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the Eastside Bypass downstream to the Merced River confluence. This reach receives flows from Mud and Salt sloughs, channels that run through both agricultural and wildlife management areas.

Fresno Slough, also referred to as the James Bypass, conveys flood flows in some years from the Kings River system in the Tulare Basin to the Mendota Pool. These flows are regulated by Pine Flat Dam.

Chowchilla Bypass – The Chowchilla Bypass Bifurcation Structure at the head of Reach 2B regulates the flow split between the San Joaquin River and the Chowchilla Bypass. The structure is operated depending on flows in the San Joaquin River, flows from the Kings River system via Fresno Slough, water demands in Mendota Pool, and seasonality. The Chowchilla Bypass extends to the confluence of Ash Slough, which marks the beginning of the Eastside Bypass.

Eastside Bypass, Mariposa Bypass, and Tributaries – The Eastside Bypass extends from the confluence of Ash Slough and the Chowchilla Bypass to the confluence with the San Joaquin River at the head of Reach 5. It is subdivided into three reaches. Eastside Bypass Reach 1 extends from Ash Slough to the Sand Slough Bypass confluence, and receives flows from the Chowchilla River. Eastside Bypass Reach 2 extends from the Sand Slough Bypass confluence to the head of the Mariposa Bypass. Eastside Bypass Reach 3 extends from the head of the Mariposa Bypass to the head of Reach 5, and receives flows from Deadman, Owens, and Bear creeks. Eastside Bypass Reach 3 downstream from the confluence of Bear Creek to its confluence with Reach 5 is alternatively known as Bear Creek. The Mariposa Bypass extends from the Mariposa Bypass Bifurcation Structure to the head of Reach 4B2. A drop structure is located near the downstream end of the Mariposa Bypass that dissipates energy from flows before flows enter the mainstem San Joaquin River.

2. Project Purpose

The SJRRP will implement the Settlement consistent with the Act. The Settlement requires changes to the operation of Friant Dam to support achieving the restoration goal while reducing or avoiding adverse impacts to Friant Division long-term contractors’ water deliveries caused by releasing Interim and Restoration Flows, which is the water management goal. Implementation will occur in phases over the long-term. Friant Dam and downstream control structures will be reoperated to release Interim and Restoration Flows, as constrained by then-existing channel capacities, and make supplies available to Friant Division long-term contractors at a pre-established rate. Reclamation will provide funding to support additional maintenance activities, including patrolling to assess levee conditions when increased potential for seepage is identified through monitoring, as described in the Physical Monitoring and Management Plan (see Appendix D of the *Draft Program Environmental Impact Statement/Environmental Impact Report* (PEIS/R) for the SJRRP (Reclamation and DWR 2011)); performing any additional operations and maintenance needed on flap gates in the Eastside and Mariposa bypasses, at the Chowchilla Bypass Bifurcation Structure, at the Eastside bypass Bifurcation Structure, or at the Mariposa Bypass Bifurcation Structure to facilitate routing Interim and Restoration Flows; and removing vegetation and sediment by mechanical or chemical means that will cause interim and Restoration flows to exceed channel capacity. Recapture of Interim and Restoration Flows will occur at existing facilities within the San Joaquin River between Friant Dam and the confluence of the Merced River (restoration area) and in the Delta. Interim/Restoration Flows will be reduced, redirected or rediverted to reduce flow in downstream reaches to address any issues identified through implementation of the Physical Monitoring and Management Plan. Releases will be modified from Friant Dam to adjust flows to flush or mobilize spawning gravel based on monitoring reports and recommendations on spawning gravel conditions.

3. Regulatory Framework

This opinion is required under Section 7 of the Endangered Species Act to allow for implementation of the SJRRP through December 2025. Reclamation determined the project, as proposed, may affect but is not likely to adversely affect individual fish from the federally listed SR winter-run Chinook salmon and CV spring-run Chinook salmon evolutionary significant units (ESUs), the CCV steelhead distinct population segment (DPS), and the Southern DPS of North American green sturgeon. Reclamation has also determined that the project may affect but will not adversely affect critical habitat for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and Southern DPS green sturgeon. The project will adversely affect essential fish habitat for Pacific salmon (*Oncorhynchus* spp.) or starry flounder (*Platichthys stellatus*).

For the purposes of implementation and ESA consultation the SJRRP has been divided into two levels of actions; project level actions and program level actions (Table 1). Project level actions are those that will occur in the relative short-term and for which Reclamation has sufficient data and information to evaluate the potential impacts to listed anadromous fishes. Project level actions include: the short-term reoperation of Friant Dam to release flows up to 1,660 cfs; the reoperation of the Chowchilla Bypass Bifurcation Structure; operation and monitoring of Hills Ferry Barrier; establishment of the Recovered Water Account and Program; and the recapture of Interim and Restoration Flows within the restoration area and the Delta. Program level actions will occur over the long-term and impacts to species cannot be quantified now. Potential adverse impacts to listed species and their habitats may occur from construction activities, flow management and/or monitoring. Program level actions include: the reoperation of Friant Dam to release flows above 1,660 cfs up to 4,500 cfs; the reoperation of the San Joaquin River Headgate Structure; the recapture of Interim and Restoration Flows in the restoration area, the lower San Joaquin River and the Delta; recirculation of recapture flows; channel restoration projects to improve fish habitat fish passage, floodplain creation for juvenile rearing habitats, reduction of predator habitats such as mining pits, and improvements in spawning habitat; Chinook salmon reintroduction; and physical and biological monitoring.

Table 1. Project level actions versus Program level actions

Project Actions	**Program Actions**
Flow releases up to 1,660 cfs	Flow releases beyond 1,660 cfs up to 4,500 cfs
Reoperation of Chowchilla Bifurcation Structure	Reoperation of the entire San Joaquin River Flood Control Project
Hills Ferry Barrier	Flow recapture in the lower San Joaquin River
Recovered Water Account	Recirculate recaptured water
Flow recapture in Restoration Area and Delta	Fish passage improvements
	Predator habitat reduction
	Floodplain creation
	Spawning habitat improvements
	Salmon reintroduction/supplementation
	Physical and biological monitoring

B. Consultation History

On May 22, 2009, the U.S. Bureau of Reclamation (Reclamation) initiated section 7 Endangered Species Act (ESA) consultation with the NOAA's National Marine Fisheries Service (NMFS) for the Water Year 2010 Interim Flows Project (WY 2010 Project). On September 23, 2009, NMFS issued a concurrence letter concluding that the WY 2010 Project was not likely to adversely affect federally threatened California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*), Sacramento River (SR) winter-run Chinook salmon (*O. tshawytscha*), Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), the Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), or their respective habitats.

On November 2009, NOAA's National Marine Fisheries Service (NMFS) began discussing the program-wide consultation approach during the San Joaquin River Restoration Program (SJRRP) Environmental Compliance and Permitting Workgroup meetings including participants from the U.S. Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), and California Department of Water Resources (CDWR). Because hydrologic modeling for the Draft SJRRP Programmatic Environmental Impact Statement/Report (PEIR/S) (April 2011) used the 2005 version of the CALSIM model, Reclamation proposed to conduct a sensitivity analysis between 2005 conditions and current conditions to evaluate potential impacts to listed fish species and their habitats. NMFS provided technical assistance regarding the development of the sensitivity analysis from November 2009 through February 2010.

On June 22, 2010, Reclamation initiated a section 7 ESA consultation with NMFS for the Water Year 2011 Interim Flows Project (WY 2011 Project). On July 23, 2010, NMFS requested additional information with an insufficiency letter. NMFS and Reclamation met to discuss the WY 2011 Project consultation on August 26, 2010. Reclamation proposed changes to the project description that will ensure that potential impacts to listed species will be minimized and avoided to the fullest extent practicable and agreed to provide clarifying support for Reclamation's analysis of effects related to the proposed action. Supplemental information involving: (1) recirculation and recapture; (2) Hills Ferry Barrier operation; (3) overall effects to CCV steelhead; (4) Delta operations and the Vernalis Adaptive Management Program, and (5) effects of the proposed action on essential fish habitat, was received via email on September 13, 2010. NMFS issued a concurrence letter on September 30, 2010, concluding that the WY 2011 Project was not likely to adversely affect federally threatened CCV steelhead, SR winter-run Chinook salmon, CV spring-run Chinook salmon, the Southern distinct population segment (DPS) of North American green sturgeon, or their respective habitats.

On June 8, 2011, NMFS received the First Administrative Draft Programmatic Biological Assessment (BA) for review. NMFS provided comments to Reclamation on July 14 and July 28, 2011, concerning the following areas of the BA: (1) incomplete analysis of potential impacts to habitat in the San Joaquin River tributaries from the Vernalis Adaptive Management Program; (2) inappropriate use of green sturgeon as a surrogate for steelhead and overall project impacts to steelhead not well described; (3) Action Area, Baseline, and Proposed Action not clearly defined; (4) hydrologic modeling assumptions and potential changes in the Delta are not clear; (5) flood flows and all Friant Dam operations were not evaluated; (6) and Chinook salmon reintroduction activities were not adequately described.

On July 20, 2011, Reclamation initiated a section 7 ESA consultation with NMFS for the Water Year 2012 Interim Flows Project (WY 2012 Project). NMFS issued a concurrence letter on September 30, 2011, concluding that the WY 2012 Project was not likely to adversely affect federally threatened CCV steelhead, SR winter-run Chinook salmon, CV spring-run Chinook salmon, the Southern distinct population segment (DPS) of North American green sturgeon, or their respective habitats.

On September 29, 2011, NMFS received the 2nd Administrative Draft Programmatic BA for review. NMFS provided comments to Reclamation on October 26, 2011, concerning the following areas of the BA: (1) Proposed Action is still unclear; (2) monitoring should be included; (3) impacts to steelhead within the restoration area not addressed; (4) flood flows and all Friant Dam operations were not evaluated; and (5) need to describe short-term/near future flow releases and subsequent potential impacts to listed fish and their habitats.

On November 17, 2011, NMFS received Reclamation's application for a research permit pursuant to section 10(A)1(a) of the ESA. Reclamation requested ESA coverage for take of CCV steelhead associated with research monitoring activities taking place in steelhead habitat in the San Joaquin River. On December 13, 2011, NMFS published a notice of receipt in the Federal Register outlining the research activities and take of ESA-listed species proposed under Permit 16608 (76 FR 77490). The public comment period for Permit 16608 closed January 12, 2012. No comments we received from the public. NMFS issued Permit 16608 to Reclamation on January 26, 2012.

On November 30, 2011, Reclamation initiated section 7 ESA consultation for the SJRRP with the submittal of the Programmatic BA. After an initial review of the BA, NMFS and Reclamation met on January 4, 2012, to discuss the BA insufficiencies.

On January 26, 2012, NMFS sent an insufficiency letter to Reclamation outlining the following issues with the BA: (1) Proposed Action – Consulting on an alternative that has not been selected as the preferred alternative in the PEIR/S can delay consultation, all Friant Dam operations must be evaluated, the project description must have a temporal component based on near-future program implementation, operation of Hills Ferry Barrier unclear, and need program-level monitoring; (2) Action Area – definitive description of the Action Area and how the analysis supports selection of the action area; (3) Critical Habitat – need additional analysis of critical habitat for steelhead and green sturgeon; (4) Effects Analysis – additional analysis on effects of the proposed action on listed species and their habitats is needed; and (5) Essential Fish Habitat – additional analysis of essential fish habitat for Pacific salmon is needed.

On June 25, 2012, NMFS received additional information from Reclamation in response to the insufficiency letter addressing each outstanding item. NMFS requested additional clarifying language during a call with Reclamation on June 25, 2012. Information was received via email on July 10, 2012.

NMFS sent Reclamation a sufficiency letter on August 1, 2012, initiating formal consultation.

NMFS received a letter from Reclamation on August 21, 2012 clarifying the consultation approach for the SJRRP in relationship to other Friant operations, including flood flows, which will be handled in a separate consultation.

II. DESCRIPTION OF THE PROPOSED ACTION

B. Project Actions

The reoperation of Friant Dam and downstream flow control structures are evaluated at both the project level and the program level in this biological opinion (BO) even though it was not presented that way in the BA. The short-term reoperations are evaluated as a project-level action considering the current river and bypass water conveyance capacity constraints due to levee stability and seepage. The long-term reoperation is evaluated in this BO as a program-level action with the understanding that additional analysis of the impacts to covered species from higher flow regimes will be evaluated in a subsequent consultation. All other Friant Dam operations, including flood operations will be addressed in a future and separate consultation regarding the Central Valley Project (CVP) and State Water Project (SWP) long-term operations (CVP/SWP BO).

1. Project-level actions

Project-level actions include the release of Interim and Restoration Flows up to 1,660 cfs, and subsequent reoperation of downstream flow control structures, establishing the Recovered Water Account (RWA), and recapture and recirculation of Interim and Restoration Flows as stipulated in the Settlement and described in the following sections.

a. *Reoperate Friant Dam*

Operations at Friant Dam will change to release Interim and Restoration Flows to the San Joaquin River, according to the six flow schedules specified in Exhibit B of the Settlement, as shown in Figure 2 (Appendix B). The flow schedules are specified based on six water year types: Critical-Low, Critical-High, Dry, Normal-Dry, Normal-Wet, and Wet. The water year types were determined using an index for a particular water year of the total annual unimpaired runoff at Friant Dam for the period of 1922 through 2004. The Settlement includes an annual allocation of Interim and Restoration Flows that can follow the schedules in Exhibit B or follow a more continuous hydrograph. The Settlement allows for potential alternate pathways for the transformation of allocated Restoration Flows between monthly flow schedules based on ecological intentions of the flow schedules to support spring-run and fall-run Chinook salmon. In addition, real-time flow changes can be made to improve habitat conditions using flexible flow periods, buffer flows, and acquired water. Table 2 (as cited in the SJRRP BA, Reclamation 2011) contains the Settlement-recommended release schedule for Interim and Restoration Flows.

Table 2. Schedule for Release of Interim and Restoration Flows

Year(s)	Days	Release Flows
2009	October 1 through November 20	Of a timing and magnitude, as defined in the appropriate year type release schedule specified in Exhibit B of the Settlement, and without exceeding then-existing channel capacities[1]
2010	February 1 through December 1	Of a timing and magnitude, as defined in the appropriate year type release schedule specified in Exhibit B of the Settlement, and without exceeding then-existing channel capacities[1]
2011 – 2012	February 1 through May 1	Of a timing and magnitude, as defined in the appropriate year type release schedule specified in Exhibit B of the Settlement, and without exceeding then-existing channel capacities
	May 1 through December 1	To wet the channel down to the Chowchilla Bypass Bifurcation Structure to collect information regarding seepage losses[2]
2012 – 2014	January 1 through December 31	Of a timing and magnitude, as defined in the appropriate year type release schedule specified in Exhibit B of the Settlement, and without exceeding then-existing channel capacities or interfering with any remaining in-channel construction activities; continues until modifications identified in Paragraph 11(a) of the Settlement are completed and full restoration flows begin
2014 and later	January 1 through December 31	Of a timing and magnitude, as defined in the appropriate year type release schedule specified in Exhibit B of the Settlement, and without exceeding then-existing channel capacities or interfering with any remaining in-channel construction activities

Notes:

[1] Interim Flows during Water Year 2010 (October 1, 2009, through September 30, 2010) are described in the *Water Year 2010 Interim Flows Project Environmental Assessment/Initial Study* released by Reclamation and DWR in September 2009. Interim Flows during Water Year 2011 (October 1, 2010, through September 30, 2011) are described in the *Water Year 2011 Interim Flows Project Supplemental Environmental Assessment* released by Reclamation in September 2010.

[2] This period is intended to correspond to construction activities in Paragraph 11(a). Actual time period of these releases would be coincident with these activities.

Paragraph 15 of the Settlement describes an interim research program that includes the release of Interim Flows beginning in October 2009 and continuing until full Restoration Flows begin (anticipated in January 2014), as constrained by then-existing channel capacities. Interim Flows for years 2009 through 2012 have already undergone consultation and will be not addressed in this consultation. The Restoration Administrator (RA) in consultation with the Technical Advisory Committee, the Secretary, and other appropriate Federal, State and local agencies, will develop and recommend a program of Interim flows to the Secretary. Interim flows are intended to allow collection of relevant data concerning flows, temperatures, fish needs, seepage losses, and water recirculation, recapture and reuse. The Interim flows include flow releases identified in Exhibit B of the Settlement for the appropriate water year type, including the flexible flow provisions of Exhibit B, to the extent that such releases will not impede or delay completion of actions specified in Paragraph 11(a) of the Settlement, or exceed downstream channel capacities. Once Paragraph 11(a) modifications are completed full Restoration Flows will commence.

Paragraph 13(c) of the Settlement identifies procedures to address unexpected seepage losses, including acquiring water or options on water from willing sellers to be utilized for additional releases from Friant Dam. The RA is responsible for recommending to the Secretary the date for commencing full Restoration Flows in consideration of the completion of Phase I improvements. Several State and Federal actions, including channel capacity modifications, are necessary before full Restoration Flows are released. The release of full Restoration Flows is subject to the provisions for the flexible flow periods, buffer flows, and purchased water, as well as the provisions described above for Interim flows. Six locations are identified for meeting the Restoration Flow targets: (1) Friant Dam; (2) Head of Reach 2A; (3) Head of Reach 3; (4) Head of Reach 4A; (5) Head of Reach 4B; and (6) Confluence of Merced River. Flow targets vary by restoration year type, and range from zero to 4,055 cfs at the Merced River confluence. In some years, the flow targets could be met partially or entirely by flood releases or by local runoff or return flows. If full Restoration Flows are not released in any given year, beginning January 1, 2014, the Secretary, in consultation with the RA, will bank, store, exchange, transfer, or sell the water through mutually acceptable agreements with Friant Division long-term contractors or third parties, or release the water from Friant Dam during times of the year other than those specified in the applicable flow schedule. The Settlement also includes provisions for the release of pulse flows in Normal-Wet and Wet Years to perform several geomorphic functions such as flushing spawning gravels. Flushing flows will be accomplished with a quantity of water based on an average flow of 4,000 cfs from April 16 to 30, and include a peak release as close to 8,000 cfs as possible for several hours, within the constraints of the channel capacity.

Reclamation and the San Joaquin River Exchange Contractors have entered into a Second Amended Contract for Exchange of Waters (Contract Ilr-1144)(Exchange Contract), dated February 14, 1968. Under that contract Reclamation is obligated to make available required water deliveries from the Delta-Mendota Canal or releases from Millerton Reservoir (Friant Dam). When these deliveries are made via the San Joaquin River they will have a higher priority for channel capacity than the Interim and Restoration Flows, which means that Interim and Restoration Flows could be reduced to accommodate the Exchange Contract deliveries.

Due to current channel capacity, seepage and levee stability issues, Interim and Restoration Flow releases from Friant Dam will consist of up to 1,660 cubic feet per second (cfs). As improvements are made to increase channel capacity and as project-level conservation strategy actions are implemented, Reclamation will consult with NMFS to increase flows up to the full flow releases called for in the Settlement.

The maximum extent and rate of released Interim and Restoration Flows will be limited to then-existing channel capacities. As channel capacity is increased through structural changes, Interim/Restoration Flows will correspondently increase. Interim/Restoration Flows will be reduced to address material seepage issues. If flood releases are required from Friant Dam, concurrent Interim and Restoration Flows will be reduced by an equivalent amount to the required flood control release. If flood control releases from Friant Dam exceed the concurrent scheduled Interim and Restoration Flows, no additional releases above those required for flood control will be made for SJRRP purposes. The action to release Interim and Restoration Flows includes measures that will achieve the following objectives: (1) commit Reclamation to implementing actions that will meet performance standards that minimize increases in flood risk as a result of Interim and Restoration Flows; (2) limit the release and conveyance of Interim and Restoration Flows to those flows that will remain in-channel until adequate data are available to apply the performance standards and until the performance standards are satisfied; and (3) enable the Settlement to be implemented in coordination with other ongoing and future actions outside the Settlement that could address channel capacity issues identified in the Settlement or the SJRRP or other programs. Reclamation will implement the following three integrated measures that collectively minimize increases in flood risk as a result of Interim and Restoration Flow during the Settlement implementation: (1) establish a channel conveyance advisory group and determine and update estimates of then-existing channel capacities as needed; (2) maintain Interim and Restoration Flows below estimates of then-existing channel capacities; (3) closely monitor erosion and perform maintenance and/or reduce Interim and Restoration Flow as necessary to avoid erosion-related impacts. Refer to the SJRRP BA pg. 3-17 to 3-20 for a detailed discussion of these three measures.

The levee design criteria developed by the U.S Army Corps of Engineers (USACE) will be applied throughout the restoration area to identify the Interim and Restoration Flows that will not cause the “Factor of Safety” to be reduced below 1.4, a requirement of all federally authorized flood control projects. The Factor of Safety is equivalent to one over the exit gradient, as measured at the toe of the levee. Reclamation will limit Interim and Restoration Flows to levels that correspond to the Factor of Safety. Ongoing monitoring at potential erosion sites will indicate increased flood risks due to erosion, seepage, boils, impaired emergency levee access. This will trigger an immediate reduction, redirection, or re-diversion of Interim and Restoration Flows.

b. *Reoperate Downstream Flow Control Structures*

In order to route Interim and Restoration Flows through the restoration area, Reclamation proposes to reoperate the Lower San Joaquin River Flood Control Project and the Hills Ferry Barrier. This reoperation does not involve physical, construction related activities to modify channels.

The Chowchilla Bypass Bifurcation Structure regulates flow into the Chowchilla Bypass on one side of the structure at the entrance to the Chowchilla Bypass and into the San Joaquin River Reach 2B through a series of radial gates. The San Joaquin River side of the Chowchilla Bifurcation Structure will be reoperated to convey Interim and Restoration Flows into Reach 2B. The structure is currently operated as part of the flood management system to direct flood flows and irrigation deliveries based on several factors including flows in Reach 2A, the capacity of Reach 2B, flows from the Kings River system via Fresno Slough, and water demands in Mendota Pool.

Reoperation of the San Joaquin River Headgate and the Eastside and Mariposa bypass bifurcation structures to convey flows into Reach 4B1 and Reach 4B2, respectively, are described and analyzed as program level actions.

c. *Operate and Monitor Hills Ferry Barrier*

The main purpose of the Hills Ferry Barrier (HFB) is to redirect upstream-migrating adult fall-run Chinook salmon into suitable spawning habitat in the Merced River and prevent migration into the main-stem San Joaquin River upstream, where conditions are currently considered unsuitable for Chinook salmon and steelhead. The California Department of Fish and Game (CDFG) operates the barrier under the Delta Fish Agreement with the California Department of Water Resources as a mitigation action for impacts to fish caused by water diversions at the Banks Pumping Plant. It is unclear at this time whether the operation of this barrier will continue and for how long. If the State of California determines that the barrier will no longer be utilized, Reclamation will coordinate with NMFS to determine appropriate actions related to species effects. As part of the ongoing barrier monitoring, Reclamation proposes to implement the Central Valley Steelhead Monitoring Plan (Plan) for the SJRRP, in coordination with NMFS. The purpose of this Plan is to monitor the presence of steelhead upstream of the barrier, capture and relocate observed steelhead to a location downstream of the Merced River confluence. The Plan will not be implemented during flood flows. The details of the Plan are not described here because the monitoring activities are covered under an ESA Section 10 research permit (#16608).

d. *Establish Recovered Water Account and Program*

Consistent with paragraph 16(b) of the Settlement, Reclamation will identify delivery reductions to Friant Division long-term contractors associated with the release of Interim and Restoration Flows, as part of the Recovered Water Account (RWA). Paragraph 16(d) also provides for the delivery of water during wet hydrologic conditions to Friant Division long-term contractors at a cost of $10 per acre-foot, which could affect the amount of water that is released to the San Joaquin River in excess of Restoration Flow requirements during wet periods. It is anticipated that Friant Division long-term contractors will be able to accept delivery of some Paragraph 16(b) water using existing conveyance and storage and it is expected that contractors could develop additional local conveyance and storage capacity to increase their ability to receive Paragraph 16(b) water. This action is evaluated in consideration of the range of potential changes in water diversions that could result from implementing water facility improvements in the Friant Division to increase delivery capability. Facility improvements will require separate environmental analysis and are not included as part of this action. Reclamation is currently working with Friant Division long-term contractors and appropriate agencies to develop procedures for implementing this program.

e. *Recapture Interim and Restoration Flows*

Reclamation proposes to recapture Interim and Restoration Flows using existing facilities in the restoration area and the Delta in the near term. Recapture opportunities in the San Joaquin River downstream of the restoration area may be considered in the future, so are not included here as a project-level action.

Reclamation proposes to recapture up to the quantity of Interim and Restoration Flows (556 thousand acre feet (TAF)) within the restoration area using existing facilities. The actual quantity of recaptured water will likely be less than 556 TAF during the period when only 1,660 cfs can be released from Friant Dam. Paragraph 16(a)(1) of the Settlement provides that recapture and recirculation of Interim and Restoration Flows "shall have no adverse impact on the restoration goal, downstream water quality, or fisheries." Because recapture within the restoration area could prevent the flow targets from being met, recapture within the restoration area will occur only if necessary to avoid interfering with in-channel construction activities associated with the restoration goal, or avoid potential material adverse impacts from groundwater seepage, or for other emergency actions to avoid immediate adverse impacts. Interim and Restoration Flows will be recaptured consistent with Federal, State, and local laws, and future agreements with downstream entities, and landowners. Potential locations within the restoration area for recapture include the Mendota Pool, and the East Bear Creek Unit located in Eastside Bypass Reach 3. Recapture activities will fall within the current operational requirements at each diversion. Any increase in recapture in the restoration area or the Delta will be available for recirculation to the Friant Division contingent on subsequent exchange contracts.

Interim and Restoration Flows could be diverted from Mendota Pool replacing CVP water supplies that will otherwise be delivered via the Delta Mendota Canal making the CVP water available for delivery to the Friant Division. Delta exports will not change from existing conditions. If considerations in Reach 5 or in downstream reaches require that less flow enters those reaches, Interim and Restoration Flows could be diverted to the East Bear Creek Unit in Eastside Bypass Reach 3. This facility has a pump lift station with a 60 cfs capacity and is unscreened.

Interim and Restoration Flows reaching the Delta will be recaptured at the existing Jones and Banks pumping facilities within the Delta consistent with applicable laws, regulations, BOs, and court orders in place at the time the water is recaptured. Any increase in Delta water exports under this action will not require or imply a change in export rules.

f. Recirculate Recaptured Interim and Restoration Flows

Reclamation proposes to recirculate up to the full amount of recaptured Interim and Restoration Flows (1,660 cfs) to the Friant Division to minimize water supply impacts to Friant Division long-term contractors as stipulated in the Settlement. Water recaptured and recirculated to the Friant Division in this manner will require exchange agreements; the details negotiated between affected parties. Any mutual agreements negotiated to facilitate delivery of water to Friant Division contractors using CVP/SWP facilities will be negotiated so as not to impact CVP/SWP deliveries or operation of the CVP/SWP deliveries or operations of the CVP/SWP. Agreements could detail the use of the water to either: (1) bank, store, or exchange water for future use to supplement future Restoration Flows or; (2) transfer or sell such water and deposit proceeds of such transfer or sale into the restoration fund created by this Settlement. Paragraph 13(i) also specifies the release of water from Friant Dam during times of the year other than those specified in the applicable hydrograph.

<u>2. Program-level actions</u>

a. *Reoperate Friant Dam*

Operations at Friant Dam will continue for the life of the SJRRP to release Interim and Restoration Flows to the San Joaquin River, according to the six flow schedules specified in Exhibit B of the Settlement as described and analyzed under project-level actions. Water releases up to 1,660 cfs are described and analyzed under project-level actions. Because of the uncertainties regarding river conditions, the use of the restoration area by steelhead, and what level of flow will be released, flows above 1,660 cfs up to 4,500 cfs will be analyzed under separate consultation(s).

b. *Reoperate Downstream Flow Control Structures*

The San Joaquin River Headgate Structure will be reoperated to convey Restoration Flows into Reach 4B1. Because the current capacity of Reach 4B1 is unknown and could be as low as zero in some locations, the San Joaquin River Headgate Structure, as part of the flood management system, is maintained in a closed position whereby all flows are routed into the bypass system. The San Joaquin River Headgate Structure will be operated to release Interim and Restoration Flows up to 475 cfs into Reach 4B1 after completion of both modifications to Reach 4B1 (to provide for increased capacity) and to the headgate structure are complete. The remaining Interim and Restoration Flows will be conveyed through the Eastside and Mariposa bypasses. The specifics of this action will be further developed during the planning process for the Reach 4B project.

b. *Recapture Interim and Restoration Flows*

Reclamation proposes to recapture Interim and Restoration Flows within the restoration area, downstream of the Merced River on the San Joaquin River and in the Delta. Recapture within the restoration area and Delta are described and analyzed as project-level actions. Recapture within the San Joaquin River downstream of the Merced River confluence will occur at existing CVP-contractor facilities with potential in-district modifications and new infrastructure. All of the CVP-contractor facilities in this area have existing or planned fish screens on the diversion. Recapture could also occur through building new pumping facilities to increase pumping capacity. The existing facilities that may be utilized have not been identified and the exact the location of any potential new pumping facilities have not been identified.

c. *Recirculate Recaptured Interim and Restoration Flows*

Reclamation proposes to recirculate up to the full amount of recaptured Interim and Restoration Flows (4,500 cfs) to the Friant Division to minimize water supply impacts to Friant Division long-term contractors as stipulated in the Settlement. Water recaptured and recirculated to the Friant Division in this manner will require exchange agreements; the details negotiated between affected parties. Any mutual agreements negotiated to facilitate delivery of water to Friant Division contractors using CVP/SWP facilities will be negotiated so as not to impact CVP/SWP deliveries or operation of the CVP/SWP deliveries or operations of the CVP/SWP. Agreements could detail the use of the water to either: (1) bank, store, or exchange water for future use to supplement future Restoration Flows or; (2) transfer or sell such water and deposit proceeds of such transfer or sale into the restoration fund created by this Settlement. Paragraph 13(i) also specifies the release of water from Friant Dam during times of the year other than those specified in the applicable hydrograph.

d. Common Restoration Actions

Common restoration actions will be evaluated at a program level and include actions stipulated in Paragraph 11 and 14 of the Settlement, as well as additional structural or channel improvement that may further the success of achieving the restoration goal.

Paragraph 11(a) Common Phase 1 Actions include two phases of channel modifications. Phase 1 actions are considered the highest priority channel improvements. Two potential actions will be further evaluated to determine their necessity: (1) modifications to the San Joaquin River Headgate Structure at the head of Reach 4B1; and (2) modifications in the Eastside and Mariposa bypasses to provide fish passage under low flows.

Paragraph 11(a)(1) of the Settlement stipulates the creation of a bypass channel around Mendota Pool to convey at least 4,500 cfs from Reach 2B downstream to Reach 3. Paragraph 11(a)(2) of the Settlement stipulates modification in channel capacity, and incorporation of new floodplain habitat and related riparian habitat, to convey at least 4,500 cfs between Chowchilla Bypass Bifurcation Structure and the new Mendota Pool Bypass. Constructing the Mendota Pool Bypass includes building a bypass around the Mendota Pool to convey at least 4,500 cfs from Reach 2B to Reach 3 downstream from Mendota Dam. This also includes constructing a bifurcation structure that will include a fish screen or other positive fish barrier to direct fish into the bypass channel and away from the Mendota Pool. The Mendota Pool Bypass will include one or more grade control structures to control bedform and create stable and suitable habitat conditions for fish.

Modifying Reach 2B to convey at least 4,500 cfs includes expanding the capacity with integrated floodplain habitat. New levees will be constructed, potentially along either or both sides of Reach 2B, to create average floodplain widths of between 500 feet and 3,700 feet and associated levee width of between 700 feet and 3,900 feet and levee heights of an average 4 to 5 feet. Specific levee alignments and floodplain configurations will be determined though a separate, project-specific study that consider many factors. The San Mateo Road, which crosses the river in Reach 2B, may cause backwater effects and downstream scour, and may act as a barrier to upstream anadromous fish migration during low flows. Subsequent, project-specific technical studies of this crossing will identify the necessary modifications for fish passage. Flood flows from the James Bypass and water deliveries to Mendota Pool could reduce the ability to convey 4,500 cfs of Restoration Flows.

Modifications that occur to Reach 4B1 to convey 475 cfs will not include "substantial" construction, as per the Settlement. These modifications are anticipated to include removing in-channel vegetation and modifying road crossings but not changes to existing levees. Modifying Reach 4B1 could also include modifications to establish a low-flow channel to support fish migration, ranging from a single channel to several terraced channels to convey up to 475 cfs. Five road crossings in this reach could require modifications to convey 475 cfs and/or to provide fish passage: Washington Road, Turner Island Road and three unnamed crossings. These modifications could include installing culverts, restructuring the channel, and/or constructing clear span bridges. Each structure will be further evaluated and the necessary modification evaluated for impacts in a subsequent consultation.

Modifications will be made to the San Joaquin River Headgate to enable fish passage and flow routing between 500 and 4,500 cfs into Reach 4B1 as consistent with the decision on whether to route 4,500 cfs through Reach 4B1. As this structure consists of one slide gate, modifications to accommodate any range of flows will likely involve complete removal and replacement of this structure.

Because the Sand Slough Control Structure likely presents a barrier to upstream migrating adult salmonids, Paragraph 11(a)(5) stipulates that modifications be made to the structure to allow fish passage. The structure currently acts like a broad-crested weir with six rectangular openings and a concrete flume on the downstream side of the structure. Each opening is designed to accommodate a slide gate or stop logs. Modification could include removing the existing flume and replacing it with a gated structure. Modifications will be designed to not adversely affect flood conveyance capacity or functionality of the existing structure.

Paragraph 11(a)(6) and 11(a)(7) of the Settlement includes modifications to Arroyo Canal to prevent entrainment of anadromous fish and modifications at Sack Dam for fish passage. This action could include installation of a screen operating up to 4,500 cfs diversion to prevent entrainment into Arroyo Canal and construction of a fish ladder at Sack Dam (which is a fish barrier under most flow conditions) to facilitate flow and fish passage for a range of flows up to 4,500 cfs.

Pursuant to Paragraph 11(a)(8) of the Settlement, modifications to structures in the Eastside and Mariposa bypass channels will provide anadromous fish passage on an interim basis until completion of Phase 2 actions described below. Pursuant to Paragraph 11(a)(9) of the Settlement, the Eastside and Mariposa bypass channels will be modified to establish a suitable low-flow channel if the Secretary in consultation with the RA determines that such modifications are necessary to support anadromous fish migration through these channels. Potential actions include: no modifications to the bypass channels; modifications to develop a single low-flow channel to convey at least 475 cfs; a series of terraced channels to convey incremental low flows up to 475 cfs in conjunction with either modifying the Mariposa Bypass Bifurcation Structure for a range of flows up to 4,500 cfs; and constructing a fish ladder at the Mariposa Bypass Drop Structure to allow upstream and downstream fish passage a range of flows up to 4,500 cfs or removing the structure. Modifications will allow the structures to handle 8,000 cfs while not increasing upstream water levels from existing conditions.

Modifications to Mud and Salt sloughs will be made to enable the deployment of barriers at these sloughs to prevent adult salmonids from entering these potentially false migration pathways, consistent with Paragraph 11(a)(10) of the Settlement. The specific plans for these modifications are not yet available.

Paragraph 11(b) Phase 2 Common Actions involve improving conditions for fish at the Chowchilla Bypass Bifurcation Structure and gravel pits.

Modifications to Chowchilla Bypass Bifurcation Structure to provide fish passage and prevent fish entrainment will be made if deemed necessary to achieve the restoration goal by the Secretary, the RA, NMFS, and USFWS, pursuant to 11(b)(2) of the Settlement. In addition, gaps present in the structure may allow fish to pass through the structure and become stranded in the bypass. This may be rectified in one of the following ways: no modifications; monitoring and management of fish stranding under flood conditions; evaluating ranges of flows for screening the Chowchilla Bypass to prevent fish from entering the bypass; and retrofitting the gates to prevent fish from passing through gaps and/or adding additional screened gate to the structure. Modifications to the structure will not adversely affect the flood conveyance capacity or functionality of the existing structure.

Paragraph 11(b)(3) of the Settlement stipulates filling or isolating the highest priority gravel pits in Reach 1 based on their relative potential for reducing juvenile salmon mortality, as determined by the Secretary in consultation with the RA. A project specific technical study will be conducted to identify the highest priority pits and then an appropriate action within the following range of actions will be implemented: no modifications; filling or isolating some or all pits; and regrading the floodplain to fill pits. Modifications to gravel pits could be implemented in connection with other restoration actions.

Paragraph 12 Common Actions involve additional structural or channel improvements that may be undertaken if these actions further enhance the success of achieving the restoration goal.

Depending on whether spawning gravel is necessary, the range of potential actions include: no action; augmenting and/or conditioning gravel with clean, spawning-sized gravel at existing riffles in Reach 1; or establishing new riffles to increase and enhance salmonid spawning habitat in Reach 1.

The range of potential actions to reduce redd superimposition or hybridization includes: no modifications; the deployment of seasonal barriers to separate runs of salmon; and also could include potential operations and monitoring of the Hills Ferry Barrier on a seasonal basis. The location and design of barriers has yet to be determined. The current evaluation of spawning and holding habitat availability and quality will guide this decision.

Additional actions could be necessary to supplement the naturally reproducing salmon population, particularly in years following salmon reintroduction. The range of potential actions to supplement the Chinook salmon population could include: no supplementation; the release of hatchery fish to supplement the natural population for monitoring and management of the natural population; and/or release of hatchery fish to supplement the natural population when natural production is low such as during Critical-Low and Critical-High water year types when spring flows are absent or inadequate to sustain the Chinook salmon populations.

It could be necessary to modify floodplain or side-channel habitat beyond Reaches 2B or 4B1 to benefit migrating Chinook salmon and other native fishes by providing additional food sources, increased protection from predators, and other habitat improvements. The range of actions could be: no modifications; creating and/or enhancing additional floodplain habitat outside Reaches 2B or 4B1; creating, enhancing, or isolating side channels by dredging or widening channels; and filling or berming to provide suitable rearing habitat for juvenile Chinook salmon or serve as holding habitat for adult Chinook salmon and/or reduce sand transport. The quantity of sand in Reaches 1 and 2 may cause channel stability and facilities problems if mobilized into lower reaches. Control of sediment at tributary sources could include settling basins, bed stabilization (such as floodplain widening to reduce sediment transport potential) in areas where the bed is degrading, and bank stabilization in meandering reaches. In channel sediment could be removed periodically with dredging or creating instream sediment detention basins, with sand being removed from the traps periodically.

Enhancing in-channel habitat will incorporate channel modifications to provide salmon habitat including instream cover such as undercut banks, overhanging vegetation, boulders, large wood, surface turbulence, and features providing refuge from predation. Enhancing in-channel habitat could also include modifications such as construction of pools or dredging and grading to develop or maintain cooler water temperatures. Reducing the potential for aquatic predation of juvenile salmonids could include capturing and removing nonnative aquatic predatory fish species.

The Settlement does not stipulate the screening of small diversions within the restoration area but screening could be beneficial to prevent the entrainment of juvenile salmonids. This action could include not screening diversions, or installing or modifying screens at small diversions throughout the restoration area. The need and extent of screening will be determined though future studies based on the relative impacts of individual diversions to fish.

There may be some obstacles to successful fish migration beyond those specified in the Settlement, such as hydraulic conditions at road crossings, small tributaries unsuitable for spawning, hydraulic conditions in the river at low flows and other river physical features. Actions to improve these conditions could include: no action; establishing and/or maintaining low-flow channels in other areas of the river not including the Eastside and Mariposa bypasses and Reach 4B1 through invasive vegetation management; removing sand by dredging; maintaining bed and bank stability; trapping (passive or active) and hauling juveniles in Reach 1 and 2 to bypass potential entrainment or poor conditions such as high temperatures or discontinuous flow; and trapping and hauling adults to bypass intermediate reaches where migration conditions are not suitable; modifying road crossings by installing culverts; restructuring the channel and/or constructing clear span bridges; and installing temporary or permanent barriers to prevent straying into tributaries, flood bypasses, or river reaches with undesirable habitat conditions.

Additional actions not specifically identified in the Settlement could be necessary to improve fish passage and flow conveyance at flood control structures, including the Chowchilla Bypass Bifurcation Structure, the Sand Slough Control Structure and structures in the Eastside and Mariposa bypasses. Actions to improve these structures could include: no modifications; retrofitting gates at flood control structures to prevent flow loss; and/or installing grade control structures to address backwater effects of the Chowchilla Bypass Bifurcation Structure, which may be contributing to the accumulation of Reach 2A and if mobilized could compromise the ability to convey Interim and Restoration Flows.

Paragraph 14 of the Settlement addresses reintroducing spring-run and fall-run Chinook salmon between Friant Dam and the confluence of the San Joaquin River with the Merced River by December 31, 2012. If introducing both runs is not possible then priority will be given to spring-run. The Secretary, through the U.S. Fish and Wildlife Service (USFWS), and in consultation with the Secretary of Commerce, CDFG and the RA, will reintroduce spring-run and fall-run Chinook salmon "at the earliest practical date after commencement of sufficient flows and the issuance of necessary permits". To help facilitate reintroduction of salmon, a management plan has been developed to help guide implementation of reintroduction actions. The range of potential actions for Chinook salmon reintroduction spans from reintroducing only spring-run Chinook salmon to reintroducing both spring-run and fall-run Chinook salmon, and could include more than one life stage. Potential broodstock have been identified and ideally broodstock will be acquired from a variety of sources.

Propagation and management of the broodstock and fish for direct reintroduction could be done in the existing San Joaquin hatchery, another existing hatchery or a new conservation facility. An interim facility is currently operational at the San Joaquin hatchery site and a new conservation facility is in the planning and design phase. A new conservation facility could potentially provide for initial reintroduction of spring-run and fall-run Chinook salmon and/or other native fishes and could be used to supplement the wild population until the fish population is reestablished, at which time the conservation facility could be phased out of use. The restoration goal and Paragraph 14 of the Settlement emphasize the need to restore self-sustaining fish populations. Therefore, conservation facility populations alone will not fulfill the restoration goal, and naturally reproducing individuals will need to be distinguished from hatchery or conservation-facility produced individuals.

The specifics of spring-run Chinook salmon reintroduction will undergo separate ESA consultation through the evaluation of the USFWS 10(A)1(a) enhancement of the species permit application. Additional evaluation regarding the reintroduction of fall-run Chinook salmon is underway but not covered under this consultation.

Monitoring is essential to Chinook salmon reintroduction as well as to evaluate whether the restoration goal is being achieved. Monitoring and management guidelines related to biological conditions for fish are separately described in Appendix E, "Fisheries Management Plan," of the Draft PEIS/R (Reclamation and DWR 2011). Fisheries monitoring, which is currently ongoing, is developed by the Fisheries Management Workgroup on an annual basis and integrated into the annual Monitoring and Analysis Plan process. Current activities include monitoring for: temperature; the effectiveness of Hills Ferry Barrier; egg survival; gravel mobility; juvenile survival; captive rearing techniques; adult passage; ecosystem modeling; and assessment of existing fish community within the restoration area. Specific fisheries monitoring activities are not proposed for this consultation and will be covered for ESA purposes through different avenues such as 4(d) and 10(A)1(a) research and recovery permits.

3. <u>Physical Monitoring and Management Plan</u>

The Physical Monitoring and Management Plan provides guidelines for observing and adjusting to changes in physical conditions within the restoration area and consists of five component plans: (1) flow – to ensure compliance with the hydrograph releases in Exhibit B of the Settlement and any other applicable flow releases (*e.g.* Buffer flows); (2) groundwater seepage – reduce or avoid adverse or undesirable seepage impacts; (3) channel capacity – maintain flood conveyance capacity; (4) propagation of native vegetation – establish and maintain native riparian habitat; and (5) suitability of spawning gravel – maintain gravels for Chinook salmon spawning. The plan includes monitoring activities and a set of immediate (project level) and long-term (program level) responses that will be implemented as needed to attain management objectives.

Monitoring will involve the following: (1) Flow – flow, cross sections, and surface water stage at six gaging stations and at additional locations during high-flow events; (2) Groundwater level monitoring – groundwater elevation in monitoring wells; (3) Aerial and topographic surveys – true color aerial photographs and topographic surveys to assess river stage, hydraulic roughness, river width, bed elevation, and vegetation conditions; (4) Vegetation surveys – surveys the seed dispersal start and peak times, and native riparian vegetation establishment; (5) Sediment mobilization monitoring – sediment mobilization, bar formation, and bank erosion through aerial and topographic surveys or areas with elevated erosion potential; and (6) Spawning gravel – pebble count or photographic surveys of riffles following Normal-Wet or Wet water year types.

Immediate Management Actions (Project-level) could occur to address seepage, channel capacity, or spawning gravel conditions. The actions that could be taken to address seepage are: (1) reductions of Interim or Restoration Flow releases at Friant Dam to limit potential for seepage impacts to occur downstream; (2) redirection of Interim or Restoration Flows into the bypass system at the Chowchilla Bypass Bifurcation Structure, which will reduce flows in Reach 2B and downstream reaches; (3) delivery of Interim and Restoration Flows at Mendota Pool which will reduce flows in Reach 3 and downstream reaches; (4) delivery of Interim and Restoration Flows at Arroyo Canal when not operating at full capacity to reduce flows in Reach 4A and downstream reaches; and (5) redirection of Interim and Restoration Flows at Sand Slough Control Structure into the bypasses to reduce flows in Reach 4B. Actions to address channel capacity could involve the removal of vegetation (mechanical or chemical means) and debris that will cause Interim or Restoration Flows to exceed channel capacity. Actions to address spawning gravel could involve modifications to releases from Friant Dam to flush or mobilize gravels based on monitoring and recommendations.

Long-term Management Actions (Program-level) could occur to address flow, seepage, channel capacity, native vegetation, and spawning gravel. Paragraph 13(c) of the Settlement provides for adjusting releases due to unexpected seepage losses. These actions could include but will not be limited to acquisition and release of purchased water from willing sellers. The procedures for purchasing and releasing additional water are under development and will be detailed in the Restoration Flow Guidelines, a document that will be attached to the Friant Dam operation guidelines. Long-term management actions for seepage may include, but will not be limited to purchasing easements and/or compensation for seepage effects, construction of slurry walls to reduce seepage flows, construction of seepage berms to protect affected lands, or installation of tile drains on affected lands. Long-term management actions for channel capacity may include, but will not be limited to providing a larger floodplain between levees through the acquisition of land and construction of setback levees, regrading of land between levees, construction of sediment traps, construction of grade control structures, or channel grading. Long-term management actions for native vegetation may include, but will not be limited to active plantings and irrigation of desired native plants. Long-term management actions for spawning gravel may include, but will not be limited to gravel augmentation and/or conditions at existing riffles, establishment of new riffles, engineered channel modifications, construction of sediment traps on the San Joaquin River or tributaries with high sediment loads, or construction of grade control structures.

C. Conservation Measures

Reclamation has indicated that they believe this action will not result in incidental take of listed salmonids and green sturgeon. Reclamation has proposed a conservation strategy for the SJRRP that will reduce and minimize impacts to covered species and their habitats. The conservation strategy focuses on: (1) conserving riparian vegetation and waters of the United States, including wetlands; (2) controlling and managing invasive species; and (3) conserving special-status species and their habitats. Specific measures of the strategy are:

(1) Riparian habitat and other sensitive natural communities:

RHSNC-1 – Avoid and minimize loss of riparian habitat and other sensitive natural communities: Biological surveys will be conducted to identify, map, and quantify riparian and other sensitive habitats in potential construction areas; construction activities will be avoided in areas containing sensitive natural communities, as appropriate; if effects occur to riparian habitat, emergent wetland, or other natural communities associated with streams, the State lead agency will comply with Section 1602 of the CDFG code; compliance may include measures to protect fish and wildlife resources during the project.

RHSNC-2 – Compensate for loss of riparian habitat and other sensitive natural communities: The Riparian Habitat Mitigation and Monitoring Plan for the SJRRP will be developed and implemented in coordination with CDFG. Credits for increased acreage or improved ecological function of riparian and wetland resulting from the implementation of the SJRRP actions will be applied as compensatory mitigation before additional compensatory measures are required; if losses of other sensitive communities will not be offset by the benefits of the SJRRP, then additional compensation will be provided through creating, restoring, or preserving in perpetuity in-kind communities at a sufficient ratio for no net loss of habitat function or acreage; the appropriate ratio will be determined in consultation with USFWS, NMFS, and/or CDFG, depending on agency jurisdiction.

(2) Waters of the United States/waters of the State:

WUS-1 – Identify and quantify wetlands and other waters of the United States: Before SJRRP actions may affect waters of the United States or waters of the State, Reclamation will map the distribution of wetlands (including vernal pools and other seasonal wetlands) in the Eastside and Mariposa bypasses; the project proponent will determine, based on the mapped distribution of these wetlands and hydraulic modeling and field observation, the acreage of effects, if any, on waters of the United States; if it is determined that vernal pools or other seasonal wetlands will be affected by the SJRRP, the project proponent will conduct delineations of waters of the United States, and submit the delineation to USACE for verification; construction and modification of road crossings, control structures, fish barriers, fish passages, and other structures will be designed to minimize effects on waters of the United States and waters of the State; and projects will employ Best Management Practices (BMPs) to avoid direct and indirect effects on water quality.

WUS-2 – Obtain permits and compensate for any loss of wetlands and other waters of the United States/waters of the State: The project proponent, in coordination with USACE, will determine the acreage of effects on waters of the United States and waters of the State that will result from implementation of the SJRRP; the project proponent will adhere to a "no net loss" basis for the acreage of wetlands and other waters of the State that will be removed and/or degraded; wetland habitat will be restored, enhanced, and/or replaced at acreages and locations and by methods agreed to by the USACE, the Central Valley Regional Water Quality Control Board, and CDFG, as appropriate, depending on agency jurisdiction; the project proponent will obtain Section 404 and Section 401 permits and comply with all permit terms; the acreage, location, and methods for compensation will be determined through the Section 401 and Section 404 permitting process; and the compensation will be consistent with recommendations in the Fish and Wildlife Coordination Act report.

(3) Southern DPS of North American green sturgeon:

GS-1 – Avoid and minimize loss of habitat and individuals: The SJRRP will be operated in such a way that actions within green sturgeon habitat shall be done in accordance with existing operating criteria of the CVP and SWP, and prevailing and relevant laws, regulations, BOs, and court orders in place when the action(s) are performed.

(4) California Central Valley steelhead:

CVS-1 – Avoid loss of habitat and risk of take of species: (a) impacts to habitat conditions (*i.e.*, changes in flows potentially resulting in decreased flows in the tributaries, increases in temperature, increases in pollutant concentration, change in recirculation/recapture rates and methods, decrease in floodplain connectivity, removal of riparian vegetation, decrease in quality rearing habitat, *etc*.) must be analyzed in consultation with NMFS; (b) the Hills Ferry Barrier will be operated and maintained to exclude CCV steelhead from the restoration area during construction activities and until suitable habitat conditions are restored; (c) maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive; (d) before implementation of site-specific actions, the action agency shall conduct an education program for all agency and contracted employees relative to the federally listed species that may be encountered within the study area if the action, and required practices for their avoidance and protection; a NMFS-appointed representative shall be identified to employees and contractors to ensure that questions regarding avoidance and protection measures are addressed in a timely manner; (e) disturbance of riparian vegetation will be avoided to the greatest extent possible; (f) a spill prevention plan will be prepared describing measures to be taken to minimize the risk of fluids or other materials used during construction (*e.g.*, oils, transmission and hydraulic fluids, cement, fuel) from entering the San Joaquin River or contaminating riparian areas adjacent to the river itself; in addition to a spill prevention plan, a cleanup protocol will be developed before construction begins and shall be implemented in case of a spill; (g) stockpiling of materials, including portable equipment, vehicles and supplies, such as chemicals, shall be restricted to the designated construction staging areas, exclusive of any riparian and wetland areas; (h) a qualified biological monitor will be present during all construction activities, including clearing, grubbing, pruning, and trimming of vegetation at each job site during construction initiation, midway through construction, and at the close of construction, to monitor implementation of conservation measures and water quality; and (i) the San Joaquin River channel shall be designed to decrease or eliminate predator holding habitat, in coordination with NMFS.

CVS-2 – Minimize loss of habitat and risk of take of species: (a) in-channel construction activities that could affect designated critical habitat for CCV steelhead will be limited to the low-flow period between June 1 and October 1 to minimize potential for adversely affecting federally listed anadromous salmonids during their emigration period; (b) in-channel construction activities that could affect designated critical habitat for CCV steelhead will be limited to daylight hours during weekdays, leaving a nighttime and weekend period of passage for federally listed fish species; (c) construction BMPs for off-channel staging, and storage of equipment and vehicles, will be implemented to minimize the risk of contaminating the waters of the San Joaquin River by pilled materials; BMPs will also include minimization of erosion and stormwater runoff, as appropriate; (d) riparian vegetation removed or damaged will be replaced at a ratio, coordinated with NMFS, within the immediate area of the disturbance to maintain habitat quality; (e) if individuals of listed species are observed present within a project area, NMFS must be notified; NMFS personnel shall have access to construction sites during construction, and following completion, to evaluate species presence and condition and/or habitat conditions; and (f) if bank stabilization activities are necessary, then such stabilization shall be constructed to minimize predator habitat, minimize erosion potential, and contain material suitable for supporting riparian vegetation.

(4) Sacramento River winter-run Chinook salmon:

WRCS-1 – Avoid and minimize loss of habitat and individuals: The SJRRP will be operated in such a way that actions related to the SJRRP in the vicinity of winter-run Chinook salmon habitat shall be performed in accordance with existing operating criteria of the CVP and SWP, and prevailing and relevant laws, regulations, BOs, and court orders in place at the time the actions are performed.

(5) Central Valley spring-run Chinook salmon:

SRCS-1 – Avoid and minimize loss of habitat and individuals: (a) the SJRRP will be operated in such a way that actions in the vicinity of spring-run Chinook salmon habitat shall be done in accordance with existing operating criteria of the CVP and SWP, and prevailing and relevant laws, regulations, BOs, and court orders in place at the time the actions are performed; and (b) SJRRP actions shall be performed in accordance with the Experimental Population 10(j) and 4(d) rules, as they are developed, and where applicable.

D. Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area, for the purposes of this BO, encompasses the lands and waterways of the southern Sacramento-San Joaquin Delta, the San Joaquin River from its mouth to Friant Dam, the Stanislaus River (mouth to Goodwin Dam), the Tuolumne River (mouth to La Grange Dam), and the Merced River (mouth to Crocker-Huffman Dam). Major waterways within the south Delta include the San Joaquin River, Old River, Middle River, Woodward and North Victoria canals, Grant Line and Fabian canals, Italian Slough, Tom Paine Slough and the adjoining canals of the CVP and SWP.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following federally listed species ESUs and DPSs and designated critical habitat occur in the action area and may be affected by the proposed SJRRP:

Sacramento River winter-run Chinook salmon ESU
Endangered (June 28, 2005, 70 FR 37160)

Sacramento River winter-run Chinook salmon designated critical habitat
(June 16, 1993, 58 FR 33212)

Central Valley spring-run Chinook salmon ESU
Threatened (June 28, 2005, 70 FR 37160)

California Central Valley steelhead DPS
Threatened (January 5, 2006, 71 FR 834)

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

Southern DPS of North American green sturgeon
Threatened (April 7, 2006, 71 FR 17757)

Southern DPS of North American green sturgeon designated critical habitat
(October 9, 2009, 74 FR 52300)

A. Species and Critical Habitat Listing Status

In 2005, NMFS conducted its status review of 16 salmon ESUs, including SR winter-run Chinook salmon and CV spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (70 FR 37160, June 28, 2005). On January 5, 2006, NMFS published a final listing determination for 10 steelhead DPSs, including CCV steelhead. This listing concluded that CCV steelhead remain listed as threatened (71 FR 834). The status of the species was updated again on August 15, 2011, (FR 50447) with publication in the Federal Register of the availability of the 5-year status reviews for 5 ESUs of Pacific salmon and 1 DPS of steelhead in California, including the SR winter-run Chinook salmon and CV spring-run Chinook salmon, and the CCV steelhead. The status review determined that the status of winter-run Chinook salmon should remain as endangered, and that similarly, the status of CV spring-run Chinook salmon and CCV steelhead should remain as threatened. The 2011 review indicated that although the listings remained unchanged since the 2005 and 2006 reviews for SR winter-run and CV spring-run Chinook salmon and CCV steelhead, the status of these populations of salmonids has worsened over the past 5 years since the 2005/2006 reviews.

SR winter-run Chinook salmon were originally listed as threatened by an emergency interim rule, which was published on August 4, 1989 (54 FR 32085). A new emergency interim rule was published on April 2, 1990 (55 FR 12191). A final rule listing SR winter-run Chinook salmon as threatened was published on November 5, 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper SR in California's Central Valley. The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. The Livingston Stone National Fish Hatchery (LSNFH) population has been included in the listed SR winter-run Chinook salmon population (70 FR 37160, June 28, 2005). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at river mile (RM) 302 to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. Critical habitat for SR winter-run Chinook salmon occurs within the action area as part of the south Delta.

CV spring-run Chinook salmon were listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent modification of the CV spring-run Chinook salmon listing status (70 FR 37160, June 28, 2005). Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). It includes stream reaches of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the main stem of the Sacramento River from Keswick Dam through the Delta; and portions of the network of channels in the northern Delta. Critical habitat for CV spring-run Chinook salmon does not include the south Delta and does not occur in the action area for the proposed SJRRP.

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 CCV steelhead status as threatened and also listed several 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 2011a). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches of the American, Feather, and Yuba rivers, and Deer, Mill, Battle, Antelope, and Clear creeks in the Sacramento River basin; the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers in the San Joaquin River basin; and the Sacramento and San Joaquin rivers and Delta. Currently the CCV steelhead DPS and critical habitat extends up the SJR up to the confluence with the Merced River.

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006 (71 FR 17757). The Southern DPS presently contains only a single spawning population in the Sacramento River, and rearing individuals may occur within the action area. Critical habitat was designated for the Southern DPS of green sturgeon on October 9, 2009 (74 FR 52300). Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line except for certain excluded areas. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, and the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery. Coastal Marine areas include waters out to a depth of 60 meters from Monterey Bay, California, to the Juan De Fuca Straits in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for Southern DPS green sturgeon. Designated critical habitat for the Southern DPS of green sturgeon occurs within the action area of the SJRRP.

B. Species Life History and Population Dynamics

1. <u>Chinook Salmon</u>

a. *General Life History*

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon can exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in the fall, and some of the juveniles may spend a year or more in freshwater before emigrating. The remaining fraction of the juvenile spring-run population may also emigrate to the ocean as young-of-the-year in spring. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only four to seven months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

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

During their upstream migration, adult Chinook salmon require 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 65ºF for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70ºF, and that fish can become stressed as temperatures approach 70ºF. Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60ºF, though salmon can tolerate temperatures up to 65ºF before they experience an increased susceptibility to disease (Williams 2006).

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

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

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

During the four to six 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 post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small aquatic 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 are displaced downstream by the stream’s current. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991). Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996a). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). When juvenile Chinook salmon reach a length of 50 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 channel 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 (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of maturation (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depicts that 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, presumably dependent on the physiological stage of the juvenile and ambient 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 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1982).

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). 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). 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). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54ºF to 57ºF (Brett 1952). In Suisun and San Pablo Bays water temperatures can reach 54ºF by February in a typical year. Other portions of the Delta (*i.e.*, south Delta and central Delta) can reach 70ºF by February in a dry year. However, cooler temperatures are usually typical until after the spring runoff has ended.

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

b. *Sacramento River Winter-run Chinook Salmon*

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

Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past the RBDD from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (see Table 1 in text; Yoshiyama *et al*. 1998, Moyle 2002). Spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick Dam and RBDD (Vogel and Marine 1991). The majority of SR winter-run Chinook salmon spawners are three years old.

Table 2. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

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

KL = Knights Landing

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

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

SR winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994). Emigration of juvenile SR winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). Juvenile SR winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57; USFWS 2001a,b).

The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 millimeters (mm) and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continue through May (Fisher 1994, Myers *et al.* 1998).

Historical SR winter-run Chinook salmon population estimates, which included males and females, were as high as near 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,869), 2005 (15,875) and 2006 (17,304) show a recent increase in the population size (CDFG GrandTab 2011) and a 4-year average of 12,316 (see Table 3 in text and Appendix B: Figure 3). The 2006 run was the highest since the 1994 listing. Abundance measures over the last decade suggest that the abundance was initially increasing (Good *et al*. 2005). However, escapement estimates for 2007, 2008, 2009, and 2010 show a precipitous decline in escapement numbers based on redd counts and carcass counts. Estimates place the adult escapement numbers for 2007 at 2,542 fish, 2,830 fish for 2008, and 4,658 fish for 2009 (CDFG Grand Tab 2011) and 1,596 fish for 2010 (NMFS 2011b[JPE letter]).

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

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends (excluding the 2007-2010 escapement numbers). An age-structured density-independent model of spawning escapement by Botsford and Brittnacker (1998 as referenced in Good *et al*. 2005) assessing the viability of SR winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley *et al*. (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the SR winter-run Chinook salmon population had been improving until as recently as 2006, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al*. 2005). Recent population trends in the previous four years have indicated that the status of the winter-run Chinook salmon population may be changing as reflected in the diminished abundance during this period. The current winter-run Chinook salmon JPE for 2011 is only 332,012 fish entering the Delta, a substantial decline from the previous JPE values seen in the last decade.

Table 3. Winter-run Chinook salmon population estimates from RBDD counts (1986 to 2001) and carcass counts (2001 to 2006), and corresponding cohort replacement rates for the years since 1986 (CDFG Grand Tab 2011).

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated Juvenile Production Estimate (JPE)[c]
1986	2596				
1987	2185				
1988	2878				
1989	696		0.27		
1990	430	1,757	0.20		
1991	211	1,280	0.07		40,100
1992	1240	1,091	1.78		273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1297	664	1.05	0.94	338,107
1996	1337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	2992	1,338	2.31	2.48	454,792
1999	3288	1,959	2.46	2.80	289,724
2000	1352	1,970	1.54	2.90	370,221
2001	8224	3,347	2.75	2.76	1,864,802
2002	7441	4,659	2.26	2.26	2,136,747
2003	8218	5,705	6.08	3.02	1,896,649
2004	7869	6,621	0.96	2.72	881,719
2005	15839	9,518	2.13	2.84	3,556,995
2006	17296	11,333	2.10	2.71	3,890,534
2007	2542	10,353	0.32	2.32	1,100,067
2008	2830	9,275	0.18	1.14	1,152,043
2009	4537[d]	8,609	0.26	1.00	1,144,860[e]
2010	1,596	5,760	0.63	0.70	332,012
median	2,542	1970	1.29	2.29	412,507

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

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

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

[d] CDFG (2011)

[e] NMFS (2010) preliminary estimate to Reclamation

Recently, Lindley *et al.* (2007) determined that the SR winter-run Chinook salmon population that spawns below Keswick Dam is at a moderate extinction risk according to population viability analysis (PVA), and at a low risk according to other criteria (*i.e.*, population size, population decline, and the risk of wide ranging catastrophe). However, concerns of genetic introgression with hatchery populations are increasing. Hatchery-origin winter-run Chinook salmon from LSNFH have made up more than 5 percent of the natural spawning run in recent years and in 2005, it exceeded 18 percent of the natural run. If the proportion of hatchery origin fish from the LSNFH exceeded 15 percent in 2006-2007, Lindley *et al*. (2007) recommended reclassifying the winter-run Chinook population extinction risk as moderate, rather than low, based on the impacts of the hatchery fish over multiple generations of spawners. However, since 2005, the percentage of hatchery fish recovered at the LSNFH has been consistently below 15 percent. Furthermore, Lindley's assessment in 2007 did not include the recent declines in adult escapement abundance which may modify the conclusion reached in 2007.

Lindley *et al.* (2007) also states that the winter-run Chinook salmon population fails the "representation and redundancy rule" because it has only one population, and that population spawns outside of the ecoregion in which it evolved. In order to satisfy the "representation and redundancy rule," at least two populations of winter-run Chinook salmon will have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley *et al*. 2007).

Viable Salmonid Population Summary for Sacramento River Winter-run Chinook Salmon

Abundance. During the first part of this decade, redd and carcass surveys as well as fish counts, suggested that the abundance of winter-run Chinook salmon was increasing since its listing. However, the depressed 2007, 2008, 2009, and 2010 abundance estimates are an exception to this trend and may represent a combination of a new cycle of poor ocean productivity (Lindley *et al.* 2009) and recent drought conditions in the Central Valley. Population growth is estimated to be positive in the short-term trend at 0.26; however, the long-term trend is negative, averaging 0.14. Recent winter-run Chinook salmon abundance represents only 3 percent of the maximum post-1967, 5-year geometric mean, and is not yet well established (Good *et al.* 2005). The current annual and five year averaged cohort replacement rates (CRR) are both below 1.0. The annual CRR has been below 1.0 for the past four years and indicates that the winter-run population is not replacing itself.

Productivity. ESU productivity has been positive over the short term, and adult escapement and juvenile production had been increasing annually (Good *et al.* 2005) until recently, with declining escapement estimates for the years 2007 through 2010. However, the long-term trend for the ESU remains negative, as it consists of only one population that is subject to possible impacts from environmental and artificial conditions. The most recent CRR estimates suggest a reduction in productivity for the three separate cohorts.

Spatial Structure. The greatest risk factor for winter-run Chinook salmon lies with their spatial structure (Good *et al.* 2005). The remnant population cannot access historical winter-run Chinook salmon habitat and must be artificially maintained in the Sacramento River by a regulated, finite cold-water pool behind Shasta Dam. Winter-run Chinook salmon require cold water temperatures in summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek remains the most feasible opportunity for the ESU to expand its spatial structure, which currently is limited to the upper 25-mile reach of the mainstem Sacramento River below Keswick Dam. Based on Reasonable and Prudent Alternative Actions described in the 2009 CVP/SWP BO, passage of winter-run Chinook salmon above Keswick and Shasta dams is being considered as one of the actions. This will reintroduce winter-run Chinook salmon into regions they had historically occupied and significantly benefit the spatial structure of the ESU.

Diversity. The second highest risk factor for the SR winter-run Chinook salmon ESU has been the detrimental effects on its diversity. The present winter-run Chinook salmon population has resulted from the introgression of several stocks that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam and there may have been several others within the recent past (Good *et al.* 2005). Concerns of genetic introgression with hatchery populations are also increasing. Hatchery-origin winter-run Chinook salmon from LSNFH have made up more than 5 percent of the natural spawning run in recent years and in 2005, it exceeded 18 percent of the natural run. The average over the last 10 years (approximately 3 generations) has been 8 percent, still below the low-risk threshold for hatchery influence. Since 2005, the percentage of hatchery fish in the river has been consistently below 15 percent.

c. *Central Valley Spring-Run Chinook Salmon*

Historically, spring-run Chinook salmon were the second most abundant salmon run in the Central Valley (CDFG 1998). These fish occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley Technical Review Team (CVTRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations and four diversity groups (Lindley *et al.* 2004). Of these 18 populations, only three extant populations currently exist (Mill, Deer, and Butte creeks on the upper Sacramento River) and they represent only the northern Sierra Diversity group. All populations in the Basalt and Porous Lava group and the Southern Sierra Nevada Group have been extirpated.

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced rivers extirpated CV spring-run Chinook salmon from these watersheds. Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

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 between March and September, primarily in May and June (see Table 4 in text; Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2007) indicates adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid-April and mid-June. Typically, 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).

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

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 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2007). Studies in Butte Creek (Ward *et al*. 2002, 2003, McReynolds *et al*. 2005) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January, and February; and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al*. 2007).

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). The emigration period for spring-run Chinook salmon extends 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 (CDFG 1998). 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). Based on the available information, the emigration timing of CV spring-run Chinook salmon appears highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998).

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

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

Relative Abundance: [H] = High [M] = Medium [L] = Low

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

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

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon have not always been temporally separated in the hatchery, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 24,903 in 1998 (see Table 5 in text and Appendix B: Figure 4). Sacramento River tributary populations in Mill, Deer, and Butte creeks are probably the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although trends through the first half of the past decade were generally positive, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance. The past several years (since 2005) have shown declining abundance numbers in most of the tributaries. Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 70^{o}F for 10 or more days in July (reviewed by Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris Disease (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Lindley *et al*. (2007) indicated that the spring-run population of Chinook salmon in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their PVA model and the other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence). The Mill Creek population of spring-run Chinook salmon is at moderate extinction risk according to the PVA model, but appears to satisfy the other viability criteria for low-risk status. However, like the winter-run Chinook salmon population, the CV spring-run Chinook salmon population fails to meet the "representation and redundancy rule" since there is only one demonstrably viable population out of the three diversity groups that historically contained them. The spring-run population is only represented by the group that currently occurs in the northern Sierra Nevada. The spring-run Chinook salmon populations that formerly occurred in the basalt and porous-lava region and southern Sierra Nevada region have been extirpated. The northwestern California region contains a few ephemeral populations (*e.g.*, Clear, Cottonwood, and Thomes creeks) of spring-run Chinook salmon that are likely dependent on the Northern Sierra Nevada populations for their continued existence. 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 spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Table 5. Central Valley Spring-run Chinook salmon population estimates from CDFG Grand Tab (2011) 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 of 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	25,696	1,433	24,263						
1987	13,888	1,213	12,675						
1988	18,933	6,833	12,100						
1989	12,163	5,078	7,085		0.29			0.47	
1990	7,683	1,893	5,790	12,383	0.46		15,673	0.55	
1991	5,926	4,303	1,623	7,855	0.13		11,719	0.31	
1992	3,044	1,497	1,547	5,629	0.22		9,550	0.25	
1993	6,076	4,672	1,404	3,490	0.24	0.27	6,978	0.79	0.48
1994	6,187	3,641	2,546	2,582	1.57	0.52	5,783	1.04	0.59
1995	15,238	5,414	9,824	3,389	6.35	1.70	7,294	5.01	1.48
1996	9,083	6,381	2,702	3,605	1.92	2.06	7,926	1.49	1.72
1997	5,193	3,653	1,540	3,603	0.60	2.14	8,355	0.84	1.84
1998	31,649	6,746	24,903	8,303	2.53	2.60	13,470	2.08	2.09
1999	10,100	3,731	6,369	9,068	2.36	2.75	14,253	1.11	2.11
2000	9,244	3,657	5,587	8,220	3.63	2.21	13,054	1.78	1.46
2001	17,598	4,135	13,463	10,372	0.54	1.93	14,757	0.56	1.27
2002	17,419	4,189	13,230	12,710	2.08	2.23	17,202	1.72	1.45
2003	17,691	8,662	9,029	9,536	1.62	2.04	14,410	1.91	1.42
2004	13,982	4,212	9,770	10,216	0.73	1.72	15,187	0.79	1.35
2005	16,126	1,774	14,352	11,969	1.08	1.21	16,563	0.93	1.18
2006	10,948	2,181	8,767	11,030	0.97	1.29	15,233	0.62	1.20
2007	9,974	2,674	7,300	9,844	0.75	1.03	13,744	0.71	0.99
2008	6,420	1,624	4,796	8,997	0.33	0.77	11,490	0.40	0.69
2009	3,801	989	2,812	7,605	0.32	0.69	9,454	0.35	0.60
2010	3,792	1,661	2,131	5,161	0.29	0.53	6,987	0.38	0.49
Median	10,100	3,657	7,085	8,303	0.74	1.71	13,054	0.79	1.31

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

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Abundance. Over the first half of the past decade, the CV spring-run Chinook salmon ESU has experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). There has been more opportunistic utilization of migration-dependent streams overall. The FRH spring-run Chinook salmon stock 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. In contrast to the first half of the decade, the last 5 years of adult returns indicate that population abundance is declining from the peaks seen in the 5 years prior (2001 to 2005) for the entire Sacramento River basin. The recent declines in abundance place the Mill and Deer Creek populations in the high extinction risk category due to the rate of decline, and in the case of Deer Creek, also the level of escapement. Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in the past several years is nearly sufficient to classify it as a high extinction risk based on this criteria. Some tributaries, such as Clear Creek and Battle Creek, have seen population gains, but the overall abundance numbers are still low.

Productivity. The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run Chinook salmon populations ranges from 491 to 4,513 fish (Good *et al.* 2005), indicating increasing productivity over the short-term and was projected to likely continue into the future (Good *et al.* 2005). However, as mentioned in the previous paragraph, the last 5 years of adult escapement to these tributaries has seen a cumulative decline in fish numbers and the CRR has declined in concert with the population declines. The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run ESU currently is unknown.

Spatial Structure. Spring-run Chinook salmon presence has been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is unknown. Butte Creek spring-run Chinook salmon cohorts have recently utilized all currently available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the spring-run Chinook salmon ESU has been reduced with the extirpation of all San Joaquin River basin spring-run Chinook salmon populations. In the near future, an experimental population of CV spring-run Chinook salmon will be reintroduced into the San Joaquin River below Friant Dam as part of the San Joaquin River Settlement Agreement. Its long term contribution to the CV spring-run Chinook salmon ESU is uncertain. The populations in Clear Creek and Battle Creek may add to the spatial structure of the CV spring-run population if they can persist by colonizing waterways in the Basalt and Porous and Northwestern California Coastal Range diversity group areas.

Diversity. The CV spring-run Chinook salmon ESU is comprised of two genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the Northern Sierra Nevada spring-run Chinook salmon population complex (Mill, Deer, and Butte creeks) retains genetic integrity. The genetic integrity of the Northern Sierra Nevada spring-run Chinook salmon population complex in the Feather River has been somewhat compromised. The Feather River spring-run Chinook salmon have introgressed with the fall-run Chinook salmon, and it appears that the Yuba River population may have been impacted by FRH fish straying into the Yuba River. Additionally, the diversity of the spring-run Chinook salmon

ESU has been further reduced with the loss of the San Joaquin River basin spring-run Chinook salmon populations.

2. California Central Valley Steelhead

CCV Steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Only winter-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).

CCV steelhead remain in the ocean for up to four years before returning to their natal streams as adults to spawn (Shapovalov and Taft 1954). Adult steelhead size depends on the length of their ocean residency (Meehan and Bjornn 1991). 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). CCV steelhead generally leave the ocean from August through April (Busby *et al.* 1996) and enter freshwater from August to November and spawn from December to April, with peaks from January through March, in small streams and tributaries where cool, well oxygenated water is available year-round (Table 1; Williams 2006; Hallock *et al.* 1961; McEwan and Jackson 1996). Some CCV steelhead hold in pools while maturing sexually, while others begin sexual maturation in the ocean and spawn within a few months after entering streams (Williams 2006). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972).

Adults typically spend a few months in freshwater before spawning (Williams 2006). Female steelhead construct redds in suitable gravels, primarily in pool tailouts and heads of riffles. Steelhead generally return to freshwater at ages two and three and range in size from two to twelve pounds (Reynolds *et al.* 1993). The number of eggs laid per female depends on size and origin of the fish (Moyle 2002). Steelhead about 55 cm long may have fewer than 2000 eggs, whereas steelhead 85 cm long can have 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991).

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

(a) Adult migration/holding

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

(b) Juvenile migration

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

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

Sources: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et al.* 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data 2007; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980, 1997.

Unlike Pacific salmon, steelhead are iteroparous, which are capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider *et al.* 1986). Post-spawning steelhead may migrate downstream to the ocean immediately after spawning or may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Steelhead eggs hatch in three to four weeks at 50°F to 59°F (Moyle 2002). The length of time it takes for eggs to hatch depends mostly on water temperature. 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, and start to feed actively, often in schools (Barnhart 1986; NMFS 1996a). Then the newly emerged fry move to the shallow, protected areas associated within the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954). Fry are typically less than 50 millimeters standard length (SL) (Moyle 2002). As fry increase in size and their swimming abilities improve during late summer and fall, they increasingly use areas with cover and exhibit a preference for higher velocity, deeper mid-channel areas near the thalweg (Hartman 1965; Everest and Chapman 1972; Fontaine 1988). Optimal water temperatures for growth range from 59°F to 64°C (Moyle 2002).

Juvenile steelhead (parr) rear in freshwater for one to three years before outmigrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater appears to be related to growth rate, with larger, faster-growing members of a cohort smolting earlier (Peven *et al.* 1994). Juveniles occupy a wide range of habitats, preferring deep pools, as well as higher velocity rapid and cascade habitats (Bisson *et al.* 1982, 1988). During periods of low temperatures (< 44.6° F) 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). Juveniles' winter hiding behavior reduces their metabolism and food intake requirements and minimizes their exposure to predation and high flows (Bustard and Narver 1975). Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Steelhead smolts migrate downstream during most months of the year, but the peak period of emigration occurs in spring, with a much smaller peak in the fall (Hallock *et al.* 1961). Emigrating steelhead use the lower reaches of a river and the Delta for rearing and as a migration corridor to the ocean. Juvenile steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002). Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead migrate downstream during most months of the year, but the peak period of emigration occurred in the spring with a much smaller peak in the fall. Nobriga and Cadrett (2003) also have verified these temporal findings based on analysis of captures at Chipps Island, Suisun Bay.

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 of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

About 80 percent of habitat in the Central Valley was historically available to anadromous *O. mykiss* is now behind 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 to the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

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

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

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

Until recently, CCV steelhead were thought to be extirpated from the San Joaquin River system. Monitoring has detected small self-sustaining [reproducing] populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer Fish Sciences 2009). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon, and 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 2012a,b). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but no juvenile *O. mykiss* were caught during the 2012 season (FishBio 2012b). Rotary screw trapping on the Merced River has occurred since 1999, however, a counting weir has not been installed on this river. Juvenile *O. mykiss* have not been reported on the Merced River until 2012. A total of 266 *O. mykiss* were caught in the rotary screw traps. The unusual high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24-hour period. Zimmerman *et al.* (2008) has documented CCV steelhead in the Stanislaus, Tuolumne, and Merced rivers based on otolith microchemstry.

CDFG staff has prepared Kodiak Trawl catch summaries for juvenile migrant CCV steelhead on the San Joaquin River near Mossdale, which represents migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at Mossdale between 1988 and 2001, as well as rotary screw trap efforts in all three tributaries, Marston (2004) stated that it is "clear from this data that *O. mykiss* do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River." Mossdale Kodiak Trawl catches continue to occur and are still being conducted by CDFG to this day. A total of 15 O. mykiss were caught during the 2012 season. The documented adult returns on the order of single fish in these tributaries and the low numbers of juvenile migrants captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The potential loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

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 2011a). 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 11 years ago for Nimbus stock, and 3 years ago for Feather River stock.

Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin have been generally showing a continuing 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 most recent status review of the CCV steelhead DPS (NMFS 2011a) 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. Analysis of data from the Chipps Island monitoring program 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. Since 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-clip steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. In recent years, the proportion of hatchery produced juvenile steelhead in the catch has exceeded 90 percent and in 2010 was 95 percent of the catch. 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.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities has also shown a shift towards reduced natural production. The annual salvage of juvenile steelhead at the two facilities in the South Delta has fluctuated since 1993. In the past decade, there has been a marked decline in the total number of salvaged juvenile steelhead, with the salvage of hatchery produced steelhead showing the larger decline at the facilities in absolute numbers of fish salvaged. However, the percentage of wild fish to hatchery produced fish has also declined during the past decade. Thus, while the total number of salvaged hatchery produced fish has declined, naturally produced steelhead have also declined at a consistently higher rate than hatchery produced fish, thereby consistently reducing the ratio of wild to hatchery produced steelhead in the salvage data (NMFS 2011a).

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 2011a). 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. The returns of wild fish remained steady, even during the recent poor ocean conditions and the 3-year drought in the Central Valley, while hatchery produced fish showed a decline in the numbers returning to the hatchery (NMFS 2011a). Furthermore, the continuing widespread distribution of wild steelhead throughout most of the watersheds 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 2011a).

Viable Population Summary for CCV Steelhead

Abundance. 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 2011); the long-term trend remains negative. Comprehensive steelhead population monitoring has not taken place in the Central Valley, despite 100 percent marking of hatchery steelhead since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being considered (NMFS 2011). Hatchery production and returns are dominant over natural fish and include significant numbers of non-DPS-origin Eel River steelhead stock. Continued decline in the ratio between wild 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 ad-clipped fish to wild adipose fin bearing fish has steadily increased over the past several years.

Productivity. An estimated 100,000 to 300,000 natural 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 existing populations of CCV steelhead on these tributaries are severely depressed. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend in the overall abundance of the CCV steelhead DPS (Williams *et al.* 2011). Updated through 2010, the trawl data indicate that the apparent decline in natural production of steelhead has continued since the 2005 status review. Catch-per-unit-effort has fluctuated over the past decade, but the proportion of the catch that is ad-clipped (100 percent of all hatchery produced steelhead have been ad-clipped since 1998) has steadily increased, exceeding 90 percent in recent years and reaching 95 percent in 2010 (Williams *et al.* 2011). Because hatchery releases have been fairly constant over the years, these data suggest that natural production of steelhead has been declining (NMFS 2011).

Spatial Structure. Steelhead appear to be well-distributed where found throughout the Central Valley (Good *et al*. 2005, NMFS 2011). In the San Joaquin River Basin, steelhead have been confirmed in all of the tributaries: Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced rivers. Zimmerman *et al.* (2008) 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. The efforts to provide passage of salmonids over impassable dams may increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for steelhead. In addition, the 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 spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead as well (NMFS 2011).

Diversity. CCV steelhead abundance and growth rate continue to decline, largely the result of a significant reduction in the diversity of habitats available to CCV steelhead (Lindley *et al.* 2006). Recent reductions in natural population sizes have created genetic bottlenecks in several Central Valley steelhead stocks (Good *et al.* 2005, 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 CCV steelhead is also compromised by hatchery origin fish, which likely compromise the majority of the natural spawning run, placing the natural population a high risk of extinction (Lindley *et al.* 2007). There are four hatcheries (Coleman NFH, 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 (mainly from the Eel River) and are not presently considered part of the DPS.

3. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

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

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

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

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

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

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River and its tributaries (Stanislaus, Tuolumne, and Merced rivers) occurred early in the European settlement of the region. During the latter half of the 1800s, impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. Additional impacts to the watershed include the increased loads of selenium entering the system through agricultural practices in the western side of the San Joaquin Valley. Green sturgeon have recently been identified by University of California, Davis, researchers as being highly sensitive to selenium levels (Kaufmann *et. al.* 2008). Currently, only white sturgeon have been encountered in the San Joaquin River system upstream of the Delta, and adults have been captured by sport anglers as far upstream on the San Joaquin River as Hills Ferry and Mud Slough which are near the confluence of the Merced River with the mainstem San Joaquin River (Dubois *et al* 2012).

Kelly *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn (see Table 6 in text). The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature, and Kelly *et al*. (2007) surmised that they are related to resource availability and foraging behavior. Recent acoustical tagging studies on the Rogue River (Erickson *et al*. 2002) have shown that adult green sturgeon will hold for as much as 6 months in deep (> 5m), low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 59^{o}F and 73^{o}F. When ambient temperatures in the river dropped in autumn and early winter (<50^{o}F) and flows increased, fish moved downstream and into the ocean. Erickson *et al.* (2002) surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Benson *et al.* (2007) found similar behavior on the Klamath and Trinity River systems with adult sturgeon acoustically tagged during their spawning migrations. Most fish held over the summer in discrete locations characterized by deep, low velocity pools until late fall or early winter when river flows increased with the first storms of the rainy season. Fish then moved rapidly downstream and out of the system. Recent data gathered from acoustically tagged adult green sturgeon revealed comparable behavior by adult fish on the Sacramento River based on the positioning of adult green sturgeon in holding pools on the Sacramento River above the Glenn Colusa Irrigation District (GCID) diversion (RM 205). Studies by Heublein (2006), Heublein *et. al.* (2009) and Vogel (2008) have documented the presence of adults in the Sacramento River during the spring and through the fall into the early winter months. These fish hold in upstream locations prior to their emigration from the system later in the year. Like the Rogue and Klamath river systems, downstream migration appears to be triggered by increased flows, decreasing water temperatures, and occurs rapidly once initiated. It should also be noted that some adults rapidly leave the system following their suspected spawning activity and enter the ocean only in early summer (Heublein 2006). This behavior has also been observed on the other spawning rivers (Benson *et al*. 2007*)* but may have been an artifact of the stress of the tagging procedure in that study.

Eggs and Larvae. Currently spawning appears to occur primarily above RBDD, based on the recovery of eggs and larvae at the dam in monitoring studies (Gaines and Martin 2001, Brown 2007). Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 59^{o}F (Van Eenennaam *et al.* 2001, Deng *et al.* 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 57.2^{o}F and 62.6^{o}F. Temperatures over 73.4^{o}F resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 63.5^{o}F and 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 57.2^{o}F, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

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

Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al*. 2002) and are approximately 75 mm TL. At this stage of development, the fish are considered juveniles and are no longer larvae.

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other Acipenseridae. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s

(2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46.4^{o}F, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9 to 10 month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.,* growth, food conversion, swimming ability) between 59^{o}F and 66.2^{o}F under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath River systems range from 39^{o}F to approximately 75.2^{o}F. The Sacramento River has similar temperature profiles, and, like the previous two rivers, is a regulated system with several dams controlling flows on its mainstem (Shasta and Keswick dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus dams).

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

Larval and juvenile sturgeons have been caught in traps at two sites in the upper Sacramento River: below the RBDD (RM 243) and from the GCID pumping plant (RM 205) (CDFG 2002). Larvae captured at the RBDD site are typically only a few days to a few weeks old, with lengths ranging from 24 mm to 31 mm. This body length is equivalent to 15 to 28 days post hatch as determined by Deng *et al.* (2002). Recoveries of larvae at the RBDD rotary screw traps (RSTs) occur between late April/early May and late August with the peak of recoveries occurring in June (1995 - 1999 and 2003 - 2008 data). The mean yearly total length of post-larval green sturgeon captured in the GCID rotary screw trap, approximately 30 miles downstream of RBDD, ranged from 33 mm to 44 mm between 1997 and 2005 (CDFG, 2002) indicating they are approximately three to four weeks old (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Taken together, the average length of larvae captured at the two monitoring sites indicate that fish were hatched upriver of the monitoring site and drifted downstream over the course of two to four weeks of growth. According to the CDFG document commenting on the NMFS proposal to list the southern DPS (CDFG 2002), some green sturgeon rear to larger sizes above RBDD, or move back to this location after spending time downstream. Two sturgeon between 180 mm and 400 mm TL were captured in the rotary-screw trap during 1999 and green sturgeon within this size range have been impinged on diffuser screens associated with a fish ladder at RBDD (K. Brown, USFWS, pers. comm. as cited in CDFG 2002).

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

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

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

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

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

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 (2005a); [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 (2008)

Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Collection Facility (Fish Facilities) in the south Delta, and captured in trawling studies by CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 mm and 500 mm, indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates that juveniles of the Southern DPS of green sturgeon likely hold in the mainstem Sacramento River, as suggested by Kynard *et al.* (2005).

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001 (see Appendix A: Table 1 and Appendix B: Figures 7a and 7b). The average number of North American green sturgeon taken per year at the John E. Skinner Fish Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386, April 6, 2005). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386, April 6, 2005). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386, April 6, 2005). No green sturgeon were recovered at either the CVP or SWP in 2010. Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS North American green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006b) indicates spawning populations of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71).

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

Available information on green sturgeon indicates that, as with winter-run Chinook salmon, the mainstem Sacramento River may be the last viable spawning habitat (Good *et al.* 2005) for the

Southern DPS of green sturgeon. Lindley *et al.* (2007) pointed out that an ESU represented by a single population at moderate risk is at a high risk of extinction over the long term. Although the extinction risk of the Southern DPS of green sturgeon has not been assessed, NMFS believes that the extinction risk has increased because there is only one known population, that which is spawning within the mainstem Sacramento River.

Population Viability Summary for the Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon has not been analyzed to characterize the status and viability as has been done in recent efforts for Central Valley salmonid populations (Lindley *et al*. 2006, Good *et al.* 2005). NMFS assumes that the general categories for assessing salmonid population viability will also be useful in assessing the viability of the Southern DPS of green sturgeon. The following summary has been compiled from the best available data and information on North American green sturgeon to provide a general synopsis of the viability parameters for this DPS.

Abundance. Currently, there are no reliable data on population sizes, and data on population trends is also lacking. Fishery data collected at Federal and State pumping facilities in the Delta indicate a decreasing trend in abundance between 1968 and 2006 (70 FR 17386).

Productivity. There is insufficient information to evaluate the productivity of green sturgeon. However, as indicated above, there appears to be a declining trend in abundance, which indicates low to negative productivity.

Spatial Structure. Current data indicates that the Southern DPS of North American green sturgeon is comprised of a single spawning population in the Sacramento River. Although some individuals have been observed in the Feather and Yuba rivers, it is not yet known if these fish represent separate spawning populations or are strays from the mainstem Sacramento River. Therefore, the apparent presence of a single reproducing population puts the DPS at risk, due to the limited spatial structure.

Diversity. Green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and therefore, the species was divided into Northern and Southern DPSs. However, the genetic diversity of the Southern DPS is not well understood.

C. Definition of Critical Habitat Condition and Function for Species' Conservation

1. Critical Habitat for Sacramento River Winter-run Chinook Salmon

The designated critical habitat for SR winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by SR winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

2. Critical Habitat for California Central Valley Steelhead

Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). 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. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of one to two 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 (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CCV steelhead, and as physical habitat elements for SR winter-run Chinook salmon.

PCE for Central Valley steelhead include:

a. Spawning Habitat

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

b. Freshwater Rearing Habitat

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

c. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value even if the migration corridors are significantly degraded compared to their natural state.

d. Estuarine Areas

Estuarine areas 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 LWM, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas are considered to have a high conservation value as they provide factors which function to provide predator avoidance and as a transitional zone to the ocean environment.

3. Critical Habitat for the Southern DPS of North American Green Sturgeon

Critical habitat was designated for the Southern DPS of North American green sturgeon on October 9, 2009 (74 FR 52300). Critical habitat for Southern DPS green sturgeon includes the stream channels and waterways in the Sacramento – San Joaquin River Delta to the ordinary high water line except for certain excluded areas. Critical habitat also includes the main stem Sacramento River upstream from the I Street Bridge to Keswick Dam, and the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery. Coastal Marine areas include waters out to a depth of 60 meters from Monterey Bay, California, to the Juan De Fuca Straits in Washington. Coastal estuaries designated as critical habitat include San Francisco Bay, Suisun Bay, San Pablo Bay, and the lower Columbia River estuary. Certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) are also included as critical habitat for Southern DPS green sturgeon.

Critical habitat for the Southern DPS of North American green sturgeon includes the estuarine waters of the Delta, which contain the following primary constituent elements:

a. 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.

b. Water Flow

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

c. Water Quality

Adequate water quality, including temperature, salinity, oxygen content, and other chemical characteristics, is necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 75°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 parts per thousand (ppt)) to salt water (33 ppt). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels (Allen and Cech 2007), whereas subadults and adults tolerate a wide range of salinities (Kelly *et al.* 2007). Subadult and adult green sturgeon occupy a wide range of dissolved oxygen (DO) levels (Kelly *et al.* 2007, Moser and Lindley 2007). Adequate levels of DO are also required to support oxygen consumption by juveniles (ranging from 61.78 to 76.06 mg O_2 hr^{-1} kg^{-1}, Allen and Cech 2007). Suitable water quality also includes water free of contaminants (*e.g*., organochlorine pesticides, poly aromatic hydrocarbons (PAHs), or elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.

d. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for the safe and timely passage of adult, sub-adult, and juvenile fish within the region's different estuarine habitats and between the upstream riverine habitat and the marine habitats. Within the waterways comprising the Delta, and bays downstream of the Sacramento River, safe and unobstructed passage is needed for juvenile green sturgeon during the rearing phase of their life cycle. Rearing fish need the ability to freely migrate from the river through the estuarine waterways of the delta and bays and eventually out into the ocean. Passage within the bays and the Delta is also critical for adults and subadults for feeding and summer holding, as well as to access the Sacramento River for their upstream spawning migrations and to make their outmigration back into the ocean. Within bays and estuaries outside of the Delta and the areas comprised by Suisun, San Pablo, and San

Francisco bays, safe and unobstructed passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean.

e. Water Depth

A diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly *et al*. 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from three to eight feet deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966). Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

f. 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.

D. Factors Impacting Listed Species

1. Habitat Blockage

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

As a result of migrational barriers, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations have been confined to lower elevation mainstems that historically only were used 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 late-summer and fall are also a major stressor to adult and juvenile salmonids. According to Lindley *et al.* (2004), of the four independent populations of Sacramento River winter-run Chinook salmon that occurred historically, only one mixed stock of winter-run Chinook salmon remains below Keswick Dam. Similarly, 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, Clear, Thomes, Beegum, and Stony creeks, but rely on the three extant independent populations for their continued survival. CCV steelhead historically had at least 81 independent populations based on Lindley *et al.* (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. Green sturgeon populations have been similarly affected by these barriers and alterations to the natural hydrology. In particular, RBDD blocked access to a significant portion of the adult green sturgeon spawning run under the pre CVP/SWP BO operational procedures. Modifications to the operations of the RBDD as required under the CVP/SWP BO have substantially reduced the impediment to upstream migrations of adult green sturgeon. Post CVP/SWP BO interim operational procedures require the RBDD gates to remain in the open position from September 1 until June 15 each year. Starting on June 15, 2012, the gates are required to remain open year round.

The Suisun Marsh Salinity Control Gates (SMSCG), located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, DWR 2002a). The effects of the SMSCG on sturgeon are unknown at this time.

2. <u>Water Development</u>

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 DO levels, and decreased recruitment of gravel and large woody debris material. More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bed load movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. The storage of unimpeded runoff in these large reservoirs also has altered the normal hydrograph for the Sacramento and San Joaquin River watersheds. Rather than seeing peak flows in these river systems following winter rain events (Sacramento River) or spring snow melt

(San Joaquin River), the current hydrology has truncated peaks with a prolonged period of elevated flows (compared to historical levels) continuing into the summer dry season.

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

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

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP and SWP facilities. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (Centrarchidae). On June 4, 2009, NMFS issued a biological and conference opinion on the long-term operations of the CVP and SWP (NMFS 2009a). As a result of the jeopardy and adverse modification determinations, NMFS provided a reasonable and prudent alternative that reduces many of the adverse effects of the CVP and SWP resulting from the stressors described above.

3. <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 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 debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996b). However, it is now recognized that too much 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 50 to 100 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.

4. Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for four or five 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 two 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 debris that would otherwise be recruited into the stream channel (NMFS 1998a).

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

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley. Starting in the mid-1800s, the USACE 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 USACE 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 (Central Valley RWQCB 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. Current mining practices include suction dredging (sand and gravel mining), placer mining, lode mining and gravel mining. Present day mining practices are typically less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for concrete to construct buildings and highways.

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

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by 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. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

5. Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Central Valley RWQCB, in its 1998 Clean Water Act §303(d) list, characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes [including lindane], endosulfan and toxaphene), mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

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

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

Therefore, the degree of exposure to the salmonids and green sturgeon depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids and green sturgeon 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. For example, over the 5-year period, starting in August 2000, a DO meter recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/L DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed CCV steelhead adults and smolts will be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A: Table 8).

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

6. <u>Hatchery Operations and Practices</u>

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (U.S. Department of the Interior (DOI) 1999).

For example, the original source of steelhead broodstock at Nimbus Hatchery on the American River originally came from the Eel River basin and was not from the Central Valley. Thus, the progeny from that initial broodstock served as the basis for the hatchery steelhead reared and released from the Nimbus Fish Hatchery. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

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

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

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 percent to 37 percent naturally-produced fish by 2000 (Nobriga and Cadrett 2001), and less than 10 percent currently. The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001). Currently, hatchery produced fall-run Chinook salmon comprise the majority of fall-run adults returning to Central Valley streams. Based on a 25 percent constant fractional marking of hatchery produced fall-run Chinook salmon juveniles, adult escapement of fin clipped fish greater than 25 percent in Central Valley tributaries indicates that hatchery produced fish are the predominate source of fish in the spawning population. Recent surveys (2010) have seen percentages approaching this or exceeding it in area tributaries (Sacramento Bee, January 4, 2011, editorial by John Williams).

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

7. <u>Over Utilization</u>

a. ***Ocean Commercial and Sport Harvest – Chinook Salmon and Steelhead***

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

Since 1970, the CVI harvest index for SR winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest index was near the highest recorded level at 0.79. NMFS determined in a 1991 BO that continuance of the 1990 ocean harvest rate will not prevent the recovery of SR winter-run Chinook salmon. In addition, the final rule designating winter-run Chinook salmon critical habitat (58 FR 33212, June 16, 1993) stated that commercial and recreational fishing do not appear to be significant factors for the decline of the species. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a BO which concluded that incidental ocean harvest of SR winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001 the CVI dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other salmonids originating from the Central Valley (Good *et al*. 2005). In April 2010, NMFS reached a jeopardy conclusion regarding the ongoing Fisheries Management Plan (FMP) for west coast ocean salmon fishery in regards to its impacts on the continued survival of the winter-run Chinook salmon population (NMFS 2010).

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 4- and 5-year-old fish (CDFG 1998). Winter-run spawners have also been affected by ocean fisheries, as most spawners return as 3-year olds. As a result of very low returns of fall-run 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. The SR winter-run Chinook salmon population increased by approximately 60 percent in 2009, but declined again in 2010 to 1,596 fish. However, contrary to expectations, even with the two years of ocean fishery closures, the CV spring-run Chinook salmon population continues to decline. 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 SR winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of CV spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

b. ***Inland Sport Harvest –Chinook Salmon and Steelhead***

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

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

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

c. ***Green Sturgeon***

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 captured by sport fisherman 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 (2006a) 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 North American green sturgeon. This indicates a potential threat to the Southern DPS North American 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 3 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 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 comprised of only white sturgeon) experiences heavy fishing pressure, particularly regarding illegal snagging and it may be more than the population can support (USFWS 1995a).

8. <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 1996a, 1996b, 1998a). Specific diseases such as bacterial kidney disease, C*eratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996a, 1996b, 1998a). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that wild fish tend to be less susceptible to pathogens than are hatchery-reared fish. Nevertheless, wild salmonids may contract diseases that are spread through the water column (*i.e*., waterborne pathogens) as well as through interbreeding with infected hatchery fish. The stress of being released into the wild from a controlled hatchery environment frequently causes latent infections to convert into a more pathological state, and increases the potential of transmission from hatchery reared fish to wild stocks within the same waters.

Accelerated predation also may be a factor in the decline of SR winter-run Chinook salmon and CV spring-run Chinook salmon, and to a lesser degree 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 disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Historically, predation at RBDD and in Lake Red Bluff on juvenile winter-run Chinook salmon was high. Now the gates at RBDD are open year round and so predation should be greatly reduced. Some predation is still likely to occur due to the physical structure of the dam remaining in the water way, even with the gates in the open position.

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997, DWR 2009).

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

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

Mammals can also be an important source of predation on salmonids within the California Central Valley. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonids include: badger (*Taxidea taxus*), bobcat (*Linx 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*). These animals, especially river otters, are capable of removing large numbers of salmon and trout from the aquatic habitat (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. In the marine environment, pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) can also prey on adult salmonids in the nearshore marine environment, and at times become locally important. Although harbor seal and sea lion predation primarily is confined to the marine and estuarine environments, they are known to travel well into freshwater after migrating fish and have frequently been encountered in the Delta and the lower portions of the Sacramento and San Joaquin rivers. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable, such as the large water diversions in the south Delta.

9. 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.

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.

10. <u>Ecosystem Restoration</u>

a. *California Bay-Delta Authority*

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

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant in anadromous reaches of priority streams controlled by dams. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five priority watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users, particularly South of Delta water users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in south Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and Sacramento splittail (*Pogonichthys macrolepidotus*). However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release. Under the long term operations of the CVP and SWP, EWA assets have declined to 48 thousand acre feet after carriage water costs. The RPA actions developed within the 2009 CVP/SWP BO are designed to minimize or remove the adverse impacts associated with many of the CVP/SWP related stressors. Within the Delta, stressors such as the Delta Cross Channel (DCC) gates and export operations have been modified to reduce the hydraulic changes created by the project operations. Earlier closures of the DCC gates prevent early emigrating listed salmonids from entering the Delta interior through the open DCC gates. Management of the Old and Middle River flows prevents an excessive amount of negative flow towards the export facilities from occurring in the channels of Old and Middle River. When flows are negative, water moves in the opposite direction than would occur naturally, drawing fish into the south Delta and towards the export facilities or delaying their migration through the system.

b. *Central Valley Project Improvement Act*

The Central Valley Project Improvement Act (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 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.

c. *Iron Mountain Mine Remediation*

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

d. *State Water Project Delta Pumping Plant Fish Protection Agreement (Four Pumps Agreement)*

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

11. <u>Non-Native Invasive Species</u>

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

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

12. Summary

For SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, the construction of high dams for hydropower, flood control, and water supply resulted in the loss of vast amounts of upstream habitat (*i.e.*, approximately 80 percent, or a minimum linear estimate of over 1,000 stream miles), and often resulted in precipitous declines in affected salmonid populations. For example, the completion of Friant Dam in 1947 has been linked with the extirpation of spring-run 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/or rearing of salmonids. This requirement has been difficult to achieve in all water year types and for all life stages of affected salmonid species. Steelhead, in particular, seem to require the qualities of small tributary habitat similar to what they historically used for spawning; habitat that is largely unavailable to them under the current water management scenario. All salmonid species considered in this consultation 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*.).

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

Similar to the listed salmonids, the Southern DPS of North American green sturgeon have been negatively impacted by hydroelectric and water storage operations in the Central Valley which ultimately affect the hydrology and accesibility of Central Valley rivers and streams to anadromous fish. Anthropogenic manipulations of the aquatic habitat, such as dredging, bank stabilization, and waste water discharges have also degraded the quality of the Central Valley's waterways for green sturgeon.

F. Existing Monitoring Programs

Salmonid-focused monitoring efforts are taking place throughout the Sacramento and San Joaquin River basins and the Suisun Marsh. Many of these programs incidentally gather information on steelhead but a focused, comprehensive steelhead monitoring program has not been funded or implemented in the Central Valley. The existing salmonid monitoring efforts are summarized in Appendix A: Table 2 by geographic area and target species. Information for this summary was derived from a variety of sources:

- IEP's (1999) Steelhead Project Work Team report on monitoring, assessment, and research on steelhead: status of knowledge, review of existing programs, and assessment of needs;
- CDFG Plan;
- U.S. Forest Service Sierra Nevada Framework monitoring plan;
- ESA section 10 and section 4(d) scientific research permit applications;
- Trinity River Restoration Program biological monitoring; and
- Suisun Marsh Monitoring Program.

Studies focused on the life history of green sturgeon are currently being implemented by researchers at academic institutions such as University of California, Davis. Future plans include radio-telemetry studies to track the movements of green sturgeon within the Delta and Sacramento River systems. Additional studies concerning the basic biology and physiology of green sturgeon are also being conducted to better understand the fish's niche in the aquatic system.

V. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

A. Status of the Species and Critical Habitat within the Action Area

1. <u>Status of the Species within the Action Area</u>

The action area functions primarily as a migratory corridor for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon, but it also provides some use as holding and rearing habitat for each of these species as well.

a. *Sacramento River Winter-Run Chinook Salmon*

The temporal occurrence of SR winter-run Chinook salmon smolts and juveniles within the southern Delta action area are best described by the salvage records of the CVP and SWP fish collection. Based on salvage records covering the period between 1999 and 2009 at the CVP and SWP fish collection facilities (Reclamation 2011), juvenile SR winter-run Chinook salmon are typically present in the action area starting in December. Their presence peaks in March and then rapidly declines from April through June. The majority of winter-run juveniles (57 percent) enter the action area during the proposed reoperation of Friant Dam to release Interim and Restoration Flows (February- April). Adult winter-run Chinook salmon are expected to enter the Delta portion of the action area starting in January, with the majority of adults passing through the action area between February and April (Reclamation 2011).

b. *Central Valley Spring-Run Chinook salmon*

A similar application of the CVP and SWP salvage records for the presence of CV spring-run Chinook salmon indicates that juveniles first begin to appear in the action area in December and January, but that a significant presence does not occur until March and peaks in April. By May, the salvage of juvenile CV spring-run Chinook salmon declines sharply and essentially ends by the end of June. This pattern is further supported and consistent with salmonid passage estimates derived from rotary screw trap data collected by USFWS dating back to 2003, which indicate two significant peaks in the annual passage of juvenile spring-run Chinook salmon at RBDD occurring in the months of December and April. Adult spring-run Chinook salmon are expected to start entering the southern Delta section of the action area in approximately January. Low levels of adult migration are expected through early March. The peak of adult spring-run Chinook salmon movement through the action area in the Delta is expected to occur between April and June with adults continuing to enter the system through the summer. Currently, all known populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been extirpated, with the last known runs on the San Joaquin River being extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Kern-Friant irrigation canal.

c. *California Central Valley Steelhead*

The CCV steelhead DPS occurs in both the Sacramento River and the San Joaquin River watersheds. However the spawning population of fish is much greater in the Sacramento River watershed and accounts for nearly all of the DPS' population. Small numbers of CCV steelhead persist in the Stanislaus, Tuolumne, and Merced rivers (McEwan 2001, Zimmerman *et al.* 2008).

This indicates the possibility of small numbers of CCV steelhead to be in the San Joaquin River below the confluence of the Merced River section of the Action Area. Currently, CCV steelhead are viewed as extirpated from all waters upstream of the confluence of the Merced and San Joaquin rivers (Eilers *et al.* 2010), owing to a lack of continuity of flow and resulting poor habitat in long reaches above this point. Suitable, but presently inaccessible, habitat exists in the San Joaquin River reaches near Friant Dam.

Due to poor habitat conditions in the San Joaquin River upstream of the Merced River confluence, the CDFG has operated the Hills Ferry Barrier since 1992 to redirect fall-run Chinook salmon to the Merced River, or other suitable habitat. The operations and monitoring of this barrier are described in *Project-level actions: Operate and Monitor Hills Ferry Barrier* section of this opinion. The annual monitoring reports for 2005 to 2008 submitted to NMFS by CDFG indicate that no juvenile or adult CCV steelhead were detected during HFB operations (CDFG 2006, 2007, 2008a, 2009).

In October 2009, the SJRRP began the release of Interim flows, which occur in the fall to early spring. When these flows are sufficient to reach the Merced River, they could attract adult steelhead in the San Joaquin River upstream of the confluence of the Merced River. During the timeframe that the Hills Ferry Barrier is operated, CCV steelhead occupying that reach could be detected and potentially redirected or trapped. In 2009, one adult fall-run Chinook salmon was detected above the Hills Ferry Barrier but no CCV steelhead detections were made (CDFG 2010). In the fall of 2010, a trap was installed by CDFG and operated by Reclamation, Denver Technical Services Center to assess the barrier's effectiveness. Approximately 30 fall-run Chinook salmon were able to pass the barrier during the 2010 Interim Flow period (Portz *et al.* 2011). No steelhead were detected at HFB in 2010; however, bar spacing on the trap could allow steelhead that are smaller and slimmer than salmon to escape. The SJRRP Steelhead monitoring project in 2011 did not detect the presence of CCV steelhead above the Hills Ferry Barrier after the barrier's removal in mid-December (Portz *et al.* 2012).

Kodiak trawls conducted by the USFWS and CDFG on the mainstem of the San Joaquin River upstream from the City of Stockton routinely catch low numbers of outmigrating steelhead smolts from the San Joaquin basin during the months of April and May. CCV steelhead smolts first start to appear in the south Delta in November based on the records from the CVP and SWP fish salvage facilities (Reclamation 2011). Their presence increases through December and January and peaks in February and March before rapidly declining in April. By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP.

d. *Southern DPS of North American Green Sturgeon*

Juvenile green sturgeon from the Southern DPS are routinely collected at the SWP and CVP salvage facilities throughout the year. However, numbers are considerably lower than for other species of fish monitored at the facilities. Based on the salvage records from 1981 through 2007, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August. The sizes of these fish are less than 1 meter and average 330 mm with a range of 136 mm to 774 mm. The size range indicates that these are sub-adult fish rather than adult or larval/juvenile fish. It is believed that these sub-adult fish utilize the Delta for rearing for up to a period of approximately three years. The action area is located off the main migratory route that juvenile green sturgeon utilize to enter the Delta from their natal areas upstream on the upper Sacramento River and off the main migratory route utilized by adult green sturgeon to access the spawning grounds in the upper Sacramento River. However, based on collections at the SWP and CVP salvage facilities it is likely that adult green sturgeon will be present in the action area. Adult green sturgeon begin to enter the Sacramento – San Joaquin Delta in late February and early March during the initiation of their upstream spawning run. The peak of adult entrance into the Delta appears to occur in late February through early April with fish arriving upstream in April and May. Adults continue to enter the Delta until early summer (June-July) as they move upriver to spawn.

2. Status of Critical Habitat within the Action Area

The action area occurs within the CALWATER Hydrologic Units (HU) for the San Joaquin Delta Subbasin 5544, the Delta-Mendota Subbasin, the San Joaquin Valley Floor Subbasin, and the Stanislaus River Subbasin 5534. Designated critical habitat for SR winter-run Chinook salmon (June 16, 1993, 58 FR 33212), CCV steelhead (September 2, 2005, 70 FR 52488) and the southern DPS of green sturgeon (October 9, 2009, 74 FR 52300) occur in the San Joaquin hydrologic unit. Designated critical habitat for CCV steelhead also occurs in the Delta-Mendota, the San Joaquin Valley Floor and the Stanislaus River HUs. Although CV spring-run Chinook salmon occupy the San Joaquin Delta HU, designated critical habitat for CV spring-run Chinook salmon (September 2, 2005, 70 FR 52488) does not occur in the San Joaquin Delta HU or any other HU within the action area, so impacts to this species' critical habitat will not be analyzed in the BO. These HUs include the entire San Joaquin River, the Tuolumne River up to La Grange Dam, the Merced River up to Crocker-Huffman Dam, the Stanislaus River up to Goodwin Dam and all waterways within the south Delta. These combined hydrologic units encompass an area of approximately 4778 mi^2 and occur in portions of Contra Costa, San Joaquin, Calaveras, Stanislaus, Alpine, Tuolumne, Merced and Fresno counties. The San Joaquin Delta HU contains a single hydrologic subarea (HSA) which is occupied by the listed species described above, and contains approximately 455 miles of waterways (at 1:100,000 hydrography). NMFS biologists identified approximately 142 and 276 miles of occupied riverine habitat in this HSA for spring-run Chinook and steelhead, respectively. Occupation of the riverine habitat by winter-run Chinook salmon and green sturgeon is expected to be similar for the San Joaquin Delta HU. The critical habitat analytical review team (CHART) concluded that the San Joaquin Delta HU contained one or more PCEs for both the CCV steelhead DPS and CV spring-run Chinook salmon ESU (NMFS 2005b). The PCEs for steelhead and spring-run Chinook salmon habitat within the action area include freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The features of the PCEs included in these different sites essential to the conservation of the CCV steelhead DPS and CV spring-run Chinook salmon include the following: sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions necessary for salmonid development and mobility, sufficient water quality, food and nutrients sources, natural cover and shelter, migration routes free from obstructions, no excessive predation, holding areas for juveniles and adults, and shallow water areas and wetlands. Habitat within the action area is primarily utilized for freshwater rearing and migration by CCV steelhead and CV spring-run Chinook salmon juveniles and smolts and for adult freshwater migration. No spawning of CCV steelhead or CV spring-run Chinook salmon occurs within the action area.

The section of the San Joaquin River upstream of the Merced River confluence presently provides generally poor salmonid habitat conditions and is not included as CCV steelhead designated critical habitat because steelhead do not occupy this reach. Physical barriers, reaches with poor water quality or no surface flow, and the presence of false migration pathways have reduced habitat connectivity. Much of the surface flow in this section is from agriculture return drains or high groundwater seepage. Habitat complexity in the action area is reduced, with limited side-channel habitat or instream habitat structure, and highly altered riparian vegetation. Bypasses receive water sporadically, as necessary for flood control. Most aquatic habitat in the bypasses is therefore temporary, and its duration depends on flood flows; the bypasses are largely devoid of aquatic and riparian habitat because of efforts to maintain hydraulic conveyance for flood flows (McBain and Trush 2002).

Critical habitat for winter-run Chinook salmon includes the south Delta area within the action area. Critical habitat elements include the river water, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. Downstream migration of juveniles and upstream migration of adults should not be impeded or blocked. Adequate forage base is required to provide food for emigrating juvenile winter-run Chinook salmon.

In regards to the designated critical habitat for the Southern DPS of green sturgeon, the action area includes PCEs concerned with: adequate food resources for all life stages utilizing the Delta; water flows sufficient to allow adults, subadults, and juveniles to orient to flows for migration and normal behavioral responses; water quality sufficient to allow normal physiological and behavioral responses; unobstructed migratory corridors for all life stages utilizing the Delta; a broad spectrum of water depths to satisfy the needs of the different life stages present in the estuary; and sediment with sufficiently low contaminant burdens to allow for normal physiological and behavioral responses to the environment.

The general condition and function of the aquatic habitat has already been described in the *Status of the Species and Critical Habitat* section of this BO. The substantial degradation over time of several of the essential critical elements has diminished the function and condition of the freshwater rearing and migration habitats in the action area. It has only rudimentary functions compared to its historical status. The channels of the Delta and the lower San Joaquin River have been heavily riprapped with coarse stone slope protection on artificial levee banks and these channels have been straightened to enhance water conveyance through the system. The extensive riprapping and levee construction has precluded natural river channel migrations and the formation of riffle pool configurations in the Delta's channels. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been "reclaimed" and subsequently drained and cleared for farming. Little natural old growth riparian vegetation remains in the Delta or the San Joaquin River, having been substantially replaced by non-native species. Remaining native vegetation is primarily limited to tules or cattails growing along the foot of artificial levee banks. Shallow water habitat along the toe of the levees is limited to a narrow bench that extends out towards mid-channel from the levee, and is frequently infested with non-native plant species such as the Brazilian waterweed.

In the central and southern Delta numerous artificial channels also have been created to bring water to irrigated lands that historically did not have access to the river channels (*i.e.*, Victoria Canal, Grant Line Canal, Fabian and Bell Canal, Woodward Cut, *etc*.). These artificial channels have disturbed the natural flow of water through the southern and central Delta. As a byproduct of this intensive engineering of the Delta's hydrology, numerous irrigation diversions have been placed along the banks of the flood control levees to divert water from the area's waterways to the agricultural lands of the Delta's numerous "reclaimed" islands. Most of these diversions are not screened adequately to protect migrating fish from entrainment. Sections of the south Delta have been routinely dredged by CDWR to provide adequate intake depth to these agricultural water diversions. Shallow water conditions created by the actions of the SWP enhance the probability of pump cavitation or loss of head on siphons.

Water flow through the south Delta is highly manipulated to serve human purposes. Rainfall and snowmelt is captured by reservoirs in the upper watersheds, from which its release is dictated primarily by downstream human needs. The SWP and CVP pumps draw water towards the southwest corner of the Delta which creates a net upstream flow of water towards their intake points. Fish, and the forage base they depend upon for food, represented by free floating phytoplankton and zooplankton, as well as larval, juvenile, and adult forms, are drawn along with the current towards these diversion points. In addition to the altered flow patterns in the central and southern Delta, numerous discharges of treated wastewater from sanitation wastewater treatment plants (*e.g.*, Cities of Sacramento, Walnut Grove, Tracy, Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, Oakley, Antioch, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways are emptied into the waters of the Delta and rivers and tributaries feeding into the delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (*i.e.*, ammonia and other nitrogenous compounds, selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, pharmaceuticals, *etc*.). These chemical and physical constituents create conditions that can adversely impact aquatic life exposed to excessive levels, either through direct mortality or reduced physiological status.

Even though the habitat has been substantially altered and its quality diminished through years of human actions, its conservation value remains high for SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and southern DPS green sturgeon. Some of the juvenile winter-run and spring-run Chinook salmon, southern DPS green sturgeon, as well as all of the those CCV steelhead smolts originating in the San Joaquin River basin must pass into and through the San Joaquin Delta HU to reach the lower Delta and the ocean. All CCV steelhead juveniles originating in the San Joaquin River must pass through the other HUs described earlier in this section. Likewise, some SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and southern DPS green sturgeon adults migrating upstream to spawn will pass through San Joaquin Delta HU to reach their upstream spawning areas on the tributary watersheds or main stem Sacramento River. All migrating adult CCV steelhead moving into the San Joaquin River will pass through all of the HUs described here. In addition, if an experimental population of spring-run Chinook salmon is introduced to the San Joaquin River as part of the restoration program, those fish will utilize all of the HUs in the action area to fulfill their life cycle. Therefore, it is of critical importance to the long-term viability of the SR winter-run Chinook salmon, CV spring-run Chinook salmon ESU, the southern DPS of green sturgeon, and the CCV steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat through the action area.

B. Factors Affecting the Species and Habitat in the Action Area

The action area encompasses a small portion of the area utilized by the SR winter-run and CV spring-run Chinook salmon ESUs, and the CCV steelhead DPS as well as the Southern DPS of North American green sturgeon. Many of the factors affecting these species throughout their range are discussed in the *Status of the Species and Critical Habitat* section of this BO, and are considered the same in the action area. This section will focus on the specific factors in the action area that are most relevant to the proposed project.

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks to avoid overwhelming the flood control structures downstream of the reservoirs (*i.e.* levees and bypasses). Consequently, managed flows in the mainstem of the river often truncate the peak of the flood hydrograph and extended the reservoir releases over a protracted period. These actions reduce or eliminate the scouring flows necessary to mobilize gravel and clean sediment from the spawning reaches of the river channel.

High water temperatures also limit habitat availability for listed salmonids in the lower San Joaquin River. High summer water temperatures in the lower San Joaquin River can exceed 72°F, and create a thermal barrier to the migration of adult and juvenile salmonids (Myers *et al*. 1998). In addition, water diversions at the dams (*i.e.* Friant, Goodwin, La Grange, Folsom, Nimbus, and other dams) for agricultural and municipal purposes have reduced in-river flows below the dams. These reduced flows frequently result in increased temperatures during the critical summer months which potentially limit the survival of juvenile salmonids (Reynolds *et al*. 1993) in these tailwater sections.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and shaded riverine aquatic (SRA) cover. Individual bank protection sites typically range from a few hundred to a few thousand linear feet in length. Such bank protection generally results in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat. Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in LWM.

The use of rock armoring limits recruitment of LWM (*i.e.*, from non-riprapped areas), and greatly reduces, if not eliminates, the retention of LWM once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of LWM to become securely snagged and anchored by sediment. LWM tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place to generate maximum values to fish and wildlife (USFWS 2000). Recruitment of LWM is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectedness of remaining near shore refuge areas.

Point and non-point sources of pollution resulting from agricultural discharge and urban and industrial development occur upstream of and within the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Critical Habitat* section. Environmental stressors as a result of low water quality can lower reproductive success and may account for low productivity rates in fish (*e.g.* green sturgeon, Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (*i.e.* heavy metals) concentrations may deleteriously affect early life-stage survival of fish in the San Joaquin River (USFWS 1995b). The high numbers of diversions in the action area on the San Joaquin River and in the south Delta are also potential threats to listed fish within the action area. Other impacts to adult migration present in the action area, such as migration barriers, water conveyance facilities, water quality, NIS, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

As previously stated in the *Status of the Species and Critical Habitat* section, the transformation of the San Joaquin River from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the river's sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation in the Delta likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

VI. EFFECTS OF THE PROPOSED ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Regulations that implement section 7(b)(2) of the ESA require consultations to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require BOs to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536). This BO does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02, which was invalidated by *Gifford Pinchot Task Force v. USFWS*, 378 F.3d 1059 (9th Cir. 2004), amended by 387 F.3d 968 (9th Cir. 2004). Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This BO assesses the effects of the proposed action on endangered SR winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, and the threatened Southern DPS of North American green sturgeon and the designated critical habitat for each of these listed anadromous fish species (except CV spring-run Chinook salmon), respectively.

In the *Description of the Proposed Action* section of this BO, NMFS provided an overview of the action. In the *Status of the Species and Critical Habitat* and *Environmental Baseline* sections of this BO, NMFS provided an overview of the threatened and endangered species and critical habitats that are likely to be adversely affected by the activity under consultation.

NMFS generally approaches the "jeopardy" and critical habitat modification analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed action on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; or decreasing the age at which individuals stop reproducing). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

To conduct this assessment, NMFS examined information from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, government and non-government reports, the BA for this project, and supplemental material provided by the applicant in response to questions asked by NMFS.

B. Assessment

1. Project-level actions

a. *Reoperation of Friant Dam*

Water releases up to 1,660 cfs will be made from Friant Dam to meet the Interim and Restoration Flows as set forth in the Settlement and described in the proposed action. Overall, these releases will improve conditions for listed fish within the San Joaquin River upstream of the Merced River confluence because this section of the river was often dry prior to the initiation of Interim flow releases in 2009. Due to the uncertainties regarding seepage, levee stability and subsidence, the amount of suitable anadromous fish habitat that will be created by the 1,660 cfs releases is difficult to assess. A flow of 2,000 cfs was identified in the SJRRP: Framework for Implementation (SJRRP 2012b) as the lowest flow level that will provide "sufficient" habitat conditions for anadromous fishes to complete their life cycle. The beneficial effects to steelhead and other anadromous fishes from implementation of the full Restoration Flows are described under the *Program-level actions: Reoperation of Friant Dam* section of this BO.

Monitoring indicates that steelhead do not currently use the restoration area (Portz *et. al.* 2012). The primary impact to steelhead from increased flows in the restoration area is the potential that adult steelhead will migrate into the restoration area prior to completion of the site specific projects that will improve habitat conditions and provide fish passage to the spawning grounds. However, it is not expected that releases of 1,660 cfs will influence the migratory behavior of steelhead because the increase in flow experienced at the Merced River confluence is within the range of natural flows during flood conditions. During non-flood conditions, release of flows up to 1,660 cfs from Friant Dam could increase flows by an average of up to 220 cfs at the Merced River confluence beginning on February 1, but again the potential increase in flow falls within the natural variability of flows that steelhead currently experience. The Hills Ferry Barrier will be operated from October through mid-December which will prevent adult steelhead from entering the restoration area. The ongoing steelhead monitoring program is designed to assess whether steelhead are present in the system with emphasis on the timeframe after the Hills Ferry Barrier is removed. If steelhead are detected within the restoration area, Reclamation will notify NMFS immediately and consult with NMFS on further action.

If steelhead begin using the restoration area impacts to the species could occur from poor water quality, high water temperatures and disease. Pollutants from agricultural runoff found in the river will continue at an unpredictable level but the SJRRP water quality monitoring results for 2009 and 2010 indicate that under the current flow releases, water quality constituents of concern for aquatic life, (*i.e.* pesticides, mineral contaminants, heavy metals) do not exceed the biological thresholds set by the Environmental Protection Agency under the Clean Water Act (SJRRP 2010, 2011, 2012a) to protect fishes, including salmon, steelhead and sturgeon. Increased flows may dilute the effect of water pollutants or exacerbate the contaminant levels by suspending contaminated sediments. This potential effect cannot be fully quantified especially for the proposed 1,660 cfs release. Reclamation modeled electrical conductivity (EC) as a surrogate for water quality to assess changes from baseline conditions to conditions under full Restoration Flows, which is evaluated under the program-level actions. Water temperature modeling within the restoration area indicates improvements in water temperature from the SJRRP implementation. The details of potential water quality, temperature and disease impacts to steelhead are evaluated under the program level action.

Increased flows in the mainstem San Joaquin River and the south Delta will potentially improve conditions for both juvenile and adult steelhead by improving water quality conditions, migration cues and improved juvenile outmigration success. Potential impacts to steelhead occupying the mainstem San Joaquin River could come from increased water temperatures, increased water pollutants moving into the San Joaquin River from the upper San Joaquin River. Because the 1,660 cfs flow schedule will result in little change in flows at the Merced River confluence, temperatures and water quality are unlikely to appreciable change.

Impacts to CCV steelhead may occur in the tributaries (Stanislaus, Tuolumne, and Merced rivers) due to the water quality and flow requirements at Vernalis (lower San Joaquin River). Before implementation of the SJRRP, San Joaquin River water quality and flow requirements, including juvenile salmonid migration flows (Vernalis Adaptive Management Program) were met through releases from the three San Joaquin River tributaries. With the reoperation of Friant Dam, the San Joaquin River will contribute to meeting the water quality and flow requirements in the lower San Joaquin River which could mean that less water is released on the tributaries. Reclamation conducted a sensitivity analysis using the 2008 USFWS CVP/SWP Operations BO (USFWS 2008) and 2009 CVP/SWP BO (NMFS 2009a) reasonable and prudent alternatives (RPA) to evaluate any potential changes in flow on the San Joaquin River tributaries and in the Delta which might trigger changes in water diversions at the CVP/SWP Delta pumping facilities (Reclamation 2011). This modeling analysis indicates that reductions in tributary flows could occur on rare occasions and are not outside the range of naturally occurring flow levels the steelhead currently experience. In addition, even though the potential for less flow in the tributaries exists, the analysis indicates that flow levels will still meet the life history requirements for the species. In addition, Reclamation will routinely coordinate with NMFS regarding flows at Vernalis and will take actions necessary to prevent SJRRP flow releases from reducing tributary flows.

Adult and juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and North American green sturgeon use the south Delta portion of the action area primarily as a migration corridor (see the *Status of the Listed Species and Critical Habitat* and *Environmental Baseline* sections). Reoperating Friant Dam will increase flows entering the Delta from the San Joaquin River which could potentially trigger additional pumping at the CVP/SWP Delta pumping facilities during certain time periods, but overall CVP/SWP Delta operations will remain within the parameters set forth in the 2009 CVP/SWP BO (NMFS 2009a) and as such will not create additional impacts to these species in the Delta.

b. *Reoperation of Flow Control Structures*

Because no listed species occur within the restoration area, reoperation of the Chowchilla Bifurcation Structure to convey Interim and Restoration Flows up to 1,660 cfs will not impact listed species. If monitoring indicates that steelhead are present in the restoration area, consultation will be reinitiated.

c. *Operation and Monitoring at Hills Ferry Barrier*

The impacts to listed species from the installation of the Hills Ferry Barrier are covered under consultation with the U.S Corps of Engineers permit (2006/04665). The impacts of operation and monitoring at the Hills Ferry Barrier are covered under a Section 4d ESA permit with the CDFG (Permit #16106). The operation of the barrier will prevent steelhead from entering the restoration area during part of the adult steelhead migration period, which is beneficial to the species because river habitat conditions are not suitable for successful migration to and from their spawning grounds in the upper river at this time.

d. *Establish Recovered Water Account and Program*

The recovered water account and program is purely an accounting of water that will be made available to Friant water users through the SJRRP. The account and program themselves do not affect listed species. The potential impacts to species will occur within the specific function of recapturing Interim and Restoration Flows which will be accounted for within the recovered water account and are analyzed in the next section.

f. *Recapture Interim and Restoration Flows*

Recapture of Interim and Restoration Flows will occur at existing facilities in the restoration area and in the Delta. Recapture at Mendota Pool and the East Bear Creek Unit could impact steelhead in two primary ways; stranding due to reductions in downstream flows and entrainment into unscreened diversions. Because recapture within the restoration area could prevent the flow targets from being met, recapture within the restoration area will only occur if necessary to avoid interfering with in-channel construction activities associated with the restoration goal, or avoid potential material adverse impacts from groundwater seepage, or for other emergency actions to avoid immediate adverse impacts. Because steelhead do not currently occupy the restoration area, entrainment into these diversions will not occur. Likewise, because steelhead do not currently occupy the channels downstream of these two structures, potentially reduced instream flows will not impact the species.

SJRRP flows at or below a 1,660 cfs release from Friant Dam in the Delta are low or zero during most of the steelhead adult migration period so impacts to the species are unlikely. However, SJRRP flows in the Delta are highest during the juvenile steelhead migration period. Increased pumping at the Delta facilities for recapture could potentially increase reverse flows in Old and Middle rivers (OMR) which potentially increase entrainment of juvenile steelhead at the CVP and SWP facilities. However, the NMFS 2009 BO for CVP/SWP long-term operations contains specific restrictions on reverse flows in OMR to protect steelhead. Because the Interim and Restoration Flows reaching the Delta will be recaptured at the existing Jones and Banks pumping facilities within the Delta consistent with applicable laws, regulations, BOs, and court orders in place at the time the water is recaptured, no additional impacts to listed species are anticipated from recapturing Interim and Restoration Flows in the Delta.

2. Program-level actions

Program level action impacts are evaluated here at a cursory level because sufficient details are not available at this time to evaluate impacts. Each specific SJRRP action implemented in the future will undergo separate evaluation under ESA consultation. General effects from each program action are described in this section.

a. *Reoperate Friant Dam*

Water releases will be made from Friant Dam to meet the Interim and Restoration Flows as set forth in the Settlement and described in the proposed action. Overall, these releases will improve conditions for listed fish within the San Joaquin River upstream of the Merced River confluence because this section of the river was often dry prior to the initiation of Interim Flow releases in 2009. Year-round continuous baseflow in the San Joaquin River under the proposed action will provide river flow connectivity between the restoration area and the San Joaquin River section below the Merced River confluence, and remove some barriers that restrict fish movement, thus increasing habitat availability in all reaches of the restoration area. Increased flows upstream from the Merced River confluence may trigger adult CCV steelhead migrating toward the Merced River to continue into the San Joaquin River upstream to the restoration area, and will improve access to suitable habitats. Perennial flow will increase the quantity and quality of floodplain riparian and in-channel aquatic habitat in all reaches of the restoration area. Access to new habitat could lead to the establishment of a new steelhead population which could improve the CCV steelhead DPS. In years when flow will not result in full connectivity, measures will be in place to reduce impacts to steelhead. These measures include: (1) operation and maintenance of the Hills Ferry Barrier, (2) and a trap and haul program to move adults upstream and/or juveniles downstream through reaches that they cannot migrate through. The impacts of implementing a trap and haul program will be evaluated in a subsequent ESA consultation.

Once CCV steelhead are established in the restoration area impacts to the species and their habitats could occur from poor water quality, high water temperatures, and disease. Pollutants from agricultural runoff found in the river will continue at an unpredictable level but SJRRP water quality monitoring results for 2009 and 2010 indicate that under the current flow releases, water quality constituents of concern for aquatic life (*i.e.* pesticides, mineral contaminants, heavy metals) do not exceed thresholds (SJRRP 2010, 2011, 2012). Increased flows may dilute the effect of water pollutants or exacerbate the contaminant levels by suspending contaminated sediments. Reclamation modeled electrical conductivity (EC) as a surrogate for water quality to assess changes from baseline conditions to conditions under full Restoration Flows. This modeling indicated no differences in Reaches 1, 2, and 4 and a reduction in EC in Reaches 3 and 5 under all water year types (see Appendix H, “Modeling” in the Draft PEIS/R; Reclamation and DWR 2011). This would indicate that overall, water quality conditions within the restoration area will improve with project implementation which will improve habitat conditions for steelhead. Further evaluation will be needed to identify any specific water quality constituents that may cause deleterious effects to steelhead.

The SJR5Q water temperature modeling indicates overall improvements in water temperatures from the reoperation of Friant Dam (see Appendix H, “Modeling,” of the Draft PEIR/S; Reclamation and DWR 2011). Even though water temperatures will improve from pre-project conditions, temperatures will not be suitable for CCV steelhead or other salmonids during certain times of the year, under various water year types, in specific reaches of the river. The Interim Flows monitoring program collected water temperature data throughout the restoration area in 2009 and 2010. Data indicated that in Reach 1A water temperatures tended to remain below 60◦ F until Balls Ranch Bridge (SJRRP 2011; see temperature graphs on http://www.restoresjr.net/flows/Water%20Quality). These data indicate that water temperatures will be suitable but not always optimal in this reach where CCV steelhead spawning, egg incubation and emergence, and juvenile and adult holding, are most likely to occur. Downstream from Balls Ferry Ranch Bridge water temperatures remain below 60˚ F in the winter and early spring but increase rapidly in April and May depending on flow levels. Elevated water temperatures in the spring during the juvenile migration period could inhibit juvenile steelhead smoltification and reduce successful migration out of the San Joaquin River.

Reoperating Friant Dam to release Interim and Restoration Flows will provide access for CCV steelhead to all reaches of the San Joaquin River, which has the potential to increase the risk of disease transmission between steelhead and the resident/hatchery reared rainbow trout in the San

Joaquin River near Friant Dam. *Myxobolus cerebralis* is a parasite that causes whirling disease in salmonids which is transmitted by the oligochaete host *Tubifex tubifex* (Wagner 2002). There is an aquatic worm harvesting operation at the San Joaquin Fish Hatchery, where the worms feed on solid waste from the hatchery's effluent. CDFG conducted preliminary investigations on the species composition at the site to assess potential disease issues in 2009. Only a small percentage of the Oligochates present were tubifex (Paul Adelizi, pers. com. as cited in Reclamation 2011), which indicates that the risk for whirling disease is small but possible. This issue will be further evaluated during the planning process for the new proposed Conservation Facility.

Impacts to CCV steelhead may occur in the tributaries (Stanislaus, Tuolumne, and Merced rivers) due to the water quality and flow requirements at Vernalis (lower San Joaquin River). Before implementation of the SJRRP, San Joaquin River water quality and flow requirements, including juvenile salmonid migration flows (Vernalis Adaptive Management Program) were met through releases from the three San Joaquin River tributaries. With the reoperation of Friant Dam, the San Joaquin River will contribute to meeting the water quality and flow requirements in the lower San Joaquin River which could mean that less water is released on the tributaries. Reclamation conducted a sensitivity analysis using the 2008 USFWS CVP/SWP Operations BO (USFWS 2008) and 2009 CVP/SWP BO (NMFS 2009a) reasonable and prudent alternatives (RPA) to evaluate any potential changes in flow on the San Joaquin River tributaries and in the Delta which might trigger changes in water diversions at the CVP/SWP Delta pumping facilities (Reclamation 2011). This modeling analysis indicates that reductions in tributary flows could occur on rare occasions and are not outside the range of naturally occurring flow levels the CCV steelhead currently experience. In addition, even though the potential for less flow in that tributaries exists, the analysis indicates that flow levels will still meet the life history requirements for the steelhead as well as Chinook salmon. In addition, Reclamation will routinely coordinate with NMFS regarding flows at Vernalis and will take actions necessary to prevent SJRRP flow releases from reducing tributary flows.

As described in the *Project-level actions* section of this BO, impacts to CCV steelhead and their habitat are not expected in the San Joaquin River tributaries, the lower mainsteam San Joaquin River or the Delta as long as the CVP/SWP operations follow the operations and actions from the 2009 CVP/SWP BO (NMFS 2009a).

b. *Reoperate Downstream Flow Control Structures*

In order to route Interim and Restoration Flows through the restoration area, Reclamation proposes to reoperate the Lower San Joaquin River Control Flood Control Project and the Hills Ferry Barrier. The reoperation of the Chowchilla Bifurcation Structure and the Hills Ferry Barrier are analyzed in the *Project-level actions* section of this BO. The reoperation of the San

Joaquin River Headgate and the Eastside and Mariposa bypass bifurcation structures to convey flows into Reach 4B1 and Reach 4B2 will not occur until Reach 4B1 and 4B2 channel conveyance, seepage and levee stability issues are resolved in these sections of the river/bypass. The Reach 4B Project planning process will further define the reoperation of these structures dependent on the decision regarding flow routing through Reach 4B. The potential impacts to anadromous fishes from reoperation of these structures primarily involve fish passage impediment, creation of predator habitat, and vegetation management. These impacts from reoperating these structures will be addressed and evaluated during the ESA consultation process for the Reach 4B Project.

c. *Recapture Interim and Restoration Flows*

Recapture in the restoration area and Delta is evaluated in the *Project-level actions* section of this BO. The proposed action also includes recapture of Interim and Restoration Flows in the San Joaquin River downstream of the Merced River confluence (*i.e.* downstream of the restoration area) at existing facilities and potential new facilities.

Recapture at existing facilities on the San Joaquin River that will not require structural modifications, are screened to NMFS fish criteria, have undergone ESA consultation regarding the facilities operations, and are unlikely to cause any additional impacts to listed species. Recapture at existing facilities on the San Joaquin River that will require structural modifications would potentially impact steelhead through short-term construction impacts, entrainment in unscreened or inadequately screened diversions, and river flow alterations. Construction related effects could include: increases in stormwater discharges or turbidity; removal of vegetation; noise; vibration; and other physical changes. Operations of these facilities will fall within the current operational requirements at each diversion, so additional impacts to listed species will not occur from diversion operations.

Recapture at new facilities could result in effects to CCV steelhead from: changes in flow patterns; flow fluctuations; alterations to temperature; entrainment of fish at unscreened diversions; stress or mortality of fish from contact with fish screens; structural changes that could alter predation; false emigration pathways; or contaminant mobilization. The magnitude of effects to listed species dependent on the project locations, the utilization of the facilities, timing, seasonality of use, maintenance, or other issues is not available at this time. Reclamation will consult with NMFS regarding future actions related to the recapture of Interim and Restoration Flows and incorporate measures to avoid and/or reduce effects to species.

d. *Recirculate Recaptured Interim and Restoration Flows*

The recirculation of Interim and Restoration Flows involves the banking, storage, exchange, selling and/or transfer of water. This movement of water will occur within the realm of the Settlement requirements so as a stand-alone action will not affect listed fish. Paragraph 13 (i) also specifies the release or water from Friant Dam during times of the year other than those specific in the applicable hydrograph. The specifics of these releases are unknown at this time, but will likely improve summer conditions for juvenile steelhead within the restoration area.

e. *Common Restoration Actions*

The common restoration actions defined in Paragraph 11 and 14 of the Settlement are intended to improve habitat conditions in the restoration area of the San Joaquin River so that fall-run and spring-run Chinook salmon can be reintroduced to the restoration area. The primary impacts to listed species from these activities will be short-term impacts related to construction activities. Because these impacts are occurring within the restoration area they will not affect winter-run Chinook salmon, spring-run Chinook salmon, or green sturgeon.

Paragraph 11(a) Common Phase 1 Actions involve large construction actions to build a bypass around Mendota Pool, increase the capacity of Reach 2B to 4,500 cfs with floodplain creation, modifications to Reach 4B1 to convey at least 475 cfs and up to 4,500 cfs, and modifications to structures in the Eastside and Mariposa bypasses and establishment of a low-flow channel through the bypasses to ensure fish passage. Construction activities could result in increases in stormwater discharges or turbidity, vegetation removal, equipment spills affecting water quality, interruption in river flow continuity, noise, vibration and other physical alterations. Steelhead are not likely to inhabit the restoration area during these constructions activities and as such are unlikely to be affected by these activities. The proposed conservation measures will be incorporated into these activities to reduce or eliminate any impacts to anadromous fish habitat. Each site specific project will undergo separate ESA consultation to address potential impacts to listed species.

Paragraph 11(b) Common Phase 2 Actions could involve construction activities to modify the Chowchilla Bypass and a number of mining pits to improve conditions for anadromous fishes. Modifying or screening the Chowchilla Bypass Structure to prevent juvenile entrainment and/or improve fish passage will involve a large construction project. Construction activities could result in habitat impacts as described above. Again, steelhead are unlikely to inhabit the restoration area and as such are unlikely to be affected by these activities. Monitoring to evaluate juvenile salmonid entrainment and stranding will involve handling or possible transport of any captured fish. Construction and/or monitoring related to juvenile salmonid entrainment and stranding will be further evaluated in subsequent ESA consultations. Re-grading, isolation or filling of gravel pits will involve large construction activities spanning the potential impacts as described earlier. Again conservation measures will be in place to reduce and minimize impacts, including construction occurring during the low-flow period (June 1 through October 1) when the active channel could be isolated from construction activities.

Paragraph 12 Common Activities involve potential modifications to floodplain or side-channel habitat beyond Reaches 2B or 4B1, enhancing in-channel fish habitat to improve water temperatures, cover and spawning habitat, improving fish passage and flow conveyance at flow control structures, and/or screening diversions. These construction activities could impact habitat in ways described above and again the conservation measures will be implemented to avoid or reduce impacts to steelhead and their habitats. Some of these activities might occur later in the SJRRP implementation timeframe, which could mean that steelhead would occupy the restoration area during construction activities. Subsequent project specific ESA consultations will address potential impacts.

3. Physical Monitoring and Management Plan

Monitoring for flow and groundwater level, and vegetation surveys will have little to no effect on steelhead and its habitat unless this monitoring requires the installation of monitoring equipment within the stream channel. Installation of monitoring equipment within the stream channel will affect a small area for a short period of time, but could cause some short-term physiological impacts to fish within the area from noise, turbidity and/or ground disturbance. Monitoring of spawning gravel and sediment mobilization will require work within the channel causing temporary disturbance of sediment and gravel, which in turn could cause temporary turbidity.

The management actions that would occur from monitoring results could involve: flow manipulation; construction of seepage berms or tile drains or sediment traps or grade control structures; native vegetation planting; and spawning gravel manipulation and/or augmentation. Where, when and how these actions would be implemented is undefined at this point, thus describing the effects of these actions in a meaningful way in this BO would be speculative. Subsequent project specific ESA consultations will address potential impacts.

VII. 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 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 consultations pursuant to section 7 of the ESA.

A. Agricultural Practices

Agricultural practices in the San Joaquin River and Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the San Joaquin River and Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the San Joaquin River and Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000; Daughton 2003).

B. Increased Urbanization

The Delta, East Bay, and Sacramento regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, are expected to increase in population by nearly three million people by the year 2020. Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. For example, the General Plans for the cities of Stockton, Brentwood, Lathrop, Tracy and Manteca and their surrounding communities anticipate rapid growth for several decades to come. The City of Manteca (2007) anticipated 21 percent annual growth through 2010 reaching a population of approximately 70,000 people. The City of Lathrop (2007) expects to double its population by 2012, from 14,600 to approximately 30,000 residents. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east and Highway 205/120 in the south and west. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits, and thus will not undergo review through the ESA section 7 consultation processes with NMFS.

Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn will reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation in the San Joaquin River and Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the San Joaquin River and Delta.

C. Global Climate Change

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

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

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

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 35.6°F and 44.6°F by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by precipitation rather than snowfall. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This will truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.* SR winter-run Chinook salmon and CCV steelhead) that must hold below the dam over the summer and fall periods.

Within the context of the brief period over which the proposed project is scheduled to be constructed and operated, however, the near term effects of global climate change are unlikely to result in any perceptible declines to the overall health or distribution of the listed populations of anadromous fish within the action area that are the subject of this consultation.

VII. INTEGRATION AND SYNTHESIS

This section integrates the current conditions described in the environmental baseline with the effects of the proposed action and the cumulative effects of future actions. The purpose of this synthesis is to develop an understanding of the likely short term and long term response of listed species and critical habitat to the proposed project.

A. Summary of Current Conditions and Environmental Baseline

The *Status of Species and Critical Habitat* and *Environmental Baseline* sections show that past and present impacts to the Sacramento and San Joaquin river basins and the Delta have caused significant salmonid and green sturgeon habitat loss, fragmentation and degradation. This has significantly reduced the quality and quantity of freshwater rearing sites and the migratory corridors within the lower valley floor reaches of the Sacramento and San Joaquin rivers and the Delta region for these listed species. Additional loss of freshwater spawning sites, rearing sites, and migratory corridors have also occurred upstream of the Delta in the upper main stem and tributaries of the Sacramento and San Joaquin River basins.

Anthropogenic activities in Central Valley watersheds have contributed substantially to declines in SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and Southern DPS green sturgeon populations. In the Sacramento River basin, the winter-run Chinook salmon ESU has been reduced to one population spawning below Keswick Dam. Access to upper elevation watersheds in the Sacramento River basin have been severely curtailed for spring-run Chinook salmon and CCV steelhead by the construction of large dams on the foothill sections of the valley's major tributaries. These rim dams effectively block access of anadromous fish, including salmonids and sturgeon to the entire watershed above the dams since effective fishways and ladders are non-existent at this time. Construction of large dams on the major tributaries found in the San Joaquin River basin led to the extirpation of the endemic CV spring-run Chinook salmon populations found in the basin's watersheds. The last self-sustaining population of spring-run Chinook salmon in the San Joaquin River basin was extirpated by the completion of Friant Dam and the Kern and Friant canals in the late 1940s. The populations of steelhead that historically inhabited these various watersheds have also been severely reduced in number, with only a few small populations remaining in the tailwaters below the dams. The operations of dams have reduced the extent of suitable water temperatures for over summering steelhead juveniles to the tailwaters immediately below these dams. In some cases the water temperatures reach incipient lethal temperatures only a few miles downstream of the dams. Alterations in the geometry of the Delta channels, removal of riparian vegetation and shallow water habitat, construction of armored levees for flood protection, changes in river flow created by demands of water diverters (including pre-1914 riparian water right holders, CVP and SWP contractors, and municipal entities), and the influx of contaminants from agricultural and urban dischargers have substantially reduced the functionality of the action area's aquatic habitat. The proposed action, the implementation of the SJRRP, will take place over the next 13 years and overall will improve conditions in the San Joaquin River for listed fish. Temporary impacts to steelhead may occur primarily from construction activities, but conservation measures will be in place to reduce and/or eliminate those impacts.

B. Summary of Effects of the Proposed Action

The proposed project, the SJRRP, is not likely to adversely affect SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and Southern DPS green sturgeon. The potential impacts that may occur will occur primarily to CCV steelhead once they occupy the restoration area. These potential impacts occur primarily from construction, flow management and monitoring actions. All actions that would potentially impact listed species will undergo subsequent ESA consultation.

1. Sacramento River Winter-run Chinook Salmon

Recapture of Interim and Restoration Flows at the CVP/SWP Delta pumping facilities is the action that has the most potential to affect SR winter-run Chinook salmon. Because recapture will occur within the permitted operations for CVP/SWP under separate consultation with NMFS, no additional impacts to the species will occur from this action.

2. Central Valley Spring-run Chinook Salmon

Recapture of Interim and Restoration Flows at the CVP/SWP Delta pumping facilities is the action that has the most potential to affect CV spring-run Chinook salmon. Because recapture will occur within the permitted operations for CVP/SWP under separate consultation with NMFS, no additional impacts to the species will occur from this action.

3. California Central Valley Steelhead

The release of 1,660 cfs from Friant Dam will improve conditions for steelhead within the restoration area and in the lower San Joaquin River. Because steelhead do not currently occupy the restoration area, any actions occurring within the restoration area will not affect steelhead. Some of the proposed actions will likely occur after steelhead have become established within the restoration area at which time impacts to the species are likely to occur. Impacts related to construction and monitoring are temporary in nature and with incorporation of conservation measures will cause minimal affects to steelhead. Impacts related to flow manipulation could impact steelhead depending on where they are located within the system and their life stage. The specifics of these flow manipulations are impossible to predict but will be subject to ESA consultation.

4. Southern DPS North American Green Sturgeon

Recapture of Interim and Restoration Flows at the CVP/SWP Delta pumping facilities is the action that has the most potential to affect Southern DPS green sturgeon. Because recapture will occur within the permitted operations for CVP/SWP under separate consultation with NMFS, no additional impacts to the species will occur from this action.

5. Effects of the Project on Designated Critical Habitat

As mentioned previously, designated critical habitat for CV spring-run Chinook salmon does not occur within the action area. Recapture of Interim and Restoration Flows at the CVP/SWP Delta pumping facilities is the action that has the most potential to affect designated critical habitat for SR winter-run Chinook salmon and Southern DPS green sturgeon which occurs in the south Delta. Because recapture will occur within the permitted operations for CVP/SWP under separate consultation with NMFS, no additional impacts to the critical habitat for these two listed species will occur from this action. Critical habitat for CCV steelhead does not occur within the restoration area. Impacts to designated critical habitat for CCV steelhead could occur from construction and flow manipulation related to water recapture facilities on the lower San Joaquin River. BMPs, conservation measures and water diversion screening criteria will be incorporated into modifications to existing diversions or building of new diversions to reduce potential impacts to critical habitat. Potential flow modifications and the associated impacts cannot be predicted at this time, so impacts cannot be evaluated.

VIII. CONCLUSION

Implementation of the SJRRP as described previously in this BO, combined with the current status of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the Southern DPS of green sturgeon, the environmental baseline for the action area, the anticipated direct, indirect, and cumulative effects of the proposed action, it is NMFS' Biological Opinion that implementation of the SJRRP Preferred Alternative C1 is not likely to jeopardize the continued existence of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or Southern DPS of green sturgeon. NMFS has also determined that the action, as proposed, is not likely to destroy or adversely modify critical habitat for these species.

This no-jeopardy determination, at the project and programmatic scale, is not intended to, nor does it preclude NMFS from making future jeopardy determinations based on the effects analysis for specific implementation actions. Due to the programmatic nature of this BO, the project and action-specific information (other than for the project specific actions covered in this BO) necessary to determine the amount and extent of incidental take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and/or Southern DPS of green sturgeon associated with individual SJRRP actions is lacking. NMFS has determined that take will not occur due to the project specific actions analyzed in this BO. Therefore, incidental take of these listed anadromous fishes is not authorized in this programmatic BO. Thus, the Federal Implementing Agencies will initiate individual section 7 consultations with NMFS for specific implementation actions which may affect these listed anadromous salmonids and sturgeon. Future BOs that are tiered under this programmatic opinion will estimate, evaluate, and authorize the amount and extent of incidental take associated with action specific plans that cannot be avoided or mitigated and will not preclude survival and recovery of listed species.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without 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 NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

NMFS anticipates that the proposed action will ***not*** result in the incidental take of individuals from the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon ESUs, the Central Valley steelhead DPS, and the Southern DPS of North American green sturgeon. As such, this BO does not authorize incidental take of those species; terms and conditions, and reasonable and prudent measures are unnecessary, so not included in this ITS. The BOR must inform NMFS immediately if incidental take occurs due to the proposed action which will trigger reinitiation of consultation.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations include discretionary measures that Reclamation can take to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat, as follows:

1. Operation of the Hills Ferry Barrier or another barrier or fish passage assistance that will reduce the likelihood that adult steelhead will migrate into the project areas where they are likely to encounter adverse conditions.

2. Continue monitoring specifically for steelhead in Reach 5 of the restoration area until steelhead monitoring can be integrated into the larger monitoring program for Chinook salmon.

3. Reclamation should initiate a single ESA consultation (when possible) covering all studies proposed in the Monitoring and Analysis Plan that have the potential to affect listed fish species well in advance of study implementation.

4. Subsequent reach specific project ESA consultations should evaluate both the construction and operations of those projects.

5. Where practicable Reclamation should combine projects for ESA consultation to reduce NMFS consultation workload and accurate analysis of effects to listed species.

6. Reclamation should continue coordinating the completion of the Restoration Flow Guidelines. It is important that these guidelines include all operational aspects of Friant Dam as they relate to protecting anadromous fishes and their habitats.

7. Buffer flows, acquired water and flexible flow periods should be used to benefit Chinook salmon and steelhead habitats and optimize conditions for the completion of these species life cycles.

8. If flows are released from Friant Dam during other times than those specified in the applicable flow schedule, Reclamation should consider the needs of anadromous fishes when determining the timing and pattern of those releases.

9. Minimize pesticide (herbicide) use to control invasive vegetation. The combinations of pesticides and surfactants can cause significant effects to aquatic species.

10. Reclamation should continue close coordination with NMFS regarding all Friant Dam operations and their relationship to the operations of the larger Central Valley and State Water projects.

11. When designing site specific projects consider a holistic approach that minimizes fish passage structures along the migratory corridor.

12. Evaluate aquatic and avian fish predators and design projects to reduce and/or eliminate predation of anadromous fishes.

13. Develop a system-wide plan for recapturing Interim and Restoration Flows that closely considers the potential impacts to anadromous fishes and their habitats and minimizes negative impacts to those fish.

14. Fisheries related actions should be vetted through the Adaptive Management process as described in the SJRRP Fisheries Management Plan.

XI. REINITIATION OF CONSULTATION

This concludes consultation on the implementation of Alternative C1 for the SJRRP as described in the August 2012 Final EIR/S. As provided in 50 CFR § 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if (1) the amount or extent of incidental take specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action area is subsequently modified in a manner that causes an effect to ESA-listed species or critical habitat that was not considered in the BO; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. This project/programmatic BO does not provide incidental take authorization. However, it is expected that the Federal implementation agencies for the SJRRP will initiate consultation with NMFS for actions/activities which may affect listed anadromous salmonids and sturgeon.

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APPENDIX A : Tables

Table 1: The annual occurrence of juvenile Southern DPS of North American green sturgeon at the CVP and SWP fish collection facilities in the south Delta. (Adams et al, (2007), CDFG 2002)

Year	State Facilities		Federal Facilities	
	Salvage Numbers	Numbers per 1000 acre feet	Salvage Numbers	Numbers per 1000 acre feet
1968	12	0.0162		
1969	0	0		
1970	13	0.0254		
1971	168	0.2281		
1972	122	0.0798		
1973	140	0.1112		
1974	7,313	3.9805		
1975	2,885	1.2033		
1976	240	0.1787		
1977	14	0.0168		
1978	768	0.3482		
1979	423	0.1665		
1980	47	0.0217		
1981	411	0.1825	274	0.1278
1982	523	0.2005	570	0.2553
1983	1	0.0008	1,475	0.653
1984	94	0.043	750	0.2881
1985	3	0.0011	1,374	0.4917
1985	0	0	49	0.0189
1987	37	0.0168	91	0.0328
1988	50	0.0188	0	0
1989	0	0	0	0
1990	124	0.0514	0	0
1991	45	0.0265	0	0
1992	50	0.0332	114	0.0963
1993	27	0.0084	12	0.0045
1994	5	0.003	12	0.0068
1995	101	0.0478	60	0.0211
1996	40	0.0123	36	0.0139
1997	19	0.0075	60	0.0239
1998	136	0.0806	24	0.0115
1999	36	0.0133	24	0.0095
2000	30	0.008	0	0
2001	54	0.0233	24	0.0106
2002	12	0.0042	0	0
2003	18	0.0052	0	0
2004	0	0	0	0
2005	16	0.0044	12	0.0045
2006	39	0.0078	324	0.1235

Table 2. Salmon and Steelhead monitoring programs in the Sacramento - San Joaquin River basins, and Suisun Marsh.

Geographic Region	**Species**	**Watershed**	**Methods**	**Geographic Area Covered**	**Monitoring Parameters**	**Monitoring Period**	**Implementing Agency**
Central Valley	***Chinook Salmon, Steelhead***	Sacramento River	Scale and otolith collection	Coleman National Hatchery, Sacramento River and tributaries	Scale and otolith microstructure analysis	Year-round	CDFG
		Sacramento River and San Joaquin River	Central Valley angler survey	Sacramento and San Joaquin rivers and tributaries downstream to Carquinez	In-river harvest	8 or 9 times per month, year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at Balls Ferry and Deschutes Road Bridge	Juvenile emigration timing and abundance	Year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at RBDD	Juvenile emigration timing and abundance	Year round	USFWS
		Sacramento River	Ladder counts	Upper Sacramento River at RBDD	Escapement estimates, population size	Variable, May - Jul	USFWS
		Sacramento River	Beach seining	Sacramento River, Caldwell Park to Delta	Spatial and temporal distribution	Bi-weekly or monthly, year-round	USFWS
		Sacramento River	Beach seining, snorkel survey, habitat mapping	Upper Sacramento River from Battle Creek to Caldwell Park	Evaluate rearing habitat	Random, year-round	CDFG
		Sacramento River	Rotary screw trap	Lower Sacramento River at Knight's Landing	Juvenile emigration and post-spawner adult steelhead migration	Year-round	CDFG
		Sacramento-San Joaquin basin	Kodiak/Midwater trawling	Sacramento river at Sacramento, Chipps Island, San Joaquin River at Mossdale	Juvenile outmigration	Variable, year-round	USFWS
		Sacramento-San Joaquin Delta	Kodiak trawling	Various locations in the Delta	Presence and movement of juvenile salmonids	Daily, Apr - Jun	IEP
		Sacramento-San Joaquin Delta	Kodiak trawling	Jersey Point	Mark and recapture studies on juvenile salmonids	Daily, Apr - Jun	Hanson Environmental Consultants

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	*Chinook Salmon, Steelhead, Continued*	Sacramento-San Joaquin Delta	Salvage sampling	CVP and SWP south delta pumps	Estimate salvage and loss of juvenile salmonids	Daily	USBR/CDFG
		Battle Creek	Rotary screw trap	Above and below Coleman Hatchery barrier	Juvenile emigration	Daily, year-round	USFWS
		Battle Creek	Weir trap, carcass counts, snorkel/ kayak survey	Battle Creek	Escapement, migration patterns, demographics	Variable, year-round	USFWS
		Clear Creek	Rotary screw trap	Lower Clear Creek	Juvenile emigration	Daily, mid Dec- Jun	USFWS
		Feather River	Rotary screw trap, Beach seining, Snorkel survey	Feather River	Juvenile emigration and rearing, population estimates	Daily, Dec - Jun	DWR
		Yuba River	Rotary screw trap	lower Yuba River	Life history evaluation, juvenile abundance, timing of emergence and migration, health index	Daily, Oct - Jun	CDFG
		Feather River	Ladder at hatchery	Feather River Hatchery	Survival and spawning success of hatchery fish (spring-run Chinook salmon), determine wild vs. hatchery adults (steelhead)	Variable, Apr - Jun	DWR, CDFG
		Mokelumne River	Habitat typing	Lower Mokelumne River between Comanche Dam and Cosumnes River confluence	Habitat use evaluation as part of limiting factors analysis	Various, when river conditions allow	EBMUD
		Mokelumne River	Redd surveys	Lower Mokelumne River between Comanche Dam and Hwy 26 bridge	Escapement estimate	Twice monthly, Oct 1- Jan 1	EBMUD
		Mokelumne River	Rotary screw trap, mark/recapture	Mokelumne River, below Woodbridge Dam	Juvenile emigration and survival	Daily, Dec- Jul	EBMUD
		Mokelumne River	Angler survey	Lower Mokelumne River below Comanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	*Chinook Salmon, Steelhead, Continued*	Mokelumne River	Beach seining, electrofishing	Lower Mokelumne	Distribution and habitat use	Various locations at various times throughout the year	EBMUD
		Mokelumne River	Video monitoring	Woodbridge Dam	Adult migration timing, population estimates	Daily, Aug - Mar	EBMUD
		Calaveras River	Adult weir, snorkel survey, electrofishing	Lower Calaveras River	Population estimate, migration timing, emigration timing	Variable, year-round	Fishery Foundation
		Stanislaus River	Rotary screw trap	lower Stanislaus River at Oakdale and Caswell State Park	Juvenile outmigration	Daily, Jan - Jun, dependent on flow	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel surveys, hook and line survey, beach seining, electrofishing	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence and distribution, habitat use, and abundance	Variable, Mar- Jul	CDFG
	CV Steelhead	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	Coleman National Fish Hatchery	Returns to hatchery	Daily, Jul 1 - Mar 31	USFWS
		Clear Creek	Snorkel survey, redd counts	Clear Creek	Juvenile and spawning adult habitat use	Variable, dependent on river conditions	USFWS
		Mill Creek, Antelope Creek, Beegum Creek	Spawning survey - snorkel and foot	Upper Mill, Antelope, and Beegum Creeks	Spawning habitat availability and use	Random days when conditions allow, Feb - Apr	CDFG
		Mill Creek, Deer Creek, Antelope Creek	Physical habitat survey	Upper Mill, Deer, and Antelope Creeks	Physical habitat conditions	Variable	USFS
		Dry Creek	Rotary screw trap	Miner and Secret Ravine's confluence	Downstream movement of emigrating juveniles and post-spawner adults	Daily, Nov- Apr	CDFG
		Dry Creek	Habitat survey, snorkel survey, PIT tagging study	Dry Creek, Miner and Secret Ravine's	Habitat availability and use	Variable	CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
<u>Central Valley</u>	CV Steelhead Continued	Battle Creek	Otolith analysis	Coleman Hatchery	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	USFWS
		Feather River	Hatchery coded wire tagging	Feather River Hatchery	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR
		Feather River	Snorkel survey	Feather River	Escapement estimates	Monthly, Mar to Aug (upper river), once annually (entire river)	DWR
		Yuba River	Adult trap	lower Yuba River	Life history, run composition, origin, age determination	Year-round	Jones and Stokes
		American River	Rotary screw trap	Lower American River, Watt Ave. Bridge	Juvenile emigration	Daily, Oct- Jun	CDFG
		American River	Beach seine, snorkel survey, electrofishing	American River, Nimbus Dam to Paradise Beach	Emergence timing, juvenile habitat use, population estimates	Variable	CDFG
		American River	Redd surveys	American River, Nimbus Dam to Paradise Beach	Escapement estimates	Once, Feb - Mar	CDFG, BOR
		Mokelumne River	Electrofishing, gastric lavage	Lower Mokelumne River	Diet analysis as part of limiting factor analysis	Variable	EBMUD
		Mokelumne River	Electrofishing, hatchery returns	Lower Mokelumne River, Mokelumne River hatchery	O. mykiss genetic analysis to compare hatchery returning steelhead to residents	Variable	EBMUD
		Calaveras River	Rotary screw trap, pit tagging, beach seining, electrofishing	lower Calaveras River	Population estimate, migration patterns, life history	Variable, year-round	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel survey, hook and line survey, beach seining, electrofishing, fish traps/weirs	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence, origin, distribution, habitat use, migration timing, and abundance	Variable, Jun - Apr	CDFG
		Merced River	Rotary screw trap	Lower Merced River	Juvenile outmigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
<u>Central Valley</u>	CV Steelhead Continued	Central Valley-wide	Carcass survey, hook and line survey, electrofishing, traps, nets	Upper Sacramento, Yuba, Mokelumne, Calaveras, Tuolumne, Feather, Cosumnes and Stanislaus rivers, and Mill, Deer, Battle, and Clear Creeks	Occurrence and distribution of *O. Mykiss*	Variable, year-round	CDFG
		Central Valley - wide	Scale and otolith sampling	Coleman NFH, Feather, Nimbus, Mokelumne River hatcheries	Stock identification, juvenile residence time, adult age structure, hatchery contribution	Variable upon availability	CDFG
		Central Valley - wide	Hatchery marking	All Central Valley Hatcheries	Hatchery contribution	Variable	USFWS, CDFG
	SR Winter-run Chinook salmon	Sacramento River	Aerial redd counts	Keswick Dam to Princeton	Number and proportion of reds above and below RBDD	Weekly, May 1- July 15	CDFG
		Sacramento River	Carcass survey	Keswick Dam to RBDD	In-river spawning escapement	Weekly, Apr 15- Aug 15	USFWS, CDFG
		Battle Creek	Hatchery marking	Coleman National Fish Hatchery	Hatchery contribution	Variable	USFWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	USFWS
		Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	CV Spring-run Chinook salmon	Mill, Deer, Antelope, Cottonwood, Butte, Big Chico Creeks	Rotary screw trap, snorkel survey, electrofishing, beach seining	upper Mill, Deer, Antelope, Cottonwood, Butte, and Big Chico creeks	Life history assessment, presence, adult escapement estimates	Variable, year-round	CDFG
		Feather River	Fyke trapping, angling, radio tagging	Feather River	Adult migration and holding behavior	Variable, Apr-June	DWR
		Yuba River	Fish trap	lower Yuba River, Daguerre Point Dam	Timing and duration of migration, population estimate	Daily, Jan - Dec	CDFG
<u>Suisun Marsh</u>	***Chinook salmon***	Suisun Marsh	Otter trawling, beach seining	Suisun Marsh	Relative population estimates and habitat use	Monthly, year-round	UCDavis

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Table 3: Summary table of monthly Winter-run and Spring-run Chinook salmon loss and Combined total salvage and loss of Central Valley steelhead at the CVP and SWP fish collection facilities from water year 1999-2000 to water year 2008-2009. Data from CVO web site: (http://www.usbr.gov/mp/cvo/)

Fish Facility Salvage Records (Loss)

Winter Run (loss)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	8	55	210	1654	21	0	0	NA	NA	NA	1948
2007-2008	0	0	0	164	484	628	40	0	0	NA	NA	NA	1316
2006-2007	0	0	87	514	1678	2730	330	0	0	NA	NA	NA	5339
2005-2006	0	0	649	362	1016	1558	249	27	208	NA	NA	NA	4069
2004-2005	0	0	228	3097	1188	644	123	0	0	NA	NA	NA	5280
2003-2004	0	0	84	640	2812	4865	39	30	0	NA	NA	NA	8470
2002-2003	0	0	1261	1614	1464	2789	241	24	8	NA	NA	NA	7401
2001-2002	0	0	1326	478	222	1167	301	0	0	NA	NA	NA	3494
2000-2001	0	0	384	1302	6014	15379	259	0	0	NA	NA	NA	23338
1999-2000	0	0				1592	250	0	0	NA	NA	NA	1842
Sum	0	0	4027	8226	15088	33006	1853	81	216	0	0	0	62497
Avg	0	0	447	914	1676	3301	185	8	22	0	0	0	6553
%Wr/yr	0.000	0.000	6.828	13.947	25.581	50.364	2.828	0.124	0.330	0.000	0.000	0.000	

Spring-Run (loss)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	0	0	0	333	5912	2604	4	NA	NA	NA	8853
2007-2008	0	0	0	0	15	315	6918	4673	87	NA	NA	NA	12008
2006-2007	0	0	0	0	7	190	4700	365	0	NA	NA	NA	5262
2005-2006	0	0	0	0	104	1034	8315	3521	668	NA	NA	NA	13642
2004-2005	0	0	0	0	0	1856	10007	1761	639	NA	NA	NA	14263
2003-2004	0	0	0	25	50	4646	5901	960	0	NA	NA	NA	11582
2002-2003	0	0	0	46	57	11400	27977	2577	0	NA	NA	NA	42057
2001-2002	0	0	0	21	8	1245	10832	2465	19	NA	NA	NA	14590
2000-2001	0	0								NA	NA	NA	0
1999-2000										NA	NA	NA	0
Sum	0	0	0	92	241	21019	80562	18926	1417	0	0	0	122257
Avg	0	0	0	12	30	2627	10070	2366	177	0	0	0	15282
% SR/yr	0.000	0.000	0.000	0.075	0.197	17.192	65.896	15.481	1.159	0.000	0.000	0.000	

Steelhead (combined salvage and loss, clipped and non-clipped)

Year	October	November	Dec	Jan	Feb	March	April	May	June	July	August	September	Sum
2008-2009	0	0	0	40	571	1358	210	68	13	7	NA	NA	2267
2007-2008	0	0	0	624	4639	717	300	106	24	15	NA	NA	6425
2006-2007	0	0	10	81	1643	4784	2689	113	20	NA	NA	NA	9340
2005-2006	0	0	0	129	867	3942	337	324	619	NA	NA	NA	6218
2004-2005	0	20	70	120	1212	777	687	159	116	NA	NA	NA	3161
2003-2004	0	12	40	613	10598	4671	207	110	0	NA	NA	NA	16251
2002-2003	0	0	413	13627	3818	2357	823	203	61	NA	NA	NA	21302
2001-2002	0	0	3	1169	1559	2400	583	37	42	NA	NA	NA	5793
2000-2001	0	0	89	543	5332	5925	720	69	12	NA	NA	NA	12690
1999-2000	3	60				1243	426	87	48	NA	NA	NA	1867
Sum	3	92	625	16946	30239	28174	6982	1276	955	22	0	0	85314
Avg	0	9	69	1883	3360	2817	698	128	96	11	0	0	9071
SH %/yr	0.0	0.1	0.8	20.8	37.0	31.1	7.7	1.4	1.1	0.1	0.0	0.0	

Figure 1. San Joaquin River Reaches and Flood Bypass System in Restoration Area

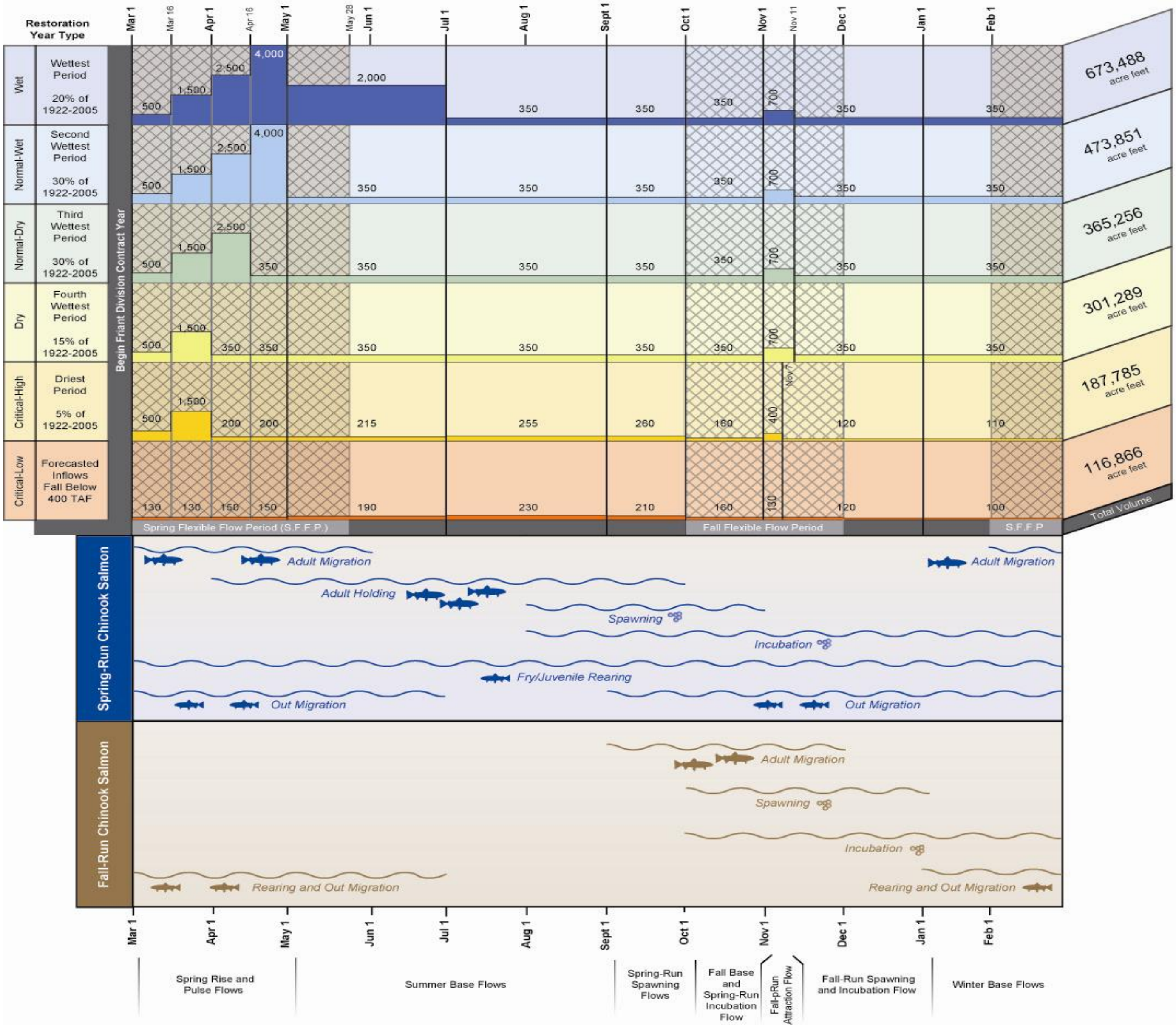


Figure 2. Restoration Flow Schedules Specified in Exhibit B of Settlement

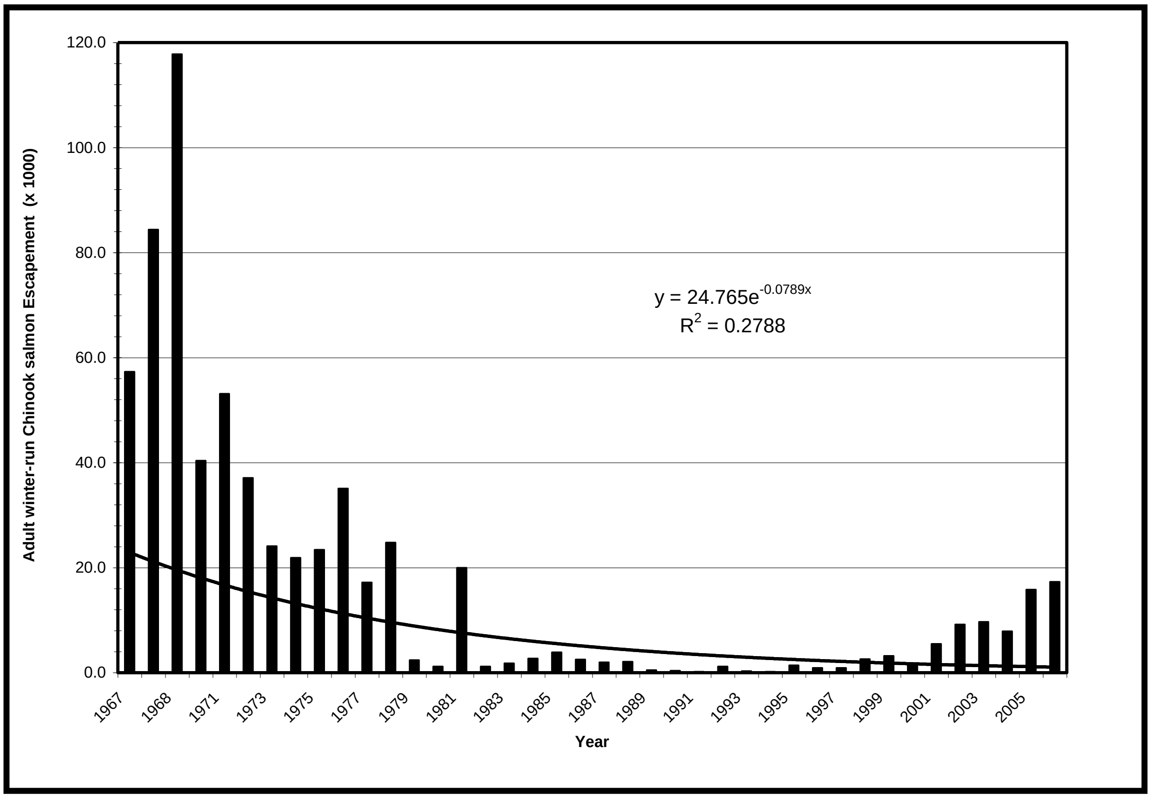


Figure 3:
Annual estimated Sacramento River winter-run Chinook salmon escapement population 1967 through 2006. Sources: PFMC 2004, CDFG 2004, NMFS 1997
Trendline for figure 3 is an exponential function: $Y=24.765\ e^{-0.0789x}$, $R^2=0.2788$.

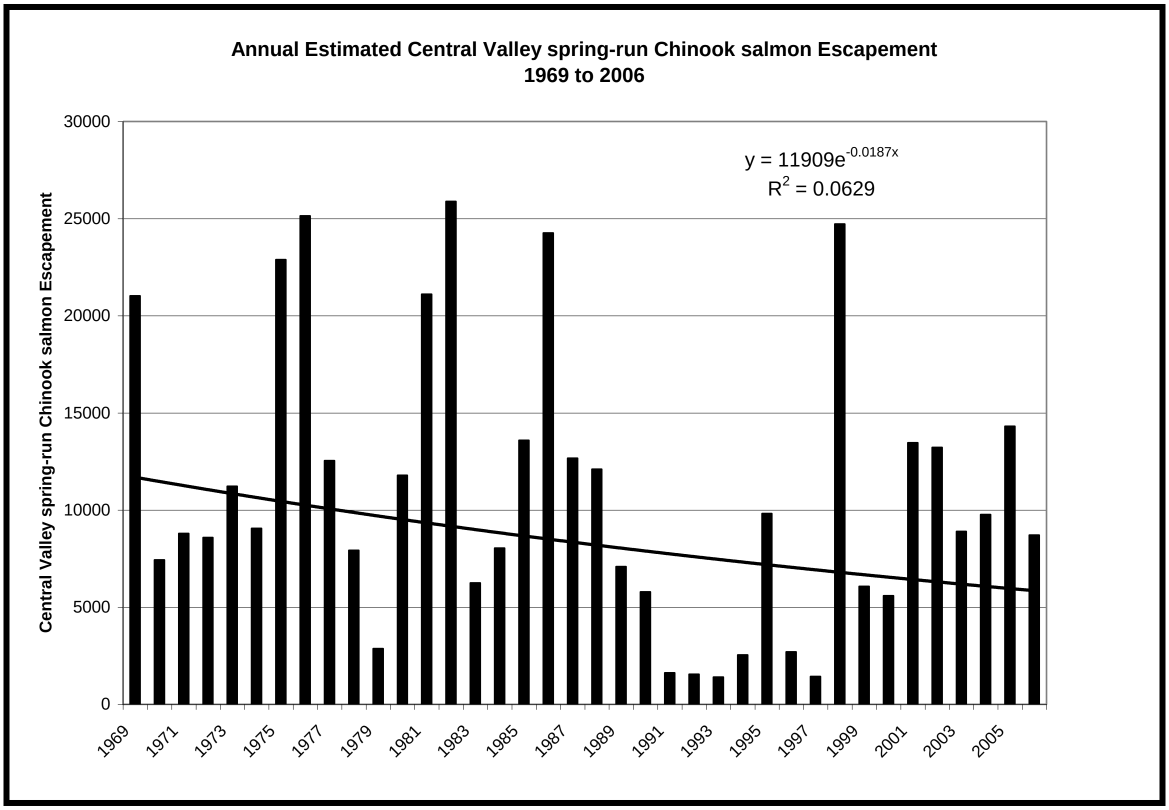
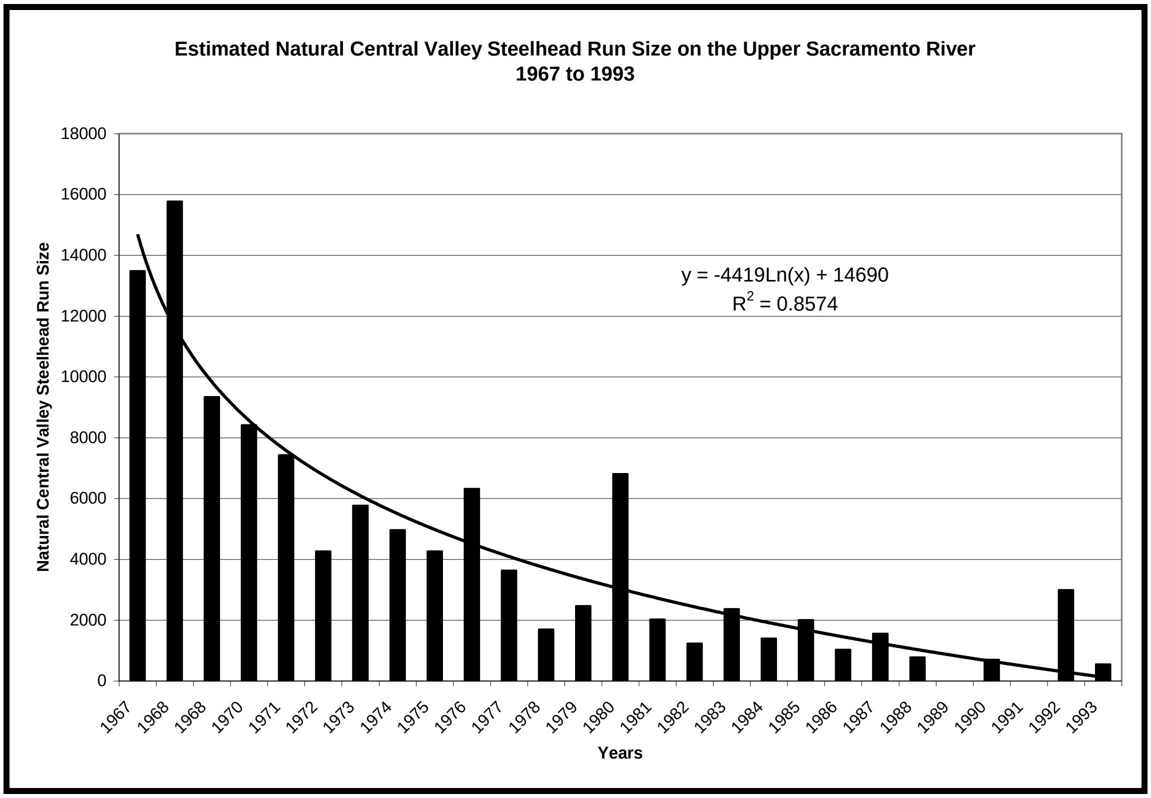


Figure 4:
Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1969 through 2006.
Sources: PFMC 2004, CDFG 2004, Yoshiyama 1998, GrandTab 2011.
Trendline for figure 4 is an exponential function: $Y=11909\ e^{-0.0187}$, $R^2 = 0.0629$.



Note: Steelhead escapement surveys at RBDD ended in 1993

Figure 5:
Estimated Central Valley natural steelhead escapement population in the upper Sacramento River based on RBDD counts.
Source: McEwan and Jackson 1996.
Trendline for Figure 5 is a logarithmic function: Y= -4419 Ln(x) + 14690 R^2= 0.8574

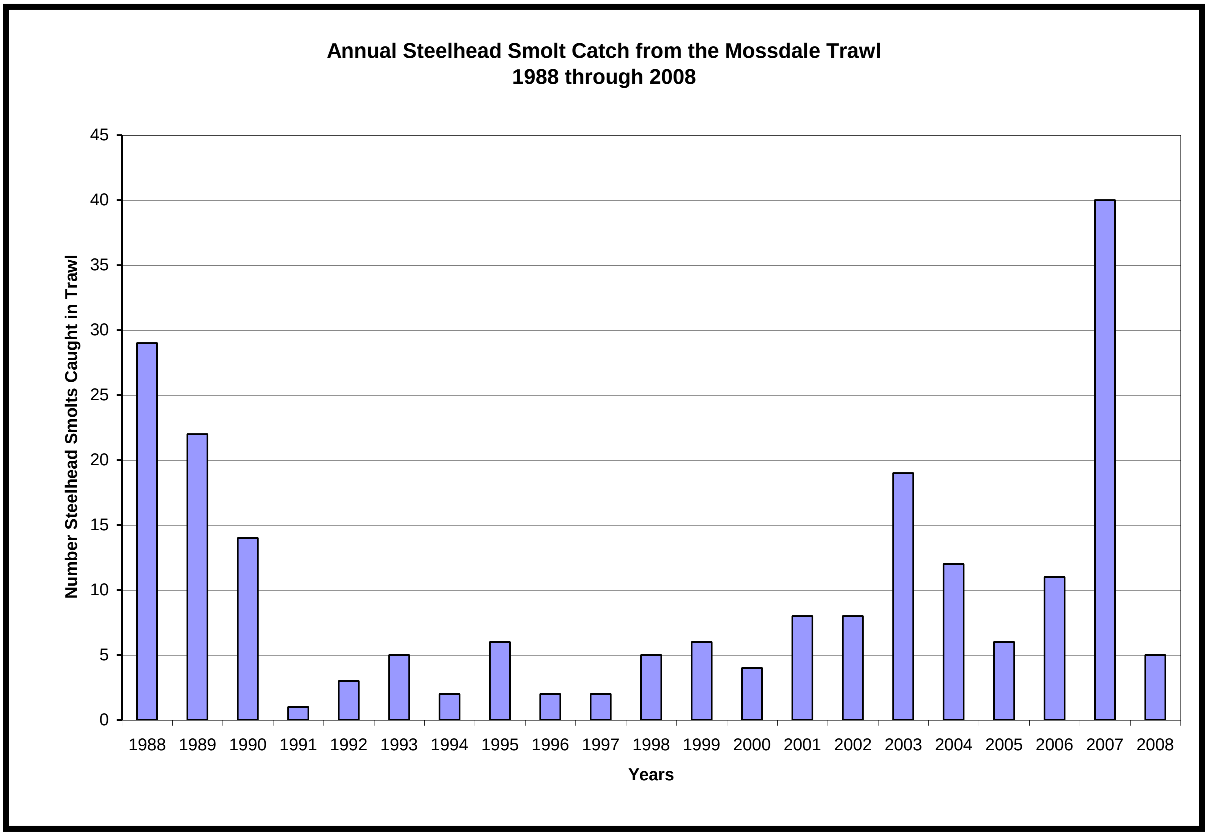


Figure 6: Annual number of California Central Valley steelhead smolts caught while Kodiak trawling at the Mossdale monitoring location on the San Joaquin River (Marston 2004, SJRG 2007).

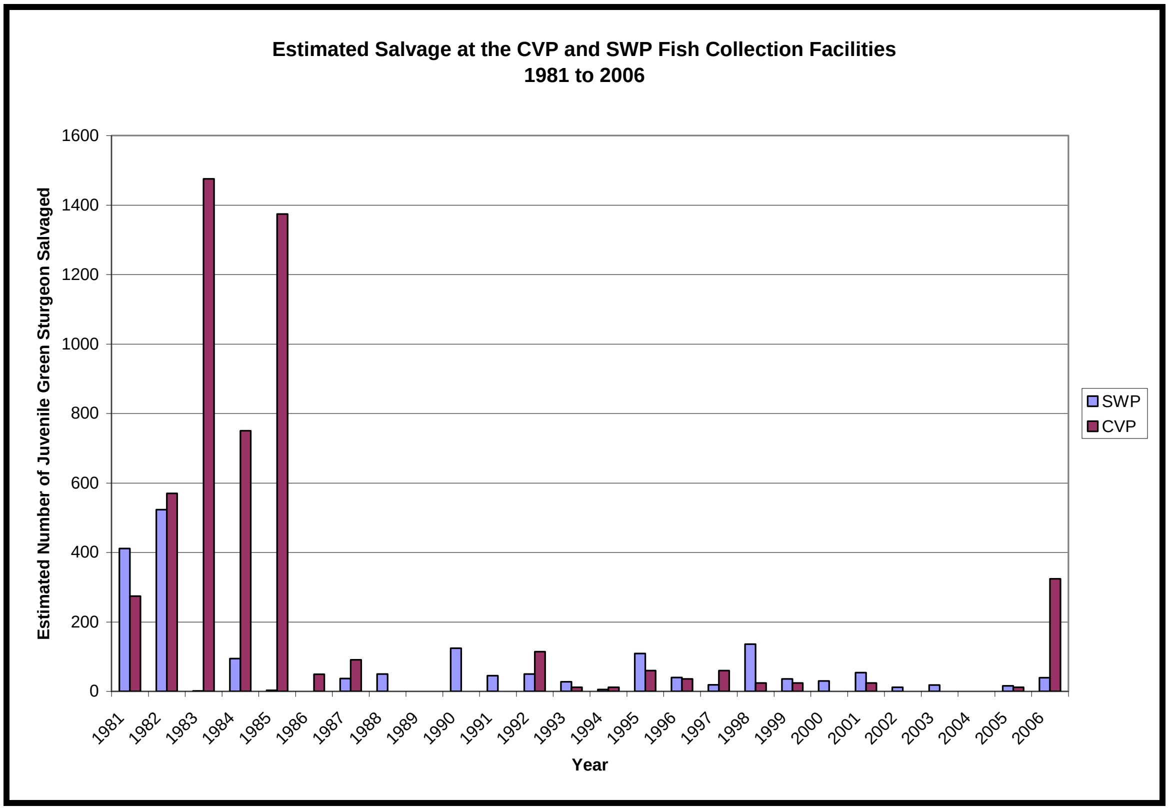


Figure 7a: Estimated number of North American green sturgeon (Southern DPS) salvaged from the State Water Project and the Central Valley Project fish collection facilities.

Sources: Beamesderfer *et al.*, 2007, CDFG 2002, Adams *et al.* 2007.

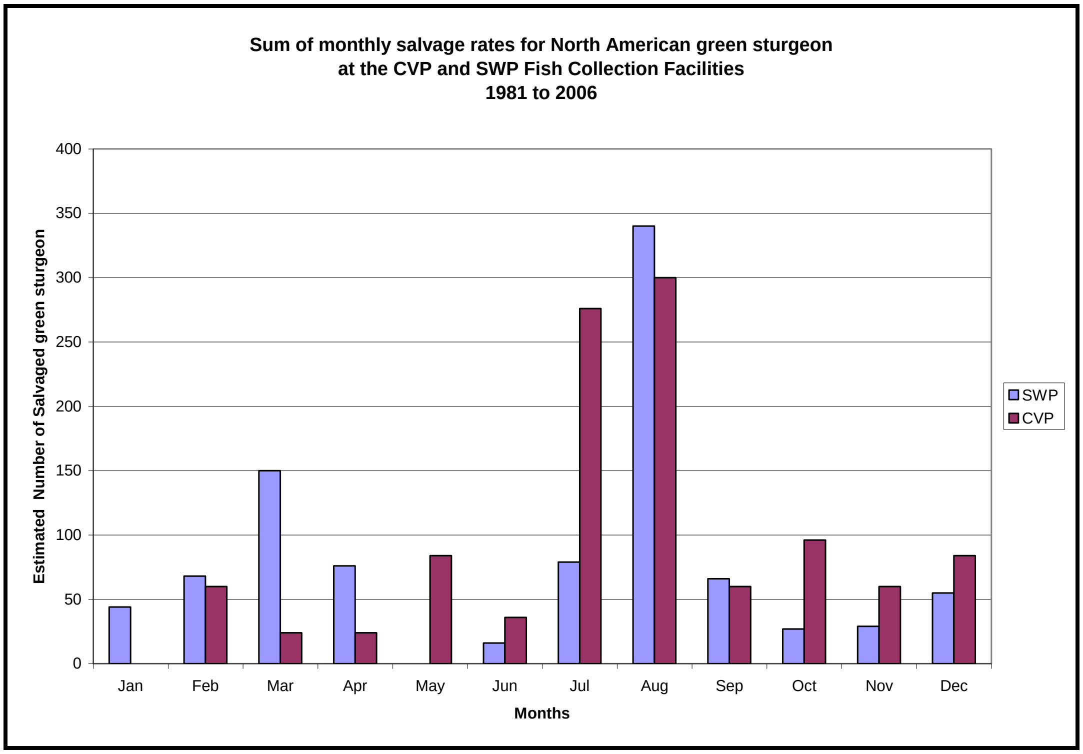


Figure 7b: Estimated number of North American green sturgeon (southern DPS) salvaged monthly from the State Water Project and the Central Valley Project fish collection facilities.

Source: CDFG 2002, unpublished CDFG records.

Enclosure 2

Magnuson-Stevens Fishery Conservation and Management Act

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.S.C. 180 *et seq*.), requires that essential fish habitat (EFH) be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NOAA's National Marine Fisheries Service (NMFS) on any activity which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "water" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project area is within the region identified as EFH for Pacific salmon (*Oncorhychus* spp.) in Amendment 14 of the Pacific Salmon FMP.

Starry flounder (*Platichthys stellatus*) are managed under the Pacific Groundfish Management Plan and were consulted on by Reclamation because of their interaction with the CVP/SWP Delta pumping facilities. Because the project Interim and Restoration Flow recapture activities at the Delta pumping facilities will operate under current regulatory requirements, biological opinions, and EFH assessments regarding Delta operations, no additional impacts to starry flounder EFH are expected from this project. Thus, starry flounder will not be further addressed in this assessment.

An adverse effect is defined as any impact which reduces the quality and/or quantity of essential fish habitat. Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. (50 CFR 600.810)

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta hydrologic unit (1804003), the San Joaquin-Lower Chowchilla hydraulic unit (18040001) and the Middle San Joaquin-Lower Merced-Lower Stanislaus hydraulic unit (18040002). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species under the Pacific Coast Salmon FMP that will occur in these hydrologic units.

Historical factors limiting salmon populations in the San Joaquin Delta, San Joaquin-Lower Chowchilla and the Middle San Joaquin-Lower Merced-Lower Stanislaus hydraulic units include primarily the building and operation of Friant Dam. Once Friant Dam became completely operational the decision was made not to release any water for fish and wildlife purposes. Though approximately 52,000 acre feet were released for downstream riparian users the flow ceased after Gravelly Ford. This decision effectively dewatered some 62 miles of channel downstream of this point (Raines 1992). Despite efforts by state and federal agency personnel to get salmon past the dry reaches, the spawning beds were unreachable to the spawning salmon. The runs continued to return and die in the river until 1949 at which time spring-run Chinook salmon were extirpated. A barrier (Hills Ferry Barrier) was placed on the San Joaquin River above the Merced River confluence to prevent fall-run Chinook salmon from entering the San Joaquin River and direct them into the Merced River to complete their life cycle.

In September 2006, an 18-year lawsuit to provide sufficient fish habitat in the San Joaquin River below Friant Dam near Fresno, California, by the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council (NRDC), and the Friant Water Users Authority (FWUA) reached a settlement. The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement the Stipulation of Settlement in *NDRC, et al., v. Kirk Rodgers, et al.* (Settlement). Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act), including in Public Law 111-11. The five implementing agencies for the SJRRP are the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the California Department of Fish and Game, and the California Department of Water Resources. In October 2009, Interim Flows were released from Friant Dam, and will continue as required in the Settlement. By December 31, 2012, in accordance with the Settlement, Central Valley spring-run Chinook salmon and/or fall-run Chinook salmon are to be reintroduced to this section of the San Joaquin River. Restored flow and improved habitat conditions in the river should also allow for establishment of new Chinook salmon populations in the San Joaquin River where they once historically resided.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, riprapping, *etc*. (Dettman *et al.* 1987; California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b). Factors affecting salmon populations in Suisun Bay include heavy industrialization within its watershed and discharge of wastewater effluents into the bay. Loss of vital wetland habitat along the fringes of the bay reduce rearing habitat and diminish the functional processes that wetlands provide for the bay ecosystem.

A. Life History and Habitat Requirements

1. Pacific Salmon

General life history information for Central Valley Chinook salmon is summarized below. Further detailed information on Chinook salmon Evolutionarily Significant Units (ESUs) are available in the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESUs of Chinook salmon (63 FR 11482).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin rivers from July through December and spawn from October through December while adult Central Valley late fall-run Chinook salmon enter the Sacramento and San Joaquin rivers from October to April and spawn from January to April (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NMFS 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

Adult spring-run Chinook salmon tolerate water temperatures ranging from 38°F–56°F (3.3°C–13.3°C) (Bell 1991). The upstream migration of adult Chinook salmon from the Delta to the San Joaquin River is reported to have been prevented by water temperatures above 70°F (21.1°C). Records indicate that spring-run Chinook salmon in the Sacramento-San Joaquin River system spend the summer holding in large pools where summer temperatures are usually below 69.8°F–77°F (21°C–25°C) (Moyle et al. 1995). Sustained water temperatures above 80.6°F (27°C) are lethal to adult spring-run Chinook salmon (Moyle et al. 1995). Spring-run Chinook salmon may rear in streams for 3-15 months, depending on flow conditions (Moyle 2002b). Further downstream, rearing fry use low velocity areas where substrate irregularities and other habitat features create velocity refuges and they may increasingly rely on turbidity as cover (DWR et al. 2000). Juvenile Chinook salmon are opportunistic drift feeders and eat a wide variety of terrestrial and aquatic insects. They feed mostly during the day, with peak feeding at dawn and during the afternoon (Moyle 2002b).

II. PROPOSED ACTION

The proposed action is described in section II (*Description of the Proposed Action*) of the preceding biological and conference opinion for endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*) and critical habitat for winter-run Chinook salmon, steelhead and green sturgeon. (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on salmonid habitat (*i.e.*, for spring-run and winter-run Chinook salmon) are described at length in section VI (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH.

Effects to EFH stemming from fluctuations in flow due to the release of Interim and Restoration Flows from Friant Dam, construction activities related to fish passage and river restoration, and monitoring activities may contribute to sediment oscillations and increased turbidity. These effects to EFH may result in temporary disturbances to some individuals, primarily migrating adult and rearing juvenile salmonids, but, due to the temporary nature and infrequency of these disturbances, the adverse effects that are anticipated to result from the proposed project are not of the type, duration, or magnitude that would be expected to adversely affect or modify EFH to the extent that it could lead to an appreciable reduction in the function and conservation role of the affected habitat. NMFS expects that nearly all of the adverse effects to EFH from this project will be of a short term/infrequent nature and will not affect future generations of listed fish.

Program-level actions, such as having sustained flows, providing fish passage to spawning grounds, and improved instream and floodplain habitats in the San Joaquin River from Friant Dam to the Merced River confluence will directly benefit EFH for Pacific salmon.

IV. CONCLUSION

Based on the best available information, and upon review of the effects of the proposed San Joaquin River Reintroduction Program, NMFS believes that the implementation of the San Joaquin River Restoration Program through 2025 may adversely affect EFH of Pacific salmon. However, the proposed action includes adequate measures (described in the conservation strategy in the preceding biological opinion) to avoid, minimize, or otherwise offset the adverse effects to EFH. In the long-term the San Joaquin River Restoration Program will actually benefit EFH for Pacific salmon in the action area.

V. EFH CONSERVATION RECOMMENDATIONS

As the habitat requirements of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley fall-run/late fall-run within the action area are similar to those of the federally listed species addressed in the attached biological opinion, NMFS recommends that conservation recommendations prepared for Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon in the associated biological opinion be adopted as EFH conservation recommendations. Those conservation measures which require the submittal of reports and status updates can be disregarded for the purposes of this EFH consultation as there is no need to duplicate those submittals.

VI. STATUTORY REQUIREMENTS

Section 305 (b)4(B) of the MSA requires that the Federal lead agency provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR §600.920[j]). In the case of a response that is inconsistent with our recommendations, the lead agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

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