Appendix D

Biological Opinion from the National Marine Fisheries Service

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

January 20, 2015 **Refer to NMFS No: 2014-1480**

David E. Hyatt
Supervisory Wildlife Biologist
U.S. Bureau of Reclamation
South-Central California Area Office
1243 N Street
Fresno, California 93721-1813

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the San Luis Water District (SLWD) and Panoche Water District (PWD) Interim Renewal Contracts 2015-2017

Dear Mr. Hyatt:

Thank you for your letter of September 12, 2014, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the 2015-2017 San Luis Water District (SLWD) and Panoche Water District (PWD) Interim Renewal Contracts (IRC).

The attached NMFS Biological Opinion (Opinion) reviews the effects of the proposed actions 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 (CCV) steelhead (*O. mykiss*), the threatened Southern distinct population segment (sDPS) of North American green sturgeon (green sturgeon) (*Acipenser medirostris*), and the designated critical habitat of CCV steelhead and sDPS green sturgeon, in accordance with section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C 1531 *et seq.*).

Based on the best scientific and commercial information, the Opinion concludes that the 2015-2017 SLWD and PWD IRC, as presented by the US Bureau of Reclamation (Reclamation), are not likely to jeopardize the continued existence of the listed species or to destroy or adversely modify designated critical habitat. NMFS has also included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take of listed salmonids and sturgeon associated with the project.

This letter also transmits NMFS' essential fish habitat (EFH) conservation recommendations for Pacific salmon 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 execution of the SLWD and PWD IRC will adversely affect the EFH of Pacific salmon in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the 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 (k)). 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. Sierra Franks in our California Central Valley Area Office at (916) 930-3720 or via email at Sierra.Franks@noaa.gov, if you have any questions regarding this document or require additional information.

Sincerely,

for William W. Stelle, Jr.
Regional Administrator

Enclosure

cc: ARN: 151422WCR2014SA00237

Jennifer Lewis
Wildlife Biologist
U.S. Bureau of Reclamation
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Endangered Species Act (ESA) Section 7(a)(2) Biological and Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

San Luis Water District and Panoche Water District Interim Renewal Contracts 2015-2017

NMFS Consultation Number: 151422WCR2014SA00237

Action Agency: U.S Bureau of Reclamation

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	Endangered	No	No	No
Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	No	No	No
Central Valley spring-run Chinook salmon experimental population(*O. tshawytscha*)	Candidate	Yes	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No
Southern distinct population segment of North American green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By: William W. Stelle Jr.
Regional Administrator

Date: January 20, 2015

1. INTRODUCTION

This document transmits the NOAA's National Marine Fisheries Service (NMFS) biological and conference opinion based on our review of the proposed San Luis Water District and Panoche Water District Interim Renewal Contracts 2015–2017 project located in Merced, Stanislaus, and San Joaquin counties in California in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). Your September 12, 2014, request for formal consultation was received on September 15, 2014. Consultation was initiated following the receipt of a complete consultation package on September 15, 2014. This Opinion is based on information provided in the September 2014 biological assessment (BA), communication with the Bureau, and other sources of information.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the Opinion and incidental take statement portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). A complete record of this consultation is on file at NMFS California Central Valley Area Office.

1.2 Consultation History

On December 29, 2008, NMFS provided a no jeopardy/no adverse modification Opinion for the San Luis Water District (SLWD) and Panoche Water District (PWD) Interim Renewal Contracts (2008/04445) (SLWD and PWD Interim Renewal Contracts 2009-2011 Opinion) which covered the time period from January 1, 2009 through February 28, 2011.

On February 23, 2011, NMFS provided a no jeopardy/no adverse modification Opinion for the San Luis Water District and Panoche Water District Interim Renewal Contracts (2010/04827) (SLWD and PWD Interim Renewal Contracts 2011-2013 Opinion) which covered the time period from March 1, 2011 through February 28, 2013.

On February 11, 2013, NMFS provided a no jeopardy/no adverse modification Opinion for the San Luis Water District and Panoche Water District Interim Renewal Contracts (2012/05021) (SLWD and PWD Interim Renewal Contracts 2013-2015 Opinion) which covered the time period from March 1, 2013 through February 28, 2015.

On September 15, 2014, NMFS received a formal request and accompanying BA from the Bureau of Reclamation to initiate formal consultation under section 7 of the ESA for the San Luis Water District and Panoche Water District Interim Renewal Contracts for the period of 2015-2017.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02).

The Central Valley Project (CVP) is the largest water storage and delivery system in California, with a geographic scope covering 35 of the State's 58 counties. The CVP is divided into nine separate divisions. This Opinion addresses the interim water service contract for two of the eight contractors in the West San Joaquin Division, San Luis Unit of the CVP, Panoche Water District (PWD) and San Luis Water District (SLWD). Reclamation and the two contractors propose to enter into interim water service contracts to deliver water from the CVP to the contractors' service areas for existing agricultural and municipal and industrial uses. These contracts would allow CVP water deliveries to the two contractors to continue after the previous long-term water service contracts expired on December 31, 2008, as directed by Section 3404(c)(1) of the Central Valley Project Improvement Act (CVPIA). Under these interim contracts, there are no changes in contract amounts, contractor service areas (areas where CVP water may be delivered under the IRC), sources of water, diversion amounts, amounts of water used for agricultural vs. municipal and industrial uses, or water availabilities for fish and wildlife.

The proposed Federal action analyzed in this Opinion is just the implementation of the SLWD and PWD IRC 2015-2017. The effects of existing coordinated long-term operation of the CVP and State Water Project (SWP) and its operational effects to listed species and designated critical habitat because the effects of those Federal activities (e.g., storing, pumping, and releasing water for agricultural and municipal and industrial uses) were already analyzed in the 2009 NMFS CVP/SWP Opinion (NMFS 2009b). In addition, this consultation will not analyze potential effects resulting from the following independent actions each requiring its own separate permitting and consultations:

- Any future water assignments of CVP water service contracts involving San Luis Unit contractors.
- Water transfers and exchanges involving San Luis Unit contractors.
- Inclusion and Exclusions to the district boundaries for the San Luis Unit contractors, including land annexations.
- Any changes in place or purpose of use.
- Renewal of long-term water service contracts.

- Other measures/activities that are considered as part of the environmental baseline, such as the Central Valley Habitat Monitoring Program, the Central Valley Project Conservation Program, the San Joaquin River Restoration Program (SJRRP), or CVPIA activities designated in Section 3406 (b)(l) (other).
- Other programs in place under CVPIA or portions of the Delta Stewardship previously known as the CALFED program.

Instead, the focus of this consultation is the potential effects of the delivery of CVP water to SLWD and PWD from calendar year 2015 to 2017, and the resulting discharge of drainage water to streams in which listed species and designated critical habitats under NMFS' jurisdiction occur.

Project Description

The proposed federal action is the execution of IRC for the delivery of water from the CVP to the PWD and SLWD for a period of 24 months (see Table 1). However, the likelihood of full deliveries of the contract amounts in every year is quite small due to delivery constraints (including hydrological, climatological, and the requirements of laws and regulations) (Reclamation 2004).

Table 1.
Central Valley Project (CVP) Interim Water Service Contract Amounts and Service Areas for Contractors in the San Luis Unit

Contractor	Current Contract Number	Water Service Contract Amount (acre-feet)	Primary Contract Use	Contract Period
Panoche Water District	14-06-200-7864A-IR4	93,988	Agriculture	03/01/15–02/28/17
San Luis Water District	14-06-200-7773A-IR4	125,080	Agriculture	03/01/15–02/28/17

These IRC will provide for the continued delivery of the same quantities of CVP water contract amounts to the same lands currently covered under the existing IRC. Like the water service contracts for contractors in the San Luis Unit, the IRC authorize deliveries of CVP water from both the San Luis and Delta-Mendota Canals, if those contractors have the capability to take CVP water via both canals. Water deliveries will be made through existing CVP facilities. The project does not require the construction of any new facilities, the installation of any new structures, or the modification of existing facilities. The water will be beneficially used within the authorized place of use for CVP water south of the Delta.

Of the approximately 38,000 acres in PWD and 3,882 acres in SLWD with potential drainage issues, 30,000 of those acres have been improved with subsurface drainage systems (Reclamation 2006 from Table C1-4). The drainage facilities are owned and operated by a public agency that is separate from the CVP water service contractor. In the case of PWD, that agency is the Panoche Drainage District, which serves additional acres outside PWD; in the case of SLWD, that agency is the Charleston Drainage District. The amount of salt and selenium discharged by PWD (as Panoche Drainage District) and a portion of SLWD (Charleston Drainage District) have decreased substantially over time (Table 2). Load reduction requirements for selenium and salts for the Grasslands Bypass Project (GBP) continue through 2019. While there will continue to be annual variability based on water year types and load requirements, the Districts anticipate overall decreased discharges from the

Grassland Drainage Area as they continue to work towards "zero" discharge (Reclamation and Authority 2009).

Table 2 Drainage Discharge for Panoche and San Luis Water Districts from the Grassland Drainage Area

	Charleston Drainage District (includes SLWD)			**PWD as Panoche Drainage District**		
Year[1]	**Discharge (AF)**	**Salt Load (tons)**	**Selenium Load (pounds)**	**Discharge (AF)**	**Salt Load (tons)**	**Selenium Load (pounds)**
2013	33	164	6	3,066	21,675	283
2012	54	267	10	3,633	18,390	289
2011	125	545	24	8,345	40,276	1,003
2010	171	908	43	6,829	31,468	806
2009	310	1,123	69	6,615	29,780*	735
2008	213	372	45	6,298	28,353*	848
2007	1,482	8,218	423	6,583	29,638*	1,285
2006	1,748	8,381	330	8,189	36,868*	1,007
2005	2,056	10,890	554	13,825	62,236*	2,020
2004	1,180	6,111	399	9,003	40,531*	3,216
2003	943	5,172	271	9,928	44,694*	1,504
2002	1,179	6,653	327	9,351	42,097*	1,548
2001	533	3,370	205	11,436	51,484	1,882
2000	869	4,210	256	13,047	53,487	1,790
1999	983	4,787	233	12,823	55,483	1,771
1998	1,674	8,100	456	19,268	82,142	3,662
1997	1,509	6,676	349	17,028	76,824	3,250
1996	3,897	14,771	609	24,538	103,384	5,276
1995	4,316	19,376	971	28,533	121,128	5,942
1994	3,199	14,330	808	19,265	85,959	4,083
1993	1,858	8,412	425	19,774	90,696	4,779
1992	730	3,279	153	12,658	58,766	2,824
1991	781	3,161	227	14,092	60,414	2,558
1990	2,126	8,592	387	21,462	88,117	4,009
1989	2,799	12,068	519	24,075	92,633	4,032
1988	5,015	20,062	906	31,575	114,989	4,930
1987	4,769	19,023	946	35,229	111,435	4,990
1986	3,186	10,699	474	31,573	102,699	4,480
Average	1,705	7,490	372	15,287	73,072	2,672
Maximum	5,015	20,062	971	35,229	121,128	5,942
Minimum	33	164	6	3,066	18,390	283
*Amounts based on estimated values						

[1] These data are based on the October 1-September 30 water year, rather than a calendar year.

Year[1]	Charleston Drainage District (includes SLWD)			PWD as Panoche Drainage District		
	Discharge (AF)	Salt Load (tons)	Selenium Load (pounds)	Discharge (AF)	Salt Load (tons)	Selenium Load (pounds)
Source: Summers Engineering 2014 and San Francisco Estuary Institute 2013.						

Project History

The water service contract amounts and approximate acreages within the two service areas designated for use of CVP water in this analysis are summarized in the above Table 1. Portions of the groundwater in the San Luis Unit exceed the California Regional Water Quality Control Board's recommended Total Dissolved Solids (TDS) concentration. Calcium, magnesium, sodium, bicarbonates, selenium, sulfates, and chlorides are all present in significant quantities as well (Reclamation 2005). The high TDS content of groundwater is due to recharge of stream flow originating from marine sediments in the Coast Range (DWR 2003) and is the result of concentration of salts due to evaporation and poor drainage from naturally saline and high clay content soils, which restricts drainage.

At present, drainage water from each of the districts is disposed of by reuse on the 6,000-acre San Joaquin River Water Quality Improvement Project (SJRIP; a closed collection system) and/or discharged through the Grassland Bypass Project (GBP; as per the New Use Agreement) into the San Luis Drain, Mud Slough North and ultimately, the San Joaquin River (Reclamation 2009, Reclamation 2012, NMFS 2009d). This is the only route for disposal of drainage water that leaves the service districts' boundaries.

The Central Valley Regional Water Quality Control Board (Regional Board) issued Waste Discharge Requirements for the GBP that specify the conditions for discharging drainage water in the San Joaquin River and specified channels within the Grassland watershed by certain dates (Regional Board 1998). Discharge requirements for the GBP account for the type of water year (Wet, Above Normal, Dry/Below Normal, and Critical) and include maximum annual loads of selenium (Figure 1). Measures are taken to assess and monitor selenium concentrations within the waters, sediment, fish, invertebrates, and plants.

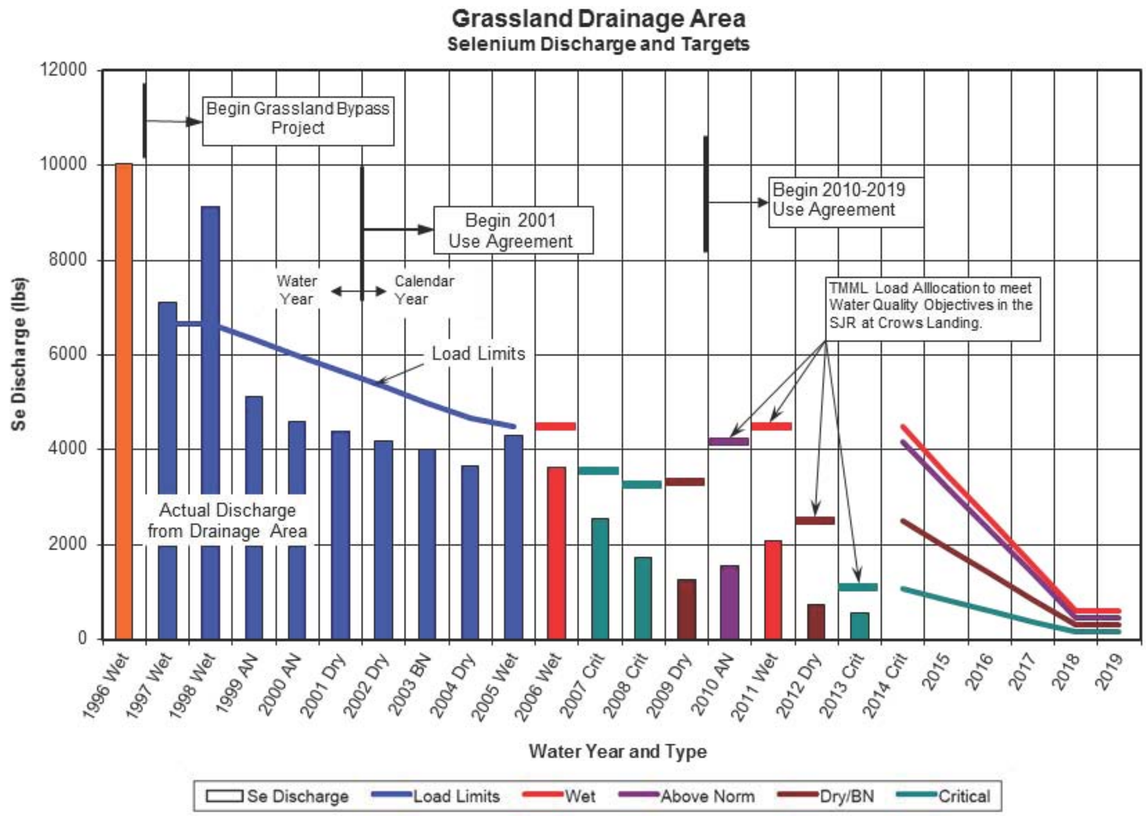


Figure 1. Grassland Drainage Area Selenium (Se) Discharge (lbs) and Targets by Type of Water Year. Total Maximum Monthly Load (TMML). Taken from San Francisco Estuary Institute 2013.

The GBP has been successful in such reductions, meeting current water quality objectives for selenium load in the San Joaquin River below the Merced River (5 parts per billion [ppb] 4- day average) for above normal and wet year types (Reclamation 2009, San Francisco Estuary Institute 2013). A performance goal of 5 ppb (0.00272 lbs Se/acre-foot = 1 ppb) monthly mean selenium is in effect for the San Joaquin River below the Merced River for Critical and Dry/Below Normal Water Year types. However, the Mud Slough North and the San Joaquin River, from the Mud Slough confluence to the Merced River, has been unable to fully manage all drainage water discharges to meet the 5 ppb monthly mean water quality objective. The Regional Board extended the date for meeting the selenium objective in Mud Slough North and the San Joaquin River from the Mud Slough confluence to the Merced River (through 31 December 2019), and established an interim selenium performance measure of 15 ppb monthly mean (Regional Board 2010).

Farmers have effectively reduced the volume of drainage water that reaches Mud Slough North and ultimately the San Joaquin River through on-farm water conservation, more efficient irrigation practices, and displacing drainage waters by irrigating a variety of salt tolerant grasses and crops like pistachios and asparagus (San Francisco Estuary Institute 2013). This displacement of drainage waters occurs within the SJRIP and has been a crucial tool for farmers to reduce drainage water (including selenium and salts; Tables 3-4), as specified in the New Use Agreements and Waste Discharge Requirements by the Regional Board.

The GBP has been in operation since October 1996 and has effectively reduced the volume of drainage water discharged, resulting in substantive reductions in selenium contamination in local water supply channels and the San Joaquin River (Figure 2). The current Use Agreement (3rd Use Agreement; Reclamation and Authority 2009) includes economic incentives to end selenium discharges by 2015. NMFS analyzed species affects from the implementation of the GBP as part of the PWD and SLWD IRC (NMFS 2008, NMFS 2011, NMFS 2013a).

Table 3 Grassland Drainage Area – Volume and Loads*.

Water Year	Discharge (acre feet)	Selenium Load (lbs)	Boron Load (lbs)	Salt Load (tons)
1995	57,570	11,875	868,000	237,530
1996	53,000	10,036	830,700	197,500
1997	39,860	7,096	682,300	172,600
1998	49,244	9,118	967,200	213,500
1999	32,310	5,124	630,200	149,100
2000	31,260	4,603	606,700	135,000
2001	28,254	4,377	423,300	120,000
2002	28,391	3,939	550,500	116,100
2003	27,290	4,029	575,000	118,152
2004	27,700	3,871	536,000	120,200
2005	29,960	4,288	585,000	138,900
2006	25,995	3,563	538,000	119,646
2007	18,531	2,554	278,000	79,094
2008	15,695	1,737	280,000	66,459
2009	13,166	1,264	236,000	56,223
2010	14,529	1,577	315,000	67,661
2011	18,513	2,085	419,000	87,537
% Reduction 95-10	75%	87%	64%	72%
% Reduction 96-11	68%	82%	52%	63%

Note: WY 97, 98 and 2005 include discharges through Grasslands Water District.

*Taken from San Francisco Estuary Institute 2013

Table 4 San Joaquin River Improvement Project – Volume and Loads*.

Water Year	Reused Drain Water	Displaced Selenium	Displaced Boron	Displaced Salt
	(acre feet)	(pounds)	(pounds)	(tons)
1998*	1,211	329	NA	4,608
1999*	2,612	321	NA	10,230
2000*	2,020	423	NA	7,699
2001	2,850	1,025	61,847	14,491
2002	3,711	1,119	77,134	17,715
2003	5,376	1,626	141,299	27,728
2004	7,890	2,417	193,956	41,444
2005	8,143	2,150	210,627	40,492
2006	9,139	2,825	184,289	51,882
2007	11,233	3,441	210,582	61,412
2008	14,955	3,844	238,435	80,900
2009	11,595	2,807	198,362	60,502
2010	13,119	3,298	370,752	75,362
2011	22,695	4,674	510,194	117,350
2012	23,735	3,293	545,180	118,445
2013	26,170	3,527	568,907	118,883

*Taken from San Francisco Estuary Institute 2013

On October 5, 2010, the Central Valley RWQCB (2010) adopted Resolution R5-2010-0046 amending the Sacramento River and San Joaquin River Basin Plan (Basin Plan) to modify the existing compliance schedule for the GBP selenium control plan to allow agricultural subsurface drainage discharges to the Lower San Joaquin River to continue through December 31, 2019. Since October 2005, the Basin Plan set the selenium objective at 5 ppb over a 4-day average in the San Joaquin River at the confluence of the Merced River. This same objective was used in the drainage analysis in the SLWD and PWD IRC 2009-2011, 2011-2013 and 2013-2015 Opinion's and is still in place over the same portion of the San Joaquin River for this project. This original objective was intended to extend up the San Joaquin River upstream of the Merced River to Sack Dam and Mud Slough (north) on October 1, 2009. The Resolution R5-2010-0046 delays that extension for a 2-mile portion of the San Joaquin River and 7-miles of Mud Slough (north) until 2019.

Both SLWD and PWD have also adopted the Westside Regional Drainage Plan (incorporated by reference into the 2015-2017 BA) that includes the following actions intended to reduce agricultural drainage to zero subsurface discharge:

- Lining District water delivery facilities to the extent that available funding will allow.
- Encouraging grower participation in programs to acquire and install high efficiency (*i.e.*, drip) irrigation systems.
- Operation of the PWD Russell Avenue Recirculation System which captures and re-

circulates drainage generated within the PWD.

- Continuing drainwater displacement projects such as road wetting for dust control.
- Continuing to develop, manage, and utilize 6,000 acres of regional reuse facilities where collected subsurface drainage is applied to salt tolerant crops under monitored and controlled conditions.
- Participating in well installation and pumping activities of the Westside Regional Drainage Plan to reduce downslope migrations or hydraulic pressure on lower lying lands.

1.4 Action Area

"Action area" means 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 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 described in the BA includes the consolidated subsurface drainage from the SLWD and PWD, through the GBP. The GBP conveys these drainage flows through the San Luis Drain. The water then flows through 6 miles of Mud Slough (north) (Figure 2), and converges with the San Joaquin River upstream of the confluence with the Merced River (approximately where Merced and Stanislaus county lines meet in Figure 2). From there, the water flows through the San Joaquin River to the southern Sacramento – San Joaquin River Delta, including Old River and Middle River, which lie south of the City of Stockton. This falls predominantly within the hydrologic units of the Middle San Joaquin – Lower Merced – Lower Stanislaus and the San Joaquin Delta, 18010002 and 18040003, respectively.

For the purposes of this biological opinion, the action area includes the area described above as well as the following details from the previous SLWD and PWD IRC consultations (for years 2009–2011, 2011–2013 and 2013-2015) incorporated by reference. As described above, the northern portion of the action area includes Old and Middle rivers. More specifically the action area extends down to the point where State and Federal pumping facilities divert a substantial portion of those waters to the California Aqueduct and the Delta-Mendota Canal, and thereby influence the direction of flow, at approximately the confluence with the Grant Line and Victoria canals, respectively. Operation of the State and Federal pumps combined with tidal influence causes a reverse (*i.e.*, upstream) flow in the mainstem San Joaquin River from the Delta to approximately the confluence with Old River just below Mossdale. Therefore, the waters of Mud Slough enter the San Joaquin River and flow downstream to Old River where they converge with waters flowing upstream in the San Joaquin River from the Delta and entering Old River as well. This segment of the San Joaquin River and the associated waterways described above pass through portions of Merced, Stanislaus, and San Joaquin counties. The direct and indirect effects of the proposed project are anticipated to encompass the entire width of the river channel from levee to levee, along the entire length of the reach defined above. The scope and sensitivity of these impacts will be discussed in the effects analysis section of the opinion.

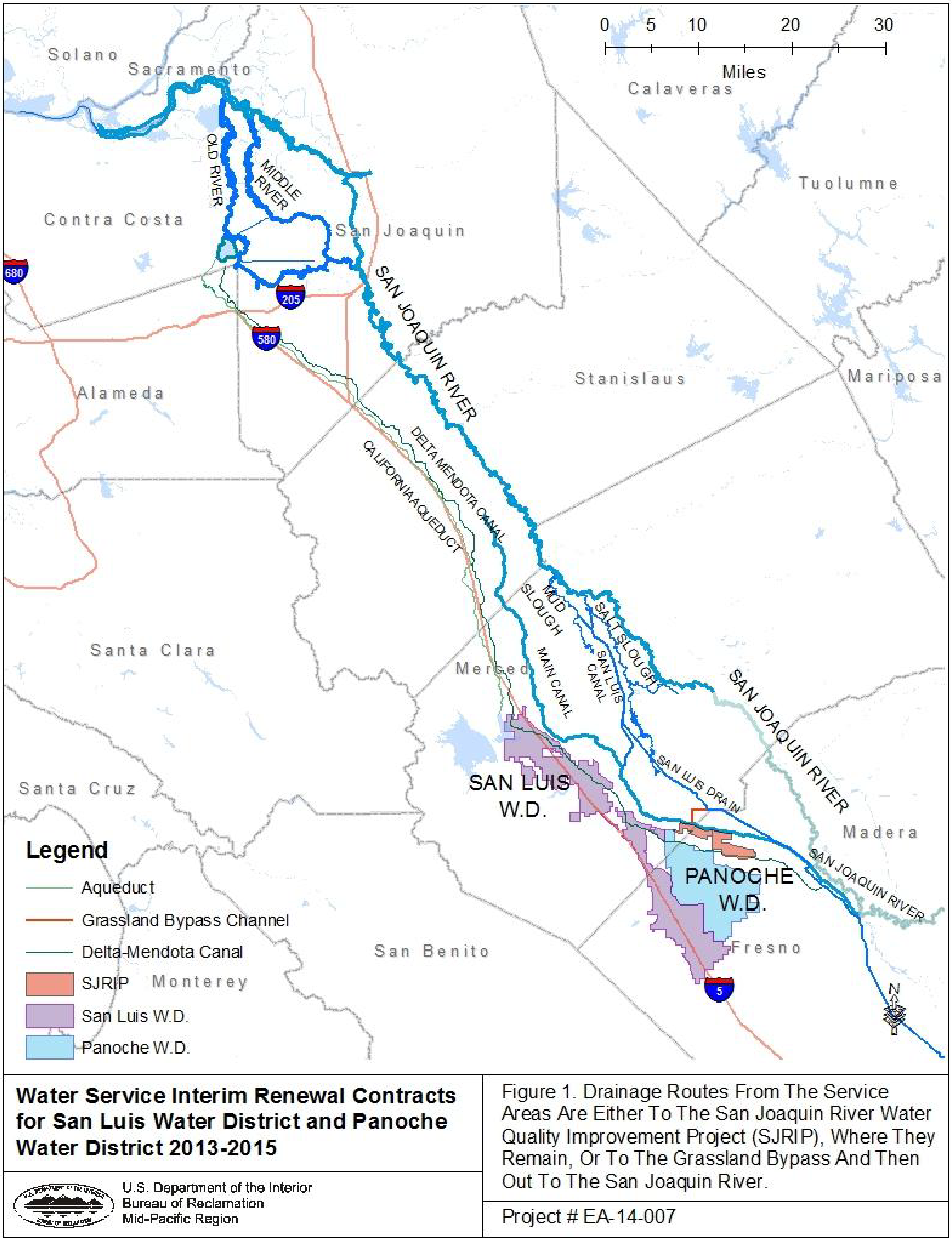


Figure 2. Map depicting the Service Area

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1 Analytical Approach

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

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[2]

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

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.

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

- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

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

<u>Information Available for the Analytical Approach</u>

To conduct the assessment, NMFS examined evidence 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, governmental and non-governmental reports, and the BA for this project.

<u>Assumptions Underlying This Analytical Approach</u>

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

One factor affecting the rangewide status of federally listed endangered SR winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, the threatened sDPS green sturgeon, and aquatic habitat at large, is 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 along 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 listed salmonid and sDPS green sturgeon primary constituent elements (PCEs). Increased winter precipitation and decreased snow pack 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 result in 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 +2^{o}C and +7^{o}C by 2100 (Dettinger *et al.* 2004, Hayhoe *et al.* 2004, Van Rheenen *et al.* 2004, Dettinger 2005), with a drier hydrology predominated by rainfall rather than snowfall. This will alter river runoff patterns and transform some of the tributaries that feed the Central Valley from spring/summer snowmelt dominated systems to winter rain dominated systems. 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 rainfall runoff. This should truncate the period of time that suitable cold-water conditions occur 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.

The following sections describe the status of each species administered by NMFS and presumed to be present in the action area, which includes sDPS green sturgeon (*Acipenser medirostris*), CCV steelhead (*Oncorhynchus mykiss*) DPS, SR winter-run Chinook salmon (*O. tshawytscha*) Evolutionarily Significant Unit (ESU), and CV spring-run Chinook salmon (*O. tshawytscha*) ESU. In addition, the action area falls within critical habitat for the sDPS green sturgeon and CCV steelhead DPS. All information in the following sections is organized by species.

2.2.1 SOUTHERN DPS OF NORTH AMERICAN GREEN STURGEON

Listed as threatened (71 FR 17757; April 7, 2006)
Designated critical habitat (74 FR 52300; October 9, 2009)

Green sturgeon (*Acipenser medirostris*) are a species of ancient fish, highly adapted to benthic environments, and very marine oriented, entering freshwater mainly to spawn, but residing in bays, estuaries, and near coastal marine environments for the vast majority of their lifespan. They are known to be long lived; green sturgeon captured in Oregon have been age-estimated up to 52 years old, using a fin-spine analysis (Farr and Kern 2005). They are iteroparous, meaning they can spawn multiple times withing their lifespan. The details of their biology are fascinating and are described in the life history section of this document, and also in various literature sources such as Moyle (2002), (Adams *et al.* 2007), (Beamesderfer *et al.* 2007) , (Israel and Klimley 2008), and in NMFS' 5-year status review and in the Green Sturgeon Recovery Plan.

Green sturgeon are broken into two distinct population segments (DPSs), a northern DPS (nDPS) and a southern DPS (sDPS), and while individuals from the two DPS's are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed, nor do they utilize the spawning areas of each other's natal rivers. In this document we are concerned primarliy with sDPS green sturgeon because of its status as a listed species under the Endangered Species Act, and consequently the legal implications of such a listing. Current understanding states that sDPS green sturgeon include those green sturgeon that spawn south of the Eel River, specifically within the Sacramento River and the Feather River, possibly also the Yuba River. The nDPS is currently not listed under the ESA, but NMFS notes it as a "species of concern". In this document we review the life history of sDPS green sturgeon, discuss population viability parameters, identify extinction risk, discuss critical habitat features and their conservation values, and we discuss the suite of factors affecting the species. The reader is encouraged to note that while the information contained herein is tailored to sDPS green sturgeon, much of this information is common to nDPS green sturgeon. Furthermore, in many instances where laboratory or field studies have been performed upon green sturgeon, the study subject has been exclusively nDPS green sturgeon, and where we are lacking equivalent information for sDPS green sturgeon, we borrow these informational results in order to paint a complete picture, noting that we are doing as such so that the reader remains informed. To a lesser extent, and only when necessary to fill in knowledge gaps, we also include information about white sturgeon (*Acipenser transmontanus*) and other sturgeon species, again keeping the reader informed of this cross-species informational exchange.

A. Species Listing History

In June of 2001, NMFS received a petition to list green sturgeon under the ESA and to designate ciritical habitat. After completion of a status review (Adams *et al.* 2002), NMFS found that the species was comprised of two DPS's that qualify as species under the ESA, but that neither DPS warranted listing. In 2003 this "not warranted' decision was challenged in federal court, and NMFS was asked to reconsider available information, taking into account rapidly developing new information. In April of 2005 NMFS (National Marine Fisheries Service 2005a) revised its "not warranted" decision and proposed to list the sDPS as threatened. In its 2006 final decision to list sDPS green sturgeon as threatened, NMFS cited concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats with regard to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities. A more full account of this listing history and decision making process can be found in the Federal Register (71 FR 17757). Since the original 2006 listing decision, much new information has become available, and this new information has generally been reinforcing to the original reasons or thought process for listing sDPS green sturgeon, and reaffirming NMFS concerns that sDPS green sturgeon face substantial threats, challenging their recovery.

B. Critical Habitat Listing History and Description

NMFS designated critical habitat for sDPS green sturgeon on October 9, 2009 by authority of Section 4(b) of the ESA. Out of 41 habitat units considered, 14 units were excluded from designation as critical habitat because the economic benefit of exclusion outweighed the conservation benefits of designation, and these exclusions would not significantly impede the conservation of the species (74 FR 52300). Briefly, critical habitat for sDPS green sturgeon includes, (1) the Sacramento River from the I-Street Bridge to Keswick Dam, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge (2) the Feather River up to the Fish Barrier Dam, (3) the Yuba River up to Daguerre Point Dam (4) the Sacramento-San Joaquin Delta (as defined by California Water Code section 12220), but with many exclusions (see 74 FR 52300), (5) San Francisco Bay, San Pablo Bay, and Suisun Bay, but with many exclusions, and (6) coastal marine areas to the 60 fathom depth bathymetry line, from Monterey Bay, California to the Strait of Juan de Fuca, Washington. For more details, see 74 FR 52300.

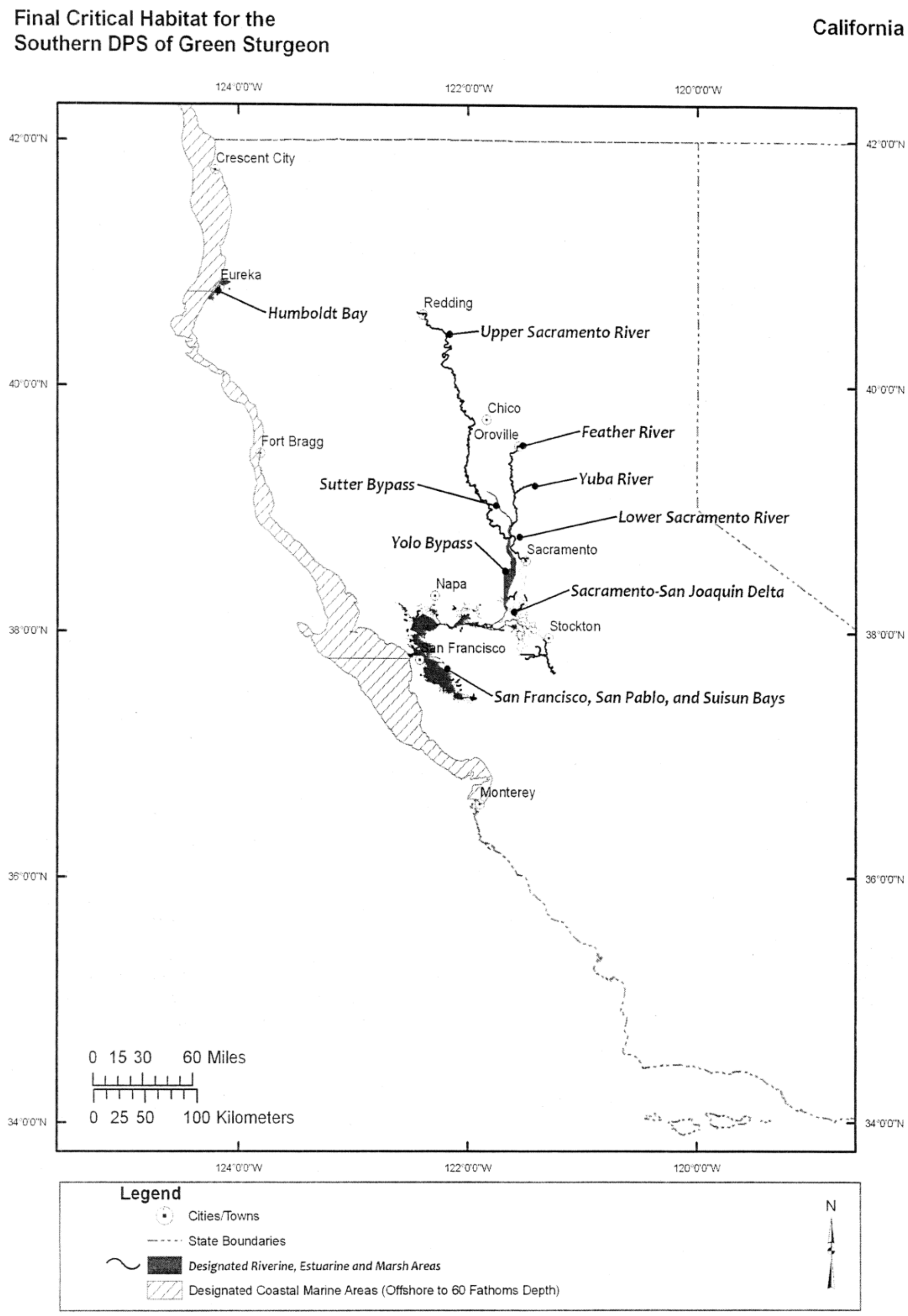
Critical habitat for sDPS green sturgeon is composed of certain habitat features necessary to the conservation of the species; a composition of biological and physical constituent elements, together known as primary constituent elements (PCEs). PCEs for sDPS green sturgeon have been designated for freshwater riverine systems, estuarine habitats, and nearshore coastal marine waters. In this document, we focus primarily upon the California Central Valley, omitting a discussion of PCE's for the marine environment, and making concise our discussion of PCE's for freshwater and estuarine systems, but the interested reader may find greater detail upon reading the Federal Register (74 FR 52300).

1. Freshwater Riverine Systems

Freshwater riverine systems are used by sDPS green sturgeon for spawning, and for adult holding after spawning. The eggs of sDPS green sturgeon hatch in freshwater and the larvae spend their initial days and weeks in freshwater, migrating to estuarine areas in a relatively short period of time, the typical length of this migration a subject of ongoing research, and discussed more fully in the Life History section of this document. Following is a discussion of PCE's necessary for the conservation of sDPS green sturgeon in freshwater riverine systems.

a. Food Resources

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



source: 50 CFR 226.219

Figure 3: Critical Habitat of sDPS green sturgeon

b. Substrate Type or Size

Critical habitat in the freshwater riverine system should include substrate suitable for egg deposition and development, larval development, and adult life stages. It is generally believed that green sturgeon spawn over a range of substrates from clean sand to gravel. (Poytress *et al.* 2011) conducted spawning substrate surveys at certain spawning locations on the Sacramento River and found that within the micro habitats where eggs were collected, pockets of small to medium gravel (gravel is defined as 2.0 – 64.0 mm) were consistently observed amongst generally larger substrate. Eggs are likely to adhere to substrates, or settle into crevices between substrates (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Larvae exhibited a preference for benthic structure during laboratory studies (Van Eenennaam *et al.* 2001, Deng *et al.* 2002, Kynard *et al.* 2005), and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2006).

c. Water Flow

An adequate flow regime is necessary for normal behavior, growth, and survival of all life stages in the upper Sacramento River. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (14 – 17.5°C) ((Mayfield and Cech 2004, Van Eenennaam *et al.* 2005, Allen *et al.* 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs, and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding. Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cubic feet per second (cfs)(average daily water flow during spawning months: 6,900 – 10,800 cfs; Brown (2007)). In Oregon's Rogue River, nDPS green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 10° C and flows increased (Erickson *et al.* 2002). On the Klamath River, the fall outmigration of nDPS green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson *et al.* 2007). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

d. 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, salinities, and dissolved oxygen levels are discussed in detail in the life history section.

e. Migratory Corridor

Safe and unobstructed migratory pathways are necessary for adult green sturgeon to migrate to and from spawning habitats, and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. This PCE is highly degraded compared to its historical condition due to man-made barriers and alteration of habitat. Keswick Dam, at RM 302, forms a complete barrier to any potential sturgeon migration on the Sacramento River, but downstream of this point, good spawning and rearing habitat exists, primarily in the river reach between Keswick Dam and Red Bluff Diversion Dam (RBDD)(RM 242). The Feather River and Yuba River also offer potential green sturgeon spawning habitat, but those rivers contain their own man-made barriers to migration and are highly altered environments. Within the California Central Valley, the conservation of green sturgeon depends heavily upon the maintenance of this PCE, and if possible, an expansion or improvement upon it. For more information, the green sturgeon Recovery Plan contains an in-depth discussion on this topic and recommends remedies that could bolster the recovery of sDPS green sturgeon.

f. Depth

Deep pools of more than five meter depth are critical for adult green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of green sturgeon are observed in these pools in the upper Sacramento River above the Glenn Colusa Irrigation District (GCID) diversion. The significance and purpose of these aggregations are unknown at the present time, but may be a behavioral characteristic of green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, and/or refuge from high water temperatures (Erickson *et al.* 2002, Benson *et al.* 2007). As described above approximately 54 pools with adequate depth have been identified in the Sacramento River above the GCID location (Thomas *et al.* 2013).

g. Sediment Quality

Sediment should be of the appropriate quality and characteristics necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants [*e.g.*, elevated levels of heavy metals (*e.g.*, mercury, copper, zinc, cadmium, and chromium), PAHs, and organochlorine pesticides] that can result in negative effects on any life stage of green sturgeon or their prey. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of green sturgeon.

<u>2. Estuarine Habitats</u>

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 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 upstream spawning migrations.

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, salinities, and dissolved oxygen necessary for green sturgeon are discussed in detail in the life history section.

d. Migratory Corridor

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

One of the key areas of concern is the Yolo and Sutter bypasses. These leveed floodplains are engineered to convey floodwaters of the greater Sacramento Valley and they include several concrete weir structures that allow flood flows to escape into the bypass channels. Adult sturgeon migrating upstream are attracted into the bypasses by these high flows. However the weirs can act as barriers and block the passage of fish. Fish can also be trapped in the bypasses as floodwaters recede (USFWS 1995, DWR 2005). Some of the weir structures have been designed with fish ladders to provide upstream adult salmon passage but these ladders have shown to be ineffective for providing upstream passage to adult sturgeon (DWR and BOR 2012). In addition there are irregularities in the splash basins at the foot of these weirs and multiple road crossings and agricultural impoundments in the bypasses that block hydraulic connectivity and can impede fish passage. As result sturgeon may become stranded in the bypasses and face delayed migration and lethal and sub-lethal effects from poaching, high water temperatures, low dissolved oxygen, and desiccation.

e. Water Depth

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

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 (see description of *sediment quality* for riverine habitats above).

3. Coastal Marine Areas

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

4. Critical Habitat Summary

The current condition of critical habitat for sDPS green sturgeon is degraded over its historical condition. In particular, migratory corridor and water flow PCEs have been particularly impacted by human actions, substantially altering the historical environmental characteristics in which sDPS green sturgeon evolved. Water temperature profiles, especially in the upper Sacramento River below Keswick Dam, are currently managed for the benefit of winter-run Chinook salmon, producing water temperature regimes that may not be ideal for sDPS green sturgeon larval growth. The conservation value of the green sturgeon PCE's is high, and maintaining the current quality of these PCE's is our foremost priority lest we should suffer any further degradation. Opportunities to improve the condition of these PCE's may include removal of barriers to migration and provision of elevated springtime flows. The issues and their solutions are complex, and it is beyond the scope of this document to fully discuss all aspects of green sturgeon conservation; for more detail, NMFS' Green Sturgeon Recovery Plan is the definitive source for establishing our framework of green sturgeon conservation and recovery.

C. Life History

1. General Information

When NMFS originally received a petition to list green sturgeon in 2003, scientific understanding of the species was in its infancy. Few scientific studies had been condcuted and what was known was subject to much uncertainity. In the early years of the 2000's, and most especially since listing sDPS green sturgeon as threatened in 2006, information has been developing rapidly. Beginning in 2001, but most significanlty since 2007, the USFWS has been conducting monitoring and research of green sturgeon in the Sacramento River. In 2011 researchers at DWR gathered conclusive evidence that green sturgeon can spawn in the Feather River (Seesholtz *et al.* 2014). In 2013 researchers at UC Davis began to release research findings to shed light upon the population dyamics of breeding adults in Sacramento River, including abundance estimates and spawing periodicity. These are but a few examples to highlight both the timeframe and the pace at which green sturgeon research is occuring. Thanks to the efforts of the U.S. Fish amd Wildlife Service, Bureau of Reclamation, UC Davis, Department of Water Resources, U.S. Army Corps of Engineers (Corps), and California Department of Fish and Wildlife, and NOAA's own Science Centers, NMFS is in a continually improving position to understand sDPS green sturgeon biologal needs and evaluate impacts to the species and habitat. In this section we review what is known about sDPS greens sturgeon life history so that is may form a basis for understanding and give creedence to NMFS' consultations, technical assistance, and recovery planning efforts on behalf of sDPS green sturgeon.

a. Life History Table

A general timeline of green sturgeon development is given in Table 5. Developmental stage is given by size which is a common practice in fisheries biology, to infer lifestage through the measured length of the fish. As Table 5 notes there is considerable variability across categories, such as size or age at maturity.

Table 5. A general time-table of green sturgeon life history, from egg to adult, with length-lifestage information given. Although not a perfect method, length is often used to determine age or dvelopmental stage in fish. Alternative methods for measuring age, such as counting bone growth rings, are possibly more accurate, but far more invasive than taking a simple length measurement.

Timeline	Lifestage, Length-Age relationship
Fertilization of eggs (spawning)	Spawning occurs primarily in deepwater (> 5m) pools[1] at very few select sites[2], predominantly in the Sacramento River, predominantly in time period mid-April to mid-June[3]
144 – 192 hours (6-8 days) after fertilization of eggs	Newly hatched larve emerge. **Larvae are 12.6 – 14.5 mm** in length[4]
6 days post hatch	Nocuturnal swim up, hide by day behavior observed[4]
10 dph (days post hatch)	Exogenous feeding begins around 10 dph[4]. Larvae begin to disperse downstream
2 weeks old (approx)	Larvae appear in USFWS rotary screw traps at RBDD at lengths of 24 to 31 mm.
45 days post hatch	Larval to juvenile metamorphosis complete. Begin juvenile life stage. **Juveniles are 63 – 94 mm** in length.
45 days to 1.5 years	Juveniles migrate downstream and into the Delta or the estuary and rear to the sub-adult phase. **Juveniles range in size from around 70 mm to 90 cm**. Little information avaialble about this life stage.
1.5 – 4 years	Juvenile green sturgeon migrate to sea for the first time, thereby entering the sub-adult phase. **Subadults are 91cm to 149 cm**.
1.5 years to 15-17 years	Sometime between the age of 1.5 to 4 years, green sturgeon enter the ocean for the first time where they grow and develop, reaching maturity between 15-17 years of age*
15-17 years*	Green sturgeon reach sexual maturity and become adults, with **males maturing around 120 cm and females maturing around**

	145 cm[5] (based on Nakamoto's Klamath River studies)
15 years to 50+ years	Green sturgeon have a lifespan that can reach 50 or more years, and can grow to a **total length of over 2 meters**
References 1. Thomas *et al.* (2013) 2. Ethan Mora, UC Davis, unpublished data 3. Poytress *et al.* (2013) 4. Deng *et al.* (2002) 5. Nakamoto *et al.* 1995 *Nakamoto *et al.* (1995) found that green sturgeon in the Klamath River might reach sexual maturity as early as 13 years for females and 9 years for males. More research is needed to determine the typical age and size of sDPS green sturgeon at maturity.	

2. Adult Migration and Spawning

Green sturgeon reach sexual maturity around 15–17 years of age (Beamesderfer *et al.* 2007), and they typically spawn once every 2-5 years (average = 3.75 years)(Mora unpublished data). Based on data from acoustic tags (unpublished data from California Fish Tracking Consortium database 2013 (currently Hydra database);(Heublein *et al.* 2009), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between late January and early May and begin their spawning run. Migration through the estuary lasts about a week, and progress is farily rapid to their upriver spawning sites. Larval green sturgeon hach in the late spring or summer and progress downriver towards the Delta and estuary, rearing into juveniles. The time of first ocean entry marks the transition of a green sturgeon from juvenile to sub-adult. The table below gives relative abundance of various life stage catogories by location.

Table 6. Migration timing of sDPS green sturgeon by location and life stage.

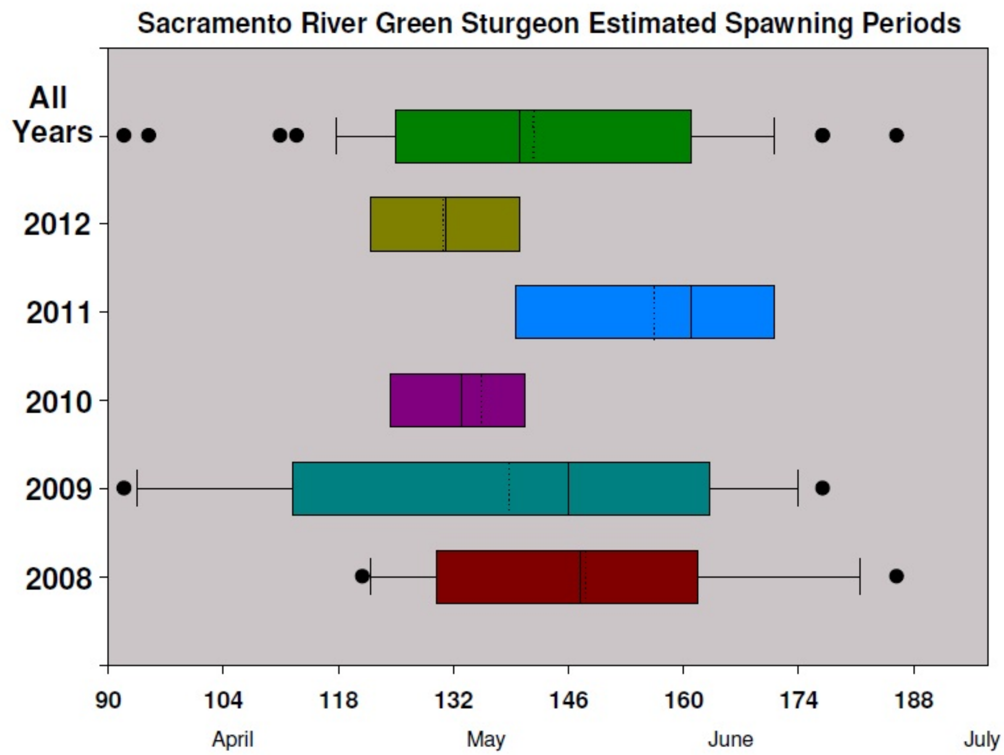
				Low	Medium	High	Medium	Low			
a) Spawning adults											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry, heading upstream	Low	High	High	High	Low							
Arrival at Rio Vista, heading upstream	Low	High	High	High	Low							
Arrival to spawning grounds on upper Sacramento River		Low	High	High	Medium	Low						
Sacramento River spawning period				Medium	High	High	Low					
Sacramento River upriver presence	High	Low	High	High	High	High	High	High	High	High	High	High
Arrival at Rio Vista, heading downstream	High	Low						Low		Low		High
Arrival at Golden Gate, heading seaward	High	Low								Medium		High
b) Summer and fall residence of subadults and non-spawning adults in the San Francisco Bay Estuary												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry				Medium	Medium	High	High	Medium				
Residing in estuary				Medium	High	High	High	High	High	Medium	Low	
Golden Gate departure				Low	Low	High	Low	Medium	High	Medium	Low	
c) YOY/Juveneiles												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
YOY at Red Bluff Diversion Dam					High	High	High	Low	Low			
YOY at GCID					Medium	High	High	Medium	Low			
Juveniles from Delta salvage (<50cmTL)		Low	Medium	Low	Low	Low	Low	High	Low	Medium	Medium	Low
Juveniles residing in San Francisco Bay Estuary	High	High	High	High	High	High	High	High	High	High	High	High

It has long been known that green sturgeon spawn in the Sacramento River, but only in 2011 was spawning confirmed in the Feather River by DWR, and suggested in the Yuba River by a report released by Cramer Fish Sciences (Bergman *et al.* 2011). Given these separate spawning areas, it is logical to wonder if sDPS green sturgeon are all of a single population, or if perhaps there are multiple populations. However, as Table 7 shows, the vast majority of adult presence, and therefor spawning activity, is in the Sacramento River.

Table 7: Estimates of sDPS adult green sturgeon presence and abundance in known or suspected spawning rivers. Numbers given are likely unique individuals, although this is unverifiable given the survey methods used to collect this data. Data sources: Sacramento River (UC Davis/Ethan Mora, unpublished data), Feather River (Alicia Seesholtz, DWR, unpublished data), Yuba River (Cramer Fish Sciences, 2011).

	Sacramento River	Feather River	Yuba River
2010	164	data unavailable	data unavailable
2011	220	25	4 or 5
2012	329	data unavailable	Presumed to be zero, but data unavailable
2013	data unavailable	data unavailable	Presumed to be zero, but data unavailable
2014	data unavailable	data unavailable	Presumed to be zero, but data unavailable

Timing of migration and spawning varies by individual, or from year to year, but in general sDPS green sturgeon leave the ocean and enter the SF Bay Delta and estuary in late winter/early spring, and are spawning predominantly in May and June. Post spawning, adults have been observed to leave the system rapidly, or to hold and migrate downriver in winter.



Boxplots displaying Julian days of median (line) and mean (dotted), 10th, 25th, 75th and 90th percentiles, and outliers of estimated spawning events derived from annual egg mat sample collections for the period 2008 through 2012. from Poytress *et al.* (2013)

Most green sturgeon spawning activity occurs on the Sacramento River, and although a number of spawning sites are known, just 3 sites on the Sacramento River account for over 50% of green sturgeon spawning (Mora unpublished data). Due to this concentration of spawning habitat, sDPS green sturgeon are particularly vulnerable to anything that might negaitvely affect these areas, such as an envornmental disturbance for example. Table 8 shows known spawning locations on the Sacramento River.

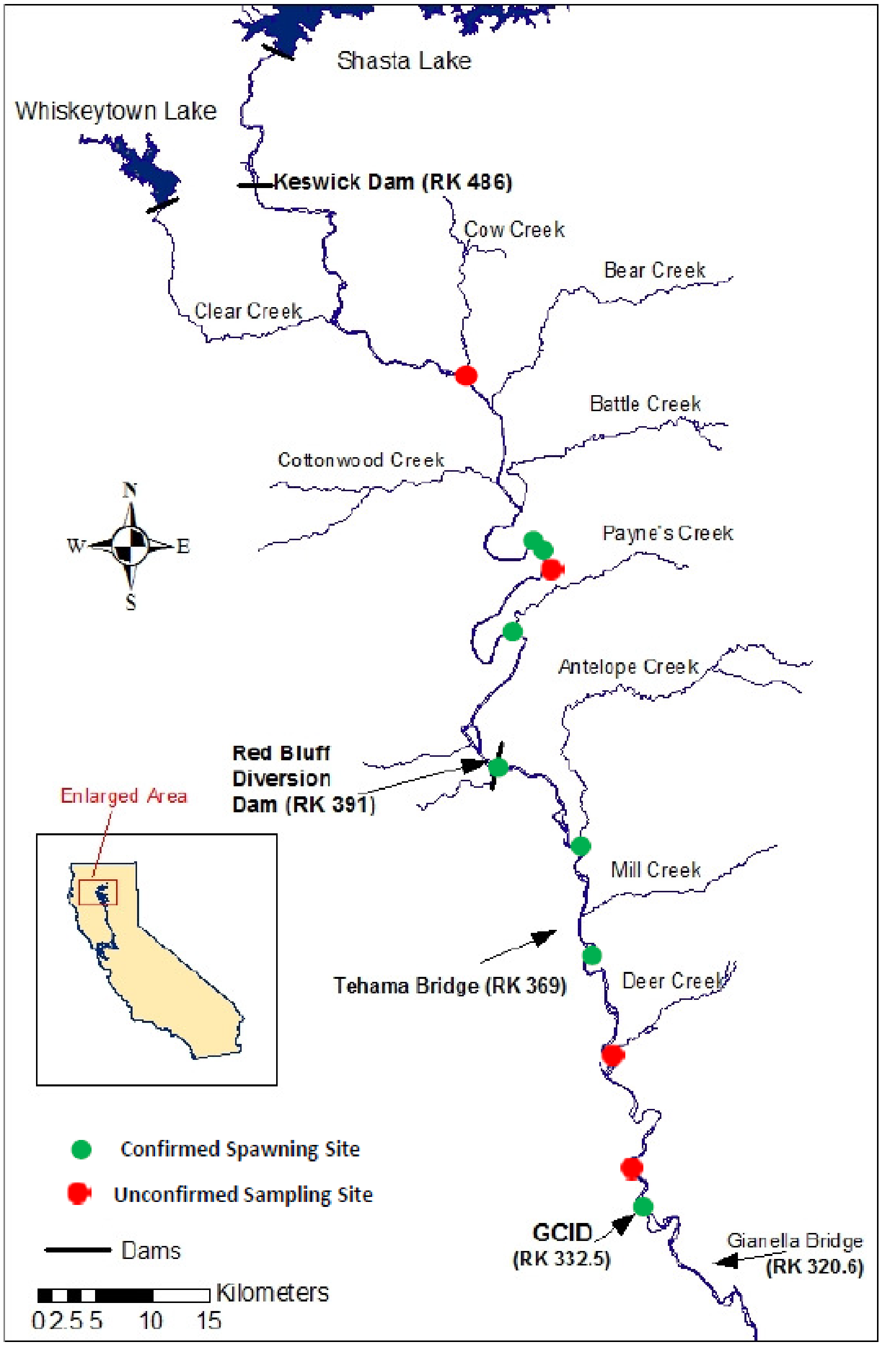


Figure 4: Green sturgeon known spawning locations on the upper Sacramento River, as identified by USFWS during the 2008-2012 field sampling seasons. Source: Poytress *et al.* (2012). An uncomfirmed sampling site indicates an

area where sturgeon have been known to congregate but where evidence of spawning was not able to be obtained in the study.

3. Egg and Larval Stages

Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15° C (59° F) (Van Eenennaam *et al.* 2001, Deng *et al.* 2002). Studies conducted at the University of California, Davis by Van Eenennaam *et al.* (2005) using nDPS green sturgeon juveniles indicated that an optimum range of water temperature for egg development ranged between 14° C (57.2°F) and 17.5° C (62.6°F). Temperatures over 23 °C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5° C (63.5°F) and 22° C (71.6°F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14° C (57.2°F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam *et al.* 2005). Further research is needed to identify the lower temperatures limits for eggs and larvae. Table 4 shows tempearture tolerance by life stage for all stages of green sturgeon development.

Table 8: Temperature tolerance range by life stage

Green Sturgeon Temperature Tolerance by Life Stage

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

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

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

Information about larval sDPS green sturgeon in the wild is very limited. The U.S. Fish and Wildlife Service (USFWS) conducts annual sampling for eggs and larvae in the mainstem Sacramento River. Larval green sturgeon appear in USFWS rotary screw traps at Red Bluff Diversion Dam from May through August (Poytess *et al.*, 2010) and at lengths ranging from 24 to 31 mm fork length, indicating they are approximately two weeks old (California Department of Fish and Game 2002, U.S. Fish and Wildlife Service 2002). USFWS data reveals some limited information about green sturgeon larvae, such as time and date of capture, and corresponding river conditions such as temperature and flow parameters. Unfortunately, there is little information on diet, distribution, travel time through the river, and estuary rearing. Laboratory studies have provided some information about this initial life stage, but the relevance to fish in their natural habitat is unknown. Probably the most significant use of the USFWS data on larval green sturgeon has been to infer larval growth rates and correlations of these growth rates to temperature and flow conditions, making comparisons with larval green sturgeon growth rates in other river systems. There is some concern that the Sacramento River may have temperature regimes too cold for optimal larval growth (NMFS Green Sturgeon Recovery Plan) or for optimal hatching success in the upper regions of the river (Poytress *et al.* 2013).

4. Juvenile Development and Outmigration

Young green sturgeon appear to rear for the first one to two months in the Sacramento River (California Department of Fish and Game 2002). Growth is rapid as juveniles move downstream and reach up to 300 mm the first year and over 600 mm in the first 2 to 3 years (Nakamoto *et al.* 1995). Juvenile sDPS green sturgeon have been salvaged at the Federal and State pumping facilities (which are located in the southern region of the Delta), and collected in sampling studies by CDFW during all months of the year (California Department of Fish and Game 2002). The majority of juveniles that were captured in the Delta were between 200 and 500 mm indicating they were from 2 to 3 years of age, based on age/growth studies from the Klamath River (Nakamoto *et al.* (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures seems to suggest that individuals smaller than 200mm simply aren’t present in the Delta, and therefore may be rearing in the Sacramento River or its tributaries. Possibly, juvenile sDPS green sturgeon hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard *et al.* (2005). Juvenile green sturgeon captured in the Delta by Radtke (1966) ranged in size from 200-580 mm, further supporting the hypothesis that juvnile green sturgeon don’t enter the Delta until a certain age/size of approximatley 10 months/200mm. There is much that is unknown about the green sturgeon juvenile life stage in the wild, especailly the first several months of life; we simply don’t know what they do or where they go between the time they are detected as larvae in the mid Sacrametno River and when they are detected again in the Delta as older juveniles around 200 mm.

Much of what is known about juvenile green sturgeon comes from laboratory studies. Both nDPS and sDPS green sturgeon juveniles tested under laboratory conditions, with either full or reduced rations, had optimal bioenergetic performance (*i.e.,* growth, food conversion, swimming ability) between 15^{o} C (59^{o} F) and 19^{o} C (66.2^{o} F) , thus providing a temperature related habitat target for conservation of this rare species (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed.

Radtke (1966) inspected the stomach contents of juvenile green sturgeon (range: 200-580 mm) in the Delta and found food items to include mysid shrimp (*Neomysis awatschensis),* amphipods (*Corophium sp.),* and other unidentified shrimp. In the northern estuaries of Willapa Bay, Grays Harbor, and the Columbia River, where both sDPS and nDPS green sturgeon exist, green sturgeon have been found to feed on a diet consisting primarily of benthic prey and fish common to the estuary. For example, burrowing thalassinid shrimp (mostly *Neotrypaea californiensis*) were important food items for green sturgeon taken in Willapa Bay, Washington (Dumbauld *et al.* 2008).

5. Estuarine Rearing

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

6. Ocean Rearing

Once green sturgeon juveniles make their first entry into sea, they enter the sub-adult phase and spend a number of years migrating up and down the coast. While they may enter river mouths and coastal bays throughout their years in the sub-adult phase, they do not return to their natal freshwater environments before they are mature. In other words, sDPS green sturgeon sub-adults and adults may be found in various bays and estuaries and marine environments, from California to Canada, but not until sexually mature and ready to spawn will they return to the Sacramento River or its tributaries.

In the summer months, multiple rivers and estuaries throughout the sDPS range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley *et al.* 2011). Some of these aggregations are mixtures of both sDPS and nDPS green sturgeon, and there is considerable overlap in their ranges. However, nDPS green sturgeon do not appear to migrate into San Francisco Bay. Genetic studies on green sturgeon stocks indicate that the green sturgeon in the San Francisco Bay ecosystem belong to the sDPS (Israel *et al.* 2009). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly *et al.* 2007, Heublein *et al.* 2009, Lindley *et al.* 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean, and why they aggregate episodically (Lindley *et al.* 2008, Lindley *et al.* 2011).

Adult sDPS green sturgeon begin their upstream spawning migrations into freshwater as early in the year as late February with spawning occuring between April and July, with most spawning activity seemingly concentrated in the mid-April to mid-June time period (Poytress *et al.* 2013). Various studies of spawning site charecterstics, for example (Poytress *et al.* 2011), (Thomas *et al.* 2013), (Mora unpublished data) agree that spawning sDPS green sturgeon typically favor deep, turbulent holes over 5 meters deep, featuring sandy, gravel, and cobble type substrates. Water depth may be negotiable, as spawning has been documented in depths as shallow as 2 meters (Poytress *et al.* 2011). However, substrate type is likely constrained as the interstices of the cobble and gravel are probably important to catch and hold the eggs while they develop, or else the eggs would wash downstream. Temperature and flow characteristics are also very important, but in complicated ways not fully understood nor easily summarized. In general, flows need to be sufficient to create the deep, turbulent holes that green sturgeon seem to favor for spawning. Temperatures for successful egg development are too cold as they approach 11° C on the low end, and too warm approaching 19° C on the upper end. Note that larvae and juveniles appear to have broader temperature tolerances. See Table 8 for more information and supporting references.

Poytress *et al.* (2012) conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 and has identified a number of confirmed spawning locations (Figure 4). Green sturgeon fecundity is approximately 50,000 to 80,000 eggs per adult female (Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon. The outside of the eggs are mildly adhesive, and are more dense than than those of white sturgeon (Kynard *et al.* 2005, Van Eenennaam *et al.* 2009).

Post spawning, green sturgeon may exhibit a variety of behaviors. Ultimately they will return to the ocean, but how long they take to do this and what they do along the way are topics of ongoing research. Benson *et al.* (2007) conducted a study in which 49 nDPS green sturgeon were tagged with radio and/or sonic telemetry tags and tracked manually or with receiver arrays from 2002 to 2004. Tagged individuals exhibited four movement patterns: upstream spawning migration, spring outmigration to the ocean, or summer holding, and outmigration after summer holding.

In the case of sDPS green sturgeon, a number of ongoing studies are using surgically inserted acoustic tags that can be detected by an array of sensors that extends through the Sacramento River watershed, the Bay-Delta, and the nearshore coast. The data from these tag detections helps biologists to understand where and when green sturgeon are occuring, revealing clues about the timing of thier migration patterns, residence times in particular environments, and so forth. Much of the database for these acoustic tag detections contains data from the latter half of the 2010’s, ie 2006, 2007, and up to 2014, and thus published papers on this data are not yet available, but should be forthcoming. Nevertheless, this database has been investigated by NMFS biologists and it appears that normal adult post-spawning behavior is that following spawning, sDPS green sturgeon will hold for several months in deep pools within their spawning reach. Then they migrate downstream toward the ocean, re-entering the ocean generally from November through January (with the onset of the first winter storms), with migration through the estuary lasting about a week.

In summary, and to reiterate the most important points briefly, a very general model of green sturgeon habitat usage, intended to inform management decisions, would be as follows; adult green sturgeon enter the San Francisco Bay from late February through April and transition farily quickly, maybe in just a week’s time, towards their spawning grounds, primarily on the upper Sacramento River. There seems to be an overwhelming preference for just a few select spawning sites. Spawning ocurs from April to July. Post spawning, adults may hold for up to several months before migrating in the winter downriver and back into the ocean. Larvae hatch in the spring and summer, and migrate downriver fairly quickly, perhaps in just a couple weeks time.

Juveniles rear in riverine and estuarine habitats for at least 1.5 years before making their first entry into the ocean whereupon they are classified as sub-adults. Sub-adults mature in coastal marine environments and in bays and estuaries until at least 9-17 years of age before returning to their natal freshwater river to spawn. An individual may spawn once every 3-5 years and live for 50 years or more.

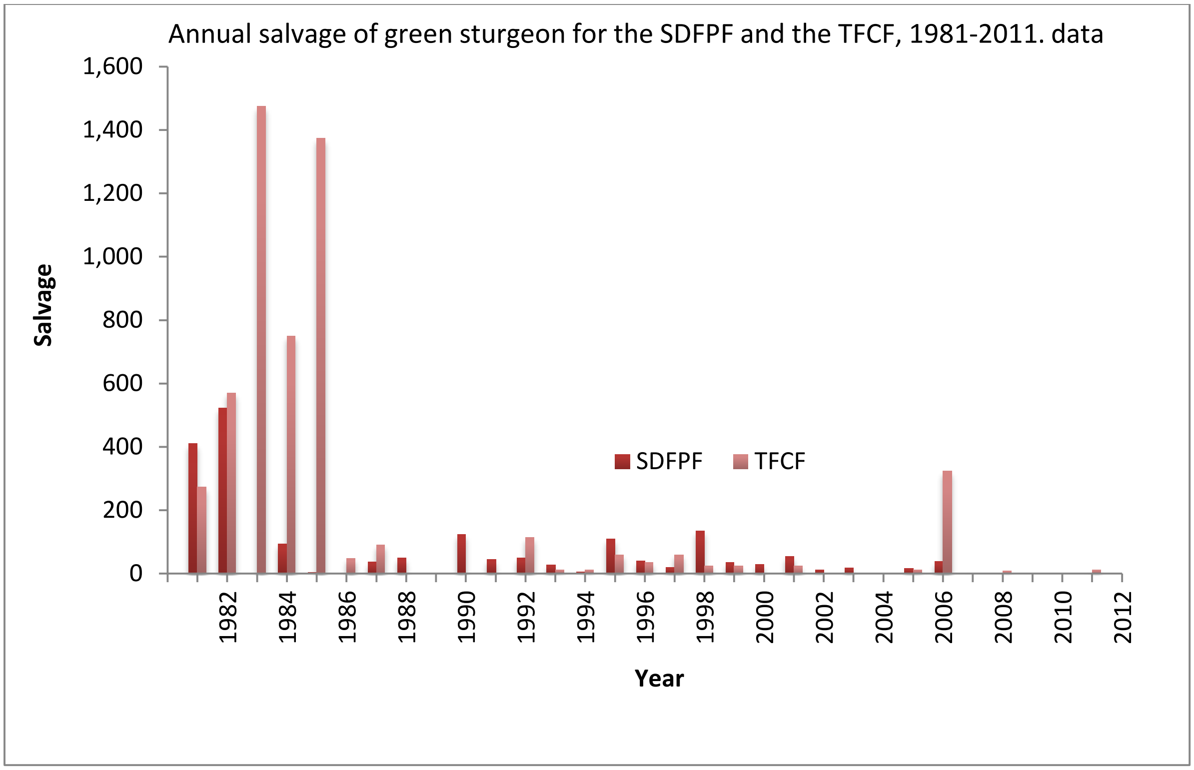
D. Description of Viable Salmonid Population (VSP) Parameters

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

1. Abundance

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

A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities; the Skinner Delta Fish Protection Facility (SDFPF) and the Tracy Fish Collection Facility (TFCF). This data should be interpreted with some caution; operations and practices at the facilities have changed over the decades, which may affect the salvage data shown below (Figure 5).



Data source: ftp://ftp.delta.dfg.ca.gov/salvage

Figure 5. Annual salvage of green sturgeon for the SDFPF and the TFCF from 1981 to 2012

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

Beginning in 2010, more robust estimates of sDPS green sturgeon have been generated. As part of a doctorate thesis at UC Davis, Ethan Mora has been using acoustic telemetry to locate green sturgeon in the Sacramento River, and to derive an adult spawner abundance estimate. This information is stated in the Green Sturgeon Recovery Plan:

Results of these surveys indicate an average annual spawning run of 272 fish (Mora unpublished data). This estimate does not include the number of spawning adults in the lower Feather River, where green sturgeon spawning was recently confirmed. This estimate is preliminary and involves a number of untested assumptions regarding sampling efficiency, discrimination between green and white sturgeon, and spawner residence time. Although caution must be taken in using this estimate to infer the spawning run size for the Sacramento River until further analyses are completed, this preliminary estimate provides reasonable order-of-magnitude numbers for recovery planning purposes until such time as new information is developed.

2. Productivity (population growth rate)

There are several questions about sDPS green sturgeon productivity and related parameters that are important to address. First and foremost, can the population replace itself (*i.e.* is the population growth rate near or above 1.0)? Secondly, what is the environment's carrying capacity for sDPS green sturgeon? These, and other related questions are important but poorly understood. The Green Sturgeon Recovery Plan calls for specific abundance levels yet the ability of the population to achieve these levels is untested and unknown. So let's address what is known. We do have larval count data from rotary screw traps set seasonally near RBDD and GCID. This data, provided by the USFWS Red Bluff office, shows enormous variance between years and suggests that some years are highly successful larval production years. In particular, 2011 appears to have been a banner year, with over 3700 larvae captured (Poytress *et al.* 2012). In other years, larval counts were an order of magnitude lower. However some caution is required as these data are not standardized between years, and there are lingering questions about sampling methodology. In general, sDPS green sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010b). It is unclear if the population is able to consistently replace itself or grow to greater abundance than levels currently observed. Other indicators of productivity, such as cohort replacement ratios, and spawner abundance trends, require data sets that simply do not exist for sDPS green sturgeon. The long lifespan of the species and long age to maturity makes trend detection dependent upon data sets spanning decades, something that is currently lacking. The acoustic telemetry work begun by Ethan Mora (UC Davis) on the Sacramento River and by Alicia Seesholtz (DWR) on the Feather River, as well as larval and juvenile studies begun by Bill Poytress (USFWS) may eventually produce enough data to gain statistically robust insights into productivity.

<u>3. Spatial Structure</u>

Green sturgeon, as a species, are known to range from Baja California to the Bering Sea along the North American continental shelf. 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 1991, Moser and Lindley 2007). Based on genetic analyses and spawning site fidelity (Adams *et al.* 2002, Israel *et al.* 2004), green sturgeon are comprised of at least two DPSs.

1. A northern DPS (nDPS) consisting of populations originating from coastal watersheds northward of and including the Eel River (*i.e.* Klamath, Trinity, and Rogue Rivers).

2. A southern DPS (sDPS) consisting of populations originating from coastal watersheds south of the Eel River.

Throughout much of their range, sDPS and nDPS green sturgeon are known to co-occur, especially in northern estuaries and over-wintering grounds. Israel *et al.* (2009) found that green sturgeon within the inland waters of California are almost entirely sDPS green sturgeon. Further studies based upon work done with acousitc tagging of sDPS green sturgeon, enable us to state with high levels of certainty that those green sturgeon found within the San Fancisco Bay estuary and further inland are exclusively sDPS green sturgeon.

Considering the waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and the delta and range up the Sacramento River, Feather

River, and the Yuba River. In the Yuba River, green sturgeon have been documented up to Daguerre Point Dam (Bergman *et al.* 2011). Migration past Daguerre Point Dam is not possible for green sturgeon, although potential spawning habitat upriver does exist. The same can be said about the Feather River, where green sturgeon have been observed by DWR staff up to the Fish Barrier Dam. On the Sacramento River, Keswick Dam, located at RK (river kilometer) 486, marks the highest point on the river accessible to green sturgeon, and it might be presumed that green sturgeon would ultilize habitat up to this point. However, USFWS sampled for larvae in 2012 at RK 430 and at RK 470 and no larve were caught at these locations; habitat usage could not be confirmed any further upriver than the confluence with Ink's Creek (RK 426), which was a confirmed spawning site in 2011 (Poytress *et al.* 2012). Adams *et al.* (2007) summarizes information that suggests green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers. (Mora *et al.* 2009) analyzed and characterized known green sturgeon habitat and used that characterization to identify potential green sturgeon habitat within the Sacramento and San Joaquin River basins that now lies behind impassable dams. This study concludes that about 9% of historically available habitat is now blocked by impassible dams, but more importantly, this blocked habitat was of likely high quality for spawning.

Studies done by UC Davis (Mora unpublished data) have revealed that green sturgeon spawning sites are concentrated in just a handful of locations. Mora found that on the Sacramento River, just 3 sites accounted for over 50% of the green sturgeon documented in June of 2010, 2011, and 2012. All of these green sturgeon were presumed to be there to spawn. This is a critical point with regards to the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure. Given a high concentration of individuals into just a few spawning sites, extinction risk due to stochastic events would be expected to be increased.

Green sturgeon were historically present in the San Joaquin River; (Radtke 1966) reports catching green sturgeon at the Santa Clara Shoals (which is near the confluence ot the San Joaquin River and the Sacramento River) and to a much lesser extent, west of Stockton. However, there is no known modern usage of the San Joaquin River by green sturgeon. Anglers have reported catching green sturgeon at various locations within the San Joaquin River basin; however none of these reports have been verified and no photographic evidence has surfaced. Unless stronger evidence can be shown, it is currently believed that green sturgeon do not use the San Joaquin River or its tributaries.

In summary, current scientific understanding indicates that sDPS green sturgeon is composed of a single, independent population, which pricipally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and possibly even the Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent extirpation from the San Joaquin River narrows the habitat usage by the species, offering fewer alternatives to impacts upon any portion of that habitat.

4. Diversity

Diversity, as defined in the VSP concept in (McElhany *et al.* 2000), includes genetic traits such as DNA sequence variation, and other traits that are influenced by both genetics and the environment, such as ocean behavior, age at maturity, and fecundity. Variation is important to the viability of a species for several reasons. First, it allows a species to utilize a wider array of environments that they could without it. Second, diversity protects a species from short term spatial and temporal changes in the environment by increasing the likelihood that at least some individuals will have traits that allow them to persist in spite of changing environmental conditions. Third, genetic diversity provides the raw material necessary for the species to have a chance to adapt to changing environmental conditions over the long term.

While it is recognized that diversity is crucial to the viability of a species in general, it is not well understood how well sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long term extinction risk. In general, a larger number of populations and number of individuals within those populations should offer increased diversity, and therefore greater chance of long term viability. The recovery plan for sDPS green sturgeon focuses on trying to bolster both the number of individuals of sDPS green sturgeon, and seeks to establish a second breeding population, outside the Sacramento River, with the Feather River being best positioned, and to a lesser extent, the Yuba River. The diversity of sDPS green sturgeon is probably low, given abundance estimates. Also, because human alteration of the environment is so pervasive in the California Central Valley, basic diversity principles such as run timing and behavior are likely adversely influenced through mechanisms such as diminished springtime flow rates as water is impounded behind dams, to give but one example.

5. Conclusion

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010a). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany *et al.* 2000). The best available scientific information does not indicate that the extinction risk facing sDPS green sturgeon is negligible over a long term (~ 100 year) time horizon; therefore the DPS is not believed to be viable. To support this statement, the population viability analysis (PVA) that was done for sDPS green sturgeon in relation to stranding events (Thomas *et al.* 2013) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley *et al.* (2007), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, the position of NMFS, upon weighing all available information (and lack of information) has stated the extinction risk to be moderate (National Marine Fisheries Service 2010a).

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their habitat needs. We need to better understand how to manage river flows and temperatures to best balance the needs of green sturgeon with other considerations such as flood control and water storage for anthropogenic uses. In the past several years much new information has become available, but due to the longevity of green sturgeon and their complex life history, studies need to be conducted on decades-long time scales.

2.2.2 CALIFORNIA CENTRAL VALLEY STEELHEAD

Listed as threatened (71 FR 834; January 5, 2006)
Designated critical habitat (70 FR 52488; September 2, 2005)

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

A. Critical Habitat and Primary Constituent Elements for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta (Figure 6). Currently the CCV steelhead DPS and critical habitat extends up the San Joaquin River up to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999; 70 FR 52488). Critical habitat for CCV steelhead is defined as specific areas that contain the primary constituent elements (PCEs) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CCV steelhead:

1. Spawning Habitat

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, egg incubation, and larval development. Most of the available spawning habitat for steelhead in the Central Valley is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have adverse effects upon salmonids spawning and rearing below the dams. 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.

2. 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 survival; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material (LWM), log jams, 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.

3. 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 and downstream passage of adults, and the emigration of smolts. 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.

4. 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.

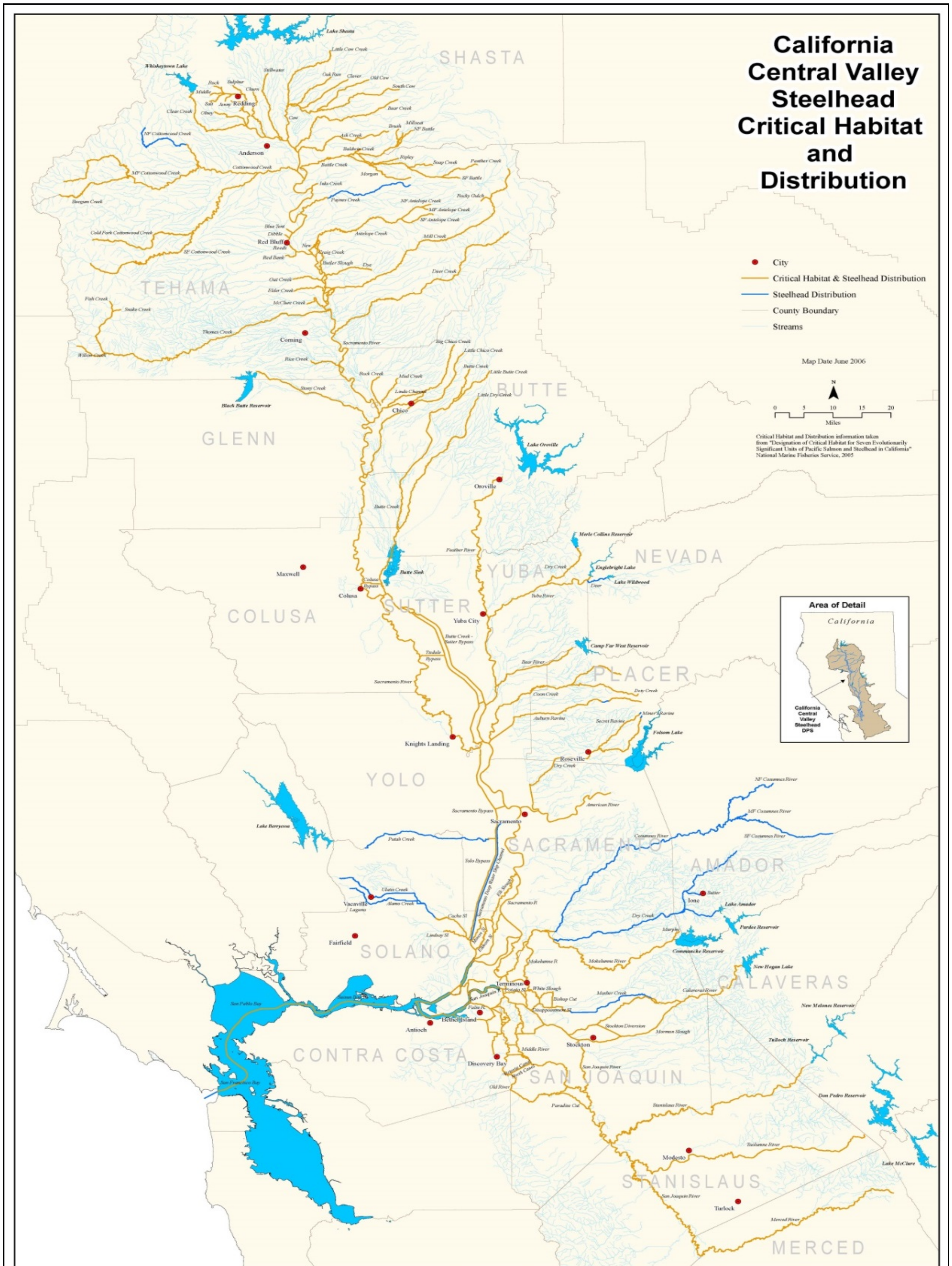


Figure 6. California Central Valley steelhead designated critical habitat.

B. Life History

1. Egg to Parr

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

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965; Everest and Chapman 1972; Fontaine 1988).

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or bolders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 15°C (59°F) to 20°C (68°F) (McCullough *et al.* 2001, Spina 2006). Cherry *et al.* (1975) found preferred temperatures for rainbow trout ranged from 11°C (51.8°F) to 21°C (69.8°F) depending on acclimation temperatures (cited in Myrick and Cech 2001).

2. Smolt Migration

Juvenile steelhead will often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch *et al.* 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean, and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage in the California Central Valley.

3. Ocean Behavior

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

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

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

4. <u>Spawning</u>

CCV steelhead generally enter freshwater from August to November (with a peak in September [Hallock *et al.* 1961]), and spawn from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Table 9; Williams 2006; Hallock *et al.* 1961; McEwan and Jackson 1996). The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman *et al.* 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F maximum water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern as this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

Few direct counts of fecundity are available for CCV steelhead populations, but since the number of eggs laid per female is highly correlated with adult size, adult size can be used to estimate fecundity with reasonable precision. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after one or two years at sea (Hallock *et al.* 1961), and adults typically range in size from two to twelve pounds (Reynolds *et al.* 1993). Steelhead about 55 cm (FL) long may have fewer than 2,000 eggs, whereas steelhead 85 cm (FL) long can have 5,000 to 10,000 eggs, depending on the stock (Meehan and Bjornn 1991). The average for Coleman National Fish Hatchery since 1999 is about 3,900 eggs per female (USFWS 2011).

Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards 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, Shapolov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek. Null *et al.* (2013) found between 36 percent and 48 percent of kelts released from Coleman NFH in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman NFH in the 1971 season, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider *et al.* 1986).

5. Kelts

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

Table 10. The temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead at locations in the Central Valley. Darker shades indicate months of greatest relative abundance.

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

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

Relative Abundance: = High = Medium = Low

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

C. Description of Viable Salmonid Population (VSP) Parameters

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

1. Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the Red Bluff Diversion Dam (RBDD) declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers *et al.* 2010).

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

Coleman National Fish Hatchery (Coleman) operates a weir on Battle Creek, where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of steelhead captured at and passed above this weir represent one of the better data sources for the Central Valley DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman stopped transferring all adipose-fin clipped steelhead above the weir, resulting in a large decrease in the overall numbers of steelhead above the weir in recent years (Figure 8). In addition, in 2003, Coleman transferred about 1,000 clipped adult steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery and natural-origin steelhead in Battle Creek were not differentiable, and all steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin steelhead in Battle Creek began in 2001. These estimates of steelhead abundance include all *O. mykiss*, including resident and anadromous fish.

Steelhead returns to Coleman NFH have fluctuated greatly over the years. From 2003 to 2012, the number of hatchery origin adults has ranged from 624 to 2,968. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200-500 fish each year.

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 151 redds have been counted in Clear Creek from 2001 to 2010 (Figure 10; data from USFWS), and an average of 154 redds have been counted on the American River from 2002-2010 (Figure 9; data from Hannon and Deason 2008, Hannon *et al.* 2003, Chase 2010).

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

The returns of steelhead to the Feather River Hatchery have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 11). This is despite the fact that almost all of these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt and/or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. However, preliminary return data for 2011(CDFG) shows a slight rebound in numbers, with 712 adults returning to the hatchery through April 5th, 2011.

The Clear Creek steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001 (Figure 10). The average redd index from 2001 to 2011 is 157, representing somewhere between 128 and 255 spawning adult steelhead on average each year. The vast majority of these steelhead are wild fish, as no hatchery steelhead are stocked in Clear Creek.

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

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

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

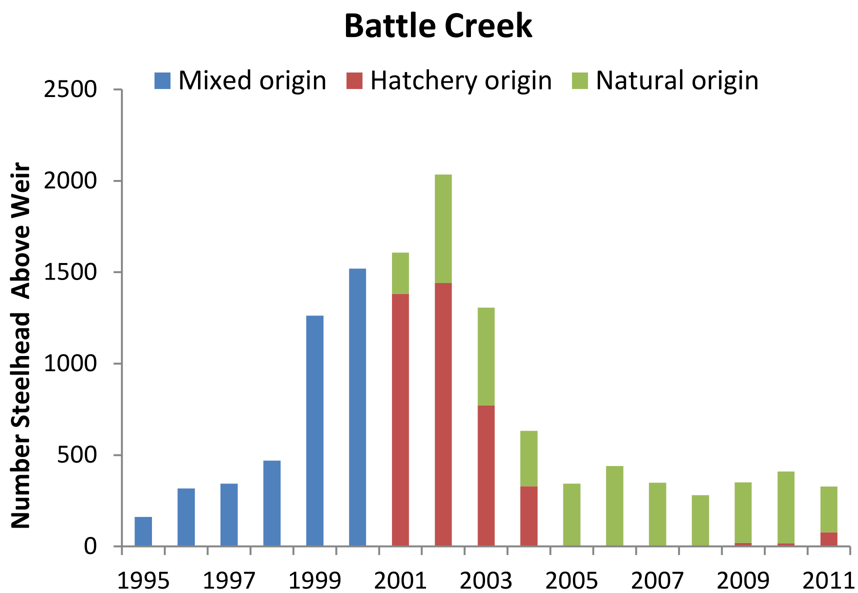


Figure 7. Steelhead returns to Battle Creek from 1995-2009. Starting in 2001, fish were classified as either wild (unclipped) or hatchery produced (clipped). Includes fish passed above the weir during broodstock collection and fish passing through the fish ladder March 1 to August 31. Data are from USFWS.

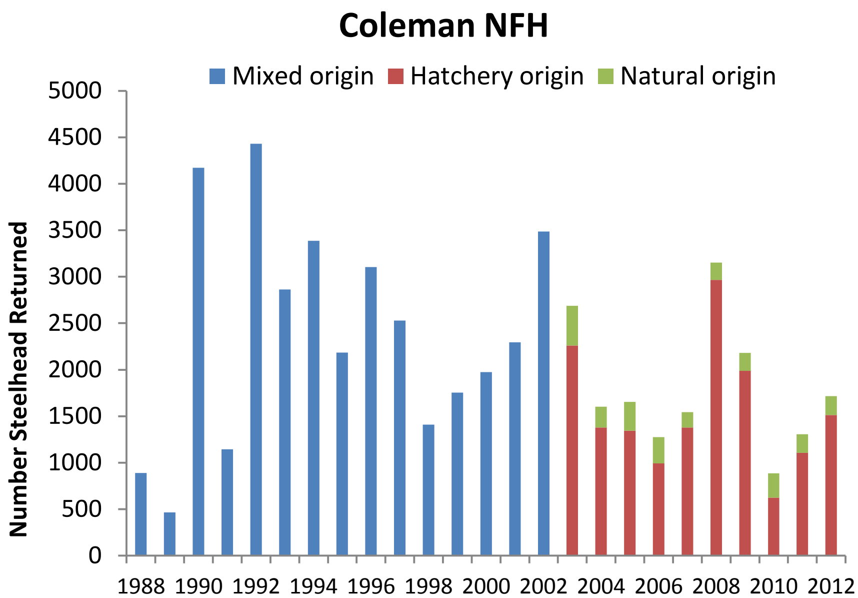


Figure. 8. Number of steelhead that returned to the Coleman National Fish Hatchery each year. Adipose fin-clipping of hatchery smolts started in 1998, and since 2003 all returning steelhead have been categorized by origin.

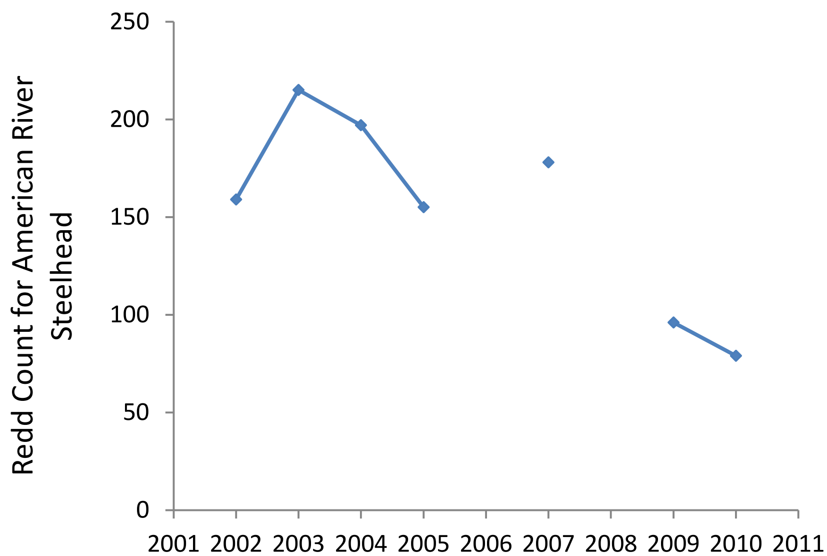


Figure 9. Steelhead redd counts from USBR surveys on the American River from 2002-2010. Surveys could not be conducted in some years due to high flows and low visibility.

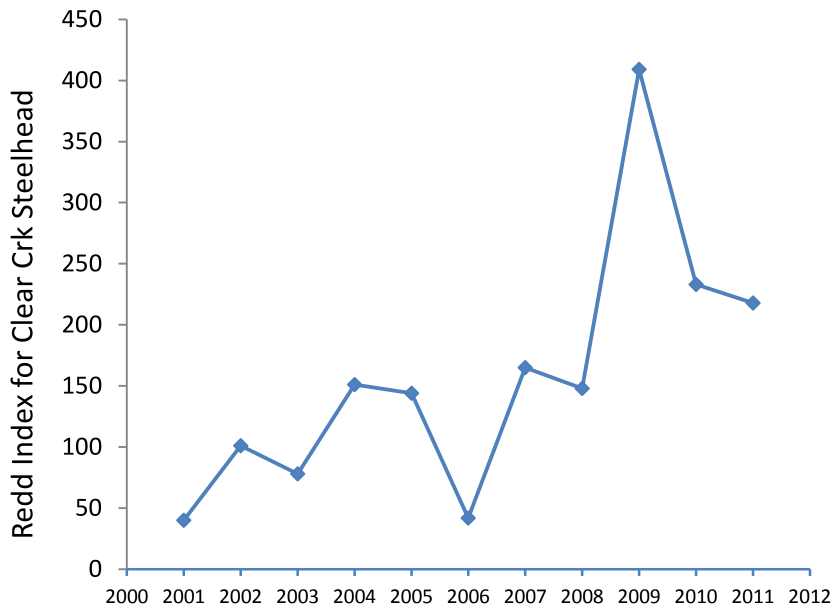


Figure 10. Redd counts from USFWS surveys on Clear Creek from 2001-2011.

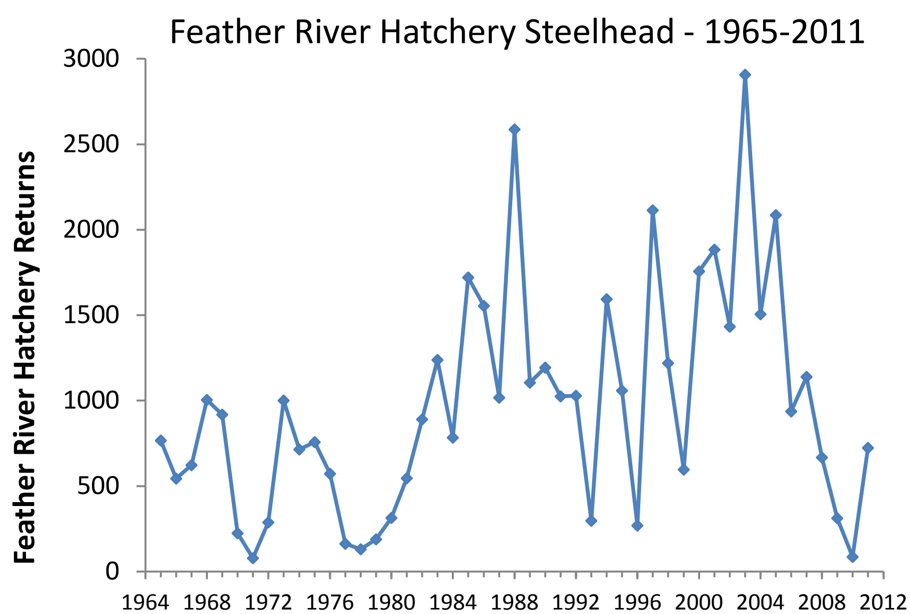


Figure 11. Number of steelhead that returned to the Feather River Fish Hatchery each year. Almost all fish are hatchery origin.

2. <u>Productivity</u>

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and

USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams *et al.* 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Good *et al.* (2005) made the following conclusion based on the Chipps Island data:

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

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

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural steelhead production has continued to decline, and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Beginning in 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of Ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. The proportion of hatchery fish exceeded 90% in 2007, 2010, and 2011 (Figure 12). Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley.

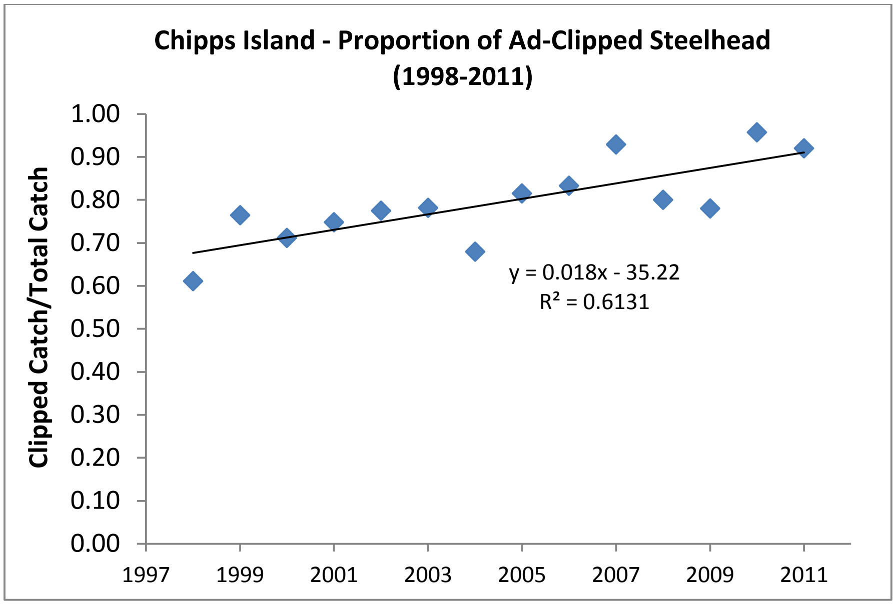


Figure 12. Catch of steelhead at Chipps Island by the USFWS midwater trawl survey from 1998 to 2011. (Fraction of the catch bearing an adipose fin clip). All hatchery steelhead have been marked starting in 1998.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities also indicates a reduction in the natural production of steelhead (Figure 13). The percentage of unclipped juvenile steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (NMFS 2011).

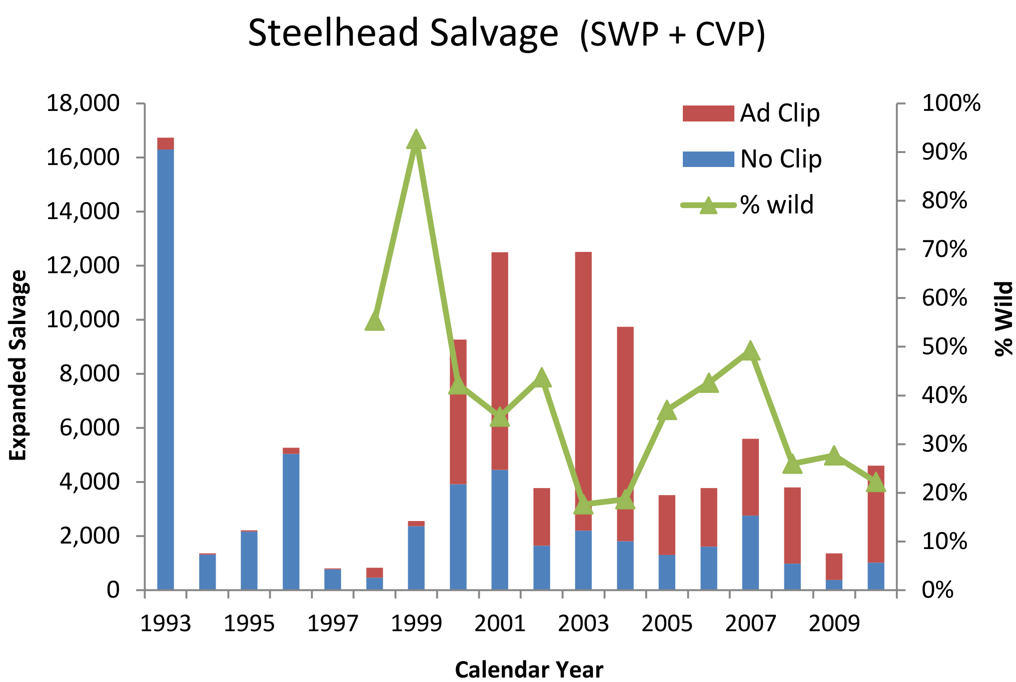


Figure 13. Steelhead salvaged in the Delta fish collection facilities from 1993 to 2010. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFG, at: ftp.delta.dfg.ca.gov/salvage.

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011). 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.

3. <u>Spatial Structure</u>

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley *et al.* 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama *et al.* 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

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

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer Fish Sciences 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO 2012, 2013a). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FISHBIO 2013c). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24 hour period. Annual Kodiak trawl surveys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

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

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

4. <u>Diversity</u>

a. Genetic Diversity:

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

The genetic diversity of CV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley *et al.* 2007). There are four hatcheries (Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

b. Life-History Diversity:

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

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

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

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

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

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

5. <u>Summary of ESU Viability</u>

All indications are that natural Central Valley 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. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock.

Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

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

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are likely very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

The most recent status review of the CCV steelhead DPS (NMFS 2011) 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.

2.2.3 SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

Listed as endangered (70 FR 37160; June 28, 2005)
Designated critical habitat (June 16, 1993, 58 FR 33212)

The SR winter-run Chinook salmon (winter-run, *Oncorhynchus tshawytscha*) ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085) and formally listed as a threatened species in November 1990 (55 FR 46515). On January 4, 1994 (59 FR 440), NMFS re-classified winter-run as an endangered species. NMFS concluded that winter-run in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run (August 15, 2011, 76 FR 50447).

On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of five Pacific salmon ESUs, including the winter-run ESU, and determined that the species' status should again remain as "endangered" (August 15, 2011, 76 FR 50447).

The 2011 review concluded that although the listing remained unchanged since the 2005 review, the status of the population had declined over the past five years (2005–2010).

The winter-run ESU currently consists of only one population that is confined to the upper Sacramento River (spawning below Shasta and Keswick dams) in California's Central Valley. In addition, an artificial propagation program at the Livingston Stone National Fish Hatchery (LSNFH) produces winter-run that are considered to be part of this ESU (June 28, 2005, 70 FR 37160). Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Remaining spawning and rearing areas are completely dependent on cold water releases from Shasta Dam in order to sustain the remnant population.

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 from San Pablo Bay to the Golden Gate Bridge. In the Sacramento River, critical habitat includes the river water, river bottom, and the adjacent riparian zone.

A. Critical Habitat: Essential Features for Sacramento River Winter-run Chinook Salmon

Critical habitat for winter-run is defined as specific areas (listed below) that contain the physical and biological features considered essential to the conservation of the species (Figure X1). This designation includes the river water, river bottom (including those areas and associated gravel used by winter-run as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing (June 16, 1993, 58 FR 33212). NMFS limits "adjacent riparian zones" to only those areas above a stream bank that provide cover and shade to the near shore aquatic areas. Although the bypasses (*e.g.*, Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run may use tributaries of the Sacramento River for non-natal rearing. Critical habitat also includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile outmigration or adult spawning migration.

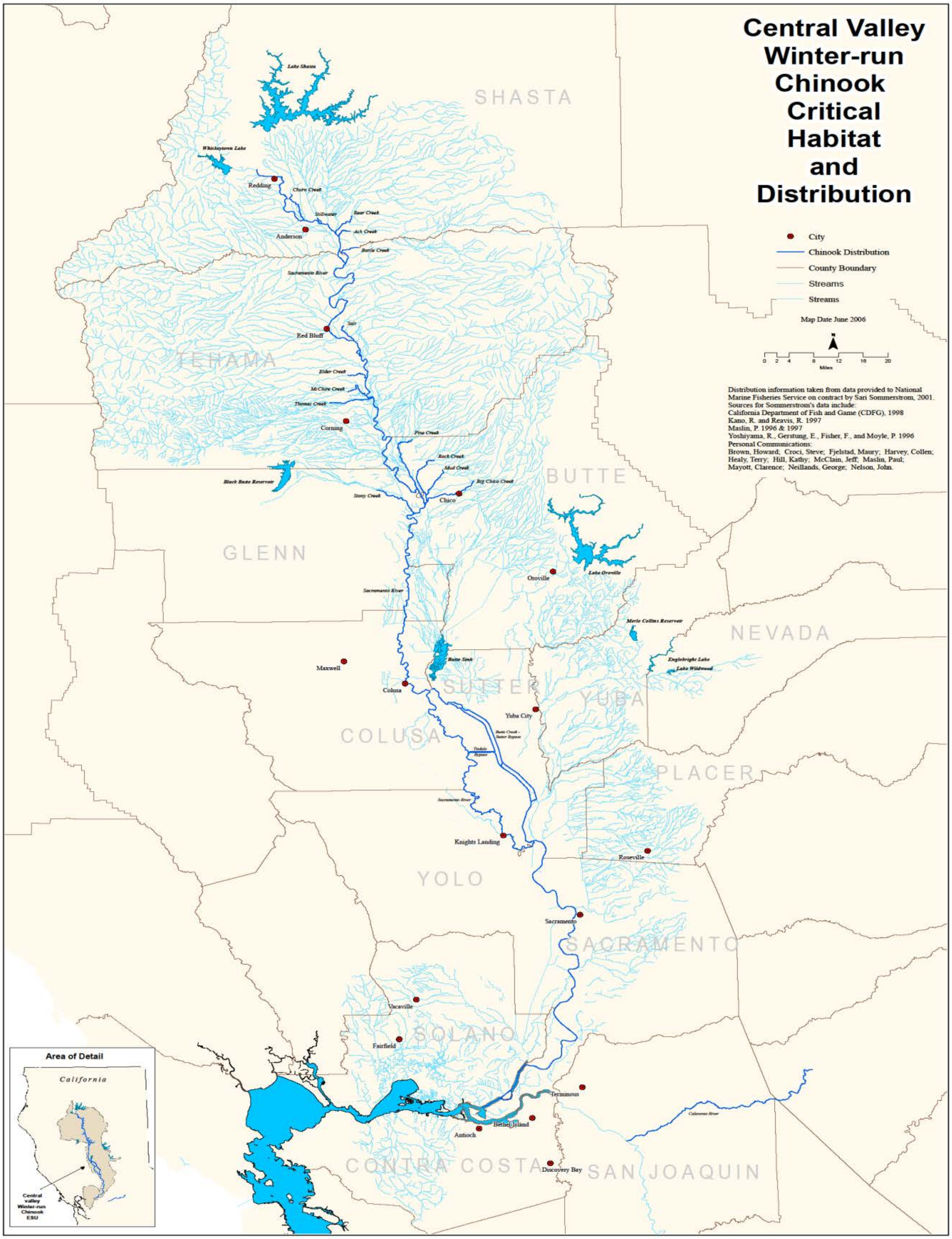


Figure 14. Winter-run Chinook salmon designated critical habitat and distribution.

The following is the status of the physical and biological habitat features that are considered to be essential for the conservation of winter-run (June 16, 1993, 58 FR 33212):

1. Access from the Pacific Ocean to Appropriate Spawning Areas

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover, shelter and safe passage conditions in order for adults to reach spawning areas. Adult winter-run generally migrate to spawning areas during the winter and spring. At that time of year, the migration route is accessible to the appropriate spawning grounds on the upper 60 miles of the Sacramento River, however much of this migratory habitat is degraded and they must pass through a fish ladder at the Anderson-Cottonwood Irrigation Dam (ACID). In addition, the many flood bypasses are known to strand adults in agricultural drains due to inadequate screening (Vincik and Johnson 2013). Since the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

2. The Availability of Clean Gravel for Spawning Substrate

Suitable spawning habitat for winter-run exists in the upper 60 miles of the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD). However, the majority of spawning habitat currently being used occurs in the first 10 miles below Keswick Dam. The available spawning habit is completely outside the historical range utilized by winter-run upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, the U.S. Bureau of Reclamation (Reclamation) annually injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the upper Sacramento River reach continues to support a small naturally-spawning winter-run Chinook salmon population. 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.

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

An April 5, 1960, Memorandum of Agreement between Reclamation and the California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in State Water Resource Control Board (SWRCB) Water Rights Order (WRO) 90-05 for the protection of Chinook salmon. This order includes a minimum flow release of 3,250 cubic feet per second (cfs) from Keswick Dam downstream to RBDD from September through February during all water year types, except critically dry.

4. Water Temperatures at 5.8–14.1°C (42.5–57.5°F) for Successful Spawning, Egg Incubation, and Fry Development

Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of winter-run migration, spawning, egg incubation, fry development, and emergence. This pattern, the opposite of the pre-dam hydrograph, benefits winter-run by providing cold water for miles downstream during the hottest part of the year. The extent to which winter-run habitat needs are met depends on Reclamation's other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir end of September storage levels required in the NMFS 2009 biological opinion on the long-term operations of the Central Valley Project and State Water Project (CVP/SWP, NMFS 2009a). WRO 90-05 and 91-1 require Reclamation to operate Shasta, Keswick, and Spring Creek Powerhouse to meet a daily average water temperature of 13.3°C (56°F) at RBDD. They also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. Based on these requirements, Reclamation models monthly forecasts and determines how far downstream 13.3°C (56°F) can be maintained throughout the winter-run spawning, egg incubation, and fry development stages.

In every year since WRO 90-05 and 91-1were issued, operation plans have included modifying the TCP to make the best use of the cold water available based on water temperature modeling and current spawning distribution. Once a TCP has been identified and established in May, it generally does not change, and therefore, water temperatures are typically adequate through the summer for successful winter-run egg incubation and fry development for those redds constructed upstream of the TCP (except for in some critically dry and drought years). However, by continually moving the TCP upstream, the value of that habitat is degraded by reducing the spawning area in size and imprinting upon the next generation to return further upstream.

5. Habitat and Adequate Prey Free of Contaminants

Water quality conditions have improved since the 1980s due to stricter standards and Environmental Protection Agency (EPA) Superfund site cleanups (see Iron Mountain Mine remediation under Factors). No longer are there fish kills in the Sacramento River caused by the heavy metals (*e.g.,* lead, zinc and copper) found in the Spring Creek runoff. However, legacy contaminants such as mercury (and methyl mercury), polychlorinated biphenyls (PCB), heavy metals and persistent organochlorine pesticides continue to be found in watersheds throughout the Central Valley. In 2010, the EPA listed the Sacramento River as impaired under the Clean Water Act, section 303(d), due to high levels of pesticides, herbicides, and heavy metals (http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml). Although most of these contaminants are at low concentrations in the food chain, they continue to work their way into the base of the food web, particularly when sediments are disturbed and previously entombed compounds are released into the water column.

Adequate prey for juvenile salmon to survive and grow consists of abundant aquatic and terrestrial invertebrates that make up the majority of their diet before entering the ocean. Exposure to these contaminated food sources such as invertebrates may create delayed sublethal effects that reduce fitness and survival (Laetz *et al*. 2009). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities (*e.g.*, mercury contamination as a result of gold mining or processing). Areas with low human impacts frequently have low contaminant burdens, and therefore lower levels of potentially harmful toxicants in the aquatic system. Freshwater rearing habitat has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

6. <u>Riparian and Floodplain Habitat that Provides for Successful Juvenile Development and Survival</u>

The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from predators. Juvenile life stages of salmonids are dependent on the natural functioning of this habitat for successful survival and recruitment. Ideal habitat contains natural cover, such as riparian canopy structure, submerged and overhanging large woody material (LWM), aquatic vegetation, large rocks and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Riparian recruitment is prevented from becoming established due to the reversed hydrology (*i.e*., high summer time flows and low winter flows prevent tree seedlings from establishing). However, there are some complex, productive habitats within historical floodplains [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, fish in Yolo and Sutter bypasses experience rapid growth and higher survival due to abundant food resources) seasonally available that remain in the system. Nevertheless, the current condition of degraded riparian habitat along the mainstem Sacramento River restricts juvenile growth and survival (Michel 2010, Michel *et al.* 2012).

7. <u>Access Downstream so that Juveniles Can Migrate from the Spawning Grounds to San Francisco Bay and the Pacific Ocean</u>

Freshwater emigration corridors should be free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. Migratory corridors are downstream of the Keswick Dam spawning areas and include the mainstem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

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. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River and in the Delta. Predators such as striped bass (*Morone saxatilis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon.

Water pumping at the CVP/SWP export facilities in the South Delta at times causes the flow in the river to move back upstream (reverse flow), further disrupting the emigration of juvenile winter-run by attracting and diverting them to the interior Delta, where they are exposed to increased rates of predation, other stressors in the Delta, and entrainment at pumping stations. NMFS' biological opinion on the long-term operations of the CVP/SWP (National Marine Fisheries Service 2009a) sets limits to the strength of reverse flows in the Old and Middle Rivers, thereby keeping salmon away from areas of highest mortality. Regardless of the condition, the remaining estuarine areas are of high conservation value because they provide factors which function to as rearing habitat and as an area of transition to the ocean environment.

8. Summary of the Essential Features of Winter-run Chinook Salmon Critical Habitat

Critical habitat for winter-run is composed of physical and biological features that are essential for the conservation of winter-run, including upstream and downstream access, and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these physical and biological features are degraded, and provide limited high quality habitat. Additional features that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows in the Delta, and the lack of floodplain habitat.

In addition, water operations that limit the extent of cold water below Shasta Dam have reduced the available spawning habitat (based on water temperature). Although the habitat for winter-run has been highly degraded, the importance of the reduced spawning habitat, migratory corridors, and rearing habitat that remains is of high conservation value.

B. Life History

1. Adult Migration and Spawning

Winter-run exhibit a unique life history pattern (Healey 1994) compared to other salmon populations in the Central Valley (*i.e.*, spring-run, fall-run, and late-fall run), in that they spawn in the summer, and the juveniles are the first to enter the ocean the following winter and spring. Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the RBDD from mid-December through early August (National Marine Fisheries Service 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 T1 below; Yoshiyama *et al.* 1998, Moyle 2002).
Winter-run tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (Healey 1991). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River reach (50 miles) between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run deposit and fertilize eggs in gravel beds known as redds excavated by the female that then dies following spawning. Average fecundity was 5,192 eggs/female for the 2006–2013 returns to LSNFH, which is similar to other Chinook salmon runs [*e.g.*, 5,401 average for Pacific Northwest (Quinn 2005)]. Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature is between 55–57°F (13–14°C) degrees (Snider *et al.* 2001). The majority of winter-run adults return after three years.

Table 11. The temporal occurrence of adult (a) and juvenile (b) winter-run in the Sacramento River. Darker shades indicate months of greatest relative abundance.

Winter run relative abundance	High				Medium				Low			
a) Adults freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]												
Upper Sacramento River spawning[c]												
b) Juvenile emigration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff [d]												
Sacramento River at Knights Landing[e]												
Sacramento trawl at Sherwood Harbor[f]												
Midwater trawl at Chipps Island[g]												

Sources: [a] (Yoshiyama *et al*. 1998); (Moyle 2002); [b](Myers *et al.* 1998) ; [c] (Williams 2006) ; [d] (Martin *et al.* 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

2. Eggs/Fry Emergence

Winter-run incubating eggs are vulnerable to adverse effects from floods, flow fluctuations, siltation, desiccation, disease, predation during spawning, poor gravel percolation, and poor water quality. The optimal water temperature for egg incubation ranges from 46–56°F (7.8–13.3°C) and a significant reduction in egg viability occurs in mean daily water temperatures above 57.5°F (14.2°C; Seymour 1956, Boles 1988, U.S. Fish and Wildlife Service 1998, U.S. Environmental Protection Agency 2003, Richter and Kolmes 2005, Geist *et al.* 2006). Total embryo mortality can occur at temperatures above 62°F (16.7°C; National Marine Fisheries Service 1997). Depending on ambient water temperature, embryos hatch within 40-60 days and alevins (yolk-sac fry) remain in the gravel beds for an additional 4–6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding in their natal stream, typically in late July to early August and continuing through October (Fisher 1994).

3. Juvenile/Outmigration

Juvenile winter-run have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman *et al.* 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only 4 to 7 months of river life, while others hold and rear upstream and spend 9 to 10 months in freshwater. Emigration of juvenile winter-run fry and pre-smolts past RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September (Table 11), and can continue through March in dry years (Vogel and Marine 1991, National Marine Fisheries Service 1997).

4. Estuarine/Delta Rearing

Juvenile winter-run emigration into the estuary/Delta occurs primarily from November through early May based on data collected from trawls in the Sacramento River at Sherwood Harbor (West Sacramento), RM 57 (U.S. Fish and Wildlife Service 2001). The timing of emigration may vary somewhat due to changes in river flows, Shasta Dam operations, and water year type, but has been correlated with the first storm event when flows exceed 14,000 cfs at Knights Landing, RM 90, which trigger abrupt emigration towards the Delta (del Rosario *et al.* 2013). Residence time in the Delta for juvenile winter-run averages approximately 3 months based on median seasonal catch between Knights Landing and Chipps Island. In general, the earlier juvenile winter-run arrive in the Delta, the longer they stay and rear, as peak departure at Chipps Island regularly occurs in March (del Rosario *et al.* 2013). The Delta serves as an important rearing and transition zone for juvenile winter-run as they feed and physiologically adapt to marine waters (smoltification). The majority of juvenile winter-run in the Delta are 104 to 128 millimeters (mm) in size based on U.S. Fish and Wildlife Service (USFWS) trawl data (1995-2012), and from 5 to 10 months of age, by the time they depart the Delta (Fisher 1994, Myers *et al.* 1998).

5. Ocean Rearing

Winter-run smolts enter the Pacific Ocean mainly in spring (March–April), and grow rapidly on a diet of small fishes, crustaceans, and squid. Salmon runs that migrate to sea at a larger size tend to have higher marine survival rates (Quinn 2005). The diet composition of Chinook salmon from California consist of anchovy, rockfish, herring, and other invertebrates (in order of preference, Healey 1991). Most Chinook from the Central Valley move northward into Oregon and Washington, where herring make up the majority of their diet. However winter-run, upon entering the ocean, tend to stay near the California coast and distribute from Point Arena southward to Monterey Bay. Winter-run have high metabolic rates, feed heavily, and grow fast, compared to other fishes in their range. They can double their length and increase their weight more than ten-fold in the first summer at sea (Quinn 2005). Mortality is typically highest in the first summer at sea, but can depend on ocean conditions. Winter-run abundance has been correlated with ocean conditions, such as periods of strong up-welling, cooler temperatures, and El Nino events (Lindley *et al.* 2009). Winter-run spend approximately 1-2 years rearing in the ocean before returning to the Sacramento River as 2-3 year old adults. Very few winter-run Chinook salmon reach age 4. Once they reach age 3, they are large enough to become vulnerable to commercial and sport fisheries.

C. Description of Viable Salmonid Population (VSP) Parameters

Abundance

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011). In recent years, since carcass surveys began in 2001 (Figure 15), the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. However, from 2007 to 2012, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011 (Figure 15). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley *et al.* 2009), drought conditions from 2007-2009, and low in-river survival (National Marine Fisheries Service 2011). In 2013, the population increased to 6,075 adults, well above the 2007–2012 average, but below the high for the last ten years.

Although impacts from hatchery fish (*i.e.*, reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the winter-run conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes RBDD, approximately 4.7 million (2002–2010 average, Poytress and Carrillo 2011). Therefore, hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year.

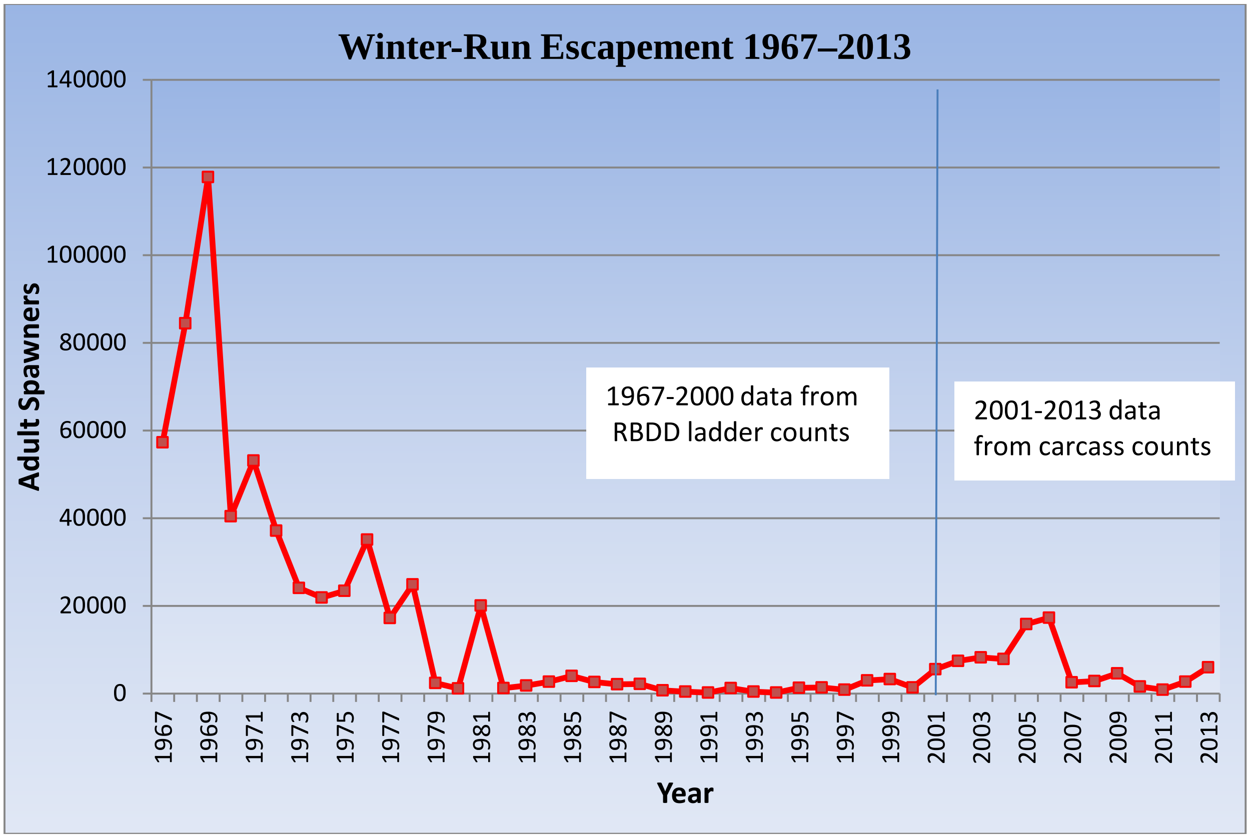


Figure 15. Winter-run Chinook salmon escapement numbers 1970-2013, includes hatchery broodstock and tributaries, but excludes sport catch. RBDD ladder counts used pre-2000, carcass surveys post 2001.

Productivity

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative (Figure 16) with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggests a reduction in productivity (Figure 16), and indicates that the winter-run population is not replacing itself. In 2013, winter-run experienced a positive CRR, possibly due to favorable in-river conditions in 2011 (a wet year), which increased juvenile survival to the ocean.

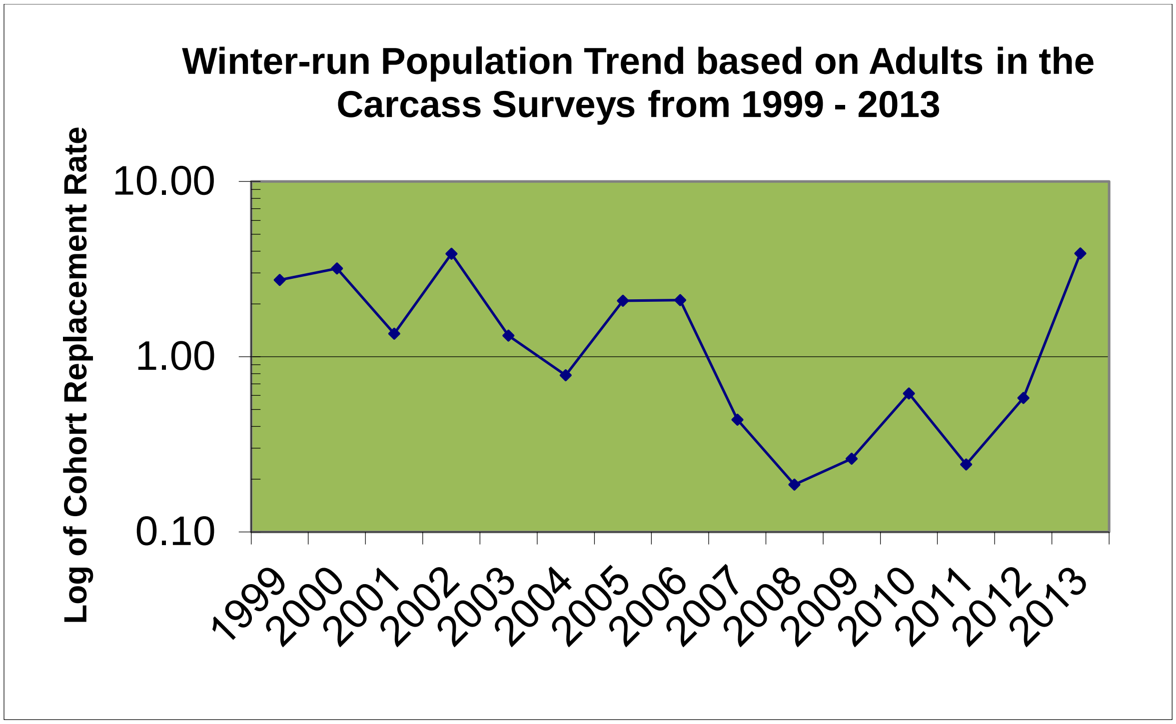


Figure 16. Winter-run population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1986–2013.

An age-structured density-independent model of spawning escapement by Botsford and Brittnacher (1998) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females (Good *et al.* 2005). Lindley and Mohr (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the growth rate for the winter-run population improved up until 2006, it exhibits the typical variability found in most endangered species populations. The fact that there is only one population, dependent upon cold-water releases from Shasta Dam, makes it vulnerable to periods of prolonged drought (National Marine Fisheries Service 2011). Productivity, as measured by the number of juveniles entering the Delta, or juvenile production estimate (JPE), has declined in recent years from a high of 3.8 million in 2007 to 1.1 million in 2013 (Table 12). Due to uncertainties in the various factors, the JPE was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences model), and again in 2013 with a change in survival based on acoustic tag data (National Marine Fisheries Service 2014). However, juvenile winter-run productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

Table 12. Winter-run adult and juvenile population estimates based on RBDD counts (1986–2001) and carcass counts (2001–2013), with corresponding 3-year-cohort replacement rates.

Return Year	Adult Population Estimate[a]	Cohort Replacement Rate[b]	NMFS-calculated Juvenile Production
1986	2596		
1987	2185		
1988	2878		
1989	696	0.27	
1990	430	0.20	
1991	211	0.07	
1992	1240	1.78	40,100
1993	387	0.90	273,100
1994	186	0.88	90,500
1995	1297	1.05	74,500
1996	1337	3.45	338,107
1997	880	4.73	165,069
1998	2992	2.31	138,316
1999	3288	2.46	454,792
2000	1352	1.54	289,724
2001	8224	2.75	370,221
2002	7441	2.26	1,864,802
2003	8218	6.08	2,136,747
2004	7869	0.96	1,896,649
2005	15839	2.13	881,719
2006	17296	2.10	3,556,995
2007	2542	0.32	3,890,534
2008	2830	0.18	1,100,067
2009	4537	0.26	1,152,043
2010	1,596	0.63	1,144,860
2011	827	0.29	332,012
2012	2,674	0.59	162,051
2013	6,075	3.88	1,196,387
median	2,542	0.95	412,507

[a] Population estimates include adults taken into the hatchery and were based on ladder counts at RBDD until 2001, after which the methodology changed to carcass surveys (California Department of Fish and Game 2012).
[b] Assumes all adults return after three years. NMFS calculated a CRR using the adult spawning population, divided by the spawning population three years prior. Two year old returns were not used.
[c] JPE estimates include survival estimates from the spawning gravel to the point where they enter the Delta (Sacramento I St Bridge), but does not include through-Delta survival.

Spatial Structure

The distribution of winter-run spawning and initial rearing historically was limited to the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pit River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963 *op. cit.* Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration (*i.e.*, a number of small hydroelectric dams situated upstream of the Coleman Fish Hatchery weir). The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, which should restore spawning and rearing habitat for winter-run in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run. Yoshiyama *et al.* (2001) estimated that in 1938, the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for winter-run lies within its spatial structure (National Marine Fisheries Service 2011). The remnant and remaining population cannot access 95% of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and, (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures. Winter-run require cold water temperatures in the 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 is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2017 (BCSSRP). The draft Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (National Marine Fisheries Service 2009b). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam.

<u>Diversity</u>

The current winter-run population is the result of the introgression of several stocks (*e.g.*, spring-run and fall-run Chinook) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007) recommended reclassifying the winter-run population extinction risk from low to moderate, if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery winter-run recovered in the Sacramento River has only been above 15 percent in two years, 2005 and 2012 (Figure 17).

Concern over genetic introgression within the winter-run population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run have made up more than 5 percent of the natural spawning run in recent years and in 2012, it exceeded 30 percent of the natural run (Figure 17). However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15%) used for hatchery influence (Lindley *et al.* 2007).

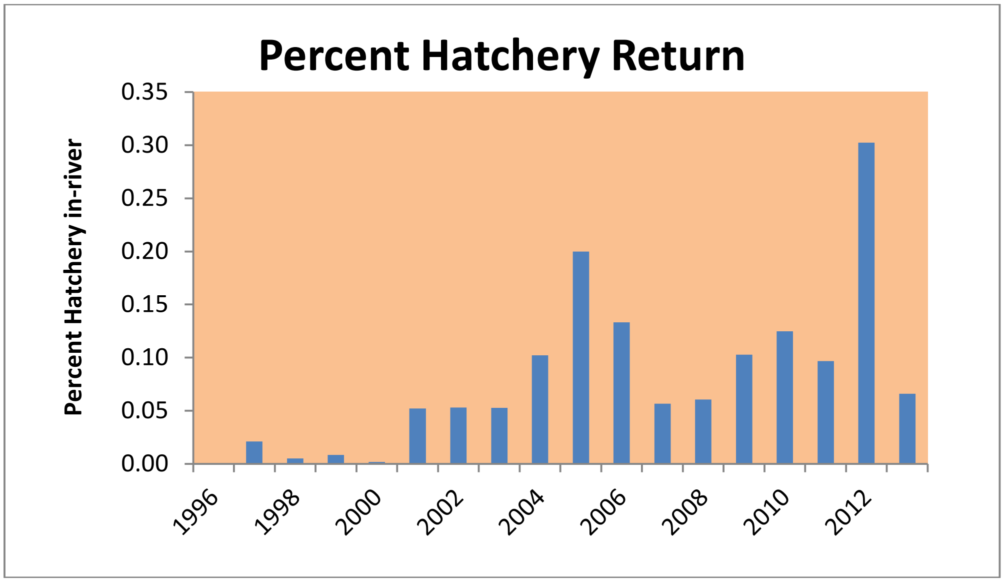


Figure 17. Percentage of hatchery-origin winter-run Chinook salmon naturally spawning in the Sacramento River (1996–2013). Source: CDFW carcass surveys, 2013.

Summary of ESU Viability

There are several criteria (only one is required) that would qualify the winter-run ESU at moderate risk of extinction, and since there is still only one population that spawns below Keswick Dam, that population would be at high risk of extinction in the long-term according the criteria in Lindley *et al.* (2007). Recent trends in those criteria are: (1) continued low abundance (Figure 15); (2) a negative growth rate over 6 years (2006–2012), which is two complete generations (Figure 16); (3) a significant rate of decline since 2006; and (4) increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change). The most recent 5-year status review (National Marine Fisheries Service 2011) on winter-run concluded that the ESU had increased to a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the winter-run ESU has increased from moderate risk to high risk of extinction since 2005 (last review), and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (National Marine Fisheries Service 2011).

2.2.4 Central Valley Spring-Run Chinook salmon (*Oncorhynchus tshawytscha*)

Listed as threatened (70 FR 37160; June 28, 2005)
Designated Critical Habitat (September 2, 2005, 70 FR 52488)

In August 2011, NMFS completed an updated status review of five Pacific Salmon ESUs, including Central Valley (CV) spring-run Chinook salmon, and concluded that the species' status should remain as previously listed (76 FR 50447). The 2011 Status Review (NMFS 2011) additionally stated that although the listings will remain unchanged since the 2005 review, and the original 1999 listing (64 FR 50394), the status of these populations has worsened over the past five years and recommended that the status be reassessed in two to three years as opposed to waiting another five years.

CV spring-run Chinook salmon were originally 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 Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent CV spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

A. Critical Habitat and Primary Constituent Elements for CV Spring-run Chinook Salmon

Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488). Critical habitat for CV spring-run Chinook salmon is defined as specific areas that contain the primary constituent elements (PCEs) and physical habitat elements essential to the conservation of the species. Following are the PCEs for CV spring-run Chinook salmon.

1. Spawning Habitat

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

2. Freshwater Rearing Habitat

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

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. They contain natural cover such as riparian canopy structure, submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks which augment juvenile and adult mobility, survival, and food supply. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. The stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik and Johnson 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PCE. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic conservation value to the species.

4. Estuarine Areas

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

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

B. Life History

1. Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (California Department of Fish and Game 1998) and enter the Sacramento River beginning in March (Yoshiyama *et al.* 1998). Spring-run Chinook salmon move into tributaries of the Sacramento River (*e. g.* , Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley *et al.* 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley *et al.* 2004, see Table 13 in text). 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). 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 3ºC (38ºF) to 13ºC (56ºF) (Bell 1991, CDFG 1998). Boles (1988) recommends water temperatures below 18ºC (65ºF) for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 21ºC (70ºF), and that fish can become stressed as temperatures approach 21ºC (70ºF). Reclamation reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 15. 6 ºC (60ºF); although salmon can tolerate temperatures up to 18 ºC (65ºF) before they experience an increased susceptibility to disease (Williams 2006).

2. Adult Spawning

Spring-run Chinook salmon spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994); spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

Spring-run Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995, NMFS 2007). 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. The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Velocity typically ranging from1. 2 feet/second to 3. 5 feet/second, and water depths greater than 0. 5 feet (YCWA *et al.* 2007) . The upper preferred water temperature for spawning Chinook salmon is 13 ºC to 14 ºC (55ºF to 57ºF) (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, CDFG 2001). Chinook salmon are semelparous (die after spawning).

3. Eggs and Fry Incubation to Emergence

The CV spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sac prior to emergence. The length of time for CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intergravel environs where water temperatures range from about 5 to 13ºC (41to 55. 4ºF) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (NMFS 2014). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence conducted by Shelton (1955) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 5 ºC to 14 ºC (41ºF to 56ºF) (National Marine Fisheries Service 1997, Rich 1997, Moyle 2002). A significant reduction in egg viability occurs at water temperatures above 14 ºC (57. 5ºF) and total embryo mortality can occur at temperatures above 17 ºC (62ºF) (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16ºC and 3ºC (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 remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The newly emerged fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 mm to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

3. Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other

salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).
When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (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 development (Kjelson *et al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. The daily migration of juveniles passing Red Bluff Diversion Dam is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River. As Chinook salmon begin the smolt stage, they prefer to rear further downstream where ambient salinity is up to 1. 5 to 2. 5 parts per thousand (Healey 1980, Levy and Northcote 1981)

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings. The modal size of fry migrants at approximately 40 millimeters between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). Studies in Butte Creek (Ward *et al.* 2003, McReynolds *et al.* 2007) found the majority of CV spring-run Chinook salmon migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run Chinook salmon were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). The California Department of Fish and Game (1998) observed the emigration period for spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).
Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, CDFG 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal

mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 12ºC to 14 ºC (54ºF to 57ºF) (Brett 1952).

4. Estuarine Rearing

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings *et al.* 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean.

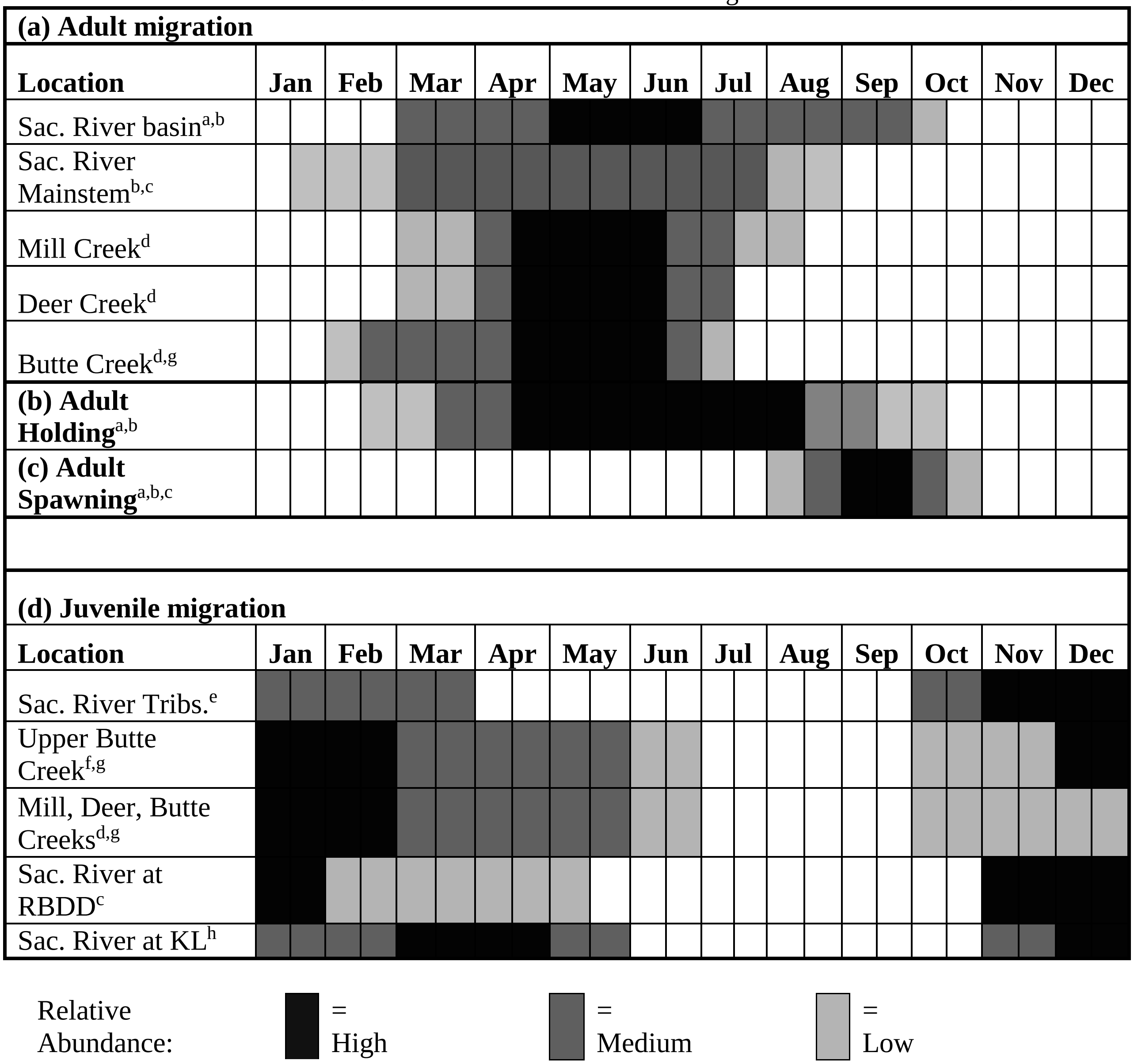
5. Ocean Rearing

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California Current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002, Lindley *et al.* 2009). After entering the ocean, juveniles become voracious predators on small fish and crustaceans, and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic planktivore is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The Ocean stage of the Chinook life cycle lasts one to five years. Information on salmon abundance and distribution in the ocean is based upon CWT recoveries from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns.

Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point

Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement (adult spawner populations that have "escaped" the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

Table 13. 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.



Sources: [a]Yoshiyama *et al.* (1998); [b]Moyle (2002); [c]Myers *et al.* (1998); [d]Lindley *et al.* (2004); [e]CDFG (1998); [f]McReynolds *et al.* (2007); [g]Ward *et al.* (2003); [h]Snider and Titus (2000)
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. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

C. Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the CV spring-run Chinook salmon ESU, and determine the extinction risk of the ESU, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany *et al.* 2000)

1. Abundance

Historically spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).
The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH spring-run Chinook salmon population has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRFH. Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 2 fish in 1978 (California Department of Water Resources 2001). However, after 1981, CDFG (now California Department of Fish and Wildlife (CDFW)) ceased to estimate in-river spawning spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races. Spring-run Chinook salmon estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages have declined each year to a low of 1,783 fish in 2011 (CDFG Grandtab 2013). Genetic testing has indicated that substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (CDWR 2001). Because Chinook salmon have not always been spatially separated in the FRFH, spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock (CDFG and DWR 2012, Good *et al.* 2005). In addition, CWT information from these hatchery returns has indicated that fall-run and spring-run Chinook salmon have overlapped (CDWR 2001). For the reasons discussed above, the FRFH spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

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

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 14). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000. During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish and just over 1,000 fish, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remained well below estimates of historic abundance.

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the diseases.

From 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1960.

Table 14. Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2013) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib. CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0. 89			1. 93	
1990	3,485	1,893	1,592	1,658	5. 24		4,948	2. 30	
1991	5,101	4,303	798	1,376	0. 36		5,240	0. 56	
1992	2,673	1,497	1,176	1,551	0. 60		5,471	0. 38	
1993	5,685	4,672	1,013	1,307	0. 64	1. 54	4,795	1. 63	1. 36
1994	5,325	3,641	1,684	1,253	2. 11	1. 79	4,454	1. 04	1. 18
1995	14,812	5,414	9,398	2,814	7. 99	2. 34	6,719	5. 54	1. 83
1996	8,705	6,381	2,324	3,119	2. 29	2. 73	7,440	1. 53	2. 03
1997	5,065	3,653	1,412	3,166	0. 84	2. 77	7,918	0. 95	2. 14
1998	30,534	6,746	23,788	7,721	2. 53	3. 15	12,888	2. 06	2. 23
1999	9,838	3,731	6,107	8,606	2. 63	3. 26	13,791	1. 13	2. 24
2000	9,201	3,657	5,544	7,835	3. 93	2. 44	12,669	1. 82	1. 50
2001	16,869	4,135	12,734	9,917	0. 54	2. 09	14,301	0. 55	1. 30
2002	17,224	4,189	13,035	12,242	2. 13	2. 35	16,733	1. 75	1. 46
2003	17,691	8,662	9,029	9,290	1. 63	2. 17	14,165	1. 92	1. 43
2004	13,612	4,212	9,400	9,948	0. 74	1. 79	14,919	0. 81	1. 37
2005	16,096	1,774	14,322	11,704	1. 10	1. 23	16,298	0. 93	1. 19
2006	10,948	2,181	8,767	10,911	0. 97	1. 31	15,114	0. 62	1. 21
2007	9,726	2,674	7,052	9,714	0. 75	1. 04	13,615	0. 71	1. 00
2008	6,368	1,624	4,744	8,857	0. 33	0. 78	11,350	0. 40	0. 69
2009	3,801	989	2,812	7,539	0. 32	0. 69	9,388	0. 35	0. 60
2010	3,792	1,661	2,131	5,101	0. 30	0. 54	6,927	0. 39	0. 49
2011	4,967	1,969	3,067	3,961	0. 65	0. 47	5,731	0. 78	0. 53
2012	18,275	7,465	10,810	4,713	3. 84	1. 09	7,441	4. 81	1. 34
2013	38,556	20,057	18,499	7,464	8. 68	2. 76	13,878	2. 00	0. 86
Median	10,962	4,456	6,508	6,324	2. 08	1. 83	10,258	1. 00	1. 29

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

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

2. Productivity

The productivity of a population (*i.e.,* production over the entire life cycle) can reflect conditions (*e. g.,* environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany *et al.* 2000). In general, declining productivity equates to declining population abundance. McElhany *et al.* (2000) suggested criteria for a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation.

From 1993 to 2007 the 5-year moving average of the tributary population CRR remained over 1. 0, but then declined to a low of 0. 47 in years 2007 through 2011. The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown; however the FRFH currently produces 2,000,000 juveniles each year. The CRR for the 2012 combined tributary population was 3. 84 and 8. 68 in 2013, due to increases in abundance for most populations.

3. Spatial Structure

The Central Valley Technical Review Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure 15) (Lindley *et al.* 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Construction of low elevation dams in the foothills of the Sierras on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced rivers has thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2013 unpublished data).

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

With only one of four diversity groups currently containing viable independent populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon adult returns are currently utilizing all available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration projects completed and more underway, are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the spring-run Chinook salmon ESU would still be lacking due to the extirpation of all San Joaquin River basin spring-run Chinook salmon populations, however recent information suggests that perhaps a self-sustaining population of spring-run Chinook is occurring in some of the San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne rivers.

A final rule was published to designate a nonessential experimental population of CV spring-run Chinook salmon to allow reintroduction of the species below Friant Dam on the San Joaquin River as part of the SJRRP (78 FR 251; December 31, 2013). Pursuant to ESA section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking CV spring-run Chinook salmon within the experimental population area, and in specific instances elsewhere. The first release of CV spring-run Chinook salmon juveniles into the San Joaquin River occurred in April, 2014. The SJRRP's future long-term contribution to the CV spring-run Chinook salmon ESU has yet to be determined.

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009, has indicated upstream migration of adult spring-run Chinook salmon (Anderson *et al.* 2007). Genetic testing is needed to confirm that these fish are spring-run Chinook salmon, to determine which strain they are. Finally, rotary screw trap (RST) data provided by Stockton USFWS corroborates the spring-run Chinook salmon adult timing, by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with spring-run juvenile emigration (Franks 2013 unpublished data). Plans are underway to re-establish a spring-run Chinook salmon population in the San Joaquin River downstream of Friant Dam, as part of the San Joaquin River Restoration Program. Interim flows for this began and spring-run Chinook salmon are expected to be released in 2013. The San Joaquin River Restoration Programs' future long-term contribution to the CV spring-run Chinook salmon ESU is uncertain.

Lindley *et al.* (2007) described a general criteria for "representation and redundancy" of spatial structure, which was for each diversity group to have at least two viable populations. More specific recovery criteria for the spatial structure of each diversity group have been laid out in the NMFS Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014). According to the criteria, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group, in addition to maintaining dependent populations are needed for recovery. It is clear that further efforts will need to involve more than restoration of currently accessible watersheds to make the ESU viable. The NMFS Central Valley Salmon and Steelhead Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams, such as the reintroduction of a population upstream of Shasta Dam, and to facilitate passage of fish upstream of Englebright Dam on the Yuba River (NMFS 2014).

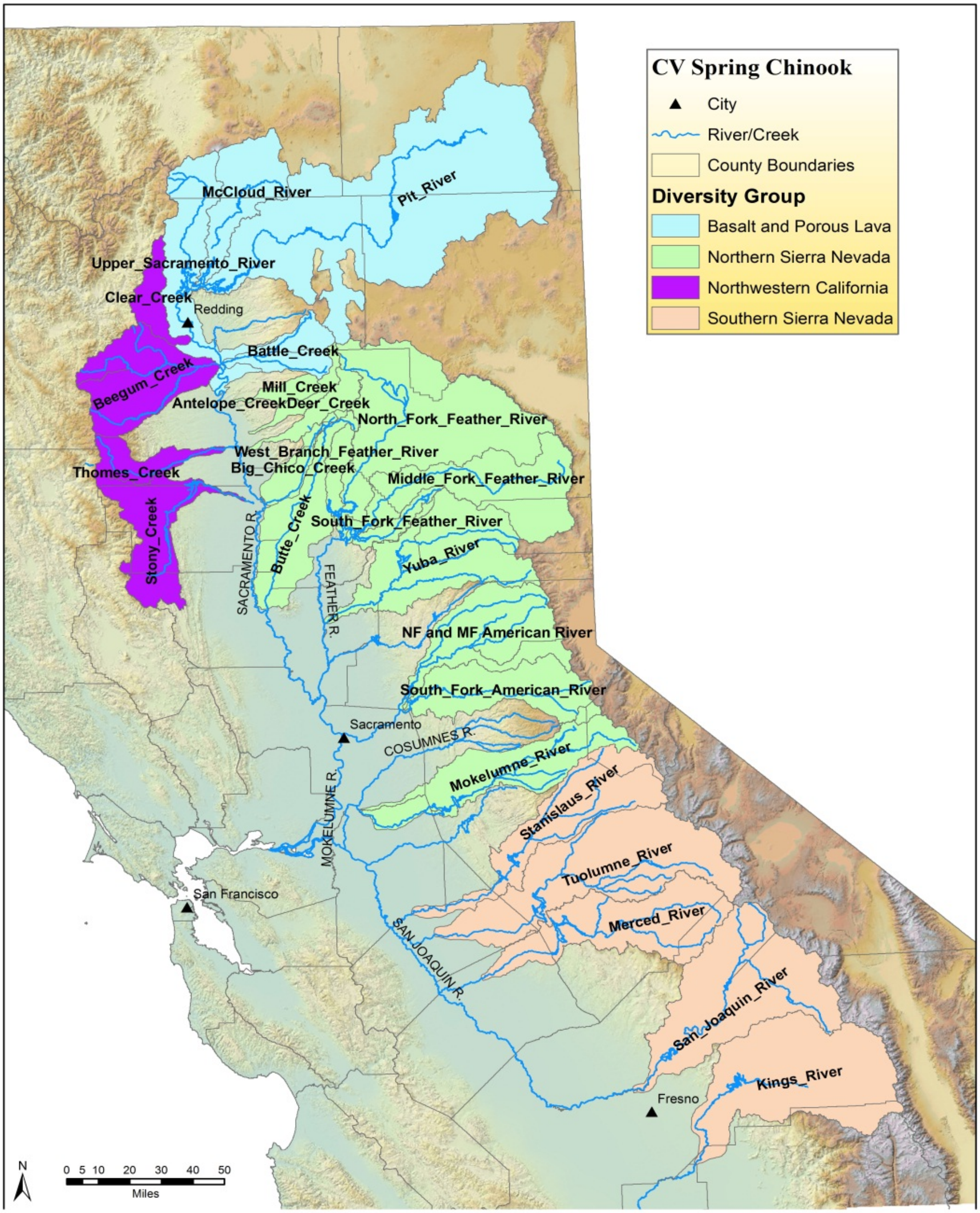


Figure 18. Diversity Groups for the Central Valley spring-run Chinook salmon ESU.

4. Diversity

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

The CV spring-run Chinook salmon ESU is comprised of two known genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retains genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised. The Feather River spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon, and it appears that the Yuba River spring-run Chinook salmon population may have been impacted by FRFH fish straying into the Yuba River (and likely introgression with wild Yuba River fall-run has occurred). Additionally, the diversity of the spring-run Chinook salmon ESU has been further reduced with the loss of the majority if not all of the San Joaquin River basin spring-run Chinook salmon populations. Efforts underway like the San Joaquin River Restoration Project (to reintroduce a spring-run population below Friant Dam), are needed to improve the diversity of CV spring-run Chinook salmon.

5. Summary of ESU Viability

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

Until 2012, the status of CV spring-run Chinook salmon ESU had deteriorated on balance since the 2005 status review and Lindley *et al.* 's (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams *et al.* 2011). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

The most recent viability assessment of CV spring-run Chinook salmon was conducted during NMFS' 2011 status review (NMFS 2011). This review found that the biological status of the ESU had worsened since the last status review (2005) and recommend that its status be reassessed in two to three years as opposed to waiting another five years, if the decreasing trend continues and the ESU does not respond positively to improvements in environmental conditions and management actions. In 2012 and 2013, tributary populations have had an increase in returning adults, averaging over 14,000, in contrast to returns in 2006 through 2011 averaging less than 5,000. A status review is currently underway and expected to be completed before the end of 2015.

2.3 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).

1. <u>Habitat Blockage</u>

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, SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead populations have been confined to lower elevation mainstems that historically were only 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 SR winter-run Chinook salmon that occurred historically, only one mixed stock of SR winter-run Chinook salmon remains below Keswick Dam. Similarly, of the 18 independent populations of CV spring-run Chinook salmon that occurred historically, only 3 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, and Beegum creeks and the Yuba River, but are thought to 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.*'s (2006) analysis of potential habitat in the Central Valley. However, due to dam construction, access to 80 percent of the historically available habitat has been lost. SDPS green sturgeon populations were also likely affected by barriers and alterations to the natural hydrology of Central Valley river systems. In particular, RBDD blocked access to a significant portion of the adult sDPS green sturgeon spawning run under the operational procedures prior to the CVP/SWP Opinion. Modifications to the operations of the RBDD as required under the CVP/SWP Opinion will substantially reduce the impediment to upstream migrations of adult sDPS green sturgeon. As of summer 2012, a new fish screen became operational, and the RBDD 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 are known to block or delay passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, DWR 2002). 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 materials (LWM). More uniform flows year round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stabilized 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 stream flow 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 and San Joaquin rivers, 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* spp.). On June 4, 2009, NMFS issued a biological and conference opinion on the long-term operations of the CVP and SWP (NMFS 2009b). 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 watersheds supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects.

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

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

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

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of stream bank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWM; and removal of riparian vegetation, resulting in increased stream bank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc.* Agricultural practices in the Central Valley have eliminated large trees and logs and other woody 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 (approximately 345,947 acres) of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin rivers, and another 800 km^2 (approximately 197,684 acres) of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 (approximately 543,632 acres) of tidally influenced marsh present within the Delta and San Francisco Bay, only about 125 km^2 (approximately 30,888 acres) of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999). Even more extensive losses of wetland marshes occurred in the Sacramento and San Joaquin River Basins. Little of the extensive tracts of wetland marshes that existed prior to 1850 along the valley's river systems and within the natural flood basins exist today. Most has been "reclaimed" for agricultural purposes, leaving only small remnant patches.

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

Urban storm water and agricultural runoff may be contaminated with pesticides, oil, grease, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other organics and nutrients (Regional Board 1998) that can potentially destroy aquatic life necessary for salmonid survival (NMFS 1996a, b). Point source (PS) and non-point source (NPS) pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e.*, concrete, asphalt, and buildings) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996a, b). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. In addition to the PS and NPS inputs from urban runoff, juvenile salmonids and sturgeon 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 and sturgeon 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 salmonids and sturgeon habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for concrete to construct buildings and highways.

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

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years show a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a reduction in phytoplankton and zooplankton. These conditions have contributed to increased mortality of juvenile Chinook salmon, 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 and sturgeon. The Regional Board, in its 1998 Clean Water Act §303(d) list, characterized the Delta as an impaired water body 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 lessen 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 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 (EPA 1994). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids 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 the Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the West Complex). During 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. 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 would be utilizing this portion of the San Joaquin River as a migratory corridor. 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 [Department of the Interior (DOI) 1999]. For example, the primary steelhead broodstock at Nimbus Hatchery on the American River originated from the Eel River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that 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 FRFH 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 FRFH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRFH, 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- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount of water available for steelhead spawning and rearing the rest of the year.

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

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

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. Over Utilization

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). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI 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 rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of 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 biological opinion 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 CDFW 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 2010b).

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). SR 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 2 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 Fish and Game 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 California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run 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 CDFW regulations. The current regulations, including those developed for SR winter-run Chinook salmon provide some level of protection for CV spring-run Chinook salmon (CDFG 1998).

There is little information on CCV steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River CCV 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 CCV 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 CCV steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally produced adult CCV 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, 2007) 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 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, 2007) 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 (2006) and past tagged fish returns reported by CDFW (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 sDPS green sturgeon. This indicates a potential threat to the sDPS green sturgeon population. Beamesderfer *et al.* (2007) estimated that sDPS 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.

sDPS 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 sDPS green sturgeon in the upper Sacramento River from unnecessary harm due to fishing pressure (CDFG freshwater fishing regulations 2010-2011).

Poaching rates of sDPS 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 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 SR winter-run Chinook salmon was high. Now the gates at RBDD are open year round; therefore, 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, CDFW conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 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. CDFW conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (Edwards *et al.* 1996, Tillman *et al.* 1996, NMFS 1997).

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

Mammals can also be an important source of predation on salmonids within the California Central Valley. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). 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. <u>Environmental Variation</u>

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

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

10. <u>Ecosystem Restoration</u>

a. *Central Valley Project Improvement Act*

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

b. *San Joaquin River Restoration Program (SJRRP)*

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the CVP Friant Division Contractors. After more than 18 years of litigation of this lawsuit, known as *NRDC, et al. v. Kirk Rodgers, et al.*, a settlement was reached. On September 13, 2006, the Settling Parties, including NRDC, Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce, filed a stipulation of the terms and conditions of the settlement (Settlement), which was subsequently approved by the U.S. District Court, Eastern District of California, on October 23, 2006. The Settlement establishes restoration and management goals. The Restoration Goal is to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River below Friant Dam to the confluence with the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish. The Water Management Goal is to reduce or avoid water supply impacts to all of the Friant Division long-term contractors that may result from the Interim and Restoration Flows provided for in the Settlement. President Obama signed the San Joaquin River Restoration Settlement Act on March 30, 2009, which authorized implementation of the Settlement, as part of the Omnibus Public Land Management Act of 2009 (Act; Pub. L. No. 111-11, 123 Stat.991).

To achieve the Restoration Goal, the Settlement calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of Chinook salmon, *O. tshawytscha* no later than December 31, 2012, consistent with applicable law. Title X, section 10011(b) of the Act states that spring-run Chinook salmon shall be reintroduced in the San Joaquin River below Friant Dam pursuant to section 10(j) of the ESA, provided that a permit for the reintroduction may be issued pursuant to section 10(a)(1)(A) of the ESA. In addition, Title X, section 10011(c)(2) of the Act states that the Secretary of Commerce shall issue a final rule pursuant to section 4(d) of the ESA governing the incidental take of reintroduced CV spring-run Chinook salmon prior to the reintroduction. Furthermore, Title X, section 10011(c)(3) of the Act states that the rule issued under paragraph 2 shall provide that the reintroduction will not impose more than *de minimus* water supply reductions, additional storage releases, or bypass flows on unwilling third parties due to such reintroduction. Third parties, in this context, are defined as persons or entities delivering or receiving water pursuant to applicable State and Federal laws and shall include CVP contractors outside of the Friant Division of the CVP and the SWP. On December 31, 2013 (78 FR 251)), the final rule was published in the Federal Register to address these statutory requirements related to designation of an experimental population of CV spring-run Chinook salmon under ESA section 10(j); the first release of CV spring-run Chinook salmon into the San Joaquin River below Friant Dam occurred in April of 2014.

c. *San Joaquin River Improvement Project (SJRIP)*

In December of 2000, Panoche Drainage District began implementation of the SJRIP as a tool to help manage subsurface drainage water generated throughout the Grasslands Drainage Area. Drainage flows collected from the Grasslands Drainage Area are removed from the Grasslands Bypass Project and used to irrigate salt tolerant crops within the approximately 6,000-acre SJRIP which has reduced the volume of agricultural subsurface drain water discharged to the San Joaquin River. Water that is brought in from the Grassland Drainage Area to the SJRIP remains within the SJRIP and is, therefore, considered a closed system.

d. *San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District*

Reclamation will construct, operate, and maintain for 18 months a facility for drainage treatment within the geographical boundaries of the existing SJRIP reuse area after receiving easement(s) from Panoche Drainage District. A Finding of No Significant Impact was signed for the project in June of 2012; therefore, the operation of the pilot facility will likely overlap the majority of the proposed project's 24-month duration. The facility will occupy a rectangular area approximately 4 acres in size, adjacent to and immediately north and east of Panoche Drainage District's existing perpendicular drainage distribution canals. Pipelines will be constructed to convey drainage water from the seven existing reuse sumps to the facility. Drainage water treatments will include reverse osmosis, microfiltration, and ultrafiltration and a proprietary biological treatment system for selenium removal.

11. Non-Native Invasive Species (NIS)

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 reduction in forage base can adversely impact the health and physiological condition of these salmonids and sDPS green sturgeon 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 Elodea (*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 can have negative effects on 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 and its associated water distribution canals in 1947 has been linked with the extirpation of CV spring-run Chinook salmon in the San Joaquin River upstream of the Merced River within just a few years. The reduced populations that remain below Central Valley dams are forced to spawn in lower elevation tailwater habitats of the mainstem rivers and tributaries that were previously not used for this purpose. This habitat is entirely dependent on managing reservoir releases to maintain cool water temperatures suitable for spawning, and/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, and exposure to novel diseases).

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).

Similar to the listed salmonids, the sDPS green sturgeon has 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 the sDPS green sturgeon.

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

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

The action area functions primarily as a migratory corridor for adult and juvenile CCV steelhead and CV spring-run Chinook salmon due to the SJRRP. All adult CCV steelhead originating in the San Joaquin River watershed (primarily San Joaquin River tributaries) will have to migrate through the action area in order to reach their spawning grounds and to return to the ocean following spawning. Likewise, all CCV steelhead smolts originating in the San Joaquin River watershed will have to pass through the action area during their emigration to the ocean. The waterways in the action area are expected to provide some rearing benefit to emigrating CCV steelhead smolts and CV spring-run Chinook salmon as they move through the action area. The action area also provides some use as a migratory corridor and rearing habitat for juvenile SR winter-run Chinook salmon, as well as CCV steelhead and CV spring-run Chinook salmon from the Sacramento River watershed, that are drawn into the Central and south Delta by the actions of the CVP and SWP water diversion facilities, and must therefore emigrate towards the ocean through the lower San Joaquin River system. The action area also functions as migratory, holding, and rearing habitat for adult and juvenile sDPS green sturgeon.

a. *Sacramento River winter-run Chinook salmon*

The temporal occurrence of SR winter-run Chinook salmon smolts and juveniles in the action area is best described by the salvage records of the CVP and SWP fish handling facilities. Based on salvage records covering 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 south Delta action area starting in December. Their presence peaks in March and then rapidly declines from April through June. Nearly 50 percent of the average annual salvage of SR winter-run Chinook salmon juveniles occurs in March (50.667 percent) (Table 15). Salvage in April accounts for only 2.8 percent of the average annual salvage and falls to less than 1 percent for May and June combined. The presence of juvenile SR winter-run Chinook salmon in the south Delta is a function of river flows on the Sacramento River, where the fish spawn, and the demands for water diverted by the SWP and CVP facilities. When conditions on the Sacramento River are conducive to stimulating outmigration of juvenile SR winter-run Chinook salmon, the draw of the CVP and SWP pumping facilities pulls a portion of these emigrating fish through the waterways of the Central and southern Delta from one of the four access points originating on the Sacramento River (Georgiana Slough, the Delta Cross Channel, Three Mile Slough, and the San Joaquin River via Broad Slough). The combination of pumping rates and tidal flows moves these fish towards the southwestern corner of the Delta. When the combination of pumping rates and fish movements are high, significant numbers of juvenile SR winter-run Chinook salmon are drawn into the south Delta.

b. *Central Valley spring-run Chinook salmon*

Like the SR winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in the action area is under the influence of the CVP and SWP water diversions and the flows on the Sacramento River and its tributary watersheds. Juvenile CV spring-run Chinook salmon first begin to appear in the action area in January. A significant presence of fish does not occur until March (12.361 percent of average annual salvage) and peaks in April (54.380 percent of average annual salvage). By May, the salvage of CV spring-run Chinook salmon juveniles declines (29.481 percent of average annual salvage) and essentially ends by the end of June (3.585 percent of average annual salvage) (Table 15).

Currently, all acknowledged populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations of spring-run Chinook salmon have been deemed extirpated. Reintroduction of CV spring-run to this diversity group is a priority objective for recovery of the species. Due to the actions of the SJRRP, CV spring-run Chinook salmon have been released in 2014 to the San Joaquin River upstream of the confluence with the Merced River (and therefore into the proposed project's action area). Releases are expected to continue during the 24-month duration of the proposed project. A final rule has been published, which became effective on January 30, 2014, to designate an experimental population for the reintroduction and to establish protective regulations under ESA section 4(d) for the proposed experimental population (78 FR 251; December 31, 2013). Pursuant to ESA section 10(j), with limited exceptions, each member of an experimental population shall be treated as a threatened species. However, the rule includes proposed protective regulations under ESA section 4(d) that would provide specific exceptions to prohibitions under ESA section 9 for taking CV spring-run Chinook salmon within the experimental population area and in specific instances elsewhere. In addition, ESA section 7 applies differently to experimental populations, requiring a conference rather than consultation in most cases for nonessential experimental populations (see ESA section 10(j)(2)(C); see also 78 FR 251, December 31, 2013).

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. Like SR winter-run Chinook salmon, Sacramento River CCV steelhead can be drawn into the south Delta by the actions of the CVP and SWP water diversion facilities. Small, remnant populations of CCV steelhead are known to occur on the Stanislaus, Tuolumne, and Merced rivers (McEwan 2001, Zimmerman *et al*. 2008). This indicates the likelihood 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 the San Joaquin River upstream of the confluence with the Merced River (Eilers *et al.* 2010), owing to the 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 near Friant Dam. It should be noted however, that CCV steelhead can be present above the confluence with the Merced River when the Hills Ferry Barrier (HFB) is not there and steelhead have been caught by anglers in 1995-1996 near Fresno when the San Joaquin River was at flood stage (Reed personal communication).

Due to poor habitat conditions in the San Joaquin River upstream of the Merced River confluence, the CDFW has operated the HFB since 1992 from the periods of October 1 to December 15 (on average) to redirect fall-run Chinook salmon to the Merced River, or other suitable habitat. The annual monitoring reports for 2005 to 2008 submitted to NMFS by CDFW indicate that no juvenile or adult CCV steelhead were detected during the HFB operations (CDFG 2006, 2007. 2008b, 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 CCV steelhead into the portion of the action area in the San Joaquin River upstream of the confluence of the Merced River. During the timeframe that the HFB 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 HFB but no CCV steelhead detections were made (CDFG 2010). In the fall of 2010, a trap was installed by CDFW and operated by Reclamation's 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 Plan in 2011 did not detect the presence of CCV steelhead above the HFB after the barrier's removal in mid-December (Portz *et al.* 2012). From 2012-2014 Reclamation's Denver Technical Services Center continued to trap and transport fall-run Chinook per the SJRRP. Up to 500 fall-run Chinook were trapped annually, but no steelhead were reported.

Kodiak trawls conducted by the USFWS and CDFW on the mainstem of the San Joaquin River upstream from the City of Stockton routinely catch low numbers of outmigrating CCV steelhead smolts from the San Joaquin basin during the months of April and May. CCV steelhead smolts first start to appear in the action area as early as October based on the records from the CVP and SWP fish salvage facilities. Their presence increases through December and January (20.969 percent of average annual salvage) and peaks in February (40.110 percent) and March (33.562 percent) before rapidly declining in April (8.513 percent). By June, the emigration has essentially ended, with only a small number of fish being salvaged through the summer at the CVP and SWP (See table 15).

Table 15: Summary table of monthly SR winter-run and CV spring-run Chinook salmon loss, and Combined total salvage and loss of CCV steelhead at the CVP and SWP fish collection facilities from water year 1999-2000 to water year 2011-2012. Data from CVO web site: (http://www.usbr.gov/mp/cvo/). Note: Data listed for water year 2009-2010 through water year 2011-2012 is preliminary.

Fish Facility Salvage Records (Loss)

Winter-Run (loss)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Sum
2011-2012	0	0	0	318	867	1870	161	76	0	NA	NA	NA	3292
2010-2011	0	0	1119	866	1516	2262	58	4	0	NA	NA	NA	5825
2009-2010	0	0	3	1206	1582	1183	46	4	0	NA	NA	NA	4024
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	5149	10616	19053	38321	2118	165	216	0	0	0	75638
Ave	0	0	429	885	1588	2948	163	13	17				5818
%WrYr	0.000	0.000	7.375	15.205	27.289	50.664	2.800	0.218	0.286				

Spring-Run (loss)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Sum
2011-2012	0	0	0	0	0	624	1528	530	3	NA	NA	NA	2685
2010-2011	0	0	0	23	0	747	15862	31635	5030	NA	NA	NA	53297
2009-2010	0	0	0	0	0	403	2319	3270	160	NA	NA	NA	6152
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	115	241	22793	100271	54361	6610	0	0	0	184391
Ave	0	0	0	10	22	2072	9116	4942	601				16763
%WrYr	0.000	0.000	0.000	0.062	0.131	12.361	54.380	29.481	3.585				

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

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Sum
2011-2012	0	0	7	45	176	911	352	33	20	NA	NA	NA	1544
2010-2011	7	0	3	244	801	496	275	301	560	NA	NA	NA	2687
2009-2010	0	0	7	568		1288	221	190	158	NA	NA	NA	2432
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	10	92	642	17803	31216	30869	7830	1800	1693	22	0	0	91977
Ave	1	7	54	1484	2838	2375	602	138	130	11			7075
%WrYr	0.011	0.100	0.756	20.969	40.110	33.562	8.513	1.957	1.841	0.155			

d. *Southern DPS of North American Green Sturgeon*

Juvenile sDPS green sturgeon 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 2006, green sturgeon may be present during any month of the year, and have been particularly prevalent during July and August (Figure 5). 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 3 years. The action area is located off of the main migratory route that juvenile sDPS 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 sDPS green sturgeon to access the spawning grounds in the upper Sacramento River. However, collections at the CVP and SWP facilities and their proximity to the action area would indicate that sub-adult sDPS green sturgeon have a strong potential to be present within the action area.

2. Status of Critical Habitat within the Action Area

The action area is predominately within the Middle San Joaquin – Lower Merced – Lower Stanislaus and the San Joaquin Delta hydrologic units (HU) (18040002 and 18040003, respectively). Designated critical habitat for the sDPS green sturgeon (74 FR 52300; October 9, 2009) occurs within the Sacramento-San Joaquin Delta which includes the San Joaquin Delta HU. Designated critical habitat for CCV steelhead (70 FR 52488; September 2, 2005) includes the San Joaquin Delta HU and the Middle San Joaquin-Lower Merced-Lower Stanislaus HU. Although SR winter-run Chinook salmon occupy the San Joaquin Delta HU, designated critical habitat for SR winter-run Chinook salmon (58 FR 33212, June 16, 1993) does not occur in the action area so impacts to this species' critical habitat will not be analyzed in this Opinion. Similarly, CV spring-run Chinook salmon occupy the San Joaquin Delta HU, but 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 this Opinion. The action area includes the portion of the San Joaquin River from the confluence of the Merced River upstream to Mud Slough (north), which is not critical habitat for CCV steelhead. This opinion will focus on the mainstem San Joaquin River as well as those waterways in the southern portions of the Delta, which are expected to show expressions of water quality characteristics influenced by discharges originating in the GBP.

The San Joaquin Delta HU is in the southwestern portion of the CCV steelhead DPS range and includes portions of the south Delta channel complex. The San Joaquin Delta HU encompasses approximately 938 square miles, with 455 miles of stream channels (at 1:100,000 hydrography). The critical habitat analytical review team (CHART) identified approximately 276 miles of occupied riverine/estuarine habitat in this hydrologic subunit area (HSA) that contained one or more PCEs for the CCV steelhead (NMFS 2005b). The PCEs of CCV steelhead critical habitat within the action area relate to 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, natural levels of 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 juveniles and smolts and for adult upstream migration. No spawning of CCV steelhead 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. 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 agricultural 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. Prior to the legal settlement that resulted in the SJRRP, operation of Friant Dam and its water delivery system precluded normal flows down the San Joaquin River. Flood flows have been routed into bypass structures away from the main channel. The SJRRP will restore some flow to the river.

In regards to the designated critical habitat for the sDPS 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 substantial degradation over time of several of the essential features of these PCEs has diminished the function and condition of the critical habitat in the action area. It has only rudimentary functions compared to its historical status. The channels of the Delta have been heavily riprapped with coarse rock slope protection on artificial levee banks and these channels have been straightened to facilitate water conveyance through the system. The extensive riprapping and levee construction has precluded river channel migrations and the formation of natural riverine/estuarine features in the Delta's channels. The natural floodplains have essentially been eliminated, and the once extensive wetlands and riparian zones have been cleared for farming. Little riparian vegetation remains in the Delta, limited mainly to tules growing along the foot of artificial levee banks. 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 altered the natural flow of water through the 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 Delta have been routinely dredged by DWR to provide adequate intake depth for these agricultural water diversions, particularly in the south Delta. Likewise, the main channels of the San Joaquin River and the Sacramento River have been routinely dredged by the Corps to create artificially deep channels to provide passage for ocean going commercial shipping to the Port of Stockton and the Port of Sacramento.

Water flow through the 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 for portions of Old and Middle rivers that are north of the pumps. The San Joaquin River south of the pumps still flows downstream, but into the pumps. 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 Delta, numerous discharges of treated wastewater from sanitation wastewater treatment plants (*e.g.*, the Cities of Tracy, Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways empty into the waters of the San Joaquin River and the channels of the Delta. This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (*i.e.*, selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, *etc*.).

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 the sDPS green sturgeon. Some of the juvenile winter-run and spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon that originate in the Sacramento River basin pass into and through the San Joaquin Delta HU to reach the lower Delta and ocean. In addition, 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 sDPS 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, the experimental population of CV spring-run Chinook salmon released into the San Joaquin River as part of the SJRRP 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 ESU, CV spring-run Chinook salmon ESU, sDPS green sturgeon, and CCV steelhead DPS to maintain a functional migratory corridor and freshwater rearing habitat throughout 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 Chinook salmon and CV spring-run Chinook salmon ESUs, CCV steelhead, and sDPS 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 biological opinion, 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 execution of the SLWD and PWD IRC 2015–2017.

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed species in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal, industrial, 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 low lying terraces under cultivation (*i.e.*, orchards and row crops) in the natural floodplain along the basin tributaries. Consequently, managed flows in the mainstem of the river often truncate the peak of the flood hydrographs and extend the reservoir releases over a protracted period. These actions reduce or eliminate the scouring flows necessary to mobilize sediments and create natural riverine morphological features within the action area. Furthermore, the unimpaired river flow in the San Joaquin River basin is severely reduced by the combined storage capacity of the different reservoirs located throughout the basin's watershed. Very little of the natural hydrologic input to the basin is allowed to flow through the reservoirs to the valley floor sections of the tributaries leading to the Delta. Most is either stored or diverted for anthropogenic uses. Elevated flows on the valley floor are typically only seen in wet years or flood conditions, when the storage capacities of the numerous reservoirs are unable to contain all of the inflow from the watersheds above the reservoirs.

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 frequently exceed 72^{o}F (CDEC database), 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, Crocker-Huffman 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. 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 cumulative 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 for extended periods 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. Farmland irrigation contributed to selenium exceedances in subsurface drainage in the Grasslands Watershed. As a result, the Grasslands Watershed marshes and a portion of the San Joaquin River were placed on California's Clean Water Act section 303(d) list of impaired waters in 1988. The listing Mud Slough and Salt Slough, followed in 1990. The Grasslands Bypass Project implemented agricultural best management practices and area wide measures to reroute drainage and reduce the total selenium loading. These efforts led to significant selenium load reductions, which in turn resulted in the de-listing of Salt Slough (10 miles) in 2008 and three segments of the San Joaquin River (totaling 40.4 miles) in 2010. Environmental stresses 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 Central Valley watersheds (USFWS 1995b). The high number of diversions in the action area in the San Joaquin River and in the south Delta are also potential threats to listed fish. 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.

2.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is the execution of interim water service contracts for the continued delivery of the same quantities of CVP water to the same lands currently covered under the previous long-term water service contracts and current IRC for the San Luis and Panoche Water Districts. The new interim contracts would extend these agreements for a period of up to 24 months. The proposed action does not require the construction of any new facilities, the installation of any new structures, or the modification of existing facilities, but operational aspects of these continued water deliveries may adversely affect several life stages of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon in the action area. Adverse effects to these species and their habitat may result from changes in water quality resulting from the discharge of subsurface agricultural drainage water originating from within the San Luis and Panoche water districts. The execution of the IRC includes continuing implementation of the Westside Regional Drainage Plan and participation in programs such as the Grasslands Bypass Project, SJRIP, and San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District. The implementation leads to the objective of reducing the amount of selenium entering the waterways of the San Joaquin Valley over time and thereby minimizing the potential impacts to water quality associated with agricultural drainage discharges to the San Joaquin River.

1. Presence of Listed Salmonids and sDPS of North American Green Sturgeon in the Action Area

Adult SR winter-run and CV spring-run Chinook salmon migrate through the Delta on their way to upstream spawning sites in the Sacramento River and its tributaries. Adult SR winter-run Chinook salmon are most likely to be present in the action area, specifically in the Delta, between November and May while CV spring-run Chinook salmon adults are most likely to occur there from late January through May. Timing of juvenile emigration for both species through the action area on their way to the sea is highly variable depending on water flows and temperatures, but the highest occurrence of rearing and/or migrating juveniles of both ESUs in the Delta generally occurs between November and May. Therefore, both adult and juvenile SR winter-run and CV spring-run Chinook salmon pass through the action area and would be exposed to project-related effects for a brief period during either their migration to upstream spawning sites or out to sea. The project-related effects, namely selenium exposure originating from SLWD and PWD agricultural runoff, are present in the Delta where SR winter-run and CV spring-run Chinook salmon are known to occur; however, the selenium levels in the areas where SR winter-run and CV spring-run Chinook salmon are known to occur are diluted to levels of 0.4 ppb or less, according to the supplemental information provided by Reclamation. Due to the fact that adults migrating upstream do not forage, and the juveniles that enter the action area do not remain there for more than a short period of time, it is unlikely that project related effects will result in adverse effects to either of these ESUs.

As indicated above in the *Environmental Baseline* section of this biological opinion, a final rule has been published to designate an non-essential experimental population for CV spring-run Chinook salmon released into the San Joaquin River between Friant Dam and the confluence with the Merced River as part of the SJRRP (78 FR 251; December 31, 2013). The first release of spring-run Chinook salmon juveniles into the San Joaquin River occurred in April, 2014.

Adult CCV steelhead begin to migrate into the region's watersheds (San Joaquin, Stanislaus, Tuolumne, and Merced rivers) during the period between September and the end of December, particularly when increased flows are being released from San Joaquin River reservoirs to enhance fall-run Chinook salmon spawning habitat in the San Joaquin River tributaries or when early winter rains cause increased flows in the system. The peak of juvenile Central Valley steelhead emigration from their tributaries in the San Joaquin Valley occurs during the period between February and May. There are, however, larger steelhead smolts that migrate at other times of the year, including the fall and early winter period (S.P. Cramer and Associates 2005), and thus may be exposed to the project-related effects during their passage through the action area as well. Depending on HFB operations, it is reasonable to assume that CCV steelhead may have access to the San Joaquin River upstream of the confluence of the Merced River, as a result of the SJRRP, within the time period of this IRC.

Low numbers of sDPS green sturgeon are anticipated to be present in the action area throughout the year, and in the case of rearing juveniles, they may be present for up to 3 or 4 years before emigrating to the ocean. Although information on the density of sDPS green sturgeon in the action area is not currently available, their occasional occurrence in sampling studies targeting other fish species indicates that they may be present throughout the year within the mainstem of the San Joaquin River and thus vulnerable to the adverse effects of the project.

2. Effects of the Action on Listed Species

The San Luis and Panoche Water Districts discharge subsurface drainwater into drainage district conveyance facilities owned and operated by the Charleston and Panoche Drainage Districts, respectively. Both drainage districts prohibit the discharge of surface return flows into their systems, but occasionally storm events generate substantial surface runoff from agricultural areas that will enter regional conveyances and eventually reach natural streams, including Mud Slough, the San Joaquin River, and the Delta. The RWQCB issued waste discharge requirements for the GBP that conveys the subsurface drainage delivered by the Charleston and Panoche Drainage Districts into natural waterways, establishing a performance goal of 5 ppb monthly mean selenium for the San Joaquin River below the Merced River for critical, dry, and below normal water year types, and 5 ppb 4-day average during normal and wet years. In addition, the RWQCB adopted Resolution Number R5-2010-0046 on October 5, 2010, which extended the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan) upstream beyond the previous compliance point on the San Joaquin River. The resolution provides an interim performance measure of 15 ppb monthly average through December 31, 2017, for the San Joaquin River at the confluence of the Merced River upstream to Mud Slough (north). By December 31, 2019, the 5 ppb 4-day average must be met in Mud Slough (north) and the San Joaquin River above the confluence of the Merced River. The 5 ppb RWQCB performance criteria for selenium may exceed toxic effect levels for listed salmonids and sturgeon (Beckon 2008a, 2008b); therefore, listed species may also be negatively affected by the 15 ppb monthly average interim performance criteria.

Since its inception in 1996, the GBP has been successful in helping to achieve RWQCB goals of reducing selenium inputs to the San Joaquin River by consolidating, storing, reusing, and ultimately reducing subsurface drainage waters from the participating water districts. Nevertheless, selenium concentrations in the San Joaquin River and Delta continue to rise over time due to its prevalence in the soils derived from organic-rich shales throughout the semi-arid San Joaquin Valley, as well as the persistent and additive nature of this element once it enters the aquatic environment.

Selenium efficiently bioaccumulates through aquatic food webs, and strongly biomagnifies into many components of the food web including primary producers, invertebrates, bivalves, fish, and birds. Dietary uptake of selenium through lower trophic level prey species and progressive biomagnification through the food web is the primary pathway for the disproportionately large bioaccumulation of selenium to higher trophic level predator species. Selenium is an essential element necessary for the production and proper functioning of important enzymes. However, with overexposure it rapidly surpasses required concentrations, becoming toxic and resulting in dysfunctional enzymes and disrupted proteins that can lead to reproductive failure and teratogenesis (*i.e.*, deformities in developing young). In cases of extreme contamination, it can lead to death of adult organisms. Concentrations of selenium greater than 3 µg/g in the diet of chinook salmon results in deposition of elevated concentrations in developing eggs, particularly in the yolk, and dietary selenium concentrations of 5 to 20 µg/g load eggs beyond the teratogenic threshold (Luoma and Presser 2000). In experiments conducted by Silvestre *et al*. (2010), larval green sturgeon were significantly more sensitive to temperature and selenium stress than white sturgeon. Different predator species have variable accumulation rates of dietary selenium; due to the types of prey they consume (Luoma and Presser 2000). Generally, benthic feeding fish have higher selenium concentrations than predators that feed from the water column. Of particular concern are benthic feeding predators, such as sDPS green sturgeon, that consume bivalves in their diet, especially the Asian clam *Potamocorbula amurensis*, an invasive species that has displaced several other resident species of bivalve in the Delta, and exhibits concentrations of selenium that regularly exceed the thresholds for chronic toxicity in the food of birds and fish (i.e., > 10 µg/g) (Linares-Casenave *et al.* 2014).

There is no information available on the concentration of selenium in listed salmonids and sDPS green sturgeon tissue in the action area, and no way of determining to what extent the drainwater contributed by the irrigation returns from the San Luis and Panoche Water districts might contribute to those selenium levels. However, given the fact that the drainwater from these districts is known to contain elevated levels of selenium, and the listed species occur (and feed) in the area where this drainwater is discharged into critical habitat, NMFS must make the assumption that the continuation of this situation, made possible by the proposed execution of interim water service to the San Luis and Panoche Water districts for a period of 24 months, will result in adverse effects on listed salmonids and sDPS green sturgeon. Given the data previously described on the general effects of elevated selenium levels on fish in the San Francisco Bay-Delta Estuary and given all species covered in this Opinion pass through the San Francisco Bay-Delta Estuary (Luoma and Presser 2000), NMFS concludes that the response of CCV steelhead, CV spring-run Chinook salmon and sDPS green sturgeon to the effects of the proposed action are likely to include physiological stress to the extent that the normal behavior patterns (*e.g.*, feeding, sheltering and migration) of affected individuals may be disrupted. Overall, an increased availability of selenium in prey items is expected to affect reproductive success, juvenile survival, and behavioral responses that may lead to decreased swimming performance and increased predation rates for juveniles. Because sDPS green sturgeon may spend a period of years in the action area rearing before migrating to the ocean, are demersal fish closely associated with the bottom substrate, feed by taste and feel with their barbels, and even shovel up sediment with their snouts when searching for food, it is likely that they would be subjected to a higher risk of exposure to the effects of increased selenium in their diet.

Implementing the RWQCB performance criteria of 5 ppb over a 4-day average on the San Joaquin River below the confluence with the Merced River is a good-faith effort to reduce selenium concentration in the San Joaquin Basin and Delta; however, it does not eliminate the potential for take to occur to listed species within the action area. The continued participation in the GBP, SJRIP, pilot projects such as the San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District, and implementation of the strategies developed in the Westside Regional Drainage Plan minimizes the amount of selenium entering the San Joaquin River as a result of agricultural drainage.

3. <u>Impacts to Critical Habitat</u>

There are no suitable spawning sites within the project's action area for CCV steelhead or sDPS green sturgeon. Therefore, the PCEs of CCV steelhead designated critical habitat that will be affected by the execution of the SLWD and PWD IRCs are freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The PCEs of critical habitat for sDPS green sturgeon that will be affected by the execution of the SLWD and PWD IRCs are estuarine food resources, water quality, and sediment quality. Any continued contributions of selenium from agricultural subsurface drainage and occasional storm flow runoff will be additive to the available load already present in the water, sediment, and prey items of the south Delta for both juvenile and adult CCV steelhead and sDPS green sturgeon during the course of the two-year period that the contracts would authorize continued water deliveries to the water districts.

Due to the relatively short time period (*i.e.*, two years) for which the IRCs would authorize continued deliveries of water to the San Luis and Panoche water districts, and the degree to which selenium contributions would be made from agricultural subsurface drainage and occasional storm flow runoff from these two districts relative to the contributions of other watersheds throughout the region, the above described impacts from the execution of the SLWD and PWD IRCs to food resources, water quality, and sediment quality are not expected to significantly impact or appreciably reduce the value of the designated critical habitat for the conservation of the listed species in the action area.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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).

A. Agricultural Practices

Agricultural practices in and upstream of the San Joaquin River 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 San Joaquin River. Agricultural practices in the 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 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 drainwater related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect listed salmonid and sDPS green sturgeon 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 3 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. City of Manteca (2012) observed a 32.4 percent population increase between 2001 and 2011. According to City of Lathrop website (updated in 2011), the current population was listed at 17,469 with an expected “build out” population of 70,000 (http://www.ci.lathrop.ca.us/about/). 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 water bodies, 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 re-suspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation on the San Joaquin River and south 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 south Delta. In addition to recreational boating, commercial vessel traffic is expected to increase with the redevelopment plans of the Port of Stockton. Portions of this redevelopment plan have already been analyzed by NMFS for the West Complex (formerly Rough and Ready Island) but the redevelopment of the East Complex, which currently does not have a Federal action associated with it, will also increase vessel traffic as the Port becomes more modernized. Commercial vessel traffic is expected to create substantial entrainment of aquatic organisms through ship propellers as the vessels transit the shipping channel from Suisun Bay to the Port and back again. In addition, the hydrodynamics of the vessel traffic in the confines of the channel will create sediment re-suspension, and localized zones of high turbulence and shear forces. These physical effects are expected to adversely affect aquatic organisms, including both listed salmonids and sDPS green sturgeon resulting in death or injury.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

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 sDPS 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 south 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.

The San Joaquin River basin historically contained numerous independent populations of CCV steelhead and CV spring-run Chinook salmon (Lindley *et al*. 2006, 2007). The sDPS green sturgeon may have been present in these watersheds prior to anthropogenic changes. The suitability of these watersheds to support these runs of fish changed with the onset of human activities in the region. Human intervention in the region initially captured mountain runoff in foothill reservoirs which produced hydropower and/or supplied water to farms and urban areas. As demand grew, these reservoirs were enlarged or additional dams were constructed higher in the watershed to capture a larger fraction of the annual runoff. San Joaquin Valley agriculture created ever greater demands on the water captured by these reservoirs, diminishing the flow of water remaining in the region's rivers, and negatively impacting regional populations of salmonids (and likely green sturgeon too). Reclamation actions eliminated vast stretches of riparian habitat and seasonal floodplains from the San Joaquin River watershed and Delta through the construction of levees and the armoring of banks with rock riprap for flood control. Construction of extensive water conveyance systems and water diversions altered the flow characteristics of the Delta region. These anthropogenic actions resulted in substantial degradation of the functional characteristics of the aquatic habitat in the watershed upon which the region's salmonids (and potentially green sturgeon) depended on to maintain healthy populations.

Presently, populations of CV spring-run Chinook salmon have been deemed functionally extirpated from the San Joaquin River basin and the reintroduction of the species is a priority recovery action. SR winter-run Chinook pass through the Bay-Delta Estuary, but are not part of the San Joaquin River system. Populations of CCV steelhead in the San Joaquin River basin have been substantially diminished to only a few remnant populations in the lower reaches of the Stanislaus, Tuolumne, and Merced rivers below the first foothill dams. The sDPS green sturgeon has not been documented utilizing the San Joaquin River as a spawning river in recorded history but human alterations, which have been ongoing for over 100 years in the watershed, may have extirpated these populations before accurate records were maintained. However, fish survey records indicate that juvenile and sub-adult sDPS green sturgeon use the lower San Joaquin River for rearing during the first several years of their life. Since the viability of small remnant populations of CCV steelhead in the San Joaquin River basin is especially tenuous and such populations are susceptible to temporally rapid decreases in abundance and possess a greater risk of extinction relative to larger populations (Pimm *et al.* 1988, Berger 1990, Primack 2004), activities that reduce quality and quantity of habitats, or that preclude formation of independent population units (see the representation and redundancy rule cited by Lindley *et al*. 2007), are expected to reduce the viability of the overall DPS if individual populations within the larger metapopulations become extinct (McElhany *et al.* 2000). Therefore, if activities have significant impacts on CCV steelhead populations or destroy necessary habitat, including designated critical habitat, within these San Joaquin populations, they could have significant implications for the DPS as a whole.

Sacramento River winter-run Chinook salmon

Both adult and juvenile SR winter-run Chinook salmon pass through the lower portion of the action area and will be exposed to project-related effects for a brief period during either their migration to upstream spawning sites or out to sea. However, selenium levels are expected to remain at low concentrations and may decrease for the duration of the proposed action in the areas where SR winter run Chinook salmon are known to occur. Due to the fact that adults migrating upstream do not forage, and the juveniles that enter the action area do not remain there for more than a short period of time, it is unlikely that project related effects will result in adverse effects to either of these ESUs.

Central Valley spring-run Chinook salmon

Currently, all acknowledged populations of CV spring-run Chinook salmon inhabit the Sacramento River watershed. The San Joaquin River watershed populations have been deemed extirpated, with the last known runs on the mainstem San Joaquin River were extirpated in the late 1940s and early 1950s by the construction of Friant Dam and the opening of the Friant-Kern and Madera irrigation canals. Due to actions of the SJRRP, CV spring-run Chinook salmon reintroduction actions have occurred in the San Joaquin River upstream of the confluence with the Merced River (and therefore into the proposed project's action area) over the duration of the proposed project. A final rule has been published to designate an experimental population for the reintroduction area and to establish protective regulations under ESA section 4(d) for the reintroduced fish (78 FR 251; December 31, 2013). These reintroduction actions are essential to the recovery of this species diversity group. Additionally as mentioned in the *Status of the Species* section (2.2), it is thought that CV spring-run Chinook salmon may occur in the Stanislaus and Tuolumne rivers. Returning adults and migrating juveniles of these populations would be subject to contaminants in the mainstem San Joaquin River from the proposed project however, exposure would be brief and diluted by flows from the mainstem tributaries during the upstream and downstream migration periods. Although many measures are in place to reduce selenium levels, it is possible that some CV spring-run Chinook salmon will be affected by the proposed action. Over the long term, it is expected that selenium concentrations in areas where reintroduced CV spring-run Chinook are known to occur will continue to decrease as a result of irrigation practices, other projects (*e.g.*, SJRIP, SJRRP, etc), and regulatory milestones.

California Central Valley Steelhead

Estimates of adult escapement of steelhead to all of the San Joaquin River tributaries combined are typically only a few dozen per year. This is reflected in the low number of smolts captured by monitoring activities throughout the year in different tributaries (*i.e.*, rotary screw traps on the Stanislaus, Tuolumne, Merced, and Calaveras rivers, and the Mossdale trawls on the San Joaquin River) in which only a few dozen smolts to several hundred smolts are collected each year (Marston 2004, S.P. Cramer and Associates 2005). These capture numbers have been extrapolated to estimate an annual population of only a few thousand juvenile steelhead smolts basin-wide in the San Joaquin River region. The Stanislaus River weir, which is used to count adult salmonids passing through the counting chamber, has only recorded a few adult CCV steelhead each year it has been in use. This is indicative of the low escapement numbers for adult CCV steelhead in this watershed (S.P. Cramer and Associates 2005). The other San Joaquin tributaries are thought to have similar or even lower numbers based on the superiority of the Stanislaus River in terms of habitat and water quality for CCV steelhead.

Adult CCV steelhead will travel further within the action area, through the mainstem San Joaquin River to reach spawning habitat, outside the action area, into the major tributaries (the Stanislaus, Tuolumne, and Merced rivers). Both adult and juvenile CCV steelhead will be exposed to selenium within the action area; however, the amount of exposure is expected to be brief during upstream and/or downstream migration periods. CCV steelhead are expected to spend more time within the San Joaquin River tributaries where overall habitat conditions are more favorable. CCV steelhead are currently deemed extirpated on the San Joaquin River upstream of the confluence with the Merced River (Eilers *et al*. 2010); however, it is possible that they may be attracted to the area due to agricultural return water and SJRRP Restoration Flows. Selenium levels are expected to remain low especially in the downstream portions of the action area, as a result of dilution, and may decrease for the duration of the proposed action in the areas where CCV steelhead are known to occur. Although many measures are in place to reduce selenium levels, it is possible that some CCV steelhead will be affected by the proposed action. Over the long term, it is expected that selenium concentrations in areas where CCV steelhead are known to occur will continue to decrease as a result of irrigation practices, other projects (*e.g.*, SJRIP, SJRRP, etc), and regulatory milestones.

Southern DPS of North American Green Sturgeon

Little is known about the migratory habits and patterns of adult and juvenile sDPS green sturgeon in the San Joaquin River watershed. The basic pattern described for sDPS adult green sturgeon migrations into the Delta region from the San Francisco Bay estuary is that fish enter the Delta region starting in late winter or early spring and migrate upstream towards the stretch of the Sacramento River between Hamilton City and Keswick Dam. After spawning, adults return downstream and re-enter the Delta towards late summer and fall (based on behavior of sturgeon in the Klamath and Rogue River systems. Juvenile and larval sDPS green sturgeon begin to show up in rotary screw trap catches along the Sacramento River starting in summer (Beamesderfer *et al.* 2004) and could be expected to reach the Delta by fall. The extent and duration of these fish entering and remaining in the San Joaquin River within the action area is unclear, but because of the habitat similarities and lack of barriers between the action area and documented sturgeon habitat in the Delta, NMFS believes that sDPS green sturgeon, including sub-adults, could be found at low densities during any month of the year within the action area. Both adult and juvenile sDPS green sturgeon feed on benthic invertebrates and would therefore have an increased potential to be adversely affected by exposure to increasing concentrations of dietary selenium in their prey base through a portion of their rearing habitat for a period of up to three years. However, because sDPS green sturgeon are only known to spawn in the Sacramento River, a small proportion of the overall DPS is expected to occur in the San Joaquin River drainage and be exposed to the adverse effects of the project.

Designated Critical Habitat

As described in the *Environmental Baseline* section (2.3), past and present activities within the San Joaquin River basin and waters of the south Delta have caused significant habitat loss, degradation, and fragmentation. This has significantly reduced the quality and quantity of the remaining freshwater rearing sites and the migratory corridors within the lower valley floor reaches of the San Joaquin River and the south Delta for the populations of CCV steelhead and sDPS green sturgeon that utilize this area. Alterations in the geometry of the south 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, and the influx of contaminants from agricultural and urban dischargers have also substantially reduced the functionality of the region’s waterways for listed salmonids and sDPS green sturgeon. Additional losses of freshwater spawning sites, rearing sites, and migratory corridors have occurred upstream of the action area in the tributaries of the San Joaquin and Sacramento river basins, but are outside of the action area of this consultation.

Summary

It is unlikely that SR winter-run Chinook salmon will experience adverse effects as a result of the proposed project. This is due to the low concentrations of selenium in parts of the action area where these species are known to occur and the fact that adults migrating upstream do not forage. Also, the juveniles that enter the action area do not remain there for more than a short period of time. In general, indirect, project-related, adverse effects to CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon in the San Joaquin River and southern Delta will be in the form of degraded water quality, in particular by contributing to the amount of selenium available to these species through prey items found in the action area. In this area, adult and juvenile CCV steelhead are primarily expected to begin entering the action area during late November and December, when cool and rainy weather is likely to promote upstream migration by adults, and in March and April, when juveniles are emigrating downstream through the action area. CV spring-run Chinook salmon are primarily expected to be migrating upstream through this area from March through May, and holding in pools closer to Friant Dam. Juveniles will be emigrating around December through March. As a result, the exposure time of CV spring-run Chinook salmon and CCV steelhead to project-related effects are expected to be limited to a period of weeks to months as they pass through the Delta on their way to upstream spawning locations and as juveniles are emigrating to the ocean. sDPS green sturgeon presence within the action area is considered to be year-round, with juveniles entering the Delta during the late summer and fall and potentially rearing there for several months to years before migrating to the ocean.

B. Effects of the Proposed Action on Listed Species

As a result of executing the proposed SLWD and PWD IRC, adverse impacts to sDPS green sturgeon, CV spring-run Chinook salmon and CCV steelhead stemming from the contamination of rearing and migrating habitat and food resources are expected to occur. These impacts may cause physiological stress to the extent that the normal behavior patterns (*e.g.*, feeding, sheltering and migration) of affected individuals may be disrupted. Overall, the changes in water quality associated with this project are expected to adversely affect listed species primarily by low-level alteration of habitat conditions, which may contribute to an increased availability of selenium in prey items. This may potentially affecting reproductive success, juvenile survival, and behavioral responses that may lead to decreased swimming performance and increased predation rates for juveniles. Because sDPS green sturgeon may spend a period of years in the action area rearing before migrating to the ocean, are demersal fish closely associated with the bottom substrate, feed by taste and feel with their barbels, and even shovel up sediment with their snouts when searching for food, it is likely that they would be subjected to a higher risk of exposure to the effects of increased selenium in their diet expected to be produced by the proposed project. Potential impacts are expected to be minimized by Reclamation meeting water quality objectives for agricultural subsurface drainage entering the San Joaquin River. These objectives will be met by using the following:

- Reclamation's 3rd Use Agreement for the GBP that authorizes the use of the GBP for agricultural drainwater discharges originating from the SLWD and PWD to the San Joaquin River.
- Panoche Drainage District's implementation of the SJRIP.
- Reclamation's pilot projects such as the San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District
- Reclamation requiring that the SLWD and PWD implement the strategies developed in the Westside Regional Drainage Plan for reducing the amount of selenium entering the San Joaquin River as a result of agricultural drainage.

C. Effects of the Proposed Action on Listed Species Likelihood of Survival and Recovery

1. Central Valley Spring-run Chinook Salmon and California Central Valley Steelhead

NMFS anticipates that the proposed project will result in the exposure of adult and juvenile CV spring-run Chinook salmon and CCV steelhead to increased levels of selenium in the waters and prey items of the south Delta where they migrate and rear. Exposure to this contaminant is expected to adversely affect a small number of individuals for a relatively short duration of time because the fish do not spend more than a few weeks to months in the action area during their life time. Adverse effects directly attributable to the proposed action will be minimized because contributions of drainage from these water districts meet RWQCB standards, and because the IRC authorize these continued discharges from the SLWD and PWD for a period of not more than 24 months. It should be noted that RWQCB standards may not provide adequate protection to migrating CCV steelhead and CV spring-run Chinook salmon that will have access above the confluence of the Merced River and below Mud Slough (north). Currently the HFB (HFB) is operated by the California Department of Fish and Wildlife, from October through mid-December, to keep fall-run Chinook salmon out of this reach; therefore, it also functions to exclude most of the migrating adult steelhead during this time. Following the removal of the HFB each December, Reclamation conducts the Steelhead Monitoring Program, as part of the SJRRP, to detect the presence of CCV steelhead in the San Joaquin River upstream of the confluence of the Merced River that may be present due to Restoration flows. An effectiveness study of the HFB was performed in 2010 and 2011, and no CCV steelhead were detected (Portz et al. 2011). Since implementing the Steelhead Monitoring Program in 2011, no CCV steelhead have been observed in this reach (Portz *et al.* 2012). The recently adopted interim performance measure (15 ppb monthly average through December 31, 2015) for the section of the San Joaquin River between the confluence of the Merced River and Mud Slough (north) is above toxicity thresholds for spring-run Chinook salmon and steelhead. Direct mortality of a small number of juvenile or adult fish may occur in this section of the San Joaquin River if individuals remain in this reach of the river for a long time period. The elevated stress levels may degrade the fish's health and the reproductive potential of adults, and increase the potential of juveniles to be preyed upon by striped bass or other large predators due to impaired behavioral and physiological responses. Even so, given the uncertain nature of the actual effects of the proposed project on CV spring-run Chinook salmon and CCV steelhead in the action area, it is expected that these short-term effects, when considered in the context of the current baseline and likely future cumulative effects, would not appreciably reduce the likelihood of survival and recovery of the CV spring-run Chinook salmon ESU and CCV steelhead DPS throughout their range.

2. Southern DPS of North American Green Sturgeon

Due to the lack of general abundance information regarding the sDPS green sturgeon, a variety of estimates must be utilized to determine the range of potential effects resulting from the take of green sturgeon due to the proposed action. Compared to the estimated population sizes suggested by the CDFW tagging efforts (CDFG 2002), juvenile and sub-adult captures passing Red Bluff Diversion Dam, and past IEP sampling efforts, the low level of take estimated from the proposed project would impact a small proportion of the adult and sub-adult sDPS green sturgeon in the

Sacramento River watershed. Captures of juvenile and sub-adult sDPS green sturgeon passing Red Bluff Diversion Dam have exceeded 2,000 individuals in some years. Execution of the proposed SLWD and PWD IRCs would only authorize continued discharges of agricultural subsurface drainage to the San Joaquin River for a period of 24 months. Incidental take of both adult and juvenile sDPS green sturgeon is expected to represent a small proportion of the overall population and is not expected to appreciably reduce the likelihood of survival and recovery of the sDPS green sturgeon.

C. Effects of the Proposed Action on Critical Habitat

The PCEs of designated CCV steelhead critical habitat that will be affected by the execution of the SLWD and PWD IRC 2015–2017 are freshwater rearing habitat, freshwater migration corridors, and estuarine areas.

The PCEs of proposed critical habitat for sDPS green sturgeon that will be affected by the proposed action include the food resources, water quality, and sediment quality of estuarine systems where juveniles rear for a period of up to 3 years, and through which both adults and juveniles migrate.

These effects to the PCEs of critical habitat may result in increased exposure of listed fish to selenium concentrations in the south Delta where they spend a portion of their life rearing and feeding before entering the ocean. However, NMFS expects that nearly all of the adverse effects to critical habitat from this project will be minimized when RWQCB standards on the San Joaquin River downstream from the confluence of the Merced River are being met, and when combined with the observed levels of dilution downstream of tributary inputs. In addition, there is a declining trend of selenium loading to the system predicted for the future, including the time period of these IRC. Furthermore, due to the minimal amounts of agricultural subsurface drainage originating from the San Luis and Panoche water district lands, and the limited period of 24 months that those discharges would be permitted, 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 critical habitat to the extent that it could lead to an appreciable reduction in the function and value of the affected habitat for the conservation of these species.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the SR winter-run Chinook salmon ESU, CV spring-run Chinook salmon ESU, CCV steelhead DPS, and sDPS green sturgeon or destroy or adversely modify their designated critical habitat.

2.8 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.8.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

NMFS anticipates incidental take of CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon in the San Joaquin River and south Delta as a result of increased selenium contamination in those waters through which they migrate and where juveniles of the species rear. Specifically, NMFS anticipates that juvenile and adult CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon may be adversely affected by increasing exposure to elevated levels of selenium which may impair the reproductive success, growth, and survival of these species in the wild.

NMFS cannot, using the best available information, specifically quantify the anticipated amount of incidental take of individual CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon because of the variability and uncertainty associated with the response of listed species to the effects of the project, the varying population size of each species, annual variations in the timing of spawning and migration, and individual habitat use within the project area. Additionally due to the variability of the discharge levels it confounds NMFS ability to quantify take. However, it is possible to designate ecological surrogates for the extent of take anticipated to be caused by the project, and to monitor those surrogates to determine the level of take that is occurring. The most appropriate ecological surrogates for the extent of take caused by the project are the measured concentrations of selenium in Mud Slough and the San Joaquin River, and the continued participation by the San Luis and Panoche water districts in the Grasslands Bypass Project, SJRIP, and San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District.

1. Ecological Surrogates

- The analysis of the effects of the proposed project anticipates that measured selenium concentrations in Mud Slough and the San Joaquin River will continue to be below or meet the RWQCB Basin Plan waste discharge requirements for the Grasslands Bypass Project identified in the *Effects of the Action* section, and that occurrences exceeding those thresholds will be limited to the influence of overland flow resulting from major storm events.

- The analysis of the effects of the proposed project anticipates that the San Luis and Panoche water districts will continue to participate in the Grasslands Bypass Project, the SJRIP, and the San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District throughout the life of the contracts (or for 18 months in the case of the latter project), thereby minimizing the volume and concentrations of selenium introduced into the habitat of listed species as a result of agricultural discharges from their districts.

If the specific parameters of these ecological surrogates are not met, the proposed project will be considered to have exceeded anticipated take levels, triggering the need to reinitiate consultation on the project.

2.8.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.8.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous fish. These reasonable and prudent measures also would minimize adverse effects on designated critical habitat.

1. Measures shall be taken to minimize the amount of agricultural subsurface drainage discharged to the San Joaquin River from the San Luis and Panoche water districts.

2. Measures shall be taken to ensure the continued participation in the Grasslands Bypass Project, the SJRIP, and the San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District for the duration of the Interim Renewal Contract Project (or for 18 months in the case of the latter project). This shall be done in order to ensure that anticipated take levels of listed species do not exceed those described above in A.1. Ecological surrogates.

3. Measures shall be taken to protect CCV steelhead and CV spring-run Chinook salmon from high selenium pulses in the San Joaquin River above the confluence with the Merced River through coordination with CDFW and the operation of the HFB at least during the September to December time period.

4. Measures shall be taken to assess and monitor the concentrations of selenium within the waters, sediments, vegetation, and invertebrates of the San Joaquin River as well as in the mouths of Salt Slough and Mud Slough (north) to assess the selenium contributions from each pathway. This shall be done in order to demonstrate that the proposed action does

not exceed anticipated take levels related to selenium waste discharge requirements in the RWQCB Basin Plan described above in A.1. Ecological Surrogates.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Bureau of Reclamation or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Bureau of Reclamation or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

These terms and conditions are non-discretionary and must be incorporated as binding conditions of any contracts or permits between Reclamation and the San Luis and Panoche water districts.

1. Measures shall be taken to minimize the amount of agricultural subsurface drainage discharged to the San Joaquin River from the San Luis and Panoche water districts.

    a. Reclamation shall require the water districts' continued participation in the Westside Regional Drainage Plan, which employs actions leading to zero discharge of subsurface drainage water beyond the boundaries of regional drainage management facilities, including but not limited to:

        i. Recirculating tailwater on-farm;

        ii. Employing micro irrigation and drip irrigation systems to the maximum extent practical;

        iii. Lining district water delivery facilities to the maximum extent practical;

        iv. Applying collected subsurface drainage water to salt tolerant crops and other drainwater displacement projects (such as road wetting for dust control); and

        v. Converting any remaining furrow and flood agricultural practices to contoured row agriculture employing micro, drip, or overhead sprinkler irrigation wherever feasible.

2. Measures shall be taken to ensure the continued participation in the Grasslands Bypass Project, the SJRIP, and the San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District for the duration of the Interim Renewal Contract Project (or for 18 months in the case of the latter project). This shall be done in order to ensure that anticipated take levels of listed species do not exceed those described above in A.1. Ecological surrogates.

a. Reclamation shall require the San Luis and Panoche water districts' continuing participation in the Grasslands Bypass Project, the SJRIP, and San Luis Drainage Feature Re-evaluation Demonstration Treatment Facility at Panoche Drainage District.

3. Measures shall be taken to protect CCV steelhead and CV spring-run Chinook salmon from high selenium pulses in the San Joaquin River above the confluence with the Merced River through coordination with CDFW and the operation of the HFB at least during the September to December time period.

    a. Reclamation shall coordinate with the CDFW and create an action plan to protect CCV steelhead and CV spring-run Chinook salmon from high selenium pulses in the San Joaquin River above the confluence with the Merced River through the operation of the HFB at least over the September to December time period.

4. Measures shall be taken to assess and monitor the concentrations of selenium within the waters, sediments, vegetation, and invertebrates of the San Joaquin River, and at the mouths of Salt Slough and Mud Slough (north) to assess the contributions of selenium from each pathway. This shall be done in order to demonstrate that the proposed action does not exceed anticipated take levels related to selenium waste discharge requirements in the RWQCB Basin Plan described above in A.1. Ecological Surrogates

    a. Reclamation shall design and initiate a plan for sampling the selenium concentrations in the waters, sediment, vegetation, and invertebrates of the San Joaquin River at the mouth of Mud Slough and above the confluence with the Merced River.

    b. Reclamation shall design and initiate a plan for sampling the selenium concentrations in the waters, sediment, vegetation, and invertebrates of the San Joaquin River at the mouth of Salt Slough and just upstream of the mouth of Mud Slough.

    c. Reclamation shall provide an annual report to NMFS summarizing the results of the sampling conducted in accordance with the plans described above.

Updates and reports required by these terms and conditions are due to NMFS no later than June 1, 2015, (covering the March 1, 2015, through February 28, 2016, period) and June 3, 2016, (covering the March 1, 2016, through February 28, 2017, period). These updates and reports shall be submitted to:

Assistant Regional Administrator
California Central Valley Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 5-100
Sacramento CA 95814
FAX: (916) 930-3629

2.9 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Reclamation should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage practices that avoid or minimize negative impacts to salmon, steelhead, and green sturgeon.

2. Reclamation should support anadromous salmonid monitoring programs throughout the Sacramento-San Joaquin Delta to improve the understanding of migration and habitat utilization by salmonids and green sturgeon in this region.

3. Reclamation should provide a monitoring plan in order to gather information about baseline selenium levels in waters, sediment, vegetation, and invertebrates in the San Joaquin River between the confluence of the Merced River and continuing just upstream of Salt Slough.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

2.10 Reinitiation of Consultation

This concludes formal consultation on the actions outlined in the request for consultation received from Reclamation for the San Luis Water District and Panoche Water District Interim Renewal Contracts 2015-2017.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration 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 or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the Bureau of Reclamation and descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

Reclamation proposes to execute interim water service contracts that would authorize the continued delivery of water from the Central Valley Project to the San Luis and Panoche water districts for a period of 24 months beginning on March 1, 2015, and continuing through to February 28, 2017. The proposed action is described in the Description of the Proposed Action section of the preceding biological opinion.

General life history information for CV fall-/late fall-run Chinook salmon is summarized below. Information on SR winter-run and CV spring-run Chinook salmon life histories is summarized in the preceding biological opinion for the proposed project. 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; March 9, 1998).

CV fall-run Chinook salmon enter the San Joaquin River from July through December, and late fall-run enter between October and April. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April [U.S. Fish and Wildlife Service (USFWS) 1998]. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding one foot and velocities ranging from one to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from one to four inches in diameter with less than 5 percent fines (Reiser and Bjornn 1979).

Egg incubation occurs from October through May, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). 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. Smolts generally spend a very short time in the Delta and estuary before entering the ocean.

3.2 Adverse Effects on Essential Fish Habitat

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion. A summary of the effects of the proposed action on Chinook salmon habitat are discussed below.

Adverse effects to Chinook salmon habitat will result from the execution of IRC authorizing continued water deliveries to the SLWD and PWD lands which discharge agricultural subsurface drainage that contributes selenium to the waters, sediment, vegetation, and biota of the San Joaquin River and the Delta. The effects of the proposed action are likely to include physiological stress to the extent that the normal behavior patterns (e.g., feeding sheltering, migration) of affected individuals may be disrupted. An increased availability of selenium in prey items is expected to affect reproductive success, juvenile survival, and behavioral responses that may lead to decreased swimming performance and increased predation rates for juveniles.

3.3 Essential Fish Habitat Conservation Recommendations

Considering that the habitat requirements of fall-run Chinook salmon within the action area are similar to the federally listed species addressed in the preceding biological opinion, NMFS recommends that all the Terms and Conditions as well as all the Conservation Recommendations in the preceding biological opinion be adopted as 7 EFH Conservation Recommendations.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, Reclamation must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

Reclamation must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the U.S. Bureau of Reclamation. Other interested users could include citizens of the affected areas, others interested in the conservation of the affected ESUs/DPS, water districts in the affected areas. Individual copies of this opinion were provided to Reclamation. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, if applicable, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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