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

APR 7 2009

MEMORANDUM FOR: Permit 14077 File (151422SWR2008SA00490)

FROM: For Rodney R. McInnis
Regional Administrator

SUBJECT: Documentation of Endangered Species Act section 7 consultation (PCTS TN# 2008/08036) for the issuance of section 10(a)(1)(A) scientific research Permit 14077 authorizing take of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha)*, Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and Southern DPS of North American green sturgeon (*Acipenser medirostris*)

I. CONSULTATION HISTORY

Section 10(a)(1)(A) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1536 *et seq.*), provides NOAA's National Marine Fisheries Service (NMFS) with authority to grant scientific research exemptions to the ESA's section 9 "taking" prohibitions (see regulations at 50 CFR § 222.301 through 222.308, and 50 CFR § 224.101 through 224.102). Section 10(a)(1)(A) scientific research or enhancement permits may be issued to Federal or non-Federal entities conducting research or enhancement activities that involve intentional take of ESA-listed species. Any permitted research or enhancement activities must: (1) be applied for in good faith; (2) if granted and exercised, not operate to the disadvantage of the threatened or endangered species; and (3) be consistent with the purposes and policy set forth in section 2 of the ESA [50 CFR § 222.303(f)]. When granting such permits, NMFS must consult internally under section 7 of the ESA to ensure that permits do not appreciably reduce the likelihood of survival and recovery of ESA-listed species. In compliance with section 7(a)(2) of the ESA, in this biological opinion (BO), NMFS analyzed the effects of the issuance of Permit 14077 authorizing take of ESA-listed salmonids from the following Evolutionarily Significant Units (ESUs) and Distinct Population Segments (DPSs): Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha)*, Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and Southern DPS of North American green sturgeon (*Acipenser medirostris*).

Natural Resource Scientists, Incorporated (NRSI) proposes to conduct research and monitoring activities under a section 10 permit, for the period beginning on April 1, 2009, though October 1, 2010. The take of endangered Sacramento River (SR) winter-run Chinook salmon (*Oncorhynchus tshawytscha)*, threatened Central Valley (CV) spring-run Chinook salmon (*O.*

tshawytscha), threatened CV steelhead (*O. mykiss*), and threatened Southern DPS of North American (Southern DPS) green sturgeon (*Acipenser medirostris*), is anticipated to occur during activities proposed for permitting.

On October 28, 2008, NMFS was notified of NRSI application for a new research permit pursuant to section 10(a)(1)(A) of the ESA. NRSI requests ESA coverage for take of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of green sturgeon associated with research monitoring activities taking place in salmonid and green sturgeon habitat in the Sacramento River basin.

On December 18, 2008, NMFS published a notice of receipt in the *Federal Register* outlining the research activities and take of ESA-listed salmonids proposed under Permit 14077 (73 FR 77009). The public comment period for Permit 14077 closed January 20, 2009. No comments were received regarding the permit.

II. DESCRIPTION OF THE PROPOSED ACTION

NMFS Southwest Region, Protected Resources Division proposes to issue scientific research Permit 14077 under the authority of section 10(a)(1)(A) of the ESA. Permit 14077 is for scientific research activities to be conducted in the Sacramento River watershed over an approximate 2-year period from permit issuance through September 30, 2010. The permit will authorize NRSI for non-lethal and unintentional lethal take of juvenile SR winter-run Chinook salmon, juvenile CV spring-run Chinook salmon, juvenile CV steelhead, and juvenile Southern DPS of green sturgeon. The take activities authorized under Permit 14077 will include: capture, fyke net trapping, and handling (identify, measure, and weigh) of entrained juvenile SR winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and Southern DPS of green sturgeon, and the release of any entrained live ESA-listed salmonid or green sturgeon back into the Sacramento River. Non-intentional mortality of salmonids or green sturgeon due to project activities will be collected for tissue archiving.

NRSI is contracted by the U.S. Bureau of Reclamation and is sponsored by the U.S. Fish and Wildlife Service (USFWS) to collect data for the Anadromous Fish Screening Program (AFSP). Research activities will be carried out at sampling stations established at three selected irrigation diversion outfalls off the Sacramento River, in Colusa, Sutter, and Yolo counties, Central Valley, California. The results from daily fish sampling are expected to determine total fish entrainment in relation to diverted flows and should assist in providing the technical basis to develop criteria for ranking and prioritizing diversions for future screening opportunities. NMFS expects that this information will assist resource managers in developing criteria for prioritizing fish screening projects on the Sacramento River and lead to better protection for listed salmonids and green sturgeon in the Sacramento River Basin. The proposed study supports the recommendations of the USWFS Anadromous Fish Restoration Program for the Central Valley Project Improvement Act (USFWS 1995) and the 2001 Ecosystem Restoration Program (ERP) Implementation Plan for improved understanding of potential fish losses to agricultural diversions and to quantify benefits to fish populations from screening such diversions (CALFED 2001).

A. Research Description

Permit 14077 would be in effect from date of issuance through September 30, 2010, and would be subject to the limitations of the ESA and the regulations in 50 CFR § 222, 223, and 224, unless it is modified, suspended, or revoked. Proposed take of ESA-listed salmonids and green sturgeon will occur during monitoring activities at three separate intake locations off of the Sacramento River.

NRSI will sample fish that have already been diverted out of the Sacramento River by irrigation pumps, using fyke nets positioned at each diversion outfall into irrigation canals. Fish captured on the outfall side of the pumped diversions are not expected to be alive or salvageable since fish will be mortally injured by the pumps, lethally stressed in pressurized pipes and warm water, or otherwise lost to the water distribution systems. Dead or moribund fish will be identified to species, enumerated, measured for length, and the carcasses put back into the canals at the sampling site. Any captured live listed species will be immediately returned to the river.

Potential correlations among variables are anticipated to show if and why fish are diverted at greater rates or greater numbers at some diversions compared to others, based upon the in-river flow characteristics at each site. The intent, in part, is to use this information to extrapolate to other representative sites. Daily numbers of each species entrained will be compared to determine potential differences or similarities in flow diverted/entrainment rates. If fish are not diverted in a linear relation to diverted flows, there are expected to be quantifiable characteristics to explain why. Sampling in irrigation pump outfalls during this period of the year will encompass the primary irrigation season when listed species may be entrained (Hallock 1989, Vogel and Marine 1991, Vogel 1995). The research project is designed to maximize the sampling period during normal irrigation diversions and the naturally-occurring presence or absence of listed species at the diversion sites. This research project will incorporate a process to correlate fish entrainment with physical, hydraulic, and habitat variables at diversion sites during typical irrigation diversion (riverine water extraction) periods. The project will consider the zone of influence of the specific diversions relative to the data collection methods and analyses. The intent, in part, is to use this information to extrapolate monitoring data to other representative non-screened diversion sites.

1. Methodology

NRSI will conduct daily fish sampling at each diversion outfall continuously for approximately seven days each week from April 1 through September 30, 2009, and April 1 through September 30, 2010. Fyke nets will be checked once daily. It is not expected that any fish captured on the outfall side of the pumped diversions will be alive or salvageable. Dead or moribund fish collected will be identified as to species, enumerated, measured for length, and the carcasses put back into the canals. If desired by the fishery resource agencies, specimens will be preserved. Any captured live listed species will be immediately returned to the river. Flow filtered by each net will be measured with flow meters. Fyke nets will be checked regularly for damage that may affect the quality of the sampling data. Damage to fyke nets will be repaired upon discovery.

Consideration may be given to increasing the frequency of sampling or the use of underwater cameras at some selected sites to assess diurnal/nocturnal changes in fish entrainment. Sampling of fyke nets will be carried out in a regular sequence of sites. Changes in the number of daily samplings or the use of underwater cameras shall be subject to mutual agreement by the AFSP Project Manager and NRSI.

NRSI will conduct initial inspections of each diversion site selected for the study to determine suitability for sampling fish entrained into the irrigation canals. Field examination of sites will show access to areas where fyke nets can be deployed into the canals safely and efficiently for capturing fish. It is anticipated that each location will be different and require design and fabrication of fish sampling equipment by NRSI adapted to site-specific conditions. The apparatus for sampling fish at each site will be comprised of a removable fyke net rectangular metal frame, clips and attachment points on the frame to hold and position the nylon fabric fyke net, a stationary metal channel framework to be installed in the irrigation canal to slide the fyke net frame in and out of the water and keep it in the current, a metal davit, and a winch and cable assembly to lift the frame daily to check for fish captured in the fyke net. NRSI will fabricate these materials off-site using welding equipment and perform the on-site installation of the devices at each fish sampling location. The quarter-inch netting will be custom made by a commercial net vendor according to detailed measurements for each site provided to the vendor by NRSI.

NRSI will prepare annual technical reports describing the pilot biological assessment. The annual report will include the methods and results of the fish monitoring and sampling program and include all summarized data for the year's assessment season for all sites phased in for monitoring and sampling during that period. The report shall include conclusions and any recommendations for improvements to incorporate in the next year's monitoring.

NRSI will prepare a final technical report and include a summary of the methods and results of the fish monitoring and sampling program, all data from annual reports, and a conclusion by site as well as overall conclusions and recommendations based on the results of the biological assessment. The results and conclusions of the report shall discuss any correlations that can be made regarding fish entrainment (*e.g.*, fish species, fish size, number of fish, timing of entrainment, *etc.*) and specific site characters (*e.g.*, diversion size, geographic location, intake pipe orientation, timing of diversions, *etc.*). The report will include lessons learned and any recommendations for future biological assessments at unscreened diversions.

2. Discussion

Proposed research carried out under Permit 14077 will benefit the listed fish species through the following two objectives: 1) improve understanding of the effects of unscreened diversions on the listed species which will add future knowledge and benefit to fish restoration programs (*e.g.*, assist in efficient allocation of expenditures for screening the remaining numerous unscreened small diversions), and 2) to the extent practicable, return (salvage) of any live listed species captured in the water diversion facilities (which would otherwise perish) back to the river. This particular research project is a component of a larger project. The goal of the larger project is to index unscreened diversions (under 250 cubic feet per second [cfs]) and purposely direct available funding to screen selected diversions. The intent is to create a useable directory of water diversions (under 250 cfs) for screening purposes. The proposed project is closely associated with other restoration efforts focused on improving and restoring aquatic and riparian habitats, including the efforts promoted by California Senate Bill 1086 (Upper Sacramento River Fisheries and Riparian Habitat Management Plan) and the Sacramento River Conservation Area Program.

Identifying and providing efficient fish protection and screening of diversions, especially at those sites with the greatest potential to entrain fish, will further ensure that riverine water diversions do not impair improvements to fishery production resulting from habitat restoration and other fishery conservation programs. It is expected that results of the research project will benefit endangered salmonids and aid in their recovery. Stabilizing and improving the population status of all anadromous salmonids, especially the federally ESA-listed winter and spring runs of Chinook salmon and steelhead (NMFS 1998, 2000), is a principal objective for fish screening programs. Identifying and providing efficient fish protection and screening of small diversions, especially for those with the greatest fish entrainment potential, will further insure that water diversions do not impair improvements to fishery production resulting from habitat restoration.

B. Measures to Reduce the Impacts of Permit 14077

Following are measures to be implemented to minimize any adverse impacts on ESA-listed salmonids and North American green sturgeon during research activities:

a. NMFS has reviewed the credentials of the principal investigator for the proposed research project. All investigators are well qualified and provide evidence of experience working with salmonids and/or North American green sturgeon and the concepts outlined in the proposed study. All biological technicians will be supervised by an investigator and receive NRSI training in appropriate fish handling techniques.

b. NMFS has developed nondiscretionary conditions for Permit 14077 that are necessary and appropriate to minimize take of ESA-listed salmonids. The principal investigator will ensure that all persons operating under Permit 14077 are familiar with the terms and conditions therein.

c. NMFS will monitor project activities to ensure that the project is operating satisfactorily in accordance with Permit 14077. NMFS will monitor actual take of ESA-listed species associated with the proposed research activities (as provided in annual reports or by other means) and will adjust annual permitted take levels if they are deemed to be excessive or if cumulative take levels are determined to operate to the disadvantage of listed fish.

d. All persons operating under Permit 14077 will be properly trained and have access to properly maintained state-of-the-art equipment.

e. All fish captured alive will be processed immediately, and before any other fish are processed, returned to the water. All capture buckets will be equipped with aerators/bubbler units to ensure an oxygen rich holding environment.

f. ESA-listed salmonids found dead in useable condition during sampling activities may be preserved as voucher specimens and forwarded to the appropriate person. Preservation protocol should be confirmed:

California Department of Fish & Game
Salmonid Genetic Repository
Jeanine Phillips
Fisheries Branch - Anadromous Resources Assessment Lab
8175 Alpine Ave, Suite F
Sacramento, CA 95826
jphillips@dfg.ca.gov
office 916.227.6398
fax 916.227.6399

g. North American green sturgeon found in useable condition during sampling activities will be preserved as voucher specimens and sent to:

Dr. Bernie May, Genomic Variation Lab,
Department of Animal Science, 2403 Meyer Hall,
University of California, Davis, CA 95616.

Contact Josh Israel at University of California, Davis for preservation protocol and questions at jaisrael@ucdavis.edu or at (530) 752-6351.

C. Description of the Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 404.2). For purposes of this biological opinion, there are three areas (the outfall at each water diversion facility) where monitoring and sampling will take place. The three selected sites are located within a 36-river mile stretch along the Sacramento River and are identified as follows:

(1) *Study Site 1:* Sutter Mutual – State Ranch, Sutter County
River Mile 96.25
Latitude: 38°52'13.31"N
Longitude: 121°45'11.93"W

(2) *Study Site 2:* River Garden Farms #2 – Missouri Bend, Yolo County
River Mile 96.7
Latitude: 38°51'52.70"N
Longitude: 121°45'28.50"W

(3) *Study Site 3:* Sycamore Mutual Water Corporation (Davis Ranches Site 2), Colusa County
River Mile 132.5
Latitude: 39°08'12.9"N
Longitude: 121°56'23.1"W

D. Requested Amount of Take and Unintentional Mortality

The requested amount of take and unintentional mortality has been estimated by NRSI based upon previous captures in the maximum appropriate amount necessary to achieve the goals and objectives of the research programs proposed under Permit 14077.

NRSI estimates an annual take of 656 SR winter-run, 798 CV spring-run, 85 CV steelhead, and 115 Southern DPS green sturgeon at study site 1; 137 winter-run, 163 spring-run, 13 steelhead, and 13 green sturgeon at study site 2; and 673 winter-run, 346 spring-run, 57 steelhead, and 56 green sturgeon at study site 3 (Table 7). For all three study sites, NRSI requests authorization for an annual non-lethal cumulative take of 1,466 juvenile Sacramento River winter-run Chinook salmon, 1,307 Central Valley juvenile spring-run Chinook salmon, 155 Central Valley juvenile steelhead, and184 juvenile southern DPS of green sturgeon. The total take estimates of fish captured behind the agricultural diversion pump sites during the 2-year study period are 5,856 salmonids and 368 green sturgeon.

1. <u>Estimate of Take</u>

The average potential entrainment in the diversions to be monitored is based on results from past experimental releases of hatchery Chinook salmon upstream of two diversions on the Sacramento River. Hansen (2001) studied juvenile Chinook salmon entrainment at unscreened diversions during June at the Princeton Pumping Plant (RM 164.4) and at the Wilkins Slough Diversion (river mile [RM] 117.8). He found that the percent of the released hatchery Chinook diverted was 0.05 to 0.07 times the percent of the Sacramento River flow diverted for the two sites, respectively. For calculating entrainment into diversion study sites, an average percent of juveniles diverted was estimated to be 0.06 times the percentage of the Sacramento River flow. The average juvenile Chinook salmon (for each run) and steelhead trout (resident and anadromous forms not differentiated) passage past Red Bluff Diversion Dam (Gaines and Martin 2002) for brood years 1995 through 1999 were used for the number and timing of winter-run, spring-run and steelhead present in the Sacramento River (Table 2). The diversions to be monitored on the Sacramento River are located over 100 miles downstream of Red Bluff Diversion Dam. There is some unquantified mortality that occurs within this reach and a timing delay between the time fish pass RBDD and when they reach the diversions.

Timing and quantity of water diversions was estimated by the diversion operators based on the past monthly use figures (Table 1).

Table 1. Monthly diversions cubic feet per second (cfs) for each of the diversions to be monitored

Landowner	River Mile	Orientation	Charac.	April	May	June	July	August	September	Average cfs
Sutter Mutual - State Ranch	96.25	4-slant	straight	55.3	85.9	98.9	109.8	92.8	17.6	76.7
River Garden Farms #2 - Missouri Bend	96.7	slant	inside bend	11.7	12.7	14.2	12.3	7.2	8.7	11.1
Davis Ranches Site 2	132.5	2-slant	straight	23.1	48.8	33.7	51.3	56.5	34.8	41.4

The number of fish diverted was calculated for each of the three diversion entrainment monitoring sites for each month and then the fish numbers summed for an overall estimate of potential take for each run. No specific information on the configuration of the diversion points relative to fish habitat was used in the entrainment estimates. Only the amount of water diverted by month was used. *O. mykiss* use slightly different habitats than Chinook so the past entrainment monitoring of Chinook is probably not that representative of *O. mykiss*, but we used it in the absence of other data.

Table 2. Estimated monthly passage of juvenile winter-run Chinook, spring-run Chinook, and *O. mykiss* past RBDD based on rotary screw trap catches

Juvenile Emigration Data, Sacramento River at RBDD

Numbers of winter-run Chinook salmon passing RBDD by month, Gaines and Martin 2002.

Brood Year	April	May	June	July	Aug	Sep	Total
BY 95	236	0	0	751	81,804	1,147,684	1,230,475
BY 96	1,378	272	0	903	18,836	228,197	249,586
BY 97	732	0	0	18,584	134,165	925,284	1,078,765
BY 98	1,754	262	0	184,896	1,540,408	2,128,386	3,855,706
BY 99	1,092	375	0	8,186	91,836	404,378	505,867
Average	**1,038**	**182**	**0**	**42,664**	**373,410**	**966,786**	**1,384,080**
% of year total	0.1%	0.0%	0.0%	2.2%	19.5%	50.4%	72.2%

Numbers of spring-run Chinook salmon passing RBDD by month, Gaines and Martin 2002.

Brood Year	April	May	June	July	Aug	Sep	Total
BY 94							
BY 95	49,304	6,105	0	0	0	0	55,409
BY 96	136,766	3,889	404	99	0	0	141,158
BY 97	70,874	10,762	482	0	0	0	82,118
BY 98	20,608	3,004	110	129	0	0	23,851
BY 99	281,808	19,374	466				301,648
Average	**111,872**	**8,627**	**292**	**57**	**0**	**0**	**120,837**
% of year total	21.7%	1.7%	0.1%	0.0%	0.0%	0.0%	23.4%

Numbers of O.mykiss passing RBDD by month, Gaines and Martin 2002.

Brood Year	April	May	June	July	Aug	Sep	Total
BY 94							
BY 95	5,626	39,102	2,541	2,230	22,418	34,485	106,402
BY 96	2,524	4,412	3,098	1,342	8,012	34,164	53,552
BY 97	8,183	6,796	4,951	3,686	5,282	1,758	30,656
BY 98	5,083	11,632	4,777	3,647	12,889	10,432	48,460
BY 99	1,571	8,040	4,465	5,092	12,810	11,605	43,583
Average	**4,597**	**13,996**	**3,966**	**3,199**	**12,282**	**18,489**	**56,531**
% of year total	4.5%	13.6%	3.9%	3.1%	11.9%	18.0%	54.9%

Green Sturgeon at Sacramento River Sites

The potential take of green sturgeon was estimated by examining screw trap catches of sturgeon at Glenn-Colusa Irrigation Dam (GCID) and Red Bluff Diversion Dam (RBDD) (Table 4 and 5 and Figure 2). Most of the sturgeon captured in these traps are young of the year and too small to identify to species. Based on a sample of these sturgeon that have been raised to an identifiable size they appear to be mostly green sturgeon. White sturgeon spawn mostly downstream of GCID. The GCID screw trap at river mile 205 is the closest monitoring point to the diversions to be studied so the catches from that trap were used to estimate potential entrainment. This screw trap has not been calibrated for expanding catch to total passage. We assumed an efficiency of 0.1 percent at the GCID screw trap for green sturgeon. Because young green sturgeon tend to be bottom oriented the screw trapping efficiency for them is likely lower than for salmon. Salmon often migrate higher up in the water column where screw traps are more likely to capture them. The total estimated entrainment of green sturgeon is 184 green sturgeon (Table 6). This is based on the total diversion rate of the three diversions to be sampled compared to the total river flow at Wilkins slough. An average of 0.06 times the percentage of the Sacramento River flow diverted (same as for Chinook) is used as the percentage of green sturgeon that would be entrained when passing the monitored diversion sites.

Table 3. Estimates of potential annual take during diversion entrainment monitoring

Calculated Fish Diverted

Diversion Name	Channel Location	River Mile	Winter Run	Spring Run	O.mykiss
Sutter Mutual - State Ranch	straight	96.25	655.5	79.7	42.4
River Garden Farms #2 - Missouri Bend	inside bend	96.7	137.3	16.3	6.7
Davis Ranches Site 2	straight	132.5	673.1	34.6	28.3
Total Fish Diverted during April through September			**1,466**	**131**	**77**
Adjustment factor for juveniles entering river from tributaries below RBDD			1.0	10.0	2.0
Total Entrainment Estimate			**1,466**	**1,307**	**155**

Table 4. Rotary screw trap catches of sturgeon at Glenn Colusa Irrigation District, 1994-2005

			Sturgeon in CDF&G Screw Trap at GCID										
1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average	Median	Std Dev
0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
0	113	27	0	0	1	3	8	0	1	0	12.8	0.5	32.5
20	10	126	0	23	13	13	1	4	3	5	19.2	11.0	34.4
205	180	52	0	214	18	16	0	3	1	23	59.8	17.0	85.9
77	109	24	0	52	2	1	0	1	0	4	22.5	1.5	37.0
4	2	3	0	1	0	0	0	1	0	1	1.1	1.0	1.3
306	414	232	0	290	34	33	9	9	5	33	115.3	33.0	149.9

Table 5. Sturgeon captured at Red Bluff Diversion Dam rotary screw traps

Year	Months Captured	# of Sturgeon
1995	June - August	1364
1996	May - August	410
1997	May - July	354
1998	July - August	302
1999	Feb - Oct	80
2000	May - June	98
2001	No sampling	-------
2002	May - July	35
2003	June - November	360
2004	May - July	643
2005	May - August	271
2006	June - August	191

Figure 1. Sturgeon captured at RBDD and GCID (BDAT 8/29/2006)

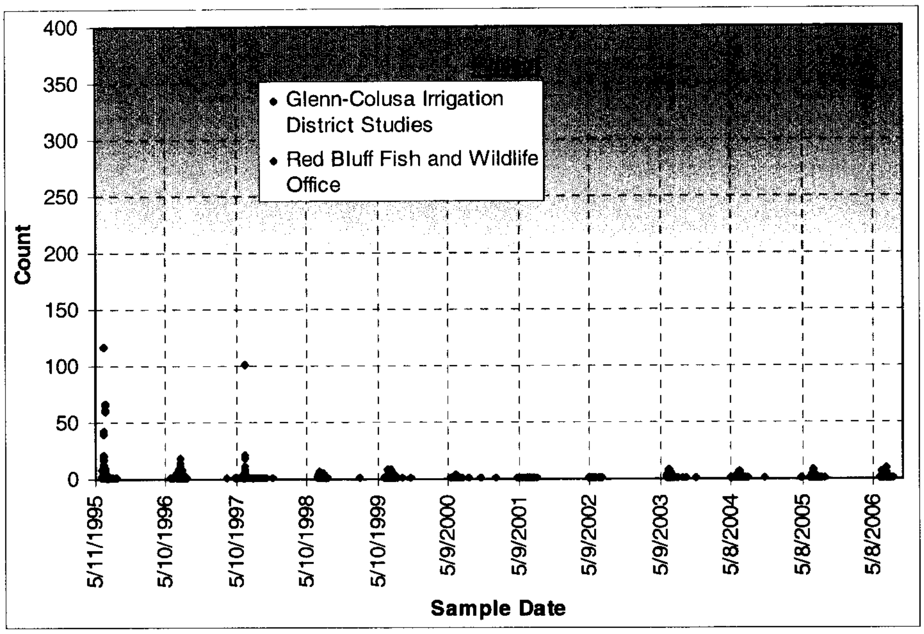

Table 6. Potential green sturgeon entrainment at the 2009-2010 monitoring sites

Sutter Mutual-State Ranch	April	May	June	July	August	September	Total
Sturgeon catch (average 94-2005)	0.0	12.8	19.2	59.8	22.5	1.1	115
Total Sturgeon at 0.1% efficiency	0	12,750	19,167	59,833	22,500	1,083	115,333
Flow at Wilkins Slough	5,268	5,000	5,000	7,328	5,036	5,007	
Total Diversion	55.3	85.9	98.9	109.8	92.8	17.6	
% of flow diverted	1.0%	1.7%	2.0%	1.5%	1.8%	0.4%	
% of fish diverted	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	
Number of Sturgeon Diverted	**0**	**13**	**23**	**54**	**25**	**0**	**115**

River Garden Farms #2 - Missouri Bend	April	May	June	July	August	September	Total
Sturgeon catch (average 94-2005)	0.0	12.8	19.2	59.8	22.5	1.1	115
Total Sturgeon at 0.1% efficiency	0	12,750	19,167	59,833	22,500	1,083	115,333
Flow at Wilkins Slough	5,268	5,000	5,000	7,328	5,036	5,007	
Total Diversion	11.7	12.7	14.2	12.3	7.2	8.7	
% of flow diverted	0.2%	0.3%	0.3%	0.2%	0.1%	0.2%	
% of fish diverted	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Number of Sturgeon Diverted	**0**	**2**	**3**	**6**	**2**	**0**	**13**

Sycamore Mutual (Davis Ranches Site 2)	April	May	June	July	August	September	Total
Sturgeon catch (average 94-2005)	0.0	12.8	19.2	59.8	22.5	1.1	115
Total Sturgeon at 0.1% efficiency	0	12,750	19,167	59,833	22,500	1,083	115,333
Flow at Wilkins Slough	5,268	5,000	5,000	7,328	5,036	5,007	
Total Diversion	23.1	48.8	33.7	51.3	56.5	34.8	
% of flow diverted	0.4%	1.0%	0.7%	0.7%	1.1%	0.7%	
% of fish diverted	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	
Number of Sturgeon Diverted	**0**	**7**	**8**	**25**	**15**	**0**	**56**

The take activities associated with research on juvenile ESA-listed salmonids and green sturgeon include capture (fyke net trap), handling (identify, measure, and weigh), tissue sampling (optional), and release of fish. No take of ESA-listed adult salmonids or adult green sturgeon are anticipated during the sampling periods. This research is part of an on-going investigation into developing criteria for prioritizing fish screening projects, and will correlate fish entrainment with the physical, hydraulic, and habitat variables at each diversion site. All fish will be identified as to species/race, enumerated, measured for length, and placed back into the canals; all entrained live fish will be returned to the river.

Table 7 documents the total amount of requested annual take and potential unintentional mortality of ESA-listed salmonids by NRSI associated with Permits 14077. It is not expected that any fish captured on the outfall side of the pumped diversions will be alive or salvageable since fish will be mortally injured by pressurized pumps and warm water. However, if live fish are encountered, captured live listed fish species will be immediately returned to the river, to the extent practicable, in aerated transport containers. The actual number of ESA-listed salmonids that are captured and handled is only likely to approach the numbers in Table 1 during seasons when ESA-listed salmonid population abundances are particularly high.

Table 7. Authorized take of ESA-listed salmonids associated with Permit 14077, 4/01 through 9/30/2009

Monitoring Site	Species	Cumulative Intentional Non-Lethal/non-intentional lethal	Take Action	Collection Method
Sutter Mutual - State Ranch Sutter County Sacramento River Mile 96.25	SR winter-run Chinook salmon	656	Observe/Sample Tissue Dead Animal	Fyke Net
	CV spring-run Chinook salmon	798	Observe/Sample Tissue Dead Animal	Fyke Net
	CV steelhead	85	Observe/Sample Tissue Dead Animal	Fyke Net
	Southern DPS Green sturgeon	115	Observe/Sample Tissue Dead Animal	Fyke Net
River Garden Farms #2 – Missouri Bend, Yolo County Sacramento River Mile 96.7	SR winter-run Chinook salmon	137	Observe/Sample Tissue Dead Animal	Fyke Net
	CV spring-run Chinook salmon	163	Observe/Sample Tissue Dead Animal	Fyke Net
	CV steelhead	13	Observe/Sample Tissue Dead Animal	Fyke Net
	Southern DPS Green sturgeon	13	Observe/Sample Tissue Dead Animal	Fyke Net
Sycamore Mutual Water Corporation (previously named Davis Ranches Site 2) Colusa County Sacramento River Mile 132.5	SR winter-run Chinook salmon	673	Observe/Sample Tissue Dead Animal	Fyke Net
	CV spring-run Chinook salmon	346	Observe/Sample Tissue Dead Animal	Fyke Net
	CV steelhead	57	Observe/Sample Tissue Dead Animal	Fyke Net
	Southern DPS Green sturgeon	56	Observe/Sample Tissue Dead Animal	Fyke Net

III. DESCRIPTION AND STATUS OF THE SPECIES AND CRITICAL HABITAT

A. Species and Critical Habitat Listing Status

This BO analyzes the effects of Permit 14077 on the salmon ESUs and steelhead and green sturgeon DPS below:

- SR winter-run Chinook salmon ESU, listed as endangered under the ESA (70 FR 37160)
- CV spring-run Chinook salmon ESU, listed as endangered under the ESA (70 FR 37160)
- CV steelhead DPS, listed as threatened under the ESA (71 FR 834)
- Southern DPS green sturgeon, listed as threatened under the ESA (71 FR 17757)

The action area for Permit 14077 is within the designated critical habitats listed below:

- SR winter-run Chinook salmon critical habitat (58 FR 33212)
- CV spring-run Chinook salmon critical habitat (70 FR 52488)
- CV steelhead critical habitat (70 FR 52488)
- Southern DPS green sturgeon designated critical habitat; proposed rule (73 FR 52084)

The proposed research activities will only result in temporary minor disturbances to creek substrate and creek banks from walking, netting, and installing fyke net traps. These minor disturbances are unlikely to adversely affect designated critical habitat and therefore will not result in any changes or effects to the role or function of designated critical habitat for ESA-listed salmonid conservation. Designated critical habitat is not considered further in this biological opinion.

B. Species Life History

1. Chinook Salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing. However, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both winter-run and spring-run tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. Fall-run enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

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

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

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

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

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. Fry typically range from 25 mm to 40 mm at this stage. Upon emergence, fry swim or are displaced downstream (Healey 1991). The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and other micro-crustaceans. Some fry may take up residence in their natal stream for several weeks to a year or more, while others are displaced downstream by the stream's current. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).
Fry then seek nearshore habitats containing riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting. The benefits of shallow water habitats for salmonid rearing have been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001).

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

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

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (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 54°F to 57°F. In Suisun and San Pablo Bays, water temperatures reach 54°F by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70°F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicate that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2001). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon), MacFarlane and Norton (2001) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

a. SR Winter-run Chinook Salmon

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

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

October (Fisher 1994). Emigration of juvenile winter-run past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile winter-run occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57) [USFWS 2001, 2001a]. The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run juveniles remain in the Delta until they reach a fork length of approximately 118 millimeters (mm) and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continue through May (Fisher 1994, Myers *et al.* 1998).

b. CV Spring-run Chinook Salmon

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

Spring-run exhibit a stream-type life history. Adults enter freshwater in the spring, hold over the summer, spawn in the fall, and the juveniles typically spend a year or more in freshwater before emigrating. Adult spring-run leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (table 4-4; Yoshiyama *et al.* 1998, Moyle 2002). Lindley *et al.* (2007) indicate adult spring-run tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al.* 1998). Reclamation reports that spring-run holding in upper watershed locations prefer water temperatures below 60°F, although salmon can tolerate temperatures up to 65°F before they experience an increased susceptibility to disease. Spring-run spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run that enter the Sacramento River basin to spawn are 3 years old (Fisher 1994).

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

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

2. <u>Steelhead</u>

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

a. CV Steelhead

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

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

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

Survival to emergence of steelhead embryos is inversely related to the proportion of fine sediment in the spawning gravels. However, steelhead are slightly more tolerant than other salmonids, with significant reductions in survival when fine materials of less than one centimeter in diameter comprise 20 to 25 percent of the substrate. Fry typically emerge from the gravel two to three weeks after hatching.

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

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

4. Green sturgeon

In North America, spawning populations of green sturgeon are currently found in only three river systems: the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Moser and Lindley 2006). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Lindley *et al.* (2008) reported that green sturgeon make seasonal migratory movements along the west coast of North America, overwintering north of Vancouver Island and south of Cape Spencer, Alaska. Southern DPS of green sturgeon have been detected in these seasonal aggregations.

a. Southern DPS of Green Sturgeon

The Southern DPS of green sturgeon includes all green sturgeon populations south of the Eel River, with the only known spawning population being in the Sacramento River. The life cycle of Southern DPS of green sturgeon can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age; (2) larvae and post-larvae less than 10 months of age; (3) juveniles less than or equal to 3 years of age; and (4) coastal migrant females between 3 and 13 years, and males between 3 and 9 years of age (Nakamoto *et al.* 1995).

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

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

Spawning in the San Joaquin River system has not been recorded historically or observed recently, but alterations of the San Joaquin River and its tributaries (Stanislaus, Tuolumne, and Merced Rivers) occurred early in the European settlement of the region. During the latter half of the 1800s, impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for approximately a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. Both white and green sturgeon likely utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of spring-run and CV steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Information regarding the migration and habitat use of the Southern DPS of green sturgeon has recently emerged. Lindley (2006) presented preliminary results of large-scale green sturgeon migration studies, and verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia River estuary. This information also agrees with the results of green sturgeon tagging studies (CDFG 2002), where CDFG tagged a total of 233 green sturgeon in the San Pablo Bay estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of the Oregon and Washington coasts. Eight of the 12 recoveries were in the Columbia River estuary (CDFG 2002).

Kelly *et al.* (2007) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature, and Kelly *et al.* (2007) surmised that they are related to resource availability and foraging behavior. Recent acoustical tagging studies on the Rogue River (Erickson *et al.* 2002) have shown that adult green sturgeon will hold for as much as 6 months in more than 5 meters depth, low gradient reaches or off channel sloughs or coves of the river during summer months when water temperatures were between 15 degrees-Celsius (°C) and 23°C. When ambient temperatures in the river dropped in autumn and early winter (less than 10°C) and flows increased, fish moved downstream and into the ocean. Erickson *et al.* (2002) surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Similar behavior is exhibited by adult green sturgeon on the Sacramento River based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205). The documented presence of adults in the Sacramento River during the spring and summer months, and the presence of larval green sturgeon in late summer in the lower Sacramento River, indicate spawning occurrence, and it appears adult green sturgeon could utilize a variety of freshwater and brackish habitats for up to 9 months of the year.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966). Adult green sturgeon caught in Washington state waters have also been found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992). Adults of the Southern DPS of green sturgeon begin their upstream spawning migrations into the San Francisco Bay by at least March, reach Knights Landing during April, and spawn between March and July. Peak spawning is believed to occur between April and June and thought to occur in deep turbulent pools (Adams *et al.* 2002). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFG (2002) indicated that the Southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City, possibly to Keswick Dam. Adult green sturgeon are gonochoristic (sex genetically fixed), oviparous and iteroparous. They are believed to reach sexual maturity only after several years of growth (10 to 15 years), and spawn every 3 to 5 years, based on sympatric white sturgeon sexual maturity (CDFG 2002). Adult female green sturgeon produce between 60,000 and 140,000 eggs each reproductive cycle, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon. Spawning females broadcast their eggs over suitable substrate, which is thought to consist of predominately large cobbles, but can range from clean sand to bedrock (USFWS 2002).

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

Green sturgeon larvae do not exhibit the initial pelagic swim–up behavior characteristic of other *Acipenseridae*. The are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al.* 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.* (2005) indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8°C, downstream migrational behavior diminished and holding behavior increased. These data suggest that 9- to 10-month old fish hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. During these early life stages, larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolmoides*) have been recorded on the Rogue River preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005).

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

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

C. Species Population Trends

1. SR Winter-run Chinook Salmon

Historical winter-run population estimates, which included males and females, were as high as near 100,000 fish in the 1960s, but declined to under 200 fish in the 1990s (Good *et al.* 2005). In recent years, the carcass survey population estimates of winter-run included a high of 17,334 in 2006, followed by a precipitous decline in 2007 that continued in 2008.

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

a. Viable Salmonid Population Summary

Abundance. Redd and carcass surveys, and fish counts suggest that the abundance of winter-run Chinook salmon is increasing. The depressed 2007 abundance estimate is an exception to this trend and may represent a new cycle of poor ocean productivity. Population growth is estimated to be positive in the short-term trend at 0.26; however, the long-term trend is negative, averaging -0.14. Recent winter-run Chinook salmon abundance represents only 3 percent of the maximum post-1967, 5-year geometric mean, and is not yet well established (Good *et al.* 2005).

Productivity. ESU productivity has been positive over the short term, and adult escapement and juvenile production have been increasing annually (Good *et al.* 2005). The long-term trend for the ESU remains negative, as it consists of only one population that is subject to possible impacts from environmental and artificial conditions. The most recent CRR estimate suggests a reduction in productivity for the 1998-2001 cohorts.

Spatial Structure. The greatest risk factor for winter-run Chinook salmon lies with their spatial structure (Good *et al.* 2005). The remnant population cannot access historical winter-run habitat and must be artificially maintained in the Sacramento River by a regulated cold water pool from Shasta Dam. Winter-run Chinook salmon require cold water temperatures in summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek remains the most feasible opportunity for the ESU to expand its spatial structure, which currently is limited to the upper 25-mile reach below Shasta Dam.

Diversity. The second highest risk factor for the Sacramento River winter-run Chinook salmon ESU has been the detrimental effects on its diversity (Good *et al.* 2005). The present winter-run population has resulted from the introgression of several stocks that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam; there may have been several others within the recent past (Good *et al.* 2005). Concerns of hatchery genetic influence are also increasing and may increase the extinction risk of the winter-run ESU population.

2. <u>CV Spring-run Chinook Salmon</u>

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

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

The spring-run ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the spring-run ESU as a whole because these streams contain the primary independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of spring-run remains well below estimates of historic abundance. Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of columnaris disease (*Flexibacter columnaris*) and ichthyophthiriasis (*Ichthyophthirius multifiis*) in the adult spring-run over-summering in Butte Creek. In 2002, this contributed to the pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run in Butte Creek.

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

a. Viable Salmonid Population Summary

Abundance. The Central Valley spring-run Chinook salmon ESU has experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good *et al.* 2005). There has been more opportunistic utilization of migration-dependent streams overall. The FRH spring-run stock has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program.

Productivity. The 5-year geometric mean for the extant Butte, Deer, and Mill Creek spring-run populations ranges from 491 to 4,513 fish (Good *et al.* 2005), indicating increasing productivity over the short-term and projected as likely to continue (Good *et al.* 2005). The productivity of the Feather River and Yuba River populations and contribution to the Central Valley spring-run ESU currently is unknown.

Spatial Structure. Spring-run Chinook salmon presence has been reported more frequently in several upper Central Valley creeks, but the sustainability of these runs is unknown. Butte Creek spring-run cohorts have recently utilized all available habitat in the creek; the population cannot expand further and it is unknown if individuals have opportunistically migrated to other systems. The spatial structure of the spring-run ESU has been reduced with the extirpation of all San Joaquin River basin spring-run populations.

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

1. CV Steelhead

River have declined substantially (figure 4-3). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

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

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

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

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

a. Viable Salmonid Population Summary

Abundance. All indications are that naturally spawned Central Valley steelhead have continued to decrease in abundance and in the proportion of the steelhead population compared to hatchery fish over the past 25 years (Good *et al.* 2005); the long-term trend remains negative. There has been little steelhead population monitoring despite 100 percent marking of hatchery steelhead since 1998. Hatchery production and returns are dominant over natural fish and include significant numbers of out-of-basin, non-DPS-origin steelhead stocks.

Productivity. An estimated 100,000 to 300,000 natural juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good *et al.* 2005). Concurrently, one million in-DPS hatchery steelhead smolts and another half million out-of-DPS hatchery steelhead smolts are released annually in the Central Valley. The estimated ratio of non-clipped to clipped steelhead has decreased from 0.3 percent to less than 0.1 percent, with a net decrease to one-third of wild female spawners from 1998 to 2000 (Good *et al.* 2005).

Spatial Structure. Steelhead appear to be well-distributed where found throughout the Central Valley (Good *et al.* 2005). Until recently, there was very little documented evidence of steelhead due to the lack of monitoring efforts. Since 2000, steelhead have been confirmed in the Stanislaus and Calaveras Rivers.

Diversity. Analysis of natural-and hatchery-steelhead stocks in the Central Valley reveal genetic structure remaining in the ESU (Nielsen *et al.* 2003). There appears to be a great amount of gene flow among upper Sacramento River basin stocks, due to the post-dam, lower basin distribution of steelhead and management of hatchery stocks. Recent reductions in natural population sizes have created genetic bottlenecks in several Central Valley steelhead stocks (Good *et al.* 2005; Nielsen *et al.* 2003). The out-of-basin steelhead stocks of the Nimbus and the Mokelumne River Hatcheries are not included in the Central Valley steelhead DPS.

4. Southern DPS of Green Sturgeon

Population abundance information concerning the Southern DPS of green sturgeon is described in the NMFS status reviews (Good *et al.* 2005). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile Southern DPS of green sturgeon per year (Adams *et al.* 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Collection Facility between 1968 and 2006 (table 4-9, figures 4-5 and 4-6). The average number of Southern DPS of green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47. For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32. In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of green sturgeon is declining. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (April 5, 2005). Catches of sub-adult and adult Northern and Southern DPS of green sturgeon, primarily in San Pablo Bay, by the IEP ranged from 1 to 212 green sturgeon per year between 1996 and 2004 (212 occurred in 2001). However, the portion of the Southern DPS of green sturgeon is unknown. Recent spawning population estimates using sibling-based genetics by Israel (2006b) indicate spawning populations of 32 spawners in 2002, 64 in 2003, 44 in 2004, 92 in 2005, and 124 in 2006 above RBDD (with an average of 71).

Based on the length and estimated age of post-larvae captured at RBDD (approximately 2 weeks of age) and GCID (downstream, approximately 3 weeks of age), it appears the majority of Southern DPS of green sturgeon are spawning above RBDD. Note that there are many assumptions with this interpretation (*i.e.*, equal sampling efficiency and distribution of post-larvae across channels) and this information should be considered cautiously.

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

a. Viable Population Summary

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

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

Spatial Structure. The spatial structure of the Southern DPS of green sturgeon is broad (Central Valley watersheds of California, eastern Pacific Ocean, Columbia River system). Its presence has also been reported in the Sacramento and Feather rivers and the Delta. By these accounts, it appears that the Southern DPS population utilizes its historical spatial structure to some extent; however, anthropomorphic impacts and loss of habitat throughout its spatial structure have likely resulted in a reduced spatial structure.

Diversity. The Southern DPS of green sturgeon is comprised of a single population that spawns in the Sacramento River above Red Bluff Diversion Dam. The Southern green sturgeon population is genetically distinct from the Northern green sturgeon population, and it represents a distinct population segment of North American green sturgeon. The genetic diversity of the Southern DPS of green sturgeon is not well understood at this time and warrants further investigation.

B. Status of the Species in the Action Area

1. SR Winter-run Chinook Salmon

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

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

Lindley *et al.* (2007) also states that the winter-run ESU fails the "representation and redundancy rule" because it has only one population, and that population spawns outside of the ecoregion in which it evolved. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley *et al.* 2007). Based on the above descriptions of the population viability parameters, NMFS believe that the winter-run ESU is currently not viable.

2. <u>CV Spring-run Chinook Salmon</u>

Lindley *et al.* (2004) identified 26 historical populations within the spring-run ESU; 19 were independent populations, and 7 were dependent populations. There is an additional extant population in the Feather River below Oroville Dam. This population became restricted to the lower reaches of the Feather River following the construction of Oroville Dam and is essentially maintained by the Feather River Hatchery. Of the 19 independent populations of spring-run that occurred historically, only three independent populations remain, in Deer, Mill, and Butte Creeks. Dependent populations of spring-run continue to occur in Battle, Big Chico, Antelope, Clear, Thomes, and Beegum Creeks, and the Yuba River, but rely on the three extant independent populations for their continued survival.

Central Valley spring-run declined drastically in the mid to late 1980s before stabilizing at very low levels in the early to mid 1990s. Since the mid 1990s, abundance has increased but continues to display wide ranges in fluctuation with some key populations (Mill and Deer Creek) reaching very low numbers. Abundance is generally dominated by the Butte Creek population. Other independent and dependent populations are smaller. The cohort replacement rate behaved similarly. The 5-year moving average cohort replacement rate, however, has remained above 1.0 since 1993.

Cohort replacement rates are indications of whether a cohort is replacing itself in the next generation. As mentioned previously, the spring-run cohort replacement rate since the late 1990s has fluctuated, and does not appear to have a pattern. Since the cohort replacement rate is a reflection of population growth rate, there does not appear to be an increasing or decreasing trend. The 5-year moving average of population estimate, however, shows an increasing trend since the mid 1990s.

3. <u>CV Steelhead</u>

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

Lindley *et al.* (2006) identified 81 historical and independent populations within the CV steelhead DPS. These populations form 8 clusters, or diversity groups, based on the similarity of the habitats they occupied. About 80 percent of the habitat that was historically available to CV steelhead is now behind impassable dams, and 38 percent of the populations have lost all of their habitats. CV steelhead may have been extirpated from their entire historical range in the San Joaquin Valley and most of the larger basins of the Sacramento River. Now, only 2 clusters contain watersheds with habitat that remains accessible to CV steelhead (Lindley *et al.* 2006). Although much of the habitat has been blocked by impassable dams, or degraded, small populations of CV steelhead are still found throughout habitat available in the Sacramento River and many of the tributaries, and some of the tributaries to the San Joaquin River.

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

4. Southern DPS of Green Sturgeon

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Due to substantial habitat loss, the decline in abundance observed at the water pumping facilities, and the occurrence of only one breeding population, the Southern DPS of North American green sturgeon continues to remain at a moderate to high risk of extinction.

D. Factors Affecting the Species in the Action Area

The Central Valley Research Programmatic Opinion (2003) describes the ongoing activities and historical events that have affected listed salmonids in the Central Valley. Water diversion operations, dredging and mining operations, and hatchery operations are among the activities that have the largest potential impacts to the populations of listed salmonids. For example, the Central Valley and State Water Projects alter historical flow volume and patterns that affect the timing of juvenile outmigration and direction of adult upstream migration of salmonids. The GCID Hamilton City Pumping Plants and similar water diversions affect the timing and behavior of fish passing through the Sacramento River mainstem, as well as increase the likelihood of fish predation on migrating salmonids by making the river environment more suitable to non-native invasive species. Dredging and sand mining projects affect habitat quality by degrading water quality, destroying vegetative cover, and temporarily disturbing fish. Finally, the large numbers of salmonids released from hatcheries can pose a threat to wild salmonids through genetic impacts such as inbreeding, and the increased competition, predation, and fishing pressure that may result from hatchery production. In addition to the factors mentioned above, urbanization and poor land-use practices also are among the major factors affecting these species and the habitats that support them (California Resource Agency 1989).

The watersheds contributing to the Sacramento River as well as to the Estuary and Delta are highly manipulated and contain substantially different water quality and outflow patterns than they did historically. The magnitude and duration of base and peak flows have been altered affecting the temporal flow patterns the North American green sturgeon has experienced over evolutionary time. These changes in outflow patterns and magnitude and the effects of water diversions such as the Central Valley and State Water Projects are thought to be a principal threat to ESA-listed species in the action area. CDFG (2002) found significant correlations between mean daily flow during the spring and white sturgeon year class strength, as well as spring outflow and annual production of white sturgeon indicating the importance of outflow for sturgeon production (these studies primarily involve the more abundant white sturgeon; however, the effects on Southern DPS of the North American green sturgeon are thought to be similar). Pollution within the Sacramento River increased substantially in the mid-1970s when application of rice pesticides increased (USFWS 1995). Increased urban and commercial land use along the mainstem of the Sacramento River resulted in additional water withdrawals and increased effluent containing pesticides, heavy metals, and organics in high levels (Central Valley Regional Water Quality Control Board 1998). Sturgeon may accumulate polychlorinated biphenyls and selenium, substances known to be detrimental to embryonic development. Concerns also exist regarding the impacts of exotic species on the diet and predation of North American green sturgeon. The exotic overbite clam *Potamocorbula amurensis*, introduced in 1988, has become the most common food of white sturgeon and was found in the only North American green sturgeon so far examined by CDFG (2002). The overbite clam, which may be a North American green sturgeon prey item, is known to bioaccumulate selenium, a toxic metal (CDFG 2002). North American green sturgeon also may experience predation by introduced species including striped bass. Sturgeons have high vulnerability to fisheries and the trophy status of large white sturgeon makes these fishes a high priority for enforcement to protect against poaching (CDFG 2002).

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 1996, 1998). Specific diseases such as bacterial kidney disease, *Ceratomyxosis shasta* (*C-shasta*), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996, 1998). Salmonids may contract diseases that are spread through the water column (*i.e.*, waterborne pathogens) as well as through interbreeding with infected hatchery fish.

Accelerated predation also may be a factor in the decline of Central Valley Chinook salmon, and to a lesser degree Central Valley 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). Sacramento pikeminnow and striped bass, of the aquatic fish predators, have the greatest potential to negatively affect the abundance of juvenile salmonids. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Catfish (order *Siluriformes*) also have the potential to significantly affect the abundance of juvenile salmonids. Prickly (*Cottus asper*) and riffle (*C. gulosus*) sculpins, and larger salmonids also prey on juvenile salmonids (Hunter 1959; Patten 1962, 1971a, 1971b).

Avian predation on fish contributes to the loss of migrating juvenile salmonids in the constraining natural and artificial production. Fish-eating birds that occur in the 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 may be an important agent of mortality to salmonids in the Central Valley. River otters (*Lutra Canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), western spotted skunk (*Spilogale gracilis*) are common predators. Other mammals that take salmonid include: American black bear (*Ursus americanus*), badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon.

1. Fish Entrainment by Unscreened Water Diversions

In 1953, the California Department of Fish and Game (CDFG) initiated surveys in Central Valley water diversions to assess fish loss regarding Chinook salmon, and correlated salmon impacts from water diversions with salmon specie migration. Dependent on diversion size and location, pumping season, and salmon migration life history, individual diversions were responsible for the loss of hundreds to thousands of fish; cumulatively, non-screened diversions caused significant impacts to migrating salmonids. Hallock and Van Woert (1959) documented high mortality of juvenile and adult salmonids and other fish, from the more than 900 non-screened irrigation (majority), industrial, and municipal water supply diversions documented in the Sacramento and San Joaquin rivers at that time. Both studies concluded that the screening of water diversions was necessary to protect anadromous fish species.

Herren and Kawasaki (2001) catalogued 2,209 water diversion structures in the Delta area, of which only one percent was screened. They found that only six percent of the 424 diversions catalogued on the Sacramento River between Keswick Dam and the I Street Bridge were screened. The effects of such diversions are largely unknown but thought to be substantial based on the number of diversions, total amount of water diverted, and the susceptibility of North American green sturgeon young to them (70 FR 17386). Increased water temperature as a result of decreased outflow, reduced riparian shading, and thermal inputs from municipal, industrial, and agricultural return water in the Sacramento River also are a threat.

NMFS has estimated that up to 10,000,000 anadromous salmonid fry are lost annually to diversions from the Sacramento River alone. Currently, there are approximately 750 unscreened agricultural diversions in the Sacramento River system, 950 in the San Joaquin River system, 2,500 in the Sacramento-San Joaquin Delta, and 360 in the Suisun Marsh basin. Since 1994, the AFSP has assisted irrigation districts and water companies with screening at 23 diversions ranging from 17 cfs to 960 cfs, cumulatively screening over 4,200 cfs.

IV. ENVIRONMENTAL BASELINE

The environmental baseline is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat, and the ecosystem in the action area. The action area for Permit 14077 includes three site-specific intake diversions and associated outflow canals located along a 36-mile reach of the Sacramento River, as a result, the current status of the species, its habitat, and the ecosystem in the action area are consistent with the ESU/DPS-wide descriptions of species population trends described in section *IV. Description and Status of the Species and Critical Habitat.* A general analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat, and the ecosystem is also described in section *IV. Description and Status of the Species and Critical Habitat*, subsection *D. Factors Responsible for Salmonid Stock Declines.*

V. EFFECTS OF THE PROPOSED ACTION

The purpose of this section is to identify effects on listed Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the threatened Southern DPS of North American green sturgeon associated with Permit 14077.

The effects of the proposed research activities on listed species are expected to be limited because data will be collected on captured fish which will have already been diverted out of the natural habitat through irrigation pumps. It is expected the majority of listed species taken from their natural habitat through the irrigation pumps will be dead or moribund from lethal injury and stress experienced in pressurized pipes and warm water. However, it is anticipated that some component of entrained fish may initially survive and potentially may be captured alive during fyke net sampling for the proposed study. NRSI estimates 1,307 juvenile winter-run Chinook Salmon, 1,466 juvenile spring-run Chinook Salmon, 155 Central Valley steelhead, and 184 juvenile North American green sturgeons will be unintentionally taken annually through the diversion pumps.

The adverse effects of Permit 14077 will be primarily associated with the non-lethal take of juvenile ESA-listed salmonids which may result in unintentional stress and injury to a number of live fish that are handled. The permit does not authorize any intentional lethal take of ESA-listed salmonids, however, some unintentional mortality of juvenile and adult ESA-listed salmonids may occur. NMFS expects that unintentional mortality to juvenile ESA-listed salmonids will be far less than that authorized based on the procedures and precautions followed by NRSI.

The effects of capture and handling on ESA-listed salmonids that will occur under Permit 14077, and the specific measures that NRSI will be performing to reduce stress, injury, and unintentional mortality to ESA-listed salmonids are discussed below.

A. Adverse Effects to Juvenile ESA-listed Salmonids

1. Direct Observation

Direct observation is the least intrusive method for determining presence/absence of a fish species and estimating their relative abundance. A cautious observer can effectively obtain data without disrupting the normal behavior of a fish.

There is no evidence that fish are injured by direct observations. Observations made by State and Federal fisheries biologists counting Chinook salmon and steelhead in Central Valley streams indicate that direct observation does not cause any behavioral effects that prevent salmon and steelhead from successfully holding, spawning, or feeding (Paul Ward, CDFG, personal communication 2002, Sarah Giovannetti, USFWS, personal communication 2003, Jeffrey Jahn, NMFS, personal communication, 2005).

2. Capture by Fyke Net Trap

Fish caught in fyke net traps can experience adverse effects including stress and injury from overcrowding, debris buildup, and in-trap predation. NRSI personnel will practice measures to minimize injury and mortality to juvenile ESA-listed salmonids that are captured by fyke net trap. Traps will be monitored at least once daily. Fish will be removed and data collected during each monitoring period; live fish will be returned to the river. Debris, which can kill or injure fish, will be immediately removed from the traps. Also, traps will be removed from the diversion outflow or closed during high stream flows (flood conditions) to avoid causing death or injury to fish that are trapped inside the trap box.

No adults are expected to be entrained by small water diversion structures at any of the three study location sites off the Sacramento River. NRSI will allow adult salmonids to pass upstream unimpeded in the mainstem migration corridor while carrying out project monitoring activities. NRSI will also monitor the traps closely to ensure that the upstream bypass is functioning and adult salmonids which are returning to sea are successfully moving downstream past the traps.

3. General Handling

The primary adverse effects to the majority of juvenile ESA-listed salmonids associated with Permit 14077 will result from the general handling of fish. Handling fish causes them stress, though they typically recover fairly rapidly from the process and, therefore, the overall effects of the handling are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the original habitat and the container in which the fish are held), low dissolved oxygen, being held out of water, and physical trauma (Kelsch and Shields 1996). Stress to salmonids increases rapidly from handling if the water temperature exceeds 60 degrees-Fahrenheit (° F) or if dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process. In addition, when fish are handled by samplers to obtain measurements and other data, it is not uncommon for fish to be dropped on the ground by the handlers because the fish are not sedated enough or properly restrained. This can result in internal injuries, especially in females with developing ovaries (Stickney 1983). An injured fish is more susceptible to developing diseases, which can lead to delayed mortality. Some of the injuries which can lead to disease are the loss of mucus, loss of scales, damage to integument, and internal damage (Stickney 1983, Kelsch and Shields 1996). The condition of fish which will be "rescued" from entrainment is expected to be poor, due to experiencing high pressure flow through the diversion structure, and an immediate increase in water temperature which will likely outside of viability range. Chances of fish survival may be influenced by the condition of the animal compounded by the amount of handling during rescue. However, NMFS believes that all entrained fish in the study can be discounted from the population if left in the diversion canals, and there may be some survival among fish released in the Sacramento River

To reduce the possibility of damage to juvenile ESA-listed salmonids from handling, NMFS has reviewed the credentials of all primary investigators working under Permit 14077. NMFS has determined that these individuals have presented sufficient evidence of experience working with salmonids to safely handle juvenile Chinook salmon, steelhead and green sturgeon. NMFS expects the highest standard of care during capture and handling procedures will occur. Permit 14077 also contains terms and conditions that NMFS believes are necessary and appropriate to minimize stress, injury, and unintentional mortality to ESA-listed salmonids.

C. Beneficial Effects

The research activities proposed by NRSI will address the lack of data on fish entrainment of ESA-listed salmonids and green sturgeon from small (under 250 cfs in size), unscreened water diversion structures in the Central Valley, California. The project will provide two years of fish loss data, including species abundance, condition and distribution of SR winter-run Chinook at three diversion sites prior to screen installation at the end of the second irrigation study season. This information will inform the AFSP on fish entrainment potential at unscreened diversion sites and the decision-making process for prioritizing those diversion sites requiring screening. NMFS believes that the project will be instrumental in contributing towards the recovery of ESA-listed salmonids and green sturgeon, and contribute to the general knowledge on the dynamics of fish entrainment and river hydrology. Identifying and providing efficient fish protection and screening of diversions, especially at those sites with the greatest potential to entrain fish, will further ensure that riverine water diversions do not impair improvements to fishery production resulting from habitat restoration and other fishery conservation programs. All research findings will be used by NMFS and AFSP to benefit ESA-listed salmonids and green sturgeon through improved conservation and management practices.

VI. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR § 402.02 as "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." Future Federal actions, including the ongoing operation of dams, hatcheries, fisheries, water withdrawals, and land management activities will be reviewed through separate section 7 consultation processes and are not considered here. Non-Federal actions that require authorization under section 10 of the ESA, and that are not included within the scope of this consultation, will be evaluated in separate section 7 consultations and are not considered here. Based on the information available, NMFS does not expect any cumulative effects beyond the effects of ongoing actions identified above in the *Description and Status of the Species and Critical Habitat.*

VII. INTEGRATION AND SYNTHESIS

Despite extensive efforts to reduce injury and mortality to ESA-listed salmonids, unintentional lethal take of juvenile ESA-listed salmonids or green sturgeon may potentially occur as a result of research activities conducted by NRSI. The actual amount of unintentional lethal take of juvenile ESA-listed salmonids and green sturgeon that will occur as a result of research activities conducted under Permit 14077 is likely far less than the amount authorized. NRSI is experienced in the capture, handling and sampling of fish and NMFS expects any unintentional lethal take of ESA-listed salmonids and green sturgeon will not exceed the authorized take of captured ESA-listed salmonids. Additionally, prior to all research activities, NRSI personnel will make observations and carefully consider the available data on site specific ESA-listed salmonids and green sturgeon populations and habitat to determine the research activities and level of potential lethal take that is appropriate at each individual research location. NRSI personnel will use their best judgment to ensure that research activities will not have the potential to harm affected ESA-listed salmonids and green sturgeon. NMFS has determined that the effects of lethal take and the factors that minimize the probability that lethal take from the research study will not affect ESA-listed salmonids populations on the ESU/DPS or watershed scale as it is expected that 100 percent mortality will be observed among fishes collected at the outfalls of the sampled water diversion facilities. All fish sampled are expected to be dead or dying when collected, due to adverse effects from passing through irrigation pumps and lethal stress in pressurized pipes and warm water. Once diverted into the irrigation canals or pipes, all fish can be expected to perish.

The condition of a live fish entrained by a water diversion pump would be physically challenged and disoriented, at best, and at worse, moribund or dead. The capture and handling of entrained fish will follow best management protocols, which may allow the best physical candidates to survive. Any additional stress brought on by project actions may exceed an animal's physiological tolerance and lead to an immediate demise; however, the fish would eventually perish in the water distribution system unless rescued and may therefore benefit from this action.

VIII. CONCLUSION

After reviewing the best available scientific and commercial data regarding the current status of the ESA-listed endangered and threatened salmonids, the environmental baseline for the action area, the effects of the proposed action, and cumulative effects, it is the biological opinion of NMFS that the issuance of Permit 14077, as proposed, is not likely to jeopardize the continued existence of SR winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, or Southern DPS of green sturgeon, and is not likely to destroy or adversely modify designated critical habitat.

IX. INCIDENTAL TAKE STATEMENT

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

The issuance of Permit 14077 authorizes intentional take of ESA-listed juvenile salmonids and green sturgeon associated with the proposed research activities. Incidental take of endangered or threatened Chinook salmon, steelhead, or green sturgeon adults is not anticipated, therefore, none is authorized by this biological opinion.

X. REINITIATION OF CONSULTATION

This concludes formal consultation on the issuance of Permit 14077. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take specified in the incidental take statement is exceeded, (2) new information reveals effects of the action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered, (3) the identified action is subsequently modified in a manner that causes an effect to ESA-listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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