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

JUL 02 2008

In response refer to:
2007/07158

Francis C. Piccola
Chief, Planning Division
U.S. Army Engineer District, Sacramento
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Piccola:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the Programmatic Biological Assessment for the remaining 24,000 linear feet of authority under the Sacramento River Bank Protection Project (SRBPP), Phase II, and the effects of this project on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), and their designated critical habitat in accordance with section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*). This biological opinion also includes a section 7(a)(2) analysis of project related effects on the threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*).

Your request for formal consultation was received on November 2, 2007. In general, the levee work would involve placing rock revetment with integrated fish habitat design features over approximately 24,000 linear feet of river bank throughout the Sacramento River Flood Control Project. Four bank repair designs will be implemented, depending on river region, and site-specific erosion and hydraulic conditions. The bank protection projects will repair bank and levee erosion and will replace and restore the riparian and shaded riverine aquatic habitat.

This biological opinion is based on information provided in the October, 2007, final biological assessment. The biological opinion also is based on design drawings for all projects, information provided at Interagency Work Group meetings, and site visits and discussions held with representatives of the U.S. Army Corps of Engineers (Corps), NMFS, the U.S. Fish and Wildlife Service, the California Department of Fish and Game, and Ayres and Associates. A complete administrative record of this consultation is on file at the NMFS Sacramento Field Office.

Based on the best available scientific and commercial information, the biological opinion concludes that implementation of the remaining projects under Phase II of the SRBPP are not likely to jeopardize the above species or adversely modify designated critical habitat. Because this is a programmatic consultation, the biological opinion does not review the effects of any specific project proposed for implementation by the Corps. As such, NMFS has included an incidental take statement and reasonable and prudent measures with non-discretionary terms and conditions that are not project-specific, but are general in nature. The reasonable and prudent measures and terms and conditions are based on anticipated reach-scale effects, and are necessary and appropriate to minimize incidental take associated with future project actions. NMFS will append this biological opinion with separate project-level analyses and incidental take statements for future actions carried our under Phase II of the SRBPP, as necessary.

Also enclosed are draft EFH Conservation Recommendations for Pacific salmon as required by the Magnuson-Stevens Fishery Conservation and Management (MSA) as amended (16 U.S.C. 1801 *et seq.;* Enclosure 2). This document concludes that the programmatic implementation of the remaining 24,000 linear feet of authority under the SRBPP, Phase II will adversely affect the EFH of Pacific Salmon in the action area and includes recommended measures that, if implemented, will minimize or avoid these adverse effects.

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

If you have any questions regarding this correspondence please contact Mr. Howard Brown in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95814. Mr. Brown may be reached by telephone at (916) 930-3608 or by Fax at (916) 930-3629.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file: 151422SWR2007SA00492:HLB
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Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Programmatic Consultation for Phase II of the Sacramento River Bank Protection Project
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2007SA00492
DATE ISSUED:	JUL 02 2008

I. CONSULTATION HISTORY

On Sept 27, 2001, NOAA's National Marine Fisheries Service (NMFS) issued a biological opinion (NMFS 2001) to the U.S. Army Corps of Engineers (Corps) assessing the effects of the Sacramento River Bank Protection Project (SRBPP) Contracts 42E and 42F on Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and their designated critical habitat. The SRBPP biological opinion required the Corps to initiate programmatic consultation for the remainder of Phase II. The biological opinion also required the Corps to develop a comprehensive aquatic monitoring plan, a standardized approach for evaluating project effects on Federally listed fish species, and an inventory and database of nearstream shade, in-stream woody material (IWM) and riprap (*i.e.*, the riprap database) within the Sacramento River Flood Control Project (SRFCP). The biological opinion required the Corps to charter and chair an interagency work group (IWG) to provide technical, biological, and regulatory assistance and approval related to the development of these products.

In 2002, the Corps chartered the IWG and began holding monthly meetings to prioritize and initiate the requirements of the biological opinion for SRBPP Contracts 42E and 42F.

In 2003, the Corps, with the assistance of the U.S. Fish and Wildlife Service's (USFWS) Sacramento Field Office, completed the riprap database. The database includes an interface with digital photo-enhanced GIS software. The purpose of the database is to evaluate the environmental baseline and potential cumulative effects of bank protection projects within the SRFCP.

In August 2004, Corps issued the final Standard Assessment Methodology (SAM) for the SRBPP (Corps 2004) pursuant to the requirements of the NMFS (2001) biological opinion for Contracts 42E and 42F. The SAM was developed to address specific habitat assessment and regulatory needs for ongoing and future bank protection actions in the SRBPP action area. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches, and to provide a tool that could systematically evaluate the possible effects, impacts, and compensation requirements of bank protection projects based on the needs of listed fish species, at both programmatic and site scales.

On January 24, 2006, representatives of USFWS, NMFS, California Department of Fish and Game (CDFG), CDWR, the Sacramento Area Flood Control Agency (SAFCA), and Stillwater Sciences met to discuss the Corps proposed approach for developing a programmatic biological assessment.

On February 24, 2006, Governor Arnold Schwarzenegger issued an emergency proclamation for California's levee system. The proclamation focused on the imminent threat of 24 critical levee erosion sites located in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties, but stated that other critical sites also shall be repaired. Some of these repairs were constructed under the SRBPP, while others, which were undertaken by CDWR, employed the construction and habitat modeling methodologies used by the SRBPP, and are included in the consultation history because they have either influenced the bank repair concepts or habitat modeling described in this biological opinion, or have repaired sites that would have otherwise been repaired under the authority of the SRBPP. A brief consultation history of emergency repairs is listed below in bullets:

- On 6 March 2006, Governor Schwarzenegger issued Executive Order S-01-06, ordering CDWR to develop a plan for repairing the critical levee erosion sites.

- On May 1, NMFS, the Corps, USFWS, and CDWR signed a Memorandum of Understanding (MOU) to expedite the environmental review process so that the proposed critical levee sites could be repaired during the summer of 2006. The MOU included a critical path timeline for completing project designs and environmental permitting.

- On June 21, 2006, NMFS issued a biological opinion for the construction of 29 critical levee repair projects.

- On September 15, 2006, the Corps requested an amendment to the June 21, 2006, biological opinion to construct 4 additional critical sites.

- On October 18, 2006, NMFS issued an amended biological opinion in response to the Corp's September 15, request.

- On October 31, 2006, the Corps requested section 7 consultation for 14 additional critical levee erosion repair projects. This request included an Action Plan and Alternative

Consultation Procedure to expedite the design, environmental review, and construction of these sites while avoiding an irreversible or irretrievable commitment of resources, pursuant to section 7(d) of the Endangered Species Act (ESA).

- On November 1, 2006, NMFS initiated formal section 7 consultation for 14 Corps-led critical levee erosion repair projects.

- On November 6, 2006, The Corps requested section 7 consultation for eight CDWR-led critical levee erosion repair projects. This request included an Action Plan and Alternative Consultation Procedure to expedite the design, environmental review, and construction of these sites while avoiding an irreversible or irretrievable commitment of resources, pursuant to section 7(d) of the ESA.

- On December 22, 2006, NMFS provided the Corps with a biological opinion for the 14 Corps-led levee repair projects.

- On August 10, 2007, NMFS issued the biological opinion for the 8 CDWR-led critical levee repair sites.

On July 25, 2006, Stillwater Sciences requested a species list to begin the preparation of a programmatic biological assessment for the remainder of Phase II of the SRBPP.

On August 22, NMFS provided Stillwater Science with a species list, and a description of designated critical habitat and Essential Fish Habitat.

In August 2006, a memorandum describing the analytical approach for the programmatic biological assessment was sent from Mike Dietl of the Corps to Jennifer Hobbs of USFWS, and to Howard Brown of NMFS (Stillwater Science 2006a).

On March 26, 2007, the Corps requested NMFS to review and comment on an administrative review draft of the programmatic biological assessment.

On May 30, 2007, NMFS provided written comments on the draft programmatic biological assessment to the Corps.

During the spring of 2007, Stillwater Sciences, began a pilot aquatic monitoring study to assess fish use of emergency critical repair sites.

On September 19, 2007, the IWG met to discuss the results of the administrative review draft of the programmatic biological assessment and the framework approach for future consultations, and to discuss finalizing the biological assessment and requesting section 7 consultation.

On November 2, 2007, NMFS received the Corps October 24, 2007 request for formal consultation for the remainder of Phase II of the SRBPP. The request included the final, October 2007, biological assessment, prepared by Stillwater Sciences.

This biological opinion is based on information provided in the October, 2007, biological assessment; discussions held with the Corps, USFWS, and CDFG; field reviews of previous and existing erosion and repair sites; Standard Assessment Method (SAM) analyses; and engineering designs. A complete administrative record of this consultation is on file at the NMFS Sacramento Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

The Corps proposes to implement the remaining 24,000 linear feet of authority under Phase II of the SRBPP. The SRBPP is a continuing construction project, authorized by the Flood Control Act of 1960, to provide protection for the existing levees and flood control facilities of the SRFCP. The purpose of the action is to ensure the reliability of the levees of the SRFCP for the life of the project, while protecting environmental values and compensating and/or mitigating effects on environmental resources to the degree feasible. The SRFCP consists of approximately 980 miles of levees plus overflow weirs, pumping plants, and bypass channels that protect communities and agricultural lands in the Sacramento Valley and Sacramento-San Joaquin Delta (Delta). A vicinity map illustrates this area in Figure 1.

The action is the future repair of waterside levee-bank erosion sites that occur within the SRBPP project area, which includes the Sacramento River from the town of Collinsville, at river mile (RM) 0 upstream to Chico at RM 194. The SRBPP also includes reaches of lower Elder and Deer creeks, Cache Creek, the lower reaches of the American River (RM 0–23), Feather River (RM 0–61), Yuba River (RM 0–11), and Bear River (RM 0–17), and portions of Threemile, Steamboat, Sutter, Miner, Georgiana, and Cache sloughs.

All levee repair sites will be selected based on a comprehensive erosion site evaluation prepared by Ayres and Associates (2005, 2006), and other inventories that may identify new erosion sites within the next few years. The evaluations are made based on field surveys and quantitative ranking of characteristics, such as bank slope, bench width, length and location of erosion, radius of curvature, bank stability, dynamic geomorphology, vegetation cover, tree hazards, soil type, water velocity, wave action, economic factors, human use, seepage potential, and tidal fluctuation. The SRBPP project area and currently identified erosion sites are shown in Figure 2.

For the purposes of this programmatic biological opinion, the SRBPP action area has been divided into four regions, organized south to north. The regions are 1a, 1b, 2, and 3. The region, water bodies, counties, reach lengths, number of existing erosions sites, and erosion site lengths are shown in Table 1. The regions are illustrated in Figure 3.

Most repairs will be accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features, and provide shallow-water habitat for juvenile fish rearing and refugia. This design, which has been employed along the lower Sacramento and American Rivers, and recently-constructed critical levee erosion repairs, will protect existing SRA habitat and create elements of natural SRA habitat that otherwise would be lost as a result of project construction activities and continued erosion.

Two types of benches will be used: (1) riparian benches, and (2) wetland benches. Riparian benches are defined as relatively flat areas within the levee slope that generally are submerged during winter/spring flows, but are dry during summer/fall flows. Riparian benches generally are designed to be seasonally inundated by average winter and spring flows. During normal water years, riparian benches are likely to be inundated from January through March, and during high flow years, they may be inundated as early as November to as late as July. During low flow years, riparian benches may not be inundated at all. Riparian benches typically will not be inundated during the summer and fall months, and will not be inundated under any flow scenario from the beginning of July through mid-November. Wetland benches are defined as relatively flat areas within the levee slope that generally are inundated by each tidal cycle. Benches will be constructed that slope toward the water, generally between the average spring and summer water surface elevation (WSEL).

A. Project Design Alternatives

Four bank repair designs will be implemented, depending on river region, and site-specific erosion and hydraulic conditions.

1. Bank fill rock slope with revegetation (Figure 4).

2. Low riparian bench with revegetation and anchored IWM enhancements installed above the summer/fall waterline upstream of RM 30 (Figure 5).

3. Low riparian bench with revegetation and anchored IWM enhancements installed above and below the summer/fall waterline upstream of RM 30 (Figure 6).

4. Delta smelt design: low riparian and wetland benches with revegetation downstream of RM 30 (Figure 7).

1. Design 1: Bank Fill Rock Slope with Revegetation

This design entails installing revetment along the levee slope from the levee's toe to crest, and provides some on-site conservation measures to improve habitat quality, including revegetation of the lower and upper bank (Figure 4). The revetment will have a median diameter (D_{50}) of 8 inches and will be placed at a constant slope of 2:1 (distance width to distance height, or dW:dH). As measured from the existing bank position, the width of the bank repair structure is expected to be approximately 5 to 10 feet. All IWM will be removed from the bank following construction and will not be replaced on the bank protection structure following construction. All existing ground cover vegetation will be removed during the first year of project construction and will be followed by replanting of the upper bank with vegetation that provides bank stabilization and riparian habitat. During construction, at least one-quarter of the existing shade-providing vegetation will be retained. During post-project years, the overhanging canopy structure is assumed to expand, as revegetation with new plants and regeneration of disturbed plants continues.

Using planting plans similar to those included in an earlier design for 14 critical erosion sites on the Sacramento River (Corps 2006), container plants and/or pole cuttings will be established along the upper bank, with the long-term goal of providing riparian and shaded riverine aquatic (SRA) cover habitat as defined by USFWS (Fris and DeHaven 1993). Species planted will be in compliance with the Corps' guidelines for landscape planting and vegetation management (Corps 2000). Planting plans will describe species to be planted within a specific elevation zone and will detail the number, area and spacing of plants to be installed, and whether the plants are from cuttings or containers. A generalized planting plan is provided in Table 2. Where there is sufficient depth along the upper levee prism, an unrestricted planting plan (installing larger sized trees such as western sycamore (*Platanus racemosa*) and cottonwood (*Populus fremontii*)) will be implemented.

2. <u>Design 2: Low Riparian Bench with Revegetation and Anchored IWM Enhancements Above the Summer/Fall Waterline Upstream of Sacramento RM 30</u>

This design provides several conservation measures that aim to provide onsite compensation for potential impacts to habitat (Figure 5). Measures include revegetation and construction of a riparian bench with integrated IWM. This design, which will be implemented at sites located upstream of RM 30, entails: (1) placing rock revetment at the levee toe and along the upper bank; (2) placing rock, and if necessary, soil, on the upper bank and on top of the lower bank's revetment to create a low riparian bench above the mean summer water level (MSWL); (3) planting vegetation on the bench and upper bank to provide bank stabilization and riparian habitat; and (4) anchoring IWM into the riparian bench to provide aquatic habitat.

In this design, the riparian bench is intended to flood at river stages corresponding to high tide (where tidally influenced) during average winter/spring flows. The riparian bench will be revegetated using planting plans similar to the planting plans included in a recent design for 14 critical erosion sites on the Sacramento River (Corps 2006). Container plants and pole cuttings will be installed along the lower bank, bench, and upper bank, with the long-term goal of providing riparian and SRA cover habitat, as defined by USFWS (Fris and DeHaven 1993). Species planted will be in compliance with the Corps' guidelines for landscape planting and vegetation management (Corps 2000). Planting plans will describe species to be planted within a specific elevation zone and will detail the number, area and spacing of plants to be installed, and whether the plants are from cuttings or containers. A generalized planting list is provided in Table 2, and in Appendix A, Table A-5. Where there is sufficient depth along the upper levee prism, an unrestricted planting plan (installing larger sized trees such as western sycamore and cottonwood) will be implemented.

The approximate slope of the entire bank protection structure will be 3:1 (dW:dH), where the slopes of the riparian bench will be constructed at 10:1 and the revetment portion below the bench will be 2:1. Because this design will be similar to several bank repair designs for the previously mentioned 14 critical erosion sites on the Sacramento River (Corps 2006), the expected width of the design 2 bank repair structure will be approximately 10 to 30 feet, as measured from the existing levee profile. The median size of bank material in contact with high (winter and spring) and low (summer and fall) water surface levels will be ¼ and 4 inches, respectively.

Anchored IWM will be embedded on top of the riparian bench above the summer/fall waterline. The IWM will be available as accessible habitat along the banks only during winter/spring flows when the bench is inundated. Individual pieces will be designed to fit the project site's hydraulic conditions. Past bank repair projects have required that woody materials: (1) be 23 to 35 feet long; (2) maintain a crown branch structure that is approximately 6 to 8 feet wide; and (3) retain limbs and root wads (to the extent feasible) for maximum habitat value.

3. Design 3: Low Riparian Bench with Revegetation and Anchored IWM Enhancements Above and Below the Summer/Fall Waterline Upstream of Sacramento RM 30

This design is identical to design 2, except that the IWM will be positioned in different locations, relative to the riparian bench (Figure 6). Under design 3, IWM will be embedded above *and* below the summer/fall waterline, thus providing year-round in-stream habitat for the focus fish species and life stages when seasonally present.

4. Design 4: Delta Smelt Design - Low Riparian and Wetland Benches with Revegetation Downstream of Sacramento RM 30

This design provides several conservation measures that are intended to provide onsite compensation designed to meet to delta smelt and salmonid habitat requirements, downstream of RM 30 (Figure 7). The features of this design include revegetation and construction of riparian and wetland benches to further increase habitat quality. The design includes: (1) placing rock revetment at the levee toe and along the upper bank; (2) placing rock, and if necessary, soil, on the upper bank and on top of the lower bank's revetment to create a riparian bench above the MSWL and a wetland bench below the MSWL; (3) planting vegetation on the benches and upper bank to provide bank stabilization and riparian habitat; and (4) restoring IWM to pre-project conditions to maintain in-stream habitat attributes.

The riparian and wetland benches are intended to flood at river stages corresponding to winter/spring (high) flows and summer/fall (low) flows, respectively. Both benches will be revegetated using planting plans similar to the planting plans included in the design for the previously cited bank repair project for 14 critical erosion sites (Corps 2006). Species planted will be in compliance with the Corps' guidelines for landscape planting and vegetation management (Corps 2000). Planting plans will describe species to be planted within a specific elevation zone and will detail the number, area and spacing of plants to be installed, and whether the plants are from cuttings or containers. A generalized planting plan is provided in Table 2. Where there is sufficient depth along the upper levee prism, an unrestricted planting plan (installing larger sized trees such as western sycamore and cottonwood) will be implemented. The wetland bench will typically be planted with hardstem bulrush (*Scirpus acutus*), California bulrush (*S. californicus*), and/or giant bur-reed (*Sparganium eurycarpum* ssp. *eurycarpum*).

The approximate slope of the entire bank protection structure will be 3:1 (dW:dH), where the slopes of the riparian and wetland benches will each be constructed at 10:1. The upper bank and the revetment portions below the benches will be constructed at a slope of 2:1. The expected width of this bank repair structure will be similar to the expected width of the structures constructed under designs 2 and 3. The median size of bank material in contact with high (winter and spring) and low (summer and fall) water surface levels will also be ¼ and 4 inches, respectively.

USFWS representatives requested no new installation of IWM downstream of RM 30, because IWM might increase habitat suitability of ambush predators, thus causing adverse effects on delta smelt (Corps 2006). Therefore, the design includes installation of IWM only to replace the pre-project coverage. Anchored IWM will be embedded on top of the riparian bench above the summer/fall waterline. The IWM will be available as accessible habitat along the banks only during winter/spring flows when the bench is inundated. Individual pieces will be designed to fit the project site's hydraulic conditions.

B. Design Selection Process

The Corps has proposed four bank protection alternatives based on the project delivery team's best professional judgment for the approximately 24,000 linear feet remaining in the construction authority. In region 1a and the lower portion of region 1b (downstream of RM 30), the primary design to be implemented will be design number 4. In the upper portion of region 1b (RM 30 to 80) and region 2, designs 2 and 3 are expected to account for 80 percent or more of the bank repair structures since there are fewer regulatory restrictions on IWM placement. In region 3, a majority (90 percent) of the repair structures will include design 3 because of the wider levee setback from the river corridor.

Other project designs, such as setback levees, biotechnical fixes, or back-side levee construction, could also be appropriate. The following process will be followed prior to selecting a final alternative for construction:

1. The Corps shall distribute the annual erosion report to the Central Valley Flood Protection Board and will encourage them to alert Reclamation Districts of erosion locations within their areas.

2. The Corps shall annually submit a list of potential sites to be constructed under the authority of the SRBPP to NMFS, USFWS, and CDFG; list submittal will be annual or as the Corps determines that a site is to be constructed under the SRBPP authority.

3. The Corps will request that the Central Valley Flood Protection Board ask potentially affected land owners (land owners of a SRBPP identified site in item 2 above) if they are willing to sell their land for project purposes, which may include either setback levee construction, or land-side reinforcement.

4. The Corps shall meet with NMFS, USFWS, and CDFG at proposed bank protection sites to discuss design alternatives.

5. The Corps shall prepare a design alternatives report and distribute it to NMFS, USFWS, and CDFG documenting items 1 through 4, prior to submitting the proposed bank protection construction under the SRBPP's programmatic biological opinion.

C. Construction staging, sequencing, and equipment

Revetment will be placed from cranes mounted on barges or from adjacent landside areas. Waterside construction will occur where it minimizes noise and traffic disturbances, and effects on existing vegetation. The contractor will use adjacent landside areas for staging of vehicles, plant materials, and other associated construction equipment, as necessary. Protective fencing will be installed to prevent vehicles from approaching the waterside edge of the existing bank.

For sites downstream of RM 60 on the Sacramento River, including sloughs, all in-water construction will occur between August 1 and November 30 unless approved otherwise by NMFS. For sites within all other parts of the SRBPP action area, in-water construction will occur between July 1 and November 30 of each year unless approved otherwise by NMFS. During these low flow periods, in-water construction will help minimize water quality impacts and will avoid sensitive rearing and spawning periods for salmonid species and delta smelt. Construction or planting activities that do not have potential water quality impacts may be conducted year-round.

The contractor will first place revetment from the levee toe up to the approximate MSWL. A layer of biodegradable coir fabric may be placed on top of the revetment and covered with a layer of rock to create the wetland and riparian benches. Rock will then be placed along the upper bank slopes. The contractor may choose to use excavators, loaders, and other construction equipment once the revetment has reached the MSWL.

Once bank construction is completed, the contractor will install the plantings and IWM (if applicable). The upper bank will also be seeded and may be covered with erosion control materials such as jute net to stabilize the bank while plantings are becoming established. The contractor may decide to plant the entire length of the upper bank or may construct a section at a time, depending on material and equipment availability, or feasibility of construction. Willow cuttings and herbaceous vegetation will generally be installed after construction in the fall, whereas container plants may be installed the following spring after high water flows. Precise planting timelines will be determined upon the availability of planting materials and in coordination with NMFS, USFWS, and CDFG.

D. Operations and Maintenance

Once repairs are complete, a project site may require limited maintenance. During the initial establishment period, maintenance activities are anticipated to be required for 3 to 5 years, and include removing invasive vegetation detrimental to project success, pruning and watering planted vegetation to promote optimal growth, replacing plantings, monitoring navigational hazards, and placing fill and rock revetment if the site is damaged during high flow events or by vandalism. Once established, the riparian vegetation should be self-maintaining. Annual maintenance at each site will be limited to placement of no more than 600 cubic yards of material, which corresponds to a disturbance length of less than 300 feet; should more material be required in any year, the operating and maintaining agency (*i.e.*, Central Valley Flood Protection Board) will obtain the necessary permits from the regulatory agencies. The Corps will be responsible for ensuring that conservation measures and environmental standards are stipulated in permits and all required documentation is maintained. Similarly, if outside alterations of a project site are proposed by other agencies or private entities, the Corps will work with the NMFS to ensure that environmental features at the project sites are maintained or that off-site compensation is implemented to make up for any deficits.

Any needed in-water maintenance work will be conducted during time periods that minimize adverse effects on listed fish species. Unless approved otherwise by the NMFS, in-water maintenance will be conducted between July 1 and November 30 of each year for sites above RM 60 and between August 1 and November 30 for sites below RM 60. Any maintenance not requiring in-water work may be conducted year-round.

E. Proposed Conservation Measures

1. <u>Off-site compensation</u>

If bank repair actions are not fully self-compensating as determined by the SAM (Corps 2004) or other evaluation tools, off-site compensation measures will be implemented either following project completion, or in advance of the proposed actions. Whether constructed as part of a suite of bank protection sites or established under an agreement between the Federal agencies, off-site compensation sites will focus on replacing and enhancing habitat values for the listed species addressed in this biological opinion. Proposed off-site conservation measures include the use of one or more of the following elements:

1. Setback levees to reestablish natural bank conditions along the main channel, increase shallow water habitat, provide a seasonally inundated floodplain, and increase overhead riparian cover with structural diversity (Figure 8). Under these conditions, active channel

migration could re-initiate and would be subject to the natural cycles of habitat disturbance and renewal.

2. Levee breaching and flooding of delta islands to increase shallow water and wetland habitats for juvenile rearing.

3. Construction of in-channel and off-channel wetland benches or less steeply sloping banks to provide juvenile rearing habitat.

4. Planting riparian trees for bank shading and long-term production of in-stream wood for aquatic habitat.

5. Installation of in-stream wood for the creation of in-stream cover and feeding areas.

Other compensation measures may be adopted on a project-by-project basis to increase the bank length or the areal extent of particular habitat features required by various life stages of the species addressed in this biological opinion. The general off-site compensation process is outlined below:

1. Off-site compensation requirements for one or more individual project sites will be determined using the SAM (Corps 2004) or other assessment tools recognized by the resource agencies (*i.e.*, NMFS, USFWS, CDFG). A combination of pre-construction survey data, SRA habitat modeling, or post-construction survey data will be used to verify assumptions used in the SAM model or other assessment tools.

2. Proposed compensation sites will be surveyed for SRA and other attributes using established methods; recommended compensation measures will be submitted for approval by the resource agencies. If significant setback levee action (or other significant restorative action) is designed and developed with the intent of off-setting future SRBPP bank protection debits, the action shall be subject to current Federal conservation banking guidelines.

3. Using the SAM (Corps 2004) or other assessment tool, the functional equivalence of the project and compensation sites will be determined by site locations (*i.e.*, compensation sites located where they can be colonized by the affected life stages of the focus fish species), site attributes (*i.e.*, potential exchanges between one or more SRA attributes such as IWD, substrate, shade, etc.), relative sizes of the sites, and compensation timing.

4. Timing of project site construction, compensation site construction, and SRA habitat evolution will be evaluated using the SAM (Corps 2004) or other assessment tool; the goal will be to achieve a net positive time-integrated relative response for the project and compensation sites at all times.

5. Compensation requirements are to be met within the previously described timelines and shall be on a bank length basis of 1:1 (project site length to compensation site length) using the SAM (Corps 2004) or other approved methodology. Compensation requirements that remain unmet for periods longer than recommended time periods shall be subject to additional accumulated habitat compensation requirements under the framework established by the SAM or other approved methodology.

2. Location of Compensation Sites

For the purposes of this programmatic biological opinion, compensation requirements for the remaining construction authority have been determined within each of the four regions shown in Figure 4, with the intent of completing the proposed conservation measures at sites selected as close as practicable to bank protection project sites. Whether two potential project and compensation sites are ecologically interchangeable can be assessed by determining whether fish species or specific life stages could inhabit the two sites at the same time of year.

Two potential compensation sites have been identified at the time of this consultation, including the 1992 SRBPP Cache Slough/Yolo Bypass Cross-Levee project in region 1a, and a lower American River compensation site at RM 0.5R being developed by the Corps and Central Valley Flood Protection Board in coordination with the Sacramento Area Flood Control Agency (SAFCA) in region 1b. The Cache Slough site will be used only for Delta smelt conservation. Additional compensation sites within these regions and in regions 2 and 3 will identified and developed to address unmet on-site conservation requirements from future planned bank protection projects. Final compensation site locations may be constrained by: (1) limited potential for habitat improvements to listed species from planned acquisition or enhancement; (2) location of property relative to site(s) requiring off-site compensation; (3) compatibility of nearby land uses with proposed land use at the compensation site; (4) available funding; and (5) the willingness of potential landowners to sell their properties.

3. Compensation timing

Compensation timing refers to the time between the initiation of bank repairs at a particular site and the attainment of the habitat improvements to protected species from designated compensation sites. In general, compensation time is the time required for on-site plantings to provide significant amounts of shade or structural complexity from woody debris recruitment. Significant long-term improvements have often been considered as appropriate to offset small short-term losses in habitat for listed species in the past, as long as the overall action contributes to recovery of the listed species. The authority to compensate prior to or concurrent with project construction is given under the Water Resources Development Act of 1986 (33 USC § 2201–2330).

The following compensation time periods (based loosely on life expectancy) will be considered as guidelines for compensation for a proposed project:

- Chinook salmon, 5 yrs
- Central Valley steelhead, 4 yrs

4. Use of off-site conservation banks

Protection of listed species habitat through the use of conservation banks may be considered as a means to satisfy off-site compensation requirements once all available on-site conservation alternatives have been exhausted. For compensation sites constructed in advance of proposed bank repair sites, medium- to long-term habitat improvements will potentially accumulate for use within a conservation banking process. Conceptually, conservation banking is an extension of wetland mitigation banking where development of wetlands and/or other aquatic resources are restored, created, or enhanced expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. With minor differences, conservation banking transfers this concept of wetlands mitigation banking into endangered and threatened species habitat conservation. One difference lies in the goals of wetlands mitigation vs. conservation banking. In wetlands mitigation banking, the goal is to replace the exact functions and values of the specific wetland habitat that will be adversely affected by the proposed action. In conservation banking (and within the SRBPP context), the goal is to offset adverse impacts to the Federally listed and Federally protected fish species addressed in this programmatic biological opinion.

Although the use of conservation banks for the SRBPP shall be accomplished through the section *7* consultation process, conservation banking agreements shall be generally consistent with established criteria and guidelines of the involved agencies. A planning framework was previously established by the Corps et al. (1995) and was supplemented by the Corps *et al*. (2000). The Corps, USFWS, and NMFS are joint parties to both of these Federal guidance documents, which will be followed for SRBPP actions to the extent practicable and consistent with USFWS and NMFS fulfilling their statutory obligations under section *7* of the ESA. In addition, site selection and management will be directed by the USFWS' *Guidance for the Establishment, Use, and Operation of Conservation Banks*, as finalized in May 2003 (USFWS 2003). Additional guidance for state agencies may be found in *Official Policy on Conservation Banks*, issued in April 1995 (Wheeler and Strock 1995).

Although these relevant Federal and state guidance documents for conservation and mitigation banking provide the fundamental precepts under which conservation banking for the SRBPP shall be undertaken, SRBPP banking actions and proposals may sometimes be unique and variable. Therefore, some of the more important additional guidelines that shall also apply to conservation banking relative to the SRBPP are as follows:

- A setback levee (or other significant restorative action) for compensation that is part of a suite of discrete bank protection sites analyzed and evaluated together as one SRBPP project, may not need the coverage of a formal conservation banking agreement, provided the Corps and State of California have addressed the relevant conservation banking issues in their environmental documentation for the overall programmatic action;

- The IWG shall support an independent re-analysis of the 1992 SRBPP Cache Slough/Yolo Bypass Cross-Levee project in Solano County, California, to determine whether any excess conservation banking credits may now exist, which could be applied to future SRBPP compensation needs. If such credits do exist, their application and use will be subject to appropriate conservation (and mitigation) banking guidance;

- On-site compensation efforts that create substantially more compensation than necessary to fully offset on-site impacts may have the excess compensation credited, accounted for, and used, under appropriate conservation (and mitigation) banking guidance;

- The project service area for each conservation bank may vary and shall be defined at the time each bank is established;

- Conservation bank credits may either be withdrawn directly by the Corps and the State of California (in the case of banks the State may choose to operate), or purchased from an intermediate, private seller/bank operator. However, all accounting, regardless of credits originating from a government or private bank, shall be based on the SAM (Corps 2004) or other methodology approved by the resource agencies;

- Each IWG agency shall be given an opportunity to participate in development and to become a party to any conservation banking agreements which are developed;

- The Corps and the State of California declare their intent to routinely subrogate, to private entities capable of providing such services and that are agreeable to IWG agencies, their responsibilities for: (1) preparing banking agreements, and (2) conducting operations, maintenance, monitoring, and accounting for conservation banks; and

- Protections and management of conservation banks shall be established in perpetuity. Management measures shall be implemented to ensure adequate control of undesirable activities (*i.e.*, trash dumping, tree-cutting, off-road vehicle use, and invasions by exotic vegetation). Management elements that maintain the habitat for the various listed species shall also be included, as necessary. However, for management and maintenance of all banking sites, the guiding principle shall be to achieve to the extent feasible, a largely unmanaged operation based on natural river functions and processes.

F. Monitoring plan

The Corps shall submit a detailed monitoring plan as part of the request to append to the programmatic biological opinion. The monitoring plan will include, at a minimum: (1) monitoring methods, performance standards for SAM variables, and success criteria for riparian vegetation and SRA cover; and (2) a protocol for implementing remedial actions should any success criteria not be met.

Once reviewed, this monitoring plan shall be incorporated into an Operations and Maintenance (O&M) manual. An annual monitoring report that evaluates how the site meets the conservation success criteria will be submitted to the resource agencies by December of each year. Monitoring will be conducted until the projected improvements of conservation actions are either substantially confirmed or discounted.

To ensure that on-site and off-site habitat features are functioning as designed to specifically benefit Federally protected fish species, fishery monitoring efforts will be reported separately from the monitoring efforts described above. An initial fishery monitoring effort is currently ongoing and will continue through at least 2012 to determine the effects of bank protection installed between 2001 and 2006 on listed species. Yearly adjustments and expansion of the fisheries monitoring plan to include new repair sites will be made through the IWG; the Corps will submit a draft monitoring plan to NMFS by November 30 of each year. A draft monitoring report will be submitted to NMFS by December 30 of each year.

G. Additional Minimization and Conservation Measures

The Corps shall implement additional measures, consistent with earlier biological opinions (NMFS 2004a, USFWS 2006a, NMFS 2006a, NMFS 2006b) for the SRBPP, to help conserve and minimize impacts on listed species, including:

- Where feasible, preventative measures to treat failure mechanisms that minimize project size.
- Stockpiling of construction materials such as portable equipment, vehicles, and supplies, including chemicals, at designated construction staging areas and barges will avoid riparian and wetlands areas.
- Erosion control measures (*i.e.*, best management practices (BMPs)) that minimize soil or sediment from entering the river. BMPs shall be installed, monitored for effectiveness, and maintained throughout construction operations.
- Limiting site access to the smallest area possible in order to minimize disturbance.

- Daily removal of all litter, debris, unused materials, equipment, and supplies from areas below the ordinary high water line. Such materials or waste will be deposited at an appropriate disposal or storage site.

- Immediate (within 24 hours) cleanup and reporting of any spills of hazardous materials to the resource agencies. Any such spills, and the success of the efforts to clean them up, shall also be reported in post-construction compliance reports.

- Designating a Corps-appointed representative as the point-of-contact for any contractor who might incidentally take a living, or find a dead, injured, or entrapped threatened or endangered species. This representative shall be identified to the employees and contractors during an all-employee education program conducted by the Corps.

- An on-site inspection tour, led by the Corps' biologist/environmental manager or contractor, if requested by USFWS or NMFS personnel or other resource agencies, during or upon completion of construction activities.

- Screening any water pump intakes as specified by NMFS and USFWS screening specifications. Water pumps will maintain an approach velocity of 0.2 feet per second or less when working in areas that may support delta smelt.

- A Corps representative assigned to work closely with the contractor(s) through all construction stages, to ensure that any living riparian vegetation or IWM within vegetation clearing zones is avoided and left undisturbed to the extent feasible.

Furthermore, the Corps will seek to avoid and minimize construction effects on listed species and their critical habitat to the extent feasible. A number of measures will be applied to the entire project or specific actions, and other measures may be appropriate at specific locations within the action area. Avoidance activities to be implemented during final design and construction may include, but are not limited to, the following.

- Identifying all habitats containing, or with a substantial possibility of containing, listed terrestrial, wetland, and plant species in the potentially affected project areas.

- Minimizing effects by modifying engineering design to avoid potential direct and indirect effects.

- Incorporating sensitive habitat information into project bid specifications.

- Incorporating requirements for contractors to avoid identified sensitive habitats into project bid specifications.

- Minimizing vegetation removal to the extent feasible.

- Whenever possible, performing no grubbing or contouring of the sites.
- Whenever possible, placing fill materials with no excavation or movement of existing materials on site.
- Ensuring all construction activities, including clearing, pruning, and trimming of vegetation, is supervised by a qualified biologist to ensure these activities have a minimal effect on natural resources.
- If a cofferdam is needed during construction, constructing it by placing the sheet piles sequentially from the upstream to the downstream limits of the construction area. If substrate, cover, and water depths allow, seining would be conducted within the cofferdam with a small-mesh seine to remove as many fish as possible before the cofferdam is closed; upon completion of seining, exclusionary nets would be placed in the river to prevent fish from re-entering the dammed area. Once the cofferdam is closed the area will be partially dewatered, and a final seining and dipnetting effort will be conducted to capture any remaining fish. Only low-flow pumps with screened intakes will be used during dewatering operations. Any captured fish would be released downstream of the construction area.

I. Consultation Approach for Future Projects

The Corps will continue to review all future levee bank repair projects conducted under Phase II of the SRBPP. If future projects meet conditions outlined in this programmatic biological opinion, the Corps will request to have the project appended to this programmatic biological opinion. The following process will be used to append future projects to this biological opinion:

The Corps will send a letter to NMFS requesting that a project be appended to the programmatic biological, and submit the following project specific information:

1. Project location(s), including: reach, river mile, county, quadrangle, latitude, and longitude.
2. Map showing project location(s).
3. The design(s) that will be implemented at each site.
4. Design cross section Figures showing elevations, placement of fill materials, and existing levee bank profile(s).
5. Material quantities that will be installed including revetment, soil, and plants.

6. Estimates of project dimensions including the linear feet of waterside levee that will be repaired and the approximate acreage above and below the mean summer water level (MSWL).

7. Project schedule.

8. A list of all Federally threatened and endangered species, and critical habitat that may be affected by the project.

9. Site specific SAM analyses.

10. An analysis of how the project will affect Federally listed species and designated critical habitat.

11. A detailed vegetation and aquatic habitat monitoring plan.

NMFS will review the information provided by the Corps and will review it to determine if (a) the submittal requirements described above are complete, and (b) the project is consistent with the programmatic biological opinion. If these conditions are met, NMFS will append the programmatic biological opinion with a supplemental section 7 consultation and, if necessary, an incidental take statement.

J. Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The SRBPP action area extends south-to-north along the Sacramento River from the town of Collinsville, at river mile (RM) 0 upstream to Chico at RM 194, and includes reaches of lower Elder and Deer creeks. The SRBPP also includes Cache Creek, the lower reaches of the American River (RM 0–23), Feather River (RM 0–61), Yuba River (RM 0–11), and Bear River (RM 0–17), as well as portions of Threemile, Steamboat, Sutter, Miner, Georgiana, and Cache sloughs. Currently, installation of approximately 24,000 linear feet (4.5 miles) of bank protection (either rock revetment or levee setback) remains within the SRBPP's authority for Phase II.

For the purposes of this programmatic biological opinion, the SRBPP action area has been divided into four regions, organized south to north by the location of the downstream terminus of each watercourse with the mainstem Sacramento River. These four regions represent biologically similar habitat functions. The regions are 1a, 1b, 2, and 3. The waterbodies within these regions are described in Table 1, and illustrated in Figure 3.

Table 1. Watercourses, counties, region lengths, number of erosion sites, and erosion site lengths within the four SRBPP regions.

Region	Watercourse	Reach length (miles)	Number of erosion sites[1,2]	Length of erosion sites[3]		Number of erosion sites in revetment database[4]	Length of erosion sites in revetment database	
				feet	miles		feet	miles
1a	Sacramento River from Collinsville to Isleton (RM 0–20)	20.7	2	1,973	0.37	1	1,216	0.23
	Threemile Slough	3.7	0	0	0	–	–	–
	Georgiana Slough	12.4	18	15,720	2.98	18	15,720	2.98
	Steamboat Slough	13.1	9	3,374	0.64	9	3,374	0.64
	Yolo Bypass	37.9	NS	–	–	–	–	–
	Miner Slough	7.7	0	0	0	0	0	0
	Portions of Lindsey Slough	7.5	0	0	0	0	0	0
	Cache Slough	10.7	4	2,073	0.39	0	0	0
	Ulatus Creek Bypass Unit 2	1.6	NS	–	–	–	–	–
	Haas Slough	2.8	NS	–	–	–	–	–
	Sutter Slough	6.8	4	4,068	0.77	4	4,068	0.77
	Putah Creek	29.5	NS	–	–	–	–	–
	Willow Slough Bypass	7.4	NS	–	–	–	–	–
	Sacramento Bypass	1.8	NS	–	–	–	–	–
	Cache Creek	13.3	7	2,574	0.49	0	0	0
	Knights Landing Ridge Cut	6.4	NS	–	–	–	–	–
1b	Sacramento River from Isleton to Feather River	60.3	48	31,827	6.03	48	31,827	6.03

Region	Watercourse	Reach length (miles)	Number of erosion sites[1,2]	Length of erosion sites[3]		Number of erosion sites in revetment database[4]	Length of erosion sites in revetment database	
				feet	miles		feet	miles
	(RM 20-80)							
	American River from Sacramento River to RM 13	13.2	4	1,204	0.23	3	1,068	0.20
	Natomas East Main Drain	16.0	NS	–	–	–	–	–
	Natomas Cross Canal	5.3	NS	–	–	–	–	–
	Coon Creek Group Interceptor Unit 6	7.9	NS	–	–	–	–	–
2	Sacramento River from Feather River confluence to Colusa (RM 80–143)	62.3	36	31,684	6.0	36	31,684	6.00
	Colusa Basin Drain	35.8	NS	–	–	–	–	–
	Sutter Bypass	37.2	NS	–	–	–	–	–
	Tisdale Bypass	4.3	NS	–	–	–	–	–
	Wadsworth Canal	4.6	NS	–	–	–	–	–
	Colusa Bypass	2.8	NS	–	–	–	–	–
	Cherokee Canal	18.2	NS	–	–	–	–	–
	Butte Creek	32.5	NS	–	–	–	–	–
	Feather River from Sacramento River	30.8	9	4,908	0.93	9	4,908	0.78

Region	Watercourse	Reach length (miles)	Number of erosion sites[1,2]	Length of erosion sites[3]		Number of erosion sites in revetment database[4]	Length of erosion sites in revetment database	
				feet	miles		feet	miles
	upstream to RM 31							
	Bear River from the Feather River to upstream end of levees above Hwy 65	12.6	4	3,346	0.63	0	0	0
	Yuba River from the Feather River upstream to RM 5	4.9	NS	–	–	0	0	0
	Marysville Units 1,2, and 3	7.5	NS	–	–	–	–	–
	Honcut Creek	8.0	NS	–	–	–	–	–
	Feather River from RM 31 to Honcut Creek right bank	13.2	NS	–	–	–	–	–
	Feather River from RM 31 to Western Canal left bank	27.2	NS	–	–	–	–	–
3	Sacramento River from Colusa to Chico (RM 143–194)	50.3	9	6,885	1.30	9	6,885	1.30
	Mud Creek	8.0	NS	–	–	–	–	–
	Deer Creek	6.7	NS	–	–	–	–	–
	Elder Creek	4.0	NS	–	–	–	–	–
Total			**154**	**109,636**	**20.76**	**137**	**100,750**	**18.92**

[1] Source: Erosion Site Inventory from Ayres Associates (2005, 2006). Sites repaired by Corps in 2006 are not included. Sites repaired by CDWR in 2006 are included.
[2] NS: reach was not surveyed.
[3] Site length determined from waypoints and GIS analysis.
[4] Includes only those sites located within the Corps revetment database coverage (USFWS 2002b, Corps 2006a).

Table 2. Generalized planting plan data used for shade modeling for representative project sites within programmatic regions.

Species	Common Name	Restricted Planting (No./ha)	Unrestricted Planting (No./ha)
Acer negundo	box elder		23
Alnus rhombifolia	white alder		23
Fraxinus latifolia	Oregon ash		23
Platanus racemosa	Western sycamore		69
Populus fremontii	Fremont cottonwood		69
Quercus lobata	Valley oak		69
Salix gooddingii	Goodding's willow		23
Salix laevigata	red willow	427	46
Salix lasiolepis	arroyo willow		46
Rosa californica	California wild rose	428	23
Salix exigua	Narrowleaf willow	428	46
	Total per ha (hex)	1,283	460

Figure 1. Vicinity map of the SRBPP action area.

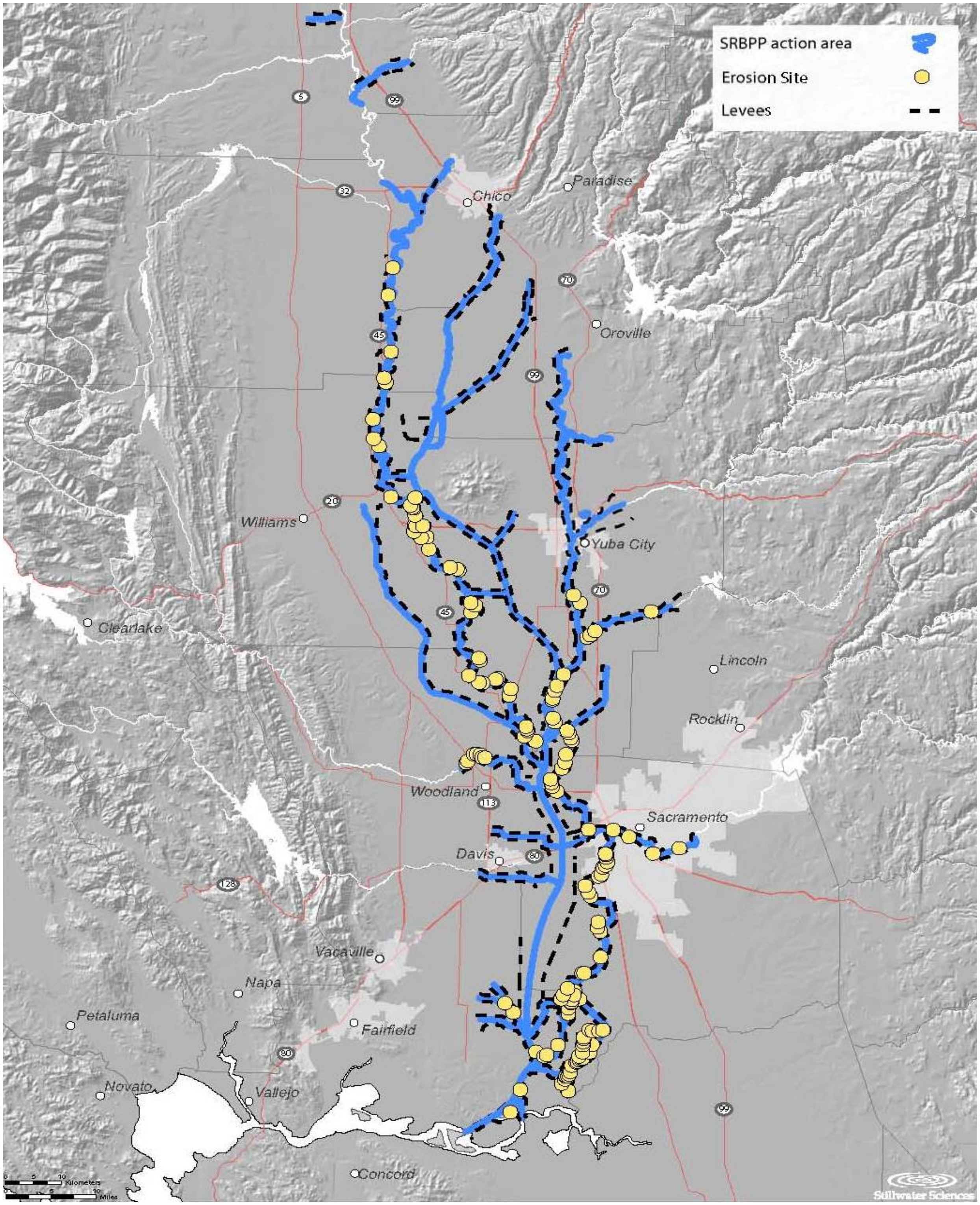

Figure 2. Identified erosion sites within the SRBPP planning area.

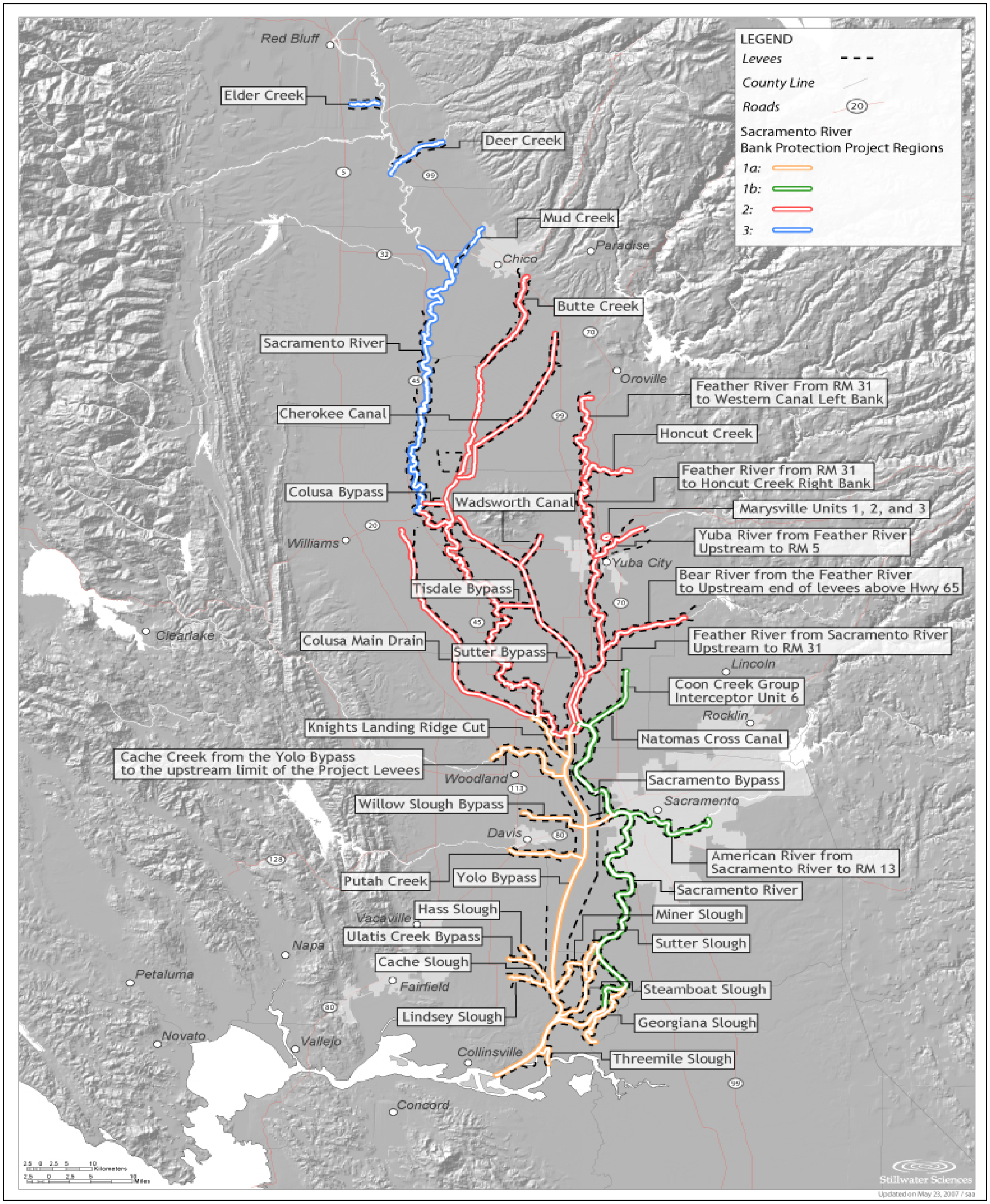

Figure 3. Subregions designated for the SRBPP action area.

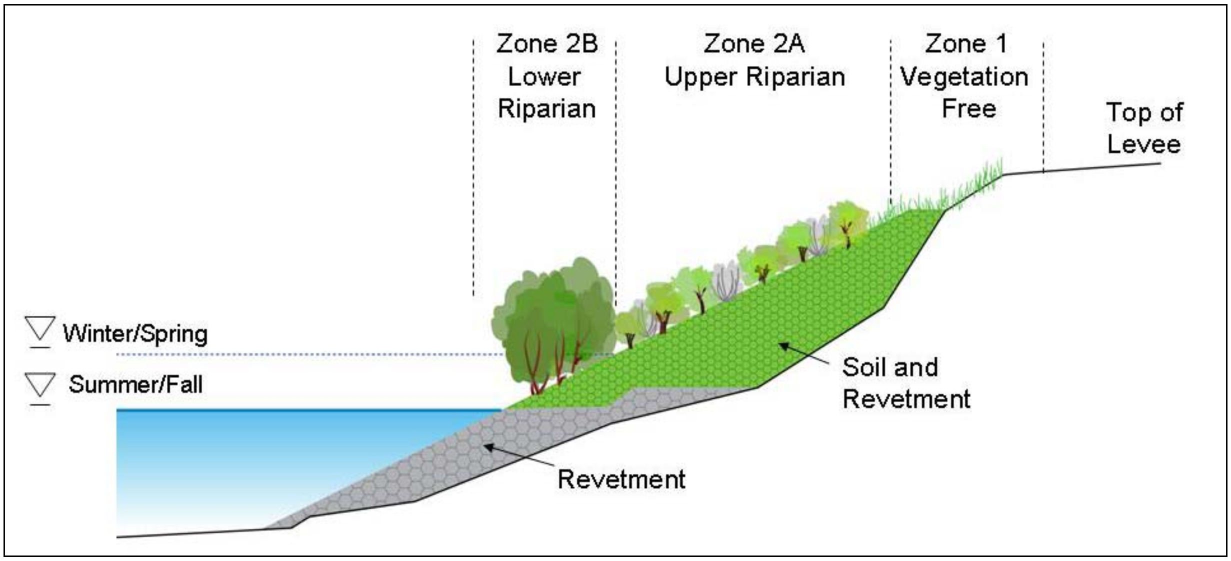

Figure 4. Design 1 – Bank fill rock slope with revegetation.

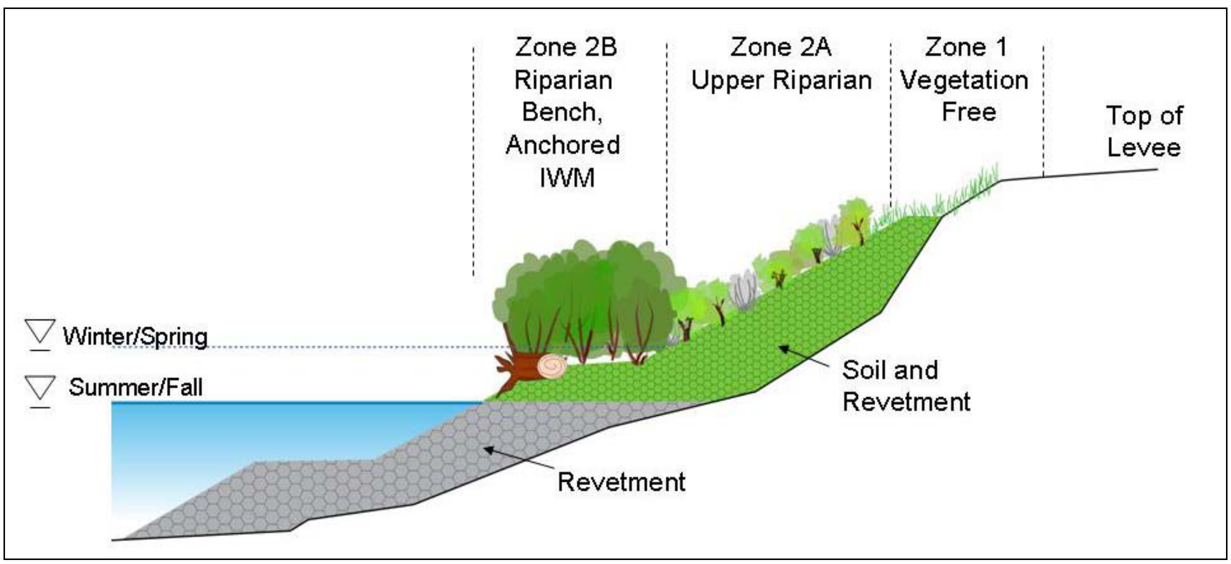

Figure 5. Design 2 – Low riparian bench with revegetation and anchored in-stream woody material enhancements *above* the summer/fall waterline upstream of RM 30.

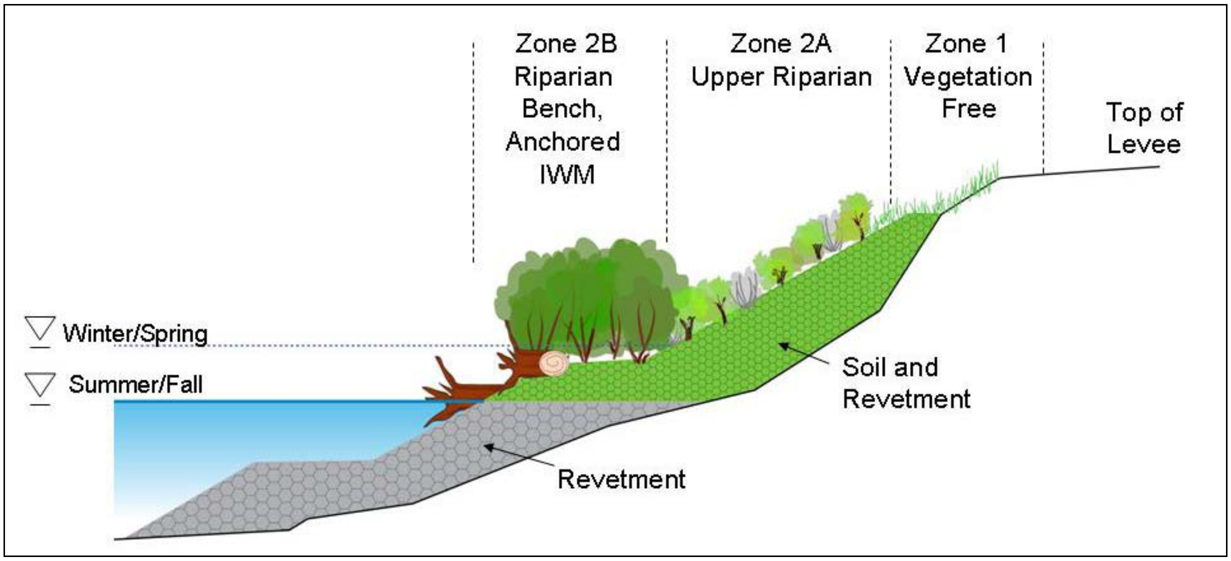

Figure 6. Design 3 – Low riparian bench with revegetation and anchored in-stream woody material enhancements *above and below* the summer/fall waterline upstream of RM 30.

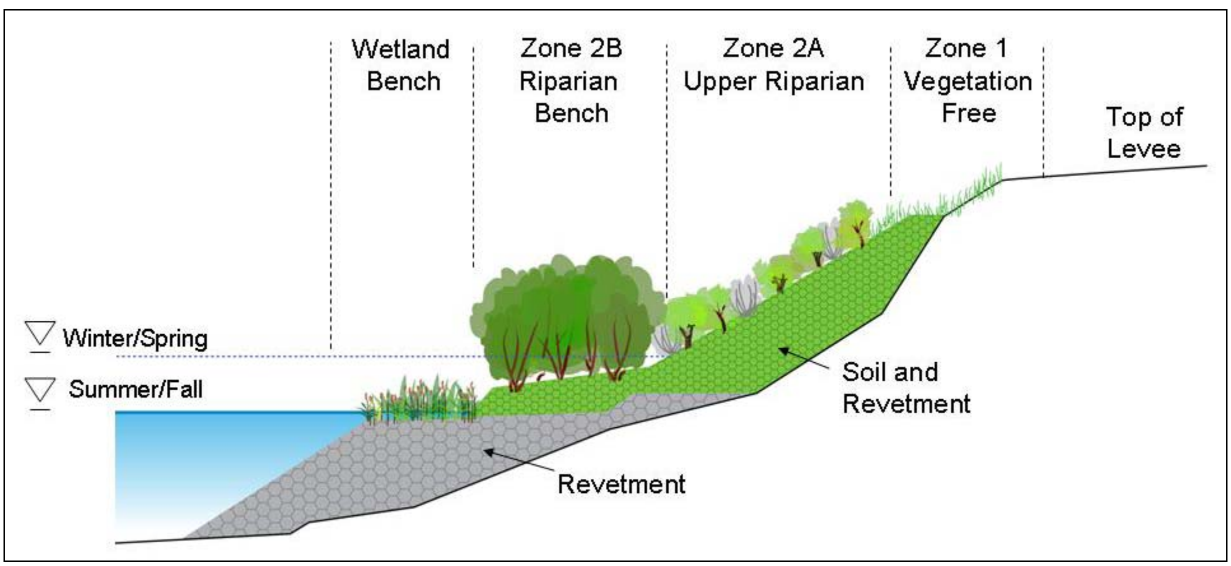

Figure 7. Design 4: Delta smelt design – Low riparian and wetland benches with revegetation downstream of RM 30.

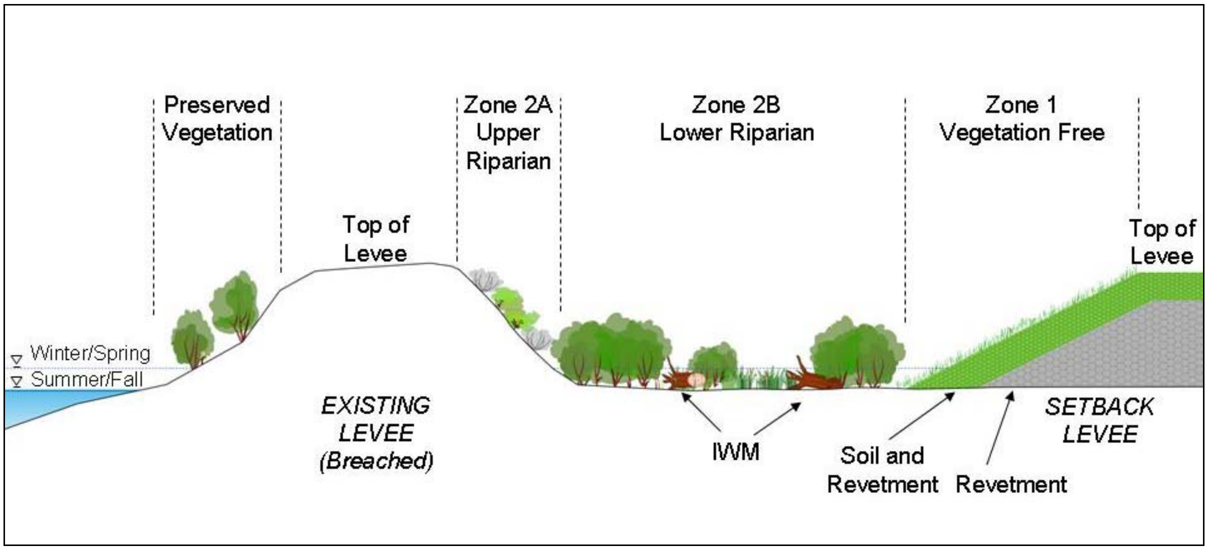

Figure 8. Conceptual design of a setback levee with revegetation and in-stream woody material enhancements.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
endangered (June 28, 2005, 70 FR 37160)
Sacramento River winter-run Chinook salmon designated critical habitat
(June 16, 1993, 58 FR 33212)
Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat
(September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*)
threatened (December 22, 2005)
Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 70 FR 17386)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. <u>Chinook Salmon</u>

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate in-stream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon 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).

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 *et al*. 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al.* (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream (California Bay-Delta Authority (CALFED) 2001) several days at a time. 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, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring conducted by LGL Environmental Research Associates (LGL 2006) showed peak upstream movement of adult CV spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring the in the four 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). Upon emergence, fry swim or are displaced downstream (Healey 1991). Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depicts that the daily migration of juveniles passing RBDD is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in the stream for a period of time from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, MacFarlane and Norton 2001, Sommer *et al.* 2001).

As juvenile Chinook salmon grow 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 by the USFWS (1997) exhibited larger juvenile captures in the main channel and smaller sized fry along the margins. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1980). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Kjelson *et al*. 1982, Brandes and McLain, 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 fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

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 1981, Healey 1991). 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. Juvenile Chinook salmon were found to spend about 40 days migrating through the Sacramento-San Joaquin Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallone Islands (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. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon originally were listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160). The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

Sacramento River winter-run Chinook salmon adults enter the Sacramento River basin between December and July; the peak occurring in March (Table 3; 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 Red Bluff Diversion Dam (RBDD) (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, 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 small insects and crustaceans.

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years

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

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives on temperature, flow, and operations of the Central Valley Project (CVP) and State Water Project (SWP); (2) Regional Board decisions requiring compliance with Sacramento River water temperature objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from CALFED (*i.e.*, installation of a fish screen on the Glenn Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account (EWA); (6) Environmental Protection Agency actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

Table 3. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

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

b) Juvenile

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

Source: [1]Yoshiyama *et al*. 1998; Moyle 2002; [2]Myers *et al*. 1998; [3]Martin *et al.* 2001; [4]Snider and Titus 2000; [5]USFWS 2001

Relative Abundance: ▓ = High ▒ = Medium ░ = Low

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and females, were as high as near 100,000 fish in the 1960s; however, populations monotonically declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,701), 2005 (15,730), and 2006 (17,334) (CDFG 2008) show a recent increase in the population size and a 4-year average of 12,315. The 2006 run was the highest since the listing. However, the preliminary adult population estimate of winter-run Chinook salmon in 2007 was only 2,542 (CDFG 2008). The freshwater life history traits and habitat requirements of juvenile winter-run Chinook salmon and fall-run Chinook salmon are similar. Therefore, the unusual and poor ocean conditions that are suspected to have caused the drastic decline in returning fall run Chinook salmon populations coast wide in 2007 (Varanasi and Bartoo 2008) are likely to have also caused the observed decrease in the winter-run Chinook salmon spawning population in 2007.

Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method, and the Juvenile

Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003 (Gaines and Poytress 2004). Averaging these 2 estimates yields an estimated population size of 3,782,476.

Based on the RBDD counts, the population has been growing rapidly since the 1990s with positive short-term trends. An age-structured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al*. 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley *et al*. (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population is improving, 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). Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the draft recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the draft recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0 (NMFS 1997). Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population.

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

Abundance. Redd and carcass surveys, and fish counts, suggest that the abundance of winter-run Chinook salmon has been 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, however, as it consists of only one population that is subject to possible impacts from environmental and artificial conditions. The most recent juvenile production estimates 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, finite 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 of the mainstem Sacramento River below Keswick Dam.

Diversity. The second highest risk factor for the Sacramento River winter-run Chinook salmon ESU has been the detrimental effects on its diversity. 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).

b. *Central Valley Spring-run Chinook Salmon*

NMFS listed the Central Valley spring-run Chinook salmon (CV spring-run Chinook salmon) ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although CV spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte Creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 4; Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2006a) indicates adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998).

Spring-run Chinook salmon 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*. 2006a). Studies in Butte Creek (Ward *et al*. 2002, 2003, McReynolds *et al*. 2005) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January and February; and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer Creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the-year (YOY) migration and an earlier yearling migration (Lindley *et al*. 2006a).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac (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. 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). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

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

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

(a) Adult

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

(b) Juvenile

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

Source:[1]Yoshiyama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2006a; [5]CDFG 1998; [6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

Relative Abundance: (dark shading) = High; (medium shading) = Medium; (light shading) = Low

CV spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1992) and were found in both the Sacramento and San Joaquin drainages. More than 500,000 CV spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama *et al.* 1998). The San Joaquin populations essentially were extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Yoshiyama *et al.* 1998). Populations in the upper Sacramento, Feather, and Yuba Rivers were eliminated with the construction of major dams during the 1950s and 1960s. Naturally spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005 (for the purposes of this biological opinion, the average adult population is assumed to be 16,349 until new information is available) (CDFG 2008). Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook ESU as a whole because these streams contain the primary independent populations with 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 CV spring-run Chinook salmon remains well below estimates of historic abundance. Additionally, in 2003, high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter Columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek (Ward 2005).

Several actions have been taken to improve habitat conditions for CV spring-run Chinook salmon, including: improved management of Central Valley water (*i.e.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist.

There have been significant habitat improvements (including the removal of several small dams and increases in summer flows) in CV spring-run Chinook salmon watersheds, as well as reduced ocean fisheries and a favorable terrestrial and marine climate. It appears that the three independent spring-run Chinook salmon populations in the Central Valley are growing (Good *et al*. 2005). All three spring-run Chinook salmon populations show signs of positive long- and short-term mean annual population growth rates. Although CV spring-run Chinook salmon have some of the highest population growth rates in the Central Valley, other than Butte Creek and the hatchery-influenced Feather River, population sizes are relatively small compared to fall-run Chinook salmon populations (Good *et al*. 2005). Because the CV spring-run Chinook salmon ESU is spatially confined to relatively few remaining streams, continues to display broad fluctuations in abundance, and a large proportion of the population (*i.e.*, in Butte Creek) faces the risk of high mortality rates, the population remains at a moderate to high risk of extinction.

(1) Viable Salmonid Population Summary for CV Spring-run Chinook Salmon

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 population complex has been somewhat compromised. The Feather River spring-run have introgressed with the fall-run, and it appears that the Yuba River population may have been impacted by FRH fish straying into the Yuba River. Additionally, the diversity of the spring-run ESU has been further reduced with the loss of the San Joaquin River basin spring-run populations.

2. <u>Central Valley Steelhead</u>

Central Valley steelhead (CV steelhead) were originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River basins in California's Central Valley. In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488).

Steelhead can be divided into two life history types, 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. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are 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 North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

In the Sacramento River, adult winter steelhead migrate upstream during most months of the year, beginning in July, peaking in September, and continuing through February or March (Hallock 1987). 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 (Hallock *et al.* 1961, McEwan and Jackson 1996) (Table 5). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, 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). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

The female selects a site where there is good intergravel flow, then digs a redd and deposits eggs while an attendant male fertilizes them. The eggs are then covered with gravel when the female begins excavation of another redd just upstream. 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 four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). 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 young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

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 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.

CV steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). Lindley *et al*. (2006b) estimated that historically there were at least 81 indpendant CV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin Rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006b).

Historic CV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead 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.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 (mean 200,000) smolts emigrate to the ocean per year representing approximately 3,600 female CV steelhead spawners in the Central Valley basin (Good *et al*. 2005). This can be compared with McEwan's (2001) estimate of one million to two million spawners before 1850, and 40,000 spawners in the 1960s.

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

Until recently, CV steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). 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).

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 steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff have prepared juvenile migrant CV steelhead catch summaries on the San Joaquin River near Mossdale representing 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 staff 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” (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). 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.

Table 5. The temporal occurrence of adult (a) and juvenile (b) CV steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

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

(b) Juvenile

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

Source: [1]Hallock 1961, 1987; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et a*l. 1957; [6]Bailey 1954;
[7]CDFG Steelhead Report Card Data; [8]CDFG unpublished data; [9]Snider and Titus 2000;
[10]Nobriga and Cadrett 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance: (dark) = High (medium) = Medium (light) = Low

Lindley *et al*. (2006b) 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). The future of CV steelhead is uncertain due to limited data concerning their status. CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

(1) Viable Salmonid Population Summary for CV Steelhead

Abundance. All indications are that natural Central Valley steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good *et al.* 2005); 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 non-DPS-origin Eel River steelhead stock.

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 nonclipped 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 DPS (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 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 Mokelumne River hatcheries are not included in the Central Valley steelhead DPS.

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

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386) and includes the North American green sturgeon population spawning in the Sacramento River and utilizing the Sacramento River, the Delta, and the San Francisco Estuary.

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The Southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The Southern DPS of North American green sturgeon life cycle 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, and males between 3 and 9 years of age (Nakamoto *et al*. 1995, Jeff McLain, NMFS, pers. comm., 2006).

New information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has emerged. Lindley (2006c) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis 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. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeon in the San Pablo 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 Oregon and Washington. Eight of the 12 recoveries were in the Columbia Estuary (CDFG 2002). In addition, recent analysis by Israel (2006a) indicates a substantial component of the population (*i.e.*, 50-80 percent). of Southern DPS North American green sturgeon to be present in the Columbia estuary.

Kelley *et al.* (2006) 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 the authors surmised they are related to resource availability (Kelley *et al*. 2006). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al*. 2002). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al*. 2002). The authors surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205) and 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 indicating spawning ocurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Ray Beamesderfer, S.P. Cramer & Associates, Inc., pers. comm. 2006).

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, Adams *et al*. 2002, Jeffrey Stuart, NMFS, pers. comm. 2006). Adult sturgeon caught in Washington State waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

Based on the distribution of sturgeon eggs, larva, and juveniles in the Sacramento River, CDFG (2002) indicated that Southern DPS of green sturgeon spawn in late spring and early summer above Hamilton City possibly to Keswick Dam. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (*i.e.*, 10 to 15 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). Southern DPS Green sturgeon adults begin their upstream spawning migrations into the San Francisco Bay in March, reach Knights Landing during April, and spawn between March and July (Heublein *et al*. 2006). Peak spawning is believed to occur between April and June (Table 6) and thought to occur in deep turbulent pools (Adams *et al*. 2002). Substrate is likely large cobble but can range from clean sand to bedrock (USFWS 2002a). Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length. According to Heublein (2006) all adults leave the Sacramento River prior to September 1 of each year.

After approximately 10 days, 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 2002a). 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, approximatley 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*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al*.'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first six months of life. When ambient water temperatures reached 46 ^{o}F, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the 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 juvenile Southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al*. (2005).

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). CDFG (2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Additional analysis of North American green and white sturgeon taken at the Fish Facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386). Catches of sub-adult and adult North American green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the portion of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of Northern and Southern DPS North American green sturgeon. Recent spawning population estimates using sibling based genetics by Israel (2006b) indicates a maximum spawning population 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 two weeks of age) and GCID (downstream; approximately three weeks of age), it appears the majority of Southern DPS North American green sturgeon are spawning above RBDD. Note, 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.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al*. 2004), however, there are no observations of juvenile or larval sturgeon even prior to the 1960s when Oroville Dam was built (NMFS 2005a). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later 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 over 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. It is likely that both white and green sturgeon 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 CV spring-run Chinook salmon 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.

Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning (Lindley *et al*. 2006b) suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperatures, and geology summarized). This spawning habitat may have extended into the three major branches of the Sacramento River; the Little Sacramento River, the Pit River system, and the McCloud River (NMFS 2005a). Due to substantial habitat loss as well as existing threats to the Southern DPS of North American green sturgeon, it continues to remain at a moderate to high risk of extinction.

Table 6. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

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

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

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

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

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

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

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

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

Source: [1]USFWS 2002a; [2]Moyle *et al*. 1992; [3]Adams *et al*. 2002 and NMFS 2005a; [4]Kelley *et al*. 2006; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al*. 1995; [8]Heublein *et al*. 2006
* Fish Facility salvage operations

Relative Abundance: = High   = Medium   = Low

The freshwater habitat of North American green sturgeon in the Sacramento-San Joaquin drainage varies in function, depending on location. Spawning areas currently are limited to accessible upstream reaches of the Sacramento River. Preferred spawning habitats are thought to contain large cobble in deep cool pools with turbulent water (CDFG 2002, Moyle 2002).

Migratory corridors are downstream of the spawning areas and include the mainstem Sacramento River and the Delta. These corridors allow the upstream passage of adults and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers which can include dams, unscreened or poorly screened diversions, and degraded water quality. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their 1 to 3 year residence in freshwater. Rearing habitat condition and function may be affected by variation in annual and seasonal flow and temperature characteristics.

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

The Southern DPS of North American green sturgeon was not included or analyzed in recent efforts to characterize the status and viability of Central Valley salmonid populations (Lindley *et al*. 2006a; Good *et al.* 2005). However, the following summary has been compiled from the best available data and information on North American green sturgeon to provide a general synopsis of the viability parameters for this DPS.

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

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

Spatial Structure. Current data indicates that the Southern DPS of North American Green Sturgeon is comprised of a single spawning population in the Sacramento River. Although some individuals have been observed in the Feather and Yuba Rivers, it is not yet known if these fish represent separate spawning populations. Therefore, the apparent presence of a single reproducing population puts the DPS at risk, due to extremely tenuous spatial structure.

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

B. Critical Habitat and Primary Constituent Elements

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

Critical habitat for CV spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta. Critical Habitat for CV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope Creeks in the Sacramento River basin; and, the San Joaquin River its tributaries, and the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (70 FR 52488). Critical habitat for CV spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CV spring-run Chinook salmon and CV steelhead, and as physical habitat elements for Sacramento River winter-run Chinook salmon.

1. Spawning Habitat

The essential features of freshwater spawning sites include water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. The current spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams (*i.e.*, Whiskeytown, and Oroville Dams), and in certain undammed tributaries to the Sacramento River (*i.e.*, Mill, Deer, and Butte Creeks) that contain suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. Spawning habitat plays an essential roll in the conservation of listed salmonids as its function directly affects the spawning success and reproductive potential of these species.

2. Freshwater Rearing Habitat

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

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of obstruction with water quantity and quality conditions and contain natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility, survival and food supply. Migratory corridors are downstream of the spawning area and include the lower Sacramento River and the Delta. The conservation roll of these corridors is to provide for the unimpeded upstream passage of adults, and the safe and healthy downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly- screened diversions, and degraded water quality. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage.

4. Estuarine Areas

Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large wood, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas play an important conservation roll for listed anadromous fish as they function as rearing habitat and as an area of transition to the ocean environment.

C. Factors Affecting the Species and Critical Habitat

1. Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Spring-run Chinook Salmon

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for west coast Chinook salmon (Myers *et al*. 1998) and steelhead (Busby *et al*. 1996). Also, the NMFS Biological Review Team (BRT) published a draft updated status review for west coast Chinook salmon and steelhead in November 2003 (NMFS 2003a), and an additional updated and final draft in 2005 (Good *et al*. 2005). NMFS also assessed the factors for Chinook salmon and steelhead decline in supplemental documents (NMFS 1996, 1998). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*i.e.*, 58 FR 33212; 59 FR 440; 62 FR 24588; 62 FR 43937; 63 FR 13347; 64 FR

24049; 64 FR 50394; 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Program (CALFED 2000), and the Final Programmatic EIS for the CVPIA provide a summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley. The following general description of the factors affecting Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead is based on a summarization of these documents.

In general, the human activities that have affected listed anadromous salmonids and the PCEs of their critical habitats consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) over-utilization; (3) disease or predation; and, (4) other natural and manmade factors.

(a) *Habitat Blockage*

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds resulting in the complete loss of substantial portions of spawning, rearing, and migration PCEs. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat actually was available before dam construction and mining, and concluded that 82 percent is not accessible today. Yoshiyama *et al*. (1996) surmised that steelhead habitat loss was even greater than salmon loss, as steelhead migrated farther into drainages. The California Advisory Committee on Salmon and Steelhead Trout (1988) estimated that there has been a 95 percent reduction of Central Valley anadromous fish spawning habitat. In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds.

(b) *Water Diversion*

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles under which juvenile and adult salmonids have evolved. Changes in stream flows and diversions of water affect spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and IWM. More uniform flows year-round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These altered flow patterns have resulted in reduced bedload movement, caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the quality and quantity of available spawning and rearing habitat below dams. In addition, Brown and May

(2000) found stream regulation to be associated with declines in benthic macroinvertebrate communities in Central Valley rivers. Macroinvertebrates are key prey species for juvenile salmonids.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Water temperatures in the Sacramento River have limited survival of young salmon.

(c) *Water Conveyance and Flood Control*

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

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

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996). However, it is now recognized that too much large woody debris was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996). Areas that were subjected to this removal of large woody debris are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry. Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood. Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (NMFS 1996). Wood enters streams inhabited by salmonids either directly from adjacent riparian zones or from riparian zones in adjacent non-fish bearing tributaries. Removal of riparian vegetation and in-stream woody material (IWM) from the streambank results in the loss of a primary source of overhead and in-stream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

(d) *Land Use Activities*

Land use activities such as agricultural conversion, and industrial and urban development continue to have large impacts on salmonid habitat in the Central Valley watershed, affecting spawning habitat, freshwater rearing habitat, freshwater migration corridors, estuarine areas, and nearshore marine area PCEs. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The California Bay-delta Authority (CALFED (2000)) estimated that wetter perimeter reductions in the Delta have decreased from between 25 and 45 percent since 1906. Historically, the San Francisco Estuary included more than 242,000 acres of tidally influenced bay-land habitats and tidal marsh and tidal flats accounted for 98 percent of bay-land habitats. Today only 70,000 acres of tidally influenced habitat remain (CALFED 2000). While historical uses of riparian areas (*i.e.,* wood cutting, clearing for agricultural uses) have substantially decreased, urbanization still poses a serious threat to remaining riparian areas. Riversides are desirable places to locate homes, businesses, and industry. Further, development within the floodplain results in vegetation removal, stream channelization, habitat instability, and point source and non-point source pollution (NMFS 1996). The impacts of riparian vegetation and IWM loss are discussed in section (3) *Water Conveyance and Flood Control.* This habitat simplification has caused a decrease in the diversity of anadromous salmonid species habitat (NMFS 1996).

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

(e) *Over Utilization*

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

Since 1970, the CVI for Sacramento River winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of Sacramento River winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of Sacramento River winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent. In 2001 the CVI dropped to 0.27, most likely due to the reduction in harvest and the higher abundance of other salmonids originating from the Central Valley (Good *et al*. 2005).

Ocean fisheries have affected the age structure of CV spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Ocean harvest rates of CV spring-run Chinook salmon are thought to be a function of the CVI (Good *et al*. 2005). Harvest rates of CV spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of CV spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

(f) *Disease and Predation*

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 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). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that native fish tend to be less susceptible to pathogens than hatchery reared fish. 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 Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, and to a lesser degree CV steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961). Predation on juvenile salmon has increased as a result of water development activities which have created ideal habitats for predators and non-native species. Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile steelhead migrants and increase their avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time.

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion facility, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*i.e.*, Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to in-stream structures and flow dynamics associated with the operation of this facility. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are flushed under the dam gates where they are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. Sacramento pikeminnow is a species native to the Sacramento River basin and has evolved with the anadromous salmonids in this system. However, rearing conditions in the

Sacramento River today (*i.e.*, warm water, low-irregular flow, standing water, diversions) compared to its natural state and function 70 years ago, are more conducive to warm water species such as Sacramento pikeminnow and striped bass than native salmonids. Tucker *et al.* (1998) showed that predation during the summer months by Sacramento pikeminnow on juvenile salmonids jumped to 66 percent of total weight of stomach contents. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also showed that the percent frequency of occurrence for juvenile salmonids and other fish were nearly equal in stomach contents. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area relative to the operation of the dam (*i.e.* relative abundance of predatory fish was much higher when the dam gates were in place and operating). These researchers stated the importance of free flowing conditions to reduce concentrations of forging predators.

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

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the Fish Facilities, and the Suisun Marsh Salinity Control Gates (SMSCG). Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Pickard *et al.* 1982), however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

Although the behavior of salmon and steelhead reduces the potential for any single predator to focus exclusively on them, predation by certain species can be seasonally and locally significant. Changes in predator and prey populations along with changes in the environment, both related and unrelated to development, have been shown to reshape the role of predation (Li *et al.* 1987). 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 and black bass 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).

(g) *Artificial Propagation*

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation by hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of anglers targeting hatchery fish (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels. For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of CV spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

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

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

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

(h) *Ocean Conditions*

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999). This phenomenon has been referred to as the Pacific Decadal Oscillation. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American West. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the West Coast.

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

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (Southern Oscillation-ENSO). El Niño events occur when there is a decrease in the surface atmospheric pressure gradient from the normal-steady trade winds that blow across the ocean from east to west on both sides of the equator. There is a drop in pressure in the east off South America and a rise in the pressure in the western Pacific. The resulting decrease in the pressure gradient across the Pacific Ocean causes the easterly trade winds to relax, and even reverse in some years. When the trade winds weaken, sea level in the western Pacific Ocean drops, and a plume of warm sea water flows from west to east toward South America, eventually reaching the coast where it is reflected south and north along the continents.

El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes coastal currents and upwelling. Principal ecosystem alterations include decreased primary and secondary productivity and changes in prey and predator species distributions.

(i) *Floods and Droughts*

During flood events, land disturbances resulting from logging, road construction, mining, urbanization, livestock grazing, agriculture, fire, and other uses may contribute sediment directly to streams or exacerbate sedimentation from natural erosive processes (California Advisory Committee on Salmon and Steelhead Trout 1988, NMFS 1996). Sedimentation of stream beds has been implicated as a principle cause of declining salmonid populations through-out their range. In addition to problems associated with sedimentation, flooding can cause scour and redeposition of spawning gravels in typically inaccessible areas. As streams and pools fill in with sediment, flood flow capacity is reduced. Such changes cause decreased stream stability and increased bank erosion, and subsequently exacerbate existing sedimentation problems (NMFS 1996). All of these sources contribute to the sedimentation of spawning gravels and filling of pools and estuaries used by all anadromous salmonids. Channel widening and loss of pool-riffle sequence due to aggradation has damaged spawning and rearing habitat of all salmonids.

Unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*i.e.*, Sacramento River winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall.

(j) *Ecosystem Restoration*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and in-stream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for CV steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma

Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Estuary in conjunction with tidal wetland restoration.

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward doubling the natural populations of select anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, in-stream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the Department of Interior's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for CV spring-run Chinook salmon and CV steelhead by maintaining or increasing in-stream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

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

The CDWR's Four Pumps Agreement Program has approved approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreements inception in 1986. Four Pumps projects that benefit CV spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead.

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant benefits to spring-run Chinook salmon attributed to CDFG, but the results have not been quantified.

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District, CDFG, and CDWR allows CDWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cubic feet per second (cfs), only 12 cfs has been developed to date. In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek. In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. CDWR, CDFG, and USFWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the in-stream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

2. Southern Distinct Population Segment of North American Green Sturgeon

The principal factors for the decline in the Southern DPS of North American green sturgeon are reviewed in the proposed listing notice (70 FR 17386) and status reviews (Adams *et al*. 2002, NMFS 2005b), and primarily consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) poor water quality; (3) over-utilization; (4) increased water temperatures; (5) non-native species, and (6), other natural and manmade factors.

(a) *Habitat Blockage and Range*

NMFS (2005) evaluated the ability to rank threats, but concluded that this was not possible due to the lack of information about their impact on the Southern DPS of North American green sturgeon; however, the principle threat considered is the impassible barriers, primarily Keswick and Shasta Dams on the Sacramento River and Feather River that likely block and prevent access to historic spawning habitat (NMFS 2005a). Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams. Historical habitat characteristics, temperature, and geology are summarized by Lindley *et al*. (2006b). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pit River system, and the McCloud River (NMFS 2005a). In contrast, recent modeling evaluations by Mora (2006) indicate little or no habitat in the little Sacramento River or the Pit River exists above Shasta dam; however, a considerable amount of habitat exists above Shasta on the mainstem Sacramento River. Green and white sturgeon adults have been observed periodically in the Feather and Yuba River (USFWS 1995, Beamesderfer *et al*. 2004, Jeff McLain, NMFS, pers. comm., 2006) and habitat modeling my Mora (2006) suggests there is sufficient habitat above Oroville Dam. There are no records of larval or juvenile white or green sturgeon; however, there are reports that green sturgeon may reproduce in the Feather River during high flow years (CDFG 2002), but these are unconfirmed. No green sturgeon have been observed in the San Joaquin River; however, the presence of white sturgeon has been documented (USFWS 1995, Beamesderfer *et al*. 2004) making the presence of green sturgeon likely historically as the two species require similar habitat and their ranges overlap in the Sacramento River. Habitat modeling by Mora (2006) also suggests sufficient conditions are present in the San Joaquin River to Friant Dam, and in the Stanislaus, Tuolumne, and Merced Rivers to the dams. In addition, the San Joaquin River had the largest spring-run Chinook salmon population in the Central Valley prior to the construction of Friant Dam (Yoshiyama *et al*. 2001) with escapements approaching 500,000 fish. Thus it is very possible, based on prior spring-run Chinook salmon distribution and habitat use of the San Joaquin River, that green sturgeon were extirpated from the San Joaquin basin in a similar manner to spring-run Chinook salmon. The loss of potential green sturgeon spawning habitat on the San Joaquin River also may have contributed to the overall decline of the Southern DPS of North American green sturgeon.

(b) *Water Diversion*

Based on the limited information regarding the size of green sturgeon larvae and nocturnal behavior during their development as well as the high number of diversions on the Sacramento River, it is reasonable to assume the potential threats of water diversions to green sturgeon are relatively high. 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). At 5 days of age, larvae are approximately 22 mm in total length (Van Eenennaam *et al*. 2001). Based on this information, it is assumed larvae green sturgeon are susceptible to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6), and at a total length of approximatley 22 mm.

Herren and Kawasaki (2001) documented up to 431 diversions in the Sacramento River between Sacramento and Shasta Dam, most of which were unscreened and of the vertical or slant pump type. Entrainment information regarding larval and post-larval Southern DPS of North American green sturgeon is paltry, as the field identification of green sturgeon larvae is difficult. USFWS staff are working on identification techniques and are optimistic that green sturgeon greater than 40 mm can be identified in the field (Bill Poytress, USFWS, pers. comm. 2006). Captures reported by GCID are not identified to species but are asummed to primarily consist of green sturgeon as white sturgeon are known to spawn primarily between Knights Landing and Colusa (Schaffter 1997). Screens at GCID satisfy both the NMFS and CDFG screening criteria; however, the effectiveness of NMFS and CDFG screen criteria is unknown for sturgeon and there is a possibility that larval and post-larval green sturgeon are taken at GCID. Low numbers of Southern DPS of North American green sturgeon have also been identified and entrained at the Red Bluff Research Pumping Plant (Borthwick *et al*. 1999) and the efficacy of identification and enumeration of entrained post-larval green sturgeon is unknown at this location. The ACID diversion facility also may threaten larval and post-larval Southern DPS of North American green sturgeon as the upstream location of this facility exposes larvae and post-larval stages to entrainment. Information on the entrainment and impacts of this diversion on Southern DPS North American green sturgeon are unknown. Information regarding the impacts of other small scale diversion indicated in Herren and Kawaski (2001) in the Sacramento River is unknown.

Presumably, as green sturegon juveniles grow, they become less suseptable to entrainment as their capacity to excape diversions improve. The majority of Southern DPS North American green sturgeon captured in the Delta and San Francisco Estuary are between 200 and 500 mm (CDFG 2002). Herren and Kawasaki (2001) inventoried water diversions in the Delta finding a total of 2,209 diversions of various types, only 0.7 percent of which were screened. The majority of these diversions were between 12 and 24 inches in diameter, likely with relatively little threat to larger juvenile sturgeon. The largest diversions recorded were those of the Fish Facilities in the south Delta. Based on historical data and captures at the Fish Facilities (CDFG 2002), it is reasonable to assume an unknown portion of the juvenile and adult population is excessively stressed, injured, harassed, or killed by the pumping plants.

Eight large diversions greater than 10 cfs and approximately 60 small diversions between 1-10 cfs exist on the Feather River between the Thermalito Afterbay outlet and the confluence with the Sacramento River (USFWS 1995). No studies to date have specifically addressed sturgeon entrainment on the Feather River; however, studies related to Chinook salmon entrainment at the Sutter Extension Water District’s sunrise pumps found significant losses of juvenile salmon (USFWS 1995). Based on potential entrainment problems of green sturgeon elsewhere in the Central Valley and the presence of multiple screened and unscreened diversions in the Feather River, it is assumed that water diversions on the Feather River are a possible threat to juvenile Southern DPS North American green sturgeon.

(c) *Water Conveyance*

The impacts of the development of the water conveyance system in the Central Valley have been reviewed in section C: *Factors Affecting the Species and Critical Habitat, Chinook Salmon and Central Valley Steelhead* of this biological option. As mentioned previously, the impacts of channelizing and bank riprapping include the alteration of river hydraulics and cover along the bank. These changes in bank configuration and structural features can adversely affect important ecosystem functions (Stillwater Sciences 2006). In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting secondary consumer food supply (fish). Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile fish. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. Information on the lateral dispersion of green sturgeon across channel profiles is limited. Based on the benthic orientation of green sturgeon it is assumed habitat related impacts of channelization and riprapping would primarily consist of ecosystem related impacts, such as food source changes, and altered predator densities. The impacts of channelization and riprapping are though to affect larval, post-larval, juvenile and adult stages of Southern DPS North American green sturgeon, as they are all dependant upon the food web in freshwater for at least a portion of their life cycle.

(d) *Migration Barriers*

Adult migration barriers to green sturgeon include structures such as the RBDD, ACID, Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC Gates. Major physical barriers to adult sturgeon migration on the mainstem Sacramento River are the RBDD and ACID diversion dam (USWFS 1995). Unimpeded migration past RBDD occurs when gates are raised between mid September and mid May for Chinook salmon passage measures. Fish ladders at RBDD are designed for salmonid passage and do not pass sturgeon when dam gates are lowered Mid May through mid september; however, improvements to the fish ladders may be possible if they can be designed to emulate the north ladder on Bonneville Dam on the Columbia River, which passes sturgeon successfully (CDFG 2002). Tagging studies by Heublein *et al.* (2006) found a substantial portion of tagged adults failed to pass RBDD prior to May 15 and thus were unable to access spawning habitat upstream. The fate of the blocked green sturgeon is unknown. The Sacramento River Deep Water Ship Channel connects with the Sacramento River near the Cache Slough confluence above Rio Vista and provides a deepened and straightened channel to West Sacramento for commercial shipping purposes. A set of locks at the end of the channel at the connection with Sacramento River (in West Sacramento) "blocks the migration of all fish from the deep water ship channel back to the Sacramento River" (CDWR 2003).

Fremont Weir is located at the end of Yolo Bypass, a 40-mile long basin that functions as a flood control outlet. CDWR (2003) indicates that "sturgeon and sometimes salmon are attracted by high flows into the Yolo Bypass basin and then become concentrated behind Fremont Weir." They are then subject to heavy legal and illegal fishing pressure. In addition, field and anecdotal evidence shows that adult green sturgeon migrate up the Yolo Bypass up the toe drain in autumn and winter regardless of Fremont Weir spills (CDWR 2003). The weir is approximately 90 feet long and 5 feet high containing a poorly functioning fish ladder.

Numerous weirs and barriers in the Sutter Bypass known to be passage issues for Chinook salmon also could block sturgeon migration. Sturgeon are attracted to discharges into the toe drains of the Yolo Bypass and subsequently can't re-enter the Sacramento River. In addition, sturgeon attempt to pass over the Freemont weir during flood flows and become stranded behind the flashboards when the flows recede. Though most of these barriers have fish passage structures that work during certain flows (CDWR 2003), they are mostly designed for salmonid passage and likely block sturgeon.

Upstream migrating adult Chinook salmon are known to utilize the DCC as a migratory pathway (Hallock *et al*. 1970). When the gates are open, Sacramento River water flows into the Mokelumne and San Joaquin Rivers providing migration cues. Attraction to this diverted water is thought to be one of the factors delaying and increasing the straying rate of Chinook salmon (CALFED Science Program 2001, McLaughlin and McLain 2004) and it is likely that green sturgeon are affected in a similar maner. In addition to increased travel distances, gate closures can completely block anadromous fish migrations forcing the fish to hold or retrace their routes through the Delta to reach spawning grounds upstream. DCC gate closures typically occur during the winter and early spring months when sturgeon are believed to migrate. Evidence suggests that female sturgeon reabsorb eggs and forgo spawning if prevented from reaching spawning grounds (USFWS 1995). In addition, potential spawning habitat is blocked. Habitat between RBDD and Jelly's Ferry Bridge (RM 267) contains swift current and pools over 20 feet deep as well as sand-gravel mixtures found to be preferred by spawning white sturgeon (USFWS 1995, Schaffter 1997, CDFG 2002). Significant evidence exists that green sturgeon prefer similar spawning habitat, yet spawn above white sturgeon spawning areas on the Sacramento River (CDFG 2002).

Exact sturgeon spawning locations in Feather River are unknown; however, based on angler catches, most spawning is believed to occur downstream of Thermalito Afterbay and upstream of Cox’s Spillway, just downstream of Gridley Bridge (USFWS 1995). The upstream migration barrier is likely a steep riffle 1 mile upstream of the Afterbay outlet with a depth of approximately 6 inches and length of 394 feet. Potential physical barriers to upstream migration include the rock dam associated with Sutter Extension Water District’s sunrise pumps, shallow water caused by a head cut at Shanghai Bend, and several shallow riffles between the confluence of Honcut Creek and the Thermalito Afterbay outlet (USFWS 1995). These structures are likely to present barriers to sturgeon during low flows blocking and or delaying migration to spawning habitat.

(e) *Poor Water Quality*

Point source and non-point-source pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e.* concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for steelhead survival (NMFS 1996).

Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, Reclamation District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). Discharge of rice irrigation water has caused mortality to both *Ceriodaphnia* and fathead minnows in the Sacramento River and it is believed that rice field discharges in May and June could affect sturgeon larvae survival (USFWS 1995). No specific information is available on contaminant loads or impacts to green sturgeon, however, the difference in distribution of green and white sturgeon (ocean migrants vs. estuarine inhabitants) probably makes green sturgeon less vulnerable than white sturgeon to bioaccumulation of contaminants found in the estuary (CDFG 2002).

High levels of trace elements can also decrease sturgeon early life-stage survival, causing abnormal development and high mortality in yolk-sac fry sturgeon at concentrations at the levels of parts per billion (Dettlaff *et al.* 1981, as referenced in USFWS 1995). Water discharges from Iron Mountain Mine have affected survival of fish downstream of Keswick Dam and storage limitations and limited availability of dilution flows cause downstream copper and zinc levels to exceed salmonid tolerances (USFWS 1995). Although the impact of trace elements on Southern DPS of North American green sturgeon production is not completely understood, negative impacts are suspected (USFWS 1995).

Organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Feather River (USFWS 1995). Feather River water collected at Verona on May 27 and June 5, 1987, resulted in a 50 and 60 percent mortality in *Ceriodaphnia* and fathead minnow bioassays, respectively. Similar effects were also found in the Feather River in 1988 and 1989 (Regional Board, 1991, as cited in USFWS 1995). Toxic effects were attributed to organic contaminants in rice irrigation water released into Jack Slough and into Honcut Creek and Bear River to a lesser degree. Elevated levels of arsenic, chromium, copper, and mercury exceeding median international standards were found in various fish species in the Feather River between 1978 and 1987.

(f) *Over Utilization and Poaching*

Commercial harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries (Jeff McLain, NMFS, pers. comm., 2006). Green sturgeon also have been incidentally captured in the California set-net fishery, in southern California. Adams *et al*. (2002) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River

Estuary by commercial means ranged from 240 fish per year to 6,000 fish per year. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that an average of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appear to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al*. (2002) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). While no sport fishing captures can be attributed to California as all green sturgeon captured are captured incidentally, sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time; however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by Israel (2006a) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

(g) *Increased Water Temperature*

Water temperatures greater than 63 ºF can increase sturgeon egg and larval mortality (PFMC 1992). Temperatures near RBDD on the Sacramento River historically occur within optimum ranges for sturgeon reproduction; however, temperatures downstream of RBDD, especially later in the spawning season, were reported to be frequently above 63 ºF (USFWS 1995). High temperatures in the Sacramento River during the February to June period no longer appear to be a concern as temperatures in the upper Sacramento River are actively managed for Sacramento River winter-run Chinook salmon, and the Shasta temperature control device installed at Shasta Dam in 1997 has thus far been successful in maintaining cool water conditions. A review of temperatures at RBDD during May and June between the years of 1995 and 2004 found no daily temperatures greater than 60 ºF (California Data Exchange Center preliminary data, RBDD daily water temperature data).

Approximately 5 miles downstream of Oroville Dam, water is diverted at the Thermalito Diversion Dam, into the Thermalito Power Canal, thence to the Thermalito Forebay and another powerhouse and finally into the Thermalito Afterbay. The Oroville-Thermalito Complex provides water conservation, hydroelectric power, recreation, flood control, and fisheries benefits. Feather River flows downstream of Oroville Dam to the Thermalito Diversion Dam is often referred to as the "low-flow" river section and maintains a constant 600 cfs. Thus, water temperatures downstream of the Thermalito Afterbay outlet are considerably higher than temperatures in the low-flow channel (USFWS 1995). It is likely that high water temperatures (greater than 63 ºF) cause deleterious affects on sturgeon egg and larval development, especially for late-spawning fish in drier water years (USFWS 1995). CDFG (2002) also indicated water temperatures may be inadequate for spawning and egg incubation in the Feather River during many years as the result of releases of warmed water from Thermalito Afterbay. They believed that this may be one reason neither green nor white sturgeon are found in the river in low-flow years. It is not expected that water temperatures will become more favorable in the near future (CDFG 2002) and this temperature problem will continue to be a threat.

(h) *Non-native Invasives*

Green sturgeon have most likely been impacted by non-native species introductions resulting in changes in trophic interactions in the Delta. Many of the recent introductions of invertebrates have greatly affected the benthic fauna in the Delta and bays. CDFG (2002) reviewed many of the recent non-native species introductions and the potential consequences to green sturgeon. Most notable species responsible for altering the trophic system of the Sacramento-San Joaquin Estuary include the overbite clam, the Chinese mitten crab, the introduced mysid shrimp (*Acanthomysis bowmani)*, and another introduced isopod (*Gammarus* sp.). These trophic

changes likely have affected green sturgeon by reducing food availability, with adverse impacts to juvenile growth and survival.

(i) *Dredging*

Hydraulic dredging is a common practice in the Delta and San Francisco Estuary to maintain channels for commercial and recreational vessel traffic. Such dredging operations use a cutterhead dredge pulling water upwards through intake pipelines, past hydraulic pumps, and down outflow pipelines to disposal sites placing bottom oriented fish such as North American green sturgeon at risk. Studies by Buell (1992) reported approximately 2,000 sturgeon entrained in the removal of one million tons of sand from the bottom of the Columbia River at depths of 60-80 feet. In addition, dredging operations can elevate toxics such as ammonia, hydrogen sulfide, and copper (NMFS 2006c). Other factors include bathymetry changes and acoustic impacts (NMFS 2006c).

(j) *Conservation Measures*

The AFRP specifically calls for the doubling of natural stocks of Chinook salmon, CV steelhead, striped bass, and white and green sturgeon throughout the Central Valley. Though most efforts of the AFRP have primarily focused on Chinook salmon as a result of their listing history and status, the Southern DPS of North American green sturgeon may receive some unknown amount of benefit from these restoration efforts. For example, the acquisition of water for flow enhancement on tributaries to the Sacramento River, fish screening for the protection of Chinook salmon and CV steelhead, or riparian revegetation and in-stream restoration projects would likely have some ancillary benefits to the Southern DPS of North American green sturgeon. The AFRP has also invested in one green sturgeon research project that has helped improve our understanding of the life history requirements and temporal patterns of the Southern DPS of North American green sturgeon.

Many notable beneficial actions have originated and been funded by the CALFED program including such projects as floodplain and in-stream restoration, riparian habitat protection, fish screening and passage projects, research regarding non-native species and contaminants, restoration methods, and watershed stewardship and education and outreach programs. Prior Federal Register notices have reviewed the details of CVPIA and CALFED programs and potential benefits towards anadromous fish, particularly Chinook salmon and CV steelhead (50 CFR 33102). Projects potentially benefiting North American green sturgeon primarily consist of fish screen evaluation and construction projects, restoration evaluation and enhancement activities, contaminant studies, and DO investigations related to the San Joaquin River Deep Water Ship Channel. Two evaluation projects specifically addressed green sturgeon while the remaining projects primarily address listed salmonids and fishes of the area in general. The new information from research funded by these programs will be used to enhance our understanding of the risk factors affecting recovery of North American green surgeon, thereby improving our ability to develop effective management measures.

3. Critical Habitat

According the NMFS CHART report (2005b) the major categories of habitat-related activities affecting Central Valley salmonids include: (1) irrigation impoundments and withdrawals (2) channel modifications and levee maintenance, (4) the presence and operation of hydroelectric dams, (5) flood control and streambank stabilization, and (6) exotic and invasive species introductions and management. All of these activities affect PCEs via their alteration of one or more of the following: stream hydrology, flow and water-level modification, fish passage, geomorphology and sediment transport, temperature, DO levels, nearshore and aquatic vegetation, soils and nutrients, physical habitat structure and complexity, forage, and predation (Spence *et al*. 1996). According to the NMFS CHART report (2005b), the condition of critical habitat varies throughout the range of the species. Generally, the current function of existing spawning habitat ranges from moderate to high quality, with the primary threats including changes to water quality, and spawning gravel composition from rural, suburban, and urban development, forestry, and road construction and maintenance. Downstream, river and estuarine migration and rearing corridors range in conservation condition from poor to high quality depending on location. Tributary migratory and rearing corridors tended to rate as moderate quality due to threats to adult and juvenile life stages from irrigation diversion, small dams, and water quality. Delta (*i.e.*, estuarine) and mainstem Sacramento and San Joaquin river reaches tended to range from poor to high quality, depending on location. In the alluvial reach of the Sacramento River between Red Bluff and Colusa is in good condition because, despite the influence of upstream dams, this reach retains naturally functioning channel processes that maintain and develop anadromous fish habitat. The river reach downstream from Colusa and including the Delta is poor in quality due to impaired hydrologic conditions from dam operations, water quality from agriculture, degraded nearshore and riparian habitat from levee construction and maintenance, and habitat loss and fragmentation.

Although there are degraded habitat conditions within the action area, NMFS considers the intrinsic value of this area for the conservation of the species to be high because its entire length is used for migration and rearing during extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

IV. ENVIRONMENTAL BASELINE

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

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

1. Status of the Species within the Action Area

The primary conservation roll of the action area is as a migratory corridor for adult Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead, and as migration and rearing habitat for juveniles of these species. A large proportion of all Federally listed Central Valley salmonids are expected to utilize aquatic habitat within the action area. The action area also functions as a migratory and holding corridor for adult North American green sturgeon and as rearing and migratory habitat for juvenile North American green sturgeon.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon are currently only present in the Sacramento River below Keswick Dam, and are composed of a single breeding population (*Status of the Species and Critical Habitat* section). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of Sacramento River winter-run Chinook salmon was provided in the *Status of the Species and Critical Habitat* section. Adult Sacramento River winter-run Chinook salmon are expected to be present in the Sacramento River portion of the action area between November and June (Myers *et al*. 1998, Good *et al*. 2005) as they migrate to spawning grounds. Juvenile Sacramento River winter-run Chinook salmon migration patterns in the Sacramento River and Sutter Slough can best be described by temporal migration characteristics found by the USFWS (2001) in beach seine captures along the lower Sacramento River between Sacramento and Princeton, and in the Delta south of Sacramento along the Sacramento River, and in nearby channels such as Sutter and Georgiana sloughs. Because beach seining samples the shoreline rather than the center of the channel as is often the case in rotary screw traps and trawls, it is considered the most accurate sampling effort in predicting the nearshore presence of juvenile salmonids. In the Sacramento River, between Princeton and Sacramento, juveniles were detected from September through mid April, with highest densities between December and March (USFWS 2001). Delta captures were similar, but slightly later as they are downstream; juveniles were detected between November and mid April with highest densities between December and February. Rotary screw trapping at Knights Landing on the Sacramento River by Snider and Titus (2000) captured juveniles between August and April, with heaviest densities observed first during November and December, and second during January through March. The largest captures occurred during periods of sustained high flow, generally greater that 20,000 cfs. The presence of juvenile Sacramento River winter-run Chinook salmon in Sutter slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). For example, the opening of the DCC gates increases Sacramento River flow entering Sutter Slough, thereby increasing salmonid entrainment into Sutter Slough. In most cases, past catches of Sacramento River winter-run Chinook salmon juveniles in Sutter sloughs have been relatively low (Jeff McLain, NMFS, pers. comm., 2006)

b. *Central Valley Spring-run Chinook Salmon*

CV spring-run Chinook salmon populations currently spawn in the Sacramento River below Keswick Dam, the low-flow channel of the Feather River, and in Sacramento River tributaries including Mill, Deer, Antelope, and Butte Creeks (CDFG 1998). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of CV spring-run Chinook salmon was provided in the *Status of the Species and Critical Habitat* section. Adult CV spring-run Chinook salmon are expected on the Sacramento River between March and July (Myers *et al*. 1998, Good *et al*. 2005). Peak presence is believed to be during February and March (CDFG 1998). In the Sacramento River, juveniles may begin migrating downstream almost immediately following emergence from the gravel with most emigration occurring from December through March (Moyle *et. al.* 1989, Vogel and Marine 1991). Snider and Titus (2000) observed that up to 69 percent of spring-run Chinook salmon emigrate during the first migration phase between November and early January. The remainder of the CV spring-run Chinook salmon emigrate during subsequent phases that extend into early June. The age structure of emigrating juveniles is comprised of YOY and yearlings. The exact composition of the age structure is not known, although populations from Mill and Deer Creek primarily emigrate as yearlings (Colleen Harvey-Arrison, CDFG, pers. comm., 2004), and populations from Butte Creek primarily emigrate as fry (Ward *et. al.* 2002). Younger juveniles are found closer to the shoreline than older individuals (Healey 1991). As is the case for Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in Sutter slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). In most cases, past catches of CV spring-run Chinook salmon juveniles in Sutter slough have been relatively low (Jeff McLain, NMFS, pers. comm., 2006).

c. *Central Valley Steelhead*

CV steelhead populations currently spawn in the mainstem Sacramento River as well as in tributaries to the Sacramento and San Joaquin Rivers. The proportion of steelhead in this DPS that migrate through the action area is unknown. However, because of the relatively large amount of suitable habitat in the Sacramento River relative to the San Joaquin River, it is probably high. Adult steelhead may be present in all parts of the action area from June through March, with the peak occurring between August and October (Bailey 1954, Hallock *et al.* 1957). Highest abundance of adults and juveniles is expected in the Sacramento River part of the action area. Juvenile steelhead emigrate through the Sacramento River from late fall to spring. Snider and Titus (2000) observed that juvenile steelhead emigration primarily occurs between November and May at Knights Landing. The majority of juvenile steelhead emigrate as yearlings and are assumed to be primarily utilizing the center of the channel rather than the shoreline.

d. *Southern DPS of North American Green Sturgeon*

The spawning population of the Southern DPS of North American green sturgeon is currently restricted to the Sacramento River below Keswick Dam, and is composed of a single breeding population (*Status of the Species and Critical Habitat* section), thus the entire population of adults and juveniles must pass through the action area.

A detailed assessment of the migration timing and life history of the Southern DPS of North American green sturgeon was provided in the *Status of the Species and Critical Habitat* section. Adult Southern DPS of North American green sturgeon migrate upstream through the action area primarily between March and June (Adams *et al*. 2002). Larva and post-larvae are present on the lower Sacramento River between May and October, primarily during June and July (CDFG 2002). Small numbers of juvenile Southern DPS of North American green sturgeon have been captured at various locations on the Sacramento River as well in the Delta (in the action area downstream of Sacramento) during all months of the year (IEP Database, Borthwick *et al*. 1999).

2. Status of Critical Habitat Within the Action Area

a. *Sacramento River winter-run Chinook salmon, Central Valley Steelhead and Central Valley spring-run Chinook Salmon*

The action area is within designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Habitat requirements for these species are similar. The PCEs of salmonid habitat within the action area include: freshwater rearing habitat, freshwater migration corridors, and estuarine areas. The essential features of these PCEs include adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food; riparian vegetation, space, and safe passage conditions. The intended conservation rolls of these habitats are to provide appropriate freshwater rearing and migration conditions for juveniles and unimpeded freshwater migration conditions for adults.

The conservation condition and function of this habitat has been severely impaired through several factors discussed in the *Status of the Species and Habitat* section of this biological opinion. The result has been the reduction in quantity and quality of several essential features of migration and rearing habitat required by juveniles to grow, and survive. In spite of the degraded condition of this habitat, the intrinsic conservation value of the action area is high because its entire length is used for extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in streamflows and diversions of water affect freshwater rearing habitat and freshwater migration corridor PCEs in the action area. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area. Accelerated predation as a result of habitat changes in the action area, such as the alteration of natural flow regimes and the installation of bank revetment and other instream structures such as dams, bridges, water diversions, and piers are likely a factor in the decline of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

Within the action area, the essential features of freshwater rearing and migration habitats have been transformed from a meandering waterway lined with a dense riparian vegetation , to a highly leveed system under varying degrees of constraint of riverine erosional processes and flooding. In the reach from Colusa downstream to Verona (RMs 143 to 80) levees have generally been constructed near the edge of the river (USFWS 2000). Severe long-term riparian vegetation losses have occurred in this part of the Sacramento River, and there are large open gaps without the presence of these essential features due to the high amount of riprap (USFWS 2000). Between Verona and Collinsville on the Sacramento River (RMs 80-0) the river is even more ecologically degraded having been impacted by bank protection and riprapping (USFWS 2000). Overall, more than half of the Sacramento Rivers banks in the lower 194 miles have been riprapped (USFWS 2000).

3. Southern Distinct Population Segment of North American Green Sturgeon

The action area is utilized by the Southern DPS of North American green sturgeon adults for holding and migration purposes. North American green sturgeon holding habitat consists of the bottoms of deep pools where velocities are lowest often in off-channel coves or low-gradient reaches of the main channel (Erickson *et al*. 2002). Erickson *et al*. (2002) also found many of these sites were also found close to sharp bends in the Rogue River.

The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to the Southern DPS of North American green sturgeon. It is assumed larval green sturgeon are susceptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal swim-up behavior (starting at day 6). Reduced flows in the action area likely affect year class strength of the Southern DPS of North American green sturgeon as increased flows have been found to improve year class strength.

Adult migration barriers in the action area include the Sacramento Deep Water Ship Channel locks, Fremont Weir, and DCC Gates. These barriers can delay migration of Southern DPS North American green sturgeon affecting reproductive capacity and general health. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for green sturgeon survival (NMFS 1996). In addition, juvenile and adult green sturgeon are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area.

The transformation of the Sacramento River from a meandering waterway lined with dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted ecological processes and potential prey items utilized by green sturgeon while rearing and holding. The effects of channelization on upstream migration of green sturgeon are unknown.

4. Region-specific Habitat Descriptions

This section describes baseline physical river bank conditions within the four SRBPP regions. This section also describes the extent and distribution of riparian vegetation types that occur within the bounds of existing levees, or in areas where no levees exist, within 100 feet of the high water channel edge. The extent and distribution of vegetation cover types within each region, and their associations with identified erosion sites, are presented in Table 7.

a. *Region 1a*

Below Isleton (RM 20), the Sacramento River flows into the Delta, forming a distribution network of sloughs and channels. Flow is additionally received via the Yolo Bypass, which is a leveed, wide floodplain that flows parallel to the west of the mainstem Sacramento River during high flows. Additional flow comes from several water courses that feed into the bypass, including Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, Sacramento Bypass, and Putah Creek. Seasonal high flows enter the Yolo Bypass from the Sacramento River via the Fremont Weir (RM 83) and the Sacramento Weir (RM 63). Flow velocities are low because flow is distributed throughout the Delta channels and sloughs that are bordered by relatively low levees consisting of both natural bank materials and revetment (JSA 1987). These levees and bank protection structures currently prevent the river's access to historical tidal wetlands and islands. Tidal influence extends up the Sacramento River for 80 miles to Verona, with the greatest tidal variation concentrated in the Delta. The major tidal sloughs included within the SRBPP action area are Threemile, Georgiana, Steamboat, Miner, Lindsay, Cache, Haas, and Sutter sloughs.

Sloughs and channels in this region are generally confined on both sides by natural levees enhanced by decades of man-made stabilization efforts. The individual channels and sloughs are moderately sinuous, of uniform width, and do not migrate. Compared with the upper regions, impacts of seasonal flood events are minimal due to both tidal action and the diversion of flow through the upstream flood bypasses and diversions (USFWS 2001). Historically, channel and slough morphology actively adjusted throughout the Delta in response to seasonal variations in flow and sediment load. The decrease in flow velocities caused the deposition of a gradient of coarser to finer material from upstream to downstream (fine sand to clayey silt). The intertidal deposits that border the Delta channels and sloughs are typically characterized by shallow, alternating layers of fine sandy silt and clayey silt, with occasional peaty muds. Artificial fill from hydraulic dredge soils was placed after 1900 throughout the Delta along channel margins and upon various island surfaces (Atwater 1982).

Bank revetments are common throughout this region. Based on a query of the Corps revetment database (USFWS 2002b, Corps 2006a), bank revetments account for approximately two-thirds of the shoreline's linear distance. The erosion sites inventoried by Ayres Associates (2005, 2006) are concentrated along banks with relatively little coverage from bank revetments. The revetments are composed of various material types and sizes, including medium to large (quarry) rock, small and large rubble, and medium to large cobbles. The majority of revetments consist of large (>20 in) rock.

The mapped natural riparian vegetation that falls within region 1a primarily reflects a narrow band of vegetation along the lower Sacramento River (RM 1–20). Approximately half of this area is riparian forest (Table 7). These riparian forests are primarily classified as Great Valley Mixed Riparian forest, but a small amount is classified as Great Valley Cottonwood Forest. Nearly all of the Riparian Scrub/Shrub is classified as Great Valley Riparian Scrub/Shrub. A small fraction of this area supports the invasive exotic giant reed. Ruderal vegetation covers the remaining area of mapped land in region 1a (Table 7).

The riparian community in the Delta has been significantly altered since pre-European settlement times. Broad floodplains near the Delta that were once occupied by tule marshes and vernal pools have become isolated from the channel due to revetment along the levees. Several patches of tule habitat still occur at the mouths of sloughs and several areas downstream of Rio Vista

(RM 12–13). However, riparian vegetation along the major sloughs is restricted to scattered narrow bands typically less than 30 feet wide on banks, berms, and levee faces (Corps 2004).

b. *Region 1b*

Region 1b includes the mainstem Sacramento River from Isleton (RM 20) in the Delta, upstream past the City of Sacramento, to the Feather River confluence (RM 80) at Verona. The region also includes the lower American River from the confluence with the Sacramento River upstream to RM 13, Natomas East Main Drain, Natomas Cross Canal, and Coon Creek Group Interceptor Unit 6. Seasonal high flows enter the adjacent Yolo Bypass from this reach of the Sacramento River via the Sacramento Bypass (RM 63). Tidal influence emanating from Suisun Bay extends up the Sacramento River for 80 miles to Verona, with greater tidal variations occurring downstream during low river stages in summer and fall.

Downstream from the Feather River confluence, the Sacramento River is moderately sinuous (average sinuosity of 1.3), with the channel confined on both sides by natural levees enhanced by decades of man-made stabilization efforts. The channel in this reach is of uniform width, is not able to migrate, and is typically narrower and deeper than less confined upstream reaches due to scour caused by the concentration of shear forces acting against the channel bed (Brice 1977). Channel migration is similarly limited along the lower American River due to the combined influence of closely spaced levees upon the river banks and flow regulation upstream by Folsom Dam.

The natural banks and adjacent floodplains of both rivers are composed of silt- to gravel-sized particles with low to high permeability. Historically, natural flow regimes caused the deposition of a gradient of coarser to finer material, and longitudinal fining directed downstream (sand to bay muds). The deposition of these alluvial soils historically accumulated to form extensive natural levees and splays along the rivers, 5–20 feet above the floodplain for as far as 10 miles from the channel (Thompson 1961). The present day channels are flanked by fine-grained cohesive banks with erosion due to both mass failures and fluvial erosion (C. Harvey, pers. comm., 2002).

Bank revetments currently account for two-thirds of the region-wide shorelines, which is equivalent to revetment proportions within region 1a, based on data obtained from the Corps revetment database (USFWS 2002b, Corps 2006a). At the identified erosion sites, revetments only account for one-third of the shoreline, indicating that the sites are situated along banks possessing relatively few bank revetments. The bank revetment composition includes medium to large (quarry) rock, rubble, and cobbles. The majority of revetments present at the erosion sites and along the banks without erosion sites is large (>20 in) rock.

Because most of these reaches are quite constrained, the total area mapped within this coverage is small compared to the areas mapped in Regions 2 and 3 (Table 7). The mapped area (3,646 acres) includes approximately half disturbed riparian cover types and half natural riparian cover types. Many stretches of levee bank supporting thin ruderal cover are found between patches of remnant natural riparian community types. Most of the area mapped as some kind of natural riparian community type is classified as Riparian Forest; approximately 75 percent is Great Valley Mixed Riparian Forest, and approximately 25 percent is Great Valley Cottonwood Forest. Any remainder is Riparian Scrub/Shrub.

The largest area of erosion sites within action area occurs within region 1b; approximately half of this area is classified as natural riparian vegetation (Table 7). Almost all of the natural riparian vegetation in these erosion sites is labeled Riparian Forest; most is classified as Great Valley Mixed Riparian Forest with small amounts of Great Valley Cottonwood Forest. A much smaller extent of the region 1b erosion sites occur in areas classified as Great Valley Riparian Scrub/Shrub.

c. *Region 2*

Within region 2, the mainstem Sacramento River flows from Colusa (RM 143), downstream of the Colusa Bypass, to the confluences with the Feather River and Sutter Bypass at Verona (RM 80). The channel is generally confined by levees along the river banks except in a few locations where they are set back to provide overflow across point bars of major meander bends (JSA 1987). Contributing flows into this reach are provided by Butte Creek, the Sutter Bypass, and the Feather River (RM 80). To provide flood capacity, overflows at the Tisdale Weir (RM 119) are conveyed into the Tisdale Bypass, which routes the water into the Sutter Bypass. Upstream of the reach, floodwaters may overflow the left bank into Butte Basin via three locations near Chico Landing and through the Moulton (RM 158) and Colusa (RM 146) Weirs. At extremely high river stages, floodwaters may also overflow the right bank of the river and drain into the Colusa Basin, which eventually connects to the Sacramento River and Yolo Bypass via the Colusa Main Drain. The Feather River has a relatively large drainage basin along the Sierra foothills that receives input from several key tributaries, including Honcut Creek, the Yuba River, and the Bear River. Floodwaters may alternatively exit this reach of the Sacramento River via the Fremont Weir (RM 83) into the upper Yolo Bypass.

Within region 2, the mainstem Sacramento River is primarily a sinuous single-thread channel with uniform width, an average sinuosity of about 1.8 (Brice 1977), and an average slope of 0.00003 to 0.0001 (one-tenth to one-half the slope of region 3, RM 143–194). Adjacent levees and revetment are present on both sides of the channel. A narrow berm of natural substrate inside of the levees occurs in some reaches, providing some erodible substrate; however, erosion and deposition are probably greatly diminished from pre-European settlement conditions, compared to the mainstem channel within region 3 (RM 143–194) (USFWS 2001). The adjacent floodplain and natural bank sediments are composed of alluvium consisting of clay- to gravel-sized particles. In contrast to downstream reaches located between the Feather River confluence and the Delta, floodplain sediments in region 2 are generally much finer and cohesive. The toes of the banks also tend to be composed of fine-grained and cohesive sediments, and erosion of the banks is due to both mass failures and fluvial erosion at the coarser sediment contact above the cohesive toe material (C. Harvey, pers. comm., 2002). Available region-wide floodplain habitats have been greatly reduced compared to historical conditions, due to the presence of channel confining levees.

The proportion of revetment coverage within region 2 is approximately 40 percent, based on data queries of the Corps revetment database (USFWS 2002b, Corps 2006a), which is considerably less than revetment coverage of the two downstream regions (Regions 1a and 1b). Greater revetment coverage is present along the mainstem Sacramento River than the lower Feather and Yuba rivers. In region 2, the identified erosion sites are concentrated along banks possessing a relatively high proportion of revetments; erosion sites are more common along banks with revetments than without. Bank revetment composition includes various material types and sizes, such as medium to large rock, rubble, and cobbles. Revetments at the erosion sites and along banks without erosion sites are primarily composed of medium cobble.

In-stream woody material input is only a fraction of the historical rates that occurred prior to levee construction and the clearing of floodplain forests (USFWS 2001). Riparian vegetation is limited to relict stands and individual trees that have taken root on sands deposited over bank revetment. The elimination of channel migration, chute cutoffs, and overbank deposition has reduced the availability of suitable riparian recruitment areas that are essential for developing and maintaining the riparian ecosystem and maintaining IWM recruitment to the Sacramento River over the long-term (Nanson and Beach 1977). However, several areas north of the Feather River confluence include setback levees where some channel meander and associated habitat complexity has been restored.

Except for the Colusa Main Drain, Wadsworth and Cherokee Canals, and Butte Creek, most of region 2 is included in the vegetation coverage (Corps 2007). Of this area, a little less than one-third (31 percent) is classified as natural riparian vegetation. Of the natural riparian vegetation, most is classified as Riparian Forest (3:1 Great Valley Mixed Riparian Forest to Great Valley Cottonwood). Other habitat types include Great Valley Riparian Scrub/Shrub, Emergent Marsh and Riparian Herbaceous. Large areas within the levee confines are also classified as Agricultural lands; many occur on or along the beds of bypasses and sloughs in the region (*i.e.*, the Sutter Bypass). The remaining area is primarily classified as ruderal.

In region 2, 47 of the 49 erosion sites fall within the coverage. One-quarter of the area in these 47 sites is mapped as natural riparian vegetation, most of which is classified as Great Valley Mixed Riparian.

d. *Region 3*

Downstream of Chico Landing (RM 194) to Colusa (143), the Sacramento River meanders between widely spaced setback levees, which allow the river to continue its lateral migration processes within a narrow floodplain. Levees of the Sacramento River Flood Control Project begin downstream from Ord Ferry (RM 184) on the right bank and downstream from Butte City (RM 176) on the left bank. In the uppermost section of this region, overbank flows drain into the Butte Basin along the left bank at three locations: RM 191 (M & T Bend), RM 186.5 (3B's, a natural overflow), and RM 179 (Goose Lake). Floodwaters may also flow over the right bank and drain into the Colusa Basin. Just upstream of Colusa, floodwaters are diverted over Moulton Weir (RM 158) and Colusa Weir (RM 146) into the lower Butte Basin. Also included within region 3 are lower segments of Mud, Deer, and Elder creeks that join the Sacramento River at RM 193, 220, and 230, respectively.

Within region 3, the Sacramento River is a meandering single-thread channel bordered by setback levees. Morphologic features that can be found along this reach include natural overflow areas, point bars, cut-banks, islands, and oxbows. The channel is bounded by natural stream channel and levee alluvium consisting of unconsolidated silt- to cobble-sized particles (Saucedo and Wagner 1992). The median bed material size (D_{50}) is approximately 15 millimeters (WET 1988) that provides a non-cohesive sand or gravel toe to the banks. Channel migration is limited by revetment and other bank protection structures even within the uppermost portion of this region. The highest rates of migration occur in the unconstrained sections and appear to depend upon channel cross section asymmetry and toe scour (C. Harvey, pers. comm., 2002). Additionally, bank erosion tends to be faster in sections where riparian vegetation has been reduced (Micheli et al. 2003). Chute cutoffs that lead to oxbow formations still occur within this reach when high flows breach and cut off a sinuous river bend.

Region 3 contains the smallest proportion of revetted banks, which account for only 16 percent of the total shoreline length, based on data queries of the Corps revetment database (USFWS 2002b, Corps 2006a). In contrast, approximately half of the identified erosion sites possess bank revetments, indicating that, similar to region 2, the erosion sites are concentrated along revetted banks rather than along un-revetted/natural banks. Revetment composition includes small to large rock, rubble, and cobble, with medium (12–20 in) rock and cobble accounting for the majority of revetment materials present in this region.

All of the area within region 3 is included in the vegetation coverage (Corps 2007). Of this area, half is classified as natural riparian vegetation. Over two-thirds of the natural riparian vegetation is classified as Riparian Forests (Table 7) with a 2:1 ratio of Great Valley Mixed Riparian to Great Valley Cottonwood Forests. Riparian Scrub/Shrub is also present and most often occurs along meander bends as a band of early succession Riparian Forest. Large extents of Riparian Herbaceous communities also occur in region 3. As in region 2, extensive portions of the river's historic floodplain have been converted to agricultural uses and many of the more constrained stretches of river are bordered by banks with sparse ruderal vegetation.

Six of the nine erosion sites identified within region 3 fall within areas included in the vegetation coverage, and approximately half of this area supports natural riparian vegetation. All of the erosion site areas that are identified as supporting natural riparian vegetation are classified as Great Valley Mixed Riparian Forest (Table 7).

Table 7. Existing extent of vegetation cover types between current levees and channel, or between channel and 100-foot buffer. Values presented in acres with percent area within each region provided below.

Vegetation cover type	Region 1a		Region 1b		Region 2		Region 3		Total	
	Entire Region	Erosion Sites	Entire Region	Erosion Sites	Entire Region	Erosion Sites	Entire Region	Erosion Sites	SRBPP Action Area	Erosion Sites
Riparian Forest	434	1.4	1,572	55	10,607	21	5,065	8.1	17,677	85
	9 %	100 %	43 %	47 %	21 %	21 %	36 %	54 %	24 %	36 %
Riparian Scrub/Shrub	303	0.0	117	2.7	2,284	4.7	698	0.0	3,401	7.4
	6 %	0 %	3 %	2 %	5 %	5 %	5 %	0 %	5 %	3 %
Riparian Herbaceous	74	0.0	85	0.0	1,702	0.1	1,229	0.0	3,090	0.1
	2 %	0 %	2 %	0 %	3 %	0 %	9 %	0 %	4 %	0 %
Emergent Marsh	27	0.0	12	0.0	1,096	0.0	21	0.0	1,155	0.0
	1 %	0 %	0 %	0 %	2 %	0 %	0 %	0 %	2 %	0 %
Total Natural Riparian	**838**	**1.4**	**1,786**	**57.7**	**15,689**	**25.8**	**7,013**	**8.1**	**25,323**	**92.5**
	18 %	**100 %**	**48 %**	**49 %**	**31 %**	**26 %**	**50 %**	**54 %**	**35 %**	**39 %**
Bare Ground	0	0	0	0	446	0	0	0	446	0
	0 %	0 %	0 %	0 %	0.88 %	0 %	0 %	0 %	1 %	0 %
Agricultural	0.0	0.0	0.0	0.0	5,486	0.0	1,743	0.0	7,228	0.0
	0 %	0 %	0 %	0 %	11 %	0 %	12 %	0 %	10 %	0 %
Ruderal Vegetation	3,862	0.0	1,860	60	29,070	77	5,251	7.0	40,043	144
	82 %	0 %	51 %	51 %	57 %	75 %	37 %	46 %	55 %	61 %
Total Disturbed Riparian	**3,862**	**0.0**	**1,860**	**60.0**	**35,002**	**77**	**6,994**	**7.0**	**47,717**	**144**
	82 %	**0 %**	**51 %**	**51 %**	**69 %**	**75 %**	**49 %**	**46 %**	**66 %**	**61 %**
Total acres of vegetation coverage	**4,700**	**1.4**	**3,646**	**118**	**50,691**	**103**	**14,007**	**15**	**73,040**	**237**
	100 %	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

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

Because the action area encompasses much of the range of the Sacramento River winter-run and CV spring-run Chinook salmon ESUs, and the CV steelhead DPS as well as the Southern DPS of North American green sturgeon, many of the factors affecting the species within the action area are discussed in the general *Status of the Species and Habitat* section of this biological opinion.

The following analysis will focus on portions of the action area that are most relevant to the general location of the proposed action.

1. <u>Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Spring-run Chinook Salmon</u>

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. In-stream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, the main-stream of the river often remains too high and turbid to provide quality rearing habitat. High water temperatures also limit habitat availability for listed salmonids in the lower Sacramento River. High summer water temperatures in the lower Sacramento River can exceed 72 ^{o}F, and create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al*. 1982). In addition, water diversions, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months limiting the survival of juvenile salmonids (Reynolds *et al*. 1993). Impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, non-native species, commercialization, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain essential habitat features by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and SRA. Individual bank protection sites typically range from a few hundred to a few thousand lf in length. Such bank protection generally results in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat.

Impacts at the reach level result primarily from halting erosion and reducing riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in IWM.

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

The Corp's SRBPP constructed bank protection projects at RM 149 in 2001, and 56.7 in 2004. The RM 149 project included conservation measures recommended by NMFS and the USFWS to remove the jeopardizing effects of the action. These conservation measures included the option of constructing a set-back levee, or implementing other measures identified by the IWG that would create or restore floodplain habitats, create additional riparian habitat, increase IWM recruitment, or improve the growth and survival of listed salmon and steelhead in the action area. The RM 56.7 project reaffirmed the commitment to implement conservation measures at RM 149, and described similar measures to minimize the effects of construction at RM 56.7. The RM 56.7 project also identified a timeline for implementing the conservation measures. The conservation measures as required by the biological opinions have been met through a variety of projects. Emergency levee repairs conducted between 2006 and 2007, and described below, included significant habitat enhancement measures within the action area. These habitat improvements were quantified by the Corps in their SAM analysis of 29 constructed repair sites for the SRBPP. Some small habitat deficits remained, and the Corps, with NMFS' approval, used the SAM analysis to quantify the deficit, and purchased habitat restoration credits from the Wildlands Inc., Anadromous Salmonid Conservation Bank at Fremont Landing, on the Sacramento River.

Additional off-site conservation will be implemented on the right (*i.e.*, north) bank of the Lower American River, 0.5 miles above the confluence with the Sacramento River, and at a site on the Sacramento River, near RM 81. Construction is expected to begin in 2008 or 2009.

The Lower American River compensation project length is approximately 1,000 feet, the width varies from 0 to 300 feet measured from the edge of the river, and the project footprint is approximately 4 acres. This reach of the lower American River was substantially altered by the massive amounts of sediment deposited as a result of historic hydraulic mining in the upper watershed. The result is an elevated floodplain that has significantly altered the natural relationship between the river and the surrounding floodplain. The desirable vegetation communities are not reproducing and the floodplain is rarely available to fish. The Corps has issued a design contract, and construction will be initiated during 2007. The predominant project feature would be a large graded bench with an elevation range between 4 and 12 feet covering approximately a 2.0 acre area. The majority of this area is between elevation 5 and 9 feet. These elevations are designed to produce shallow inundation at average spring and winter river stages of 8 feet and 9.5 feet, respectively. The bench area grading includes two sloping depressions that are designed with inlets from the main channel to facilitate full drainage of the project site and reduce the risk of stranding fish during the transition to very low water river stages. Overall, the site will support a broad range of riparian habitat, providing a thick band of vegetation near the river and a less dense and varied palette over the rest of the project footprint. The design also includes the incorporation of IWM to provide enhanced fish cover along the bank and brush mattresses to control erosion. A distribution of relatively level benches at various elevations will provide shallow water for diverse salmonid rearing opportunities at target river stages. Preliminary SAM modeling for conceptual designs shows that the American River site will provide extensive habitat value that may fully compensate for the habitat losses at RM 149, and 56.7.

The objectives of the lower American River restoration are to restore natural habitats that will benefit special-status species including Federally listed fish, and several other plant and wildlife species. A primary component is to create juvenile salmonid habitat by constructing a vegetated bench with a range of elevations that will be inundated by typical winter and spring river stages. The range of elevations is designed to provide shallow (*i.e.*, 1 to 3 feet) inundation in the target seasons and to create several planting zones related to hydrologic characteristics. The planting zones will provide a mixture of vegetation types to protect against erosion and provide cover for salmonids. The grading and planting plan is also designed to minimize predator species habitat and eliminate potential fish stranding in an existing closed depression in the terrace at the site. The project design is intended to be consistent with management objectives for Discovery Park, including those presented in the River Corridor Management Plan for the Lower American River.

In November 2006, The Corps SRBPP and CDWR's Division of Engineering completed construction of 33 critical levee erosion repair projects in the Sacramento River, the Bear River, and in Sutter and Cache Sloughs. The Corp's SRBPP constructed bank protection repairs at thirteen sites, along the Sacramento River between RMs 26.9 and 123.5. CDWR constructed bank protection repairs at sixteen sites in the SRFCP. Ten sites were along the Sacramento River, two sites were along the Bear River, two sites were along Cache Slough, one sight was along Sutter Slough, and one site was along Butte Creek. A setback levee was constructed at RM 145.9 to avoid adverse impacts to sensitive aquatic resources. These projects placed rock and wood revetments along the waterside slope of each erosion site. One repair along the Sacramento River was a set-back levee. Overall, these projects reinforced approximately 25,801 lf of shoreline, covering approximately 50.9 acres, with 26.4 acres of rock riprap placed below the mean summer water level. The area above the mean summer water level was covered with soil and planted with riparian vegetation at all Corps and some CDWR sites. Seasonally inundated benches total approximately 11.6 acres. Approximately 6,795 lf of IWM was placed both above the mean summer water level and 7,346 lf was placed below.

Similar to the proposed action, the previous 33 bank protection projects were designed to repair bank and levee erosion and restore and enhance the riparian and SRA habitat. Generally, this was accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features. This approach recreated the elements of natural SRA habitat that otherwise would have been lost as a result of project construction activities and continued erosion. Implementation of these conservation measures was meant to ensure that long-term impacts associated with existing, and future bank protection projects are compensated in a way that prevents incremental habitat fragmentation and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Successful implementation of all conservation measures is expected to improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area.

Despite the integrated conservation measures, short-term impacts are expected from these previously constructed projects. Primarily, long-term (*i.e.*, 5 to 50 year) impacts to listed salmonids will occur in the form of injury or death to juveniles during summer and fall WSELs from the modification of shoreline habitat and the loss of IWM and other SRA. Short-term (*i.e.*,1 to 5 year) effects will occur at winter and spring WSELs, primarily from the temporary reduction of IWM and riparian vegetation. Overall, substantial long-term improvements are expected for the life of the project due to the construction of benches, the application of soil and IWM, and the extensive planting of riparian vegetation. If the habitat values do not meet the modeled values, additional compensation measures will be implemented.

In January, 2007, the Corps began construction on an additional 14 sites, totaling approximately 9,817 lf along the Sacramento River and Sutter Slough. Similar to the 33 projects constructed in 2006, these projects involve placing rock and wood revetments along the waterside slope of each erosion site. Once complete, these projects will affect approximately 21.7 acres. Revegetation of riparian species will occur on approximately 13.3 acres and approximately 7,705 lf of IWM will be anchored along the river's edge. The effects of these projects are similar to the effects of the previously described 33 sites finished in November, 2006, with the exception that construction of the 14 ongoing projects started during winter months and overlapped with peak migration periods for several species and life-history stages of anadromous fish.

In mid-January, 2007, the Brannan-Andrus Levee Maintenance District (BALMD) began 13 levee repair projects along 3,500 lf of the Sacramento River between RMs 10.9 and 15.4. Similar to the previously described levee repair projects, the BALMD repair plans included extensive on-site compensation measures and are expected to maintain, and eventually improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area.

In January, 2007, CDWR began 8 critical levee repair projects in the action area, totaling 11,540 feet. These projects were similar to the previously described levee repairs, and included extensive onsite compensation measures and are expected to maintain and eventually improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Similar to the 14 Corps-constructed sites, these repairs also occurred during winter months, thereby overlapping with peak migration periods for several species and life-history stages of anadromous fish and likely resulted in the injury, or death of some individuals.

To offset the short-term effects of these projects, the Corps and DWR are required to purchase credits in a NMFS-approved conservation bank in the action area. Transactionsfor these credits currently are being processed and are expected to be finalized by July 2008.

Comprehensive aquatic evaluations of these previous projects are not available. Previous biological opinions written since 2001 have emphasized the need for a comprehensive monitoring and evaluation program. In response to these biological opinions, the Corps and CDWR have convened an aquatic monitoring committee that included biologists and engineers from the Corps, CDWR, USFWS, CDFG, and NMFS. The Corps and CDWR have both awarded contracts to begin preliminary aquatic and physical habitat monitoring at all of the sites they have constructed since 2001.

2. Southern Distinct Population Segment of North American Green Sturgeon

Point source and non-point source pollution resulting from agricultural discharge and urban and industrial development occurs in the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Habitat* section. Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, Reclamation District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). In addition, organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of green sturgeon. The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to North American green sturgeon. Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, non-native species, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

The action area is utilized by larvae and post-larvae and to a lesser extent, juvenile North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. 2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

3. Corps Levee Vegetation Management Policy

On September 26, 2006, the Corps' Civil Works Division issued policy guidance for the inspection of Federal and non-Federal flood damage reduction projects. The guidance emphasized that projects with unacceptable ratings would not be eligible for emergency rehabilitation funds, and may lose Federal Emergency Management Agency (FEMA) certification and eligibility for the National Flood Insurance Program (NFIP). Approximately 30 percent of the Nation's unsatisfactory levees are in California. On March 30, 2007, the Corps notified the California Central Valley Flood Protection Board of all State-sponsored projects that received such ratings, and establishing a one-year period to correct unacceptable conditions. Many unsatisfactory ratings were due to the presence of vegetation on levees. The task of correcting unacceptable conditions could require the removal of essentially all trees on levees in California, and result in substantial adverse impacts to the habitat of listed salmon and steelhead throughout the action area, because most of the levees in the action area function as the river bank and often contain the last remains of riparian habitat. This is especially true for SRBPP regions 1a, 1b, and 2, and to a lesser degree in region 3 because the levees are setback from the Sacramento River.

In response to the Corps policy, SAFCA and the Corps sponsored a levee vegetation symposium, and the California State Central Valley Flood Protection Board established an executive-level agency roundtable working group to tackle the issue of levee vegetation within the state. Participation on the roundtable includes executive staff from NMFS, USFWS, CDFG, the Corps, FEMA, the California State Central Valley Flood Protection Board, CDWR, the SAFCA, and the California Central Valley Flood Control Association. The goals of the roundtable are:

1. To establish a dialog among the leadership of levee maintaining agencies and the resources agencies regarding levee vegetation management on California's Central Valley levees.

2. To develop collaborative relationships among the stakeholders to work toward policy solutions regarding vegetation on California's central valley levees.

3. To achieve consensus on broad policy guidance on California levee vegetation standards that protect public safety and critical habitat.

4. To gain agreement on a process and next steps toward establishing and implementing sustainable California levee vegetation standards.

The Roundtable has worked together to produce a document called the California PL 84-99 Eligibility Retention and Flood System Improvement Framework. This framework will allow the 1,600 miles of levees within the Central Valley to retain eligibility under PL 84-99, while striving to protect existing riparian vegetation. The framework includes a short- and long-term conservation strategy that will avoid, minimize, and compensate for vegetation management that may be required to retain PL 84-99 eligibility. NMFS anticipates that because of this framework, significant vegetation removal actions will be avoided.

C. Likelihood of Species Survival and Recovery in the Action Area

A majority of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead currently utilize the Sacramento River for rearing and migration. Some of these fish are expected to use off-channel estuarine areas in Sutter Slough and the Bear River for rearing and migration. Although the conservation condition of critical habitat in these areas is currently degraded, they have high intrinsic conservation value for the species because the conservation roll of these habitats is essential to fulfilling specific life history requirements such as growth and predator avoidance during rearing and outmigration. Recent improvements in bank protection practices that integrate fish habitat features will contribute to improvements of habitat condition and function throughout the action area and will allow degraded areas to establish the essential features and PCEs of critical habitat over the long term.

In their recent evaluation of the viability of Central Valley salmonids, Lindley *et al*. (2006a) found that extant populations of Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon appear to be fairly viable. These populations meet several viability criteria including population size, growth, and risk from hatchery strays. The viability of the overall ESUs to which these populations belong appears low to moderate, as the ESUs remain vulnerable to extirpation due to their small-scale distribution and high likelihood of being affected by a significant catastrophic event. Lindley *et al*. were not able to determine the viability of existing steelhead populations, but believe that the DPS has a moderate to high risk of extirpation since most of the historic habitat is inaccessible due to dams, and because the anadromous life-history strategy is being replaced by residency.

The southern DPS of North American green sturgeon utilize the mainstem Sacramento River for spawning, rearing, and migration purposes. In addition, the Southern DPS of North American green sturgeon are known to occur in Delta areas, and recently have been seen in the Feather and Yuba River. Habitats of the Sacramento River are very important for the Southern DPS of North American green sturgeon as they are the only know location for spawning. Recent population estimates indicate that there are few fish relative to historic conditions, and that loss of habitat has affected population size and distribution. However, sturgeon remain widely distributed along the Pacific coast from California to Washington, and recent findings of fish in the Feather and the Yuba River indicate that their distribution in the Central Valley may be more broad than previously thought. This suggests that the DPS probably meets several viable species population criteria for distribution and diversity, and indicates that the Southern DPS of North American green sturgeon faces a low to moderate risk of extirpation.

Based on these viability assessments, and the recent habitat improvements that have been occurring throughout the action area, Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the southern DPS of North American green sturgeon are likely to continue to survive and recover in the action area.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat in 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CV steelhead, their designated critical habitat, and threatened Southern DPS of North American green sturgeon.

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

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

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

The final step in conducting the "jeopardy" analysis is to consider the additive effects of the environmental baseline, the effects of the action and any reasonably foreseeable cumulative effects to determine the potential for the action to affect the survival and recovery of the species, or the conservation condition of their designated critical habitat.

To evaluate the effects of the proposed action, NMFS examined proposed construction activities, O&M activities, habitat modification, and conservation measures, to identify likely impacts to listed anadromous salmonids within the action area based on the best available information.

The information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of riprapping and in-river construction activities on anadromous habitat and ecosystem function; and documents prepared by the Corps in support of the proposed action (Corps 2007); SAM results; project designs; field reviews, and meetings held between the Corps, NMFS, USFWS, and CDFG.

B. Assessment

The assessment will consider the anticipated nature, duration, and extent of the programmatic action relative to the migration timing, behavior, and habitat requirements of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, and the magnitude, timing, frequency, and duration of project impacts to these species. This is a progammatic analysis and conceptually evaluates effects to listed species and their designated critical habitat. More detailed, specific effects will be analized when individual or groups of actions, that are part of the SRBPP program, are proposed for construction. These future, detailed analyese will append this programmatic biological opinion. Potential effects on listed species and critical habitat include both short-term construction-related effects and long-term project-related effects. Short-term effects include effects on individuals (*i.e.*, displacement, disruption of essential behaviors, mortality) and immediate, short-term effects on habitat. Short-term effects may last several hours to several weeks. Long-term effects typically last months or years, and are generally due to physical alteration of the bank and riparian vegetation adjacent to the water's edge, with consequent impacts upon shaded riverine aquatic cover, nearshore cover, and shallow water habitat. Potentially affected habitat attributes include freshwater and estuarine rearing habitat area and quality, freshwater and estuarine migration habitat conditions, water quality, and predation. The project sites are downstream from the spawning habitat of Chinook salmon and steelhead. Therefore, no short- or long-term effects on spawning habitat for these species are expected.

Short-term construction-related effects generally are evaluated qualitatively, whereas long-term project effects are based on quantitative SAM results. Potential effects on green sturgeon are made qualitatively since this species was listed after the development of the SAM model.

1. Short-term Construction-related Impacts

In-water construction activities, including the placement of rock revetment, could result in direct effects to fish from the placement of rock into occupied habitat during peak migration periods. The project would result in localized, temporary disturbance of habitat conditions that may alter natural behavior patterns of adult and juvenile fish and cause the injury or death of individuals. These effects may include displacement, or impairment of feeding, migration, or other essential behaviors by adult and juvenile salmon, steelhead, and green sturgeon from noise, suspended sediment, turbidity, and sediment deposition generated during in-water construction activities. Some of these effects could occur in areas downstream of the project sites, because noise and sediment may be propagated downstream.

The extent of construction-related effects is dependant upon the timing of the activities, the timing of fish presence in the action area, and their ability to successfully avoid project-related disturbance. Downstream of RM 60, construction will occur between August 1 and November 30, while upstream construction will occur between July 1 and November 30. Peak winter-run Chinook salmon emigration in the action area occurs between November and January, and commonly coincides with initial flow increases of up to 20,000 cfs, which occur from December through February. Juvenile CV spring-run Chinook salmon and CV steelhead migration can begin as early as November, but similar to winter-run, the peak migration occurs during sustained high flow periods between December and March. Adult Sacramento River winter-run Chinook salmon are expected to be present in the action area from December through May, adult CV spring-run Chinook are expected in the action area from January through July, and adult CV steelhead may be present from September through May.

Green sturgeon larvae and post-larvae are present in the action area between June and October with highest abundance during June and July (CDFG 2002), and remain in freshwater portions of the Delta for up to 10 months (Kynard *et al.* 2005). In addition, small numbers of juvenile sturgeon less than two years of age have been captured in the action area sporadically in the past (Jeff McLain, NMFS, pers. comm., 2006). Adult green sturgeon holding occurs in the Sacramento River in deep pools for up to six months per year, primarily between March and July (USFWS 2002a).

a. *Potential Direct Effects from Rock Placement into Occupied Aquatic Habitat*

(1) Salmon and Steelhead. The placement of rock below the waterline will cause noise and physical disturbance that could displace juvenile and adult fish into adjacent habitats, or crush and injure or kill individuals. The impact of rock being placed in the river disrupts the river flow by producing surface water waves disturbing the water column; resulting in increased turbulence and turbidity. Migrating juveniles react to this situation by suddenly dispersing in random directions. This displacement can lead them into predator habitat where they can be targeted, and injured and killed by opportunistic predators taking advantage of juvenile behavioural changes. Carlson et al. (2001) observed this behaviour occurring in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators. Feist (1991) found that noise from pile driving activities in the Puget Sound affected the general behaviour of juveniles by temporarily displacing them from construction areas. Nearly twice as many fish were observed at construction sites on non-pile driving days compared to days when pile driving occurred.

Biological studies conducted at GCID also support that predation may be higher in areas where juveniles are disoriented by turbulent flows or are involuntarily routed into high-quality predator habitat or past areas with higher predator densities (Vogel 2006). Behavioural observations of predator and salmon interactions at GCID also surmised that predators responded quickly to the release of fish during the biological tests and preyed on fish soon after they were released into the water, even when the release locations were periodically changed (David Vogel, Natural Resource Scientists, pers. comm. 2006). This is a strong indication that predators quickly respond to changes in natural juvenile salmonid behavioural responses to disturbance.

NMFS was unable to find any scientific evidence that fish may be injured or killed by crushing from rock placement. Regardless, many juvenile fish are small, relatively slow swimmers, typically found in the upper two feet of the water column, and oriented to nearshore habitat. Larger fish, including adults and smolts probably would respond by quickly swimming away from the placement site, and would escape injury or death. Fry-sized fish (those that are less than 50mm) that are directly in the path of rock placement may be less likely to avoid the impact. Therefore, the placement of large quantities of rock into this habitat has the potential to crush and injure or kill fry-sized salmon and steelhead. However, the best available outmigration data throughout the Sacramento River, indicate that fry-size listed salmon or steelhead are unlikely to be present in the action area during the construction period, unless flood conditions wash fish downstream. In such a case, the Corps would suspend construction until flows subsided. The only area where fry-sized fish are likely to be present during construction is in region 3. Regardless of river flow, fry-sized winter-run Chinook salmon are consistently trapped by CDFG rotary screw traps (RST) at GCID from August through December. RST captures are low in August and peak from October through November. NMFS expects that the presence of these small fish in region 3, during the placement of rock into the Sacramento River, may crush and kill some winter-run Chinook salmon.

The sound generated by the operation of heavy equipment such as crane mounted barges and other construction activities may temporarily affect the behavior of migrating adult salmonids, possibly causing migration delays. However, construction activities are not likely to injure or kill adult winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead because of their crepuscular migration behavior, and because these fish tend to utilize mid-channel, deep water habitats. Construction will be restricted to the channel edge, and will include implementation of avoidance and minimization measures that will prevent impacts to the migrational behavior of listed species.

(2) *Green Sturgeon.* Rock placement will occur while green sturgeon are present in the action area. In-water activities could cause injury or mortality to individual green sturgeon that do not readily move away from the areas directly affected by rock placement. However, NMFS expects that since juvenile and adult green sturgeon show a preference for benthic habitat types, few fish should be exposed to rock placement along the shoreline, and construction activities are not likely to injure or kill juvenile or adult green sturgeon.

b. *Potential Effects of Sediment and Turbidity*

Rock placement and nearshore construction will disturb soils and the riverbed and result in increased erosion, siltation, and sedimentation. Short-term increases in turbidity and suspended sediment may disrupt feeding activities of fish or result in temporary displacement from preferred habitats.

(1) ***Salmon and Steelhead.*** Numerous studies show that suspended sediment and turbidity levels moderately elevated above natural background values can result in non-lethal detrimental effects to salmonids. Suspended sediment affects salmonids by decreasing reproductive success, reducing feeding success and growth, causing avoidance of rearing habitats, and disrupting migration cues (Bash *et al.* 2001). Sigler *et al.* (1984) in Bjornn and Reiser (1991), found that prolonged turbidity between 25 and 50 Nephelometric Turbidity Unit (NTUs) reduced growth of juvenile coho salmon and steelhead. Macdonald *et al.* (1991) found that the ability of salmon to find and capture food is impaired at turbidities from 25 to 70 NTUs. Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Increased sediment delivery can also fill interstitial substrate spaces and reduce cover for juvenile fish (Platts *et. al.* 1979) and abundance and availability of aquatic invertebrates for food (Bjornn and Reiser 1991). We expect turbidity to affect Chinook salmon and steelhead in much the same way that it affects other salmonids, because of similar physiological and life history requirements between species.

Newcombe and Jensen (1996) believe that impacts on fish populations exposed to episodes of high suspended sediment may vary depending on the circumstance of the event. They also believe that wild fish may be less susceptible to direct and indirect effects of localized suspended sediment and turbidity increases because they are free to move elsewhere in the system and avoid sediment related effects. They emphasize that the severity of effects on salmonids depends not only on sediment concentration, but also on duration of exposure and the sensitivity of the affected life stage.

Suspended sediment from construction activities would increase turbidity at the project site and could continue downstream. Although Chinook salmon, steelhead, are highly migratory and capable of moving freely throughout the action area, an increase in turbidity may injure fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Injury is caused when disrupting these behaviors increases the likelihood that individual fish will face increased competition for food and space, and experience reduced growth rates or possibly weight loss. Project-related turbidity increases may also affect the sheltering abilities of some fish and may decrease their likelihood of survival by increasing their susceptibility to predation.

Construction activities are expected to result in periodic turbidity levels that exceed 25 to 75 NTUs, and thus capable of affecting normal feeding and sheltering behavior. Based on observations during similar construction activities in the Sacramento River, turbidity plumes are not expected to extend across the Sacramento River, but rather the plume is expected to extend downstream from the site along the side of the channel. Turbidity plumes will occur during daylight hours during in-water construction. At a maximum, these plumes are expected to be as wide as 100 feet, and extend downstream for up to 1,000 feet. Most plumes extend into the channel approximately 10 to 15 feet, and downstream less than 200 feet. Once construction stops, water quality is expected to return to background levels within hours. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales and straw wattles will minimize the amount of project-related sediment and minimize the potential for post-construction turbidity changes. Since project-related turbidity plumes will be limited to shoreline construction areas, NMFS expects that individual fish will mostly avoid the turbid areas of the river. For those fish that do not avoid the turbid water, exposure is expected to be brief (*i.e.*, minutes to hours) and not likely to cause injury or death from reduced growth, or physiological stress. This expectation is based on the general avoidance behaviors of salmon and the Corps proposal to suspend construction when turbidity exceeds Regional Board standards. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume. However, those juveniles that are exposed to project construction are expected to encounter short-term (*i.e.*, minutes to hours) construction-related water quality changes that will cause injury or death to some individuals by temporarily disrupting normal behaviors, affecting juvenile sheltering abilities, and increasing their susceptibility to predation.

(2) ***Green Sturgeon.*** Green sturgeon will be present in the action area during construction, and therefore may be exposed and affected by short-term increases in turbidity and suspended sediment if these increases disrupt feeding and migratory behavior activities of post-larvae, juvenile, and adult fish. Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to utilize visual cues (Sillman *et al.* 2005). Instead, olfaction appears to be a key feeding mechanism. In addition, green sturgeon are primarily benthic, and their presence along the shoreline is not expected to be common. Therefore, adverse effects including injury or death from temporary increases in sediment and turbidity are not expected.

c. *Other Potential Water Quality Effects*

Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the Sacramento River as a result of accidental spills or leakage from machinery or storage containers, and injure or kill listed salmon, steelhead, and green sturgeon. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. NMFS expects that adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak. NMFS does not expect the project to result in water contamination that will injure or kill individual fish.

d. *Summary of Construction-related Effects*

(1) ***Salmon and Steelhead.*** NMFS expects that relatively low numbers of anadromous salmonids will be present in the action area during construction activities because the construction periods have been scheduled to minimize overlap with primary migration periods. Those fish that are exposed to these activities will encounter short-term (*i.e.*, minutes to hours) construction-related noise, physical disturbance, and water quality changes that may cause injury or death by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors, and affecting sheltering abilities. Some juvenile fish may be crushed, and killed or injured during rock placement, especially fry-sized winter-run Chinook salmon that may be present in region 3. Others may be displaced from natural shelter and preyed upon by piscivorous fish. Although construction will occur during peak migration periods, relatively few juvenile fish are expected to be injured or killed by in-river construction activities because most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors. The implementation of BMPs and other conservation measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. In addition, and with the exception of the occurrence of winter-run Chinook salmon in region 3, peak migration events correspond with periods of high river flows, when in-river construction activities are likely to be suspended. Furthermore, only one cohort, or emigrating year class, out of perhaps four to five within each salmon and steelhead population will be affected. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance.

(2) ***Green Sturgeon.*** NMFS expects that a large, but unknown, number of green sturgeon will be present in the action area during construction because it coincides with the peak spawning period, particularly in reach 2 and 3. Their spawning habitat and spawning behavior may be affected if rock is placed in to deepwater habitats in the upper regions of the action area. Green sturgeon are primarily benthic, and their presence along the shoreline is not common. Therefore, adverse effects including injury or death from construction activities are not expected.

e. *Construction-related effects to Critical Habitat*

Constuction activities will alter the site-scale physical characteristics of the PCEs of salmon and steelhead critical habitat, including elements of freshwater and estuarine rearing and migration habitat. These effects are discussed in detail below in *Section 3, Long Term Impacts*.

2. Effects of Project Operation and Maintenance

O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years) to maintain the flood control and environmental values of the site. Anticipated O&M actions include vegetation management and irrigation for up to three years, periodic rock placement to prevent or repair localized scouring, and periodic replacement or modification of IWM structures. Effects would be limited to the annual placement of up to 600 cubic yards of material at each site. Impacts from O&M actions generally will be similar to the impacts of initial construction, except that they will be smaller and localized. Effects may include injury or death to salmon and steelhead from predation cause by turbidity changes that temporarily disrupt normal behaviors, and affect sheltering abilities. However, since O&M actions are only expected to repair damaged elements of the project, they are expected to be infrequent (*i.e.*, occurring only once every several years), small (*i.e,* only affecting small sections of the project area), and will not occur at all sites. Therefore relatively few fish should be affected by O&M actions, and actual injury and mortality levels will be low relative to overall population abundance and not likely to cause any long-term, negative population responses. Any O&M actions that affect habitat conditions will incorporate BMPs, summer in-water construction windows, and other minimization and avoidance measures to reduce the potential for effects to anadromous salmonids, green sturgeon, and their habitat.

3. Long Term Impacts

a. *General Considerations*

The project is expected to result in long-term habitat modifications, including modifications to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. The modifications will affect fish behavior, growth and survival, and the PCEs of critical habitat including freshwater and estuarine rearing sites and migration corridors.

Long-term project effects include the alteration of river hydraulics and cover along approximately 24,000 lf of shoreline as a result of changes in bank configuration and structural features. These changes may affect the quantity and quality of nearshore habitat for juvenile Chinook salmon and steelhead. Simple armored slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit the deposition and retention of sediment and woody debris. These changes generally reduce the diversity of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators.

Removal of riparian vegetation and IWM from stream banks results in the temporal loss of a primary source of overhead and in-stream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. As a result, habitat diversity, complexity, and quality for survival and growth are diminished. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

Several project features were designed to address the need for ecologically functional shallow-water, floodplain habitat, riparian habitat, and cover in the confined reaches of the lower Sacramento River. The inclusion of a bench, planting riparian vegetation, and placement of IWM will help restore habitat diversity. Irregular shorelines, riparian vegetation, IWM, and variability in bench elevations are expected to create low-velocity zones of deposition where sediment and organic material will be stored and made available to aquatic invertebrates and other decomposers. Vegetated low benches also will provide high-quality shallow water habitat for fish during winter and spring that will increase in value over time, as the vegetation becomes established.

Riparian vegetation along streams provides shade, which incrementally moderates stream temperatures and prevents direct solar exposure of fish at shallow depths. The role of riparian shade in moderating stream temperatures is greatest on small streams and decreases with increasing stream size. Because of the large size of the Sacramento River, relative to its existing shoreline canopy, the effect of riparian vegetation in moderating water temperatures is minor, compared with the effects of reservoir operations, discharge, and meteorological conditions. Similarly, the effect of shade on Sutter Slough is minimal, primarily because of the low elevations and extremely warm summer air temperatures.

Most importantly, the removal of riparian vegetation reduces the potential recruitment of IWM and diverse fish habitat features at the project site and downstream. Minimizing the removal of existing riparian vegetation will reduce project impacts on IWM recruitment. However, for the purpose of the SAM assessment, it is assumed that up to 40 percent of the existing shoreline riparian canopy may be affected by project implementation. This is a very rough estimate, as effects to the riparian canopy will be necessary only to facilitate the placement of rock from a barge. Similarly, although all IWM will be left in place, some IWM will be covered with rock, and the SAM assessment assumes that up to 50 percent of the function of existing IWM will be lost to construction. Extensive revegetation, and installation of additional IWM is expected to reduce these impacts and losses of function.

b. *SAM Analysis*

Long-term project effects to critical habitat and salmonid responses to such changes are measured in terms of the length and area of bank and channel bed disturbed by construction, and the quantity and quality of habitat as measured by the SAM. The SAM was developed by the Corps, in consultation with NMFS, USFWS, CDFG and CDWR, to address specific habitat assessment and regulatory needs for ongoing and future bank protection actions in the SRBPP action area. The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species (with the exception of Southern DPS green sturgeon). A major advantage of the SAM is that it integrates species life history and flow-related variability in habitat quality and availability to generate species responses to project actions over time. Species responses represent an index of a species growth and survival based on a 30-day exposure to post project conditions for a variety of seasons and life-history stages, over the life of the project.

Instead of performing an assessment at each erosion site, the programmatic analysis establishes a representative project site within each of the four regions of the SRBPP to quantify potential impacts to listed salmonids and their habitat within each region. The length of a representative project site was determined by distributing the authorized bank repair length (approximately 24,000 ft) to each region, based on the ratio of the total length of erosion sites within the region to the total length of all erosion sites throughout all four regions. The proportions of each bank repair design were determined considering the practical installation of each of the four designs throughout each of the four regions, based on: (1) hydraulic limitations when installing the riparian and wetland benches; (2) maintenance of hydraulically smooth transitions with vegetated rock slopes (*i.e.*, design 1), upstream and downstream of installed benches that project out from the existing bank-line; and (3) practical and statutory limitations on IWM installed either above or below the mean summer/fall water line. Additionally, region 1b is separated at RM 30 due to the limitations on installing anchored IWM and to the construction of the wetland bench (design 4) downstream of RM 30. The regional proportions of the project designs are as follows:

- Region 1a: 10 percent design 1, 90 percent design 4
- Region 1b (RM 20–30): 10 percent design 1, 90 percent design 4
- Region 1b (RM 30–80): 10 percent design 1, 30 percent design 2, 60 percent design 3
- Region 2: 20 percent design 1, 40 percent design 2, 40 percent design 3
- Region 3: 10 percent design 1, 90 percent design 3

In general, the SAM quantifies habitat values in terms of a bank line or area-weighted species response index (WRI) that is calculated by combining habitat quality (*i.e.*, fish response indices) with quantity (*i.e.*, bank length or wetted area) for each season, target year, and relevant species/life stage. The fish response indices are derived from hypothesized relationships between key habitat variables and the responses of individual species and life stages. Rearing and outmigrating Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead responses to habitat variables tend to be similar, although seasonal presence and exposure may vary.

The response indices vary from 0 to 1, with 0 representing unsuitable conditions and 1 representing optimal conditions for survival and growth. For a given site and scenario (*i.e.*, with or without project), the SAM uses these relationships to determine the response of individual species and life stages to the measured or predicted values of each variable for each season and target year, and then multiplies these values together to generate an overall species response index. This index is then multiplied by the area or lf of bank or the project area to which it applies to generate a weighted species response index, expressed as feet or square feet. The species response index provides a common metric that can be used to quantify habitat values over time, compare project alternatives to existing conditions, and evaluate the effectiveness of on-site and off-site compensation actions. Positive SAM results are a relative index of improved growth and survival conditions, and negative results (SAM deficits) are indicators of reduced growth and survival conditions, or injury and death of individuals exposed to a project site.

The SAM (Corps 2004) employs the following six habitat variables to characterize nearshore and floodplain habitats of listed fish species:

- Bank slope – Bank Slope is an indicator of shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. The relationship of bank slope to fish response is related to how variations in fish size and foraging strategies affect growth potential and expose various species and life stages to predation risk. For fry and smolts of each species, shallow water near the bank is considered to be high value because it provides refuge from predators and low velocity feeding and rearing habitat (Power 1987, Waite and Barnhart 1992, and Schlosser 1991). Smaller fish can avoid predation by piscivorous fish to some degree by selecting shallower water. Although larger fish (*i.e.*, smolts) typically use deeper water habitats, it is assumed that predation risk also increases. Adult life stages are not affected by the same predation as juveniles and tend to utilize deep, mid-channel habitat as migratory corridors. Therefore, adults are not expected to be sensitive to changes in bank slope.

  Bank slope is obtained from point estimates of bank slope (horizontal change to vertical change) using data queries from the Corps revetment database (USFWS 2002b; Corps 2006a). For the purposes of this assessment, the average bank slope extending from the shoreline to a distance of 5 and 10 ft was queried from the revetment database to characterize shallow water habitat. In assessing existing conditions, seasonal water surface elevations within the four regions were not modeled due to the breadth of the action area. Therefore, bank slopes were determined using the revetment database based on summer/fall (low) flow stages and were applied to all seasons for existing conditions.

  The average bank slopes (dW:dH) within the region-wide category range between 1.7 and 2.3. The steeper banks are located in regions 2 and 3, which may be attributed to the presence of cut-banks associated with active channel migration. Conversely, shallower bank slopes are present in regions 1a and 1b, where revetted banks and levees maintain bank form and position. The average bank slopes of the representative erosion sites are nearly equal to the average bank slopes along the shoreline without erosion sites, except in region 1a where the bank slopes at the erosion sites are significantly steeper. This discrepancy in region 1a indicates that superior habitat quality is associated with shallow water habitat along those shorelines without erosion sites, based on preferences of the relevant focus species/life stages to lower bank slopes.

- Floodplain availability – This is the ratio of wetted channel and floodplain area during the 2-year flood to the wetted channel area during average winter and spring flows. Floodplain availability is used as an indicator of seasonally flooded shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. Use of seasonally inundated flooded habitat is generally considered to increase growth of juvenile salmonids due to greater access to areas with high invertebrate productivity from flooded terrestrial matter (Sommer *et al.* 2001). Predation risk in seasonally flooded areas is expected to be less in seasonally inundated areas with large amounts of hiding cover and a lack of piscivorous fish. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in floodplain availability.

  In assessing existing conditions, seasonal water surface elevations within the four regions were not modeled due to the breadth of the action area. Therefore, floodplain inundation areas were determined using the Corps revetment database (USFWS 2002; Corps 2006a), with the area inundated by the 2-year flood event taken as the area bounded by the levees situated along the channel margins (Corps 2007). Only those channel margins situated adjacent to levees were considered in the analysis. Inundation ratios were determined at 125 of the Ayres-identified sites within the geographical extent of the revetment database and then averaged and attributed to the corresponding representative erosion site within each programmatic region.

  The available floodplain habitat is expectedly greater in regions 2 and 3, compared to regions 1a and 1b, due to the presence of setback-levees. A more comprehensive GIS analysis that incorporates broad floodways, such as the Yolo and Sutter bypasses indicates that region 1a has the greatest inundation ratio due to the presence of the expansive Yolo Bypass, which typically floods in one of every two years. In all regions, the floodplain inundation ratios at the representative erosion sites were much smaller than along the shorelines without erosion sites. The greatest differences are present in regions 2 and 3 where erosion sites are concentrated along bank segments in close proximity to revetted levees. As a result, habitat quality is considered to be superior along the shorelines without erosion sites, especially in regions 2 and 3, due to the positive effects of greater inundated floodplain area on shallow water habitat.

- Bank substrate size – This is measured as the median particle diameter of the bank (*i.e.*, D50) immediately below (*i.e.*, 0 to 3 feet) each average seasonal WSEL. Bank substrate size is used as an indicator of juvenile refugia from predators, but also as an indicator of suitable predator habitat. Increased predator density has been observed at riprapped sites relative to natural banks at studies in the Sacramento River and the Delta (Michny and Deibel 1986, Michny 1989). Substrate size also is used as an indicator of food availability. The effects of substrate size on mortality risk are expected to be greatest at small grain sizes due to a lack of cover from avian and piscivorous fish predation. Predation risk is lower at intermediate sizes close to the size of the affected life stage because small interstitial spaces offer cover from predators. Predation risk is highest when grain sizes exceed the length of the affected life stage, because interstitial spaces are capable of providing effective cover for piscivorous fish species. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in bank substrate size.

For this assessment, bank substrate size represents the median particle size (D_{50} in inches) within the submerged portion of the bank immediately below (0–3 ft) the annual water surface level. The bank-length weighted estimates of substrate size were determined using the survey data from the Corps revetment database (USFWS 2002b; Corps 2006a) with a value of 0.25 inch assigned to natural bank areas with fine sediment, and the D_{50} of the dominant substrate in other bank segments dependent on expected design and construction practices at the time of implementation.

The median bank substrate sizes vary between the four regions, where the coarsest sizes are present in regions 1a and 1b, and finest sizes are present in regions 2 and 3. At the erosion sites in regions 1a and 1b, the median bank substrate sizes are nearly half of the median substrate sizes at the banks without erosion sites. This indicates superior habitat quality at the erosion sites with respect to this habitat attribute. In contrast, at the erosion sites in regions 2 and 3, the median bank substrate sizes are coarser in comparison with the median substrate sizes at the banks without erosion sites. This is due to erosion sites being concentrated along revetted banks with coarse materials. Therefore, inferior habitat quality exists at the erosion sites of these two regions with respect to bank substrate size.

- In-stream structure – This is measured as the percent of shoreline coverage of IWM along each average seasonal WSEL. The value of in-stream structure to salmonids has been directly demonstrated by various studies. In-stream structure is an indicator of juvenile refugia from predators (Michny and Hampton 1984, Michny and Deibel 1986). In-stream structure is used as an indicator of food availability, feeding station availability, and as cover and resting habitat for adults. In-stream structure provides high quality resting areas for adults and juveniles, cover from predation, and substrate for macroinvertebrate production (USFWS 2000, Lassettre and Harris 2001, Piegay 2002).

  The linear extent of existing IWM along the shoreline were queried from the Corps revetment database (USFWS 2002b; Corps 2006a) to estimate bank-line coverage. Along the banks in the four regions, similar proportions of IWM coverage are present and range between 17 percent and 20 percent. At the erosion sites of regions 1a and 1b, the proportions of IWM coverage are more than twice the proportions along the shorelines without erosion sites. These IWM coverage proportions are also nearly twice the proportions at the erosion sites in regions 2 and 3. This indicates that the erosion sites of regions 1a and 1b are concentrated along banks containing greater proportions of IWM coverage. In region 3, IWM coverage is a slightly higher proportion of the shoreline at erosion sites than along the shorelines without erosion sites. Because in-stream structure represents a significant contribution to habitat for the focus fish species life stages, superior habitat quality is present at the erosion sites in regions 1a, 1b, and 3. In region 2, IWM coverage represents a smaller proportion of bank length at the erosion sites than within the remainder of the region, which indicates inferior habitat quality at the erosion sites with respect to this habitat attribute.

- Aquatic and submerged terrestrial vegetation – This is measured as the percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal WSEL. Aquatic vegetation is used as an indicator of juvenile refugia from predators, and food availability. Rearing success is strongly affected by aquatic vegetation (Corps 2004). Biological response to aquatic vegetation is influenced by the potential for food production and cover to sensitive life stages. Because salmonid fry and juveniles are commonly found along shore in flooded vegetation (Cannon and Kennedy 2003) increases in aquatic and submerged terrestrial vegetation is expected to result in a positive salmonid response (*i.e.*, increased growth, reduced risk of predation). Adult salmonids are not expected to be sensitive to changes in aquatic or submerged terrestrial vegetation.

  Measurements of the lineal extent of existing vegetation along the summer-fall and winter-spring shorelines were queried from the Corps revetment database (USFWS 2002b; Corps 2006a) under two assumptions: (1) emergent vegetation coverage represents aquatic vegetation in summer and fall because the reported values are based on surveys conducted during those seasons; and (2) ground cover vegetation on the banks becomes submerged during seasonal high flow stages and therefore represents aquatic vegetation in winter and spring.

  Inundated bank vegetation is present in all four regions, while emergent vegetation is present only in the mainstem Sacramento River, the delta sloughs in region 1a, and the lower Feather River of region 2. The presence of this emergent vegetation signifies a unique benefit to in-stream habitat quality in summer and fall. In region 1a, the emergent vegetation is a slightly smaller proportion of the shoreline at erosion sites than along the remainder of the region, indicating inferior habitat at the erosion sites in summer and fall with respect to this habitat attribute. Compared to emergent vegetation, inundated bank vegetation represents a significantly greater proportion of the shorelines in all four regions with the highest proportions occurring in regions 1a, 1b, and 2. The erosion sites of all four regions contain greater proportions of inundated vegetation cover compared to proportions along shorelines without erosion sites. This indicates superior habitat quality at the erosion sites with respect to in-stream habitat improvements from aquatic vegetation cover.

- Overhanging shade – This is measured as the percent of the shoreline coverage of shade along each average seasonal WSEL. The value of overhanging shade is an indicator of juvenile refugia from predators, and food availability. Numerous studies have shown the importance of overhanging shade to salmonids. Overhanging shade provides overhead cover, and allochthonous inputs of leaf litter and insects which provide food for juveniles. Michny and Hampton (1984), and Michny and Deibel (1986) juvenile salmonid abundance was highest in reaches of the Sacramento River with shaded riparian cover.

Estimates of the linear extent of shade along the channel shorelines were queried from the Corps revetment database (USFWS 2002b; Corps 2006a) to estimate bank-line coverage within the regions. While the reported shade coverage represents summer-fall conditions, it is assumed that available shade decreases by 75 percent and 25 percent during winter and spring, respectively, due to seasonal patterns in die-back and leaf out.

The average proportions of shade coverage to the region-wide shade coverage ranges between 24 percent and 30 percent, with the highest proportions existing in region 1a. At the erosion sites of regions 1a and 1b, shade coverage represents greater proportions of bank length than without-erosion sites. This indicates superior habitat quality for the relevant focus fish/life stages at the erosion sites due to the positive effects of increased overhanging shade cover. In contrast, shade proportions at the erosion sites of regions 2 and 3 account for less bank length than along the shorelines without-erosion sites, indicating inferior habitat quality at the erosion sites.

The SAM was used to quantify the responses of the target fish species and life stages to with-project conditions over a 50-year project period relative to the species and life stage responses under without-project (existing) conditions. The assessment followed the general steps outlined in the SAM Users Manual (Corps 2004). All computations were performed using the electronic calculation template provided by Stillwater Sciences. The results are presented in terms of WRIs for each target species, life stages, and season of occurrence in the project area. Input data includes site- and reach-scale data on existing bank slope, floodplain availability, bank substrate size, in-stream structure, aquatic and submerged aquatic vegetation, and overhanging shade at four average seasonal WSELs.

SAM modeling input values are summarized in Appendix A Tables 3 through 22. SAM modeling results are summarized in Appendix A, Tables A-23 through A-81; and Figures A-5 through A119. Results are shown for each species, at each average seasonal WSEL, over a 50 year period, at year 1, 5, 10, 15, and 50. The results are conceptual, and based on estimates of expected project design types, distribution and size. Detailed, specific analyses for individual projects constructed pursuant to this program will be conducted when projects are proposed.

The model is capable of projecting how without-project scenario conditions would change over time. However, the modeling for this project compares the with-project conditions to a static existing baseline to simplify the interpretation of modeling results, and because the baseline SRA conditions at the project sites would decline over the projected 50-year life of the project as the small amount of remaining SRA habitat disappears, without replacement, to ongoing erosion.

Also, given the critical state of the existing sites, the without-project scenario is likely to include emergency flood fighting that would result in substantial habitat degradation.

As with many models, SAM modeling is based on many assumptions about species behavior and response to habitat changes. There also are untested assumptions regarding the response of physical project elements to river flows and other unpredictable environmental events. Therefore, there is uncertainty regarding the results. To account for some of the uncertainty, the Corps, NMFS, USFWS, and fishery scientists from Stillwater Sciences, and the URS Corporation discussed and agreed upon model input variables intended to generate conservative estimates of habitat modification and improvement. The model itself accounts for some of the uncertainty by generating results at four different average WSELs. To account for site diversity, model input values are not measured only at discrete average flow elevations, but within three feet of these elevations. Although the model focuses on a discrete average WSEL, seasonal variability of average flows is accounted for in the project designs because project features, and conservation measures (*i.e.*, benches, vegetation, and IWM) are placed at different elevations within the cross-sectional area of the site. Project-specific, and long-term comprehensive monitoring will measure the success of model results by evaluating habitat evolution. These monitoring results will be used to make adaptive project modifications necessary to ensure that fish and habitat responses occur as predicted.

Further support for expectations regarding the physical response to habitat conditions over time is supported by the monitoring results for similar projects in the American and Sacramento Rivers. Riparian and SRA monitoring at eight bank protection or revegetation projects along the American River, demonstrated that riparian goals for tree and shrub width, height, cover, and shoreline cover were met or exceeded at all sites (Ross, 2006). At the Sand Cove bank protection project, along the Sacramento River, riparian establishment rates after year 1 were high, especially on the upper slope of the project. However, along the lower slope, and on the bench, sediment deposition ranging from six inches to four feet buried much of the willow cuttings and the surface of the rock bench. The extensive placement of IWM at the site (*i.e.*, 80 percent shoreline coverage) may have played a role in the deposition by reducing local velocities. It is not yet known if the willows will emerge through the sediment, but the deposition and reduced shoreline velocities mimic natural floodplain processes that would not otherwise occur at a conventional bank protection project. Observations at the American River sites by staff from SAFCA, Jones and Stokes, and NMFS, found large numbers of salmon fry using project-constructed shallow-water habitat with integrated SRA, and NMFS has observed larval suckers using shallow water habitat refugia provided by the bench and the flooded IWM at the Sand Cove project.

c. *Long-term Region-specific Effects of SRBPP Actions on Anadromous Salmonids*

This section describes the SAM model results for each region using the expected proportions of each bank repair design. For the relevant species and life stages within each region, the habitat responses are dependent on the differences between existing and with-project conditions. In general, negative habitat responses would be expected initially (*i.e.*, years 1–5) under any combination of project designs; initial negative responses are higher in regions 1a and 1b because proportions of existing in-stream and overhead cover, and the potential impact to these habitat features are higher at the erosion sites in regions 1a and 1b, compared with regions 2 and 3 (Appendix A, Table A-3). Initial negative habitat responses would be lower in regions 2 and 3, as a result of expected implementation of project designs that contain more extensive on-site conservation features.

The potential effects on the focus fish species life stages are presented below for each region of the action area. Relative response comparisons are presented on a bank-line weighted basis in Appendix A, Tables A-23 through A-26 and Figures A-5 through A-14); wetted-area weighted results are presented in Tables A-27 through A-30 and Figures A-15 through A-24.

(1) Region 1a. In region 1a, the relatively wide Sacramento River and expansive network of delta sloughs would provide space for riparian and wetland bench construction without impacting hydraulic capacity of the channel network. Therefore, 90 percent of the with-project designs applied to this region are expected to consist of design 4, although anchored IWM in excess of existing coverage conditions would not be installed within this region. A portion of the with-project construction would include the vegetated rock slope design of design 1, in areas where bench construction is not feasible or where transition zones upstream and downstream of installed benches are required to minimize focused erosion on the entire bank protection structure.

In all seasons, the SAM model results indicate potential short-term habitat deficits for all salmon and steelhead life stages; the results are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover under both project designs. Increasing year-round shallow water habitat with aquatic vegetation, and replacing existing in-stream structure coverage under design 4, compensates for the initial reductions in bank-line cover, which later result in habitat improvements for the focus fish life stages. Rearing and emigrating juveniles and smolts typically are not present within this region during summer months. Therefore, modeled summer responses are not indicative of a true response since few listed salmonids are expected to be present and exposed to those habitat conditions.

Juvenile and smolt Chinook salmon and steelhead habitat deficits will occur during fall, winter and spring months, will last for five to ten years, and are expected to cause injury and death of individuals from reduced growth conditions and increased predation. These deficits are followed by long-term habitat gains through year 50 that will result in growth and survival conditions that exceed current baseline conditions.

Adult Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon migrate up the Sacramento River from December through July, and CV steelhead may migrate upstream from September through May. SAM model results show deficits at all sites for all adult anadromous species lasting from 1 to 50 years.

The SAM modeling shows that loss of riparian shade and IWM, may reduce habitat value for adult salmonids due to reduced cover available for resting and holding during upstream migration. Adult steelhead appear to be particularly susceptible to reductions in summer and fall IWM due to the potential importance of in-stream cover for adults that may be holding or migrating upstream. However, the SAM model represents a worst case scenario, and does not consider the proportion of the fish that will migrate close to the river and slough banks. Long-term changes in nearshore habitat conditions generally are expected to have negligible effects on adults because adult Chinook salmon and steelhead generally use deep, mid-channel habitats. Additionally, based on post-project field evaluations of similar projects constructed by the CDWR and the Corps in 2006, the changes do not appear, in any way, to obstruct or delay the upstream migration of any adult fish and will not affect their ability to successfully reach upstream spawning habitat and reproduce. Therefore, although the model shows a negative response for adult migration, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

(2) Region 1b. Channel segments in region 1b include the wide mainstem Sacramento and lower American rivers. To accommodate the USFWS concerns of IWM installation adversely affecting delta smelt habitat, this region was separated at RM 30 to produce two distinct portions, with each portion having its own set of project designs and design proportions. The downstream portion from RM 20–30 would receive the same project designs as region 1a, which would primarily consist of installing a revegetated wetland bench and replacing in-stream structure to existing conditions. The portion upstream (RM 30–80) would be expected to accommodate bench construction and anchored IWM installation along 90 percent of the shoreline. In areas where bank repairs along shorelines are without hydraulic and/or statutory restrictions, IWM would be installed lower on the bank repair structure, to provide year-round in-stream cover. Therefore, the dominant with-project design expected to be implemented in this region would be design 3, which includes installing riparian benches with year-round IWM cover. In instances where wood projections into the channel are limited, anchored IWM would be installed higher up on the repair structure and above the mean summer/fall water line (*i.e.*, design 2). Additionally, a small proportion of the with-project designs implemented in both region 1b portions would include only the vegetated rock slope structure of design 1, in areas where space limitations preclude bench construction and IWM installation or where transitions of the existing revetment upstream and downstream of installed benches are required to satisfy hydraulic factors. The results presented below are for the entire region (*i.e.*, RM 20–80) rather than for the two portions upstream and downstream of RM 30. Rearing and emigrating juveniles and smolts typically are not present within this region during summer and only in low numbers during fall. Therefore, modeled summer responses are not indicative of a true response since listed salmonids are not expected to be present and exposed to those habitat conditions, and the evaluation of fall responses should consider the low abundance.

Similar to the habitat responses in region 1a, the SAM model results indicate potential short-term deficits for juvenile and smolt salmonid habitat in winter and spring, with recovery occurring between year two and seven. These deficits are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover under all project designs implemented in region 1b. The habitat responses in winter and spring are slightly better than those modeled within region 1a, due to smaller initial reductions in in-stream structure and overhead cover. In the fall, small deficits affect Chinook salmon and steelhead juveniles through year 20 and smolts through year 45. In all cases, deficits are expected to cause injury and death of individuals from reduced growth conditions and increased predation.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar to region 1a, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

(3) Region 2. In region 2, the feasibility of installing riparian benches with IWM below the summer/fall water line is varied throughout, due to spatial restrictions imposed by hydraulic factors. Ample space for bench construction is expected along most of the mainstem Sacramento and Feather rivers, but space is more limited along narrower tributaries, such as the lower Yuba and Bear rivers. Therefore, 80 percent of the designs are expected to include riparian benches, and approximately 40 percent could support anchored IWM installed above and below the summer/fall water line (*i.e.*, design 3). In those areas with limited space, design 1 (vegetated rock slope) would be required.

As previously described, the bank coverage differences between existing and with-project conditions are less in regions 2 and 3 compared with those of regions 1a and 1b, using any project design. However, a design 3 bank repair would provide the most beneficial on-site conservation features and would potentially improve habitat quality to greater than existing conditions.

Similar to the habitat responses in region 1a and 1b, the SAM model results indicate potential short-term deficits for juvenile and smolts in fall, winter, and spring months. Fall deficits are the greatest, and recover above modeled baseline conditions by year 15. For winter and spring months, deficits for all species generally recover by year 2. These deficits are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover. In all cases, deficits are expected to cause injury and death of individuals from reduced growth conditions and increased predation.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar to regions 1a and 1b, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

(4) Region 3. In region 3, bench construction and IWM installation is allowable, given the sufficient channel widths, expansive floodplains situated between the mainstem Sacramento River and setback-levees, and relatively lighter large-boat traffic. Further, to maintain existing habitat complexity within the entirety of region 3, a large proportion of the bank repairs will likely require the most comprehensive on-site mitigating features. Therefore, 90 percent of the with-project designs would include design 3, riparian bench with year-round in-stream cover from anchored IWM below the summer/fall water line. A small proportion of the bank repair designs would require the vegetated rock slope of design 1, due to spatial limitations and hydraulic requirements on bench construction.

Similar to the habitat responses in region 2, the SAM model results indicate potential short-term deficits for juvenile and smolt salmonid habitat in fall, winter, and spring months. Fall deficits are the greatest, and recover above modeled baseline conditions between year 7 and 12. For winter and spring months, deficits for all species generally recover by year 2. These deficits are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover. In all cases, deficits are expected to cause injury and death of individuals from reduced growth conditions and increased predation.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar to regions 1a, 1b, and 2, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

d. *Project-wide Effects of SRBPP Actions on Anadromous Salmonids*

To assess aggregate project-wide species responses the SAM results from the four regions were combined. The size and magnitudes of the project-wide responses per life stage depend on the relative differences between the region-specific responses. Therefore, based on the region-specific results discussed in the previous sections, the project-wide results indicate short-term habitat deficits for most of the life stages, due to initial bank-line shade and IWM cover reductions. The potential project-wide combined effects to the focus fish species and life stages, once the expected region-specific proportions of project designs are implemented, are presented in Appendix A, Tables A-31 and A-32 and Figures A-25 through A-30.

In all seasons, the SAM model results indicate potential short-term habitat deficits for all salmon and steelhead life stages; the results are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover under both project designs. Increasing year-round shallow water habitat with aquatic vegetation, and replacing existing in-stream structure coverage compensates for the initial reductions in bank-line cover, which later result in habitat increases for the focus fish life stages. Fall deficits are the most significant with deficits affecting juveniles and smolts for eight to eleven years. Winter and spring deficits for juveniles and smolts generally last from two to four years. These deficits are expected to cause injury and death of individuals from reduced growth conditions and increased predation.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, as with the reach specific responses, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

e. *Analysis of Proposed Offsite Conservation Measures for Anadromous Salmonids*

To compensate for the long-term habitat deficits identified above, the Corps analyzed the following three off-site habitat compensation measures, assuming implementation concurrent with or prior to project construction. Some combination of these measures will be constructed to balance short-term habitat deficits that may result from the construction of levee repair projects.

- Measure 1: Setback levee
- Measure 2: IWM installation
- Measure 3: Shallow bank slope

The SAM was used to assess the effects of the three off-site habitat compensation measures upon the project-wide habitat responses of the four regions with the expected proportions of constructed project designs. Potential off-site compensation site locations within each region were identified based upon GIS analysis of the Corps revetment database (USFWS 2002b; Corps 2006a); off-site compensation sites were identified as revetted bank segments without erosion sites, with no large woody debris and/or overhead cover. Existing conditions at the sites are summarized in Appendix A, Tables A-33, A-36, A-40, and A-44.

(1) Setback Levee Construction. There are between 7,112 and 276,473 linear feet (1.3 and 52.3 linear miles) of potential setback levee identified within each region, based on the GIS analysis discussed above. Although only a fraction of the potential locations for setback levees are expected to be available, working within hydraulic and structural constraints, the proposed setback levee measure would be intended to re-establish natural bank conditions along the main channel and to increase shallow water habitat, a seasonally inundated floodplain, and overhead riparian cover with structural diversity. Active channel migration could re-initiate under these conditions, which would contribute to the natural cycles of habitat disturbance and renewal. Under this scenario, a setback levee would be constructed landward 500 feet from the existing river bank levee. Actual distances would differ depending on site characteristics. The existing levee would be retained, but would be breached in several locations so that seasonal high flows could inundate the restored floodplain situated between the existing levee and the newly constructed setback levee.

Several habitat characteristics would evolve within the modeled 50-year time period in response to the increased floodplain areas at each compensation site. Site conditions are summarized in Appendix A, Tables A-34, A-37, A-41, and A-45. The floodplain inundation ratio would initially be significantly greater than existing conditions, but would gradually decrease due to channel migration into the floodplain. The sites are assumed to migrate laterally approximately 300 ft from the current channel position over 50 years (*i.e.*, 6 ft/yr) based on a meander migration model performed for a proposed setback levee site along the Sacramento River at RM 79 (Corps 2004). During channel migration, the average bank slope of the existing levee and floodplain would likely remain relatively stable, especially in regions 1b, 2, and 3, where existing average bank slopes are characteristic of eroding banks (<3:1). The median size of bank substrates would be reduced to natural silt and sand materials following natural revetment removal and initiation of bank erosion by year 5. The reduction in bank substrate size would improve habitat quality for juvenile and smolt salmonids. Because the compensation site locations were identified along bank segments lacking any IWM or overhead cover, anchored IWM would be installed on the restored floodplains, thus providing in-stream cover during winter and spring. The floodplain and water-side of the setback levee would additionally be revegetated using planting plans similar to those included in the project designs to be implemented at the representative project sites (Corps 2007). In-stream cover from aquatic vegetation and shade from overhead tree canopy would therefore be expected to gradually increase over the modeled time period, when vegetation planted on the newly restored floodplain grows.

Implementing the region-specific proportions of the project designs and the off-site compensation with setback levees, the combined effects on all life stages of the focus fish species are discussed below; results are detailed by region on a bank-line weighted basis and shown in Appendix A, Tables A-48, A-50, A-53, and A-56 and Figures A-31 through A-33, A-37 through A-39, A-46 through A-47, and A-52 through A-53. The combined effects on all life stages of the focus fish species on a wetted-area weighted basis are also detailed by region and shown in Appendix A, Tables A-59, A-61, A-64, and A-67 and Figures A-58 through A-60, A-64 through A-66, A-73 through A-74, and A-79 through A-80). Project-wide relative response comparisons are presented in Appendix A, Tables A-70 and A-73 and Figures A-85 through A-87 and A-94 through A-96.

Based on the SAM results, the setback levee measure conditions would provide long-term improvements to habitat quality, and would potentially compensate for the project-wide habitat deficits during all seasons; the setback levee measure would drive substantial habitat gains through year 50. For all salmonid life stages in winter and spring, habitat responses would exhibit significant positive habitat gains as early as year 1. For juvenile and smolt salmonid habitat in summer and fall, some habitat deficits remain, despite compensation from the increased floodplain habitat conditions, but the habitat rapidly recovers to existing conditions by year 5, followed by long-term habitat gains. For adult habitat in summer and fall, deficits are initially greater compared to juveniles and smolts, due to its greater sensitivity to reductions in in-stream structure and shade; adult habitat recovers to existing conditions by year 15, followed by long-term habitat gains.

Installing the setback levee measure prior to construction of the proposed project designs will reduce the severity of short-term deficits from losses of cover along the newly reconstructed shorelines. Assuming the setback levee measures are implemented 5 years prior to construction of the project designs, the SAM results indicate that habitat responses for all salmonid life stages in all seasons would recover to existing conditions, followed by substantial habitat gains by year

5 at the latest. These results are shown in Appendix A, Tables A-76 and A-79 and Figures A-103 through A-105 and A-112 through A-114.

(2) Installation of Additional IWM. This off-site habitat compensation measure requires installing anchored IWM along the banks of the potential compensation site locations. As stated previously, these identified bank segments possess no large woody debris, which makes them ideal installation locations for IWM to improve habitat conditions for the focus species. Positive habitat gains resulting from the increased in-stream structure would compensate for short- and long-term habitat deficits present at the bank repair project sites in the four regions. With this compensation measure, IWM would be anchored to the existing bank at the average seasonal water surface elevation, to provide year-round in-stream structure. Bank coverage would be 40 percent, and is assumed to remain constant over the modeled time period.

Although concerns were raised during the SAM development about conflicts between beneficial effects of IWM for salmonids and adverse effects upon delta smelt due to increased predator habitat, analysis of this compensation measure proceeds by assuming that IWM installation downstream of RM 30 would be permitted at the identified compensation sites.

For the focus fish species and life stages within all four regions, the potential combined effects from implementing the expected region-specific proportions of the project designs, and the off-site compensations with installed IWM, are presented below. Relative response comparisons on a bank-line weighted basis are briefly presented in Appendix A, Tables A-49, A-51, A-54, and A-57 and in Figures A-34 through A-36, A-40 through A-42, A-48, A-49, A-54, and A-55. Wetted-area weighted results are presented in Appendix A, Tables A-60, A-62, A-65, and A-68 and in Figures A-61 through A-63, A-67 through A-69, A-75, A-76, A-81, and A-82. Project-wide relative response comparisons are presented in Appendix A, Tables A-71 and A-74 and in Figures A-88 through A-90 and A-97 through A-99.

The SAM results indicate that the IWM installation measures would improve habitat quality and would significantly compensate for the project-wide habitat deficits during all seasons. For all salmonid life stages, habitat responses exhibit positive habitat values starting in year 1 with continued habitat gains through the modeled time period. Adult and smolt salmonid habitat responses improve more compared with juvenile habitat responses because adult and smolt salmonids are more sensitive to changes in in-stream structure coverage.

If this compensation measure is implemented 5 years prior to constructing the proposed bank protection projects, SAM results indicate immediate and positive habitat gains in year 0; however, no further improvement of habitat responses occur throughout the remainder of the modeled time period. Results are presented in Appendix A, Tables A-77 and A-80, and Figures A-106 through A-108 and A-115 through A-117.

(3) Shallow Bank Slope. Construction of a shallow bank slope at bank revetment segments that lack IWM and shade coverage was selected as another potential off-site compensation measure. Positive habitat improvements would occur from reducing bank slope. The positive habitat gains would compensate for short- and long-term habitat deficits resulting from the bank repair projects in their associated regions. Under this compensation measure, material would be placed on the chosen bank segments, constructing shallow bank slopes at 3:1 (dW:dH). The existing bank slopes at all identified compensation sites are steeper than a constructed slope, except in region 1a where the existing bank slope is 4.6:1. Therefore, this compensation measure was only assessed in regions 1b, 2, and 3 (Appendix A, Tables A-39, A-43, and A-47).

For the focus fish species and life stages within the four regions, the potential combined effects from implementing the expected proportions of the project designs and this off-site compensation are presented below. Region-specific relative response comparisons on a bank-line weighted basis are presented in Tables A-52, A-55, and A-58 and Figures A-43 through A-45, A-50, A-51, A-56, andA-57. Wetted-area weighted results are presented in Appendix A, Tables A-63, A-66, and A-69 and in Figures A-70 through A-72, A-77, A-78, A-83, and A-84. Project-wide relative response comparisons are presented in Appendix A, Tables A-72 and A-75 and Figures A-91 through A-93 and A-100 through A-102.

By implementing the shallow bank slope measure, the SAM results indicate that the long-term improvements to habitat quality would potentially compensate for the project-wide habitat deficits during all seasons. Habitat responses for juvenile and smolt salmonids rapidly recover by year 1, followed by continued gains in all seasons. For adult salmonids, short-term habitat deficits in winter and spring, and long-term habitat deficits at all times, persist because adults are not affected by changes in near shore bank slope.

By implementing this off-site compensation measure 5 years prior to construction of the proposed bank protection projects, immediate habitat gains in year 0 are possible, based on the SAM results. However, habitat responses do not improve further throughout the remainder of the modeled time period (Appendix A, Tables A-78 and A-81; Figures A-109 through A-111 and A-118 through A-120). This outcome is similar to that of early installation of the IWM measure, as discussed above. However, compensation from the shallow bank slope measure offered the fewest habitat improvements per linear foot, or by area, compared with the improvements provided by the other two measures.

(4) Compensation Site Lengths. The Corps determined minimum compensation lengths for each region using each of the three compensation measures. Through iteration, the total lengths of the compensation sites were calculated by determining the lengths necessary to achieve habitat recovery by year 5, at the latest, for juvenile and smolt life stages of salmonids and all life stages of delta smelt. It was found that the smallest compensation site lengths would be required under measure 2: IWM installation, because this measure does not result in any adverse habitat effects and project-wide effects fully recover by year 5 for all species life stages. This measure is the most efficient at compensating for short- and long-term habitat deficits in comparison with the other two measures. This would potentially be due to the construction timing of the project and compensation sites, and the actual conditions at the sites.

f. *Summary of Long-term Effects to Anadromous Salmonids*

In regions 1a and 1b, and during all seasons, SAM results indicate that short- to long-term habitat deficits would potentially occur with the expected proportions of the project designs. Throughout these two regions, the identified erosion sites (Ayres 2005, 2006) were concentrated along bank segments that contain relatively high proportions of in-stream and overhead cover; the erosion sites in regions 2 and 3 were typically situated along banks and contain lower proportions of bank attributes such as shade, IWM, and shallow slope (Appendix A, Table A-3). As a result, when utilizing the expected proportions of the four bank repair designs, the differences between existing and with-project conditions were greater at the representative erosion sites of regions 1a and 1b; these differences in turn resulted in greater habitat deficits compared to those within regions 2 and 3 (Appendix A, Tables A-23 through A-26). Based on the SAM results, at the representative project sites in regions 2 and 3, initial short-term habitat deficits recovered to existing conditions by year 5 at the latest in winter and spring, and by year 15 in summer and fall. Despite the deficits modeled throughout all four regions, habitat responses exhibited continuous and long-term improvement over the modeled time-period, due to the on-site mitigating features that are implemented as part of the four project designs, especially designs 3 and 4, which include the most comprehensive elements.

Within regions 1a and 1b during all seasons, the long-term habitat deficits contributed to the negative project-wide habitat responses (Appendix A, Tables A-31 and A-32). Off-site habitat compensation utilizing one of three potential measures (setback levees, IWM installation, and shallow bank slope construction) would off-set the project-wide habitat deficits with long-term habitat gains, for all salmonid life stages. The SAM results indicated that habitat responses benefited most with the off-site compensation measure of installing IWM. With the IWM installation measure, all habitat responses exhibited rapid recovery by year 1, with long-term habitat gains through the modeled time period. Compensation from the shallow bank slope measure offered the fewest habitat benefits to the focus species life stages compared with the benefits provided by the other two measures. If implemented 5 years prior to construction of the project designs, compensation from the setback levee measure resulted in habitat response recovery by year 5 at the latest, followed by substantial habitat gains for the focus species life stages in winter and spring, primarily by seasonal floodplain inundation.

g. *Long-term Effects of SRBPP Actions on Critical Habitat*

The long-term effects of SRBPP actions on the critical habitat of winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead can be measured using the SAM results because they represent indices of fish response to habitat change. PCEs that are expected to be affected by levee repair projects includes freshwater and estuarine juvenile rearing and adult and juvenile migration habitat in regions 1a and 1b; and freshwater juvenile rearing, and adult and juvenile freshwater migration habitat in regions 2 and 3.

In region 1a, the SAM model results indicate potential short-term effects to freshwater and estuarine rearing and migration PCEs will last for five to ten years and are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover. The long-term condition of PCEs improves substantially above baseline conditions between years 10 and 50. Modeling results show that adult freshwater migration PCEs also will be affected for up to 50 years. However, since adults are expected to migrate through deeper mid-channel pathways this change will not be significant.

In region 1b, similar to the habitat responses in region 1a, the SAM model results indicate potential short-term effects to freshwater and estuarine rearing and migration PCEs during winter and spring months for 1 to 5 years that are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover. In the fall PCEs are affected for 20 to 45 years.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar to region 1a, NMFS expects that adult fish are not likely to be injured or killed as a result of the loss of overhead cover, since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

In region 2, Similar to the habitat responses in region 1a and 1b, the SAM model results indicate potential short-term effects to juvenile freshwater rearing and migration PCEs in fall, winter, and spring months. Fall effects are the greatest, and recover above modeled baseline conditions by year 15. For winter and spring months, deficits generally recover by year 2. These deficits are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar to regions 1a and 1b, although the model shows a negative response for adult migration PCEs are not expected to be significant because most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

In region 3, similar to the habitat responses in region 2, the SAM model results indicate potential short-term effect to juvenile freshwater rearing and migration PCEs for juvenile and smolt salmonid habitat in fall, winter, and spring months. Fall deficits are the greatest, and recover above modeled baseline conditions between year 7 and 12. For winter and spring months, deficits for all species generally recover by year 2. These deficits are driven by the initial reductions of existing in-stream structure, aquatic vegetation, and overhead cover.

Habitat deficits for adults persist through the modeled time period despite gradual improvements in habitat condition. However, similar region 2, although the model shows a negative response for adult migration PCEs are not expected to be significant because most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

The project, as a whole (*i.e.*, all sites and all regions combined) will cause short-term (*i.e.*, 2 to 12 years) adverse effects to juvenile rearing and migration PCEs, and substantial long-term (*i.e.*, 5 to 50 years) improvements to these PCEs at most seasonal flow elevations. Most deficits result from short-term reductions in vegetation and shade caused by construction and extension of the shoreline away from existing vegetation and shade. Revegetated areas must grow for several years before shade extends over the shoreline. Fall and summer deficits also result from the conversion of shallow-water habitat with fine-textured substrate to large angular rock placed at a 2:1 or 3:1 slope.

Despite the modeled summer and fall habitat deficits, they are not expected to reduce the overall conservation value of rearing and migration PCEs because they will be short-term and increase above baseline conditions over the 50 year life of the project.

4. Impacts of Project Monitoring

Detailed monitoring actions are not proposed as a part of the action. A detailed monitoring plan for on- and off-site monitoring will be submitted with requests to append the programmatic biological opinion for individual or groups of levee repair projects. The individual monitoring plans will include physical habitat and fishery monitoring. The physical habitat monitoring will evaluate how sites meet the compensation criteria of the SAM modeling. The monitoring of physical habitat attributes will use passive measurement techniques that are not expected to adversely affect listed fish or critical habitat.

A fishery monitoring program currently is being implemented by the Corps and CDWR to evaluate fishery responses to critical levee repair projects constructed since 2001. This monitoring program will be expanded to include projects that are built under the remaining authority of Phase II. Although the details of the monitoring effort are not finalized at the time of writing this biological opinion, fishery monitoring is expected to begin in 2009, and continue for at least 5 consecutive years.

Fishery monitoring is expected to include monthly sampling at selected project locations in the action area throughout the juvenile migration period using boat electrofishing methods. If turbidity is low, passive techniques, including direct underwater observation may be used. NMFS does not expect passive techniques to adversely affect listed fish species or critical habitat. Up to 24,000 linear feet of the action area may be monitored during periods of no bench inundation, partial bench inundation, and full bench inundation. Sampling will occur once per month throughout the migration and rearing period of juvenile fish in the action area (*i.e.*, November through May). At a maximum each project site is expected to be sampled 6 times per year. However, sampling is expected to rotate through a panel of representative sites, which will reduce the sampling frequency at an individual site. Electrofishing can result in a variety of effects from simple harassment to injury to the fish (adults and juveniles) and death. There are 2 major forms of injuries from electrofishing; hemorrhages in soft tissues and fractures in hard tissues. Electrofishing can also result in trauma to fish from stress (NMFS 2003b). Recovery from this stress can take up to several days, and during this time the fish are more vulnerable to predation, and less able to compete for resources. Stress-related deaths also can occur within minutes or hours of release, with respiratory failure usually the cause. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Studies also found dramatic negative effects of electrofishing on the survival of eggs from electroshocked female salmon (NMFS 2003b). The effects of electrofishing are further described in the Central Valley Research Opinion (NMFS 2003b).

Because of the spatial and temporal aspect of the electrofishing effort, both juvenile and adult salmonids may be exposed to the sampling; however, because this effort will be conducted along the shoreline, the probability of encountering adults is low. In addition, the study sites for electrofishing are not in the vicinity of adult salmonids in spawning condition or near redds. Juveniles are more likely to be exposed to the sampling activities, but the relatively few studies that have been conducted on juvenile salmonids indicate that spinal-injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish and may therefore be subject to lower injury rates (*e.g.*, Thompson *et al.* 1997). McMichael *et al.* (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River sub basin.

One adult CV steelhead and no listed adult Chinook salmon were captured as a result of IEP electrofishing sampling efforts in 1999, 2001, 2002, and 2003. A total of 8 juvenile Sacramento River winter-run Chinook salmon were captured, a 1 died. During the same sampling period, a total of 35 juvenile CV spring-run Chinook salmon were captured (10 in 2002, and 25 in 2003), and 10 juvenile CV steelhead were captured with no mortality. McLain and Castillo (2006) captured Chinook salmon fry in the Delta and the lower Sacramento River at rates that generally ranged from less than one, to almost five fish per minute. Most of the captured fish were classified as Central Valley fall-run Chinook salmon (CV fall-run Chinook salmon (*O. tshawytscha*)). McLain (NMFS, pers. comm. 2006) estimates that captures in the mainstem Sacramento River north of Sacramento could be as high as 10 fish per minute, and a majority of the fish likely would be fall-run Chinook salmon. McLain (NMFS, pers. comm. 2006), also estimates that each pass through a bank protection project of 1,000 feet would last about 20 minutes.

To determine the potential number of fish that could be affected, this analysis assumes that a total of 24,000 feet of project area will be electrofished up to six times per year, and sampling will last up to 20 minutes per 1,000 feet, with 10 fish captured per minute, a total of 28,800 fish would be captured per year. Assuming that 95 percent of the captured fish are non-listed CV fall-run Chinook salmon, based on juvenile abundance estimates at Red Bluff Diversion Dam (Gaines and Martin 2002) only 1,440 fish would be listed salmonids. Assuming an injury rate of 10 percent (a conservative estimate that doubles the level observed by McMichael *et al.* (1998)), 144 listed salmonids may be injured. At a mortality rate of 5 percent (common level reported in the Central Valley), 72 additional juvenile fish would be killed. If the capture, injury, and mortalities are divided equally between Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead (an assumption based on an equal level of effort occurring during the migration period of each species without accounting for fluctuating juvenile population abundance), the monitoring would result in the annual capture of approximately 480 fish, the annual injury of 48 fish, and the annual mortality of 24 fish for each species. These amounts are divided equally. Actual levels should be lower because not all sites will be sampled, and river flows and scheduling complexities are likely to reduce the sampling frequency to fewer than six times per year.

Green Sturgeon are not expected to be encountered, injured or killed during electrofishing activities. This is expectation is based on the fish's preference for deep habitats within the river corridor, and the understanding that electrofishing will be conducted in shallow water habitats along river margins. Additionally, the electrofishing of levee repair sites throughout the action area over the past two years has not yielded any green sturgeon.

The number of fish that will be captured, injured, or killed is expected to be relatively low compared to the overall abundance of juvenile Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Because sampling will be limited to nearshore areas, and not in adult migration corridors, no more that 1 adult of each species is expected to be captured each year. The anticipated low levels of capture, injury, and mortality are not expected to result in population level impacts. Monitoring results will be used to validate the effectiveness of project conservation measures for avoiding or minimizing adverse impacts of bank protection projects on Federally listed fish species.

5. Interrelated or Interdependent Actions

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). NMFS considered concurrent, ongoing repair of additional PL 84-99 repairs currently being proposed by the Corps as potentially interrelated or interdependent actions to the proposed action. These projects are expected to result in effects to listed salmon, steelhead, and sturgeon that are similar to those previously described in this biological opinion for the proposed action, including short-term adverse effects to these species and their designated critical habitat. NMFS does not consider these actions to be interrelated because there is no single authority or program that binds them together, nor are they interdependent because they would occur regardless of the proposed action.

VI. CUMULATIVE EFFECTS

Cumulative effects including the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area are considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Cumulative effects that are reasonably certain to occur in the action area include non-Federal riprap projects, continuing or future non-Federal water diversions, the discharge of point and non-point source chemical contaminant discharges, and climate change. Depending on the scope of the action, some non-Federal riprap projects carried out by State or local agencies do not require Federal permits. These types of actions, and illegal placement of non-Federal riprap are common throughout the action area. The effects of such actions result in continued fragmentation of existing high-quality habitat, and conversion of complex nearshore aquatic to simplified habitats that affect salmonids in ways similar to the adverse effects associated with the proposed action.

Water diversions through intakes serving numerous small, private agricultural lands and duck clubs along the lower Sacramento River contribute to these cumulative effects. These diversions also include municipal and industrial uses as well as water for power plants. Water diversions affect salmonids and sturgeon by entraining, and injuring or killing adult or juvenile fish.

Contaminants include selenium and numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Contaminants may injure or kill salmonids by affecting food availability, growth rate, susceptibility to disease, or other physiological processes necessary for survival.

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

Sea levels are expected to rise by 0.5 to 1.0 m in the northeastern Pacific coasts in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding and permanent inundation of low-lying natural ecosystems within the action area (*i.e.*, salt marsh, riverine, mud flats) affecting salmonid PCEs. Increased winter precipitation, decreased snow pack, and permafrost degradation could affect the flow and temperature of rivers and streams, with negative impacts on fish populations and the habitat that supports them.

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

An alarming prediction is that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains (CDWR 2006). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold-water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Shasta Lake and Lake Oroville, potentially could rise above thermal tolerances for juvenile and adult salmonids (*i.e.* Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead) that must hold below the dam over the summer and fall periods.

VII. INTEGRATION AND SYNTHESIS

A. Impacts of the Proposed Action on Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, Central Valley Steelhead

The *environmental baseline* section of this biological opinion describes how recent evaluations of the viability of Central Valley salmonids found that extant populations of Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon appear to be fairly viable because they meet several viability criteria including population size, growth, and risk from hatchery strays. The viability of the overall ESUs to which these populations belong appears low to moderate, as the ESUs remain vulnerable to extirpation due to the small-scale distribution of the remaining independent populations and high likelihood of being affected by a significant catastrophic event. Lindley *et al*. were not able to determine the viability of existing CV steelhead populations, but believe that the DPS has a moderate to high risk of extirpation since most of the historic habitat is inaccessible due to dams, and because the anadromous life-history strategy is being replaced by residency. The continued existence of green sturgeon in the Sacramento River and the observation of sturgeon in the Feather and Yuba Rivers indicate that the population is viable and faces a low to moderate risk of extinction. The largest threats to the viability of the ESUs and DPS' are related to loss of access to historic habitats, and the existence of few independent populations, which places the species at risk of extirpation from catastrophic events.

The *cumulative effects* section of this biological opinion describes how future State, tribal, local, or private actions that are reasonably certain to occur in the action area include non-Federal riprap projects, continuing or future non-Federal water diversions, the discharge of point and non-point source chemical contaminant discharges, and climate change. These actions typically result in habitat fragmentation, and conversion of complex nearshore aquatic to simplified habitats which are expected to incrementally reduce the carrying capacity of affected rearing and migration corridors.

NMFS expects that the proposed action will result in adverse short-term, construction-related impacts, O&M-related impacts, habitat impacts, and monitoring impacts that will capture, injure, and kill Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead. Construction-related effects are expected to affect juveniles. Juveniles are expected to be affected because of their small size, reliance on nearshore aquatic habitat, and vulnerability to factors that injure or kill them, or otherwise affect their growth and survival, such as noise or crushing of fish from rock placement and barge activity, changes in water quality that temporarily modify their natural behavior and may reduce their growth or expose them to predation. Although some construction will occur during peak migration periods (*i.e.*, primarily in region 3), relatively few juvenile fish are expected to be injured or killed by in-river construction activities because construction will be suspended under high flow conditions, when the largest numbers of fish are migrating; most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors; and most of those that are exposed to construction are expected to detect project-related disturbance and noise and avoid being injured or killed. Only one cohort, or emigrating year class, out of perhaps four to five within each population will be affected. Furthermore, since construction will not last throughout the entire migration period and will be suspended during high flow conditions, only a small component of that cohort actually will be exposed to construction activities. The implementation of BMPs and other on-site measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and crepuscular migratory behavior enable them to avoid temporary, nearshore disturbance.

O&M impacts will occur for the life of the project and primarily will be caused by infrequent in-water construction and rock placement necessary to maintain the project in functional condition. O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years). Individuals are expected to be injured or killed during the month of November from turbidity-induced predation during the annual placement of the bank protection material of no more than 600 cubic yards of material. Relatively few fish are expected to be injured or killed by O&M activities because the majority of construction will occur before high flows trigger peak migration, and because the implementation of BMPs and other on-site measures are expected to minimize impacts to the aquatic environment.

Fishery monitoring is expected to capture up 48,000 juvenile anadromous salmonids, but only approximately 640 of these fish are expected to be listed salmonids. Most listed fish will be captured, injured, and killed from fish sampling for this period between the months of November and May. NMFS expects that fewer than 10 percent of fish captured will be injured, and fewer than 5 percent will be killed. Consequently, monitoring is expected to injure 64 listed salmonids, and kill up to 32 listed fish. No more than an annual capture of 160 juvenile fish, including an annual injury of 16 fish, and an annual mortality of 8 fish is expected for each Federally listed anadromous salmonid ESU or DPS. No more that 1 adult of each species is expected to be captured each year. Although the specific proportions cannot be estimated because of fluctuating population trends, and inexact estimates of juvenile production; the abundance of fish that may be captured, injured, or killed will be minor compared to the baseline abundance of the species. For example, under current baseline conditions, the juvenile production estimate for winter-run Chinook salmon, which is the most reliable estimate of juvenile production of all the Chinook salmon and steelhead species, and probably lower than spring-run Chinook salmon production, has ranged from approximately 469,000 fry equivalents in 1996 to over 8,900,000 in 2005. The estimated injury and mortality of 16 and 8 individual juveniles of each species respectively, would not have an appreciable effect on these populations.

Based on the SAM results, project effects include short- and long-term habitat deficits for salmonids at various life stages. Habitat deficits will be relatively greater at levee repair projects in regions 1a and 1b because there are greater proportions of habitat attributes that could be affected in comparison with regions 2 and 3. Although on-site mitigating features will be implemented, off-site compensation will be required to compensate for the effects on salmonids, for all life stages and in all seasons. Three potential compensation measures are evaluated in the analysis: setback levee, IWM installation, and shallow bank slope. All three measures were found to compensate for habitat deficits resulting from project effects, with the IWM installation measure offering the greatest compensating benefits. If implemented 5 years prior to construction at the erosion sites, the setback levee compensation measure would provide substantial habitat improvements, which would drive recovery to pre-project conditions by year 5 at the latest, for all focus species' life stages. Compensation from the shallow bank slope measure offered the fewest habitat improvements compared with the improvements provided by the other two measures.

NMFS expects that the most significant project-level habitat deficits will occur at summer and fall flows due to the inherent difficulty of successfully establishing riparian vegetation in a zone that in impacted by boat wake erosion, and variable flow conditions typical of a regulated river system. The modeled summer and fall habitat deficits are expected to affect relatively few fish, since the majority of adult migration and juvenile rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead adult migration and juvenile rearing and emigration occurs during periods of higher flow that are more accurately represented by conditions at average winter and spring WSELs. Short-term habitat deficits at winter and spring WSELs are expected to cause injury and death of individuals at all sites from reduced growth conditions and increased predation, for 2 to 12 years. Long-term effects at the winter and spring WSELs will be substantially positive, with conditions improving beyond existing conditions through year 50.

B. Impacts of the Proposed Action on the Southern DPS of North American Green Sturgeon

NMFS also expects the action to adversely affect the Federally listed Southern DPS of the North American green sturgeon. Adverse effect to these species is expected to be limited to migrating and rearing larvae, post-larvae, juveniles and holding adults. Juveniles are expected to be affected most significantly because of their small size, reliance on aquatic food supply (allochthonous food production), and vulnerability to factors that affect their feeding success and survival. Construction activities will cause disruptions from increased noise, turbidity, and inwater disturbance that may injure or kill larvae, post-larvae, and juveniles by causing reduced growth and survival as well as increased susceptibility to predation. Adverse affects to adults are primarily limited to the alteration of habitat below the waterline affecting predator prey relationships and feeding success. In the absence of modeled response data for green sturgeon, NMFS expects responses to long-term, project-related habitat conditions to be similar to juvenile salmonids, as described above in *Long-term Effects of SRBPP Actions on Anadromous Salmonids*. However, because green sturgeon are not as near-shore oriented as juvenile Chinook salmon, the relative proportion of the green sturgeon population that will be affected by these conditions should be low.

C. Impacts of the Proposed Action on the Survival and Recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead

The adverse effects to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead within the action area are not expected to affect the likelihood of survival and recovery of the ESUs. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Most construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or juvenile fish from migrating to downstream rearing areas. The number of individuals actually injured or killed by construction and O&M activities is expected to be small because only fish that are present during the month of November are expected to be affected, and only a very small proportion of those fish present in November are expected to be injured or killed.

Similarly, the number of fish that will be injured or killed as a result of short-and long-term habitat impacts, as indexed by the SAM will be low and temporary in nature because the most significant loss of habitat condition and function is limited to the low-flow fall WSELs, while the majority of juvenile fish are expected to be present during winter and spring months, when seasonal water elevations are higher, and integrated conservation measures such as riparian vegetation, overhanging shade, IWM and engineered benches are inundated and available to the species. Although Federally listed anadromous fish may be present in the action area during the fall months, abundance is relatively low compared to the number of fish that are present during winter months. Furthermore, although there will be short-term (*i.e.*, 2 to 12 years) SAM-modeled deficits in local habitat value, this is not expected to have significant consequences to the species, because the sites will contain numerous integrated habitat features such as shallow-water benches, and large concentrations of IWM, that will function to provide rearing and refugia habitat until the riparian vegetation becomes established and covers the wetted perimeter of the river channel. Additionally, other nearby habitats will continue to be available to the species for rearing and refugia, and offsite conservation measures will be undertaken to provide compensation within the biological subregions of the action area.

Fishery monitoring will capture, injure, and kill juvenile and adult anadromous fish, but the levels are not significant compared to the overall abundance of the species, and are not expected to reduce the likelihood of the survival and recovery of Federally listed anadromous salmonids in the action area. Furthermore, monitoring will ensure that project conservation measures are functioning to benefit the species. If monitoring shows that project features are limiting the growth and survival of fish in the action area, then those features will be modified or discontinued. If monitoring shows features that are beneficial, they will continue to be maintained and applied to future projects. Monitoring is an essential component for ensuring that the overall action of stabilizing the levee system does not reduce the likelihood of the species survival and recovery in the action area.

The proposed action has specifically been designed to minimize and avoid continued nearshore aquatic and riparian habitat loss from large-scale bank protection projects. The proposed implementation of the integrated conservation measures and the commitment to implement additional compensation measures and conduct a final post-project SAM assessment will ensure that short- and long-term impacts associated with these bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and loss throughout the action area. Although some injury or death to individual fish is expected from construction activities, O&M, and short- and long-term habitat modification, successful implementation of all conservation measures is expected to improve migration and rearing conditions, and the growth and survival of juvenile salmon and steelhead during peak rearing and migration periods by protecting, restoring, and in many cases, increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead within the action area.

D. Impacts of the Proposed Action on the Survival and Recovery of the Southern DPS of North American Green Sturgeon

The adverse effects to Southern DPS of North American green sturgeon within the action area are not expected to affect the overall survival and recovery of the DPS. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses through implementation of on-site and off-site conservation measures. Construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or larvae, post-larvae, and juvenile fish from rearing or migrating to downstream rearing areas. The number of individuals actually injured or killed is expected to be undetectable and negligible and, population-level impacts are not anticipated. Implementation of the conservation measures will ensure that long-term impacts associated with bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon within the action area.

E. Impacts of the Proposed Action on Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead include the short- and long-term modification of approximately 24,000 linear feet of habitat. PCEs include estuarine and riverine areas for juvenile rearing and migration and adult migration. NMFS' CHART (2005b) described existing PCEs within the action area as ranging from high quality to degraded, with isolated fragments of high quality habitat. Even with these degraded condition, the CHART report found that the intrinsic conservation value of the entire action area is high because it is used as a rearing and migration corridor for all populations of winter-run Chinook salmon and CV spring-run Chinook salmon, and by the largest populations of CV steelhead.

Impacts to PCEs generally will last for 2 to 12 years and result from loss or modification of riparian vegetation, shallow-water habitat, and the increase in bank substrate size. These losses and modifications affect juvenile rearing and migration PCEs by reducing in-stream cover and food production. The intended conservation roll of the critical habitat in the action area is primarily as a migration corridor. Freshwater migration corridors must function sufficiently to provide adequate passage; project effects are not expected to reduce passage conditions based on the length of time individual juvenile salmonids will be exposed to the reduced quality and availability of refuge areas as they transit through the action area. Thus, NMFS does not expect the 2 to 12 year reduction in the quality and availability of refuge areas in this reach of the river to impact the current function of the action area or affect its ability to reestablish essential features that have been impacted by past and current actions. From year 12 through 50, the PCEs will improve as vegetation matures and extends over the shoreline. The improved conditions are expected to improve the growth and survival conditions for juvenile fish. Therefore, we do not expect project-related impacts to reduce the conservation condition of designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, the Southern DPS of North American green sturgeon, and CV steelhead, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the programmatic implementation of the remaining projects under Phase II of the SRBPP, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, the Southern DPS of North

American green sturgeon, or CV steelhead, and is not likely to destroy or adversely modify designated critical habitat for the salmonid species.

IX. INCIDENTAL TAKE STATEMENT

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

The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation.

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

A. Amount and Extent of Take

NMFS anticipates incidental take of Sacramento River winter-run Chinook salmon, CV steelhead, CV spring-run Chinook salmon, and the Southern DPS of North American green sturgeon from impacts related to construction, O&M, and through long-term impairment of essential behavior patterns as a result of reductions in the quality or quantity of their habitat. Take is expected to be limited to migrating adults, and migrating, rearing and smolting juveniles.

Because of the programmatic nature of this consultation, NMFS cannot, using the best available information, quantify the anticipated incidental take of individual Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. Additionally, until individual projects are developed and proposed, NMFS is not able to quantify take related to project construction, O&M activities, or fishery monitoring. However, it is possible to describe the general programmatic conditions and ecological surrogates that will lead to the take at both the regional and project-wide scale.

Accordingly, NMFS is quantifying take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon incidental to the action of long-term impacts as indexed by the SAM model, as presented in Appendix A. The following level of incidental take from program activities is anticipated:

1. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon in the form of injury and death from predation caused by construction-related turbidity that extends up to 100 feet from the shoreline, and 1,000 feet downstream, along all project reaches for construction that occurs from August 1 through November 30.

2. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, in the form of harm or injury of fish from O&M actions is expected from habitat-related disturbances from the annual placement of up to 600 cubic yards of material per site for the extent of the project life (*i.e.*, 50 years). Take will be in the form of harm to the species through modification or degradation of juvenile rearing and migration habitat.

3. Take in the form of harm, injury, and death of rearing and smolting Chinook salmon, steelhead, and green sturgeon at fall, summer, spring, and winter WSELs from the modification of nearshore habitat that adversely affects the quality and quantity of juvenile Chinook salmon, steelhead, and green sturgeon habitat as represented by the SAM results shown in Appendix A.

4. Take in the form of capture from monitoring activities is not expected to exceed an annual amount of 480 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of injury is not expected to exceed an annual amount of 48 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the form of death from monitoring activities is not expected to exceed an annual amount of 24 juvenile fish for each Federally listed anadromous salmonid ESU or DPS. Take in the

form of capture, injury, or death is not expected to exceed one adult fish for each Federally listed anadromous salmonid ESU or DPS.

Anticipated incidental take may be exceeded if project activities exceed the criteria described above, if the project is not implemented as described in the biological assessment prepared for this project, or if the project is not implemented in compliance with the terms and conditions of this incidental take statement.

B. Effect of the Take

NMFS has determined that the above level of take is not likely to jeopardize Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, or the Southern DPS of North American green sturgeon. The effect of this action in the proposed project areas will consist of fish behavior modification, temporary loss of habitat value, and potential death or injury of juvenile Sacramento River winter-run Chinook salmon, CV steelhead, and CV spring-run Chinook salmon, and the Southern DPS of North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous salmonids.

1. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids, and the Southern DPS of North American green sturgeon.

3. Measures shall be taken to insure that contractors, construction workers, and all other parties involved with these projects implement the projects as proposed in the biological assessment and this biological opinion.

D. Terms and Conditions

1. Measure shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

a. The Corps shall continue to coordinate with the IWG agencies and the Technical Team of the Interagency Collaborative Flood Management Program during the implementation and monitoring of the remainder of Phase II.

b. The Corps shall develop a soil application manual that describes techniques for integrating soil into rock for the purpose of establishing riparian vegetation and optimizing short- and long-term growth conditions. The manual shall be developed in coordination with the IWG agencies and the expert assistance of riparian ecologists and soil specialists.

c. The Corps shall develop an IWM installation manual that describes IWM placement, density, and maintenance standards.

d. The Corps shall make every reasonable effort to minimize the loss of existing riparian vegetation and allow for the establishment of riparian vegetation at all seasonal WSELs within the project footprint.

e. The Corps shall provide to NMFS a project summary and compliance report within 60 days of completion of construction. This report shall describe construction status, status of project conservation measures; compliance with and the terms and conditions of the final biological opinion; and any observations or other known effects on Sacramento River winter-run Chinook salmon, if any; and any occurrences of incidental take of Sacramento River winter-run Chinook salmon, CV steelhead, the Southern DPS of North American green sturgeon, and CV spring-run Chinook salmon.

f. The Corps shall provide additional annual reports, as necessary, to describe the implementation of off-site conservation measures, to summarize O&M actions, and summarize monitoring results.

g. The Corps shall establish and chair a Project Monitoring Subcommittee to plan monitoring efforts and provide technical support to NMFS for tracking Corps compliance with the biological opinion.

h. The Corps shall increase the duration of project-specific monitoring from 5 to 10 years for all SAM-modeled measures. NMFS does not expect that all measures or all sites will require 10 years of monitoring. Instead, through ongoing cooperation with the IWG agencies, and the Project Monitoring Subcommittee, a select, representative group of project sites will be monitored for this period. This requirement is based on the need to help validate that projects with SAM-modeled results are on a positive trajectory and successfully reaching or exceeding baseline values.

i. The Corps shall develop a final, long-term comprehensive aquatic monitoring plan for the SRBPP by June 30, 2010. Development of this monitoring plan must be done in coordination with the Corps, NMFS, the IWG agencies, and the Project Monitoring Subcommittee; must rely on the expertise of biologists, fluvial geomorphologists, statisticians, and other experts in developing aquatic monitoring plans or programs; and must meet the approval of NMFS before being finalized. The purpose of the comprehensive monitoring is ensure that integrated conservation measures are implemented as proposed, and are within the range modeled in the SAM analysis and analyzed in NMFS biological opinion; are effective for avoiding, minimizing, or enhancing habitat value for listed fish; and to validate the assumptions inherent to the SAM model. Monitoring also will be used to develop future avoidance, minimization, and enhancement measures.

   Monitoring the effectiveness of the measures installed to meet SAM values may require scientific inquiry that extends beyond in-stream data collection. Tools such as computer modeling and hydraulic models as well as tagging studies should be used as necessary to assess the relative value of each element of the SAM model. In-stream studies must include sampling procedures to determine species composition and abundance together with physical observations and measurements at selected construction and control sites.

j. Electrofishing shall be conducted following NMFS Electrofishing Guidelines.

k. The Corps shall develop an adult population index for the Southern DPS of North American Green Sturgeon within the action area. A pilot methodology must be developed by May 1, 2009, and tested during the summer of 2009. The final methodology shall be developed by May 2010 and implemented annually for the duration of SRBPP activities in the action area. This index is necessary to evaluate short- and long-term effects of SRBPP actions on this species and their habitat. Currently, there is not sufficient information available to quantify these effects, while the entire population is known to hold and spawn within the boundaries of the action area.

l. The Corps shall develop a database for storing site monitoring data. The database shall include fields that track SAM-modeled habitat attributes and fishery data over time. The database shall be developed with the oversight the Project Monitoring Subcommittee.

m. The Corps shall ensure that, for the life of the project, future maintenance actions ensure performance of the sites to a level necessary to retain the SAM-modeled habitat values.

2. Measures shall be taken to minimize the impacts of bank protection by implementing integrated onsite and offsite conservation measures that provide beneficial growth and survival conditions for juvenile salmonids.

   a. The Corps shall minimize the removal of existing riparian vegetation and IWM to the maximum extent practicable, and where appropriate, removed IWM will be anchored back into place. NMFS shall be contacted prior to the removal of any tree greater the 4 inches dbh.

   b. The landscape plan for all sites shall include planting fascine bundles as close as possible to the mean August WSEL to provide in-stream vegetation and shoreline shading from 1 year to 5 years following repairs.

   c. The Corps shall ensure that the planting of native vegetation will occur within the same year that construction occurs. All plantings must be provided with the appropriate amount of water to ensure successful establishment.

   d. The Corps shall prepare an updated SAM assessment of all sites upon completion of Phase II. If this assessment shows additional uncompensated habitat deficits, the Corps must provide a compensation strategy to NMFS within 3 months, and any necessary additional compensation must be completed within 12 months.

   e. The Corps shall limit the inwater construction period for routine O&M actions to July 1 to August 31.

   f. The Corps shall limit inwater construction in region 3 to between July 1 and August 31.

   g. The Corps shall develop an advanced compensation strategy and to the extent practicable, implements compensatory actions prior to the construction of bank protection projects.

3. Measures shall be taken to insure that contractors, construction workers, and all other parties involved with these projects implement the projects as proposed in the biological assessment and this biological opinion.

a. The Corps shall minimize the potential for incidental take resulting from the project related activities by implementing the project description as described in the biological assessment and the project description of this biological opinion.

b. The Corps shall provide a copy of this biological opinion to the prime contractor, making the prime contractor responsible for implementing all requirements and obligations included in this biological opinion and to educate and inform all other contractors involved in the project as to the requirements of this biological opinion. A notification that contractors have been supplied this biological opinion will be provided to the reporting address below.

c. A NMFS-approved Worker Environmental Awareness Training Program for construction personnel shall be conducted by the NMFS-approved biologist for all construction workers prior to the commencement of construction activities. The program shall provide workers with information on their responsibilities with regard to Federally-listed fish and their critical habitat, including an overview of the life-history of all the species, information on take prohibitions, protections afforded these animals under the ESA, and an explanation of the relevant terms and conditions of this biological opinion. Written documentation of the training must be submitted to NMFS within 30 days of the completion of training. As needed, training shall be conducted in Spanish for Spanish language speakers and other languages as needed or necessary.

Reports and notifications required by these terms and conditions shall be submitted to:

Sacramento Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento California 95814-4706
FAX: (916) 930-3629
Phone: (916) 930-3600

IX. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These conservation recommendations include discretionary measures that the Corps can implement to avoid or minimize adverse effects of past and future actions on listed species and critical habitat. NMFS provides the following conservation recommendations that would avoid or reduce adverse impacts to listed salmonids:

1. The Corps, under the authority of section 7(a)(1) of the ESA, should implement recovery and recovery plan-based actions within and outside of traditional flood damage reduction projects. Such actions may include, but are not necessarily limited to restoring natural river function and floodplain development.

2. The Corps should cooperate with local levee maintenance districts, flood control agencies, and State and Federal resource agencies to develop an anticipatory erosion repair program that emphasizes the use of biotechnical techniques, and minimizes the use of rock rip rap to treat small erosion sites before they become critical.

3. The Corps should make set-back levees integral components of the Corp's authorized bank protection or ecosystem restoration efforts.

4. The Corps should evaluate the SRFCP's effectiveness for providing flood damage reduction using regional climate change forecasts and anticipated shifts in precipitation and other related hydrologic regimes.

5. The Corps should make more effective use of ecosystem restoration programs, such as those found in Sections 1135 and 206 of the respective Water Resource Developments Acts of 1986 and 1996. The section 1135 program seems especially applicable as the depressed baselines of the Sacramento River winter-run Chinook salmon, CV steelhead, and CV spring-run Chinook salmon are, to an appreciable extent, the result of the Corps' SRBPP program.

6. The Corps should incorporate the costs of conducting lengthy planning efforts, involved consultations, implementation of proven off-site conservation measures, and maintenance and monitoring requirements associated with riprapping into each project's cost-benefit analysis such that the economic benefits of set-back levees are more accurately expressed to the public and regulatory agencies. This includes a recognition of the economic value of salmonids as a commercial and sport fishing resource.

7. The Corps should conduct or fund studies to identify set-back levee opportunities, at locations where the existing levees are in need of repair or not, where set-back levees could be built now, under the SRBPP, or other appropriate Corps authority. Removal of the existing riprap from the abandoned levee should be investigated in restored sites and anywhere removal does not compromise flood safety.

8. As recommended in the NMFS draft Recovery Plan for the Sacramento River winter-run Chinook Salmon (NMFS 1997), the Corps should preserve and restore riparian habitat and meander belts along Delta waterways with the following actions: (1) avoid any loss or additional fragmentation of riparian habitat in acreage, lineal coverage, or habitat

value, and provide in-kind compensation when such losses are unavoidable (*i.e.*, create meander belts along the Sacramento River by levee set-backs), (2) assess riparian habitat along the Sacramento River from Keswick Dam to Chipps island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run Chinook salmon, (3) develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan (*i.e.*, restore marshlands within the Delta and Suisun Bay), and (4) amend the Sacramento River Flood Control and SRBPP to recognize and ensure the protection of riparian habitat values for fish and wildlife (*i.e.*, develop and implement alternative levee maintenance practices).

9. Section 404 authorities should be used more effectively to prevent the unauthorized application of riprap by private entities.

To be kept informed of actions minimizing or avoiding adverse effects, or benefiting listed or special status species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

X. REINITIATION OF CONSULTATION

This concludes formal consultation on the remaining 24,000 linear feet of authority under the SRBPP. Reinitiation of formal consultation is required if: (1) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (2) the action, including the avoidance, minimization, and compensation measures listed in the *Description of the Proposed Action* section is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (3) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

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Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Programmatic Consultation for Phase II of the Sacramento River Bank Protection Project
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2007SA00492
DATE ISSUED:	________________________

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) on for the remaining 24,000 linear feet of authority under Phase II of the Sacramento River Bank Protection Project (SRBPP). The Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River and Sutter Slough.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for Phase II of the SRBPP addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), and Central Valley spring-run Chinook salmon (CV spring-run Chinook salmon (*O. tshawytscha*)). This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that the there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding one foot and velocities ranging from 1 to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from 1 to 4 inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION.

The Corps proposes to implement the remaining 24,000 linear feet of authority under Phase II of the SRBPP. The SRBPP is a continuing construction project, authorized by the Flood Control Act of 1960, to provide protection for the existing levees and flood control facilities of the

SRFCP. The purpose of the action is to ensure the reliability of the levees of the SRFCP for the life of the project, while protecting environmental values and compensating and/or mitigating effects on environmental resources to the degree feasible. The SRFCP consists of approximately 980 miles of levees plus overflow weirs, pumping plants, and bypass channels that protect communities and agricultural lands in the Sacramento Valley and Sacramento-San Joaquin Delta (Delta). A vicinity map illustrates this area in Figure 1.

The action is the future repair of waterside levee-bank erosion sites that occur within the SRBPP project area, which includes the Sacramento River from the town of Collinsville, at river mile (RM) 0 upstream to Chico at RM 194. The SRBPP also includes reaches of lower Elder and Deer creeks, Cache Creek, the lower reaches of the American River (RM 0–23), Feather River (RM 0–61), Yuba River (RM 0–11), and Bear River (RM 0–17), and portions of Threemile, Steamboat, Sutter, Miner, Georgiana, and Cache sloughs. The proposed action is described in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, and threatened Central Valley steelhead critical habitat. A summary of the effects of the proposed action on Central Valley fall-/late fall-run Chinook salmon EFH is provided below.

Adverse effects to Chinook salmon habitat will result from construction related impacts, operations and maintenance impacts, and long-term impacts related to modification of aquatic and riparian habitat throughout the action area. Primary construction related impacts include riprapping up to approximately 24,000 lf of riverbank. Integrated conservation measures to minimize adverse effects of riprapping will be applied to all sites. Conservation measures include construction of seasonally inundated terraces that will be planted with riparian vegetation. IWM will be placed both below and above the mean summer water surface elevation to provide habitat complexity, refugia, and food production of juvenile anadromous fish. Offsite conservation measures, including setback levees, IWM installation, and shallow-bank construction will be implemented to compensate for temporal and spatial effects of individual future actions.

In-channel construction activities such as vegetation removal, grouting, and rock placement will cause increased levels of turbidity. Turbidity will be minimized by implementing the proposed conservation measures such as implementation of BMPs and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

The effects of O&M actions will be similar to construction impacts. The Corps expects to place no more than 600 tons of rock annually. Most actions are expected to occur during the summer when anadromous fish are not expected to be present. Additionally, since O&M actions will not occur every year, and actions will be specific and localized in nature, O&M impacts will be smaller and shorter in duration.

At some sites, there will be short and long-term losses of habitat value. Long-term impacts are expected to adversely affect EFH for adult salmon at all seasonal water surface elevations for 2 to 12 years. Impacts at the fall and summer water surface elevation are expected to be the most substantial due to the inherent difficulties of re-establishing riparian vegetation in these zones. Long-term effects of the project (*i.e.*, 5 to 50 years) will be positive as riparian habitat becomes mature. Overall, the action will result in a net increase in habitat conditions essential to Chinook salmon survival and growth, especially at winter and spring flows when the majority of fish are outmigrating through the action area. This net increase is expected to maintain and improve the conservation condition of the habitat for Chinook salmon and avoid habitat fragmentation that typically is associated with riprapping.

IV. CONCLUSION

Upon review of the effects of the remaining 24,000 linear feet of authority under Phase II of the SRBPP, NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that the Terms and Condition, and the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and Central Valley steelhead ESUs be adopted as EFF Conservation Recommendations.

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

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